JACOBS

Long Range Water System Study

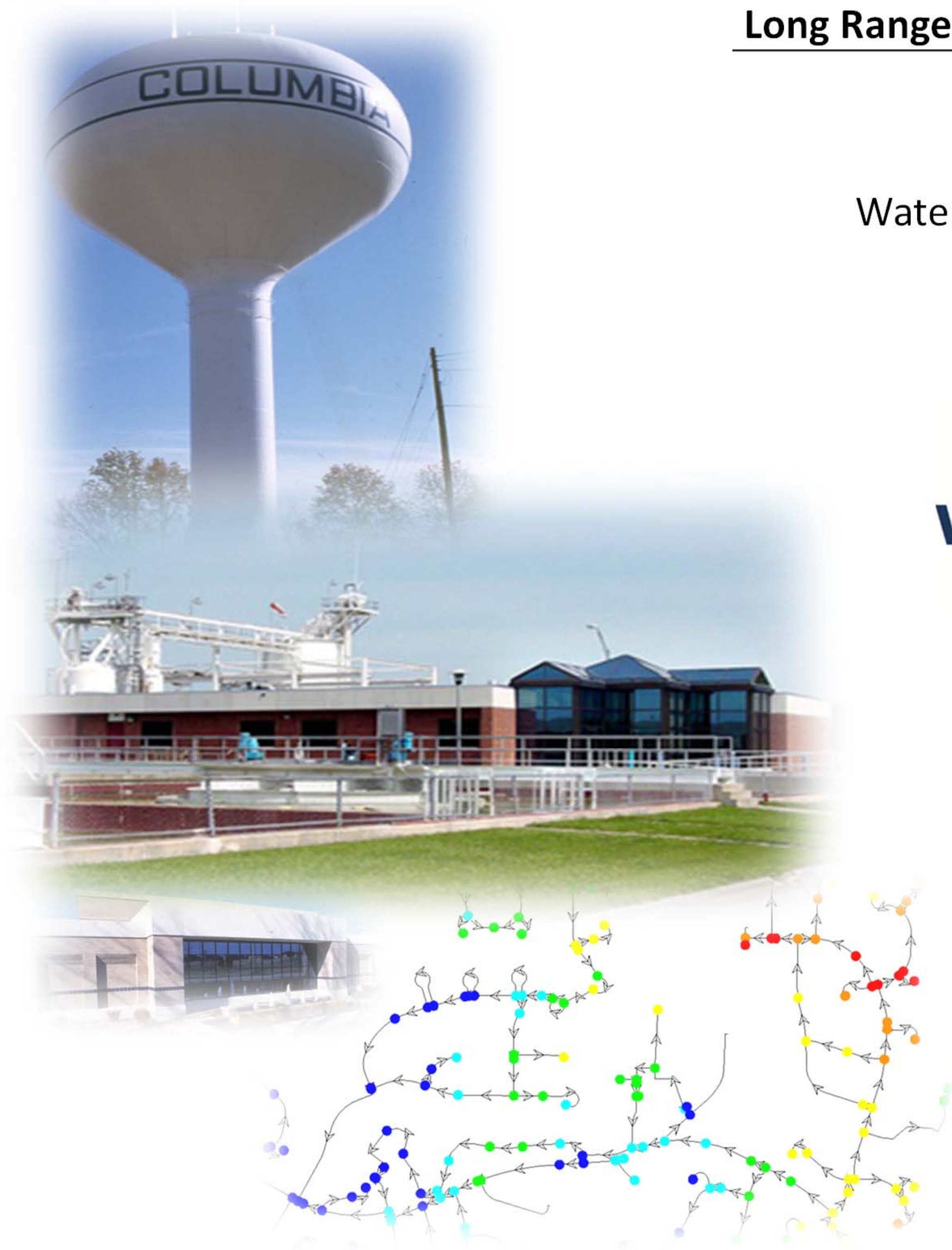
Prepared for:

City of Columbia

Water & Light Department

Columbia, Missouri

January 2015



Prepared by:

Jacobs

St. Louis, MO

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EXECUTIVE SUMMARY

i. BACKGROUND

Columbia Water & Light (CW&L) provides water service to domestic, commercial, institutional, and industrial customers within the City of Columbia (City) limits as well as small areas adjacent to the City. Additional water suppliers in the area consist of the University of Missouri (which has its own deep well based water supply) and rural water districts for the surrounding rural areas.

CW&L contracted with Jacobs Engineering Group, Inc. (Jacobs) to update the Long Range Water System Study (Study), which was submitted by Jacobs in 2008, for future water supply and distribution within CW&L's service area. The objective of this Study is to identify needed capital improvements for CW&L's continued proactive response to provide water service to the customers within their service area for a 20-year planning period (2013 to 2033).

ii. CURRENT AND FUTURE WATER DEMANDS

The nature of predicting future water demands is an inexact science, since there are several unpredictable factors that can result in the actual demands being different than those predicted. Therefore, to account for these uncertainties, the future water demands were estimated with a range of scenarios. The criteria and methodology used are discussed in Section 4.

The estimated future water production needs based on the criteria discussed in Section 4 are shown on the following table.

Estimated Future Water Production

Year	Average Daily Water Production (MGD)	Maximum Daily Water Production (MGD)
2013	15.4	23.1
2014	15.7	23.7
2015	16.1	24.4
2016	16.4	25.1
2017	16.8	25.8
2018	17.8	27.1
2019	18.2	27.9
2020	18.7	28.8
2021	19.1	29.7
2022	19.6	30.6
2023	20.1	31.6
2024	20.6	32.6
2025	21.1	33.7
2026	21.7	34.8
2027	22.3	36.0
2028	22.9	37.3
2029	23.5	38.6
2030	24.2	40.0
2031	24.9	41.5
2032	25.6	43.1
2033	26.4	44.8

iii. PROPOSED SYSTEM IMPROVEMENTS

The current CW&L Five-Year Capital Improvement Plan (CIP) was provided to Jacobs. Improvements identified within the CIP that were related to capacity upgrades (i.e., water main upgrades, new distribution or transmission mains, loop closures, storage or pumping) were evaluated with the KYPIPE model. In addition, evaluation and identification of future system improvements (in five year increments through 2033) necessary to meet the anticipated demands was conducted. The following is a brief summary of the improvements identified.

Year 2018 Proposed Improvements (Five-Year CIP) ($0)

The evaluation of the Five-Year CIP indicated that the improvements identified were adequate to meet the projected water demands. No additional capital improvements were identified for 2018.

Year 2023 Proposed Improvements ($34,119,000)

The main capital improvements are briefly discussed below. Additional information is included in Section 5.

- Elevated storage to replace the existing Prathersville Standpipe. This includes a new 2 MG elevated storage tank.
- Additional Pump Station at the site of the existing West Ash Pump Station to supply water to the new Prathersville elevated storage tank.
- 16-Inch Transmission Main. This includes a new 16-inch main for transmission purposes starting from the proposed new pump station at the existing West Ash Pump Station, and feeding directly to the new proposed elevated tower at the Prathersville site.
- 24-Inch Transmission Main to Stephens Station elevated tank. This includes approximately 28,000 feet of 24-inch main for transmission purposes to feed the existing Stephens Station elevated tank.

Year 2028 Proposed Improvements ($10,264,000)

The main capital improvements are briefly discussed below. Additional information is included in Section 5.

- 24-Inch Transmission Main from proposed new Southeast Pump Station. This includes approximately 8,600 feet of 24-inch main from the proposed new Southeast Pump Station near Gans Road and running north to Nifong Blvd, where it will connect to the existing 24-inch main.
- Additional Ground Storage at Hillsdale Pump Station. This includes an additional 2.75 MG ground storage tank at the Hillsdale Pump Station in addition to the 1.5 MG ground storage already there.
- There is insufficient treatment capacity at the McBaine WTP to meet the peak anticipated water demand of 37.3 MGD. Additional peak day demands of about 6 MGD can be met through the use of the City's Aquifer Storage and Recovery facilities (two existing facilities and one anticipated, each with about 2 MGD capacity). It is anticipated that additional treatment capacity will be required sometime between 2023 and 2028, dependent on the rate of growth over the next 10 years.

Year 2033 Proposed Improvements ($21,767,000)

The main capital improvements are briefly discussed below. Additional information is included in Section 5.

- 16-Inch Transmission Main from West Ash Pump Station to Walnut Tower.
- Additional Pump Station at Hillsdale Pump Station. This includes a 2nd pump station identical to the existing one at Hillsdale and would utilize the existing suction and discharge lines.
- Southeast (SE) Pump Station. This includes a station with 3 pumps and a capacity of approximately 5,000 gpm. Finished water for the pump station would be supplied by either the existing McBaine WTP, or the proposed new Water Treatment Plant recommended by this study.
- 3.5 MG Ground Storage tank near Southeast Pump Station.

iv. CAPITAL COST ESTIMATES

The cost estimates included in Section 6 were based on 2013 dollars, with the following notes and clarifications:

- Inflation – 5% per year for escalation of costs
- An allowance for engineering design and engineering during construction
- 15% contingency for construction costs
- Easement costs were estimated at $3,000 per residential easement

Table 7-1, in Section 7, provides a summary of the costs. These costs have been divided into pump stations, storage, other improvements, and water mains.

SECTION 1 – INTRODUCTION

1.1 BACKGROUND

Columbia Water & Light (CW&L) provides water service to domestic, commercial, institutional, and industrial customers within the City of Columbia (City) limits as well as small areas adjacent to the City. Additional water suppliers in the area consist of the University of Missouri (which has its own deep well based water supply) and rural water districts for the surrounding rural areas.

CW&L contracted with Jacobs Engineering Group, Inc. (Jacobs) to update the Long Range Water System Study (Study), which was submitted by Jacobs in 2008, for future water supply and distribution within CW&L's service area. The objective of this Study is to identify needed capital improvements for CW&L's continued proactive response to provide water service to the customers within their service area for a 20-year planning period (2013 to 2033).

1.2 SCOPE OF SERVICES

The scope of this Study included the following:

- Review of historical water consumption data and water production data to identify potential trends for estimating future water demands.
- Development of the estimated future water demands.
- Analyze the current 5-Year CIP (FY 2012 to FY 2016) for adequacy to meet the anticipated demands.
- Analysis and evaluation of the system to identify future improvements beyond the current 5-Year CIP, including the anticipated year the improvements will be required.
- Conceptual locations and sizing of future improvements.
- Estimate the total project costs for proposed improvements to provide CW&L with information for financial planning, guide in rate development, and future bond referendums.

The scope of this Study did not include the following elements:

- Water supply sources to meet future demands. This report identifies the amount of supply needed to meet the anticipated future water demands, however it does not include a detailed evaluation of the different types of supplies or adequacy of those supplies.
- Physical assessment or detailed evaluation of the City's existing facilities (treatment plant, wells, pump stations, and storage facilities) relative to the structural, mechanical or electrical condition of the facilities.
- Detailed hydraulic evaluation of the City's existing pumping stations or future pumping stations.

1.3 EXISTING REPORTS AND STUDIES

The following reports, studies and other information were reviewed and used to prepare this Study report:

- *1983 Report on Water System for Columbia, Missouri.* This report was a master plan for recommended water system improvements to meet estimated water demands through the year 2000.

- *1989 Long Range Water System Study for Columbia Water & Light Department.* This report was intended to be a plan for recommended improvements to meet estimated water demands through the year 2010.
- *1990 Water System Study for the Northeast Booster District prepared by CW&L personnel.* This report detailed the 5-year capital improvements needed to meet the water demands in the northeast area. The water demands used for the 1990 study were based on the 1989 report.
- *1996 Evaluation of Future Water Supply Sources.* This report was completed to evaluate alternative water supply sources to meet future water demands. This report also projected future water demands through 2025.
- *1999 Water Demand Projection for City of Columbia, Missouri.* This memorandum was intended to re-evaluate the water demands that were projected in the 1996 report based on a maximum day demand of about 22 MGD that was realized in July 1999. This maximum day demand was not anticipated until about year 2010.
- *2008 Long Range Water System Study. This report was completed by Jacobs in 2008 and is to be updated by virtue of this Long Range Water System Study.*

SECTION 2 – EXISTING SYSTEM REVIEW

This section presents a summary of the City's current water supply sources, treatment, distribution system, inventory of wells, storage, and pumping facilities, and a description of the computer modeling efforts.

2.1 SERVICE AREA

CW&L supplies domestic, commercial and industrial water customers within the City limits and two former rural water districts adjacent to the City. The City limits, service area boundaries, and main facilities are shown in Figure 2-1. The University of Missouri campus is located within the service area, however, it has its own deep well water system.

2.2 SOURCES OF SUPPLY AND TREATMENT

2.2.1 Water Supply Wells

The City uses a groundwater source from fifteen (15) shallow alluvial wells in the McBaine Bottoms area near the Missouri River which is pumped to the McBaine Water Treatment Plant (WTP) for treatment and distribution. The City has three (3) additional alluvial wells (16, 17, and 18) planned for construction in the future.

The City also has one (1) deep well (#7) located within the metropolitan area, which is used to serve as an emergency backup or during periods of excessive demand. This well does not include treatment, with the exception of adding chlorine prior to distribution to the system.

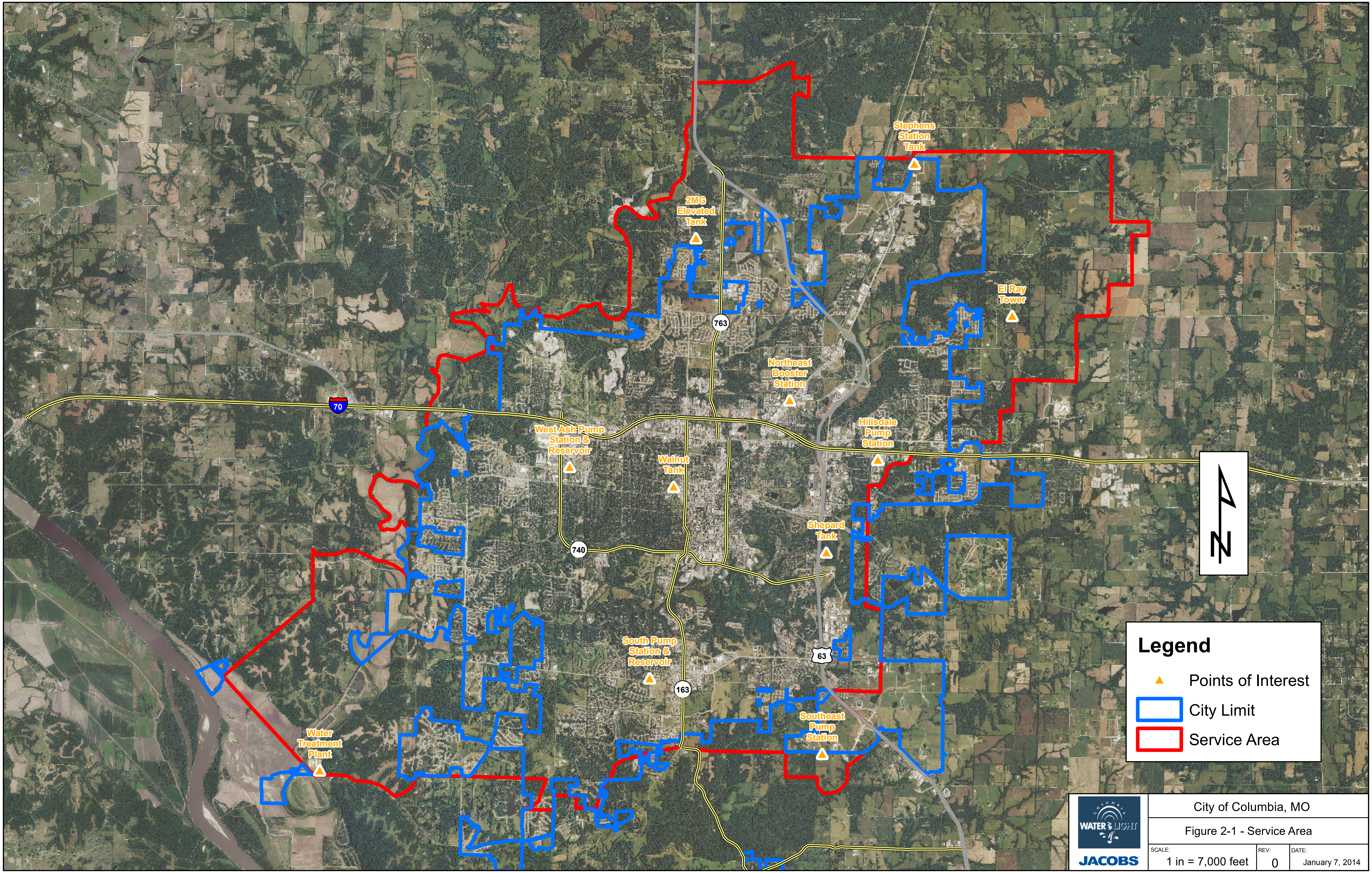
The City has converted two of their deep wells (8 and 10) into Aquifer Storage and Recovery (ASR) facilities, which allows the City to store treated water from the WTP at these locations during off-peak demand periods. Then during periods of peak demand, the City is able to supplement the supply from the WTP by pumping directly out of these ASRs into the distribution system. Each ASR has a capacity of about 2 MGD.

2.2.2 Chloramine Usage in ASRs

The City currently uses chloramines for disinfection at the WTP most of the year. Throughout the summer months, the City switches to free chlorine disinfection. It is during this time that the ASRs are charged if needed. If the ASRs are used, the chlorine level leaving the WTP is elevated and blended with the water in the ASR and then sampled prior to distribution.

The City would like to be able to charge the ASRs with chloraminated water during the off-peak months of the year. Jacobs recommends the City conduct a study on the effects of introducing chloraminated water into the ASRs sometime before 2018, when ASR#3 is planned for construction. This study will allow the City to better define the scope of what is needed for construction of ASR#3, in addition to any possible retrofits to the existing ASRs that may be required for the introduction of chloraminated water into the ASRs.

Using chloramines instead of free chlorine for disinfection allows for longer chlorine residuals in the distribution system. A drawback of recharging the ASRs with chloraminated water is the ammonia that is introduced into the aquifer. Ammonia is a



City of Columbia, MO

Figure 2-1 - Service Area

food source for bacteria and can cause microbial growth. This microbial growth can lead to well and screen plugging.

The study of the existing ASRs should include at a minimum:

- Monitoring ammonia levels in both the water coming into and out of the ASR.
- Obtain “grab samples” of influent and effluent water to the ASR. Samples should be tested for free and total chlorine, as well as free and total ammonia.
- Monitor pump flow, pressure and well drawdown to identify potential screen plugging due to microbial growth.
- Heterotrophic bacteria studies should be done to assure that biological growths are controlled.
- Testing for nitrification.

Requirements for disinfection and disinfection residuals are found in DNR’s 10 CSR 60-4.055 Disinfection Requirements. Disinfection by-products are regulated pursuant to 10 CSR 60-4.090 Maximum Contaminant Levels and Monitoring Requirements for Disinfection By-Products.

2.2.3 McBaine WTP

The majority of the City’s water is supplied from the McBaine WTP, which is located approximately 12 miles southwest of the City near the Missouri River. The McBaine WTP has a rated capacity of 32 MGD. The water from the alluvial wells is treated with aeration, lime softening, and filtration prior to disinfection and distribution. There are four (4) lagoons for storage of lime softening sludge at the WTP site. The WTP was expanded in 2006 to its current 32 MGD capacity and the plant is surrounded with a floodwall and levee system, which restricts any future footprint expansion at the current location.

2.3 EXISTING DISTRIBUTION SYSTEM

Finished water from the WTP is pumped by high services pumps at the WTP directly into two 36-inch transmission mains. The transmission mains extend from the WTP to both the West Ash Pump Station and ground storage reservoir and the South Pump Station and ground storage reservoir. Water from these two pump stations is then pumped to the distribution system.

The City distribution system includes two main pressure zones, the primary distribution system, and the Northeast pressure zone. Water main diameters in the CW&L distribution systems range in size from 4 inches to 24 inches.

2.3.1 Pump Stations

Currently, there are four pump stations within the distribution system. The following is a brief description of each pump station and a summary is included in Table 2-1.

West Ash Pump Station

This pump station is located northeast of the intersection of Ash Street and Bernadette Drive. Finished water from the transmission main fills a ground storage reservoir on site, which is on the suction side of the pump station. The pump station discharges directly to the distribution system. The station contains five (5) pumps. The total rated capacity, with one pump used for backup, is approximately 28 MGD.

South Pump Station

This pump station is located near the intersection of Nifong Road and Bethel Road. Finished water from the transmission main fills two separate ground storage reservoirs on site, which are on the suction side of the pump station. The pump station discharges directly to the distribution system. The station contains four (4) pumps. The total rated capacity, with one pump used for backup, is approximately 10 MGD.

Northeast Booster Pump Station

This booster pump station is located near the intersection of Oakland Gravel Road and Vandiver Drive. The suction side of the pump station is taken from the main distribution system (basically the discharge from West Ash Pump station and Walnut Tank) and discharges to the Northeast pressure area. The station contains three (3) pumps. The total rated capacity, with one pump used for backup, is approximately 4.2 MGD.

Hillsdale Pump Station

This pump station is located near the intersection of I-70 Drive SE and Hillsdale Road. A 1.5 MG ground storage tank was constructed by Natgun at the site in 2010 and is situated on the suction side of the pump station. Water is supplied to the ground storage tank from the Shepherd Elevated Storage Tank. The station contains four (4) pumps. The total rated capacity, with one pump used for backup, is approximately 6.5 MGD.

Table 2-1: Pump Station Summary

Station Name	Water Source	No. Pumps (Duty)	Total Capacity (MGD)	Status
West Ash Pump Station	Finished water from WTP	5	28	In Service
South Pump Station	Finished water from WTP	4	10	In Service
Northeast Booster Pump Station	Distribution system	3	4.2	In Service
Hillsdale Pump Station	Distribution system	4	6.5	In Service

2.3.2 Storage Facilities

Currently storage within the system consists of both ground, elevated, and aquifer storage. Information on the existing system storage as well as some near term planned storage is included in Table 2-2 below.

Table 2-2: Existing and Near Term Storage Facilities

Storage Facility Name	Storage Type	Capacity (gallons)	Overflow Elev. (USGS)	Status
Existing Storage				
West Ash	Ground	5,000,000	N/A	In Service
South Pump Station	Ground	4,000,000	N/A	In Service
Hillsdale Pump Station	Ground	1,500,000	821	In Service
Walnut	Elevated	1,000,000	911	In Service
Shepard	Elevated	1,500,000	912	In Service
Stephens Station	Elevated	1,500,000	1000	In Service
Prathersville	Standpipe	800,000	N/A	In Service
El Ray	Elevated	300,000	956	Not used
ASR #1 (old DW 10)	Aquifer Storage	2,000,000	N/A	Used during peaks
ASR #2 (old DW 8)	Aquifer Storage	2,000,000	N/A	Used during peaks
Total Existing Storage[1]		19,300,000		
Near Term Planned Storage				
New ASR (#3)	Aquifer Storage	2,000,000		Planned for 2018 in CIP
Prathersville[2]	Elevated	2,000,000		Planned for 2018 in CIP
Total Storage with Planned[1]		22,500,000		

(1) Totals do not include the El Ray Tank and "Total Storage with Planned" accounts for removal of the existing Prathersville Standpipe (-0.8 MG) when the elevated tank is built (+2.0 MG).

(2) This Study recommends delaying the Prathersville EST until 2023. See Section 5.3.

2.4 KYPIPE COMPUTER MODEL

KYPIPE is a computer model that can be used to perform hydraulic design and evaluations of water distribution systems. It can be used to size pumps, water mains, and tanks and also estimate system pressures. CW&L provided Jacobs with a calibrated KYPIPE computer model of the distribution system.

- Main Distribution System Model – This is a model of the distribution system including pump stations, storage tanks, and water mains. In general, water mains within the distribution system 6-inches and up are included in the model. This was the model that was used in the evaluation of proposed system improvements, as discussed in Section 5 of this report. It should be noted that the El Ray elevated tank is in the model, but it is not used.

The following is a brief description of what was added and/or updated in the Main Distribution System model:

The main distribution system model was used to evaluate the improvements necessary to meet the future years estimated average and peak day water demands placed on the water distribution system. The following assumptions were used for the modeling:

- All modeling scenarios contained in this report are based on actual demand information through March of 2013, because that was the extent of demand data available when the modeling effort was completed.
- A 48-hour extended period flow simulation was run for the analysis.
- Storage tanks were kept as full as possible
- The main pump stations (West Ash, South, Northeast and Hillsdale) were in operation with the maximum number of duty pumps for peak day demands.
- No interconnects with adjoining Water Districts were included.
- Water demands were distributed in the model in accordance with the growth areas identified and discussed in Sections 3 and 4 of this report.
- Several diurnal flow patterns (hourly variation in water demand) were used in the computer model depending on whether the demand was residential, commercial or large water users. These flow patterns were based on the patterns in the model provided by the City.

SECTION 3 – HISTORICAL DATA REVIEW

CW&L provided historical information on customers, water consumption, and water production. The following sections provide a summary of the information provided and the evaluation completed.

3.1 CUSTOMERS

A list of the number of customers from July 2007 to March 2013 was initially provided and included the number and type of customers in the following areas (The City provided data from April 2013 to August 2014 subsequent to completion of the modeling tasks associated with this report):

- Residential customers both inside the City Limits and outside the City Limits. This also included data from Master meters, which is one meter that serves more than one customer (i.e., apartments and trailer courts).
- Commercial customers both inside the City Limits and outside the City Limits
- Large Commercial customers both inside the City Limits and outside the City Limits. Large Commercial customers are defined by the City as those that exceed a usage of 374,000 gallons (500 CCF) during non-summer months.

3.2 WATER CONSUMPTION

Water consumption quantities by customer were initially provided by the City for the period July 2007 to March 2013 (The City provided data from April 2013 to August 2014 subsequent to completion of the modeling tasks associated with this report). These quantities were provided for residential, master meter, commercial, and large commercial customers. It should be noted that the quantities for master meter customers were included as residential in our evaluation. In addition, separate quantities were provided for irrigation only customers. These are customers that have a separate water meter that is strictly used for irrigation purposes.

3.3 WATER PRODUCTION

Water production data from October 2006 to March 2013 was initially provided and included the following (The City provided data from April 2013 to October 2014 subsequent to completion of the modeling tasks associated with this report):

- Water Production at the McBaine WTP, including daily flows influent to the WTP from the raw water supply wells, and daily flows to the water distribution system (effluent from the high services pumps).
- Daily water pumped from the West Ash, South, Northeast Booster, and Hillsdale pump stations.

3.4 DATA EVALUATION

The following sections provide a summary of our evaluation of the historical data.

3.4.1 Historical Population

The City and Boone County have experienced an increase in population nearly every year since 1900. Table 3-1 provides historical population data.

Table 3-1: Historical Population Data

Year[1,2]	City of Columbia Population[3]	% Change in Population
1900	5,651	-
1910	9,662	71.0
1920	10,392	7.6
1930	14,967	44.0
1940	18,399	22.9
1950	31,974	73.8
1960	36,650	14.6
1970	58,813	60.5
1980	62,061	5.5
1990	69,101	11.3
1996	75,700	9.5
1997	N/A	N/A
1998	N/A	N/A
1999	80,500	N/A
2000	85,292	5.6
2001	86,081	0.9
2002	87,003	1.1
2003	88,423	1.6
2004	89,803	1.6
2005	91,814	2.2
2006	93,219	1.5
2007	94,645	1.5
2008	100,976	6.7
2009	102,324	1.3
2010	108,500	6.0
2011	110,438	1.8
2012	113,230	2.5
2013	115,155	1.7

(1) Source for data from 1900 to 2007 was compiled from the 2008 Study.

(2) Source for data from 2008 to 2013 was taken from the City of Columbia Website: www.gocolumbiamo.com/Finance/Services/Financial_Reports/documents/2004-2013TenYearTrendManual.pdf.

(3) Data source used in 2008 Study for 1999-2007 population data is not currently available. A different data source, which is noted above, was utilized for 2008-2012 population data. These separate data sources may have used different methods to estimate population, which could account for the perceived large increase in population from 2007 to 2008.

3.4.2 Customers

The data provided by the City was reviewed and evaluated. The information was broken out into different categories, which are described as follows:

- Total Water Customers – Increased from just over 30,000 in 1997 to over 46,000 in 2014. The average yearly increase is 2.5% over that timeframe. Table 3-2 and Figure 2 in Appendix 1 show this information.
- Residential Water Customers - Increased from just under 28,000 in 1997 to almost 43,000 in 2014. The average yearly increase is 2.6% over that timeframe. Table 3-3 and Figure 3 in Appendix 1 show this information.
- Commercial Water Customers - Increased from over 2,700 in 1997 to just under 3,500 in 2014. The net average yearly increase is 1.7% over that timeframe. However, 2008 through 2011 show a decline in the total number of commercial water users, with a slight rebound since then. Table 3-4 and Figure 4 in Appendix 1 show this information.

- Large Commercial Water Customers - Declined sharply from 38 customers in 1998 to only 26 in 2014. Table 3-5 and Figure 5 in Appendix 1 show this information.
- Water Customers within the City Limits - Increased from over 29,000 in 1997 to over 45,000 in 2014. The average yearly increase is 2.5% over that timeframe. Table 3-6 and Figure 6 in Appendix 1 show this information.
- Water Customers outside the City Limits - Increased from just over 1,000 in 1997 to over 1,200 in 2014. The average yearly increase is 1.4% over that timeframe. Table 3-7 and Figure 7 in Appendix 1 show this information.
- Irrigation Only Water Customers – Increased from just over 250 in 1997 to over 1,000. in 2014. The average yearly increase is 9.1% over that timeframe. Table 3-8 and Figure 8 in Appendix 1 shows this information.

Table 3-2: CW&L Total Number of Water Customers

Year[1]	Total Water Customers[2,3,4]	% Change in Customers
1997	30,618	-
1998	32,488	6.1
1999	33,476	3.0
2000	34,367	2.7
2001	35,174	2.3
2002	36,082	2.6
2003	37,614	4.2
2004	39,246	4.3
2005	40,557	3.3
2006	41,815	3.1
2007	43,034	2.9
2008	43,554	1.2
2009	43,911	0.8
2010	44,360	1.0
2011	44,755	0.9
2012	45,263	1.1
2013	46,195	2.1
2014	46,441	0.5
Average		2.5%

(1) Data was only available to August, 2014.
(2) Customer information provided by the City.
(3) Information prior to 2007 was taken from the 2008 Study.
(4) Does not include irrigation only customers.

Table 3-3: CW&L Total Number of Residential Water Customers

Year[1]	Total Water Customers[2,3,4]	% Change in Customers
1997	27,873	
1998	29,424	5.6
1999	30,066	2.2
2000	31,033	3.2
2001	31,731	2.2
2002	32,534	2.5
2003	33,568	3.2
2004	34,944	4.1
2005	36,121	3.4
2006	37,395	3.5
2007	38,365	2.6
2008	39,304	2.4
2009	40,313	2.6
2010	40,822	1.3
2011	41,236	1.0
2012	41,731	1.2
2013	42,706	2.3
2014	42,923	0.5
Average		2.6%

(1) Data was only available to August, 2014.
(2) Customer information provided by the City.
(3) Information prior to 2007 was taken from the 2008 Study.
(4) Does not include irrigation only customers.

Table 3-4: CW&L Total Number of Commercial Water Customers

Year1	Total Water Customers[2,3,4]	% Change in Customers
1997	2,713	
1998	3,026	11.5
1999	3,375	11.5
2000	3,297	-2.3
2001	3,405	3.3
2002	3,511	3.1
2003	4,017	14.4
2004	4,273	6.4
2005	4,406	3.1
2006	4,389	-0.4
2007	4,638	5.7
2008	4,220	-9.0
2009	3,568	-15.5
2010	3,518	-1.4
2011	3,496	-0.6
2012	3,509	0.4
2013	3,463	-1.3
2014	3,492	0.8
Average		1.7%

(1) Data was only available to August, 2014.
(2) Customer information provided by the City.
(3) Information prior to 2007 was taken from the 2008 Study.
(4) Does not include irrigation only customers.

Table 3-5: CW&L Total Number of Large Commercial Water Customers

Year[1]	Total Water Customers[2,3,4]	% Change in Customers
1997	32	
1998	38	18.8
1999	35	-7.9
2000	37	5.7
2001	38	2.7
2002	37	-2.6
2003	29	-21.6
2004	29	0.0
2005	30	3.4
2006	31	3.3
2007	31	0.0
2008	30	-3.2
2009	30	0.0
2010	20	-33.3
2011	23	15.0
2012	23	0.0
2013	26	13.0
2014	26	0.0
Average		-0.4%

(1) Data was only available to August, 2014.
(2) Customer information provided by the City.
(3) Information prior to 2007 was taken from the 2008 Study.
(4) Does not include irrigation only customers.

Table 3-6: CW&L Water Customers within City Limits

Year[1]	Total Water Customers[2,3,4]	% Change in Customers
1997	29,611	
1998	31,169	5.3
1999	32,115	3.0
2000	33,206	3.4
2001	33,983	2.3
2002	34,876	2.6
2003	36,387	4.3
2004	38,051	4.6
2005	39,357	3.4
2006	40,606	3.2
2007	41,839	3.0
2008	42,357	1.2
2009	42,700	0.8
2010	43,142	1.0
2011	43,537	0.9
2012	44,042	1.2
2013	44,972	2.1
2014	45,222	0.6
Average		2.5%

(1) Data was only available to August, 2014.
(2) Customer information provided by the City.
(3) Information prior to 2007 was taken from the 2008 Study.
(4) Does not include irrigation only customers.

Table 3-7: CW&L Water Customers outside City Limits

Year[1]	Total Water Customers[2,3,4]	% Change in Customers
1997	1,007	
1998	1,319	31.0
1999	1,361	3.2
2000	1,161	-14.7
2001	1,190	2.5
2002	1,206	1.3
2003	1,227	1.7
2004	1,195	-2.6
2005	1,200	0.4
2006	1,209	0.8
2007	1,195	-1.2
2008	1,197	0.2
2009	1,211	1.2
2010	1,218	0.6
2011	1,217	-0.1
2012	1,221	0.3
2013	1,223	0.2
2014	1,219	-0.3
Average		1.4%

(1) Data was only available to August, 2014.
(2) Customer information provided by the City.
(3) Information prior to 2007 was taken from the 2008 Study.
(4) Does not include irrigation only customers.

