CITY OF GREENFIELD
POTABLE WATER DISTRIBUTION SYSTEM
MASTER PLAN
July 2016

<u>City Council</u>
Mayor John Huerta, Jr.
Mayor Pro-Tempore Raul Rodriguez
Council Member Leah Santibanez
Council Member Avelina Torres
Council Member Lance Walker

Prepared By:

Steven G. Tanaka, P.E. 49779
Principal Civil Engineer

REGISTERED PROFESSIONAL ENGINEER
STEVEN G. TANAKA
CO49779
CIVIL
STATE OF CALIFORNIA

WALLACE GROUP®

THIS PAGE LEFT INTENTIONALLY BLANK

Table of Contents

List of Tables and Figures iii

List of Acronyms iv

List of References v

1: Introduction 1-1

Purpose of the Project 1-1

Authorization and Scope of Work 1-1

Acknowledgements 1-3

2: Water Distribution System Overview 2-1

Water Distribution System Background 2-1

3: Study Area Characteristics 3-1

Land Use and Future Development 3-1

Population 3-1

4: Water Demand 4-1

Historical Water Demand 4-1

Unaccounted for Water 4-1

Water Demand Categories 4-2

Hydraulic Demand Parameters 4-2

Future Water Demands 4-4

5: Water Supply and Water Quality 5-1

Introduction 5-1

Wells 1 and 6 5-1

Well 7 5-1

Supply Redundancy 5-1

Power Redundancy 5-2

Supply Recommendations 5-3

Water Quality 5-3

Drinking Water Standards 5-3

6: Water Storage 6-1

Existing Water Storage Facilities 6-1

Existing and Future Storage Analysis 6-1

Un-useable Storage 6-1
Emergency Storage 6-1
Fire Storage 6-2
Operational Storage 6-2
Storage Summary 6-2
Storage Recommendations 6-3
Seismic Upgrades 6-3
Overall Storage Recommendations 6-3
7: Water Pump Stations 7-1
Pump Stations 7-1
Corporation Pump Station 7-1
Oak Pump Station 7-1
Prior Studies 7-2
Pump Station Recommendations 7-2
8: Water Distribution System Analysis 8-1
Water Distribution System 8-1
Water System Design Requirements 8-2
Water Model Development 8-4
Existing System Performance 8-4
Future System Performance 8-6
9: Summary of Recommendations 9-1
Water Distribution System Priorities 9-2
Master Plan Improvement Project Ranking and Costs 9-3
Other Major Capital Improvement Projects 9-4
10: Appendix A - Pump Curves 10-1

List of Tables and Figures

Table 2-1. Service Connections by Land Use 2-1
Figure 2-1. Water Distribution System 2-2
Figure 2-2 Hydraulic Profile 2-3
Table 3-1. Existing and Future Land Use 3-2
Figure 3-1. Existing Land Use 3-3
Figure 3-2. Future Growth Area Land Use 3-4
Table 4-1. Summary of Historical Water Production 4-1
Table 4-2. Existing Water Demand Factors 4-2
Table 4-3. Existing Water System Demands 4-2
Table 4-4. Average Day Demand 4-3
Table 4-5. Future Water Demand Factors 4-5
Table 4-6. Future Water System Demands 4-5
Table 5-1. Supply Well Summary 5-2
Table 5-2 Production Data By Well 5-2
Table 5-3. Supply Redundancy Evaluation 5-2
Table 5-4. Primary Drinking Water Standards and Water Quality 5-4
Table 5-5. Secondary Drinking Water Standards and Water Quality 5-5
Table 5-6. Summary of Lead and Copper Water System Sampling Results 5-5
Table 6-1. Summary of the Existing Water Storage Facilities 6-1
Table 6-2. Emergency Storage Recommendations 6-1
Table 6-3 Fire Storage 6-2
Table 6-4. Operational Storage Recommendations 6-2
Table 6-5. Required Storage Summary 6-3
Table 7-1. Pump Station Characteristics Summary 7-1
Table 7-2. Pump Station Summary 7-2
Table 8-2. Existing Water Main Inventory by Material 8-1
Table 8-1. Existing Water Main Inventory by Diameter 8-1
Table 8-3. Fire Flow Requirements by Zoning 8-3
Table 8-4. Summary of Hydraulic Parameters and Design Criteria 8-5
Table 8-5. Modeled Hazen-William's "C" Factors 8-6
Table 9-1. Summary of Pipeline Upgrades by Pipe Size, Material and Priority 9-2
Table 9-2. Unit Cost for Construction of Water Mains 9-4
Table 9-3. First Priority Master Plan Improvement Projects 9-6
Table 9-4. Second Priority Master Plan Improvement Projects 9-7
Table 9-5. Third Priority Master Plan Improvement Projects 9-8
Table 9-6. Future Priority Master Plan Improvement Projects 9-9
Figures 9-1 through 9-4. Proposed Master Plan Improvement Projects 9-10

List of Acronyms

AC	Asbestos Cement
ADD	Average Day Demand
AFY	Acre-Feet per Year
AWWA	American Water Works Association
“C” Factor	Hazen-Williams roughness coefficient
cfs	cubic feet per second
CI	Cast Iron
CIP	Capital Improvement Program
City	City of Greenfield
DI	Ductile Iron
ENR	Engineering News-Record
GIS	Geographic Information System
gal	Gallon
gpcd	gallons per capita per day
gpm	gallons per minute
hp	horse power
MG	million gallon
mgd	million gallons per day
N/A	Not Available
NFPA	National Fire Protection Agency
PF	Peaking Factor
PHD	Peak Hour Demand
Plan or WMP	Water Master Plan
PRV	Pressure Reducing Valve
PVC	Poly-Vinyl Chloride
SCADA	Supervisory Control and Data Acquisition
SWRCB-DDW	State Water Resources Control Board – Division of Drinking Water
UAW	Unaccounted-for-Water
UFC	Uniform Fire Code

List of References

1. California Code of Regulations, Title 22.
2. Billing Records: 2012-2014
3. Progress GIS Files of the Water Distribution System
4. 2005-2025 Water System Capital Improvement Plan Update and Capacity Charge Study
5. 2009 Water Financial Plan
6. 2010 Urban Water Management Plan
7. 2011 Water Rate Study
8. 2012-2014 Annual Report
9. 2012-2014 CCR Annual Water Quality Reports
10. 2001-2015 Water Production and Delivery Records
11. 2014 Water Contingency Plan
12. California Department of Public Health Water System Permit
13. Operation and Maintenance Manual for the City of Greenfield Water System
14. Greenfield Population – Historical and Projected
    2005 General Plan
15. McGraw Hill ENR Construction Cost Index of 10242 (March 2016)
16. Metcalf & Eddy design handbook "Wastewater Engineering, Treatment and Reuse, Fifth Addition", 2014.
17. Personal Communication with Mic Steinman, Community Services Director and Arturo Felix, Public Works Utilities Manager.
18. Pump Curves provided by the City of Greenfield
19. Fire Hydrant Testing conducted December 2015.
20. Draft Water Booster Pump Station Pressure Study, M.K. Nunley & Associates, February 2016

1: Introduction

The City of Greenfield (City) supplies water service and fire suppression to its customers throughout the City. As older infrastructure is replaced and new development projects are constructed, it is the City's goal to construct water improvements to meet the current and ultimate needs of the City. In order to facilitate this goal, and to adequately plan for the capital resources needed to meet this goal, the City commissioned a comprehensive Water Master Plan (Plan or WMP) that evaluates all aspects of the water distribution system and its ability to meet current and long-term needs of the City.

Purpose of the Project

Preparation of the Plan will assist the City in prioritizing both current and future water system needs and set forth a mechanism for addressing those needs. The Plan does the following:

1. Addresses existing deficiencies within the water distribution system based on today's standards and requirements;
2. Addresses deficiencies within the water distribution system to meet future build-out needs; and
3. Provides a prioritized list of recommendations with associated hard and soft costs to complete the projects.

Authorization and Scope of Work

On May 13, 2015, the City authorized Wallace Group to prepare a comprehensive Water Master Plan. The Water Master Plan was prepared in accordance with Wallace Group's proposal dated April 10, 2015. A summarized scope of work is as follows:

1. **Kick-Off Meeting, Project Review Meetings, Field Reviews and Operation Staff Interviews:** Coordinate and attend a kick-off meeting with key Team members and City staff. Immediately following the meeting, conduct an interview with the City's operations staff and an initial field investigation of the City's water tanks and pump stations to understand layouts and system operations.
2. **Existing Data Collection:** Obtain and review documents that will provide an understanding of the City's current water operations. City staff will provide the needed population projections based on City land use and zoning, General Plan and other planning information.
3. **Preliminary Findings Memorandum:** Prepare a description and general inventory of the water, storage and distribution system based on review of plans, reports, studies and other City records, visits with staff and field inspections. We will document all parts of the existing water supply, storage and distribution system, including facilities, condition of equipment and system components, processes, and hydraulic requirements for existing water sources (water supply wells), reservoirs/storage tanks, booster pump stations, pressure zones, and distribution/transmission pipelines; document capital improvements and system expansions completed over the past 10-20 years, based on record drawings and other detailed information provided by City staff; and document compliance requirements for the City's operating permit issued by the State Department of Health Services.

4. **Water Model Development and Calibration:** Utilize present and future water demand information to model and determine water distribution system improvements including upsizing pipe sizes, addition of new water mains to transport flows through the system within appropriate pressure levels to all areas within the system.
5. **Water Storage and Supply Evaluation:** Identify current and future water reservoir storage requirements for operational (peak demand), emergency, and fire storage. Wallace Group will coordinate with the City, the City Fire Department (if required), and use the current Uniform Fire Code to ascertain, update and confirm fire flow requirements throughout the service area. We will evaluate the capacity and reliability of the City's water well network, with respect to meeting current and future demands. We will review scenarios when water wells and storage tanks are out of service due to needed repairs or servicing.
6. **Develop Capital Improvement Program:** Evaluate the existing Water Distribution System and identify hydraulic deficiencies with maintenance and mitigation recommendations and identify the discrete system improvements needed to correct the deficiencies based upon Master Plan projected growth, and system design criteria. We will identify capital improvements to water supply, including potential need and timing for any additional reservoirs, pump stations, expanded waterline capacity, and recommendations for improvements to the existing SCADA systems. We will prepare a map of the water system and summary tables indicating the locations, functional data (size, capacity, material, etc.), estimated costs and implementation timeframes of the improvements proposed for inclusion in the capital improvement plan. We will prepare a short and long term capital improvement plan to address identified deficiencies including prioritization, alternatives, analysis, and schedule. This CIP will include a 5-year CIP for the purposes of subsequent water rate studies to be conducted by the City. Schedule and timing for projects identified for future build-out will be based on water demand-based "triggers" corresponding to projected growth and population forecasts provided by the City.
7. **Staff Recommendations:** Provide recommendations for staffing and organizational structure for operation and maintenance of the system. We will provide suggestions for improvements to the City's general approach to operation of the system.
8. **Regulatory Update:** Identify present and future regulatory concerns for the water treatment facilities and distribution system.
9. **Prepare Water Master Plan Report:** Prepare the Water Master Plan. Wallace Group will prepare a Draft, Draft-Final for City Council approval and a Final Report.

Acknowledgements

Wallace Group thanks and gratefully acknowledges the following for their efforts, involvements, input and assistance in preparing this Water Master Plan:

City of Greenfield City Council:

Mayor John Huerta, Jr.
Mayor Pro-Tempore Raul Rodriguez
Council Member Leah Santibanez
Council Member Avelina Torres
Council Member Lance Walker

City of Greenfield City Staff:

Susan Stanton	City Manager
Doug Pike (MNS)	City Engineer
Mic Steinmann	Acting Community Development Director
Arturo Felix	Public Works Utilities Manager
Carmen Lorenzana	Public Works Administrative Assistant

The following Wallace Group key team members were involved in the preparation of this Water Master Plan:

Steven G. Tanaka, PE	Principal Civil Engineer
Kari Wagner, PE	Director of Water Resources
Valerie Huff, PE	Senior Civil Engineer
Kyle Anderson, PE	Civil Engineer
Jeff LeNay	GIS Specialist

2: Water Distribution System Overview

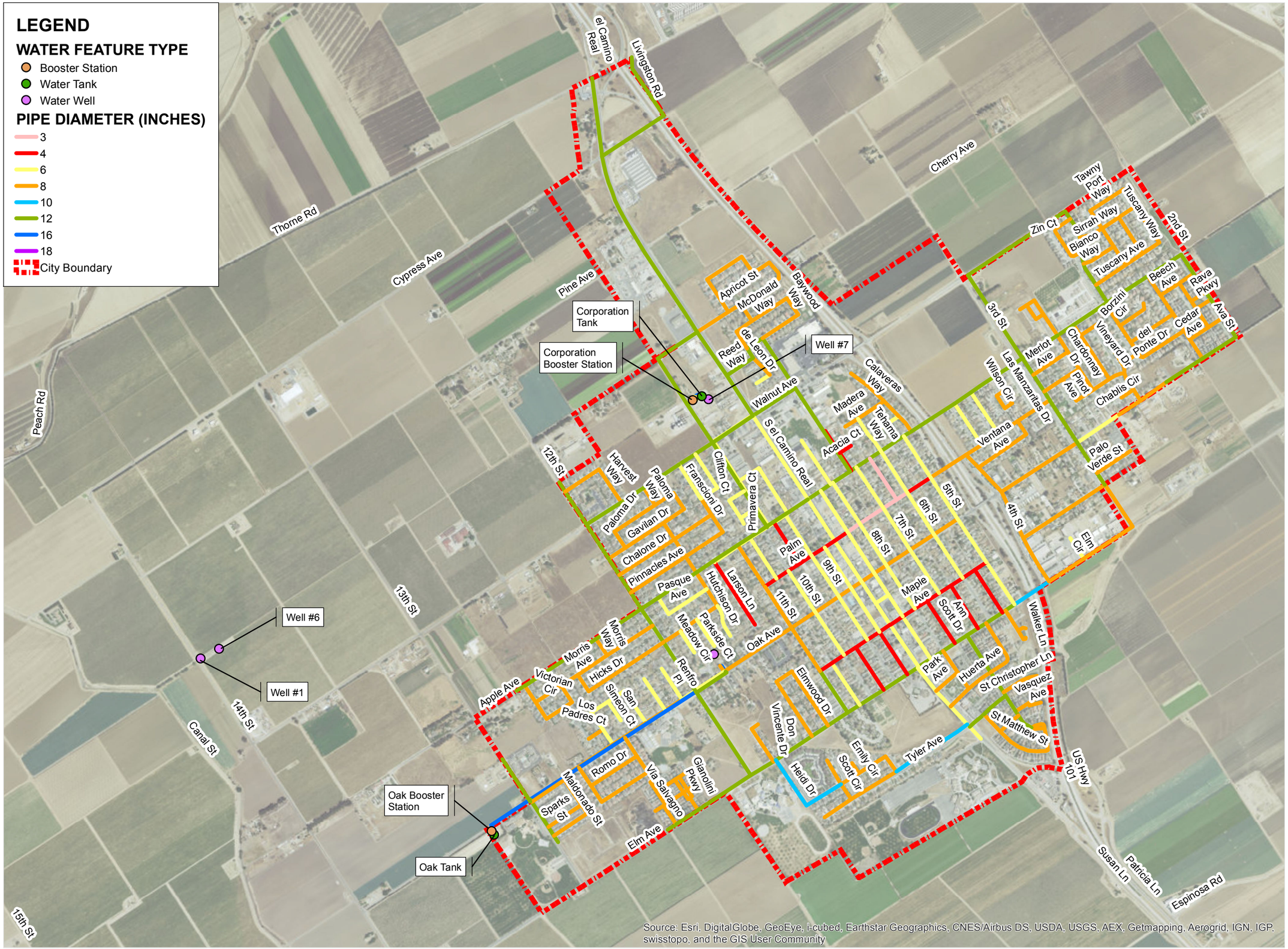
Chapter 2 provides a general overview of the features of the City's water distribution system. The details regarding the various water system features are then presented in subsequent chapters.