Table 3-8: CW&L Irrigation Only Water Customers

Year[1]	Total Water Customers[2,3]	% Change in Customers
1997	254	
1998	300	18.1
1999	357	19.0
2000	380	6.4
2001	378	-0.5
2002	382	1.1
2003	407	6.5
2004	439	7.9
2005	516	17.5
2006	696	34.9
2007	627	-9.9
2008	633	0.9
2009	647	2.2
2010	673	4.0
2011	700	4.1
2012	780	11.3
2013	883	13.3
2014	1,046	18.4
Average		9.1%

(1) Data was only available to August, 2014.
(2) Customer information provided by the City.
(3) Information prior to 2007 was taken from the 2008 Study.

In addition, Jacobs evaluated the areas within the City's service area where the majority of the customers have been added from 2008 to 2012. This was done by mapping the location where each new customer was added during that time span. CW&L provided information on the location of new customers added from 2008 to 2012. The information provided by CW&L was broken down by fiscal year, which runs from October 1 through the end of September. The following is a general description of our evaluation and Figure 3-1 shows the areas within the system where the majority of the customer growth has occurred.

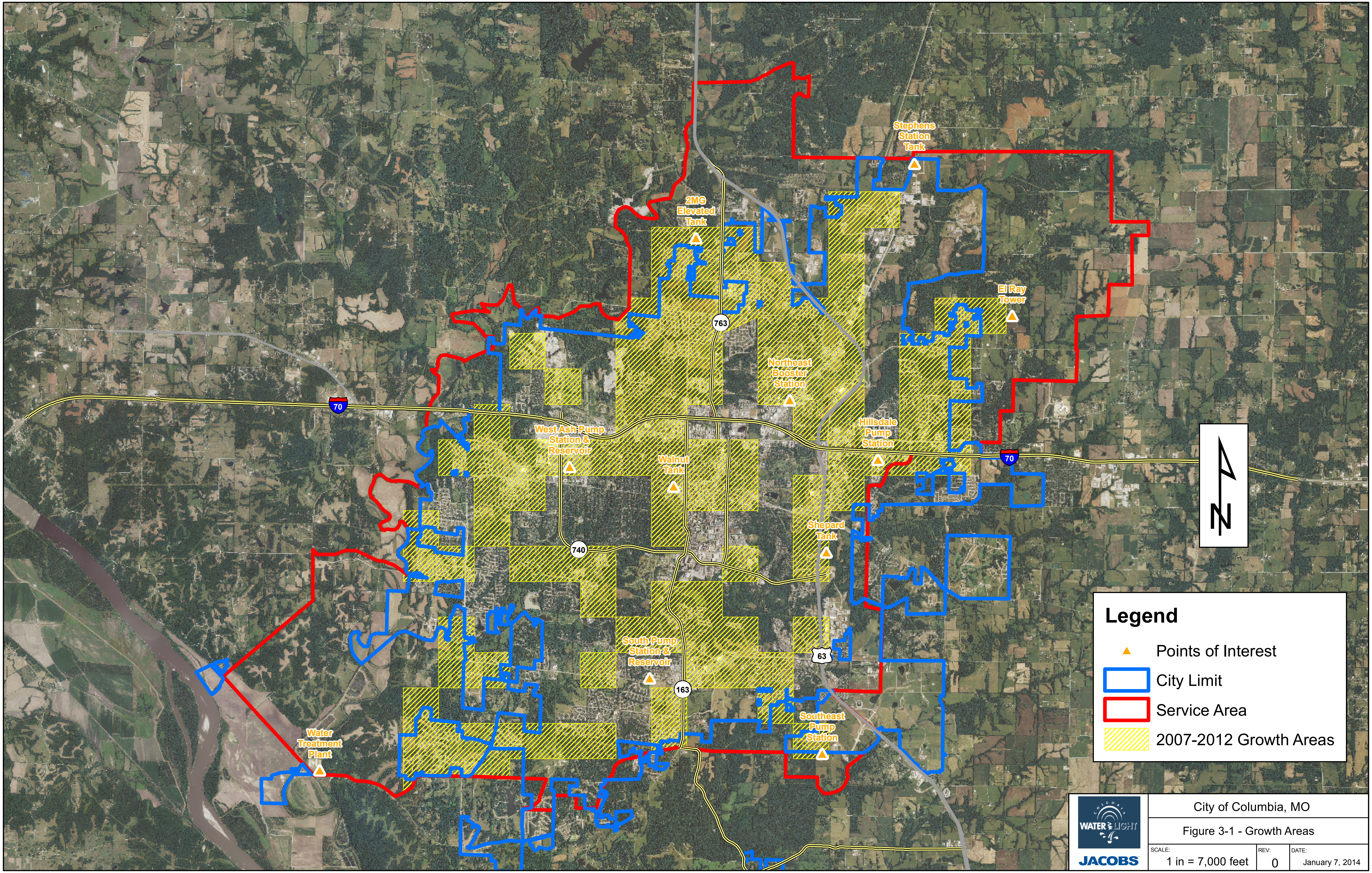
- 2008 – Based on information provided by CW&L, 540 customers were added. A significant amount of the growth was north of I-70 and west, south, and southwest of downtown, and mainly consisted of residential customers. The downtown area included both residential and commercial customers. Master meters were added south of downtown.
- 2009 – Based on information provided by CW&L, 297 customers were added. A significant amount of the growth was north of I-70 and west, south, and southwest of downtown, and mainly consisted of residential customers. The downtown area included both residential and commercial customers.
- 2010 – Based on information provided by CW&L, 392 customers were added. A significant amount of the growth was north of I-70 and west, south, and southwest of downtown, and mainly consisted of residential customers with a noticeable amount of new commercial customers in the south. The downtown area included both residential and commercial customers. Master meters were added downtown and south of downtown.
- 2011 – Based on information provided by CW&L, 422 customers were added. A significant amount of the growth was north of I-70 and west, south, and southwest of downtown, and mainly consisted of residential customers. The downtown area included both residential and commercial customers. Master meters were added south of downtown and north of I-70.
- 2012 – Based on information provided by CW&L, 219 customers were added. A significant amount of the growth was west and southwest of downtown, and mainly consisted of residential customers. The downtown area was mainly commercial customers with a few new residential customers.

CW&L anticipates that residential growth may also occur in northeast, east, and southeast portions of Columbia. Jacobs utilized the draft of the comprehensive plan Columbia Imagined as a guide to apply future water demand through 2033.

3.4.3 Water Consumption

The data provided by the City was reviewed and evaluated. The following provides a brief summary of our evaluation:

- Total Water Consumption. The total average daily consumption (including irrigation only customers) has increased from approximately 11.0 MGD in 2002 to approximately 10.8 MGD in 2014, peaking at 12.3 MGD in 2012. The peak consumption varies dependent mainly on how dry it is during the summer months. The peak daily consumption has increased from approximately 13.6 MGD in 2002 to approximately 19.7 MGD in 2012; however, it has recently dropped sharply to approximately 13.2 MGD in 2014. The average consumption per customer has decreased, from about 305 gallons/customer/day in 2002 to about 230 gallons/customer/day in 2014. This data is shown on Figures 14, 15, and 16, included in Appendix 1.



City of Columbia, MO

Figure 3-1 - Growth Areas

SCALE: 1 in = 7,000 feet | REV: 0 | DATE: January 7, 2014

- Residential Water Consumption. The residential average daily consumption (not including irrigation only customers) has increased from approximately 6.4 MGD in 2002 to approximately 6.5 MGD in 2012, peaking at 7.7 MGD in 2012. The peak residential consumption also varies dependent mainly on how dry it is during the summer months. The average consumption per residential customer has decreased, from about 200 gallons/customer/day in 2002 to about 185 gallons/customer/day in 2012, and to about 150 gallons/customer/day in 2014. This data is shown on Figures 17, 18, and 19, included in Appendix 1.
- Commercial Water Consumption – The commercial average daily consumption (not including irrigation only customers) has decreased slightly from approximately 2.2 MGD in 2002 to approximately 2.1 MGD in 2014. The peak commercial consumption also varies dependent mainly on how dry it is during the summer months. The average consumption per commercial customer has decreased from about 635 in 2002, to about 630 gallons/customer/day in 2012, and to about 600 gallons/customer/day in 2014. This data is shown on Figures 20, 21 and 22, included in Appendix 1.
- Large Commercial Water Consumption – The large commercial average daily consumption (not including irrigation only customers) has decreased from about 2.1 MGD in 2002 to about 1.5 MGD 2014. The peak consumption does not seem to correlate strongly to usage in the summer months. The average consumption per large commercial customer increased from about 58,000 gallons/customer/day in 2002, to about 70,000 gallons/customer/day in 2012, and then decreased to about 59,000 gallons/customer/day in 2014. This data is shown on Figures 23, 24, and 25, included in Appendix 1.
- Irrigation usage – The irrigation usage is predominantly used during the peak usage times (summer months). The peak consumption per irrigation customer depends on how dry the summer months are and has been as high as 3,300 gallons/customer/day in 2012, but was about 1,100 gallons/customer/day on average in 2012. This data is shown on Figures 26, 27, and 28, included in Appendix 1.
- Master Meter Consumption – The average consumption per master meter customer has decreased from about 950 gallons/customer/day in 2002, to about 770 gallons/customer/day in 2012, and to about 750 gallons/customer/day in 2014. This data is shown on Figure 29, included in Appendix 1.

3.4.4 Peak Water Consumption

Jacobs also evaluated the times of year where typical water consumption increases. From an evaluation of the data, the peaks typically occur somewhere between July and September. The average and maximum daily water consumption data was used to determine a peaking factor for each year. The consumption data is monthly, so the maximum daily water consumption was calculated by taking the maximum monthly consumption and dividing by the number of days in the given month. This data is shown in Table 3-9.

Table 3-9: Average to Peak – Total Water Consumption

Year[1]	Average Daily Water Consumption (gallons)[2,4,5]	Maximum Daily Water Consumption (gallons)[3,4,5]	Peaking Factor
2002	11,045,284	13,596,179	1.2
2003	11,385,531	15,803,720	1.4
2004	10,946,968	12,474,710	1.1
2005	12,615,487	18,793,355	1.5
2006	12,346,902	17,250,738	1.4
2007	12,238,759	17,183,429	1.4
2008	11,048,650	13,702,574	1.2
2009	10,849,309	12,610,636	1.2
2010	11,048,781	13,741,340	1.2
2011	11,088,679	16,332,797	1.5
2012	12,323,412	19,671,015	1.6
2013	11,052,736	14,537,835	1.3
2014	10,756,882	13,204,513	1.2

(1) Data prior to 2007 was taken from the 2008 Study.
(2) Average daily water consumption values were calculated by summing the total water consumption for each year and dividing by the number of days in that year.
(3) Maximum daily water consumption values were calculated by determining the month during each year of maximum consumption and dividing that total by the number of days in that month.
(4) Includes irrigation only water consumption.
(5) Total water consumption (2014) is based on available data from January 2014 to August 2014 inclusive.

3.4.5 Water Production

The data provided by the City was reviewed and evaluated. The following provides a brief summary of our evaluation:

- Water Production at the McBaine WTP. The average day water production at the WTP has increased from about 12.6 MGD in 2002 to 13.3 MGD in 2012; however, it has recently dropped to approximately 12.4 MGD in 2014. This was calculated by subtracting "in plant" water used (IPU) from the WTP effluent for each day and then totaling production for the year and dividing by the number of days in that year. The peak day water production at the WTP has increased from about 19 MGD in 2002 to over 23 MGD in 2012; however, it has recently dropped back to approximately 19 MGD in 2014. The peak day water production includes water from the ASRs, if they were used at the time of peak flow. Figure 30, included in Appendix 1 shows monthly average water production.
- West Ash Pump Station. The average day water pumped from the West Ash pump station has increased from over 8 MGD in 2002 to just over 9.5 MGD in 2014. This data is shown on Figure 31, included in Appendix 1.
- South Pump Station. The average day water pumped from the South pump station has increased from over 4 MGD in 2002 to close to 6 MGD in 2012; however, it has recently dropped to just over 3 MGD in 2014. In July 2012, the South Pump Station had peak days between 9.5 and 10 MGD, which is at the capacity of the pump station with four pumps in operation. This data is shown on Figure 32, included in Appendix 1.
- Northeast Booster Pump Station. The average day water pumped from the Northeast Booster pump station has slightly increased from 2.8 MGD in 2003 to 3 MGD in 2014. However, there was a significant drop off to about 1.8 MGD in 2012. This data is shown on Figure 33, included in Appendix 1.
- Hillsdale Pump Station. The Hillsdale pump station was built in 2008. The average day water pumped from the Hillsdale pump station has decreased from

just over 2 MGD in 2009 to under 2 MGD in 2014. This data is shown on Figure 34, included in Appendix 1.

3.4.6 Peak Water Production

Jacobs also evaluated the average and peak water production data. From an evaluation of the data, the peak months tend to occur between July and October. This trend matches the water consumption data very well. Average and peak water production data is shown in Table 3-10 below.

Table 3-10: Average to Peak - Total Water Production

Year[1]	Average Daily Water Production (MGD)	Maximum Daily Water Production (MGD)	Peaking Factor
2002	12.45	19.09	1.5
2003	13.07	21.35	1.6
2004	12.79	17.52	1.4
2005	13.83	23.69	1.7
2006	13.91	22.56	1.6
2007	14.38	23.83	1.7
2008	13.38	20.67	1.5
2009	12.32	17.09	1.4
2010	11.89	16.78	1.4
2011	12.10	20.80	1.7
2012	13.32	22.85	1.7
2013	11.19	19.21	1.7
2014	12.37	19.10	1.5

(1) Data prior to 2007 was taken from the 2008 Study.
(2) Daily water production (2014) is based on available data from January 2014 to October 2014 inclusive.

SECTION 4 – CURRENT and FUTURE WATER DEMANDS

4.1 CURRENT WATER PRODUCTION

The average day water production at the WTP has increased from over 11 MGD in 1997 to over 12 MGD in 2013, peaking at over 13 MGD in 2012. The peak day water production at the WTP has increased from almost 19 MGD in 1997 to close to 22 MGD in 2013, peaking at almost 23 MGD in 2012. A summary of the average day and peak day water production for the last 18 years is shown below in Table 4-1.

Table 4-1: Recent Water Production

Year[1]	Average Daily Water Production (MGD)	Maximum Daily Water Production (MGD)
1997	11.51	18.70
1998	12.15	18.22
1999	13.48	22.79
2000	13.02	18.01
2001	12.47	18.15
2002	12.45	19.09
2003	13.07	21.35
2004	12.79	17.52
2005	13.83	23.69
2006	13.91	22.56
2007	14.38	23.83
2008	13.38	20.67
2009	12.32	17.09
2010	11.89	16.78
2011	12.10	20.80
2012	13.32	22.85
2013	11.21	21.74
2014[2]	10.35	19.10

(1) Data prior to 2007 was taken from the 2008 Study.
(2) Water production for 2014 is based on available data from January 2014 to October 2014 inclusive.

4.2 FUTURE ESTIMATE CRITERIA

The nature of predicting future water demands is an inexact science, since there are several unpredictable factors that can result in the actual demands being different than those predicted. In 2007, a nationwide economic recession caused a stall in growth in most sectors of the economy and forced a decline in revenues for many industries. Water consumption growth in most areas of the City of Columbia either stalled or decreased during this time. The future water demand scenarios listed below were estimated while keeping in mind the slowed growth observed due to the economic conditions over the past 8 years, but also being mindful of the push for economic development.

The baseline scenario assumes growth at rates very similar to what was seen in the 10 years prior to 2013, as follows:

- Residential customer growth at 2.5% per year
- Commercial customer growth at 1.0% per year
- Large commercial growth at 1% plus a constant allowance for a high tech data center with a demand of 500,000 GPD starting in year 2018.

- Master meter customer growth at 0% (no annual growth)
- Irrigation only customer growth at 8% per year

The more conservative (worst-case) scenario assumes growth at rates higher than what was seen in the 10 years prior to 2013, as follows:
- Residential customer growth at 4% per year
- Commercial customer growth at 4% per year
- Large commercial growth at 2% per year plus a constant allowance for a high tech data center with a demand of 500,000 GPD starting in year 2018.
- Master meter customer growth at 1% per year
- Irrigation only customer growth at 10% per year

The less conservative (best-case) scenario assumes growth at rates lower than what was seen in the 10 years prior to 2013, as follows:
- Residential customer growth at 1% per year
- Commercial customer growth at 0.5% per year
- Large commercial growth at 0% (no annual growth)
- Master meter customer growth at 0% (no annual growth)
- Irrigation only customer growth at 6% per year

The future water demands were estimated based on the methodology described below.
- The number of different types of customers in year 2012 (residential, commercial, large commercial, master meter, and irrigation only) were increased yearly by the percentages discussed above over the 20 year period.
- The water consumption usage per customer in 2012, described in Section 3, was then used for each type of customer to come up with the total demands. The following was used:
    - Residential – 185 gallons / customer / day for average and 1.5 times that for peak.
    - Commercial – 630 gallons / customer / day for average and 1.4 times that for peak.
    - Large Commercial – 70,000 gallons / customer / day for both average and peak.
    - Master Meter – 770 gallons / customer / day for average and 1.1 times that for peak.
    - Irrigation only - 1,100 gallons / customer / day for average and 3,300 gallons / customer /day for peak.
- “In Plant” water used at the McBaine plant was included in the demands. Historical data was provided and evaluated. During the average days, 300,000 gpd was used, and for the peak days 420,000 gpd was used. These were increased slightly over the future to account for additional use.
- Unaccounted for Water, or “water loss" was included in the demands. This is the difference between water produced and water billed. These quantities are system specific and are due to a variety of different factors. The *1999 Water Demand Projection for City of Columbia, Missouri* report included an analysis of water produced at the WTP versus water billed from 1972 to 1999, which indicated that it averaged 13.8% over that period.

  During the project kick-off meeting, CW&L noted that unaccounted for water was over 10% for three years prior to 2012. A prolonged heat wave occurred in the summer of 2012, during which time 100 degree days were common for over a month. During that time, the City repaired over 200 water main breaks. CW&L noted that after those water mains were repaired, the City's water loss dropped to 9%.

Jacobs has reviewed the water loss for CW&L from 2002 to 2012 and observed an average yearly water loss of 11.4% over that time period. Therefore, unaccounted for water was set at 12% for future demand projections. See Table 4-2 for average yearly water loss values from 2002 to 2012.

Table 4-2: Average Yearly Water Loss

Year	Average Daily Water Production (MGD)	Average Daily Water Consumption (MGD)	Water Loss (MGD)	Water Loss %
2002	12.45	11.05	1.40	11.2%
2003	13.07	11.39	1.68	12.9%
2004	12.79	10.95	1.84	14.4%
2005	13.83	12.62	1.21	8.7%
2006	13.91	12.35	1.56	11.2%
2007	14.38	12.24	2.14	14.9%
2008	13.38	11.05	2.33	17.4%
2009	12.32	10.86	1.46	11.9%
2010	11.89	11.05	0.84	7.1%
2011	12.10	11.09	1.01	8.3%
2012	13.32	12.33	0.99	7.4%
Average				11.4%

4.3 TOTAL ESTIMATED FUTURE WATER DEMANDS

The estimated future water production needs based on the criteria discussed in this section are shown in Table 4-3 and the range of scenarios is shown graphically in Figure 4-1.

Figure 4-1 - Current and Future Water Demands

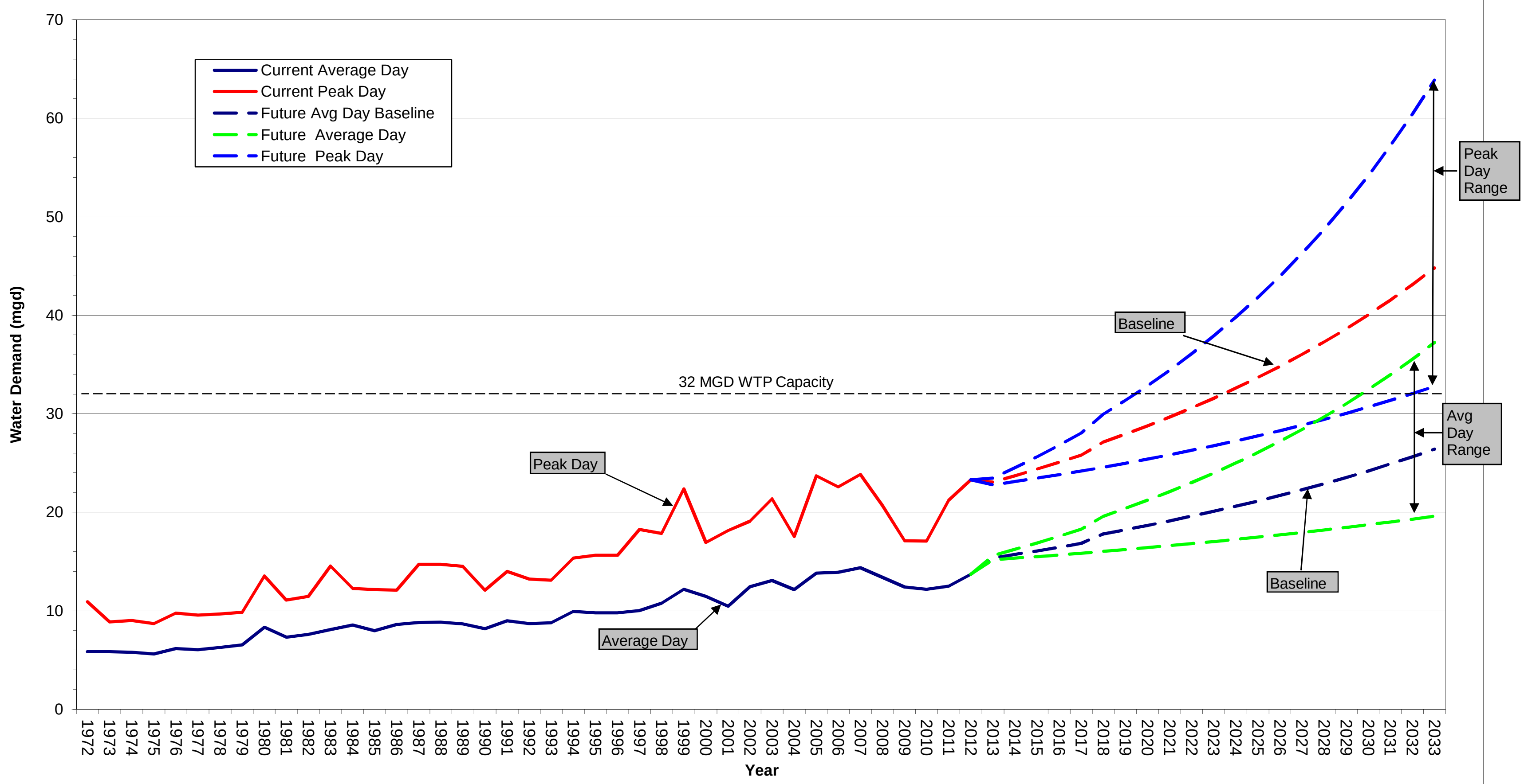


Table 4-3: Estimated Future Water Production

Year	Average Daily Water Production (MGD)	Maximum Daily Water Production (MGD)
2013	15.4	23.1
2014	15.7	23.7
2015	16.1	24.4
2016	16.4	25.1
2017	16.8	25.8
2018	17.8	27.1
2019	18.2	27.9
2020	18.7	28.8
2021	19.1	29.7
2022	19.6	30.6
2023	20.1	31.6
2024	20.6	32.6
2025	21.1	33.7
2026	21.7	34.8
2027	22.3	36.0
2028	22.9	37.3
2029	23.5	38.6
2030	24.2	40.0
2031	24.9	41.5
2032	25.6	43.1
2033	26.4	44.8

The projected water demands and peaking factors, as shown below in Table 4-4, were used for the identification of future system improvements in five year increments.

Table 4-4: Design / Study Future Water Demands

Year	2018	2023	2028	2033
Average Day (MGD)	17.8	20.1	22.9	26.4
Maximum Day (MGD)	27.1	31.6	37.3	44.8
Model Peaking Factor	1.52	1.57	1.63	1.70

In order to distribute projected future water demands effectively, the entire CW&L service area was divided into five sections and past growth rates were analyzed for each area. The five areas are as follows: northwest (NW) all areas north of I-70 and west of Highway 763, northeast (NE) all areas north of I-70 and east of Highway 763, southwest (SW) all areas south of I-70 and west of Stadium Blvd and Providence Rd, southeast (SE) all areas south of I-70 and east of College Ave and Providence Rd, and the central corridor (CC) area bound by I-70 to the north Stadium Blvd to the south and west and College Rd to the east. A weighted average of growth for each area was calculated and this average was used to anticipate future demand growth within that area relative to the system as a whole. All future residential, commercial, and large commercial demands were then distributed to individual nodes throughout their perspective areas based upon the growth areas highlighted on Figure 3-1.

SECTION 5 – PROPOSED SYSTEM IMPROVEMENTS

5.1 SYSTEM IMPROVEMENTS DESIGN CRITERIA

The Missouri Department of Natural Resources – Public Drinking Water Program states in the "*Design Guide for Community Public Water Supplies"* that a minimum pressure of 35 psi shall be maintained at ground level in all potable water distribution mains at all times not including fire flow, except that the department may approve a minimum design pressure of 20 psi in areas served by rural water districts. The design guide states that the normal working pressure in the distribution system should be 60 psi and that all booster-pumping stations shall satisfy peak demand with the largest pump out of service.

As a general rule, pressures in the water distribution system should preferably not exceed 140 psi, as measured at ground level. This is to avoid the rupture or breakage of older water mains, and other parts of system. In addition, very high pressures increase loss of water from the system from leakage. Sudden pressure variance in the water distribution system is to be avoided, since this can result in customer complaints, and if the pressure variance is excessive, it can damage the distribution system.

5.1.1 General Criteria

The system improvements discussed in this section consist mainly of elevated tanks, pumping stations, transmission mains, and ground storage tanks. The following was the general criteria used for each of these improvements.

<u>Storage Tanks</u>

Two types of storage tanks were considered, elevated and ground. Criteria for elevated tanks included volume, overflow elevation and location. Volume was set based on the sum of the average daily demand and fire demand, as discussed in Section 5.1.2. The overflow elevation was chosen to maintain sufficient pressure to nearby customers under a range of tank levels and water demands and also to avoid the installation of altitude valves.

The location of the elevated tank is another factor that determines how much pressure customers have and how much water can be pumped into the tank to keep it nearly full. It is generally best to locate elevated tanks close to customers that are at or near the highest ground elevations in the water distribution system. Elevated storage should not be located too distant from sources of supply, since this can result in high headloss, which can make it difficult to refill the tank during times of high demand.

Criteria for ground storage tanks included volume and location. Volume was again set based on the sum of the average daily demand and fire demand, as discussed in Section 5.1.2. The location of the ground storage tanks were placed at existing or proposed pump stations.

<u>Pump Stations</u>

An important criterion that was used for the pump stations was to be able to pump the peak day flow with the largest pump out of service. Other criteria include suction and discharge pressure and location. Suction pressure at in line pump stations was at least 20 psi and discharge pressure should be kept low enough so that customers in the water distribution system do not experience problems. Pump stations need to be located so that elevated storage can be kept nearly full and so that suction and discharge pressures are at acceptable levels.

Transmission Mains

Criteria for water mains included velocity and headloss. The diameters of water mains were selected so that the maximum velocity did not exceed 8 feet per second during the peak hour water demand. Water transmission mains that supply water tanks were sized to be large enough to maintain volume in the tanks.

5.1.2 Storage Requirements

Ten States Recommended Standards for Water Works recommends that a municipal water system have available storage equivalent to the average daily water demand plus the volume required for fire protection. From the *1999 Water Demand Projection for City of Columbia, Missouri* memorandum, the estimated volume required for fire protection was 2,160,000 (6,000 gpm over 6 hours).

Table 5-1 below shows estimated future average daily water demand along with overall required storage. The average daily water demand (ADD) was discussed in Section 4.

Table 5-1: Demand and Required Storage

Year	Average Daily Demand (MG)	Required Storage = ADD + Fire Demand (MG)
2013	15.4	17.6
2018	17.8	20.0
2023	20.1	22.3
2028	22.9	25.1
2033	26.4	28.6

Table 2-2 shows that the total existing storage is 19.3 MG and the total storage including the near term planned projects is 22.5 MG within the City's system. Table 5-2 below indicates the additional storage that needs to be constructed in the water distribution system in the future.

Table 5-2: Additional Storage Needed

Year	Required Storage (MG)	Existing storage (MG)[1]	Additional Storage Needed (MG) (=Required − Existing)
2013	17.6	19.3	0
2018	20.0	21.3	0
2023	22.3	22.5	0
2028	25.1	22.5	2.6
2033	28.6	22.5	6.1

1. *Existing storage total assumes that the Prathersville EST will be delayed until 2023. See Section 5.3.*

5.2 FIVE YEAR CIP EVALUATION – YEAR 2018 PROPOSED IMPROVEMENTS

The current CW&L Five-Year Capital Improvement Plan (CIP) was provided to Jacobs. This CIP is what CW&L uses to plan and budget improvements to meet water demands. Improvements identified within the CIP that were related to capacity upgrades (i.e., water main upgrades, new distribution or transmission mains, loop closures, storage or pumping) were evaluated with the KYPIPE model. Improvements identified within the CIP that were related to main replacements or other non-capacity related improvements were not evaluated.

5.2.1 KYPIPE Evaluation Results

The improvements noted in the following sub-sections were evaluated using the KYPIPE model. The anticipated year 2018 average day water demand of 17.8 MGD and peak day water demand of 27.1 MGD were input into the model and a 48-hour extended period flow simulation was conducted. Prior to including the improvements from the current CIP, the minimum observed water tower levels were as follows:

- Walnut Tower drains to about 71% full.
- Shepard Tower drains to about 63% full.
- Stephens Station Tower drains to about 74% full.

After including the improvements from the current CIP, the following results were noted:

- Walnut Tower drains to 78% full.
- Shepard Tower drains to about 73% full.
- Stephens Station Tower drains to about 85% full.

5.2.2 Water Main Improvements

Transmission and Distribution Water Main Improvements. The following improvements were included in the Five-Year CIP:

- 16" Main-Hwy 63-West Crossing to Stadium. This included replacement of 16" ductile iron main along Highway 63 from Stadium Boulevard to highway crossing at Shepard Tower.
- 8" Main-Rangeline-Smith to Bus Lp 70. This included upgrading the existing 4" cast iron main to an 8" main.
- Hackberry-6,000' of 12" Main. This included approximately 6,000 feet of 12" main along Hackberry Boulevard from N Clearview Road to E Clearview Drive.
- Lower Bear Creek Main Relocation. This included relocation of water main in conjunction with Lower Bear Creek sewer project.
- Stadium Blvd TDD Improvements. This included relocation of water mains located along Stadium Boulevard south of Interstate 70 in conjunction with roadway and storm water improvements.
- Thilly & Westmount 6" Main. This included relocation of 6" mains on Westmount Avenue and Thilly Avenue from backyards.
- Vandiver/Sylvan Storm Drainage-Main Relocation. This included relocation of approximately 450 feet of 12" ductile iron main in conjunction with storm water improvements.
- West I-70 Crossings. This included replacement of water main under Interstate 70 along Rangeline Street.
- 16" Transmission Main to Prathersville. This included a new 16" transmission main from the West Ash Pump Station north to the Prathersville Tank.
- Brown Station Rd-Stark Av-to Mojave Ct. This included replacement of water mains along Brown Station Road from Starke Avenue north to Mojave Court in conjunction with roadway improvements.
- Bus Loop-Phase 5-3,800' Main Replace. This included replacement of approximately 3,800' of main along Business Loop 70 from Providence Road east to College Avenue.
- Bus Loop-Phase 6A-3,200' Main Replace. This included replacement of approximately 3,200' of main along Business Loop 70 from College Avenue east to Old Highway 63.
- DT: 6th St: Broadway to Elm Main Upgrade. This included upgrading of approximately 1,150' of water main on Sixth Street from Broadway to Elm Street.

- DT: Paquin Av: Hitt to College Main Upgrade. This included upgrading of approximately 1,000’ of main on Paquin Ave from Hitt Street to College Avenue.
- Garth Main Replacement-2,800 FT. This included upgrading of approximately 2,800’ of 6” main to 12” main along Garth Avenue from Texas Avenue to Thurman Street.
- Hinkson Main-Williams to Old Hwy 63. This included upgrading approximately 1,400’ of 12” main along Hinkson Avenue from Williams Street to Old Highway 63.
- Old Hwy 63 N & McAlester Loop Closure. This included approximately 1,500’ of 8” water main along Old Highway 63 from McAlester Street to Ammonette Street to close the loop and improve fire flows.
- Waco Rd-Brown Station to Oakland. This included water main improvements along Waco Road from Oakland Gravel Road to Brown Station Road in conjunction with roadway improvements.

5.2.3 Storage Improvements

The CIP identifies ASR #3 to begin construction in 2018. Per section 2.2.2, Jacobs recommends the City conduct a study on the effects of introducing chloraminated water into the ASRs sometime before 2018, when ASR #3 is planned for construction. This study will allow the City to better define the scope of what is needed for construction of ASR #3, in addition to any possible retrofits to the existing ASRs that may be required for the introduction of chloraminated water into the ASRs.

5.2.4 Pumping Improvements

There are no pumping improvements identified in the Five-Year CIP.

5.3 YEAR 2023 PROPOSED IMPROVEMENTS

5.3.1 KYPIPE Evaluation Results

The improvements noted in the following sub-sections were evaluated using the KYPIPE model. The anticipated year 2023 average day water demand of 20.1 MGD and peak day water demand of 31.6 MGD were input into the model and a 48-hour extended period flow simulation was conducted. Prior to including the proposed improvements, the main issues identified were as follows:

- Stephens Station Tower drains to about 25% full by end of simulation.
- Prathersville Standpipe drops over 40 feet, surrounding pressures also drop.

After including the proposed improvements, the following results were noted:

- New Prathersville Tank stays nearly full throughout entire simulation, maintaining steady pressures in nearby system.
- Stephens station cycles normally never dropping to less than about 75% full.

5.3.2 Water Main Improvements

The following transmission main improvements were included in the 2023 Model Scenario:

- 16-Inch Transmission Main from new West Ash Pump Station to new Prathersville Elevated Tank. This includes a new 16-inch main for transmission purposes starting from the proposed new pump station at the existing West Ash Pump Station, and feeding directly to the new proposed elevated tower at the Prathersville site. The alignment used for the purposes of this study is shown in Figure 5-3.