Water Distribution System Background

The City owns and operates a water distribution system that is comprised of one distribution zone, two potable water storage tanks, and two pump stations. The City owns and operates 36 miles of water mains that span over 2.1 square miles to serve the City's ~3700 customers (connections). Table 2-1 provides a breakdown of the number of service connections by land use that the City's distribution system serves (based on 2014 delivery data). The existing water distribution system is shown in Figure 2-1. Figure 2-2 depicts the hydraulic profile of the City's water system, which shows the elevations of key water system components, including the wells, two storage tanks and two booster stations. The single pressure zone serves the City residents water, at elevation ranges between 210 feet above mean sea level (MSL) to 335 feet MSL.

Table 2-1. Service Connections by Land Use

Land Use	Connections
Single Family Residential	3,125
Multi-family Residential	292
Commercial/Institutional	139
Industrial	10
Landscape Irrigation	32
Other	55
Agricultural Irrigation	0



Greenfield

Where Historic El Camino Real Meets Monterey Wine Country

WALLACE GROUP
CIVIL ENGINEERING
CONSTRUCTION MANAGEMENT
LANDSCAPE ARCHITECTURE
MECHANICAL ENGINEERING
PLANNING
PUBLIC WORKS ADMINISTRATION
SURVEYING/GIS SOLUTIONS
WATER RESOURCES
WALLACE SWANSON INTERNATIONAL
612 CLARION COURT
SAN LUIS OBISPO, CA 93401
805 544-4011 www.wallacegroup.us

THIS MAP IS INTENDED FOR THE EXPRESSED USE OF THE CITY OF GREENFIELD AND DOES NOT CONSTITUTE A LEGAL DOCUMENT. WALLACE GROUP DID NOT PERFORM SURVEY SERVICES FOR THIS MAP. DATA COMPILED FROM MULTIPLE SOURCES.

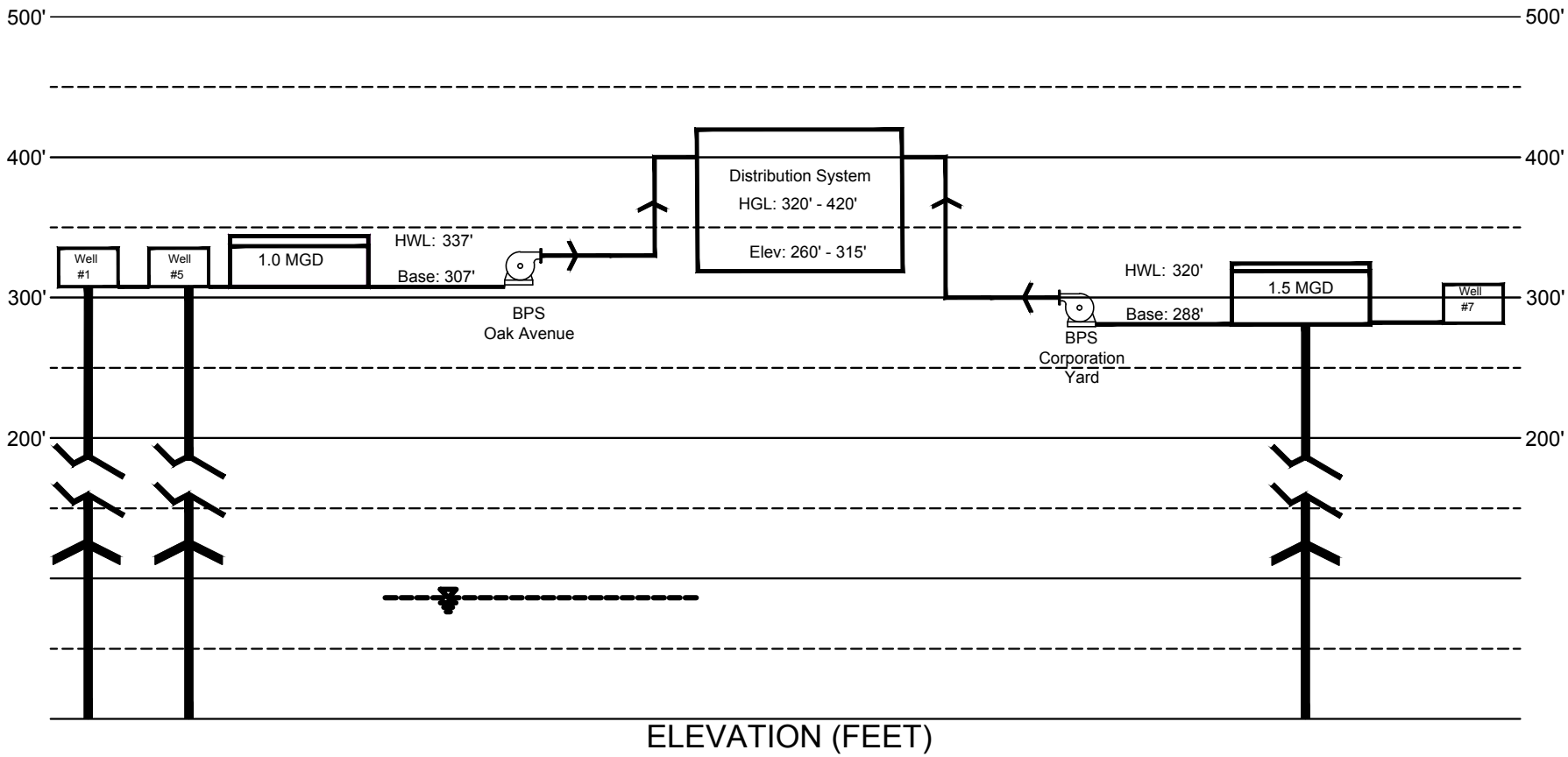
FIGURE 2-1
EXISTING WATER DISTRIBUTION SYSTEM OVERVIEW

1 inch = 1,200 feet

N

0 600 1,200
Feet

M:\1163-Greenfield, City of\005-Water and Wastewater Master Plans\06 - Reports and Calculations\03 - GIS\01 - Map Documents\Water Master Plan Exhibits\Existing Water System Overview.mxd; Author: <MAP AUTHOR>



*Well Depth Varies (~800')

WALLACE GROUP®
612 CLARION COURT
SAN LUIS OBISPO, CA 93401
T 805 544-4011
F 805 544-4294
www.wallacegroup.us

FIGURE 2-2
CITY OF GREENFIELD
WATER SYSTEM
HYDRAULIC PROFILE

JOB No. :	1163-005
DRAWING :	1163-005 HYDR PRFL
DRAWN BY:	ZRM
DATE :	05/31/2016
SCALE :	NONE

3: Study Area Characteristics

Chapter 3 describes the study area characteristics germane to this Water Master Plan for the City. Included in this chapter is a description of the various land uses in the service area, future development projections, and existing and future population projections. Future development is based on the 2005 General Plan Land Use Element and direction from City Staff. All tables and figures are located at the end of this chapter.

Land Use and Future Development

The City of Greenfield is located in the Salinas Valley in Monterey County. Founded in 1905 and incorporated in 1947, Greenfield is centered in a highly productive agricultural region. Figure 3-1 illustrates the City's boundary, and the existing Land Use Designations per the 2005 General Plan. Table 3-1 summarizes the Land Use Designations and Projections (from the 2005 General Plan) and provides a breakdown of acreage designated for each land use. Figure 3-2 illustrates the future growth areas and land uses.

Population

For this master plan, historical and future population estimates were provided by the City. The reported population for the City for 2010-2015 is as follows:

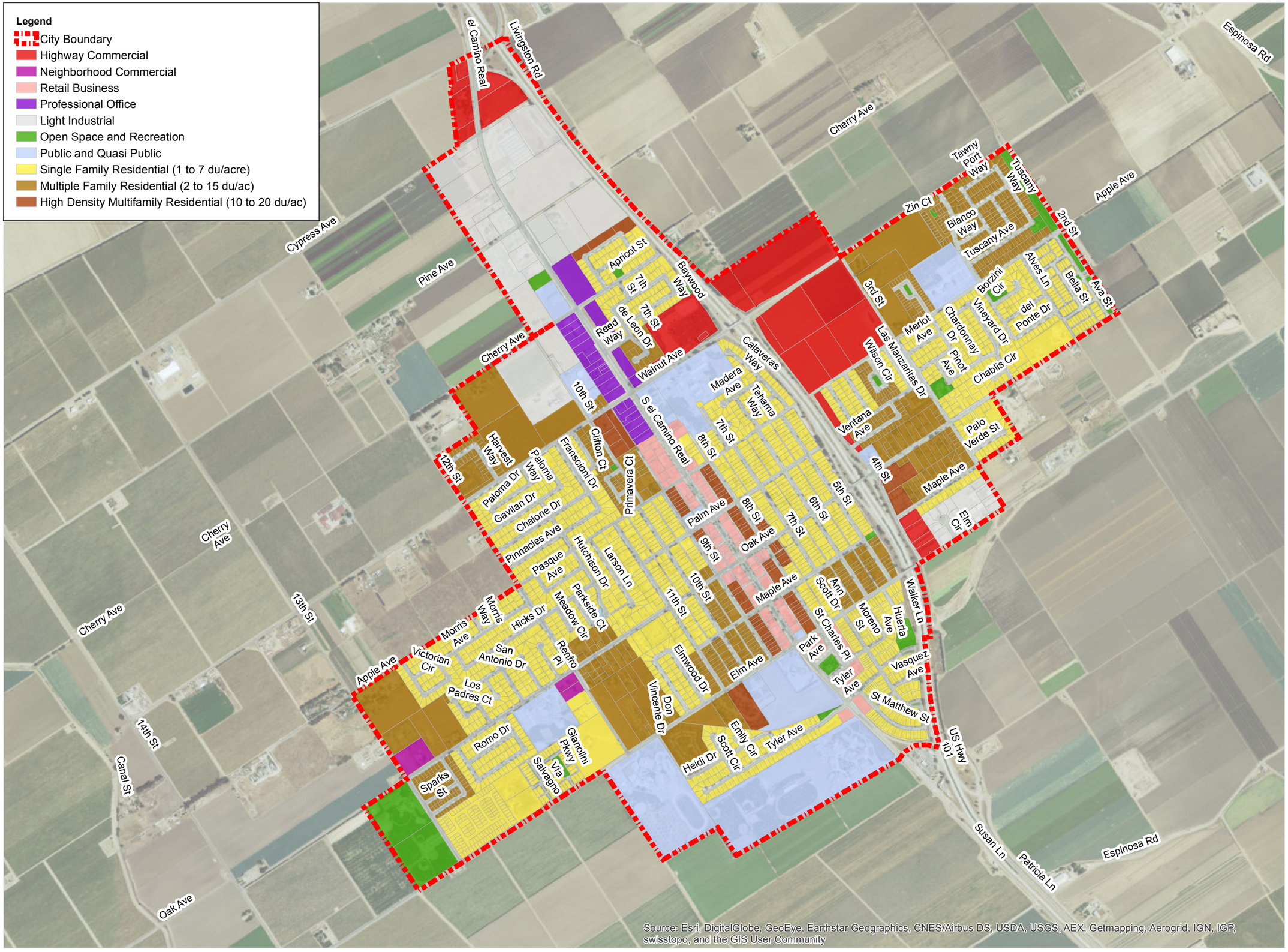
- **2010:** 16,192 persons
- **2011:** 16,396 persons
- **2012:** 16,466 persons
- **2013:** 16,784 persons
- **2014:** 16,919 persons
- **2015:** 16,870 persons

For the purposes of this Water Master Plan, the City has provided a projected population growth rate of 2.5% from the base population of 16,870 in 2015. This growth rate results in a total population of 28,400 by 2035, which correlates to the 20 year planning horizon for this Water Master Plan.

Table 3-1. Existing and Future Land Use

General Plan Land Use	Total Acreage	Future Growth Area
Single Family Residential	380.60	190.74
Multiple Family Residential	220.37	113.61
High Density Residential	30.84	0.00
Residential Estate	0.00	149.05
Neighborhood Commercial	5.24	0.00
Downtown Commercial	29.69	0.00
Highway Commercial	103.43	234.13
Professional Office	20.92	0.00
Light Industrial	108.36	32.43
Heavy Industrial	0.00	154.03
Public Quasi Public	139.22	0.00
Recreation and Open Space	34.56	0.00
Artisan Agricultural Visitor Serving	0	168.29

Source: City of Greenfield General Plan and Zoning 2010 GIS Database from PMC.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Greenfield

Where Historic El Camino Real Meets Monterey Wine Country

WALLACE GROUP
CIVIL ENGINEERING
CONSTRUCTION MANAGEMENT
LANDSCAPE ARCHITECTURE
MECHANICAL ENGINEERING
PLANNING
PUBLIC WORKS ADMINISTRATION
SURVEYING/GIS SOLUTIONS
WATER RESOURCES
WALLACE SWANSON INTERNATIONAL
612 CLARION COURT
SAN LUIS OBISPO, CA 93401
805 544-4011 www.wallacegroup.us

THIS MAP IS INTENDED FOR THE EXPRESSED USE OF THE CITY OF GREENFIELD AND DOES NOT CONSTITUTE A LEGAL DOCUMENT. WALLACE GROUP DID NOT PERFORM SURVEY SERVICES FOR THIS MAP. DATA COMPILED FROM MULTIPLE SOURCES.

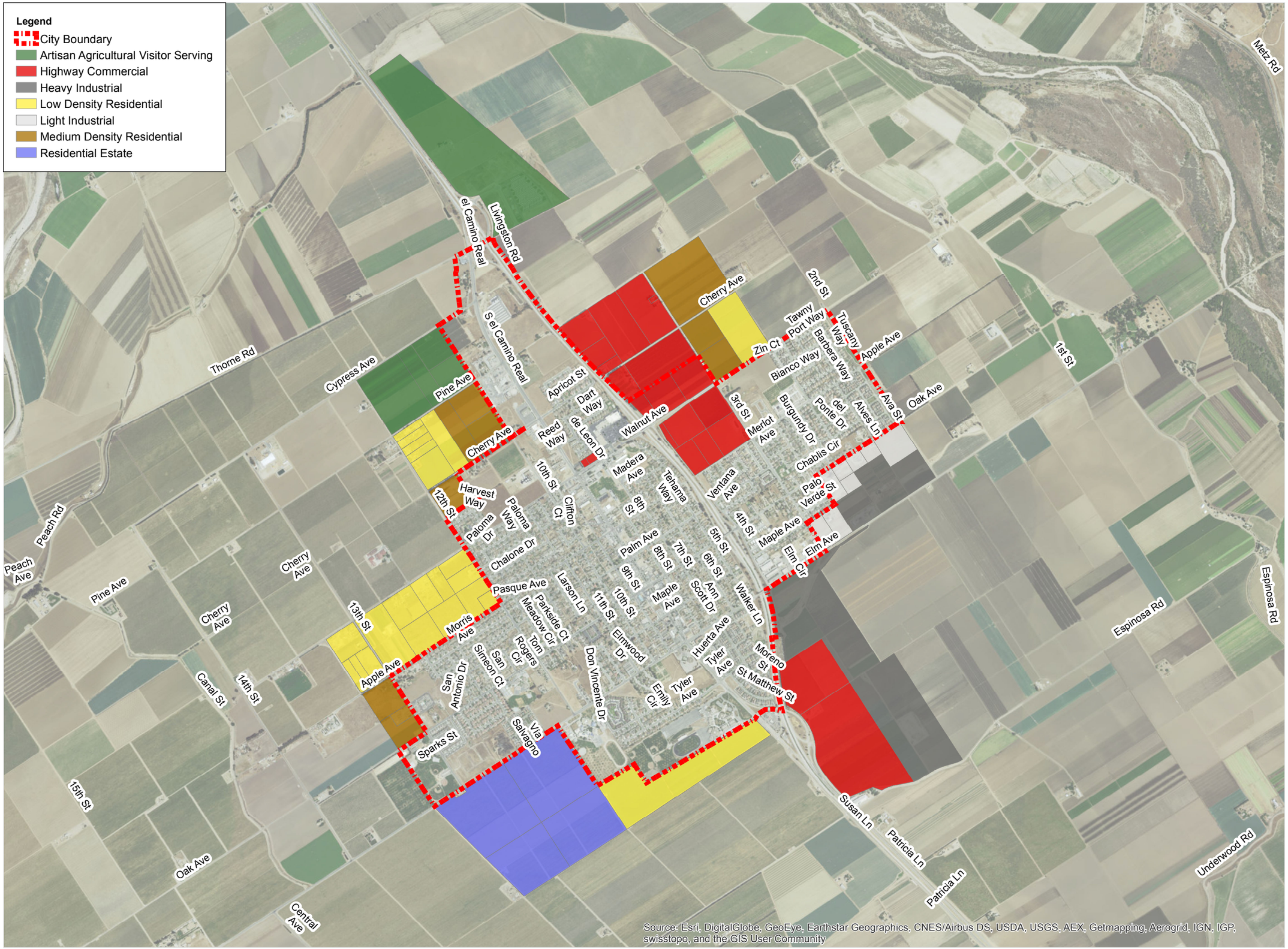
FIGURE 3-1
EXISTING ZONING

N

1 inch = 1,200 feet

0 300 600 1,200

M:\1163-Greenfield, City of\005-Water and Wastewater Master Plans\06 - Reports and Calculations\03 - GIS\01 - Map Documents\Preliminary Findings Memorandum Exhibits\Figure 1 - Existing Zoning.mxd; Author: <MAP AUTHOR>



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Greenfield

Where Historic El Camino Real Meets Monterey Wine Country

WALLACE GROUP
CIVIL ENGINEERING
CONSTRUCTION MANAGEMENT
LANDSCAPE ARCHITECTURE
MECHANICAL ENGINEERING
PLANNING
PUBLIC WORKS ADMINISTRATION
SURVEYING/GIS SOLUTIONS
WATER RESOURCES
WALLACE SWANSON INTERNATIONAL
612 CLARION COURT
SAN LUIS OBISPO, CA 93401
805 544-4011 www.wallacegroup.us

THIS MAP IS INTENDED FOR THE EXPRESSED USE OF THE CITY OF GREENFIELD AND DOES NOT CONSTITUTE A LEGAL DOCUMENT. WALLACE GROUP DID NOT PERFORM SURVEY SERVICES FOR THIS MAP. DATA COMPILED FROM MULTIPLE SOURCES.

FIGURE 3-2
FUTURE GROWTH AREA ZONING

N

1 inch = 1,800 feet

0 450 900 1,800

M:\11163-Greenfield, City of\005-Water and Wastewater Master Plans\06 - Reports and Calculations\03 - GIS\01 - Map Documents\Preliminary Findings Memorandum Exhibits\Figure 2 - Future Growth Area.mxd; Author: <MAP AUTHOR>

4: Water Demand

Chapter 4 describes the existing and projected water demands for the City. The water demand forecasts will form the basis for identifying existing and future system needs and analyzing deficiencies.

General water demand and production definitions used in this report are defined as follows:

Water Consumption – The amount of water consumed (as measured directly through customer meters).
Water Production – The amount of water produced by the City's water supply sources.
Unaccounted-for-Water (UAW) – the difference between the quantity of water produced and the amount of water consumed (as measured directly through customer meters).

Historical Water Demand

Water production data provided by the City for the years 2009 through 2013 were used for this analysis. Data from 2014 and 2015 were excluded due to the unusually low demand triggered by drought conditions. The historical production of potable water is summarized in Table 4-1.

Table 4-1. Summary of Historical Water Production

Year	Total Production (ac-ft)	Total Metered Consumption (ac-ft)	UAW (ac-ft)	UAW (%)
2009	2,020	1,965	55.3	2.7
2010	1,938	1,897	41.2	2.1
2011	1,866	1,850	16.1	0.9
2012	1,905	1,935	-30.2	-1.6
2013	1,967	1,893	74.0	3.8
2014	1,795	1,734	60.5	3.4
2015	1,536	1,461	75.2	4.9
Average	**1,939**	**1,908**	**31.3**	**1.6**

[1]Note: Average is based off of 2009-2013.

Unaccounted for Water

The City's UAW ranges between -1.6 to 3.8 percent, with an average of 1.6 percent, as noted in Table 4-1. The AWWA Manual 32 states that municipal ranges for UAW are typically between 10 and 15 percent. The City of Greenfield's UAW average is well below the range, thus they are keeping system losses to a minimum.

UAW should be minimized where possible since it requires the City's resources to produce water, but is not being accounted for and thus revenue is not being collected. UAW is typically generated from several sources including leaking pipes, water used for fires, water main flushing, and faulty or un-calibrated meters.

Since the City's UAW is low compared to AWWA standards, it is recommended that the City not pursue any immediate improvement projects to reduce UAW. UAW should be evaluated yearly to determine if UAW increases over time. If it does, the City should evaluate the causes of the UAW and take necessary actions to reduce the UAW back down.

Water Demand Categories

The production noted in Table 4-1 includes all customers within the City. The City has substantial commercial and residential growth anticipated for the future. In order to gain a better understanding of the water demands for future growth, the total production has been further broken down into the following categories:

1. Residential: Includes single family residential, multi-family residential, apartments, duplexes and mobile home parks
2. Commercial: Includes commercial, restaurants, Government facilities, churches, hotels/motels
3. Industrial
4. Schools
5. Landscape Irrigation: Includes all parks and open-space
6. Other: Includes government, fire protection and any additional users not categorized above.

Table 4-2 provides a summary of the average daily demands broken into the categories listed above from meter records for calendar year 2011 – 2013, with 1.0% factor for UAW, and the estimated quantity or unit for each category. Note that 2009 and 2010 were excluded from the analysis due to anomalies in their meter reading data. Table 4-2 also provides a use factor for the categories provided, which can further be used to estimate water demands for future growth.

Table 4-2. Existing Water Demand Factors

Use Category	Consumption (gpd)	Quantity or Units[1]		Demand Factor
Residential	1,475,460	16,549	Persons	89 gpcd
Commercial	99,601	106	Connections	937 gpd/connection
Industrial	12,310	10	Connections	1,278 gpd/connection
Schools	12,311	3,535	Students	3.5 gpd/student
Landscape Irrigation	48,839	37	Acres	1,334 gpd/acre
Other	41,144	9	Acres	4,784 gpd/acre

[1] Quantities, excluding residential population, obtained from the City's General Plan GIS data. Residential population based on average population between 2011-2013.

Hydraulic Demand Parameters

Water system demands are important characteristics of water systems, as these parameters are used to size pumping, storage, and distribution system facilities. Each community's water system exhibits unique characteristics that must be calculated and identified in order to better

Table 4-3. Existing Water System Demands

ADD (gpm)	MDD	MDD Peaking Factor	PHD	PHD Peaking Factor
1,202	3,675	3.1	5,512	4.6

evaluate existing and future water distribution system requirements. The hydraulic demand parameters used to evaluate the City's water distribution system are described in the following sections and summarized in table 4-3.

Average Day Demand (ADD)

The ADD is the average water production needed to meet the daily demand, which is calculated over the year. This demand is generally determined by production records. Table 4-4 provides a summary of the ADD for 2009 through 2013, which equates to 1,939 AFY or 1.73 mgd.

Table 4-4. Average Day Demand

Year	Total Production (ac-ft)	Average Day Demand (mgd)	Average Day Demand (gpm)
2009	2,020	1.80	1,252
2010	1,938	1.73	1,201
2011	1,866	1.67	1,157
2012	1,905	1.70	1,181
2013	1,967	1.76	1,220
2014	1,795	1.60	1,113
2015	1,536	1.37	952
Average[1]	**1,939**	**1.73**	**1,202**

[1]Average is based off of 2009-2013.

It is noted that Year 2015 and into 2016, California experienced its worst drought in recorded history. Even with a substantial rainy season in 2015/16, and above normal snowpack in the Sierra Nevadas, the effects the past several years of drought will be felt for some time. Governor Brown's Executive Order from April 2015 imposed urban water reductions of 25% as compared to 2013. The City of Greenfield is commended for meeting the Governor's setback mandate by achieving this goal in 2015. The flow reduction is seen in Table 4-4 through reduced water demand, and is also evidenced by lower flows at the wastewater treatment plant. It is expected that once the drought is over, water consumption will rebound to some degree to that of prior years; however, once strict water reduction goals are met, most residents will continue to conserve water to some degree. Thus, in projecting future water demand for the City through this master plan planning period, this will be taken under consideration.

Maximum Day Demand (MDD)

The MDD is the maximum daily production of water needed to meet the peak day demand of the year. Typically, MDD occurs during the summer as a result of increased irrigation demand and is determined by reviewing daily production records. A review of the City's daily production data showed occasional anomalies that make it difficult to determine the maximum day. Per the California Code of Regulations (CCR), Title 22, Division 4, Chapter 16, Article 2, Section B.2.A - B.2.C, if daily production data is not available for the most recent ten years, MDD can be calculated by identifying the month with the highest production during the most recent ten year period and multiplying the average daily usage for that month by a factor of 1.5. Using the CCR methodology and the City production records between

2006 and 2015, the maximum day production (based on the highest month, June 2006) was 5.29 mgd. This equates to a peaking factor of 3.1.

Peak Hour Demand (PHD)

The PHD of the system is critical in sizing water mains and pumping facilities. During PHD, customers will generally experience low service pressures in areas with undersized mains and/or lack of looped distribution water mains. The PHD is generally determined by calculating the specific demand within the day, by monitoring tank levels and pumping records. In many municipal systems, the exact calculation of this parameter is difficult to ascertain.

The City does not maintain hourly production records, which would be used to determine PHD. Per the California Code of Regulations (CCR), Title 22, Division 4, Chapter 16, Article 2, Section B.2.A - B.2.C, if hourly production data is not available for the most recent ten years, PHD can be calculated by multiplying the average hourly flow during MDD (as calculated above) by 1.5. Using the CCR methodology, the PHD for the City was 5,512 gpm. This equates to a peaking factor of 4.6.

Future Water Demands

Table 4-2 summarizes the water demand factors for each land use category. The water demand factors used in Table 4-2 were used to estimate future needs. In addition, the peaking factors identified in Table 4-3 were also be used for future needs. Table 4-5 provides the estimated future demands for the City based on the existing water demand factors and the projected population growth for the year 2035 provided by the City. Table 4-6 provide a summary of the future demand ADD, MDD and PHD.

Table 4-5. Future Water Demand Factors

Use Category	Quantity or Units[1]		Use Factor	Consumption (gpd)
Residential	28,400	Persons	89 gpcd	2,532,488
Commercial	155	Connections	937 gpd/connection	145,185
Industrial	26	Connections	1,278 gpd/connection	33,217
Schools	6,282	Students	3.5 gpd/student	21,870
Landscape Irrigation	73	acres	1,334 gpd/acre	96,959
Other	9	acres	4,784 gpd/acre	41,144
Total				**2,870,863**

[1] Residential population identified in Chapter 3. School quantity based on 2.5% growth. Commercial and Industrial quantities based on number of parcels in each category in the future growth areas. Landscape area based on 3.9% of the total developed area in 2035, equivalent to the existing landscaped area to total developed area ratio.

Table 4-6. Future Water System Demands

ADD (gpm)	MDD Peaking Factor	MDD	PHD Peaking Factor	PHD
2,014	3.1	6,154	4.6	9,232

5: Water Supply and Water Quality

Chapter 5 provides an overview of the City's water supply and water quality requirements. In addition, it provides an evaluation of the City's existing wells with regard to: reliability and redundancy, well pumping rates and standby power needs.

Introduction

The City currently obtains its water supply exclusively from groundwater. Currently, three wells (well # 1, well # 6 and Well # 7) operate to extract water from the underlying groundwater basin and pump it to two storage tanks. A summary of each well is provided below. Table 5-1 below provides a summary of well #'s 1, 6 and 7. Table 5-2 provides a summary of production by well.

Wells 1 and 6

Wells 1 and 6 are located at the intersection of Cherry Avenue and 14th street. Both wells are the only supply source for the Oak tank and booster station. Water is injected with sodium hypochlorite (12.5%) to provide residual disinfection at the well site prior to entering the distribution system. Wells 1 and 6 can either be used to fill the Oak tank or to back feed through the system to fill the Corporation tank. Wells 1 and 6 currently producing approximately 2500 gpm combined flow.