- 24-Inch Transmission Main to Stephens Station elevated tank. This includes approximately 28,000 feet of 24-inch main for transmission purposes to feed the existing Stephens Station elevated tank. This 24-inch main would connect to the existing main along Clark Lane, which is fed from the discharge of the Hillsdale Pump Station. The alignment used for the purposes of this study is shown in Figure 5-4.

5.3.3 Storage Improvements

The following storage improvements were included in the 2023 Model Scenario:

- Elevated storage to replace the existing Prathersville Standpipe. This includes a new 2 MG elevated storage tank matching the overflow elevation of the Walnut and Shepard elevated tanks. The proposed elevated storage tank would be about 120 ft to the high water level and would be a fluted column style tank, similar to the Shepard tank. This new tank would be located at or near the original location of the Prathersville Standpipe, as shown in Figure 5-1.

5.3.4 Pumping Improvements

The following pumping improvements were included in the 2023 Model Scenario:

- Additional Pump Station at the site of the existing West Ash Pump Station. This included a pump station with 3 pumps and a total capacity of approximately 5,000 gpm with 2 pumps in service and 1 pump for back up. The suction side of this new pump would connect directly to the finished water supplied by either the existing McBaine WTP, or the proposed new Water Treatment Plant recommended by this study, and would not connect to the distribution system. The discharge of the pump will feed directly into the proposed 16-inch transmission main discussed above and would operate based on the level of water in the new proposed Prathersville elevated storage tank. The location is shown on Figure 5-2.

5.3.5 Other Improvements

There are no other improvements identified for 2023.

5.4 YEAR 2028 PROPOSED IMPROVEMENTS

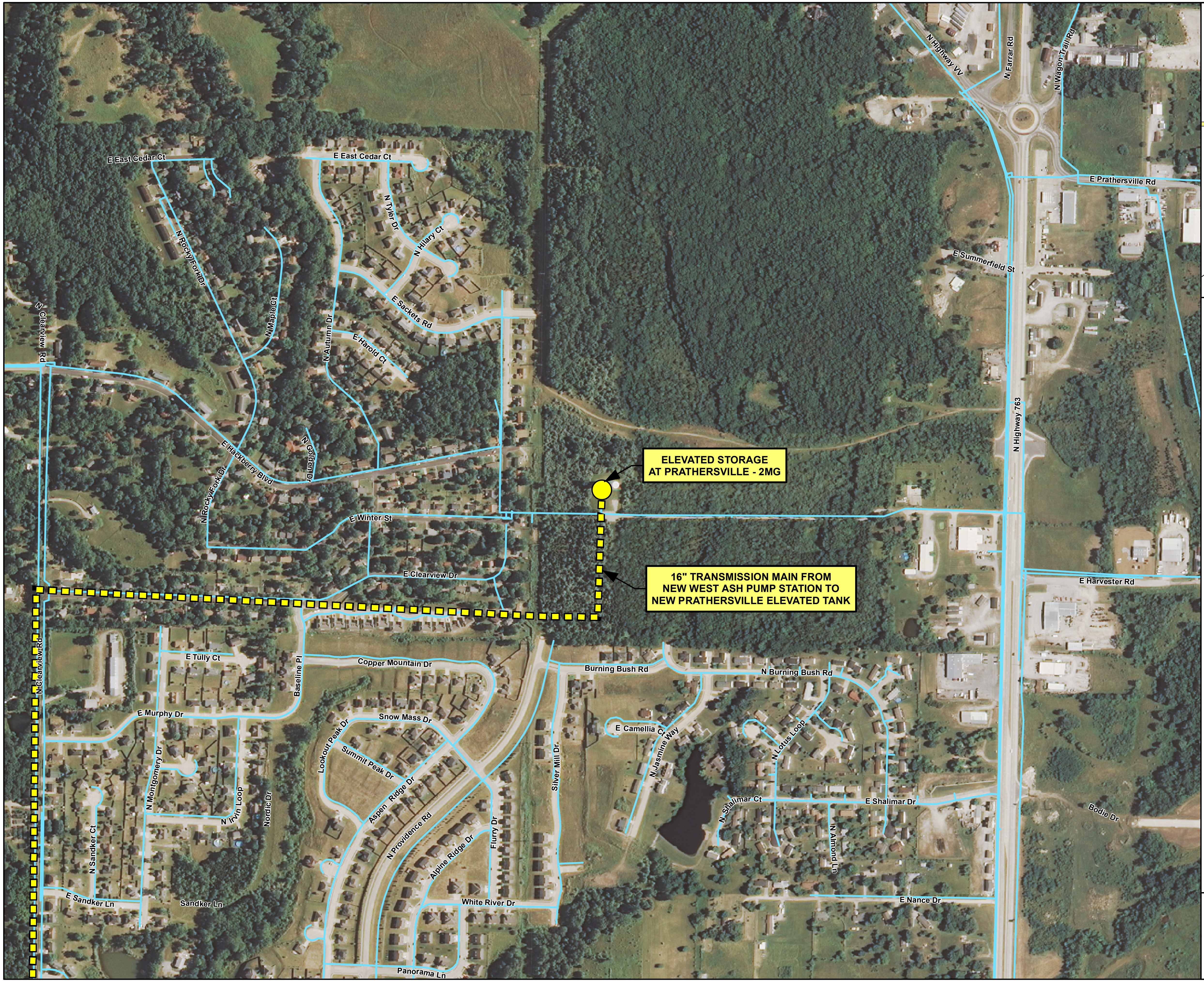
5.4.1 KYPIPE Evaluation Results

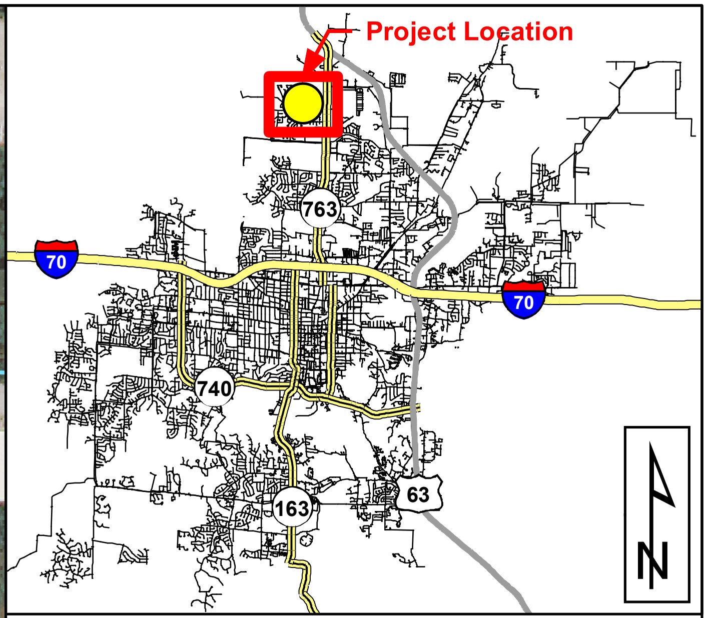
The improvements noted in the following sub-sections were evaluated using the KYPIPE model. The anticipated year 2028 average day water demand of 22.9 MGD and peak day water demand of 37.3 MGD were input into the model and a 48-hour extended period flow simulation was conducted. Prior to including the proposed improvements, the main issues identified were as follows:

- There is insufficient treatment capacity at the McBaine WTP to meet the peak anticipated water demand of 37.3 MGD.
- Walnut elevated tank empties about 17 hours into the simulation.
- Stephens Station elevated tank empties about 17 hours into the simulation and never completely recovers.
- Shepard elevated tank empties about 13 hours into the simulation.
- Hillsdale ground storage tank is only about half full by end of simulation.
- An additional 2.6 MG of storage is required.

After including the proposed improvements, the following results were noted:

- Walnut elevated storage tank remains more than 36% full throughout entire simulation and refills during off peak demand times.





Legend

- Existing Structure
- Existing Water Lines
- Proposed Storage Tank
- Adjacent Project

WATER & LIGHT

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Figure 5-1 - Elevated Storage at Prathersville - 2MG

SCALE:	REV:	DATE:
1 in = 500 feet	0	January 7, 2014

City of Columbia, MO

Figure 5-2 - New Pump Station at West Ash Site

SCALE:	REV:	DATE:
1 in = 200 feet	0	January 7, 2014

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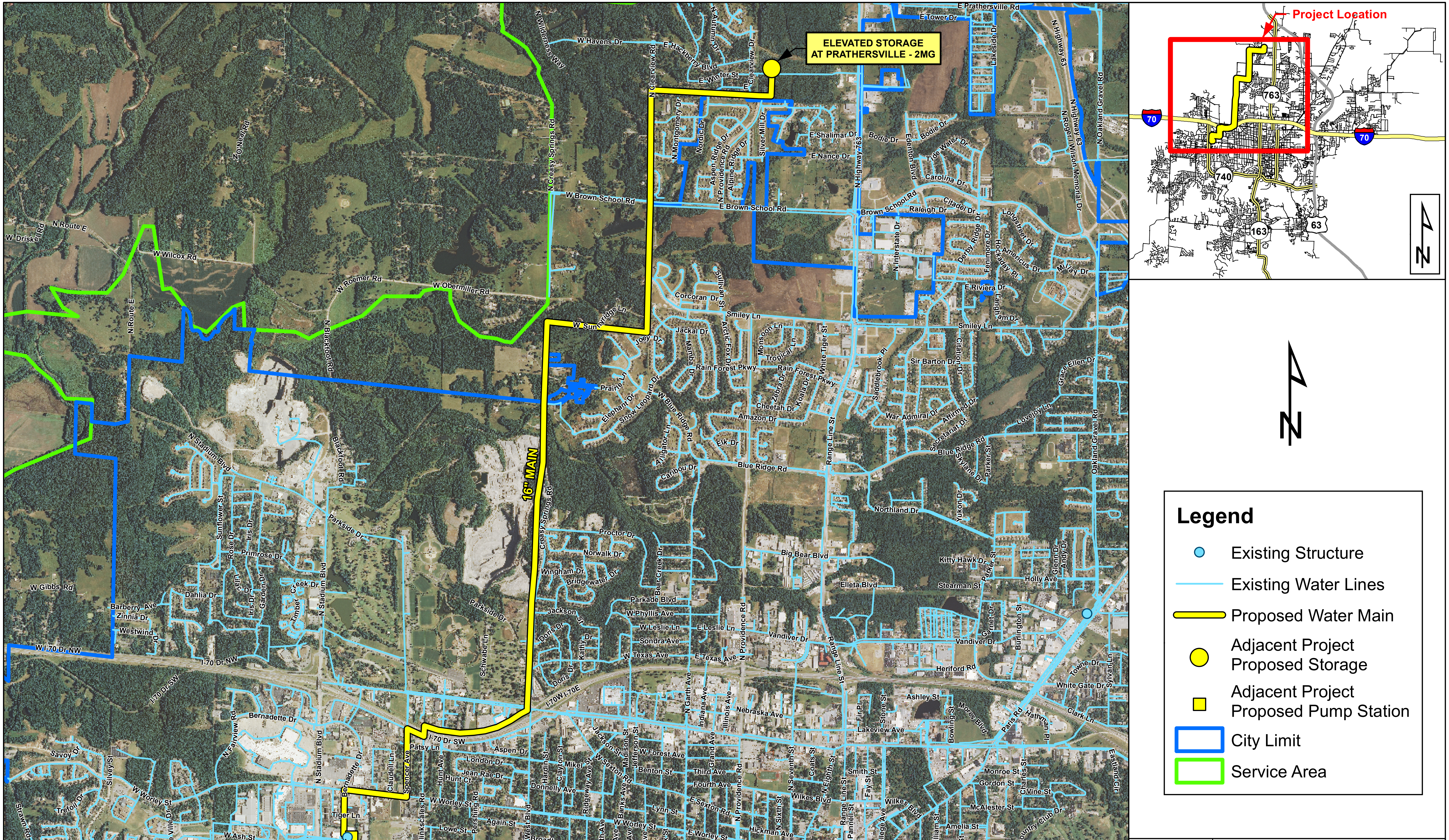
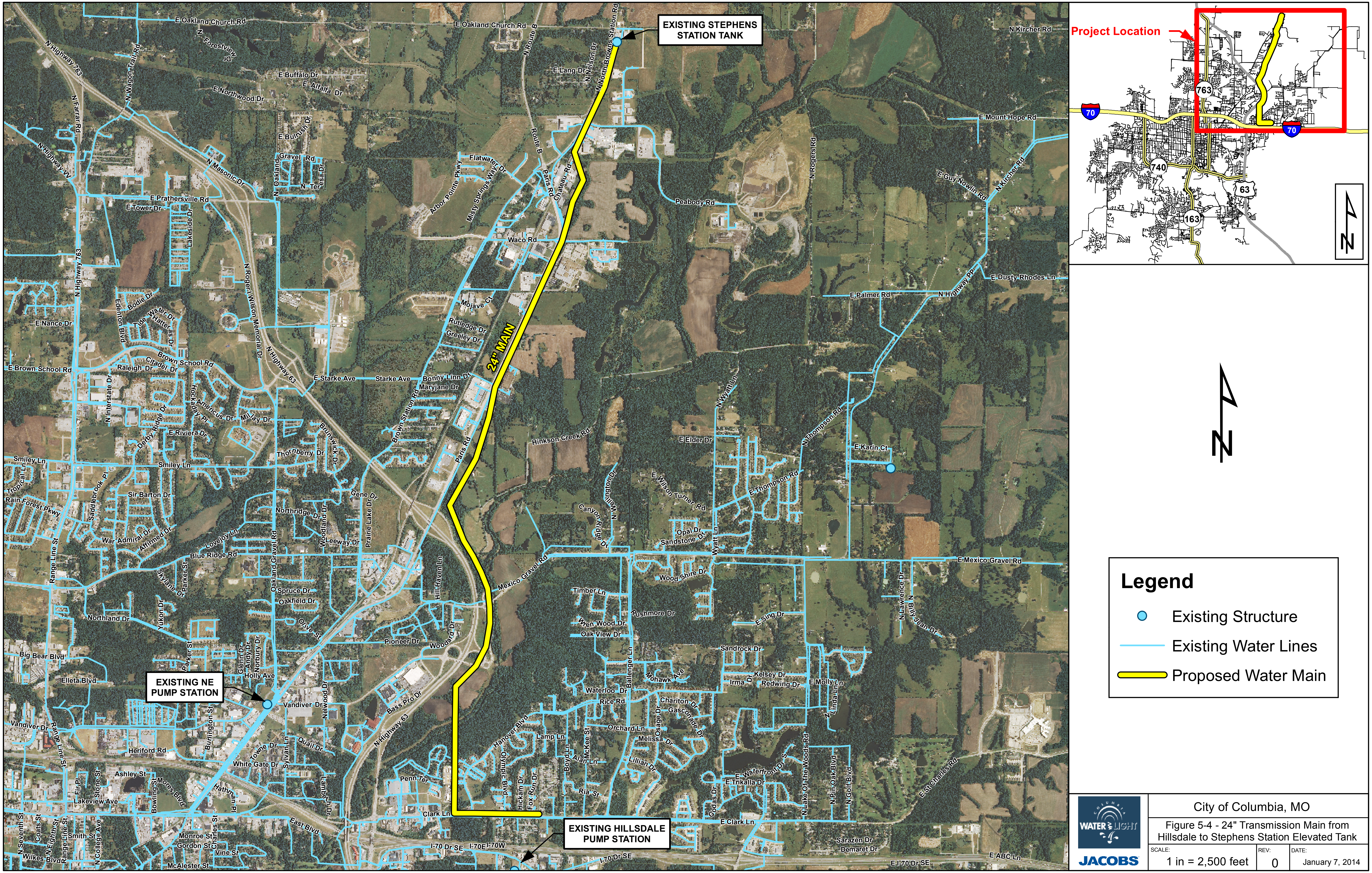


City of Columbia, MO

Figure 5-3 - 16" Transmission Main from New West Ash Pump Station to New Prathersville Elevated Tank

SCALE:	REV:	DATE:
1 in = 2,200 feet	0	January 7, 2014



City of Columbia, MO

Figure 5-4 - 24" Transmission Main from Hillsdale to Stephens Station Elevated Tank

SCALE:	REV:	DATE:
1 in = 2,500 feet	0	January 7, 2014

WATER & LIGHT

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- Stephens Station elevated tank remains more than 50% full through entire simulation.
- Shepard elevated tank cycles between full and approximately 70% full.
- Hillsdale ground storage tank stays nearly full throughout entire simulation.
- The required 2.6 MG additional storage is provided by the proposed ground storage recommended below.

5.4.2 Water Main Improvements

The following transmission main improvements were included in the 2028 Model Scenario:

- 24-Inch Transmission Main from proposed new Southeast Pump Station. This includes approximately 8,600 feet of 24-inch main from the proposed new Southeast Pump Station near Gans Road and running north to Nifong Blvd, where it will connect to the existing 24-inch main. The alignment used for purposes of this study is shown in Figure 5-6.

5.4.3 Storage Improvements

The following storage improvements were included in the 2028 Model Scenario:

- Additional Ground Storage at Hillsdale Pump Station. This includes an additional 2.75 MG ground storage at the Hillsdale Pump Station in addition to the existing 1.5 MG ground storage that was described in Section 2.3.2. The original design plans for the Hillsdale Pump Station had provisions to include room for up to 5 MG ground storage at the Hillsdale site. For purposes of estimating costs, we assumed constructing a 2.75 MG pre-stressed concrete ground storage tank. The approximate location used for the purposes of this study is shown in Figure 5-7.

The additional 2.6 MG of storage required in this scenario and additional 3.5 MG required in the next scenario could be split between the 2 proposed pump station improvements as appropriate depending upon future development, needs and site availability.

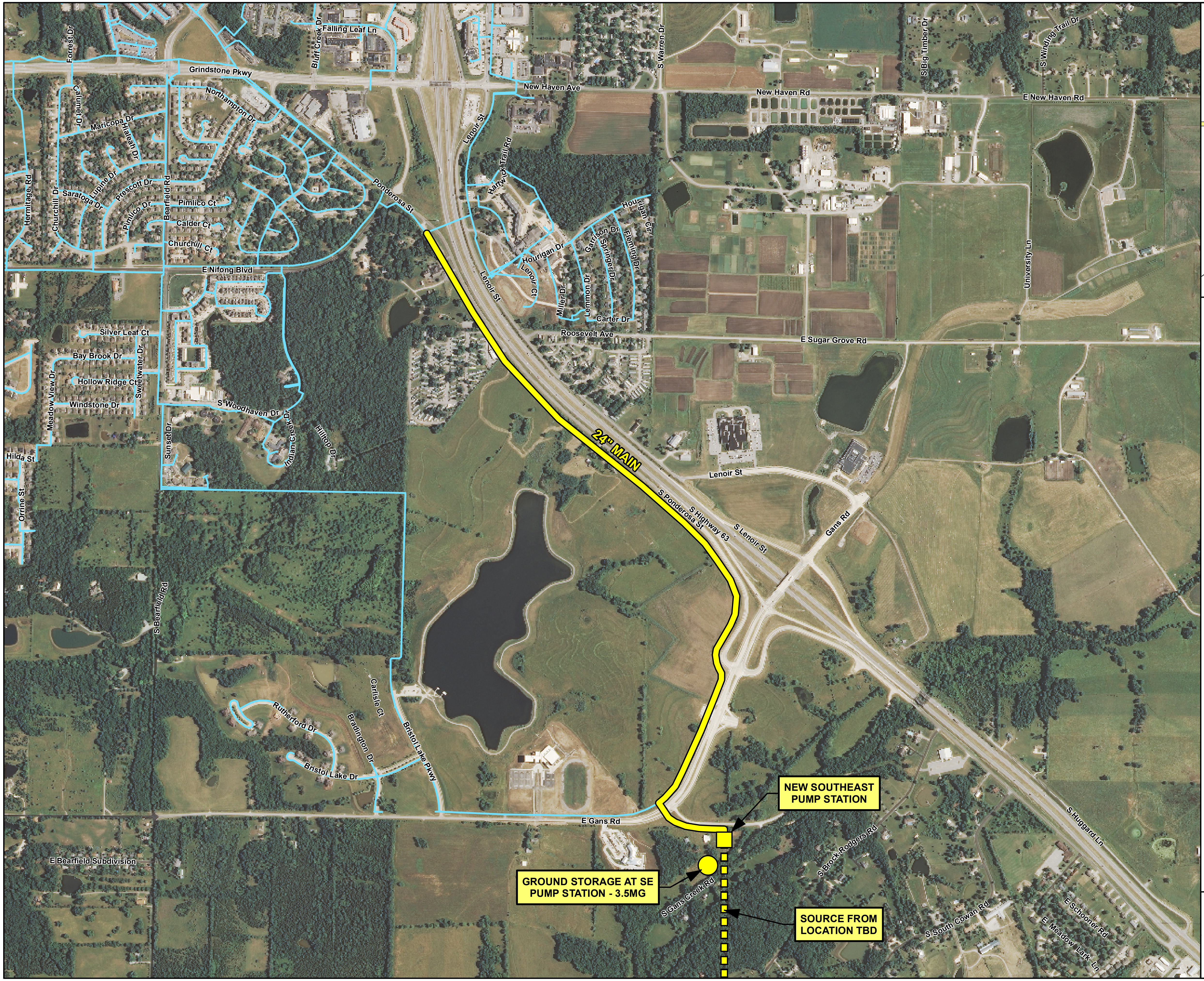
5.4.4 Pumping Improvements

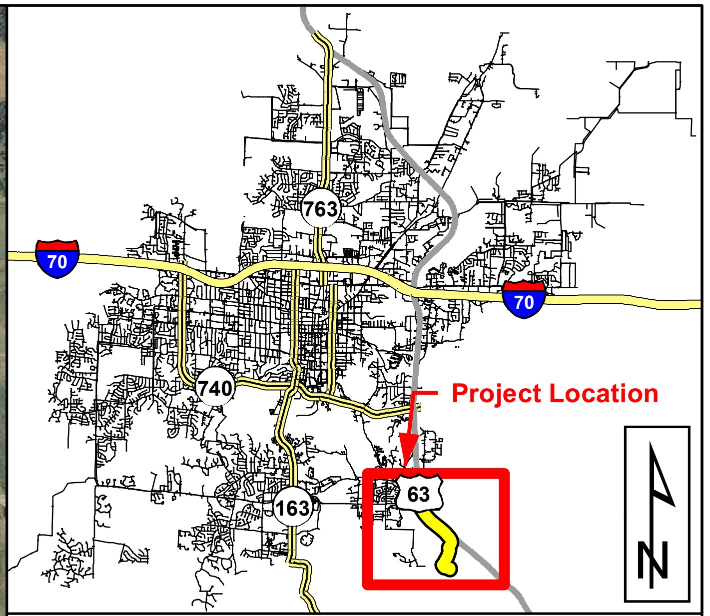
There are no pumping improvements identified for 2028.

5.4.5 Other Improvements

There is insufficient treatment capacity at the McBaine WTP to meet the peak anticipated water demand of 37.3 MGD. Additional peak day demands of about 6 MGD can be met through the use of the City's Aquifer Storage and Recovery facilities (two existing facilities and one anticipated each with about 2 MGD capacity). It is anticipated that additional treatment capacity will be required sometime between 2023 and 2028, dependent on the rate of growth over the next 10 years. This should be monitored closely in the coming years.

In addition, future transmission of the treated water to the City's distribution system will be required. Since the majority of the growth is in the south, southeast and northeast areas of the City's service area, directing this treated water to that area could benefit the City by providing redundancy through separate transmission feeds as well as relieving some of the demand on existing transmissions mains from McBaine WTP.





Legend

- Existing Structure
- Existing Water Lines
- Proposed Water Main
- Adjacent Project Proposed Storage
- Adjacent Project Proposed Pump Station
- Adjacent Project

WATER & LIGHT

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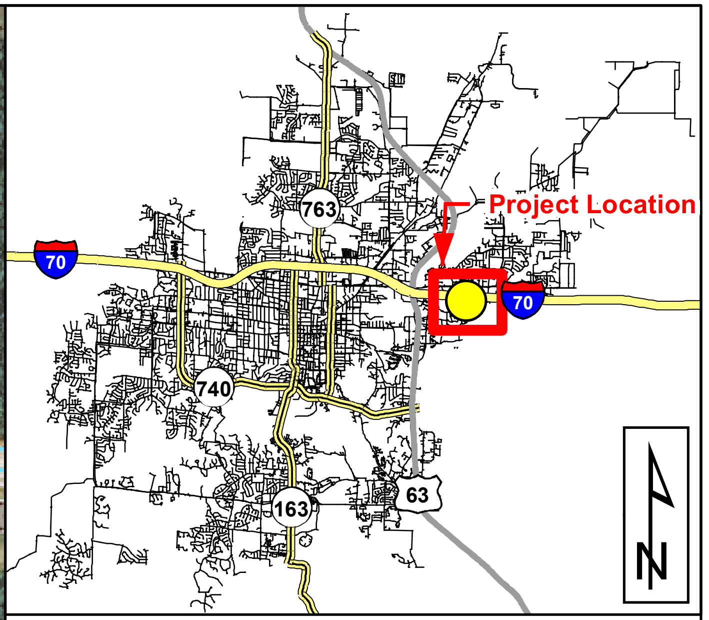
City of Columbia, MO		
Figure 5-6 - 24" Transmission Main from Southeast Pump Station		
SCALE: 1 in = 1,000 feet	REV: 0	DATE: January 7, 2014



N

Legend

- Existing Structure
- Existing Water Lines
- Proposed Storage Tank
- Adjacent Project Proposed Pump Station

WATER & LIGHT

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City of Columbia, MO		
Figure 5-7 - Ground Storage at Hillsdale - 2.75MG		
SCALE: 1 in = 500 feet	REV: 0	DATE: January 7, 2014

Therefore it is recommended that the City implement the following steps to plan for future treatment capacity (assuming the need is by 2023):

- Complete a Water Supply Source Study to evaluate the potential water supply sources needed to meet future demands. In addition to the evaluating supply sources, the Study should also evaluate potential sites for treatment. This study could take 8-12 months to complete, but should be started immediately.
- Select and acquire the future property between 2015 and 2017.
- Preliminary design for the additional treatment and transmission main to the distribution system in 2018. It is estimated that approximately 6 to 8 months will be required.
- Design, bidding and award of a construction contract for the additional treatment capacity and transmission main from 2019 to 2021. It is estimated that approximately 1.5 years will be required.
- Complete the construction of the additional treatment capacity and transmission main from 2021 to 2023. It is estimated that approximately 2 years will be required.

The costs associated with these improvements are difficult to estimate until the location of the additional treatment is completed.

5.5 YEAR 2033 PROPOSED IMPROVEMENTS

5.5.1 KYPIPE Evaluation Results

The improvements noted in the following sub-sections were evaluated using the KYPIPE model. The anticipated year 2033 average day water demand of 26.4 MGD and peak day water demand of 44.8 MGD were input into the model and a 48-hour extended period flow simulation was conducted. Prior to including the proposed improvements, the main issues identified were as follows:

- An additional 3.5 MG of storage is required.
- Stephens Station elevated tank empties about 21 hours into the simulation and never completely recovers.
- Walnut elevated tower empties about 45 hours into the simulation.

After including the proposed improvements, the following results were noted:

- The required storage is provided by the proposed Southeast ground storage tank and pump station.
- Stephens station cycles normally never dropping to less than about 70% full.
- Walnut elevated tank cycles between full and approximately 70% full.

5.5.2 Water Main Improvements

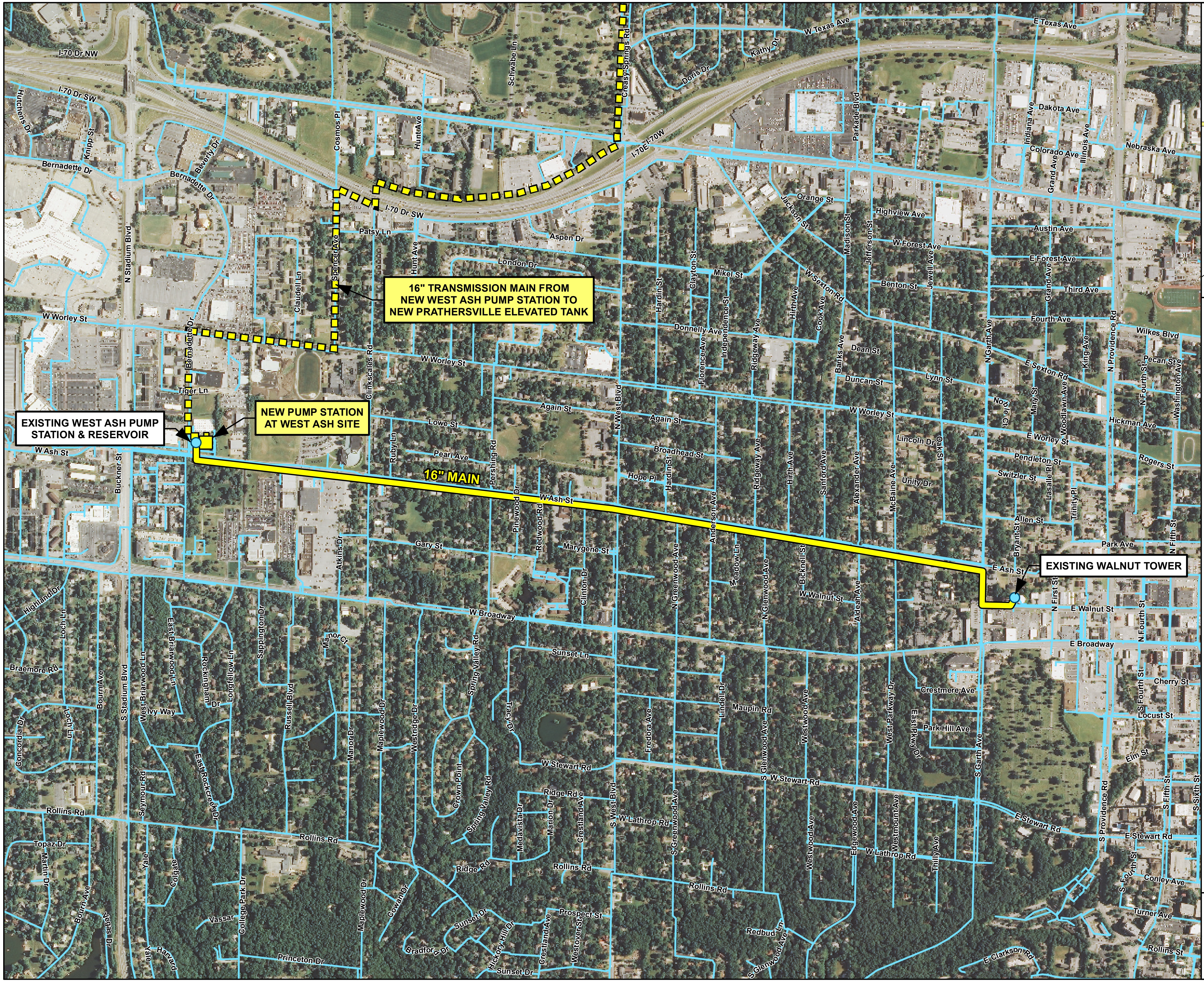
The following transmission main improvements were included in the 2033 Model Scenario:

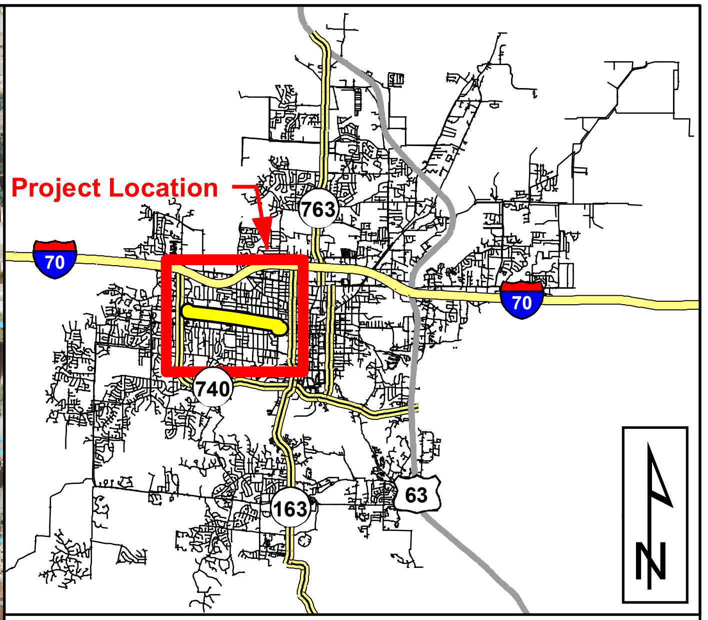
- 16-Inch Transmission Main to Walnut Elevated Tank. This includes a 16-inch main from the West Ash Pump Station and heading east to the existing Walnut elevated tank. The alignment shown in Figure 5-8 could be one possible route.

5.5.3 Storage Improvements

The following storage improvements were included in the 2033 Model Scenario:

- Ground storage at proposed Southeast Pump Station. This includes a new ground storage tank of approximately 3.5 MG capacity at the site of the proposed





Legend

- Existing Structure
- Existing Water Lines
- Proposed Water Main
- Adjacent Project Proposed Pump Station
- Adjacent Project

City of Columbia, MO

Figure 5-8 - 16" Transmission Main from West Ash Pump Station to Walnut Tower

SCALE:	REV:	DATE:
1 in = 1,000 feet	0	January 7, 2014

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new Southeast Pump Station near Gans Road (discussed in the following section). If budget allows, additional ground storage beyond what is needed for the 2033 scenario could be added at this time. For purposes of estimating costs, we assumed constructing a 3.5 MG pre-stressed concrete ground storage tank. The conceptual location used for the purposes of this study is shown in Figure 5-10.

The additional 3.5 MG of storage required in this scenario and additional 2.6 MG required in the previous scenario could be split between the 2 proposed pump station improvements as appropriate depending upon future development, needs and site availability.

5.5.4 Pumping Improvements

The following pumping improvements were included in the 2033 Model Scenario:

- Southeast (SE) Pump Station. This includes a station with 3 pumps and a capacity of approximately 5,000 gpm (with 2 pumps in service and 1 pump for back up). The suction side of this new pump station would connect directly to the proposed 3.5 MG ground storage tank discussed in Section 5.5.3. Finished water for the pump station and ground storage tank would be supplied by either the existing McBaine WTP, or the proposed new Water Treatment Plant recommended by this study. The SE pump station would feed into the proposed 24-inch main heading north to Nifong Boulevard discussed in Section 5.4.2. The conceptual location used for the purposes of this study is shown in Figure 5-5.

- Additional Pump Station at Hillsdale. This includes a 2nd pump station identical to the existing Hillsdale Pump Station and would utilize the existing suction and discharge lines. The original design plans for the Hillsdale Pump Station had provisions for a future identical station. Although it is dependent on future development, this 2nd pump station is anticipated to be necessary by 2033 to help feed the proposed 24-inch transmission main heading north to the Stephens Station elevated tank. The approximate location used for the purposes of this study is shown in Figure 5-9.

5.5.5 Other Improvements

There are no other improvements identified for 2033.

5.6 DISCOVERY RIDGE GROWTH

A residential development was evaluated within the Discovery Ridge corridor, as requested by CW&L. The specific area is shown in Figure 5-11. It is located northwest of Discovery Parkway and south of Highway 63. This general area is served by two 12" water mains that extend from the 24" transmission main along Nifong Blvd. The proposed development would be served by completing the loop with a new 12" water main extended from the existing 12" water main along Ponderosa St. and connecting to the existing 12" water main along Discovery Parkway/Gans Road.

The proposed development was evaluated based on the following:

a. Scenarios including 100, 200 and 300 additional residential customers were evaluated.
b. 2018 peak day water demands were used.

WATER & LIGHT

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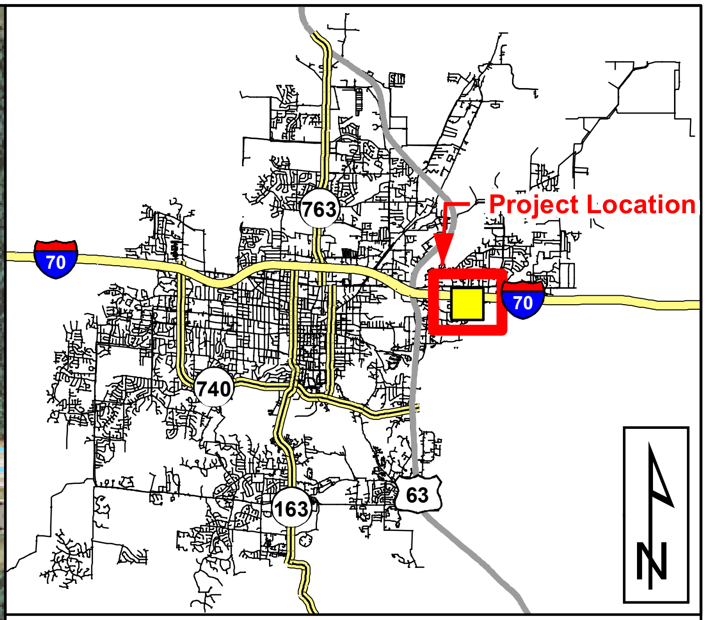
City of Columbia, MO

Figure 5-5 - New Southeast Pump Station

SCALE:	REV:	DATE:
1 in = 500 feet	0	January 7, 2014



Legend

- Existing Structure
- Existing Water Lines
- Proposed Pump Station
- Adjacent Project Proposed Storage

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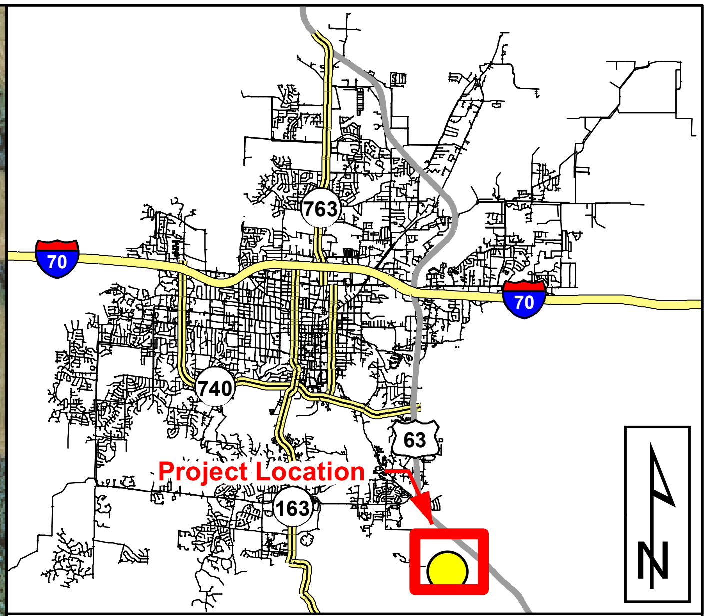
City of Columbia, MO

Figure 5-9 - New Pump Station at Hillsdale Site

SCALE:	REV:	DATE:
1 in = 500 feet	0	January 7, 2014



Legend

- Existing Structure
- Existing Water Lines
- Proposed Storage Tank
- Adjacent Project Proposed Pump Station
- Adjacent Project

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Figure 5-10 - Ground Storage at SE Pump Station - 3.5MG

SCALE:	REV:	DATE:
1 in = 500 feet	0	January 7, 2014

City of Columbia, MO

Figure 5-11 - Discovery Ridge Growth

SCALE:	REV:	DATE:
1 in = 1,000 feet	0	January 12, 2015

c. High point ground elevation for the development was 813 at node J-1683, which was used as the control node.
d. Fire flow of 2,000 GPM for four hours was added to the demand at J-1683.
e. 185 GPD/Customer was used as the basis to develop demands.
f. 1.5 peaking factor was used to develop peak day demands.
g. Residential diurnal curve was used to simulate peak hourly flows with a maximum diurnal factor of 2.6.

The results are included in Appendix 2 and summarized below:

a. Very similar results were observed for each of the three customer scenarios. Pressures at J-1683 ranged from 41psi to 51 psi throughout the 48 hour simulation.
b. Demands ranged from 5 to 50 GPM within the development for the 100 customer scenario.
c. Demands ranged from 10 to 100 GPM within the development for the 200 customer scenario.
d. Demands ranged from 12 to 150 GPM within the development for the 300 customer scenario.
e. The hydraulic grade in this area is directly related to the level in the Shepherd's Tower.
f. When the 2,000 GPM fire flow was added to the 300 residential customer scenario, the residual pressure at J-1683 dropped to 30 psi.
g. Completing the 12" water main loop through the proposed development will adequately support a development of 300 residential equivalent customers. The controlling factor to maintain service to this area of the distribution system will be to maintain an adequate water level within Shepherd's Tower.

The 300 residential customer scenario was modeled within the 2023 peak day demands. The results are included in Appendix 2 and summarized below:

a. Pressures at J-1683 ranged from 39 psi to 51 psi throughout the 48 hour simulation.
b. Under 2023 demands, levels in the Shepherd's Tower dropped below 50% capacity.
c. When the 2,000 GPM fire flow was added to the 300 residential customer scenario the residual pressure at J-1683 dropped to 0 psi as the level in Shepherd's Tower could not be maintained.
d. When a 1,000 GPM fire flow was added to the 300 residential customer scenario the residual pressure at J-1683 dropped to 25 psi, as the level in Shepherd's Tower was better maintained.
e. Additional elevated storage or pumping capacity will need to be provided to support this area depending on the level of fire protection needed.

Jacobs recommends that CW&L continue to monitor demand growth in this area. If the rate of growth exceeds expectations, CW&L may want to consider constructing the proposed Southeast Pump Station and 3.5 MG storage tank by Year 2023, instead of Year 2033, as mentioned previously in this section. The proposed Southeast Pump Station and Storage Tank were modeled in this location because CW&L had indicated a large amount of growth in this area. Depending upon the location of a new or expanded water treatment plant facility, this may not be the most suitable location for a new pump station and storage tank. A separate study should be completed to evaluate a new pump station and storage tank compared to expansion of the existing South Pump Station, based on the long term plan for the Water Treatment Plant.

SECTION 6 – COST ESTIMATES

This section presents a summary of the project costs associated with the System Improvements discussed in Section 5.

6.1 COST CRITERIA

As discussed in Section 5, the majority of the system improvements consist of elevated tanks, pumping stations, transmission mains and ground storage tanks. The cost estimates were prepared in 2013 and are based on 2013 dollars, with the following notes and clarifications:

- Inflation – 5% per year for escalation of costs
- An allowance for engineering design and engineering during construction
- 15% contingency for construction costs
- Easement costs were estimated at $3,000 per residential easement.

The following is a summary of the assumptions and criteria used to estimate the costs for these facilities:

Storage Tanks

The construction costs for the elevated tanks were broken out into two parts, including site work and the tank. The site work includes items such as yard piping, valves, grading, earthwork, site restoration, fencing, and access. These costs were estimated from recent construction bids and projects. The tank costs includes costs for the tank, internal piping, foundation, connections, access doors, painting, electrical lighting, and other tank equipment. These tank costs were received from tank manufacturers and recent project bids. It should be noted that these costs were estimated based on 2013 costs for materials such as steel and concrete.

The construction costs for ground storage tanks were also broken out into two parts, including site work and the tank. The site work includes the same items, which were estimated from recent construction bids and projects. The ground storage tank costs were based on pre-stressed concrete tanks and budgetary estimates from past projects were used.

Pump Stations

The construction costs for the pump stations were broken out into two parts, including site work and the pump station. The site work includes items such as pump station and generator foundation, yard piping, valves, grading, earthwork, site restoration, fencing, and access. These costs were estimated from recent construction bids and projects. The pump station costs were based on package type stations and include costs for the pump building, pumps, interior piping, interior valves, flow meter, electrical, controls, variable frequency drives, HVAC, lifting equipment, and other pumping equipment. These pumping station costs were received from manufacturers and recent project bids.

Transmission Mains

The construction costs for the transmission mains include the piping installed, isolation valves, air release valves and structures, site restoration, and flushing assemblies (if required). These costs were estimated from recent construction bids and projects.

6.2 ESTIMATES

Costs for each of the improvements described in Section 5 were estimated per the criteria described above. The cost estimates for each proposed improvement are included on the following pages. Table 7-1, in Section 7, provides a summary of the costs. These costs have been divided into pump stations, storage, other improvements, and water mains.

Cost Estimates
Year 2023

New Pump Station at West Ash Site

Item No.	Description	Units	Quantity	Unit Price	Extension
	Mobilization, Bonds, Insurance (3% of construction)	LS	1	$44,000.00	$ 44,000.00
	Booster Pump Station				
	7.2 MGD Booster Pump Station (Turnkey)	LS	1	$1,100,000.00	$ 1,100,000.00
	Telemetry/Control System/Electrical	LS	1	$120,000.00	$ 120,000.00
	Package Generator	LS	1	$150,000.00	$ 150,000.00
	Water Mains				
	16" DIP Water Line (open excavation)	LF	200	$120.00	$ 24,000.00
	Tie-in for 16"	EA	1	$8,400.00	$ 8,400.00
	16" Fittings (MJ) [quantity estimated]	EA	10	$1,500.00	$ 15,000.00
	Sitework				
	Earthwork (Sitework related to Booster Pump Station)	CY	400	$45.00	$ 18,000.00
	Concrete Pavement	SY	200	$65.00	$ 13,000.00
	Granular Backfill	CY	200	$35.00	$ 7,000.00
	Site Restoration - Seeding	LS	1	$3,000.00	$ 3,000.00

Construction:			$1,502,400.00
Inflation (%/yrs):	5%	10	$ 2,447,251.29
Contingency (%):		15%	$367,087.69
Engineering Design (%):		8%	$195,780.10
Engineering Construction (%):		4%	$ 97,890.05
Land Acq. / Easements (0 ea. @ $3,000)			$ -
Geotechnical			$ 5,000.00
Surveying			$ 10,000.00
Total Project Cost (Year 2023):			$ 3,123,009.13

TOTAL PROJECT COST (YEAR 2023):	**$3,124,000.00**

3/17/2015

Elevated Storage at Prathersville - 2 MG

Item No.	Description	Units	Quantity	Unit Price	Extension
	Mobilization, Bonds, Insurance (3% of construction)	LS	1	$109,000.00	$ 109,000.00
	Elevated Tank				
	2.0 MG Fluted Column Elevated Storage Tank	LS	1	$3,200,000.00	$ 3,200,000.00
	Telemetry/Control System/Electrical	LS	1	$150,000.00	$ 150,000.00
	Lighting	LS	1	$80,000.00	$ 80,000.00
	Sitework				
	Fencing (~ 1 Acre Site)	LF	1000	$32.00	$ 32,000.00
	Vehicle Slide Gate & Man Gate	LS	1	$4,100.00	$ 4,100.00
	Valve vault, valving, & yard piping	LS	1	$150,000.00	$ 150,000.00
	Gravel Access Road (100 ft x 20 ft)	SF	2000	$5.00	$ 10,000.00
	Site Restoration - Seeding	LS	1	$5,000.00	$ 5,000.00

Construction:			$3,740,100.00
Inflation (%/yrs):	5%	10	$ 6,092,228.79
Contingency (%):		15%	$ 913,834.32
Engineering Design (%):		7%	$ 426,456.02
Engineering Construction (%):		3.5%	$ 213,228.01
Land Acquisition (1 ea. @ $200,000)			$ 200,000.00
Geotechnical			$ 10,000.00
Surveying			$ 10,000.00
Total Project Cost (Year 2023):			$ 7,865,747.14

TOTAL PROJECT COST (YEAR 2023):	**$7,866,000.00**

16" Transmission Main from New West Ash Pump Station
to New Prathersville Elevated Tank

Item No.	Description	Units	Quantity	Unit Price	Extension
	Mobilization, Bonds, Insurance (3% of construction)	LS	1	$147,000.00	$ 147,000.00
	Water Mains				
	16" DIP Water Line (open excavation)	LF	28700	$120.00	$ 3,444,000.00
	Tie-in for 16"	EA	2	$8,400.00	$ 16,800.00
	Jack & Bore 16-inch (30" Casing w/ 16" Carrier Pipe)	LF	800	$300.00	$ 240,000.00
	16" DIP (RJ) Water Line thru Jack & Bore locations	LF	800	$150.00	$ 120,000.00
	Jacking/Bore Pit Excavation	EA	1	$15,000.00	$ 15,000.00
	Dewatering	LS	1	$25,000.00	$ 25,000.00
	ARVs (every 4,000 ft)	EA	8	$3,500.00	$ 28,000.00
	Pre-Cast Concrete Structures for ARVs	EA	8	$4,000.00	$ 32,000.00
	Flushout Assemblies	EA	8	$5,000.00	$ 40,000.00
	16" Gate Valve (every 4,000 ft plus 2 on each end)	EA	12	$10,500.00	$ 126,000.00
	16" Fittings (MJ) [quantity estimated]	EA	20	$1,500.00	$ 30,000.00
	Rock Excavation - open trench (10%)	CY	2700	$250.00	$ 675,000.00
	Rock Excavation - Jack & Bore 16-inch (20%)	LF	160	$540.00	$ 86,400.00
	Site Restoration - Seeding	LS	1	$20,000.00	$ 20,000.00

Construction:			$5,045,200.00
Inflation (%/yrs):	5%	10	$8,218,099.17
Contingency (%):		15%	$1,232,714.88
Engineering Design (%):		7%	$575,266.94
Engineering Construction (%):		3.5%	$287,633.47
Land Acq. / Easements (0 ea. @ $3,000)			$ -
Geotechnical			$ 20,000.00
Surveying			$ 75,000.00
Total Project Cost (Year 2023):			$10,408,714.46

TOTAL PROJECT COST (YEAR 2023):	**$10,409,000.00**

24" Transmission Main from Hillsdale
to Stephens Station Elevated Tank

Item No.	Description	Units	Quantity	Unit Price	Extension
	Mobilization, Bonds, Insurance (3% of construction)	LS	1	$180,000.00	$ 180,000.00
	Water Mains				
	24" DIP Water Line (open excavation)	LF	27400	$180.00	$ 4,932,000.00
	Tie-in for 24"	EA	2	$11,500.00	$ 23,000.00
	Jack & Bore 24-inch (36" Casing w/ 24" Carrier Pipe)	LF	300	$350.00	$ 105,000.00
	24" DIP (RJ) Water Line thru Jack & Bore locations	LF	300	$220.00	$ 66,000.00
	Jacking/Bore Pit Excavation	EA	1	$15,000.00	$ 15,000.00
	Dewatering	LS	1	$25,000.00	$ 25,000.00
	ARVs (every 4,000 ft)	EA	7	$3,500.00	$ 24,500.00
	Pre-Cast Concrete Structures for ARVs	EA	7	$4,000.00	$ 28,000.00
	Flushout Assemblies	EA	7	$5,000.00	$ 35,000.00
	24" Gate Valve (every 4,000 ft plus 3 on each end)	EA	13	$15,000.00	$ 195,000.00
	24" Fittings (MJ) [quantity estimated]	EA	16	$2,200.00	$ 35,200.00
	Rock Excavation - open trench (5%)	CY	1200	$250.00	$ 300,000.00
	Rock Excavation - Jack & Bore 24-inch (10%)	LF	30	$600.00	$ 18,000.00
	Concrete Pavement (along Clark Lane)	SY	2500	$65.00	$ 162,500.00
	Site Restoration - Seeding	LS	1	$20,000.00	$ 20,000.00

Construction:			$6,164,200.00
Inflation (%/yrs):	5%	10	$ 10,040,832.26
Contingency (%):		15%	$ 1,506,124.84
Engineering Design (%):		6.5%	$ 652,654.10
Engineering Construction (%):		3.25%	$ 326,327.05
Land Acq. / Easements (33 ea. @ $3,000)			$ 99,000.00
Geotechnical			$ 20,000.00
Surveying			$ 75,000.00
Total Project Cost (Year 2023):			$ 12,719,938.24

TOTAL PROJECT COST (YEAR 2023):	**$12,720,000.00**

Cost Estimates
Year 2028

Ground Storage at Hillsdale - 2.75 MG

Item No.	Description	Units	Quantity	Unit Price	Extension
	Mobilization, Bonds, Insurance (indicate quantity as 3% of construction)	LS	1	$48,000.00	$ 48,000.00
	Ground Storage Tank				
	2.75 MG Prestressed Concrete Ground Storage Tank	LS	1	$1,400,000.00	$ 1,400,000.00
	Telemetry/Control System/Electrical	LS	1	$20,000.00	$ 20,000.00
	Lighting	LS	1	$10,000.00	$ 10,000.00
	Valve vault, valving, & yard piping	LS	1	$150,000.00	$ 150,000.00
	Dewatering	LS	1	$5,000.00	$ 5,000.00
	Rock Excavation - NONE ANTICIPATED	CY	0	$250.00	$ -
	Site Restoration - Seeding	LS	1	$3,000.00	$ 3,000.00

Construction:			$1,636,000.00
Inflation (%/yrs):	5%	15	$3,401,126.50
Contingency (%):		15%	$ 510,168.98
Engineering Design (%):		8%	$ 272,090.12
Engineering Construction (%):		4%	$ 136,045.06
Land Acquisition / Easements (0 ea. @ $3,000):			$ -
Geotechnical (use existing info)			$ -
Surveying			$ 5,000.00
Total Project Cost (Year 2028):			$4,324,430.66

TOTAL PROJECT COST (YEAR 2028):	**$4,325,000.00**

24" Transmission Main from Southeast Pump Station

Item No.	Description	Units	Quantity	Unit Price	Extension
	Mobilization, Bonds, Insurance (3% of construction)	LS	1	$64,000.00	$ 64,000.00
	Water Mains				
	24" DIP Water Line (open excavation)	LF	8500	$180.00	$ 1,530,000.00
	Tie-in for 24"	EA	2	$11,500.00	$ 23,000.00
	Jack & Bore 24-inch (36" Casing w/ 24" Carrier Pipe) [@ E Gans Rd]	LF	100	$350.00	$ 35,000.00
	24" DIP (RJ) Water Line thru Jack & Bore locations	LF	100	$220.00	$ 22,000.00
	Jacking/Bore Pit Excavation	EA	1	$15,000.00	$ 15,000.00
	Dewatering	LS	1	$25,000.00	$ 25,000.00
	ARVs (every 4,000 ft)	EA	7	$3,500.00	$ 24,500.00
	Pre-Cast Concrete Structures for ARVs	EA	7	$4,000.00	$ 28,000.00
	Flushout Assemblies	EA	7	$5,000.00	$ 35,000.00
	24" Gate Valve (every 4,000 ft plus 1 on each end)	EA	3	$15,000.00	$ 45,000.00
	24" Fittings (MJ) [quantity estimated]	EA	10	$2,200.00	$ 22,000.00
	Rock Excavation - open trench (5%)	CY	1200	$250.00	$ 300,000.00
	Rock Excavation - Jack & Bore 24-inch (10%)	LF	30	$600.00	$ 18,000.00
	Site Restoration - Seeding	LS	1	$20,000.00	$ 20,000.00

Construction:			$2,206,500.00
Inflation (%/yrs):	5%	15	$ 4,587,155.03
Contingency (%):		15%	$ 688,073.25
Engineering Design (%):		8%	$ 366,972.40
Engineering Construction (%):		4%	$ 183,486.20
Land Acq. / Easements (6 ea. @ $3,000)			$ 18,000.00
Geotechnical			$ 20,000.00
Surveying			$ 75,000.00
Total Project Cost (Year 2028):			$ 5,938,686.89

TOTAL PROJECT COST (YEAR 2028):	**$5,939,000.00**

Cost Estimates
Year 2033

New Southeast Pump Station

Item No.	Description	Units	Quantity	Unit Price	Extension
	Mobilization, Bonds, Insurance (3% of construction)	LS	1	$46,000.00	$ 46,000.00
	Booster Pump Station				
	7.2 MGD Booster Pump Station (Turnkey)	LS	1	$1,100,000.00	$ 1,100,000.00
	Telemetry/Control System/Electrical	LS	1	$120,000.00	$ 120,000.00
	Package Generator	LS	1	$150,000.00	$ 150,000.00
	Sitework				
	Vehicle Slide Gate & Man Gate	EA	1	$4,100.00	$ 4,100.00
	Fencing	LF	1000	$32.00	$ 32,000.00
	Water Mains				
	24" DIP Water Line (open excavation)	LF	200	$180.00	$ 36,000.00
	Tie-in for 24"	EA	1	$11,500.00	$ 11,500.00
	24" Fittings (MJ) [quantity estimated]	EA	10	$2,200.00	$ 22,000.00
	Earthwork (Sitework related to Booster Pump Station)	CY	400	$45.00	$ 18,000.00
	Gravel Access Road (100 ft x 20 ft)	SF	2000	$5.00	$ 10,000.00
	Concrete Pavement	SY	200	$65.00	$ 13,000.00
	Granular Backfill	CY	200	$35.00	$ 7,000.00
	Site Restoration - Seeding	LS	1	$10,000.00	$ 10,000.00
				Construction:	$1,579,600.00
		Inflation (%/yrs):	5%	20	$ 4,191,149.06
				Contingency (%): 15%	$628,672.36
				Engineering Design (%): 8%	$335,291.92
				Engineering Construction (%): 4%	$ 167,645.96
				Land Acquisition (1 ea. @ $200,000)	$ 200,000.00
				Geotechnical	$ 5,000.00
				Surveying	$ 10,000.00
				Total Project Cost (Year 2033):	$ 5,537,759.30
				TOTAL PROJECT COST (YEAR 2033):	**$5,538,000.00**

3/17/2015

New Pump Station at Hillsdale Site

Item No.	Description	Units	Quantity	Unit Price	Extension
	Mobilization, Bonds, Insurance (3% of construction)	LS	1	$41,000.00	$ 41,000.00
	Booster Pump Station				
	6.5 MGD Booster Pump Station (Turnkey)	LS	1	$1,000,000.00	$ 1,000,000.00
	Telemetry/Control System/Electrical	LS	1	$120,000.00	$ 120,000.00
	Package Generator	LS	1	$150,000.00	$ 150,000.00
	Water Mains				
	24" DIP Water Line (open excavation)	LF	200	$180.00	$ 36,000.00
	Tie-in for 24"	EA	1	$11,500.00	$ 11,500.00
	24" Fittings (MJ) [quantity estimated]	EA	10	$2,200.00	$ 22,000.00
	Earthwork (Sitework related to Booster Pump Station)	CY	200	$45.00	$ 9,000.00
	Granular Backfill	CY	100	$35.00	$ 3,500.00
	Site Restoration - Seeding	LS	1	$3,000.00	$ 3,000.00

Construction:			$1,396,000.00
Inflation (%/yrs):	5%	20	$ 3,704,003.60
Contingency (%):		15%	$555,600.54
Engineering Design (%):		8%	$296,320.29
Engineering Construction (%):		4%	$ 148,160.14
Land Acq. / Easements (0 ea. @ $3,000)			$ -
Geotechnical (use existing info)			$ -
Surveying			$ 5,000.00
Total Project Cost (Year 2033):			$ 4,709,084.57

TOTAL PROJECT COST (YEAR 2033):	**$4,710,000.00**

Ground Storage at
SE Pump Station - 3.5 MG

Item No.	Description	Units	Quantity	Unit Price	Extension
	Mobilization, Bonds, Insurance (indicate quantity as 3% of construction)	LS	1	$58,000.00	$ 58,000.00
	Ground Storage Tank				
	3.5 MG Prestressed Concrete Ground Storage Tank	LS	1	$1,750,000.00	$ 1,750,000.00
	Telemetry/Control System/Electrical	LS	1	$20,000.00	$ 20,000.00
	Lighting	LS	1	$10,000.00	$ 10,000.00
	Valve vault, valving, & yard piping	LS	1	$150,000.00	$ 150,000.00
	Sitework				
	Dewatering	LS	1	$5,000.00	$ 5,000.00
	Rock Excavation	CY	10	$250.00	$ 2,500.00
	Site Restoration - Seeding	LS	1	$5,000.00	$ 5,000.00

		Construction:	$2,000,500.00
Inflation (%/yrs):	5%	20	$5,307,922.06
	Contingency (%):	15%	$ 796,188.31
	Engineering Design (%):	7%	$ 371,554.54
	Engineering Construction (%):	3.5%	$ 185,777.27
		Land Acquisition / Easements (0 ea. @ $3,000):	$ -
		Geotechnical	$ 10,000.00
		Surveying	$ 10,000.00
		Total Project Cost (Year 2033):	$6,681,442.18

TOTAL PROJECT COST (YEAR 2033):	**$6,682,000.00**

16" Transmission Main from West Ash Pump Station to Walnut Tower

Item No.	Description	Units	Quantity	Unit Price	Extension
	Mobilization, Bonds, Insurance (3% of construction)	LS	1	$39,000.00	$ 39,000.00
	Water Mains				
	16" DIP Water Line (open excavation)	LF	9500	$120.00	$ 1,140,000.00
	Tie-in for 16"	EA	2	$8,400.00	$ 16,800.00
	Dewatering	LS	1	$10,000.00	$ 10,000.00
	ARVs (every 4,000 ft)	EA	4	$3,500.00	$ 14,000.00
	Pre-Cast Concrete Structures for ARVs	EA	4	$4,000.00	$ 16,000.00
	Flushout Assemblies	EA	4	$5,000.00	$ 20,000.00
	16" Gate Valve (every 4,000 ft plus 2 on each end)	EA	6	$10,500.00	$ 63,000.00
	16" Fittings (MJ) [quantity estimated]	EA	10	$1,500.00	$ 15,000.00
	Site Restoration - Seeding	LS	1	$20,000.00	$ 20,000.00

Construction:			$1,353,800.00
Inflation (%/yrs):	5%	20	$3,592,034.43
Contingency (%):		15%	$538,805.16
Engineering Design (%):		8%	$287,362.75
Engineering Construction (%):		4%	$143,681.38
Land Acq. / Easements (75 ea. @ $3,000)			$ 225,000.00
Geotechnical			$ 20,000.00
Surveying			$ 30,000.00
Total Project Cost (Year 2033):			$4,836,883.73

TOTAL PROJECT COST (YEAR 2033):	**$4,837,000.00**

SECTION 7 – SUMMARY AND RECOMMENDATIONS

7.1 SUMMARY AND RECOMMENDATIONS

It is recommended that the City proceed with the system improvements discussed in Sections 5 and 6 of this report. Furthermore, it is recommended that the City review the list of improvements on an annual basis to evaluate the prioritizations based on needs, growth and actual water demands.

The following table provides a summary of the recommended improvements.

Table 7-1: Recommended Improvements

Project Description	Year Recommended	Estimated Cost
Pump Stations		
New Pump Station at West Ash Site	2023	$ 3,124,000
New Southeast Pump Station	2033	$ 5,538,000
New Pump Station at Hillsdale Site	2033	$ 4,710,000
Pump Stations – Subtotal		**$ 13,372,000**
Storage		
Elevated Storage at Prathersville – 2 MG	2023	$ 7,866,000
Ground Storage at Hillsdale– 2.75 MG	2028	$ 4,325,000
Ground Storage at SE Pump Station– 3.5 MG	2033	$ 6,682,000
Storage – Subtotal		**$ 18,873,000**
Other Improvements		
ASR #3 – Conversion of Existing Deep Well	2018	$ 600,000
Other Improvements – Subtotal		**$ 600,000**
Water Mains		
16" Transmission Main from New West Ash Pump Station to New Prathersville Elevated Tank	2023	$ 10,409,000
24" Transmission Main from Hillsdale to Stephens Station Elevated Tank	2023	$ 12,720,000
24" Transmission Main from New Southeast Pump Station	2028	$ 5,939,000
16" Transmission Main from West Ash Pump Station to Walnut Tower	2033	$ 4,837,000
Water Mains – Subtotal		**$ 33,905,000**
TOTAL – All Improvements		**$ 66,750,000**

In addition it is recommended that the City complete the following:

1. Update to this Study every five years based on the rate and specific areas of growth in the service area.
2. Begin the necessary planning and studies (described in Section 5.4.5) for additional water treatment and transmission.