Well 7

Well 7 is located in the City's corporation yard, on 10th Street between Cherry Avenue and Walnut Avenue and was installed in 2009. Well 7 is the primary supply source for the City's corporation yard tank and booster station. Water is injected with sodium hypochlorite (12.5%) to provide residual disinfection at the well site prior to entering the Corporation Tank. Well # 7 is currently producing approximately 1800 gpm.

Supply Redundancy

In the event of a system failure, per California Water Works Standards, it is recommended that the City of Greenfield maintain adequate production facilities to accommodate the future maximum day demand (MDD) with the largest production well out of service. Table 5-3 analyzes the City of Greenfield's ability to meet this criterion.

Table 5-1. Supply Well Summary

Parameter	Well # 1	Well # 6	Well # 7
Year Installed	Unknown	Unknown	2009
Well Depth, feet	~800	~800	870
Screened Interval, feet	Unknown	Unknown	540-860
Pump Horsepower	Unknown	Unknown	Unknown
Pump/Well Capacity, gpm	1000	1500	1800
Total Pump Head, feet	Unknown	Unknown	Unknown
Standby Power	Yes	Yes	Yes

Table 5-2 Production Data By Well

Year	Well 1		Well 6		Well 7		Total
	ac-ft	% of Total Production	ac-ft	% of Total Production	ac-ft	% of Total Production	ac-ft
2011	521	28%	635	34%	693	37%	1,849
2012	474	25%	691	36%	740	39%	1,905
2013	322	16%	1,442	73%	203	10%	1,967
2014	374	21%	718	40%	703	39%	1,795
2015	372	24%	598	38%	589	38%	1,559
Average	413	23%	817	45%	586	32%	1,815

Table 5-3. Supply Redundancy Evaluation

	Total Well Supply	Largest Well Out of Service	Total Available Supply w/ Largest Well Out of Service	Max Day Demand	Supply Surplus/(Deficit)
	(gpm)	(gpm)	(gpm)	(gpm)	(gpm)
Existing	4,300	1,800	2,500	3,675	(1,175)
Future	4,300	1,800	2,500	6,155	(3,655)

Power Redundancy

Power availability is a critical consideration when assessing municipal water supply. The City of Greenfield currently relies on electricity as a primary power source to all three wells. All three of the City's wells are equipped with permanent emergency generators. Therefore, in the event of a regional power outage, uninterrupted delivery of service to City of Greenfield users and emergency fire response

is maintained. Combined well production from the three wells is 4300 gpm. Comparison against existing and future Average Day Demand (Table 4-3 and 4-6), reveals a surplus of 3,098 gpm and 2,286 gpm respectively. In addition, storage tanks with a combined capacity of 2.5 MG (7.7 AF) will assist in offsetting MDD and PHD.

Supply Recommendations

Review of the City of Greenfield's water production capabilities resulting from their existing wells indicates that the City of Greenfield has a supply deficit under both existing and future maximum day demand conditions. Additional wells are needed to meet the minimum criteria set forth by the California Water Works Standards.

Water Quality

This section describes the water quality parameters associated with the City's water supplies. The City receives water from one water source (Salinas Valley Groundwater Basin), extracted from three water wells (Wells 1, 6 and 7). After chlorination, water from Wells 1 and 6 either fill the Oak tank directly, or water is back fed through the distribution system to fill the Corporation tank. Water from Well 7 is fed directly into the Corporation Yard tank.

Drinking Water Standards

Drinking water standards are established by the United States Environmental Protection Agency (EPA) and by the California Division of Drinking Water (formerly California Department of Health Services). These federal and state agencies are responsible for ensuring that all public water systems are in compliance with the Safe Drinking Water Act (SDWA). The State of California may adopt drinking water standards equal to, or more stringent than federal standards.

State and Federal water standards fall into two categories:

- Primary Standards relate specifically to the health of the community as it might be affected by the water supply. Mandatory maximum contaminant levels (MCLs) are established for specific constituents.
- State Secondary Standards relate to aesthetic qualities of the water including taste, odor, color and some minerals. In California, maximum contaminant levels (MCLs) are also established for these secondary constituents.

Tables 5-4 and 5-5 list the current MCLs which the City must meet, along with other water quality parameters (secondary aesthetic standards). The results are based on the 2014 Consumer Confidence Report (CCR). The results indicate the City's water supplies meet all primary and secondary standards. Table 5-6 shows a summary of the City's lead and copper sampling in the water distribution system, which also shows compliance with the Lead and Copper Rule.

Table 5-4. Primary Drinking Water Standards and Water Quality

CONTAMINANT[1]	M.C.L.[1]	MCLG PHG	2014 Consumer Confidence Report
Aluminum	1000		ND
Antimony	6	6	ND
Arsenic	10	0.004	1.7
Barium	1000	2000	42
Beryllium	4	4	ND
Cadmium	5	5	ND
Chromium	50	100	5
Cyanide	150		ND
Hexavalent Chromium	10	0.02	2.1
Fluoride	2000	1000	300
Gross Alpha Particle Activity, pCi/L	15	15	5.6
Combined Radium, pCI/L	5	5	0.72
Uranium, pCI/L	20	20	6.2
Mercury	2	2	ND
Nickel	100	100	ND
Nitrate (as NO3), mg/L	45	45	8
Nitrite (as N), mg/L	1	1	0.13
Selenium	50	50	1.33
Thallium	2	0.5	ND
Total Trihalomethanes	80	---	1.25

[1]Units expressed in micrgrams per liter, except where noted

Table 5-5. Secondary Drinking Water Standards and Water Quality

CONTAMINANT, (units)	M.C.L.		2014 Consumer Confidence Report
	Recommended	Upper	
Aluminum, mg/L	0.2		ND
Chloride, mg/L	250	500	47
Color, color units	15	15	0.67
Copper, mg/L	1		ND
Corrosivity (LI)	Non-Corrosive		--
Foaming agents (MBAS), mg/L	0.5		ND
Iron, ug/L	300	300	35
Manganese, mg/L	50	50	--
MTBE, mg/L	0.005		ND
Odor - Threshhold	3	3	1
Silver, mg/L	0.1		ND
Sulfate, mg/L	250	500	148
Total Dissolved Solids	500	1000	527
Turbidity (NTU)	5	5	0.08
Zinc, mg/L	5	5	ND

Notes:
ug/L=micrograms per liter (ppb)
Mg/L=milligrams per liter (ppm)
MCL=maximum contaminant level
NTU=nephelometric turbidity units
ND=non-detect
pCI/L=picocuries per liter
PHG=public health goal
LI=Langelier's Index

Table 5-6. Summary of Lead and Copper Water System Sampling Results

Constituent	No. Samples Collected	90th Percentile Level	No. of Sites Exceeding Action Level	Action Level	PHG
Lead, ug/L	30	ND	0	15	0.2
Copper, mg/L	30	0.163	0	1.3	0.2

6: Water Storage

Chapter 6 describes the existing and projected water storage requirements for the City. Adequate water storage is critical to deliver water reliably to customers, and to provide fire storage for life safety.

Existing Water Storage Facilities

The City owns and operates two tanks. The locations of these facilities are identified on Figure 2-1. Table 6-1 summarizes each of the water storage facilities.

Table 6-1. Summary of the Existing Water Storage Facilities

Water Storage Facility	~Year Installed	Material	Diameter	Base Elevation	Approximate Overflow Elevation	Top of Outlet Pipe Elevation	Total Volume	Useable Volume
			(ft)	(ft)	(ft)	(ft)	(MG) [1]	(MG)[2]
Oak	1987	Steel	75	307	337.25	308.5	1	0.95
Corporation	2009	Steel	90	288	320	289.5	1.5	1.45
						Total Useable Volume		**2.40**

[1]Total Volume is based on the volume of water between the overflow elevation and the base elevation of the tank or reservoir.
[2]Useable Volume is based on the volume of water between the overflow elevation and the top of outlet pipe elevation of the tank or reservoir.

Existing and Future Storage Analysis

It is recommended that sufficient useable storage volume be maintained for emergency, fire, and operational needs within the City's tanks. For the purposes of this report, the groundwater wells will not be considered in the storage analysis.

Un-useable Storage

Un-useable storage is the volume of water that is below the top of the outlet pipe to the bottom of the tank. This water cannot be used without the use of a sump pump and therefore is not included in the overall volume of the tank.

Emergency Storage

Emergency storage is intended to provide for conditions such as extended power outages, pump failures, and similar problems. Most water planners accept that during emergencies, supply per capita may be reduced to minimum levels. Typically, on that basis, an emergency storage volume of 50 gpcd for three days is accepted as a reasonable value. Table 6-2 provides a summary of the emergency storage

Table 6-2. Emergency Storage Recommendations

	Population	gpcd	Storage (Gallons)
Existing	16,870	50	843,500
Future	28,400	50	1,419,990

recommendations for the existing and future population for the City.

Fire Storage

Fire storage is the volume of water needed to control an anticipated fire in a building or group of buildings. The determination of this storage is based upon the most stringent zoning within the City, and the required fire flow and duration per the City Fire Department and the Uniform Fire Code (UFC). The flow rate and duration of the required fire flow varies greatly with the type of development and whether or not the buildings have sprinkler systems. The required fire flow for the City based on the most stringent land use is provided in Table 6-3. A summary of the fire flow requirements by zoning is provided in Chapter 8, Table 8-3.

Table 6-3 Fire Storage

	Fire Flow (gpm)	Duration (Hours)	Storage (Gallons)
Existing	4,000	4	960,000
Future	4,000	4	960,000

Operational Storage

Operational storage is the amount of water needed to equalize the daily supply and demand. Without this storage, water production facilities would be required to be sized large enough to meet the instantaneous peak demands of the system. With adequate operational storage, booster stations can operate at the daily average rate, while storage facilities meet the hourly peaks. AWWA M-32 recommends operational storage of 20 to 25 percent of average day demand, or up to 15 percent of the maximum day demand. Based on the more stringent criteria for the City being 15 percent of max day demand, the recommended operational storage for existing conditions is summarized for each zone in Table 6-4.

Table 6-4. Operational Storage Recommendations

	MDD (gpm)	Storage (Gallons)
Existing	**3,675**	**793,719**
Future	**6,155**	**1,329,468**

Storage Summary

The useable storage recommended for each distribution zone as noted previously is based on a summation of the emergency, fire, and operational storage recommendations as shown in the adjacent figure.

Table 6-5 provides a summary of the storage recommendations for existing conditions. As noted in Table 6-5, the City has deficient storage under both existing and future conditions.

Table 6-5. Required Storage Summary

	Emergency	Fire	Operational	Recommended Storage	Total Available	Storage Surplus/(Deficit)
	(gallons)	(gallons)	(gallons)	(gallons)	(gallons)	(gallons)
Existing	843,500	960,000	793,719	2,597,219	2,401,426	(195,793)
Future	1,419,990	960,000	1,329,468	3,709,458	2,401,426	(1,308,032)

Storage Recommendations

Review of the City of Greenfields existing water storage facilities indicates that the City of Greenfield has a storage deficit under both existing and future conditions. Additional tanks are needed to meet the minimum criteria set forth in this chapter.

Seismic Upgrades

The City's Oak Avenue tank does not meet current CDPH regulations for earthquake safety. This tank should have a seismic evaluation completed. Flexible couplings or double ball expansion joints should be installed where appropriate to bring the tank into compliance with current CDPH requirements.

Overall Storage Recommendations

Based on the analysis discussed above, the City's storage supplies are not sufficient to meet the future needs of the City. The following are the storage recommendations based on emergency, fire, and operational needs as well as long term operations and maintenance needs.

1. **Corporation Yard Tank:** Construct an additional 1,500,000 gallon tank in the City's Corporation yard at the location that was designated as a future tank site.
2. **Operation and Maintenance Considerations**: The City should continue to maintain a program of on-going routine inspections of the interior and exterior coatings of the tanks. In order to ensure protection of the City's storage assets, coating systems must be maintained. Interior coatings (epoxy) have a track record of lasting 15 years, plus or minus depending on service conditions, and polyurethane coatings can last up to 20 years. The Oak water tank was built in 1987, and it is not clear if either the interior or exterior coating systems have been re-coated in past years. If not, this tank may be due for re-coating. Budgetary considerations for tank coating are provided in Chapter 9.

7: Water Pump Stations

Chapter 7 describes the existing pump stations and provides a summary of the recommended capital improvements for the pump stations.

Pump Stations

The City owns and operates two (2) pump stations. Both of the pump stations are on the distribution side of the storage tanks and provide pressure continuously to the distribution system. Table 7-1 summarizes the function of each of the pump stations. Table 7-2 summarizes the design characteristics of each of the pump stations. Appendix A provides the manufacturers' pump curves, if available.

Table 7-1. Pump Station Characteristics Summary

Pump Station	Function	Number of Pumps	Discharge HGL[1] (ft)	TDH at Design Capacity[2] (ft)	Pumping Capacity (gpm)	Permanent Back-up Generator On-Site
Oak	Boosts water from Oak Storage Tank in to Distribution System	4	~415	2-90, 2-108	2-700, 2-1200	Yes
Corporation	Boosts water from Corporation Storage Tank in to Distribution System	4	~420	160	500 each	Yes

[1]HGL – Hydraulic Grade Line
[2]TDH – Total Dynamic Head

Corporation Pump Station

The Corporation Pump Station is located in the City's corporation yard, on 10th Street between Cherry Avenue and Walnut Avenue and was installed in 2009. The pump station is fed from the 1.5 MG Corporation Yard and contains four (4) identical 500 GPM pumps. The purpose of the Corporation Pump Station is to sustain flow and pressure on-demand, and to provide fire flow to the City.

Oak Pump Station

The Oak Pump Station is located on Oak Avenue between 13th Street and 14th Street and was installed in 1980. The pump station is fed from the 1.0 MG Oak Tank and contains two (2) 700 GPM pumps and two (2) 1200 GPM pumps. Each pump is controlled by variable frequency drives (VFDs). The purpose of the Oak Pump Station is to sustain flow and pressure on-demand, and to provide fire flow to the City.

Table 7-2. Pump Station Summary

Pump Station	Oak		Corporation
Date of Installation/ Upgrades	1980		2009
	Pumps 1&2	**Pumps 3&4**	**All Pumps**
RPM	1760	1800	1775
Phase	3	3	3
HP	19.6	40	30
Voltage	460	460	460
Pump Make & Model	Peerless 8X8X16.50	FloWay BKH (Serial No. 12060-1-1)	FloWay VTP (Serial No. 64582-1-1
Impeller Dia., (Inches)	Unknown	Unknown	Unknown
Suction/Discharge Dia. (Inches)	8/8	8/8	8/6
Design Flow (gpm)	700	1200	500
Head (ft)	90	108	160

Prior Studies

In the fall of 2015, the City retained the services of a consultant (M.K. Nunley & Associates) to evaluate the two existing booster pump stations, following a number of water main breaks and leaks noted over the year. There was concern that the operations of the two booster stations may be causing momentary excessive pressures in the water system. A draft technical memorandum was prepared and provided to the City in February 2016. As part of the consultant's analysis and recommendations, operational testing was recommended, and initial field tests were conducted. However, the testing was conducted for a brief time, and results were insufficient to be conclusive.