APPENDIX 1

Water Customer Graphs

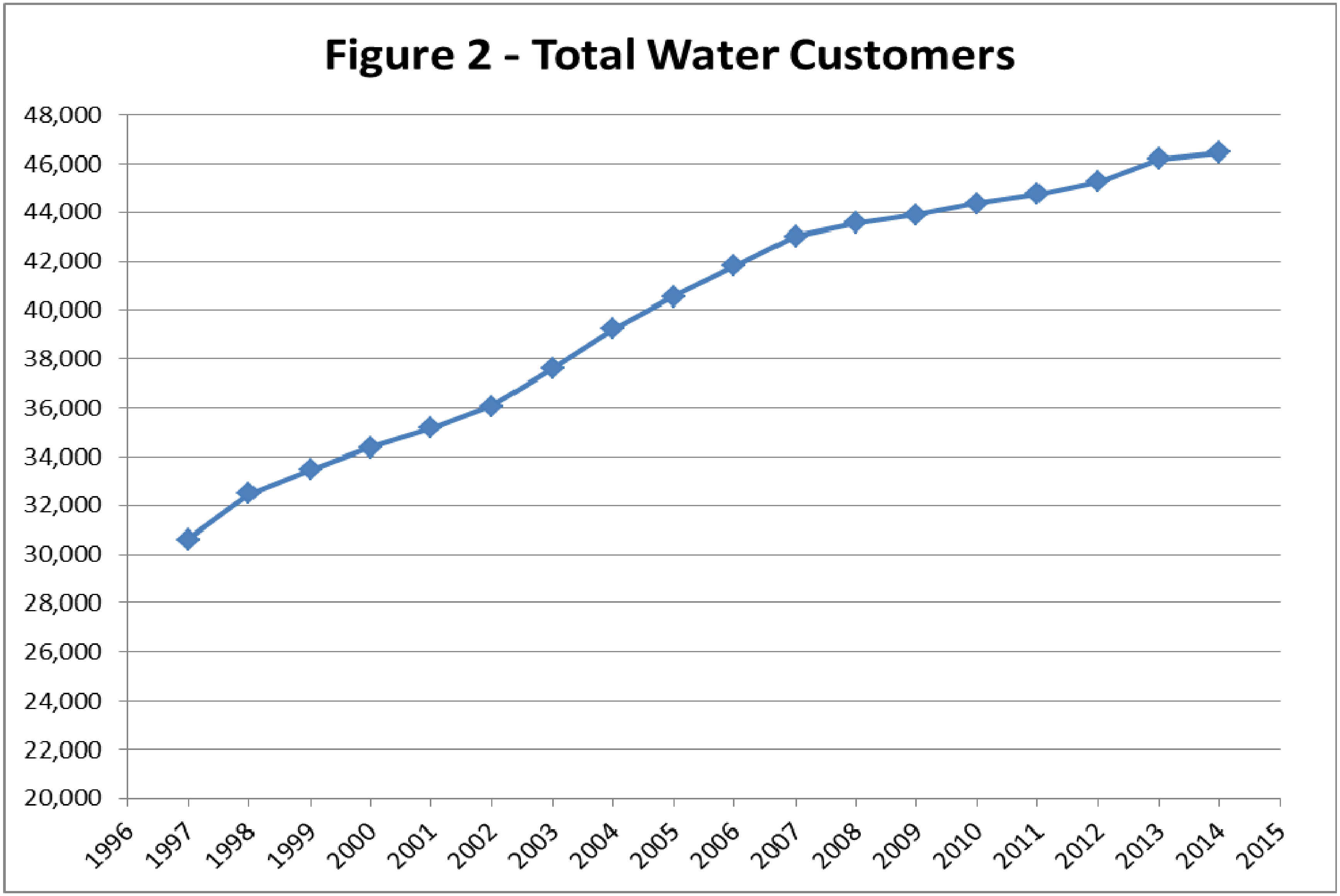


Figure 2 - Total Water Customers
48,000
46,000
44,000
42,000
40,000
38,000
36,000
34,000
32,000
30,000
28,000
26,000
24,000
22,000
20,000
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

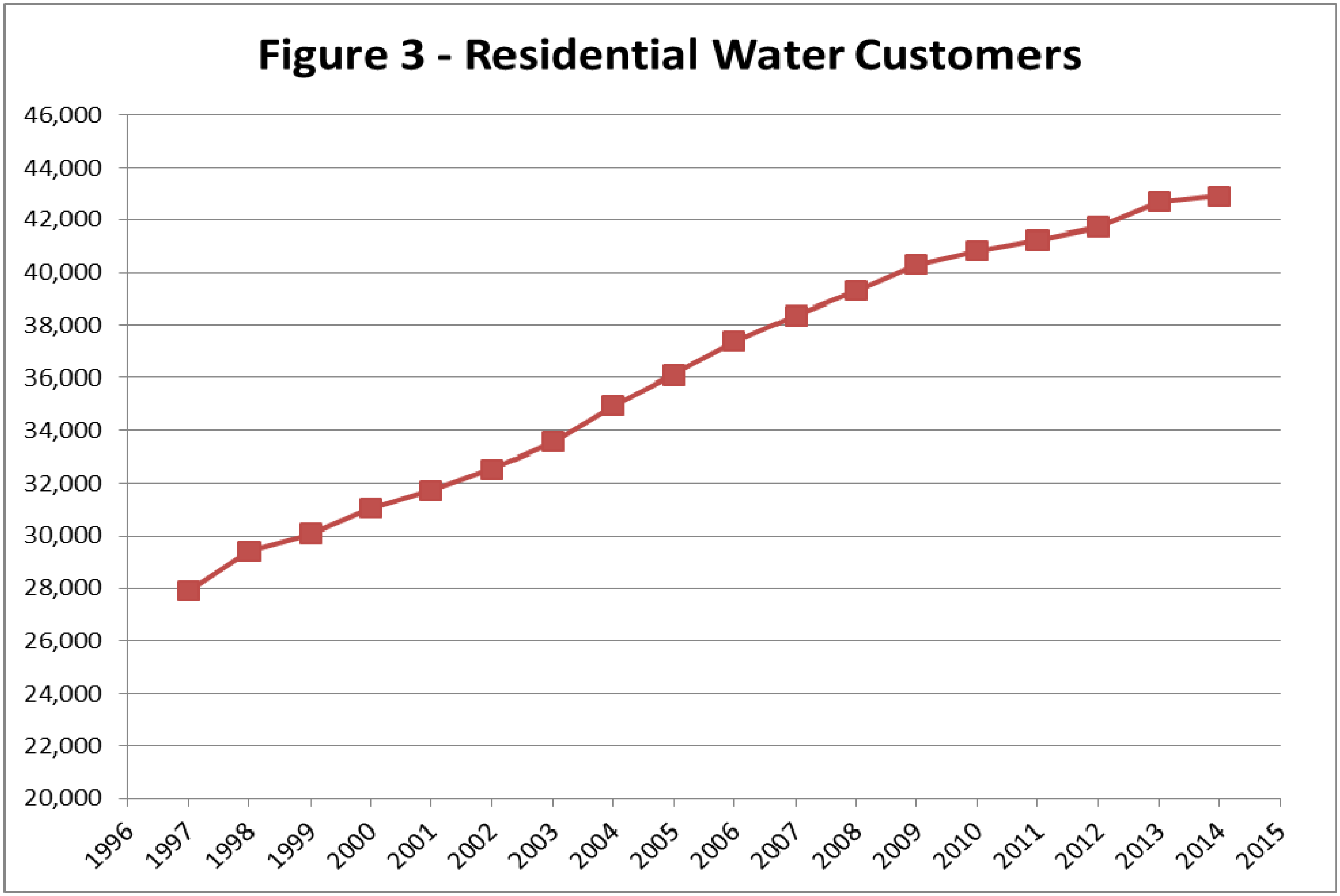


Figure 3 - Residential Water Customers
46,000
44,000
42,000
40,000
38,000
36,000
34,000
32,000
30,000
28,000
26,000
24,000
22,000
20,000
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

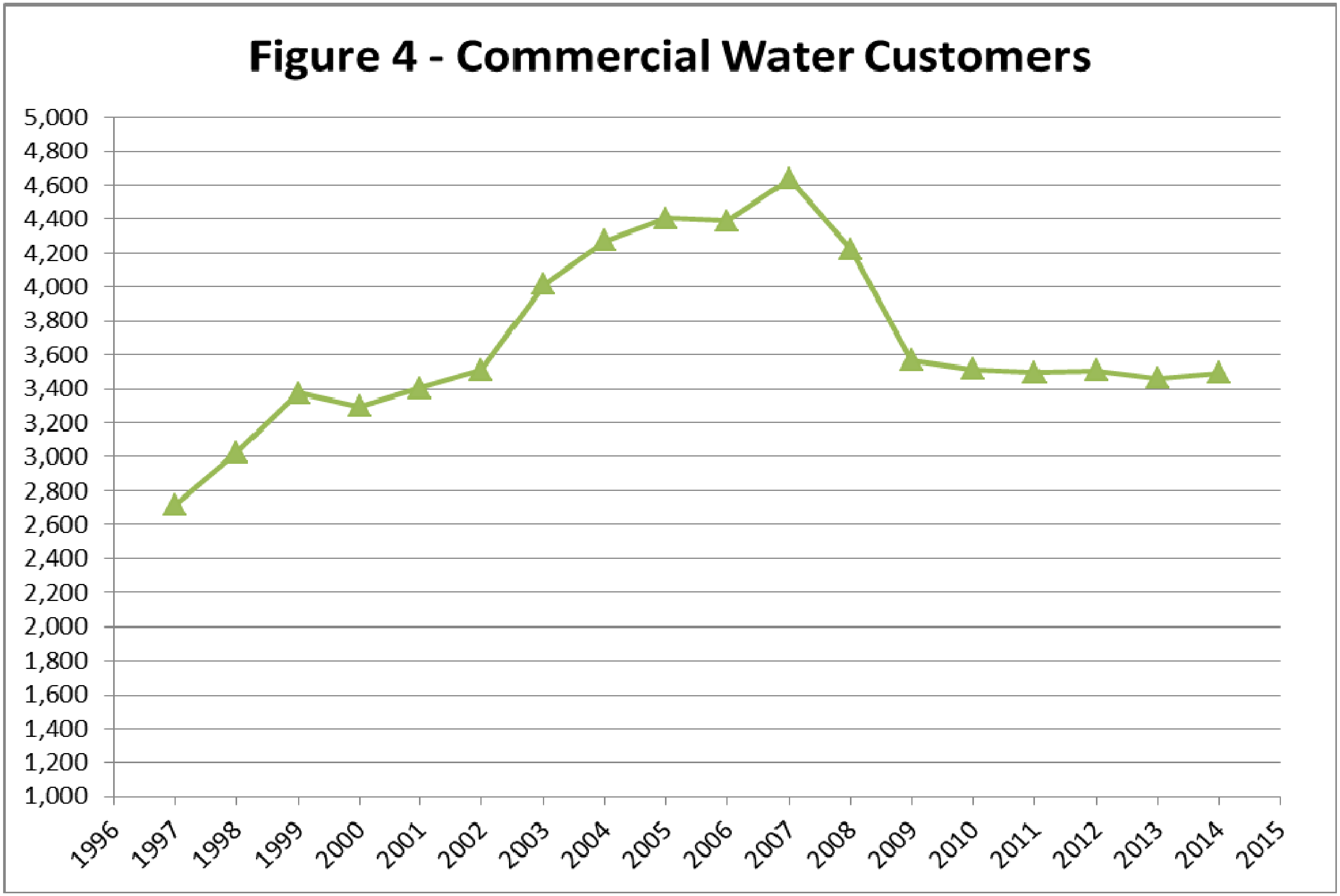
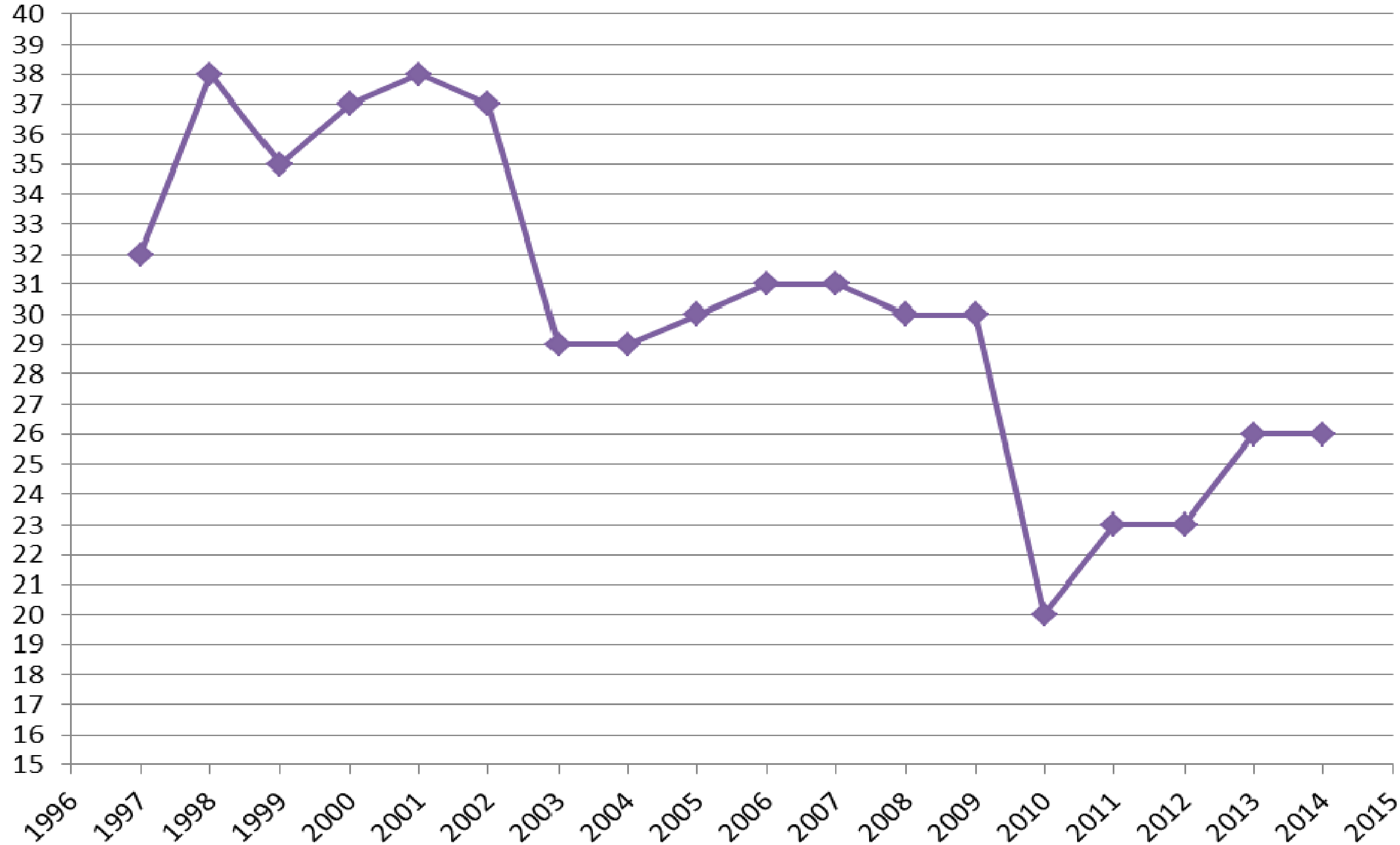


Figure 4 - Commercial Water Customers
5,000
4,800
4,600
4,400
4,200
4,000
3,800
3,600
3,400
3,200
3,000
2,800
2,600
2,400
2,200
2,000
1,800
1,600
1,400
1,200
1,000
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

Figure 5 - Large Commercial Water Customers



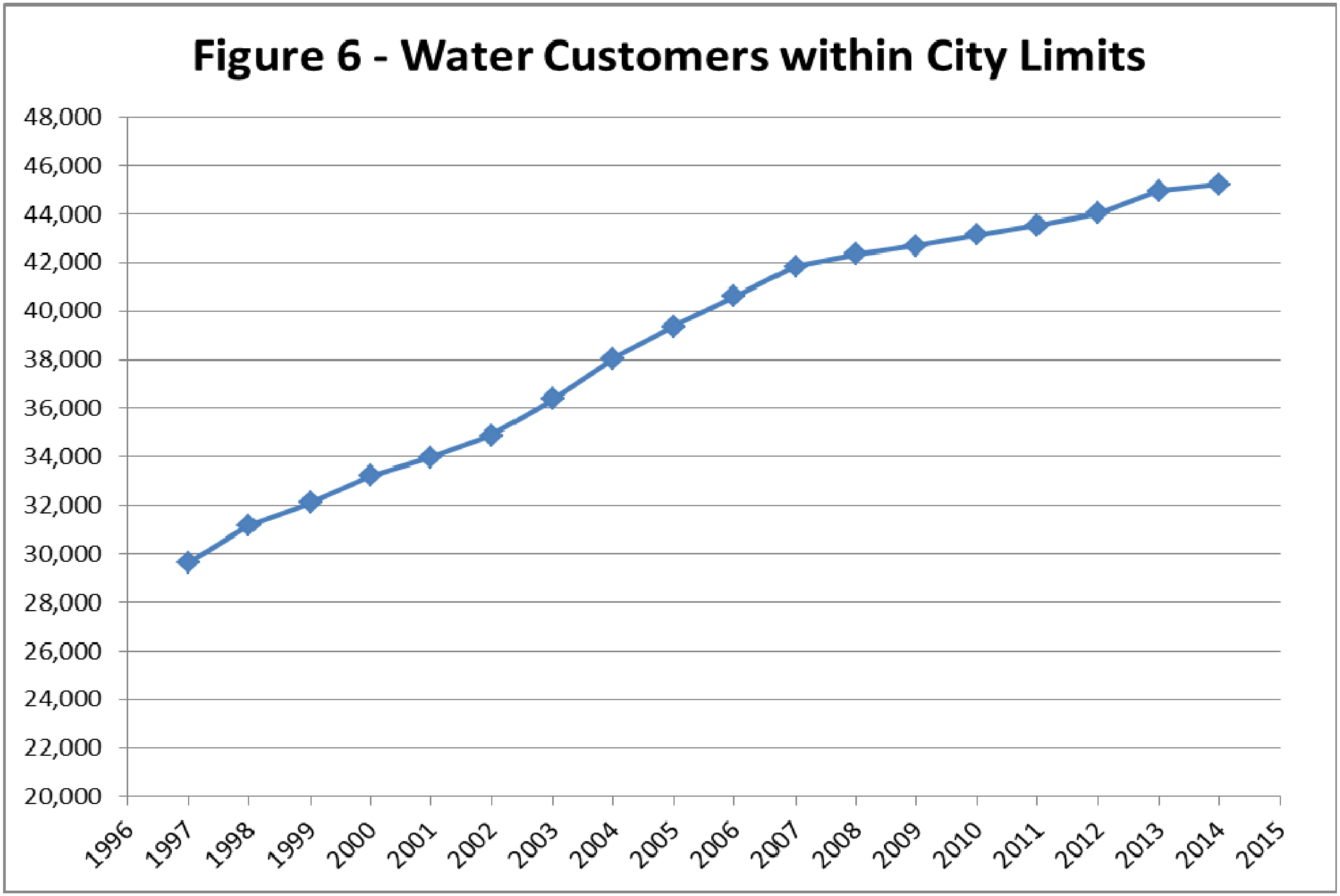


Figure 6 - Water Customers within City Limits
48,000
46,000
44,000
42,000
40,000
38,000
36,000
34,000
32,000
30,000
28,000
26,000
24,000
22,000
20,000
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

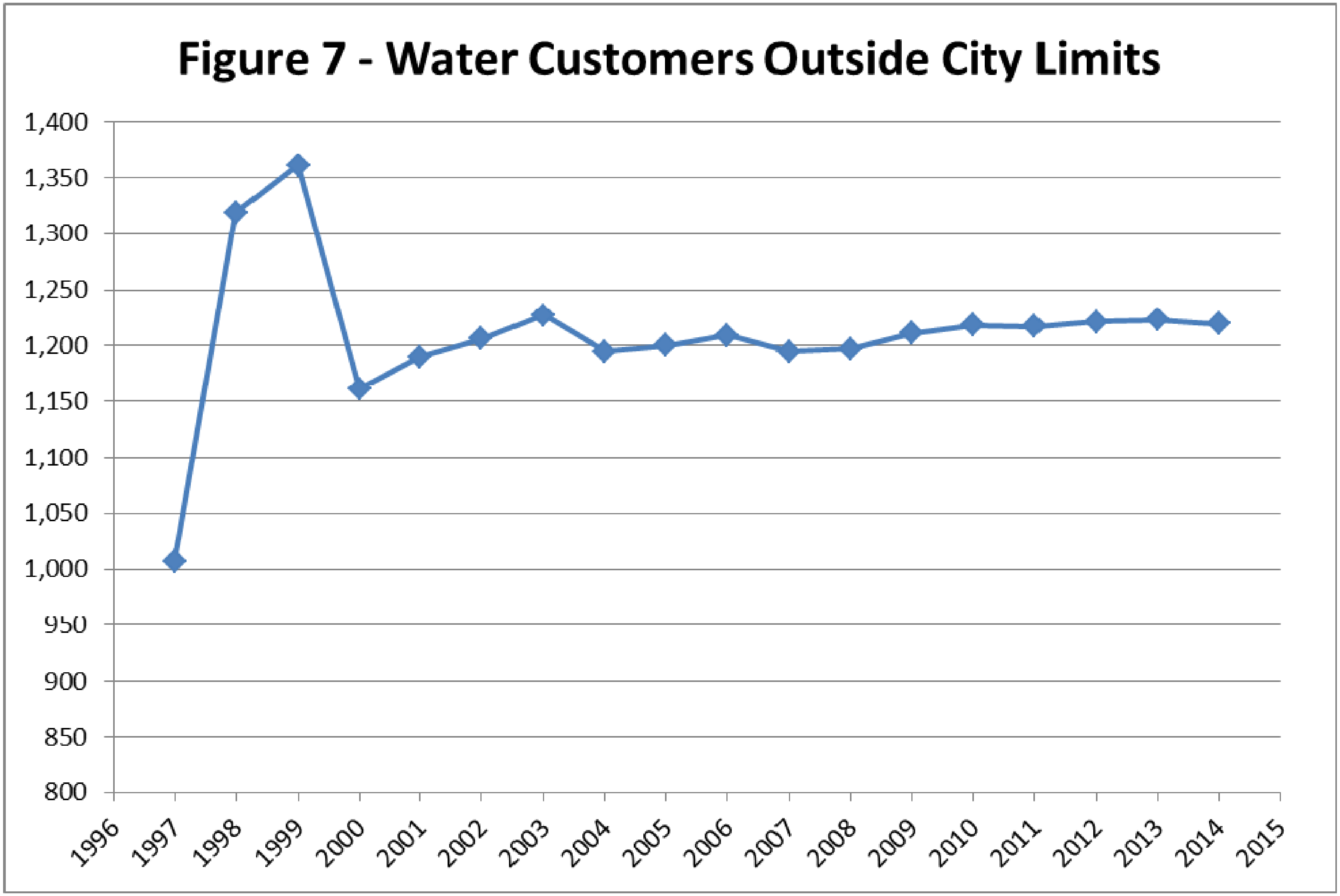


Figure 7 - Water Customers Outside City Limits
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

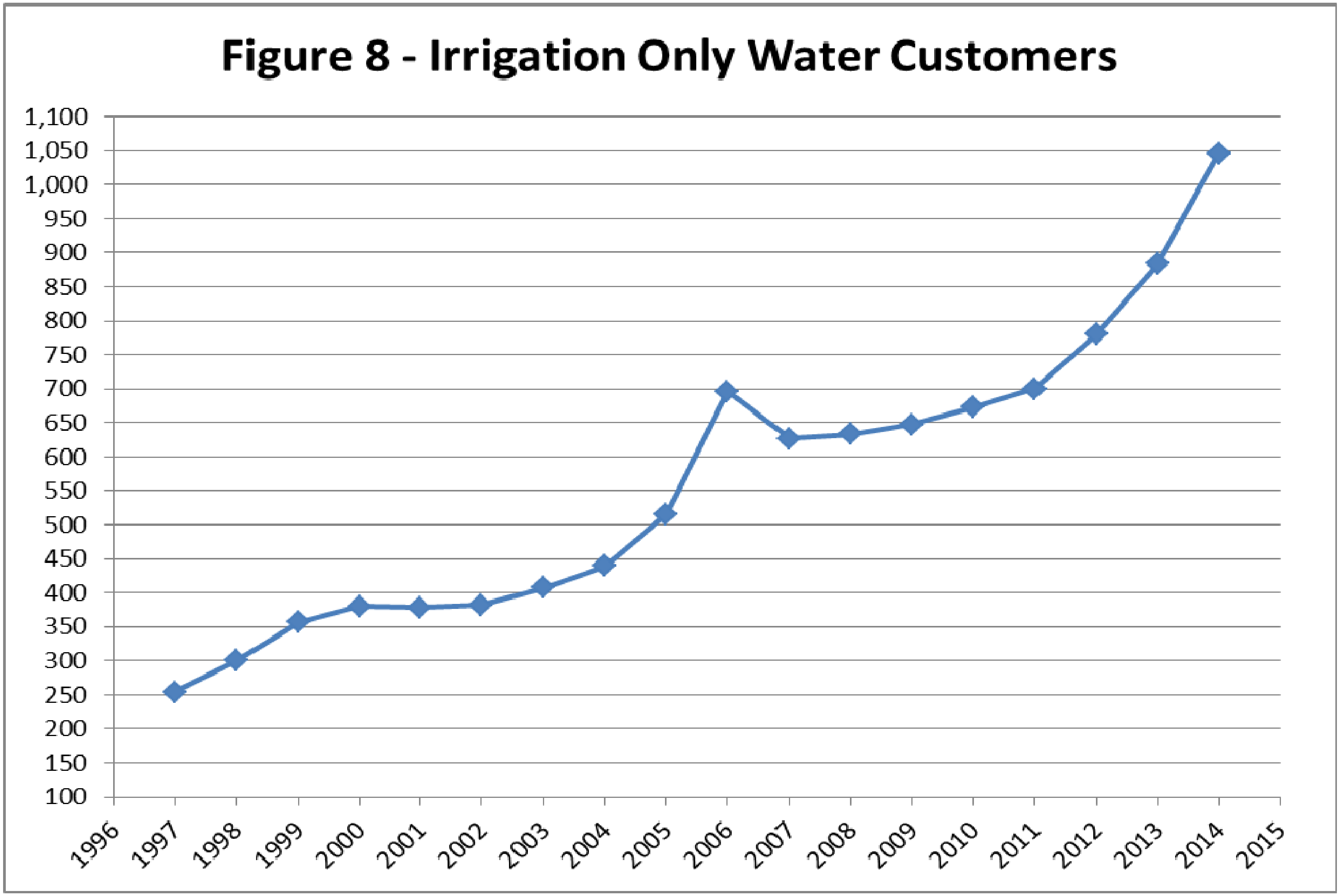


Figure 8 - Irrigation Only Water Customers
1,100
1,050
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

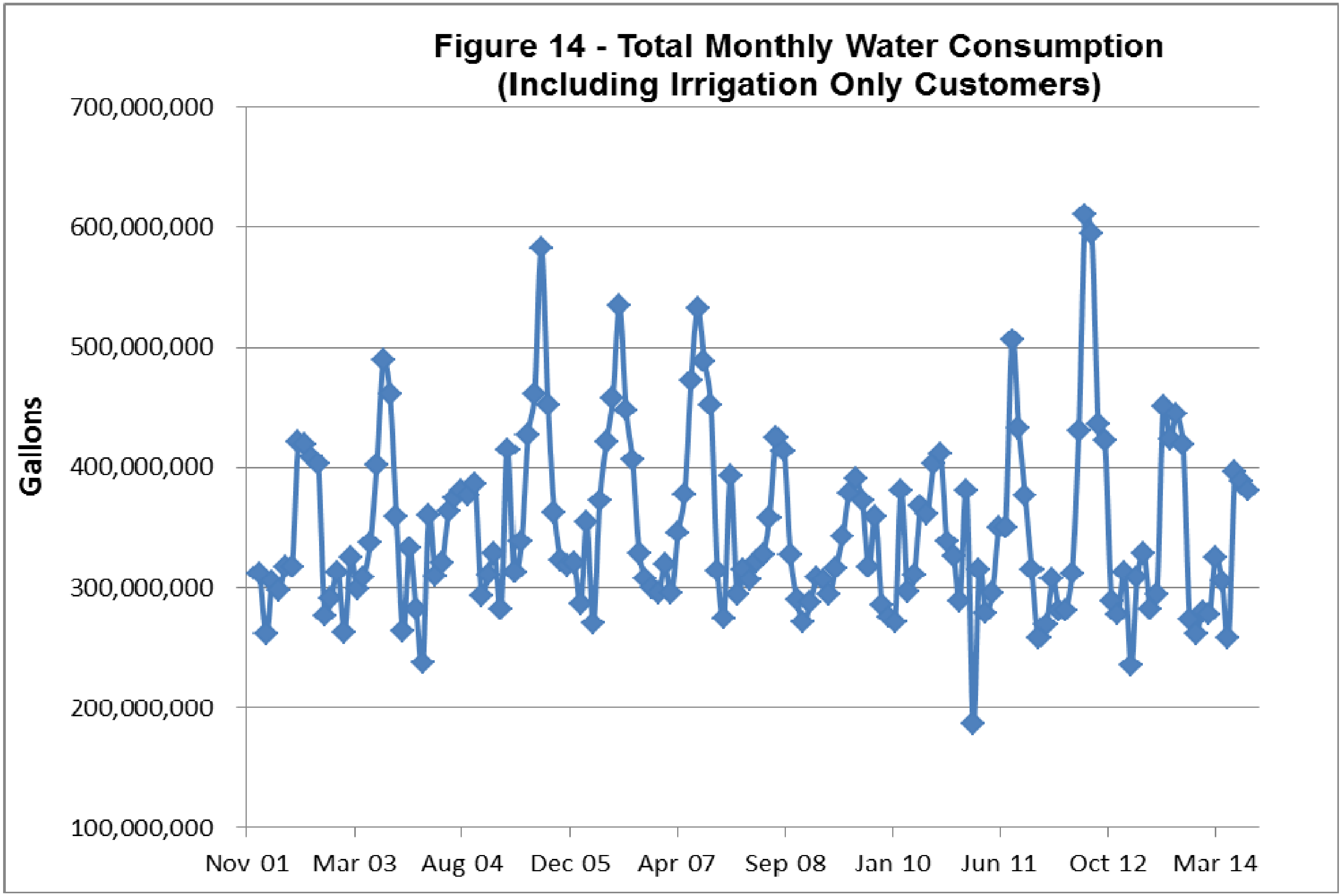


Figure 14 - Total Monthly Water Consumption
(Including Irrigation Only Customers)
Gallons
700,000,000
600,000,000
500,000,000
400,000,000
300,000,000
200,000,000
100,000,000
Nov 01
Mar 03
Aug 04
Dec 05
Apr 07
Sep 08
Jan 10
Jun 11
Oct 12
Mar 14

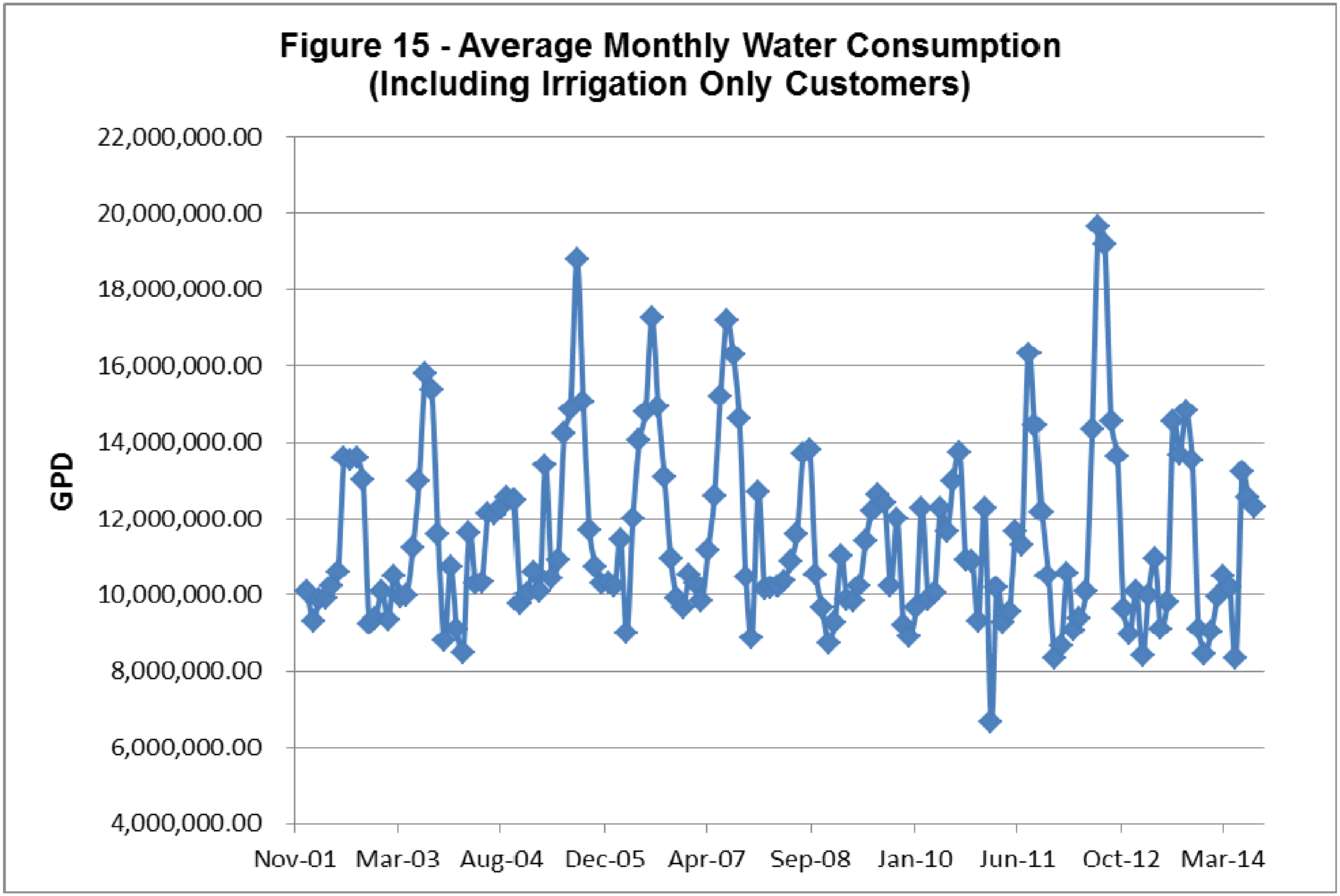


Figure 15 - Average Monthly Water Consumption
(Including Irrigation Only Customers)
GPD
22,000,000.00
20,000,000.00
18,000,000.00
16,000,000.00
14,000,000.00
12,000,000.00
10,000,000.00
8,000,000.00
6,000,000.00
4,000,000.00
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

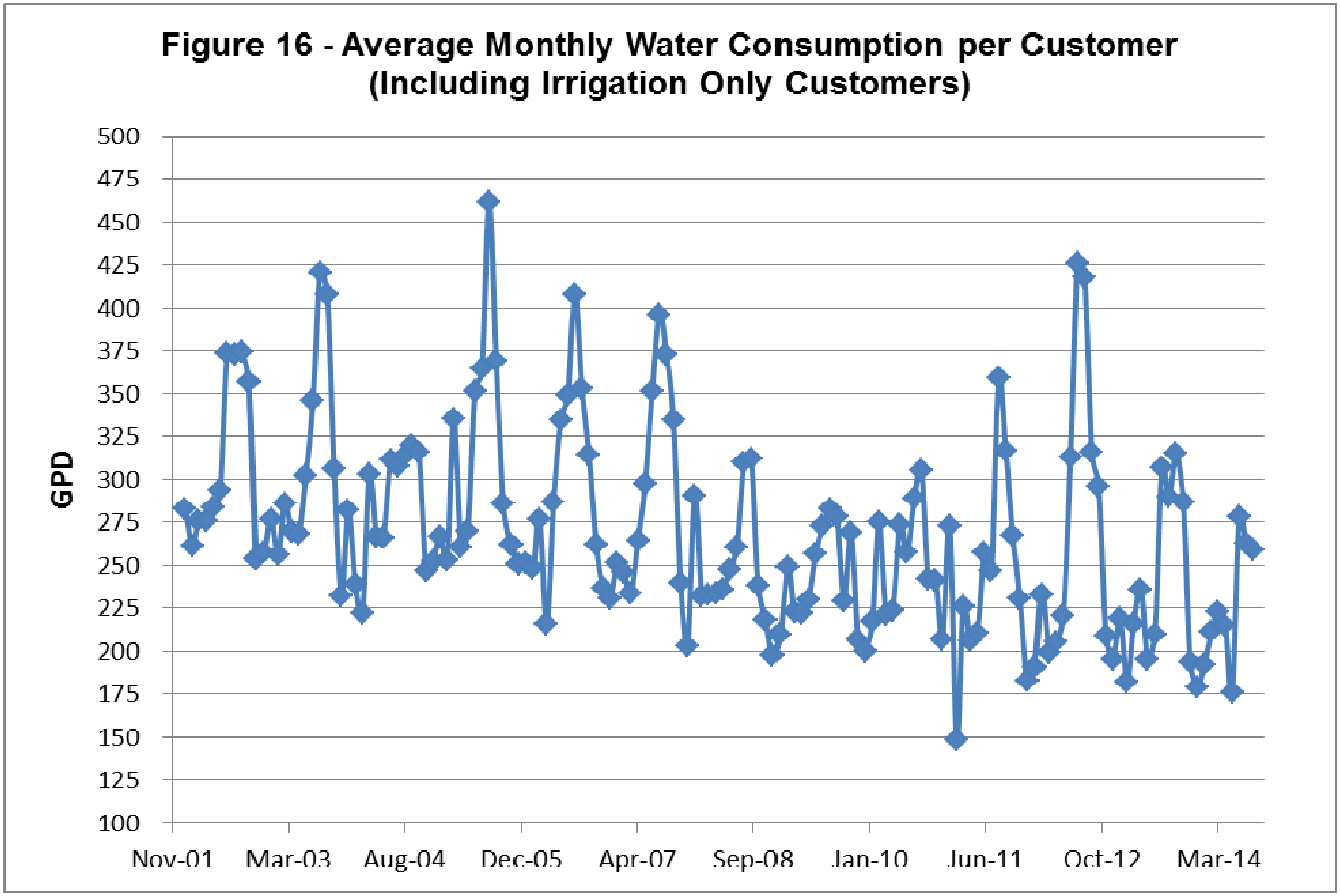


Figure 16 - Average Monthly Water Consumption per Customer
(Including Irrigation Only Customers)
GPD
500
475
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

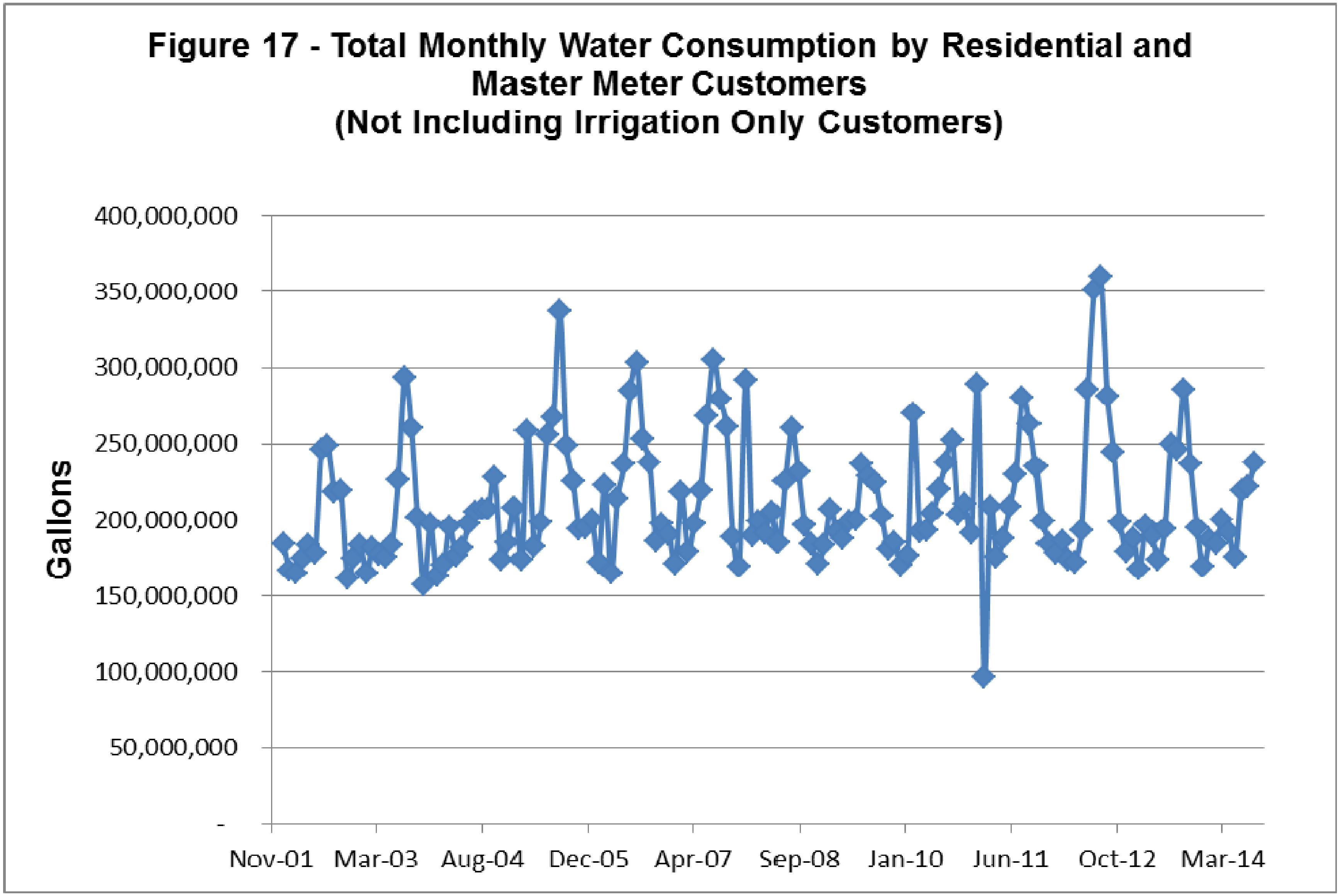


Figure 17 - Total Monthly Water Consumption by Residential and Master Meter Customers
(Not Including Irrigation Only Customers)
Gallons
400,000,000
350,000,000
300,000,000
250,000,000
200,000,000
150,000,000
100,000,000
50,000,000
-
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

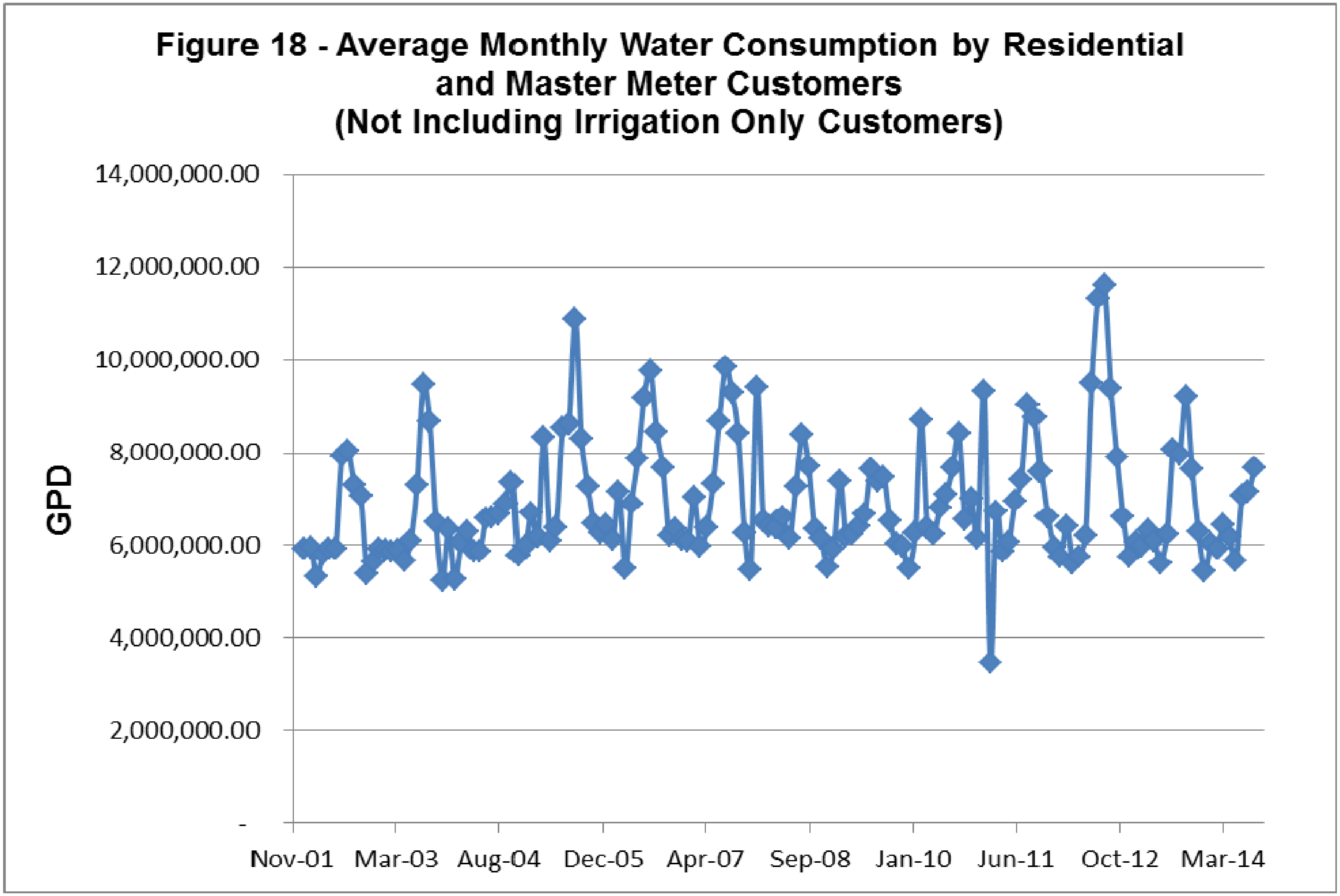


Figure 18 - Average Monthly Water Consumption by Residential and Master Meter Customers (Not Including Irrigation Only Customers)
14,000,000.00
12,000,000.00
10,000,000.00
8,000,000.00
6,000,000.00
4,000,000.00
2,000,000.00
-
GPD
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

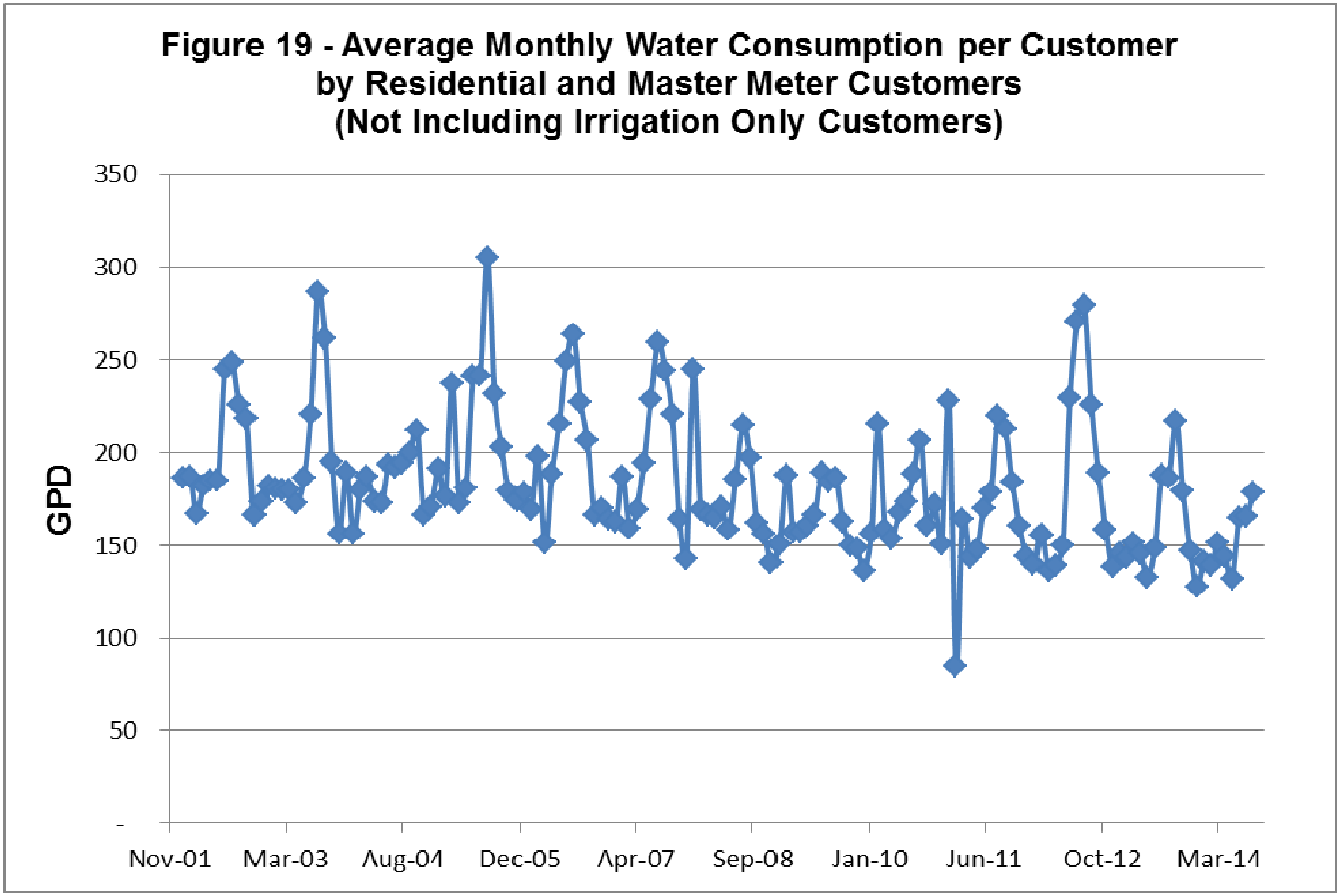


Figure 19 - Average Monthly Water Consumption per Customer
by Residential and Master Meter Customers
(Not Including Irrigation Only Customers)
GPD
350
300
250
200
150
100
50
-
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

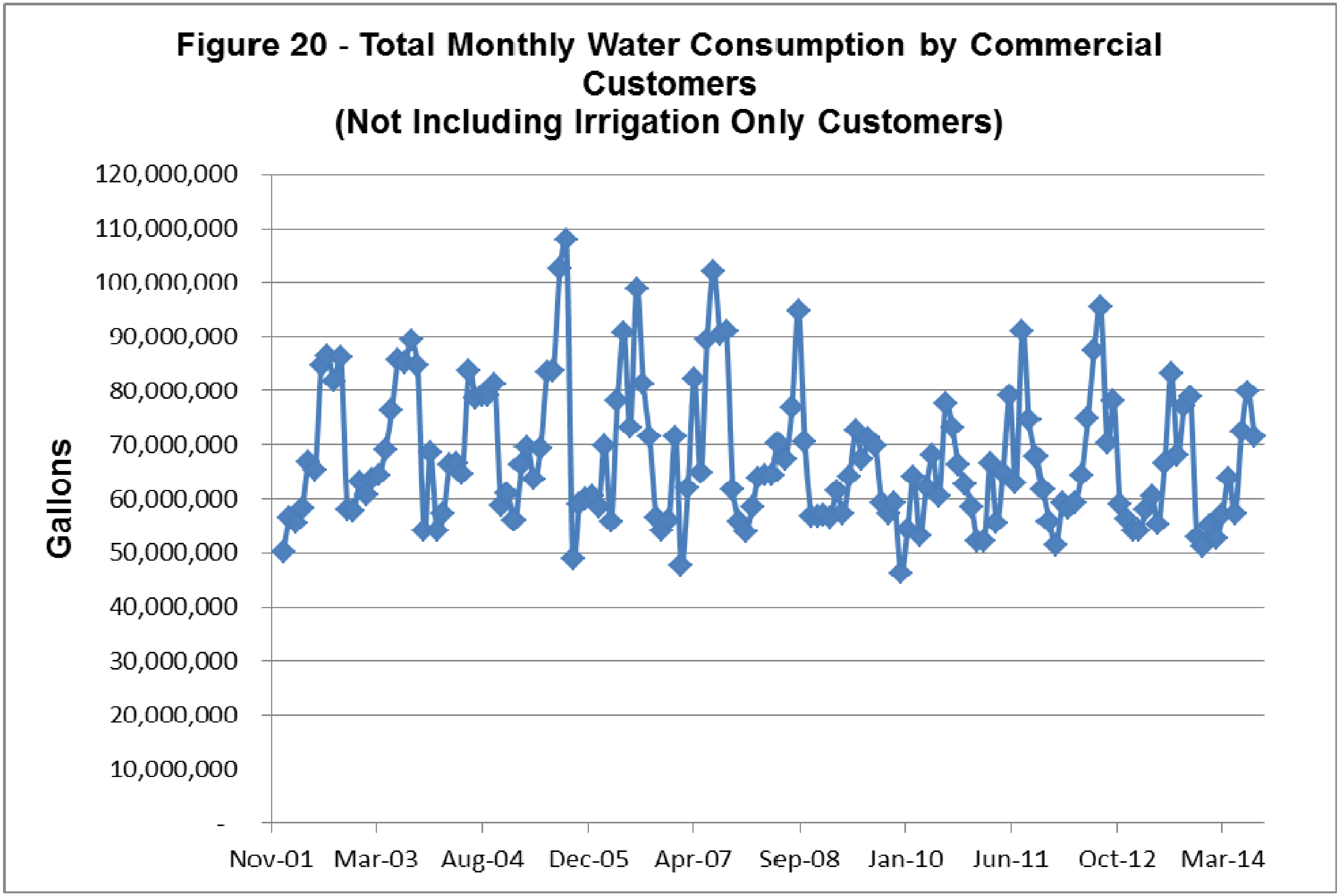


Figure 20 - Total Monthly Water Consumption by Commercial Customers
(Not Including Irrigation Only Customers)
Gallons
120,000,000
110,000,000
100,000,000
90,000,000
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
-
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

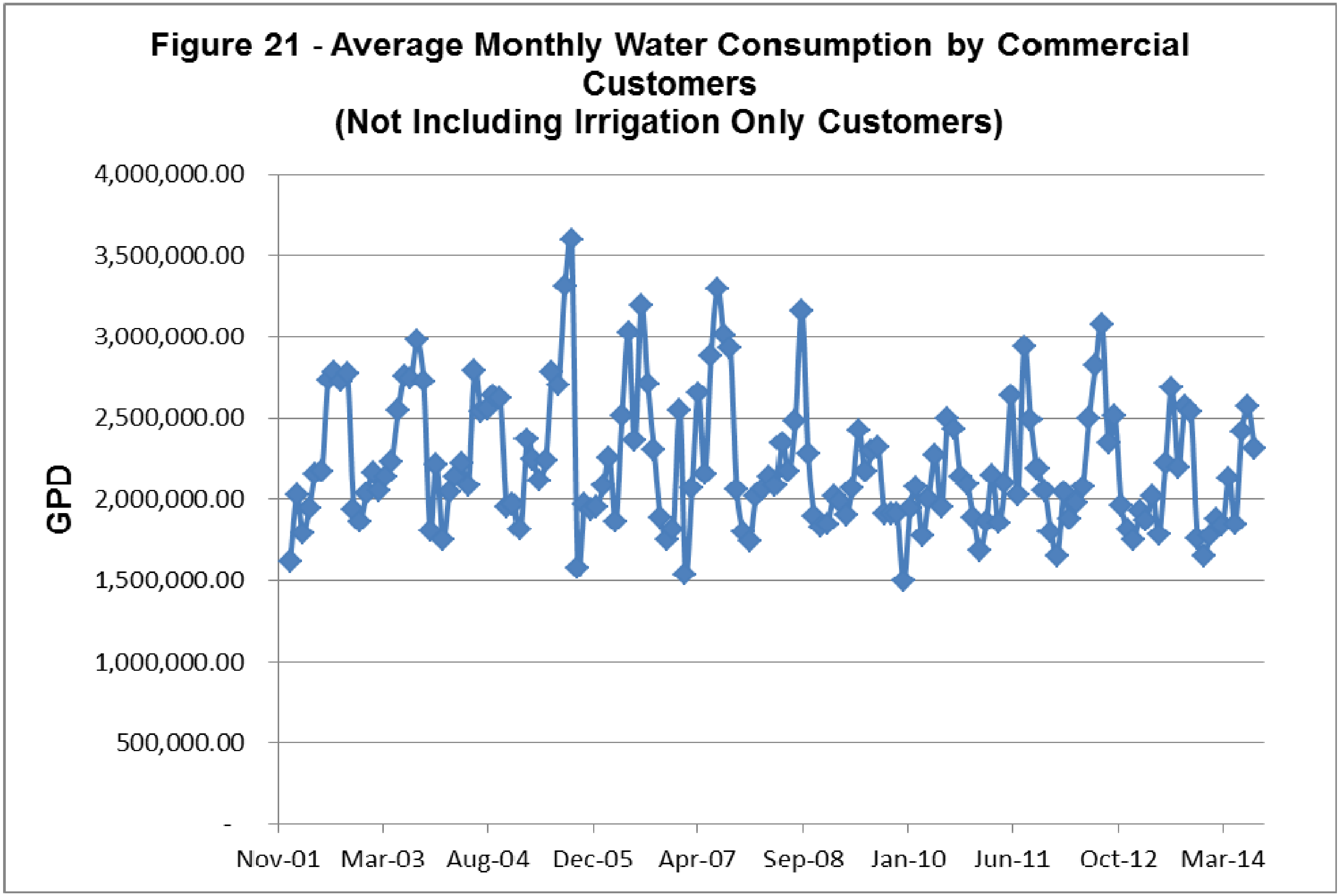


Figure 21 - Average Monthly Water Consumption by Commercial Customers
(Not Including Irrigation Only Customers)
GPD
4,000,000.00
3,500,000.00
3,000,000.00
2,500,000.00
2,000,000.00
1,500,000.00
1,000,000.00
500,000.00
-
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

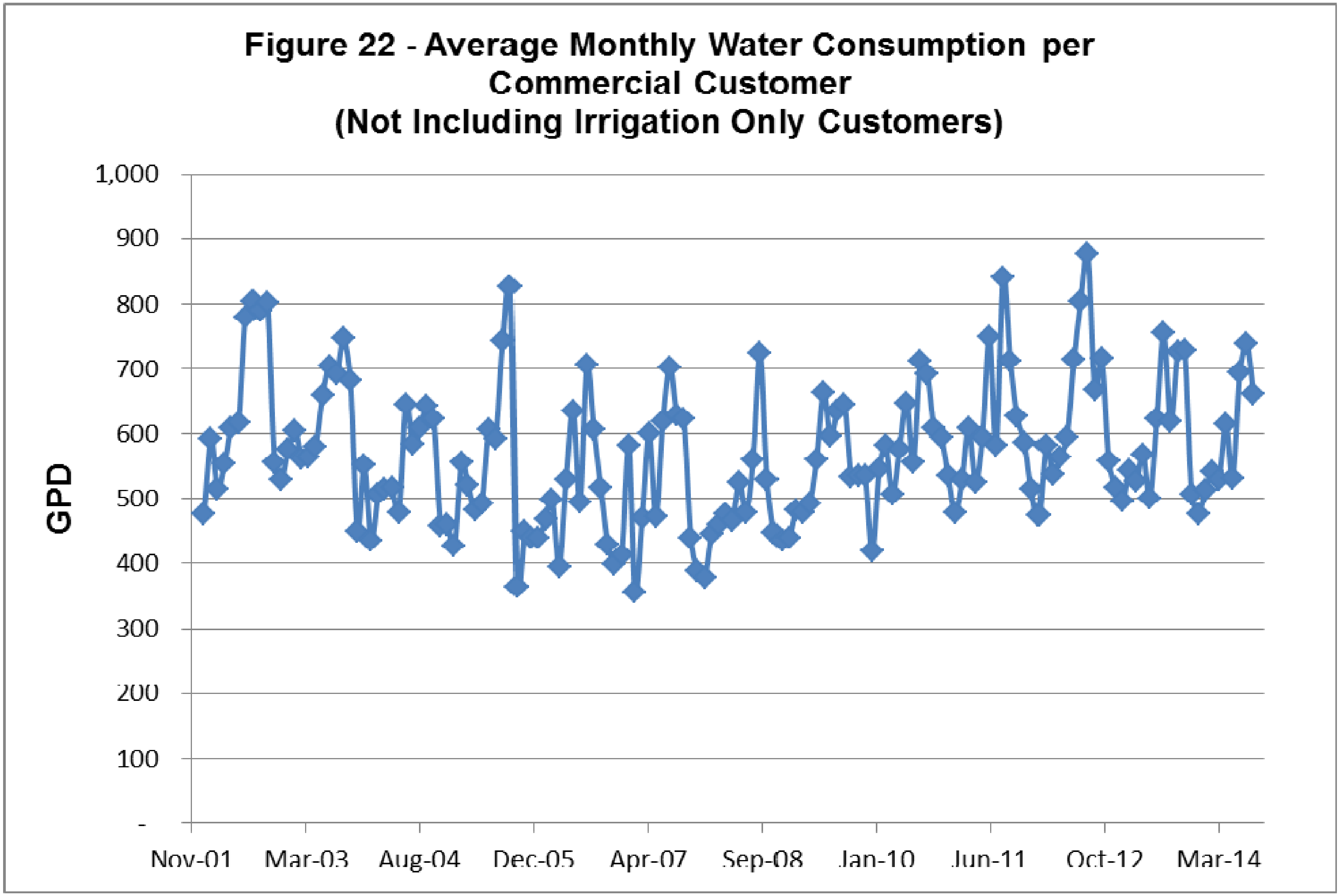
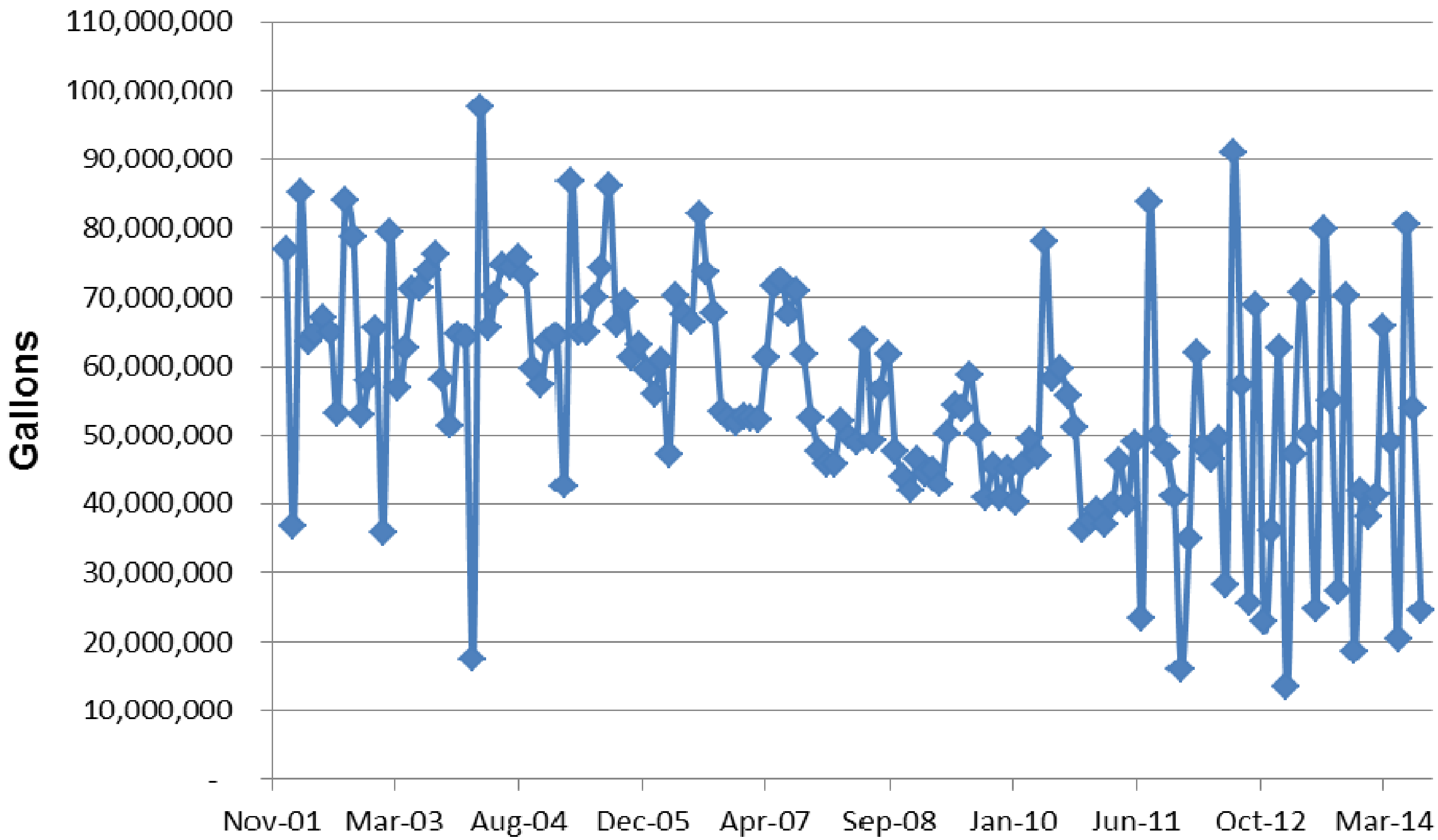


Figure 22 - Average Monthly Water Consumption per Commercial Customer
(Not Including Irrigation Only Customers)
GPD
1,000
900
800
700
600
500
400
300
200
100
-
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

Figure 23 - Total Monthly Water Consumption by Large Commercial Customers
(Not Including Irrigation Only Customers)



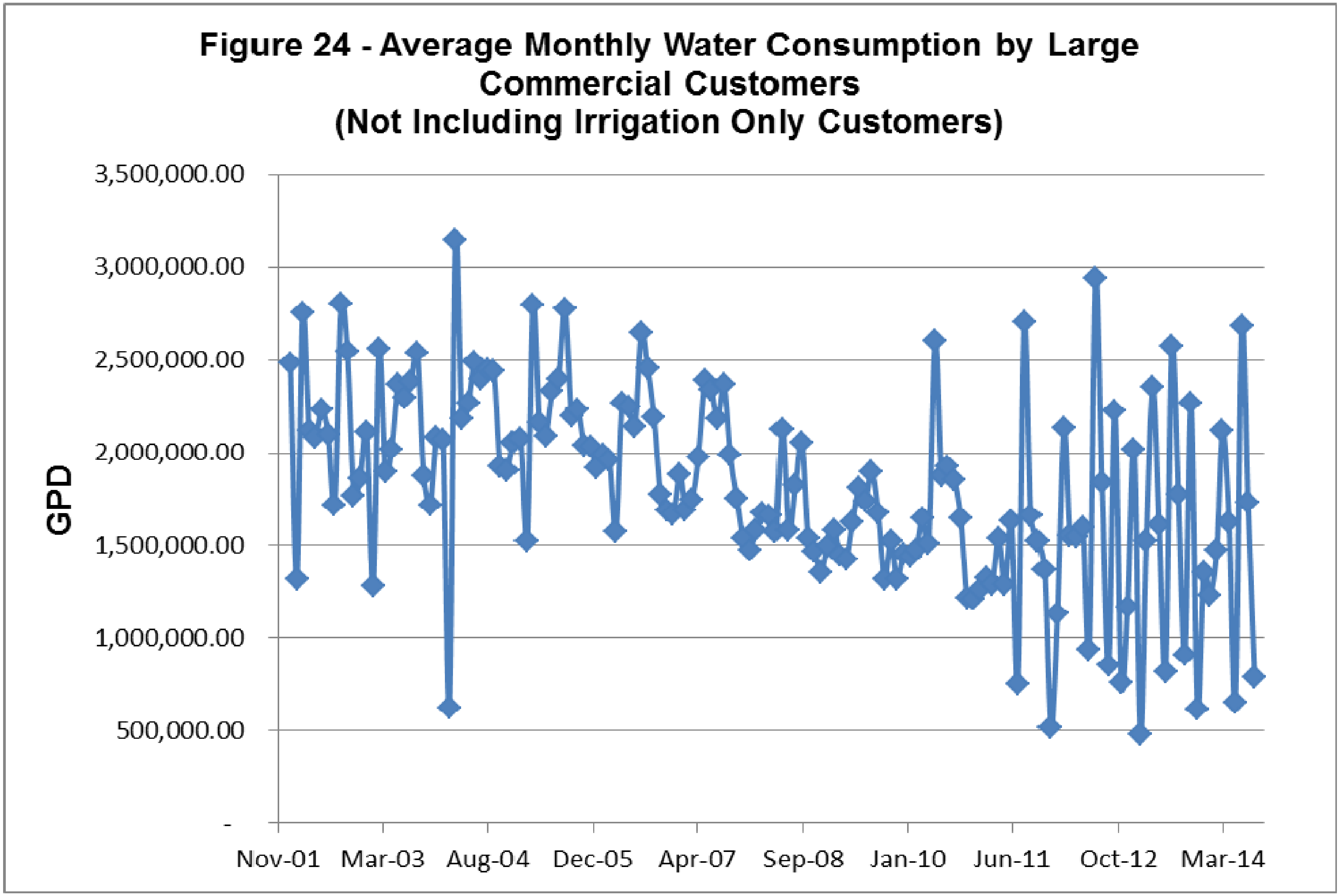


Figure 24 - Average Monthly Water Consumption by Large Commercial Customers
(Not Including Irrigation Only Customers)
GPD
3,500,000.00
3,000,000.00
2,500,000.00
2,000,000.00
1,500,000.00
1,000,000.00
500,000.00
-
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

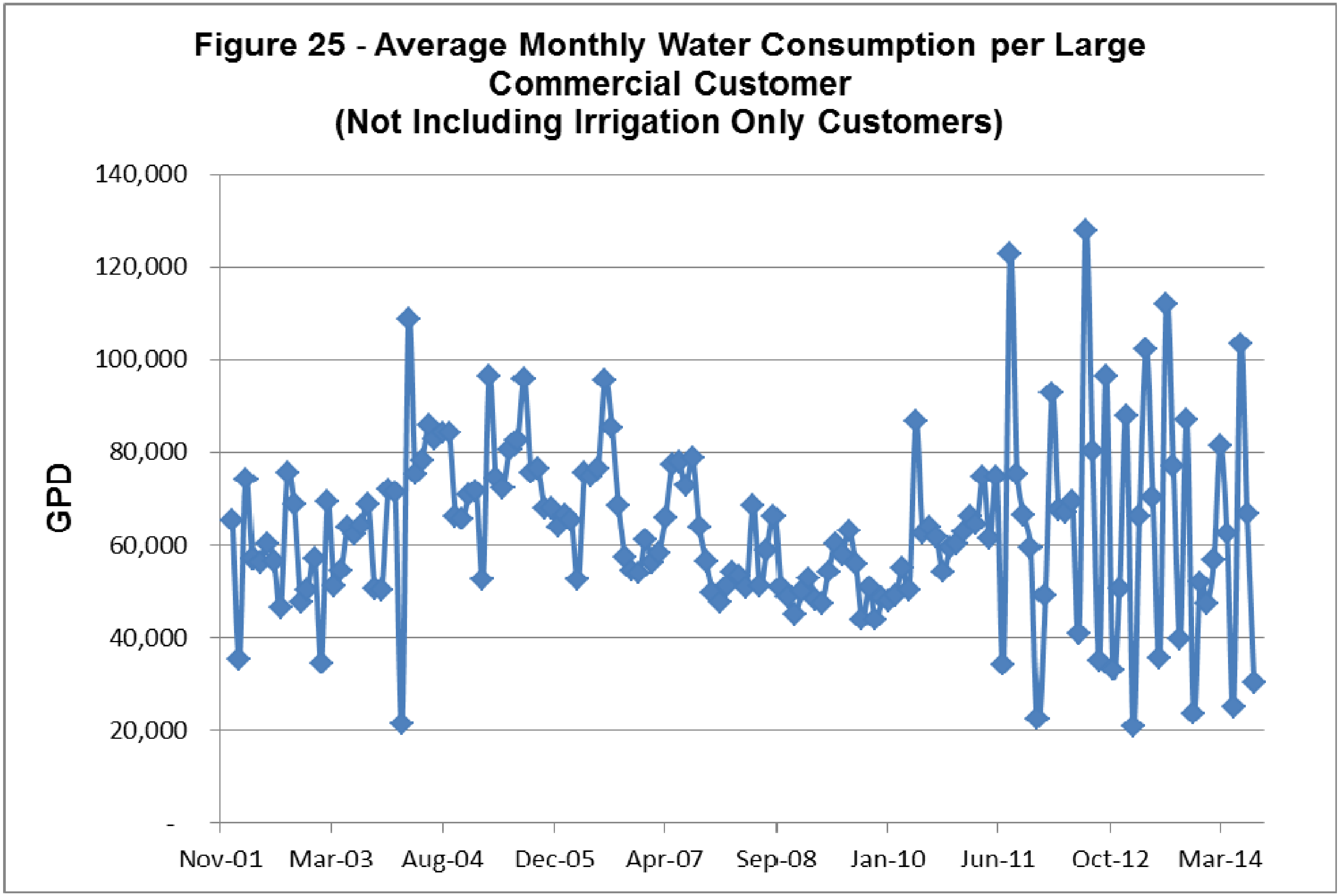


Figure 25 - Average Monthly Water Consumption per Large Commercial Customer
(Not Including Irrigation Only Customers)
GPD
140,000
120,000
100,000
80,000
60,000
40,000
20,000
-
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