Pump Station Recommendations

It is recommended at the City complete the operational testing program recommended by MKN, and report results to the consultant. This will allow further refinement of this Study, and development of detailed recommendations to address operational/controls issues with the two booster stations. The additional recommendations should be followed also, including:

1. Inspect and service pressure relief valves at each pump station, verify and check installation, set points and operational functionality.
2. Review City's water service lateral and meter replacement program to ensure regular maintenance and replacing of aging meters and laterals is being performed. This dovetails into overall recommendations that the City have sufficient resources to replace older water mains throughout the City, particularly the old asbestos cement water and cast iron water mains. This will be discussed further in Chapter 9.

8: Water Distribution System Analysis

Chapter 8 describes the existing water distribution system, water model development and calibration, design criteria, and overall system performances. .

Water Distribution System

The City owns and operates a water distribution system that is comprised of one distribution zone, two potable water storage tanks, and two pump stations. The City owns and operates 36 miles of water mains that span over 2.1 square miles to serve the City's ~3700 customers (connections). The existing water distribution system is shown in Figure 2-1. An inventory of the existing water main network by diameter is summarized in Table 8-1. Table 8-2 provides a summary of the existing water main inventory by material. Understanding material type is valuable as material types impact the water main's life expectancy.

Table 8-1. Existing Water Main Inventory by Diameter

Diameter (Inches)	Length	
	Feet	Miles
3	1,592	0.3
4	10,108	1.9
6	38,782	7.3
8	80,556	15.3
10	2,936	0.6
12	50,373	9.5
16	3,974	0.8
18	53	0.01
Total	188,374	35.7

Table 8-2. Existing Water Main Inventory by Material

Material	Length	
	Feet	Miles
Asbestos Cement	38,921	7.4
Cast Iron	35,263	6.7
Ductile Iron	698	0.1
PVC	113,492	21.5
Total	188,374	35.7

Water System Design Requirements

A hydraulic model was developed and calibrated to analyze the City's distribution system under existing and future conditions. The design requirements used to evaluate and identify deficiencies in the water distribution system relate primarily to the flow and pressure delivered by the system to the customers. SWRCB-DDW (previously CDPH) regulates the requirements for minimum system pressures within a water distribution system. Per the existing Waterworks Standards, Chapter 16, Section 64602, and last updated March 9, 2008 by the CDPH:

a) Each distribution system shall be operated in a manner to assure that the minimum operating pressure in the water main at the user service line connection, throughout the distribution system, is not less than 20 pounds per square (psi) inch at all times.
b) Each new distribution system that expands the existing system service connections by more than 20 percent or that may otherwise adversely affect the distribution system pressure shall be designed to provide a minimum operating pressure throughout the new distribution system of not less than 40 psi at all times excluding fire flow.

Ideally, normal operating (static) pressures should be within the range of 40 to 80 psi. This is the range that most people find comfortable and will serve most fire sprinkler systems. For the existing system, the design criteria for this water master plan is to recommend average day, maximum day, and peak hour pressures to be no less than 40 psi. This falls in line with Waterworks' intention for new water distribution systems or existing systems to be expanded.

It should be noted that prior to this CDPH update in 2008, the required system pressure under all conditions except fire flow was 30 psi. As noted in b) above, unless the City expands the system, the system pressure is "grand-fathered in" to a service pressure of 30 psi. When completing the water model analysis, the water system was analyzed to maintain 40 psi throughout the entire distribution system.

Pressures higher than 80 psi are acceptable within the distribution system, but should be reduced to 80 psi or lower at the service connection to prevent water hammer effects or leakage through washers and seats within a home. Reducing system pressure also helps to conserve water within the home. Pressures greater than 80 psi were not identified within the City.

It is also recommended to maintain water pressure within the distribution system at or below a maximum ceiling of 150 psi. Residual pressures throughout the entire distribution system under fire flow conditions shall be maintained at a minimum of 20 psi.

The flow requirements examined in the hydraulic model include average day demand, peak hour demand, and fire flow plus maximum day demand. The various flow scenarios are summarized as follows:

<u>Average Day Demand (ADD):</u> This flow condition is used to evaluate the system subject to the most common conditions. The existing demands were assigned throughout the distribution

system by zone, based on the demands noted in Chapter 4. In addition, all pumps at both booster stations were assumed to be operating under the current operational settings.

Peak Hour Demand (PHD): This demand condition is used to identify system deficiencies at the maximum domestic use. A peaking factor per Table 4-4 of this report was applied to average day demand to obtain peak hour demand. In addition, all pumps at both booster stations were assumed to be operating under the current operational settings.

Fire Flow (FF) Plus Maximum Day Demand (MDD): This demand condition is used to identify system deficiencies under fire flow conditions. A peaking factor per Table 4-3 of this report was applied to average day demand to obtain maximum day demand. In addition, all pumps at both booster stations were assumed to be operating under the current operational settings. Residential, commercial, industrial, hotel, church and school fire flow requirements were established based on the Greenfield Fire Protection District's requirements as well as the current Uniform Fire Code (UFC). In accordance with UFC requirements, no more than 1,000 gpm will be extracted from any single hydrant. In addition, only one fire flow is modeled at any one time.

Based on a discussion via email on January 28, 2016), Table 8-3 provides a summary of the fire flow requirements that were utilized to identify both hydraulic deficiencies throughout the water distribution system as well as to determine fire storage requirements (see Table 6-3).

Table 8-3. Fire Flow Requirements by Zoning

Zoning	Fire Flow (gpm)	Duration (hours)	Notes
Residential (low and medium density)	1,500	2	
Residential (high density)	2,000	2	
Neighborhood Commercial	1,500	2	Commercial businesses within residential neighborhoods
Commercial	2,500	2	All other commercial not identified in Neighborhood or Big Box
Big Box Commercial	4,000	4	Large square footage commercial buildings
Industrial	4,000	4	
Hotels	4,000	4	
Churches	2,500	2	
Schools	2,500	2	

The following parameters were employed to identify conditions for each run of the model:

1. Domestic pressures below 40 psi for ADD, MDD, and PHD
2. Pipeline velocities exceeding five feet per second (fps) at ADD, MDD, and PHD are identified. In general, velocities higher than five fps create excessive pressure losses.
3. Pipeline velocities exceeding 10 fps during fire flow conditions plus MDD are identified. Pipelines near the source of the fire are identified if velocities exceeded 15 fps.
4. During fire flow model runs, service pressures below 20 psi at any node within the distribution system were identified.

The hydraulic parameters and design criteria for the evaluation of the City's water system are summarized in Table 8-4.

Water Model Development

In order to evaluate the performance of the existing water system, identify deficiencies in the network, and recommend improvements, a computer based hydraulic model was developed using computer program WaterCAD by Bentley Systems Inc. Elevation, pipe diameter, and pipe material for the distribution system were obtained from record drawings provided by the City and a new GIS dataset was created to document the existing system. The City also provided water billing records and pump station data.

Table 8-5 provides a summary of the Hazen-Williams roughness coefficients ("C" factor) for the water mains used in the hydraulic model. The "C" Factor was adjusted for various water mains as part of the calibration process.

Model Calibration

The hydraulic model was calibrated using field hydrant testing that was conducted on December 2, 2015 and January 29, 2016.

The water system was analyzed in the model by simulating the field fire flow tests and comparing the resulting modeled pressures with those observed in the field. Adjustments to pipe friction factors (Hazen-Williams coefficient) were made in to calibrate the model.

Existing System Performance

The performance of the City's water distribution system was evaluated under existing ADD, PHD, and Fire Flow plus MDD to identify where the deficiencies are within the system. Recommendations for system upgrades based on the analysis described in this chapter can be found in Chapter 9.

Table 8-4. Summary of Hydraulic Parameters and Design Criteria

Hydraulic Parameters and Design Criteria	Value	Standard
Fire Flow Requirements	See Table 8-3	Uniform Fire Code and City of Greenfield Standards
Maximum Day Demand Factor	3.1 times ADD	City of Greenfield Daily Well Production Records (2006-2015) and CCR, Title 22, Division 4, Chapter 16, Article 2, Section B.2.A - B.2.C
Peak Hour Demand Factor	4.6	City of Greenfield Daily Well Production Records (2006-2015) and CCR, Title 22, Division 4, Chapter 16, Article 2, Section B.2.A - B.2.C
Minimum System Pressure at ADD, MDD, and PHD	40 psi	California State Water Resources Control Board, Drinking Water Division
Maximum System Pressure at ADD, MDD, and PHD	150 psi (80 psi at water service recommended. Install service PRV if above 80 psi)	
Minimum System Pressure at FF plus MDD	20 psi	
Maximum Pipeline Velocity at ADD, MDD, and PHD	<5 fps	
Maximum Pipeline Velocity at FF	< 10 fps (<15 fps near source of fire)	
Fire Hydrant Spacing	Residential: Maximum 500-feet, except at dead-end streets, it shall be no more than 400-feet Commercial: Maximum 250-feet	Recommended Standard
Pipe Diameter	All new water mains must be 8-inch or greater.	Recommended Standard
Valving	No shut down of greater than 500 feet in high-value districts or greater than 800 feet in other sections.	Recommended Standard

Table 8-5. Modeled Hazen-William's "C" Factors

Material	"C" Factor
Asbestos Cement	130
Cast Iron	100
Ductile Iron	120
PVC	140

Future System Performance

The performance of the City's water distribution system was evaluated under future demand conditions. The model was evaluated under ADD, PHD, and Fire Flow plus MDD. The water distribution system was modeled with all of the proposed projects that were identified as existing deficiencies completed. Recommendations for future system upgrades based on the analysis described in this chapter can in found in Chapter 9.

Since the timeframe for the construction of future development is unknown, it is recommended that as development is proposed, an evaluation be completed to identify which of the recommended projects are required to be completed to adequately serve the proposed development. This may dictate the priority and timing of a recommended CIP projects in the future.

9: Summary of Recommendations

This chapter summarizes the City's recommended master plan capital improvement projects (CIPs) to meet existing and future needs, and the master plan improvement program to assist in the financial planning aspects of implementing the recommended improvements. The improvements are described as first, second and third priorities. The City requested that a 10-Year CIP be developed as part of this master plan, to be used by rate consultants working with the City on re-structuring the City's water rates to fund such CIPs. Recommended Master Plan Improvement Projects

Based on the hydraulic model, along with recommendations for storage and supply well upgrades and upgrades due to operational needs, a series of master plan improvement projects have been identified. The projects have been classified into the following four categories:

- **First priority**: First priority projects are a result of significant health and safety concerns, including substandard pressures and fire flows during any demand situation. These projects are recommended to be completed within five years and are all identified as existing deficiencies within the City's water system. These projects are scheduled within the first 5 years of the 10-year CIP program. These projects are all identified as existing deficiencies within the City's water system.
- **Second priority:** Second priority projects address sections of the City's water system that are experiencing slightly substandard pressures and/or fire flows, but are not as critical as first priority projects. These priority 2 projects are scheduled for the remaining 5 years of the 10-Year CIP period. These projects are also existing deficiencies within the City's existing water system, but not necessarily driven by future development.
- **Third Priority:** The priority 3 projects consist mainly of older water mains that eventually require replacement. However, you will notice that those identified CIPs that include a combination of older pipe (ACP or Cast Iron) and are under-sized, are considered of higher priority than others, and therefore are scheduled within the first several years. The remaining pipe replacements were not singled out as specific project CIPs for the purposes of the 10-year CIP, but instead it is recommended that the City earmark an annual budget for older water main replacements. These projects are also existing deficiencies within the City's existing water system, not driven by future development.
- **Future Projects:** As development projects occur throughout the City, the future projects should be identified and completed to address these deficiencies prior to the proposed development being constructed. Also, the proposed land uses, distribution system layout, demands and fire flow requirements should be re-evaluated for each project in the planning stage to confirm assumptions made for the purpose of this Water Master Plan are accurate and confirm that no additional upgrades will be required.

Water Distribution System Priorities

Water distribution piping upgrades and priorities are further defined on the following subsections. As part of the 10-Year CIP developed for the rate study, a summary table of pipeline replacement projects and corresponding priorities was developed, and is included as Table 9-1.

Table 9-1. Summary of Pipeline Upgrades by Pipe Size, Material and Priority

Material	Diameter (in)	Length (ft)	Replacement Material	Replacement Diameter (in)
Cast Iron	3	1,592	PVC	8
Cast Iron	4	8,327	PVC	8
Cast Iron	6	16,526	PVC	8
Cast Iron	8	4,919	PVC	8
Asbestos Cement	4	1,618	PVC	8
Asbestos Cement	6	16,306	PVC	8
Asbestos Cement	8	10,890	PVC	8
Asbestos Cement	10	547	PVC	10
Asbestos Cement	12	8,795	PVC	12
Asbestos Cement	16	3,795	PVC	16
PVC	4	175	PVC	8

The pipeline replacement priorities are summarized as follows:

- Yellow, undersized mains of any pipe material. These are considered a higher priority and should be completed within the first 5 years.
- Orange, marginally undersized pipelines of cast iron and asbestos cement. These pipelines will eventually need replacement, and should be prioritized by hydraulic deficiency and frequency of main breaks.
- Green. These 8” asbestos cement and cast iron water mains are of lesser priority, and can be targeted last for replacement. As with the smaller water mains, these pipelines are reaching the end of their service life and eventually need to be replaced. However, such replacement can be deferred to later years, on an as needed basis.
- Blue. These asbestos cement pipelines also need to be replaced eventually, but may be deferred to later years, and/or as needed. However, preventative maintenance/replacement would always be preferred over a rushed replacement due to failure.