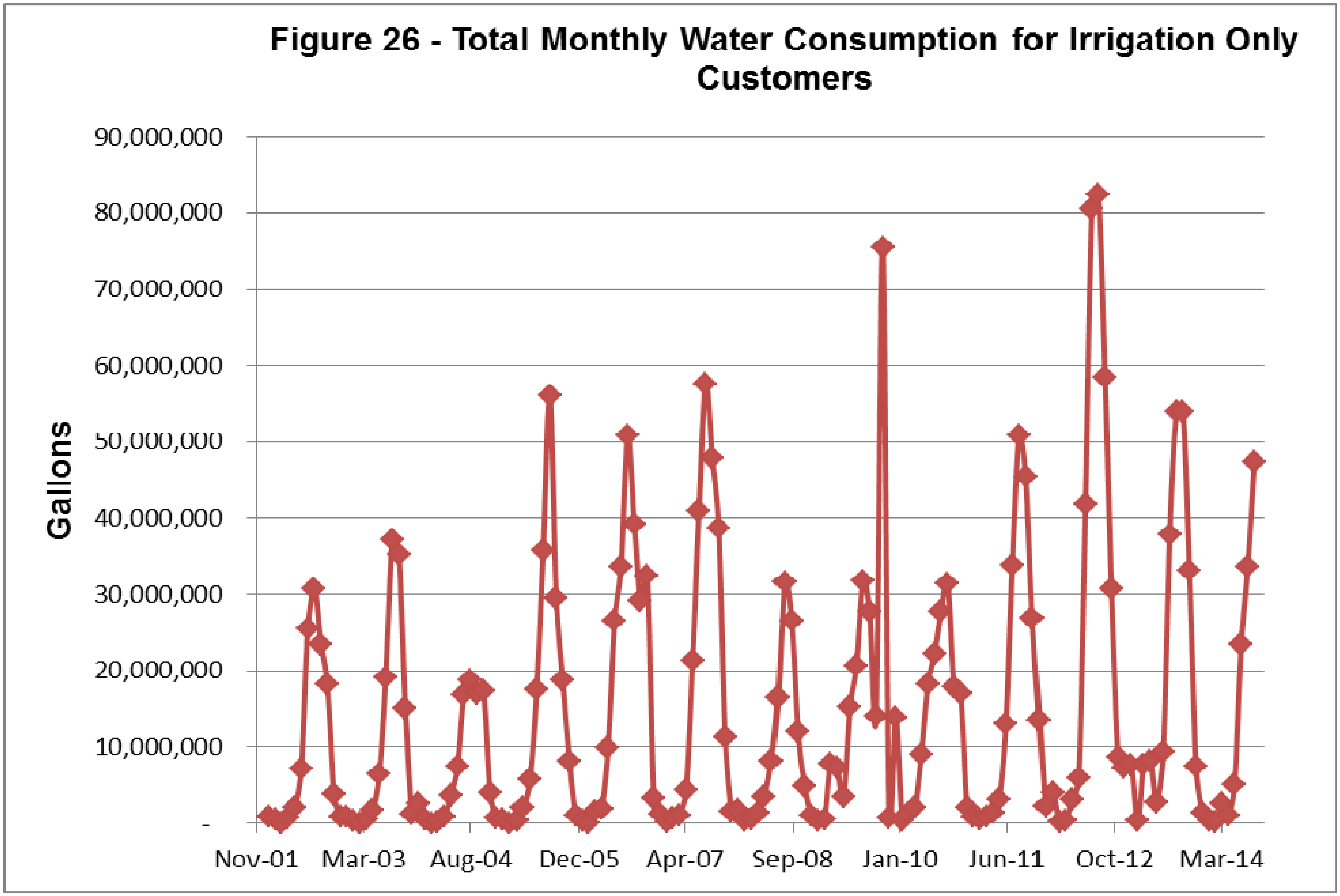
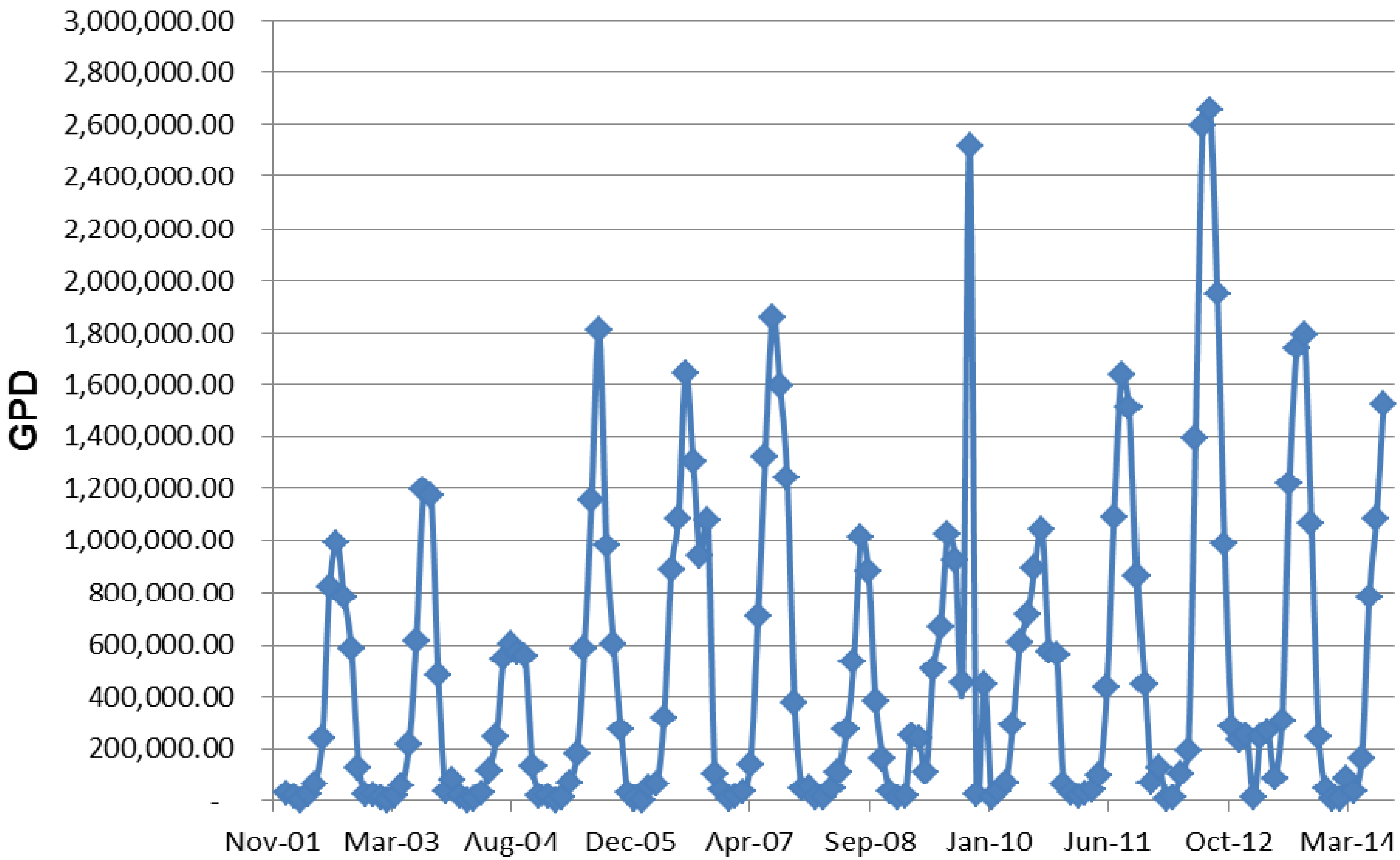


Figure 26 - Total Monthly Water Consumption for Irrigation Only Customers
Gallons
90,000,000
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
-
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

Figure 27 - Average Monthly Water Consumption for Irrigation Only Customers



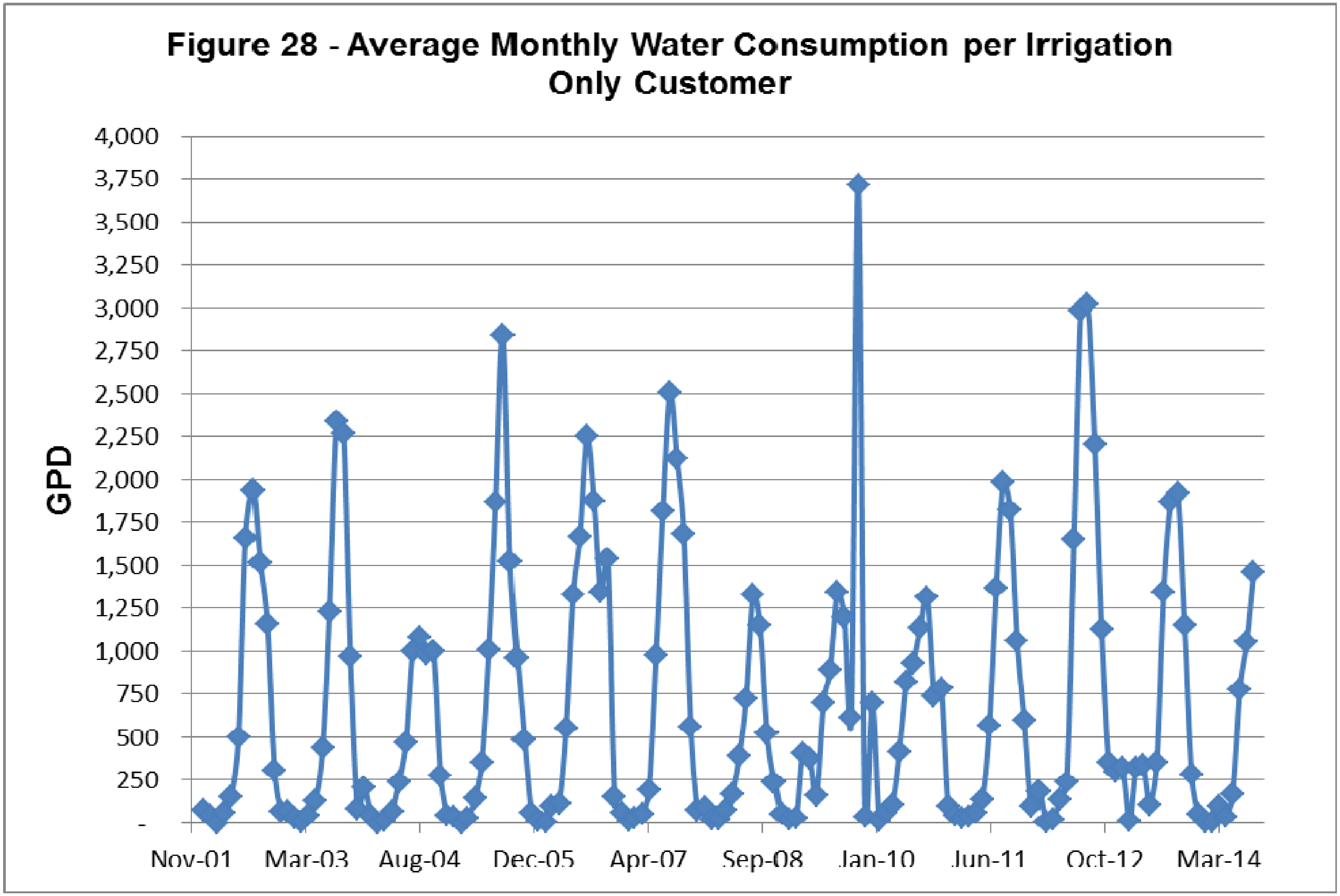


Figure 28 - Average Monthly Water Consumption per Irrigation Only Customer
GPD
4,000
3,750
3,500
3,250
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
-
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

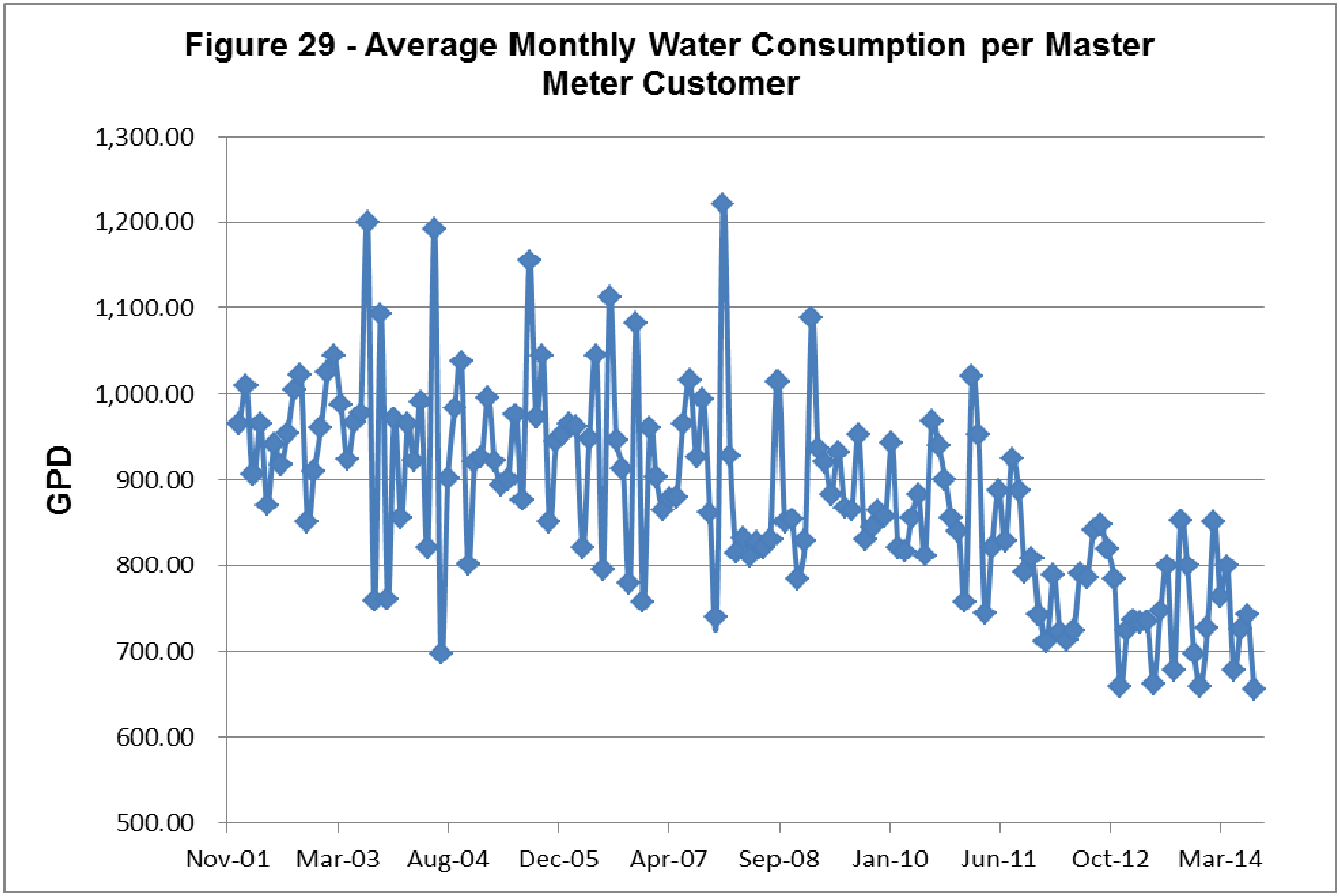


Figure 29 - Average Monthly Water Consumption per Master Meter Customer
GPD
1,300.00
1,200.00
1,100.00
1,000.00
900.00
800.00
700.00
600.00
500.00
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

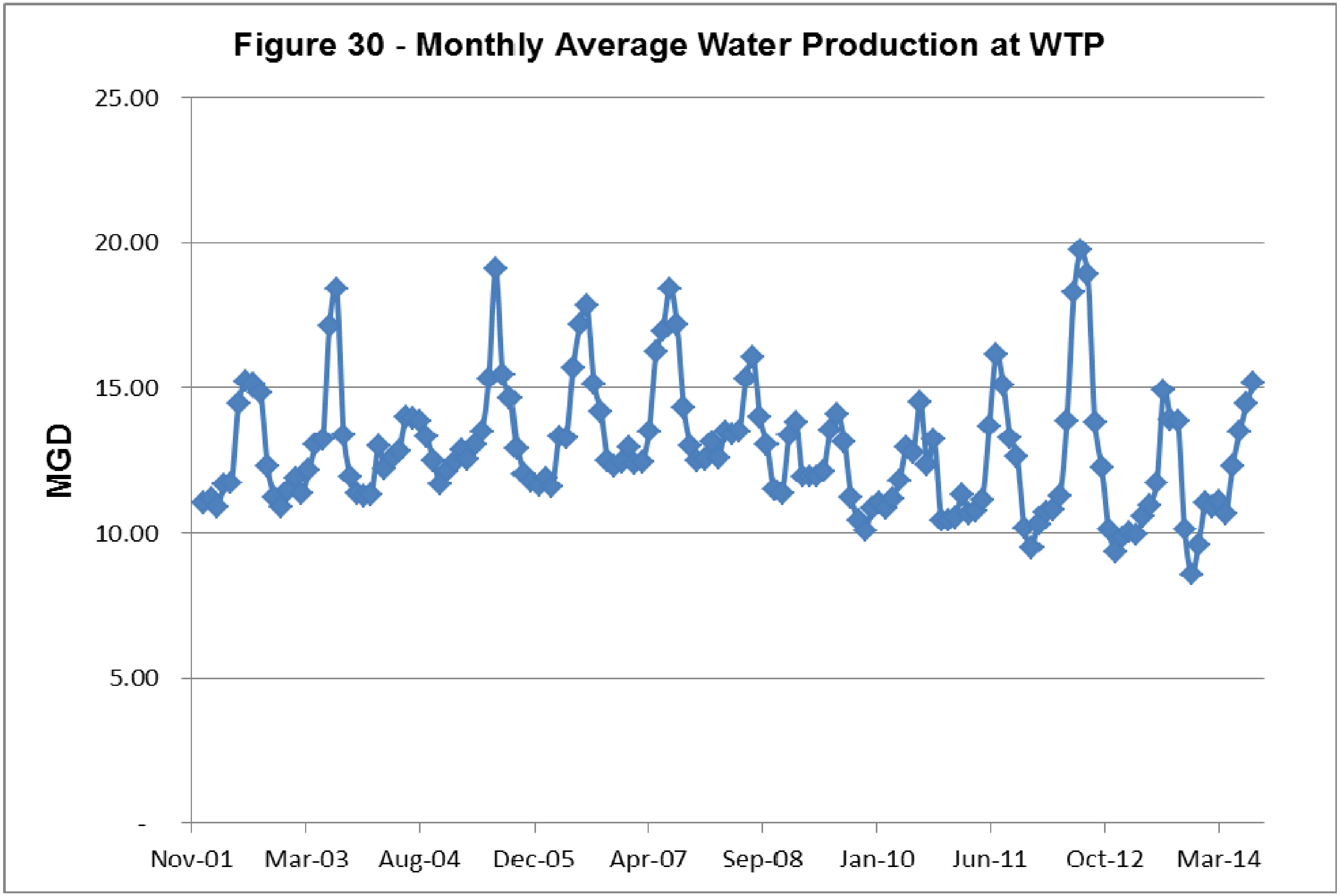


Figure 30 - Monthly Average Water Production at WTP
MGD
25.00
20.00
15.00
10.00
5.00
-
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

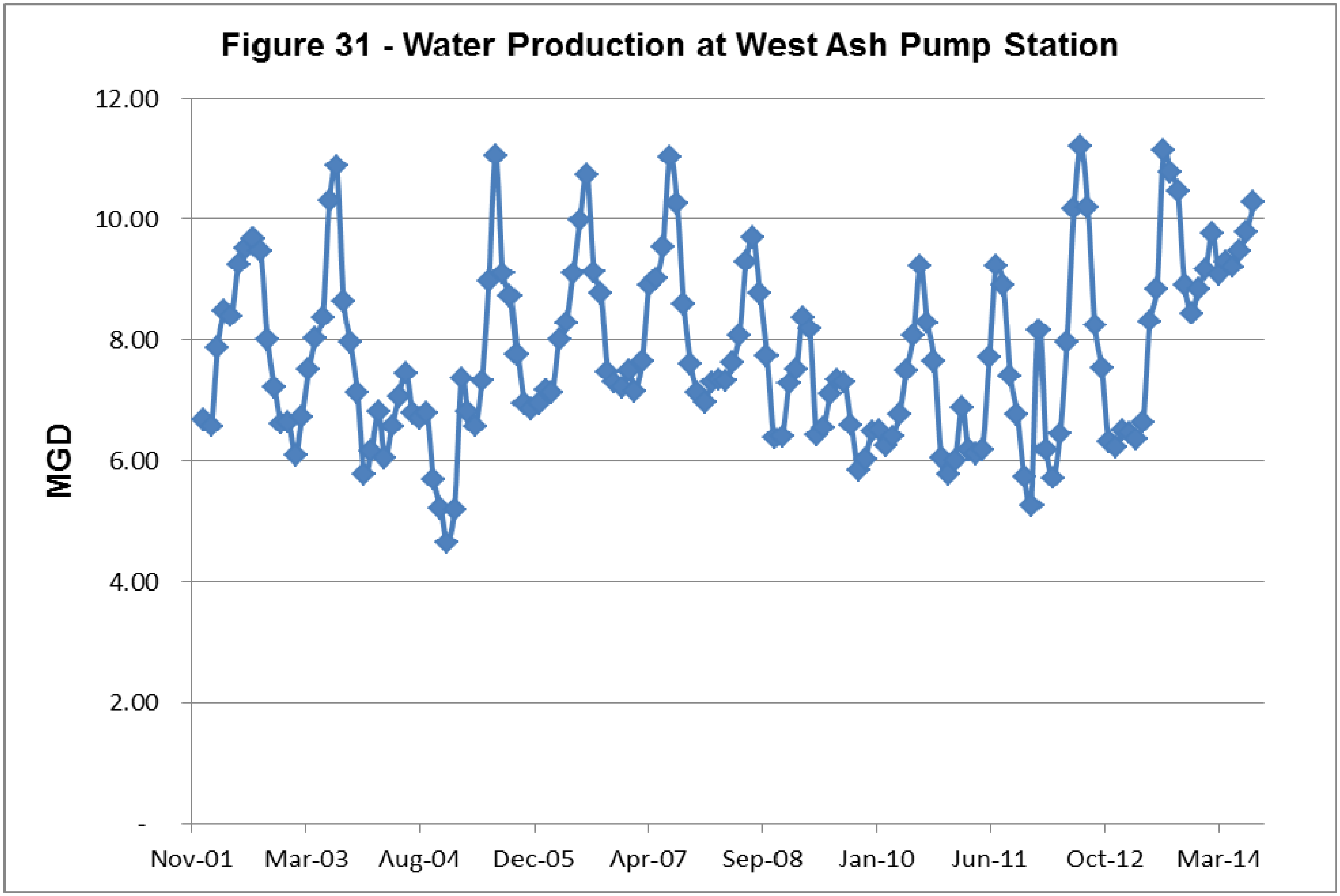


Figure 31 - Water Production at West Ash Pump Station
MGD
12.00
10.00
8.00
6.00
4.00
2.00
-
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

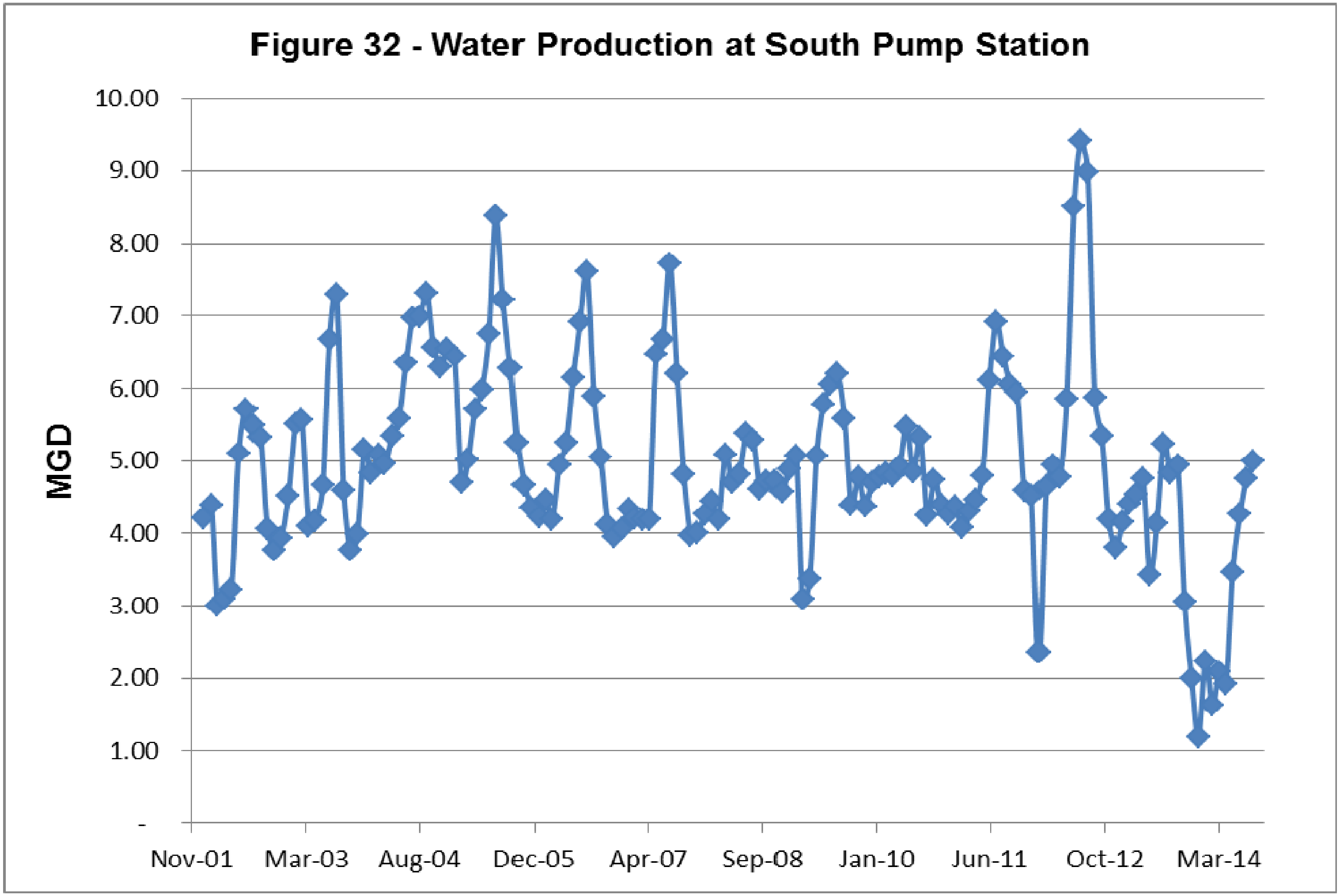


Figure 32 - Water Production at South Pump Station
MGD
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
-
Nov-01
Mar-03
Aug-04
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11
Oct-12
Mar-14

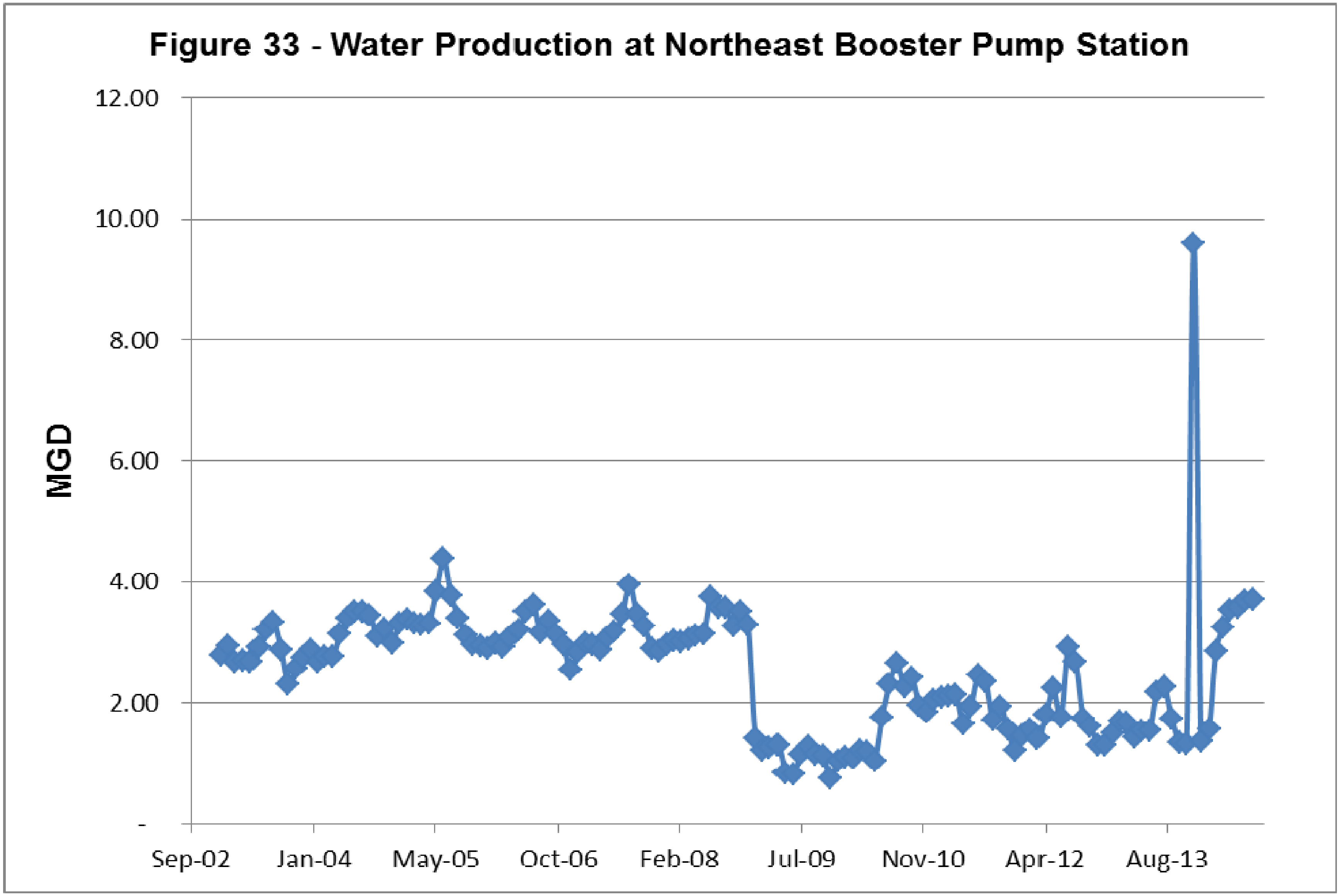


Figure 33 - Water Production at Northeast Booster Pump Station
MGD
12.00
10.00
8.00
6.00
4.00
2.00
-
Sep-02
Jan-04
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13