First Priority Master Plan Improvement Projects

First Priority Projects have the highest health and safety deficiencies within the distribution system. Typically, these deficiencies are identified due to fire flow capacities that are less than 50% of the required fire flow. First priority projects were determined using the following criteria:

- Pressures below 30 psi during ADD, MDD, PHD
- Velocities greater than 5 fps during ADD, MDD, PHD
- Fire flows that cannot meet a minimum of 50% of the required fire flow

Second Priority Master Plan Improvement Projects

Second Priority Projects have the second highest health and safety deficiencies within the distribution system. Typically, these deficiencies are identified due to fire flow capacities that are between 50% and 75% of the required fire flow. Second priority projects were determined using the following criteria:

- Pressures below 40 psi during ADD, MDD, PHD
- Fire flows that cannot meet between 50% and 75% of the required fire flow

Third Priority Master Plan Improvement Projects

Third Priority Projects have minor deficiencies within the distribution system. Typically, these deficiencies are identified due to fire flow capacities that are between 75% and 100% of the required fire flow. In addition, third priority projects are those projects that are recommended because the water main doesn't meet current day standards such as minimum pipe diameter or material. Third priority projects were determined using the following criteria:

- Fire flows that cannot meet between 75% and 100% of the required fire flow
- Water mains that do not meet current design standards (i.e. 4-inch water mains) that were not identified as hydraulic deficiencies

Master Plan Improvement Project Ranking and Costs

First, Second, Third and Future Priority Master Plan Improvement Projects were ranked to determine what priority the recommended projects should be constructed. The ranking was based on severity of the deficiency, the size of the community the deficiency impacts, and cost. Figures 9-1 through 9-4 illustrate the location of each of the proposed Master Plan Improvement Projects. Tables 9-2 through 9-5 provide a summary of all the recommended Master Plan Improvement Projects in order of ranking for first, second, third and future priority projects, respectively. These Tables also provide estimates of the construction and "soft" costs for each project. The project costs are based on engineering judgment, confirmed bid prices for similar work in the area, consultation with vendors and contractors, established budgetary unit prices for the work, and other reliable sources. The cost estimates are approximate and should be used for planning purposes only. Actual project costs will vary depending upon economic conditions at time of construction. These costs are based on Year 2016 dollars (McGraw-Hill ENR Construction Cost Index of 10242, March 2016) and need to be escalated to the year or years scheduled for the construction (escalated to midpoint of construction). Table 9-2 provides a summary of the cost per lineal foot used to develop the construction costs for the water main upgrade projects.

Table 9-2. Unit Cost for Construction of Water Mains

Size (Inches)	Replacement Material	Replacement Cost per Linear Foot (Year 2015)
8	PVC	$125
12	PVC	$150
16	PVC	$200

[1] All pipes are pressure class 150 unless otherwise stated.

Other Major Capital Improvement Projects

In addition to water distribution pipeline improvements, other significant capital improvement projects as part of the City's overall water system are recommended. These items include water supply wells, water storage, and water meter and lateral replacements.

Water Supply

In Chapter 5, it was recommended at the City provide at least one new domestic water well in the future. The additional well is needed to ensure water supply reliability for future demands, when the largest well may go out of service. A budget of $2.5 million to cover hard and soft costs should be budgeted. It is envisioned this new well should come on in line within the next several years (Priority 1 Project).

Water Booster Stations

At this time, specific capital improvement projects are not identified for the booster stations. However, it is recommended that the City work with their consultant to refine pump station settings and operations and address the recommendations made in the February 2016 technical memorandum by MKN & Associates.

Water Meters and Water Services

The February 2016 technical memorandum referenced above, also identified the need to address leaky water services and meters in need of replacement. It is difficult to quantify a CIP for these items; however, the City should maintain an annual budget to address these items as they arise. The City should inventory the meters by age, and water services by age and material. A more defined program for replacement can then be developed from this information. Furthermore, replacement of water meters and services should be considered when opportunities arise, such as when water mains are also being replaced.

Water Storage Tanks

It is recommended that one 1.5 MG water storage tank be constructed at the Corporation Yard, within the next 5 years (priority 1 CIP). This new tank is envisioned to be a welded steel tank similar to the existing Corporation Yard tank. This tank has been budgeted at approximately $1/gallon, or $2.1 Million with hard and soft costs.

In addition, the City should budget for anticipated coating of their existing water storage tanks. In particular, the Oak Tank should be slated for re-coating and re-lining in future years. The schedule and need for this work should be identified by a tank inspection by a qualified tank coating specialist. The tank interior would typically be inspected by a dive inspection. The cost for such study would be in the range of $5,000. Tank re-coating and re-lining costs can vary considerably, depending on the extent to which existing coatings must be removed/sandblasted, and the degree of spot repairs for pitted and corroded areas on the tank. Assuming that the Oak Tank will require exterior and interior re-coating, using a budget number of $6/SF, the construction cost for tank coating and lining would be approximately $200,000. A total budget of $280,000 should be set aside for coating the Oak Tank in future years. The timing of this project is not known at this time, but would likely fall within the Priority 2 time frame (within the next 10 years). The Corporation Tank should also be budgeted for this same amount, around the Year 2025 time frame (end of 10-Year CIP period, or possibly later).

Table 9-3. First Priority Master Plan Improvement Projects

Project #	Title	Description	Quantity	Length (ft)	Existing Diameter (in)	New Diameter (in)	Street	Location	Construction Cost ($)		Total Project Cost ($)
1-1	Maple and Palm Avenue	Replace 3" and 4" cast iron with 8" PVC	1	5,240	3 & 4	8	Maple Avenue/Palm Avenue	Between 5th Street and 11th Street	660,000	LS	1,000,000
1-2	Elm Avenue	Replace 6" and 8" Asbestos Cement with 16" PVC	1	880	6 & 8	16	Elm Avenue/Elm Circle	Elm Avenue from 4th Street to Elm Circle and Elm Circle	180,000	LS	260,000
1-3	7th Street	Replace 4" Asbestos Cement and PVC with 8" PVC and add hydrant at the north end of the Street	1	800	4	8	7th Street/Acacia Court	7th Street North of Apple Avenue and Acacia Court	110,000	LS	160,000
1-4	Larson Lane	Replace 4" Asbestos Cement with 8" PVC, add mid-block hydrant, and connect to 12" line in Apple Avenue	1	980	4	8	Larson Lane	Larson Lane from Apple Avenue to end.	130,000	LS	190,000
1-5	Water Storage Tank	New 1.5 MG welded steel water storage tank	1	-	-	-	-	Corporation Yard	1,500,000	LS	2,100,000
1-6	Water Supply Well	New municipal water supply well, 1,500 to 2,000 gpm capacity	1	-	-	-	-	TBD	1,750,000	LS	2,500,000
									Total First Priority Project Costs		$ 6,210,000

Table 9-4. Second Priority Master Plan Improvement Projects

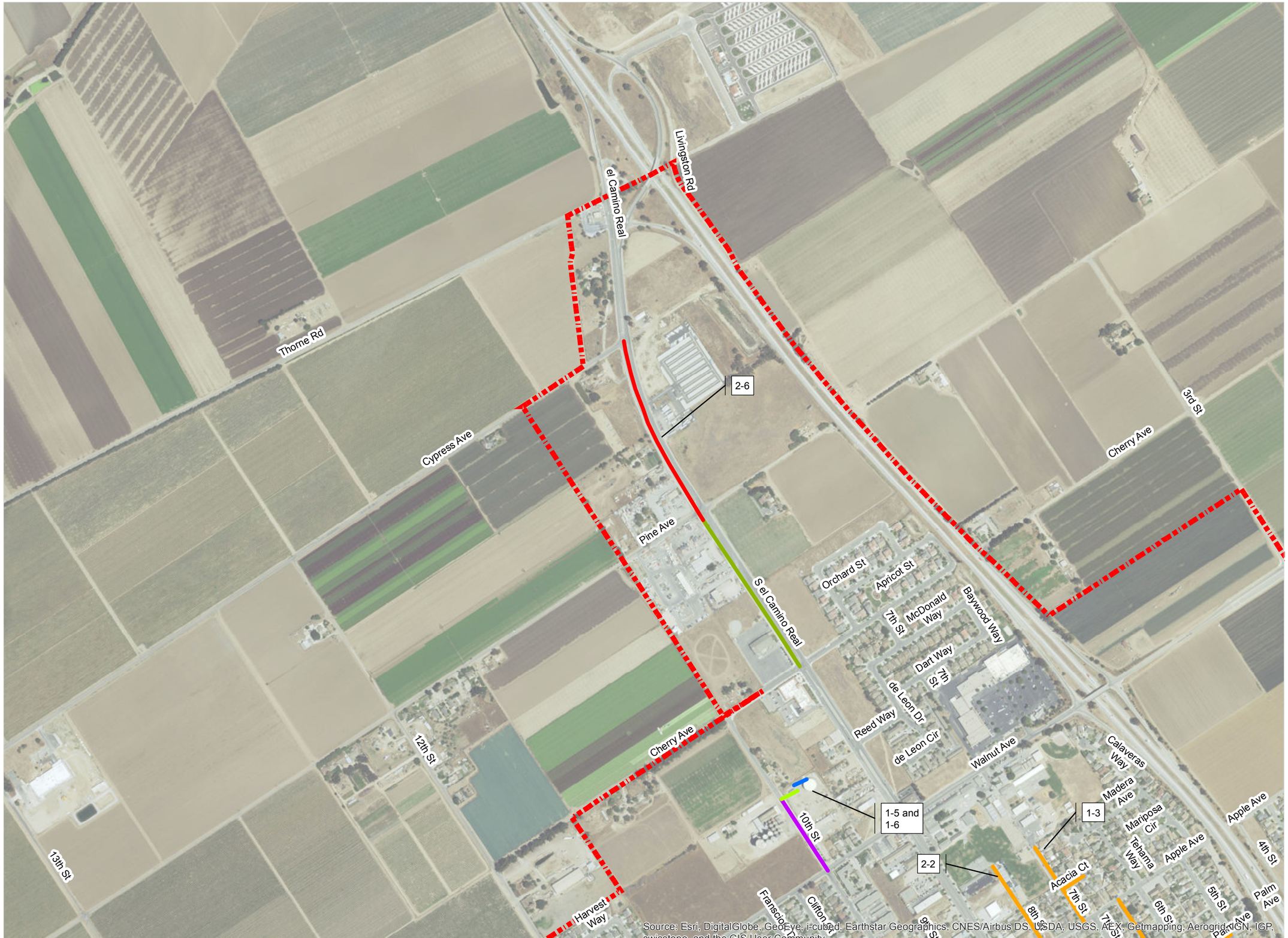
Project #	Title	Description	Quantity	Length (ft)	Existing Diameter (in)	New Diameter (in)	Street	Location	Construction Cost ($)		Total Project Cost ($)
2-1	Elm Avenue	Replace 8" Asbestos Cement with 16" PVC	1	1,430	8	12	Elm Avenue/3rd Street	Elm Avenue from Elm Circle to 3rd Street and 3rd Street from Elm Avenue to Maple Avenue	220,000	LS	310,000
2-2	8th Street	Replace 6" Asbestos Cement with 8" PVC and add two hydrants (one at mid-block and one at end)	1	690	6	8	8th Street	8th Street North of Apple Avenue to end	100,000	LS	140,000
2-3	Tom Rogers Circle	Replace 6" Asbestos Cement with 8" PVC	1	490	6	8	Tom Rogers Circle	Tom Rogers Circle from Oak Avenue to end	70,000	LS	100,000
2-4	Renfro Place	Replace 6" Asbestos Cement with 8" PVC	1	500	6	8	Renfro Place	Renfro Place from Oak Avenue to end	70,000	LS	100,000
2-5	San Antonio Drive	Replace 6" Asbestos Cement with 8" PVC and add hydrant at the end of San Simeon Court	1	1,840	6	8	San Antonio Drive	All of San Antonio Drive and San Simeon Court	230,000	LS	330,000
2-6	El Camino Real	Replace 12" PVC with 16" PVC	1	1,410	12	16	El Camino Real	El Camino Real from Pine Avenue to Cypress Avenue	290,000	LS	410,000
2-7	Oak Tank Maintenance	Re-coating and re-lining of Oak Tank	1	-	-	-	Oak Avenue	Oak Avenue Tank	200,000	LS	280,000
										Total Second Priority Project Costs	$ 1,670,000

Table 9-5. Third Priority Master Plan Improvement Projects

Project #	Title	Description	Quantity	Length (ft)	Existing Diameter (in)	New Diameter (in)	Street	Location	Construction Cost ($)		Total Project Cost ($)
3-1	Throughout City	Replace 3" Cast Iron with 8" PVC	1	650	3	8	Throughout City	Throughout City	90,000	LS	130,000
3-2	Throughout City	Replace 4" Cast Iron with 8" PVC	1	4,030	4	8	Throughout City	Throughout City	510,000	LS	800,000
3-3	Throughout City	Replace 6" Cast Iron with 8" PVC	1	16,526	6	8	Throughout City	Throughout City	2,070,000	LS	2,900,000
3-4	Throughout City	Replace 8" Cast Iron with 8" PVC	1	4,919	8	8	Throughout City	Throughout City	620,000	LS	900,000
3-5	Throughout City	Replace 6" Asbestos Cement with 8" PVC	1	12,460	6	8	Throughout City	Throughout City	1,560,000	LS	2,200,000
3-6	Throughout City	Replace 8" Asbestos Cement with 8" PVC	1	8,905	8	8	Throughout City	Throughout City	1,120,000	LS	1,600,000
3-7	Throughout City	Replace 10" Asbestos Cement with 12" PVC	1	547	10	12	Throughout City	Throughout City	90,000	LS	130,000
3-8	Throughout City	Replace 12" Asbestos Cement with 12" PVC	1	8,795	12	12	Throughout City	Throughout City	1,320,000	LS	1,900,000
3-9	Throughout City	Replace 16" Asbestos Cement with 16" PVC	1	3,795	16	16	Throughout City	Throughout City	760,000	LS	1,100,000
3-10	Apple Avenue	Remove or Abandon 6" Asbestos Cement if pipe fails.	1	1,100	6	-	Apple Avenue	Apple Avenue from Larson Lane to 9th Street		LS	
										Total Third Priority Project Costs	$ 11,660,000

Table 9-6. Future Priority Master Plan Improvement Projects

Project #	Title	Description	Quantity	Length (ft)	Existing Diameter (in)	New Diameter (in)	Street	Location	Construction Cost ($)		Total Project Cost ($)
F-1	Booster Station	Add additional pumps to existing booster station or add new booster station. Triggered by population exceeding 17,300 (based on existing 105 gpcd total system demand).	1	-	-	-	-	TBD		LS	
F-2	Elm Avenue	Replace 10" Asbestos Cement with 16" PVC. Triggered by development of parcels zoned for industrial facilities.	1	550	10	16	Elm Avenue	Elm Avenue from 5th Street to 4th Street	110,000	LS	160,000
F-3	Oak Avenue	Replace 8" and 12" PVC and 6" Cast Iron with 16" PVC. Triggered by development of parcels zoned for industrial facilities.	1	3,510	6/12/8	16	Oak Avenue/3rd Street	Oak Avenue from 3rd Street to 2nd Street and 3rd Street from Maple Avenue to Oak Avenue	710,000	LS	1,000,000
F-4	El Camino Real Industrial	Replace 12" PVC with 16" PVC. Triggered by development of parcels zoned for industrial facilities	1	1,250	12	16	El Camino Real	El Camino Real from Cherry Avenue to Pine Avenue	250,000		350,000
F-5	El Camino Real	Replace 6" Asbestos Cement with 8" PVC. Triggered by development of parcels zoned for low density residential	1	220	6	8	El Camino Real	El Camino Real from Tyler Street to south end of system	30,000		50,000
										Total Future Project Costs	$ 1,560,000



Greenfield

Where Historic El Camino Real Meets Monterey Wine Country

WALLACE GROUP
CIVIL ENGINEERING
CONSTRUCTION MANAGEMENT
LANDSCAPE ARCHITECTURE
MECHANICAL ENGINEERING
PLANNING
PUBLIC WORKS ADMINISTRATION
SURVEYING/GIS SOLUTIONS
WATER RESOURCES
WALLACE SWANSON INTERNATIONAL
612 CLARION COURT
SAN LUIS OBISPO, CA 93401
805 544-4011 www.wallacegroup.us

LEGEND

City Boundary

PIPE DIAMETER (INCHES)

- 6
- 8
- 10
- 12
- 14
- 16
- 18
- 24

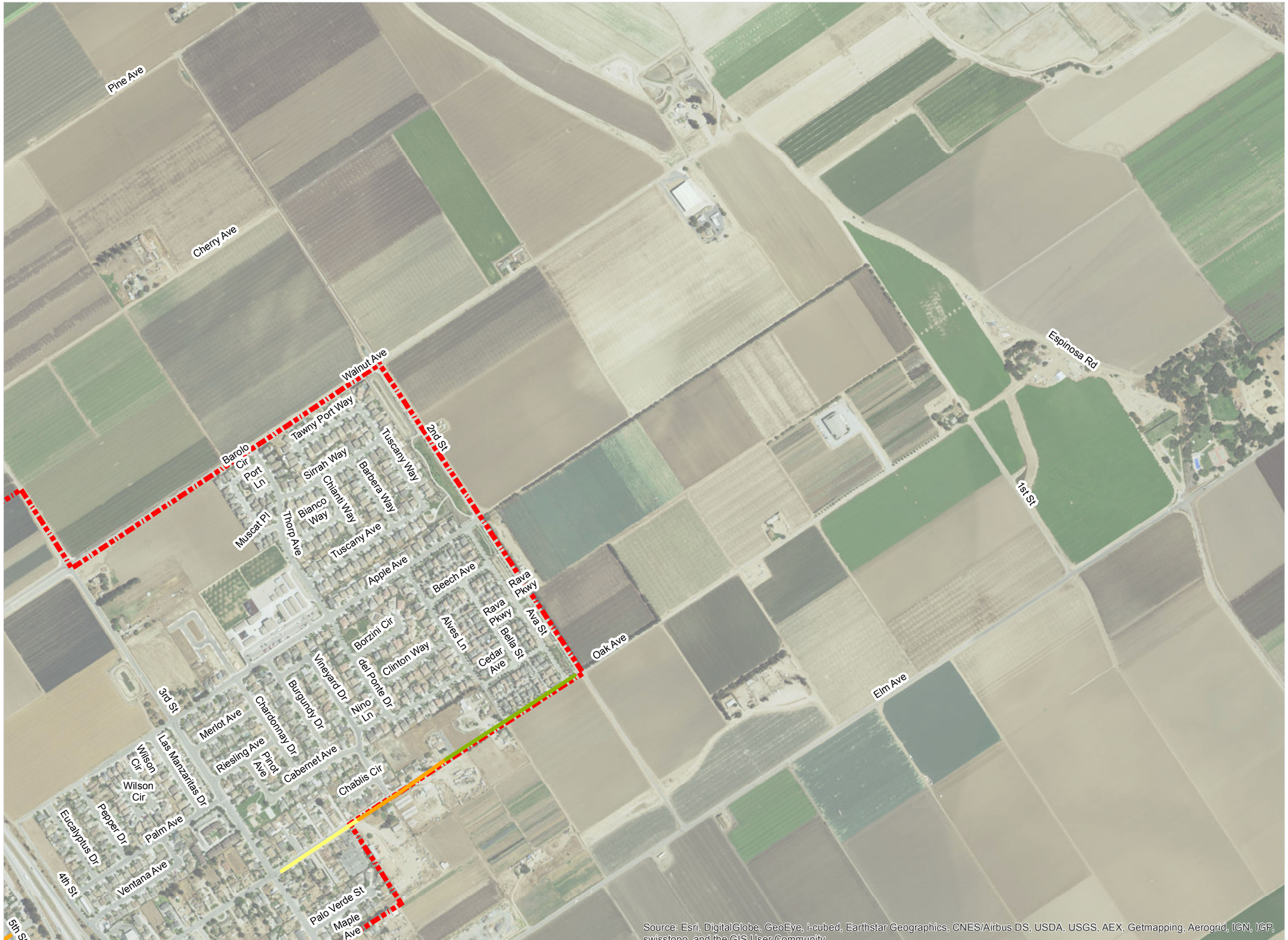
Figure 9-1

THIS MAP IS INTENDED FOR THE EXPRESSED USE OF THE CITY OF GREENFIELD AND DOES NOT CONSTITUTE A LEGAL DOCUMENT. WALLACE GROUP DID NOT PERFORM SURVEY SERVICES FOR THIS MAP. DATA COMPILED FROM MULTIPLE SOURCES.

PROPOSED MASTER PLAN WATER SYSTEM IMPROVEMENT PROJECTS

N

M:\1163-Greenfield, City of\005-Water and Wastewater Master Plans\06 - Reports and Calculations\03 - GIS\01 - Map Documents\Water Master Plan Exhibits\MP_Water_System_Improvement_Projects.mxd; Author: <MAP AUTHOR>



Greenfield

Where Historic El Camino Real Meets Monterey Wine Country

WALLACE GROUP
CIVIL ENGINEERING
CONSTRUCTION MANAGEMENT
LANDSCAPE ARCHITECTURE
MECHANICAL ENGINEERING
PLANNING
PUBLIC WORKS ADMINISTRATION
SURVEYING/GIS SOLUTIONS
WATER RESOURCES
WALLACE SWANSON INTERNATIONAL
612 CLARION COURT
SAN LUIS OBISPO, CA 93401
805 544-4011 www.wallacegroup.us

LEGEND

City Boundary

PIPE DIAMETER (INCHES)

- 6
- 8
- 10
- 12
- 14
- 16
- 18
- 24

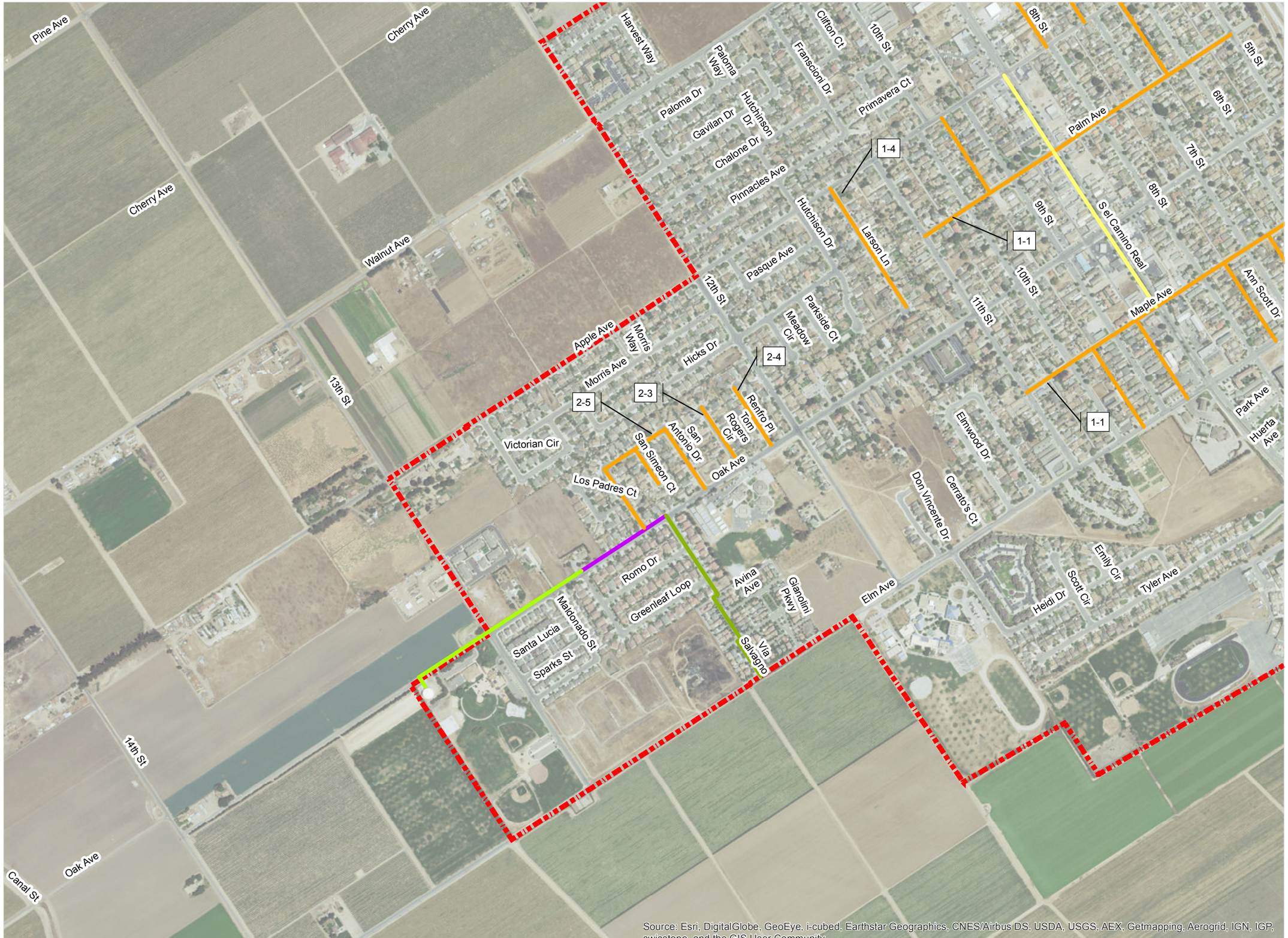
Figure 9-2

THIS MAP IS INTENDED FOR THE EXPRESSED USE OF THE CITY OF GREENFIELD AND DOES NOT CONSTITUTE A LEGAL DOCUMENT. WALLACE GROUP DID NOT PERFORM SURVEY SERVICES FOR THIS MAP. DATA COMPILED FROM MULTIPLE SOURCES.

PROPOSED MASTER PLAN WATER SYSTEM IMPROVEMENT PROJECTS

N

M:\1163-Greenfield, City of\005-Water and Wastewater Master Plans\06 - Reports and Calculations\03 - GIS\01 - Map Documents\Water Master Plan Exhibits\MP_Water_System_Improvement_Projects.mxd; Author: <MAP AUTHOR>



Greenfield

Where Historic El Camino Real Meets Monterey Wine Country

WALLACE GROUP
CIVIL ENGINEERING
CONSTRUCTION MANAGEMENT
LANDSCAPE ARCHITECTURE
MECHANICAL ENGINEERING
PLANNING
PUBLIC WORKS ADMINISTRATION
SURVEYING/GIS SOLUTIONS
WATER RESOURCES
WALLACE SWANSON INTERNATIONAL
612 CLARION COURT
SAN LUIS OBISPO, CA 93401
805 544-4011 www.wallacegroup.us

LEGEND

City Boundary

PIPE DIAMETER (INCHES)

- 6
- 8
- 10
- 12
- 14
- 16
- 18
- 24

Figure 9-3

THIS MAP IS INTENDED FOR THE EXPRESSED USE OF THE CITY OF GREENFIELD AND DOES NOT CONSTITUTE A LEGAL DOCUMENT. WALLACE GROUP DID NOT PERFORM SURVEY SERVICES FOR THIS MAP. DATA COMPILED FROM MULTIPLE SOURCES.

PROPOSED MASTER PLAN WATER SYSTEM IMPROVEMENT PROJECTS

N

M:\1163-Greenfield, City of\005-Water and Wastewater Master Plans\06 - Reports and Calculations\03 - GIS\01 - Map Documents\Water Master Plan Exhibits\MP_Water_System_Improvement_Projects.mxd; Author: <MAP AUTHOR>

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Greenfield

Where Historic El Camino Real Meets Monterey Wine Country

WALLACE GROUP
CIVIL ENGINEERING
CONSTRUCTION MANAGEMENT
LANDSCAPE ARCHITECTURE
MECHANICAL ENGINEERING
PLANNING
PUBLIC WORKS ADMINISTRATION
SURVEYING/GIS SOLUTIONS
WATER RESOURCES
WALLACE SWANSON INTERNATIONAL
612 CLARION COURT
SAN LUIS OBISPO, CA 93401
805 544-4011 www.wallacegroup.us

LEGEND

City Boundary

PIPE DIAMETER (INCHES)

- 6
- 8
- 10
- 12
- 14
- 16
- 18
- 24

Figure 9-4

THIS MAP IS INTENDED FOR THE EXPRESSED USE OF THE CITY OF GREENFIELD AND DOES NOT CONSTITUTE A LEGAL DOCUMENT. WALLACE GROUP DID NOT PERFORM SURVEY SERVICES FOR THIS MAP. DATA COMPILED FROM MULTIPLE SOURCES.

PROPOSED MASTER PLAN WATER SYSTEM IMPROVEMENT PROJECTS

N

M:\1163-Greenfield, City of\005-Water and Wastewater Master Plans\06 - Reports and Calculations\03 - GIS\01 - Map Documents\Water Master Plan Exhibits\MP_Water_System_Improvement_Projects.mxd; Author: <MAP AUTHOR>

10: Appendix A - Pump Curves

FLOWAY® PUMPS
Vertical Turbine Pumps

Pump Performance Datasheet

Customer	:	Quote number	: 143156
Customer reference	:	Size	: 10DKM
Item number	: 109	Stages	: 1
Service	:	Based on curve number	: 10DKM 1770 Rev. 1
Quantity	: 1	Date last saved	: 26 Oct 2015 12:11 PM

Operating Conditions

Flow, rated	: 500.0 USgpm
Differential head / pressure, rated (requested)	: 160.0 ft
Differential head / pressure, rated (actual)	: 161.7 ft
Suction pressure, rated / max	: 0.00 / 0.00 psi.g
NPSH available, rated	: Ample
Frequency	: 60 Hz

Performance

Speed, rated	: 3540 rpm
Impeller diameter, rated	: 5.81 in
Impeller diameter, maximum	: 6.47 in
Impeller diameter, minimum	: 5.50 in
Efficiency (bowl / pump)	: 51.12 / 50.02 %
NPSH required / margin required	: - / 0.00 ft
nq (imp. eye flow) / S (imp. eye flow)	: 63 / 164 Metric units
MCSF	: 296.6 USgpm
Head, maximum, rated diameter	: 199.6 ft
Head rise to shutoff (bowl / pump)	: 23.88 / 24.73 %
Flow, best eff. point (bowl / pump)	: 1,120.0 / 1,061.2 USgpm
Flow ratio, rated / BEP (bowl / pump)	: 44.64 / 47.12 %
Diameter ratio (rated / max)	: 89.87 %
Head ratio (rated dia / max dia)	: 80.17 %
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00
Selection status	: Acceptable

Liquid

Liquid type	: --Other
Additional liquid description	:
Solids diameter, max	: 0.00 in
Solids concentration, by volume	: 0.00 %
Solids concentration, by weight	: 0.00 %
Temperature, max	: 68.00 deg F
Fluid density, rated / max	: 1.000 / 1.000 SG
Viscosity, rated	: 1.00 cP
Vapor pressure, rated	: 0.00 psi.a

Material

Material selected	: Cast Iron/Bronze

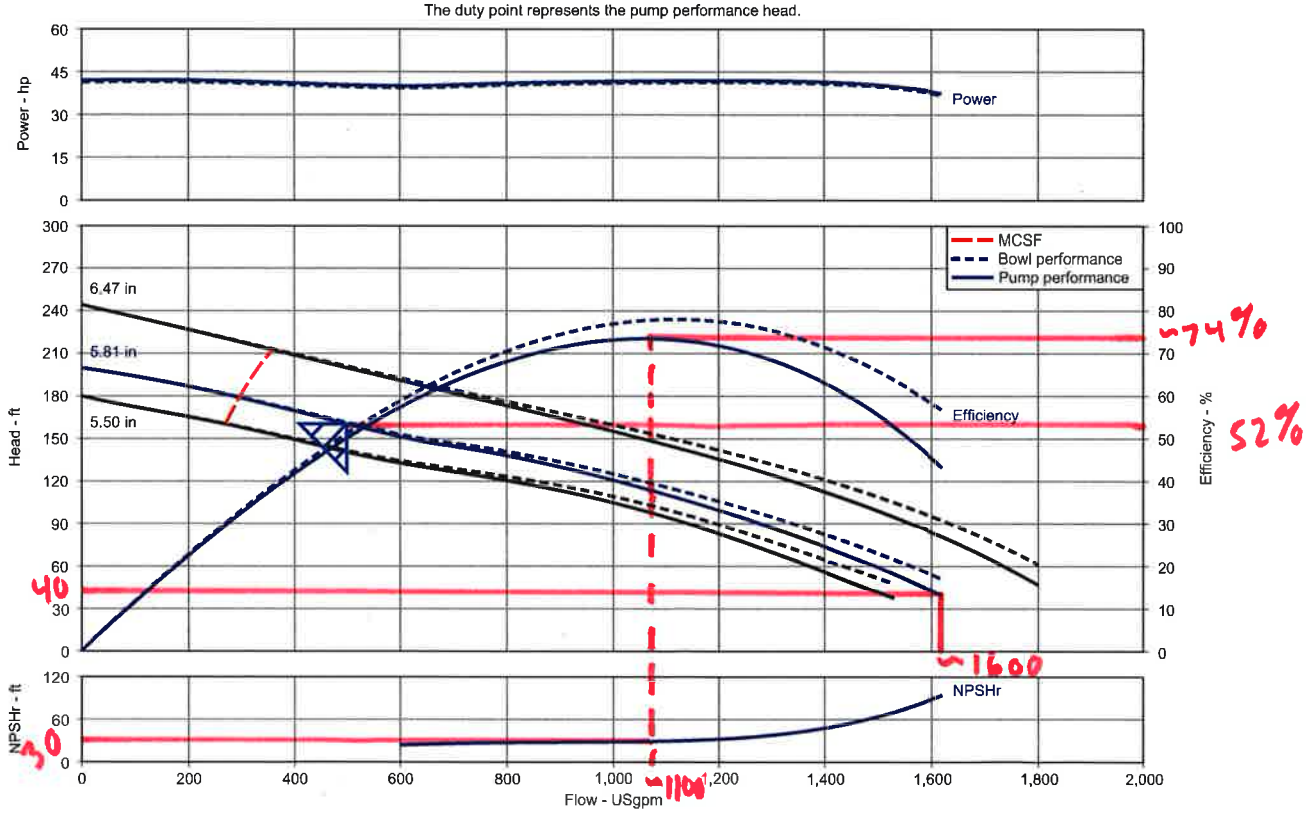
Pressure Data

Maximum working pressure	: See the Additional Data page
Component pressure limit	: See the Additional Data page
Maximum allowable suction pressure	: N/A
Hydrostatic test pressure	: See the Additional Data page

Driver & Power Data

Driver sizing specification	: Max power + 5%
Margin over specification	: 0.00 %
Service factor	: 1.00
Power, hydraulic	: 20.34 hp
Power (bowl / pump)	: 39.79 / 40.39 hp
Power, maximum, rated diameter	: 42.15 hp
Minimum recommended motor rating	: 50.00 hp / 37.29 kW

Pump and bowl (dashed) performance. Bowl adjusted for construction and viscosity.
Pump further adjusted for friction and power losses of lineshaft and thrust bearings. Pump is not adjusted for any static lift.
The duty point represents the pump performance head.



Floway

2 oak pumps

108 ft

10BKH

ENCLOSED TYPE IMPELLER 1760 RPM

NO. OF STAGES	EFF. CHANGE (NO. OF POINTS)
1	−3
2	−1
3	−0

HORSEPOWER WILL BE EFFECTED BY CHANGE IN EFFICIENCY

PERFORMANCE FOR:
Bowl Pattern No.: 547612-A-R0
Imp. Pattern No.: 547611-A-R0

PUMP DATA

Shaft Dia. (IN.)	1½
Maximum Sphere (IN.)	1
Maximum Head (FT.)*	950
Min. Submergence (IN.)**	20
Impeller Wt. (LBS.)	10.75
Thrust Constant (K)	10.0
Bowl O.D. (IN.)	9⅝

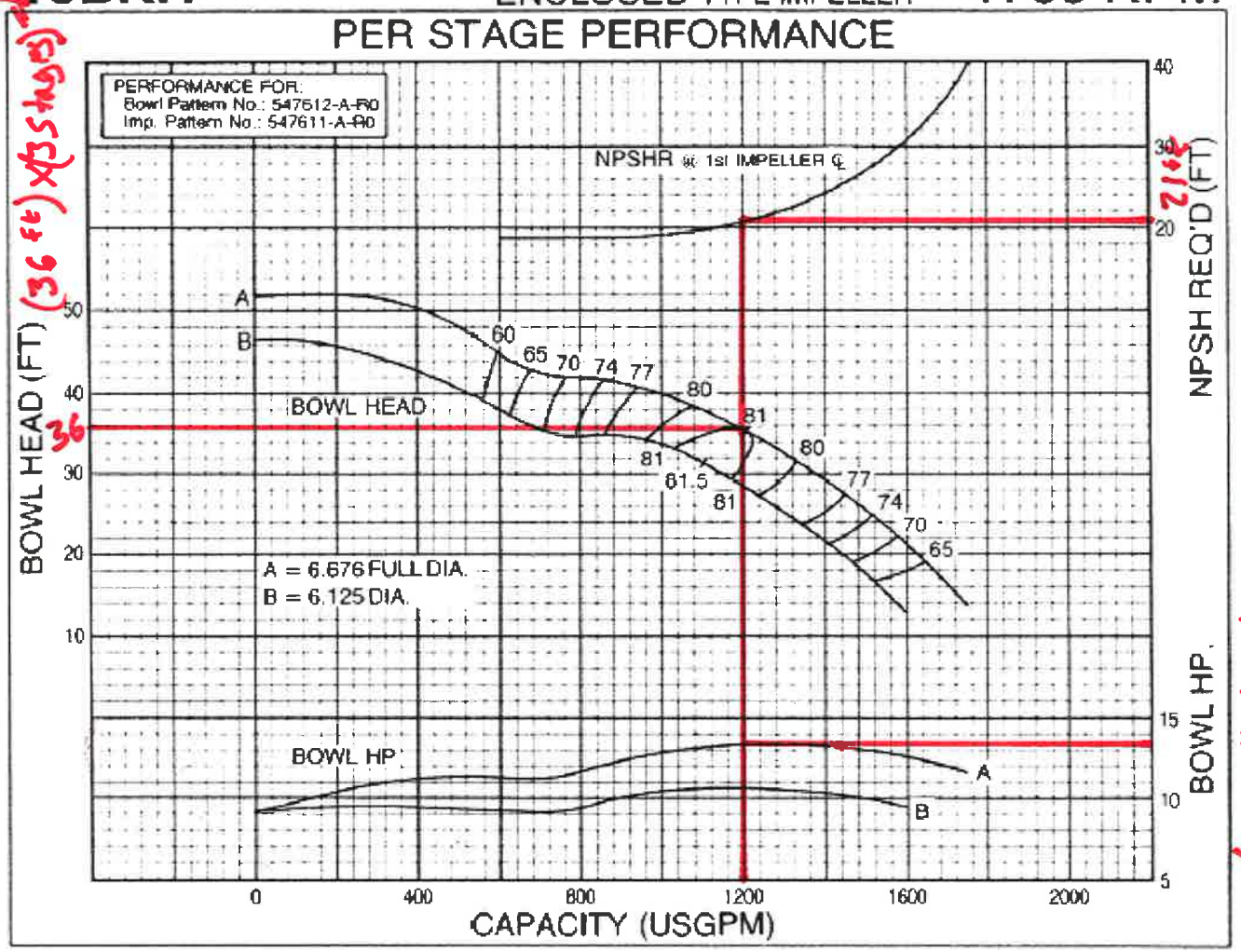
NOTES

Performance indicated based on cold water with a specific gravity of 1.0.

* Standard construction.

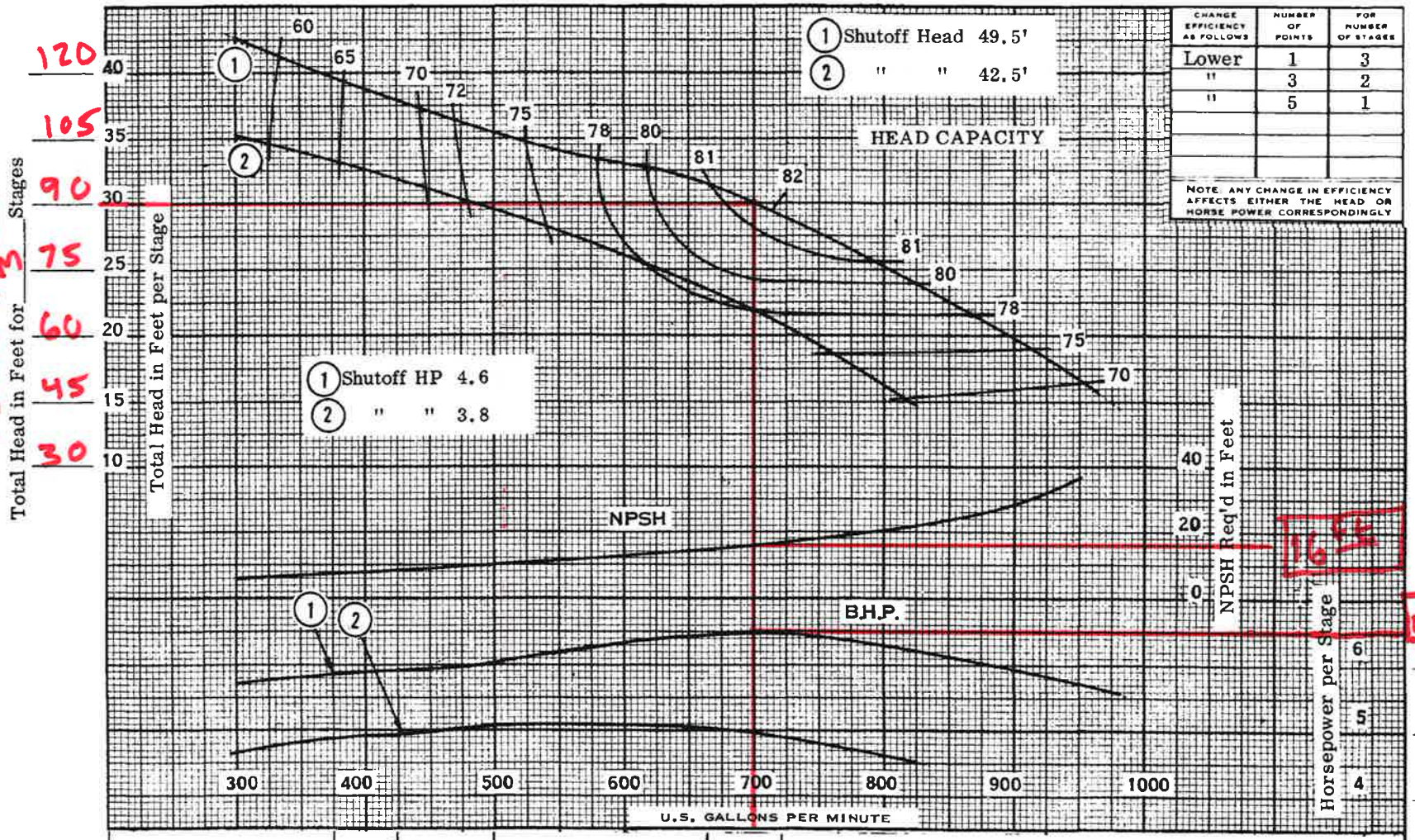
** Minimum submergence over lip of bell to prevent vortexing.

Efficiency improvements are available in certain instances. Please contact the factory.



700 GPM @ 90 ft TDH

2 of oak Pumps



CHANGE EFFICIENCY AS FOLLOWS	NUMBER OF POINTS	FOR NUMBER OF STAGES
Lower	1	3
"	3	2
"	5	1

NOTE ANY CHANGE IN EFFICIENCY AFFECTS EITHER THE HEAD OR HORSE POWER CORRESPONDINGLY

HYDRAULIC PERFORMANCE WARRANTY

Guaranteed at designated point only, and contingent on:

Proper flow to pump suction
Proper submergence
Fluid free of gas, air & abrasives
Proper lateral setting of impeller

CURVE NO.	IMPELLER NO.	IMPELLER DIA.	TAKEN FROM
1	T82337	6¼" x 7⅛"	27195
2	T82337	5 15/16" x 6 13/16"	27309
3			
4			

Customer _____

Item _____

Peerless Ref. No: _____

Laboratory Performance BOWL T82474-E

SIZE 10 HXB RPM 1760 CURVE 2811625

PUMP DESCRIPTION: Driver _____; Head _____; Column _____

GUARANTEED PERFORMANCE: BOWL ☐ FIELD ☐ Capacity 700 gpm; Head 90 ft; Eff 81.75 %; BHP 19.5

Peerless Pump Company
Indianapolis, IN 46207-7025

VERTICAL TURBINE PUMPS
Model 10HXB-1760 Rpm

SECTION 140
Page 1760-29
October, 1974