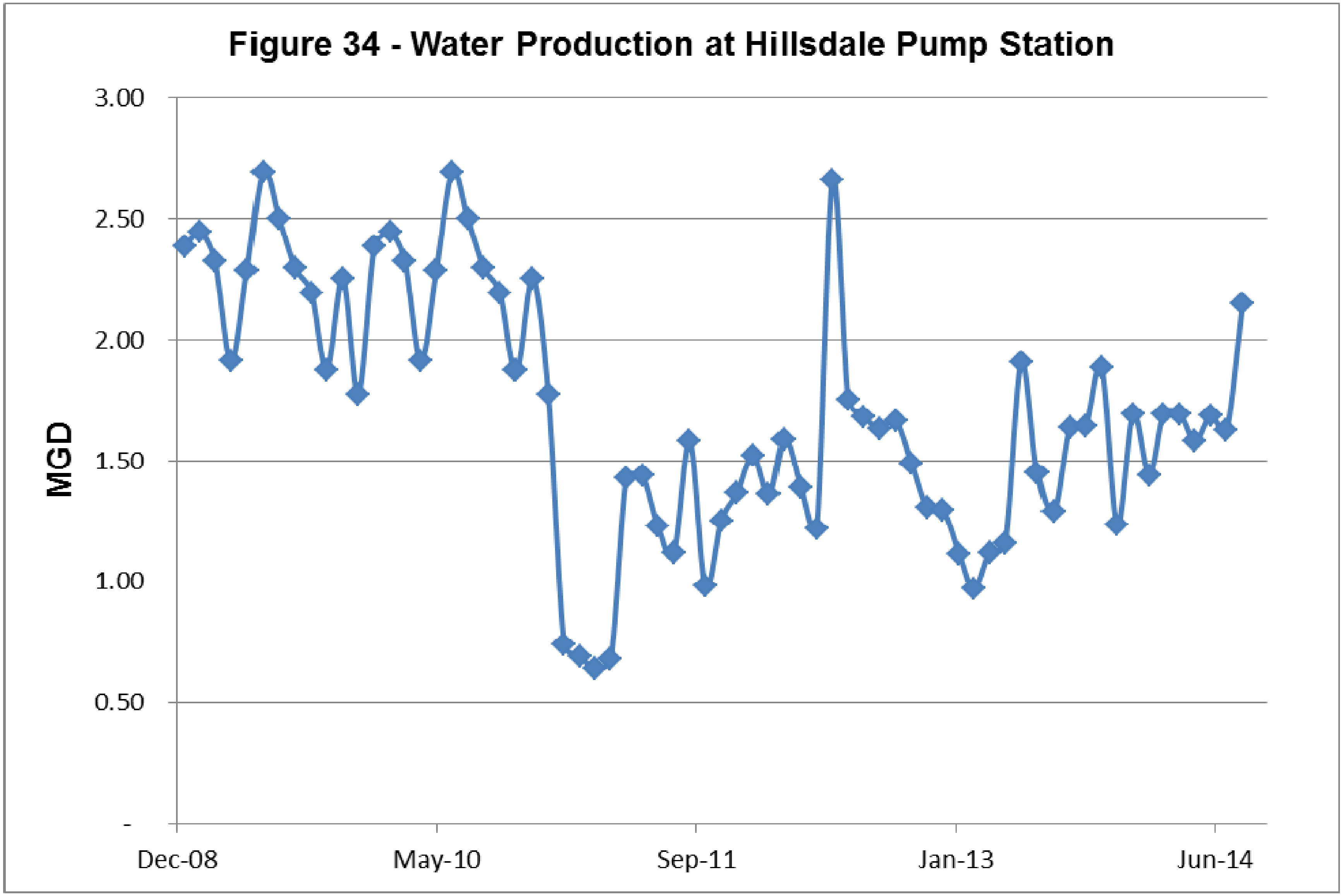


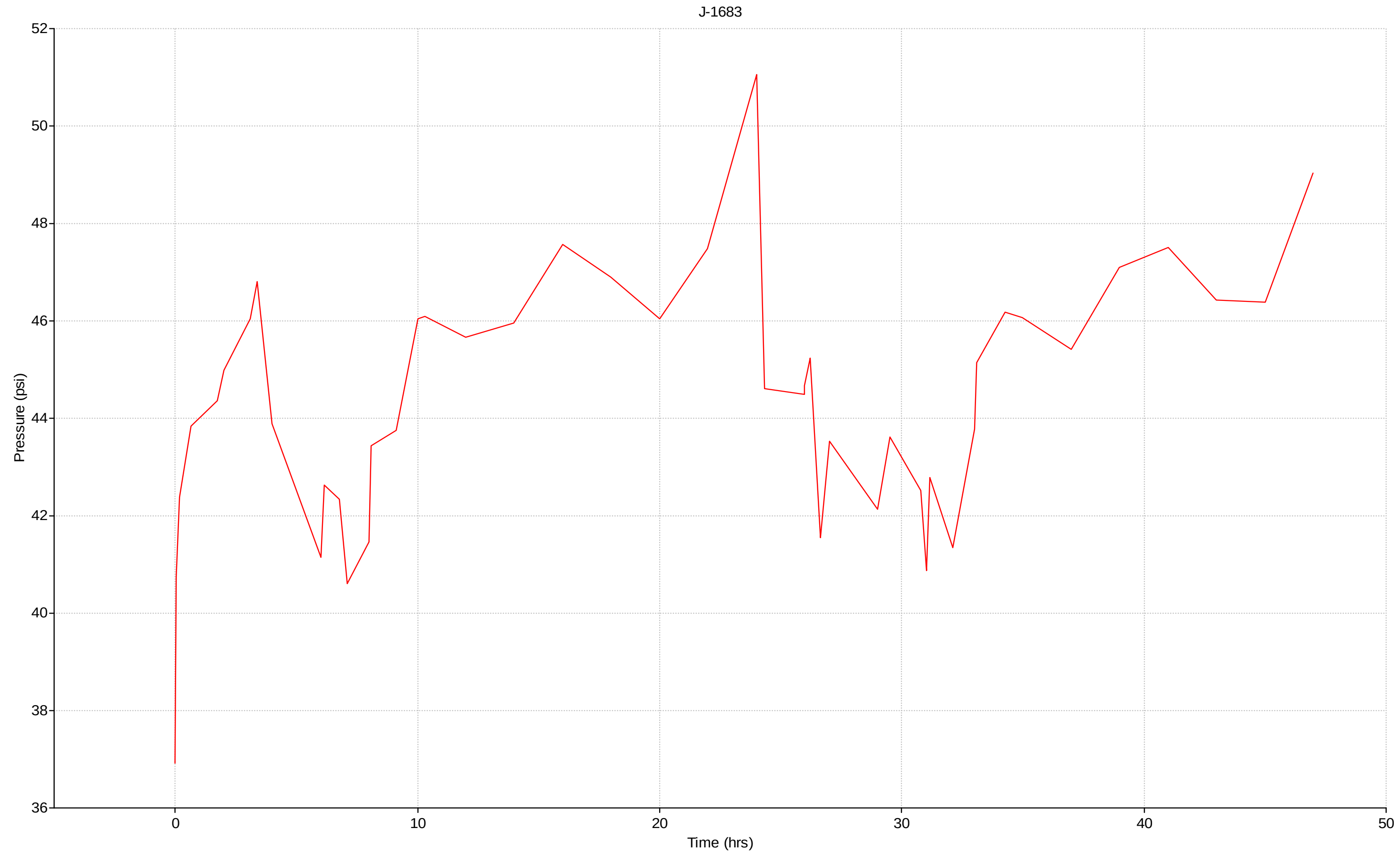
Figure 34 - Water Production at Hillsdale Pump Station
MGD
3.00
2.50
2.00
1.50
1.00
0.50
-
Dec-08
May-10
Sep-11
Jan-13
Jun-14

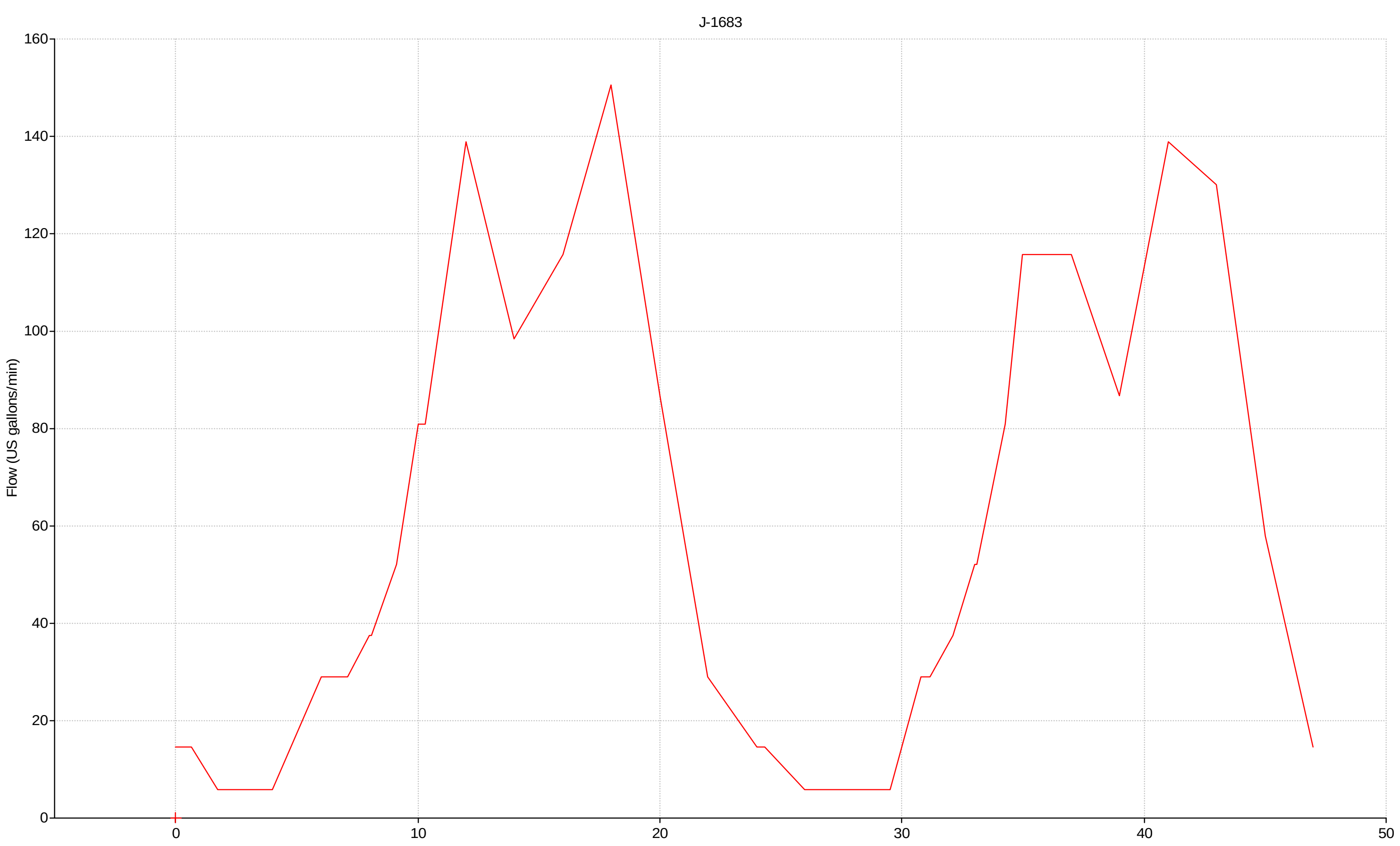
APPENDIX 2

Discovery Ridge Model Results

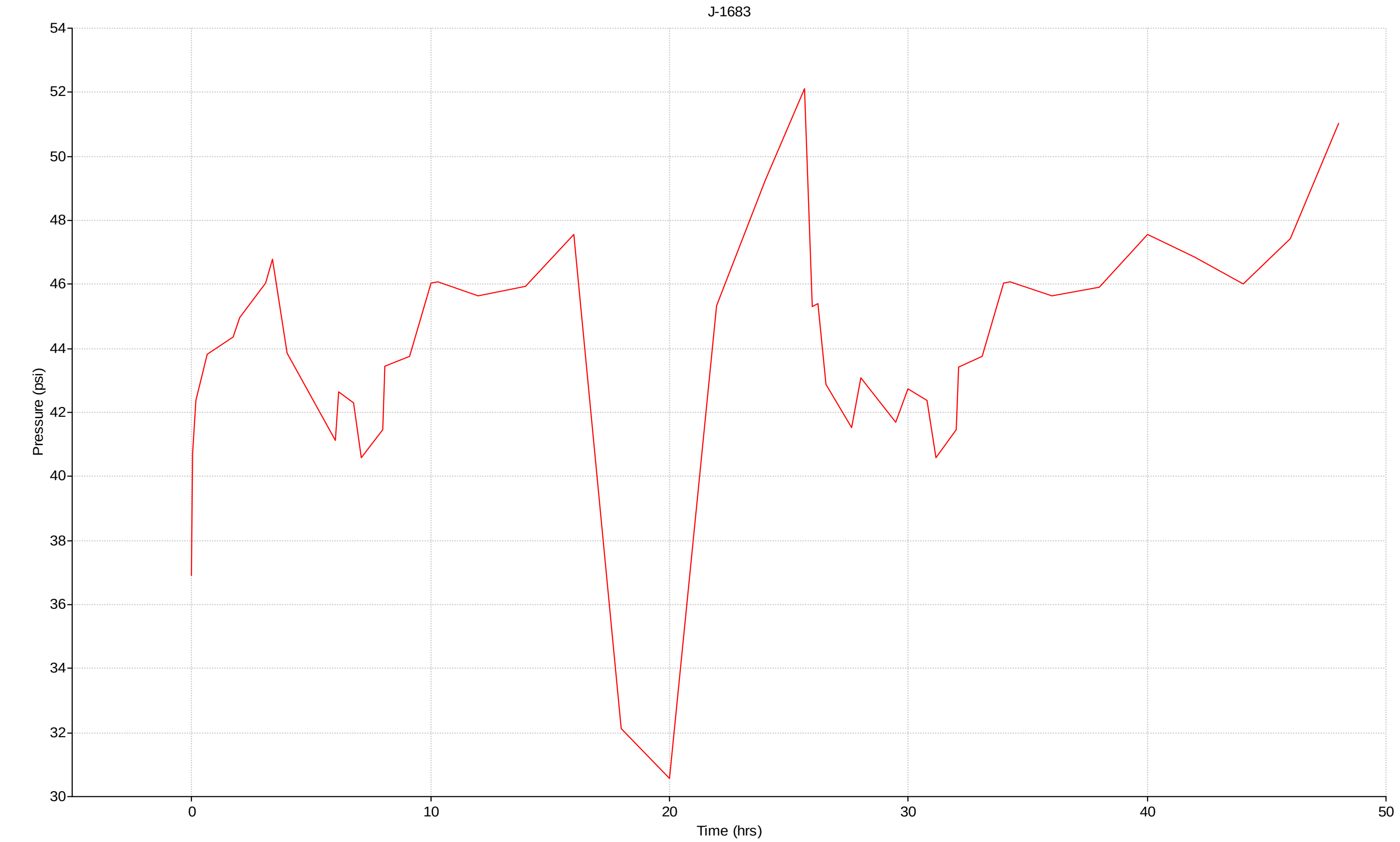
KYPIPE Model Results - 2018 peak new res.kyp

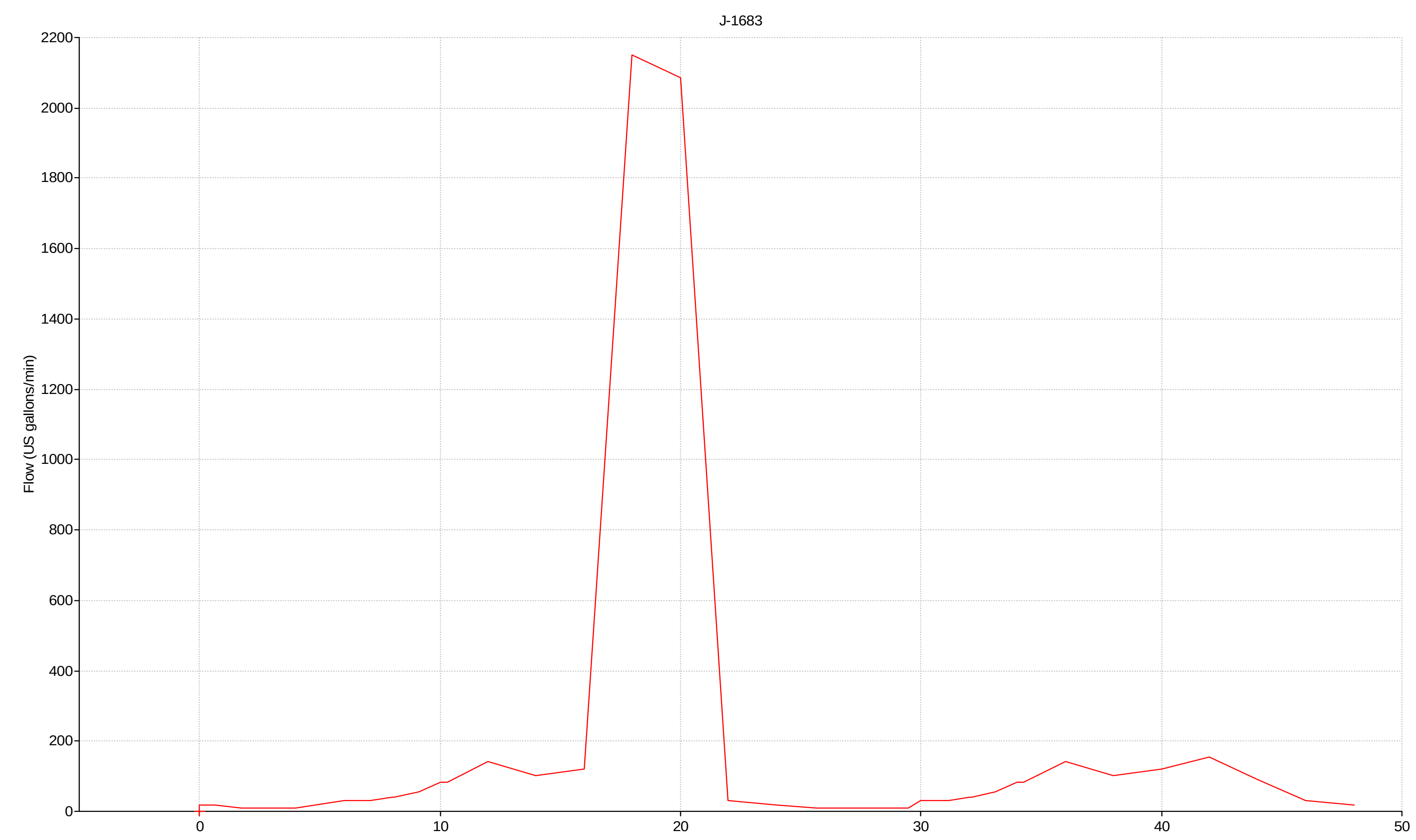
300 Residential Users





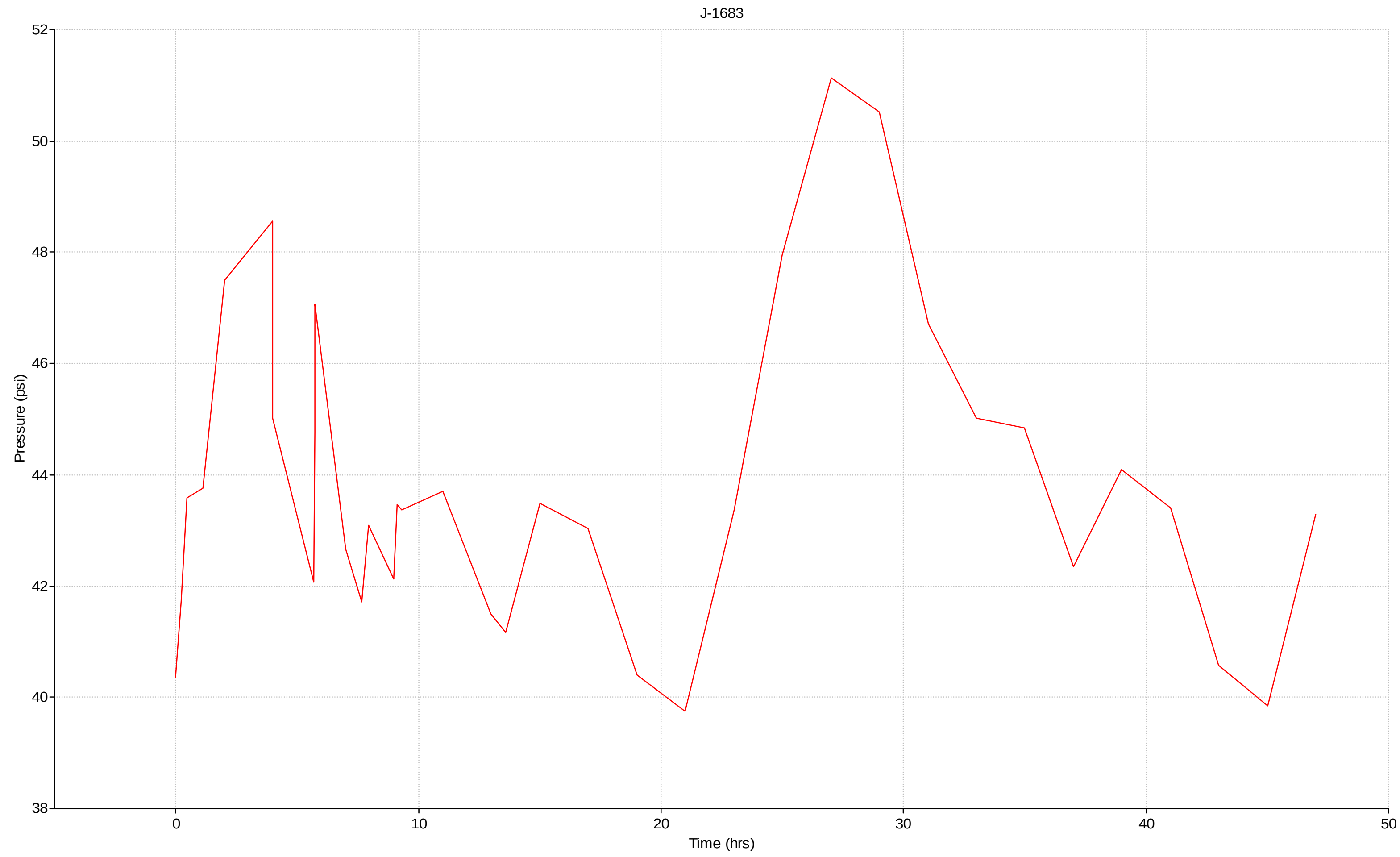
300 Residential Users plus 2,000 GPM Fire Flow

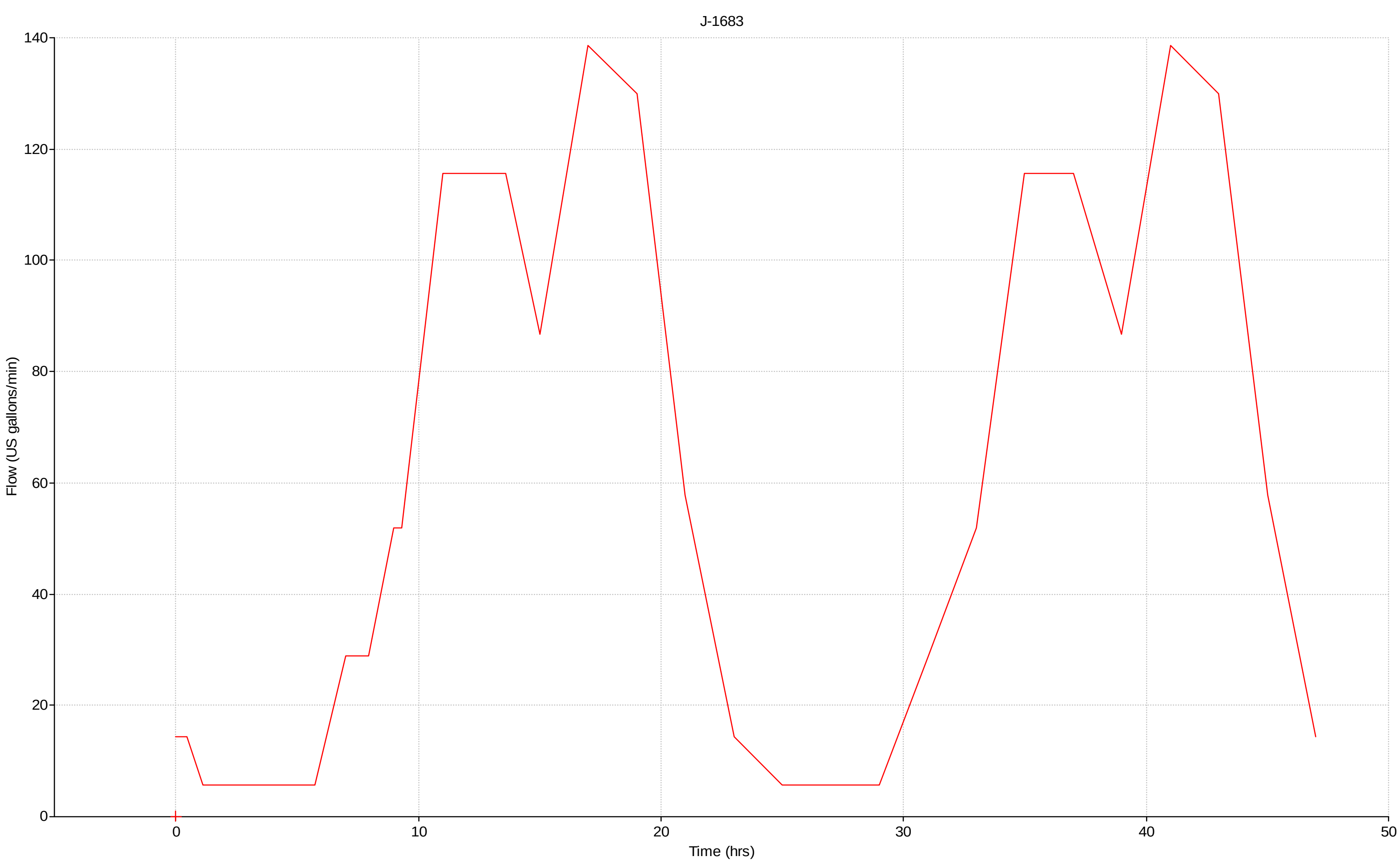


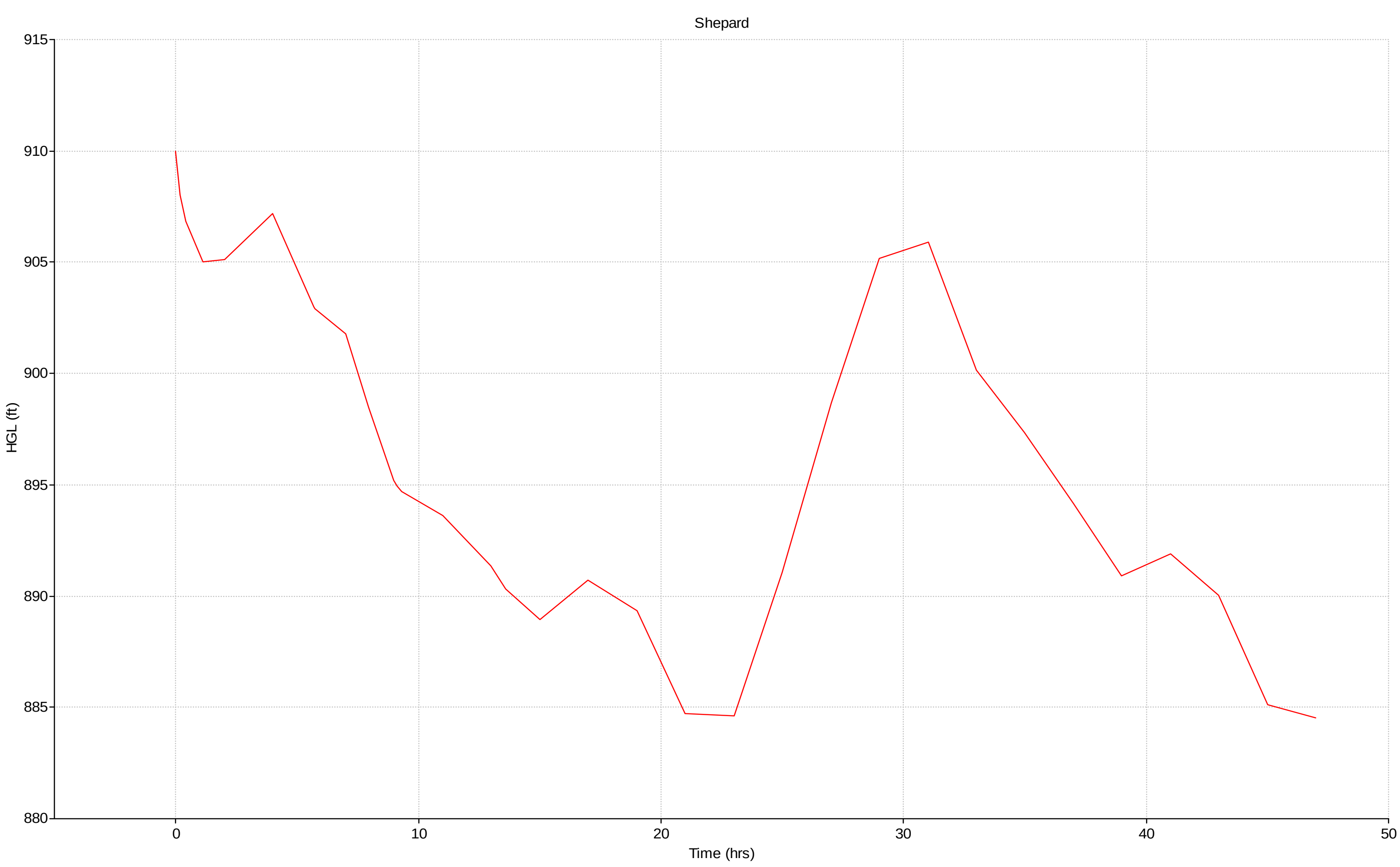


Shepard

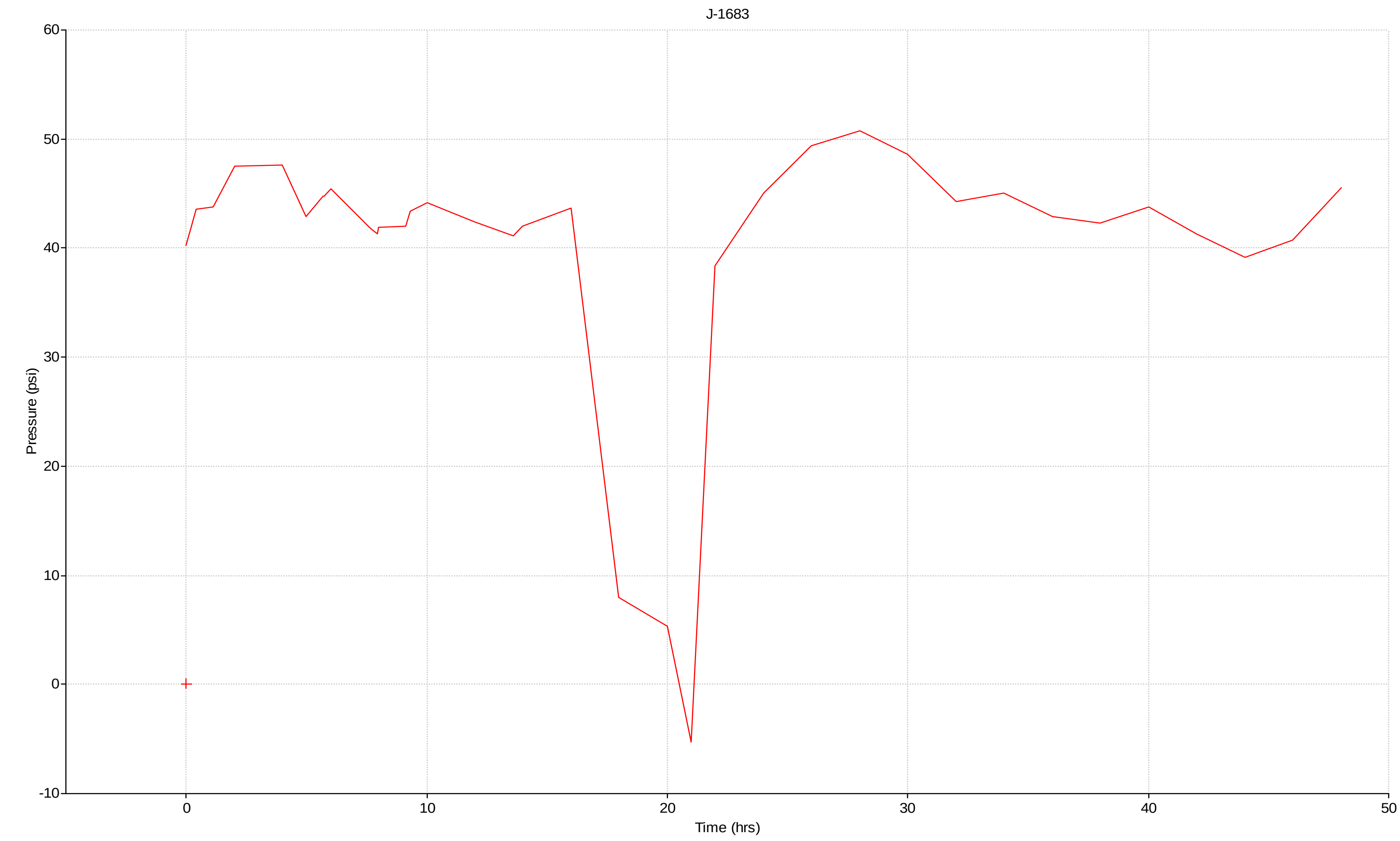
2023 Demands - 300 Residential Users

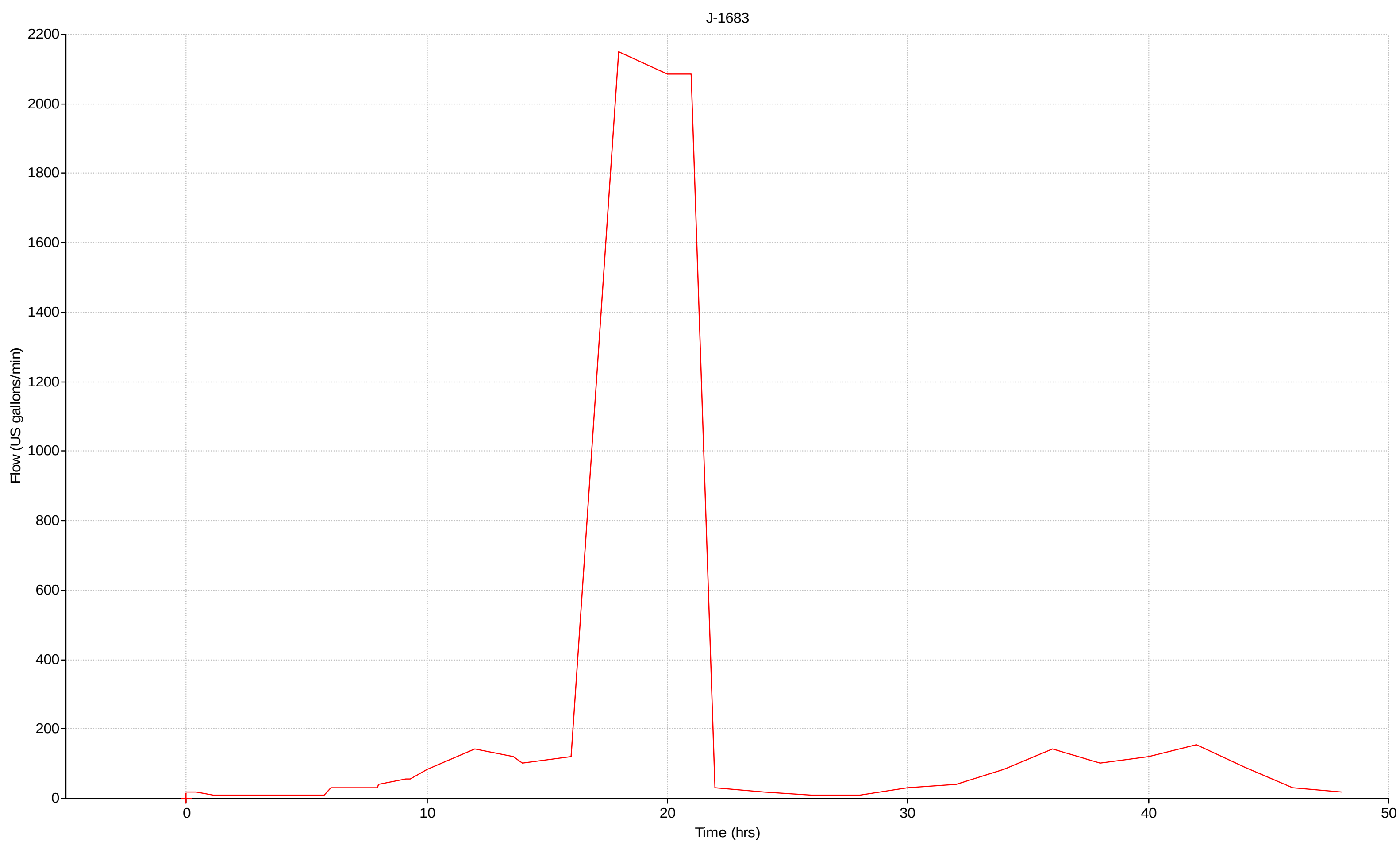


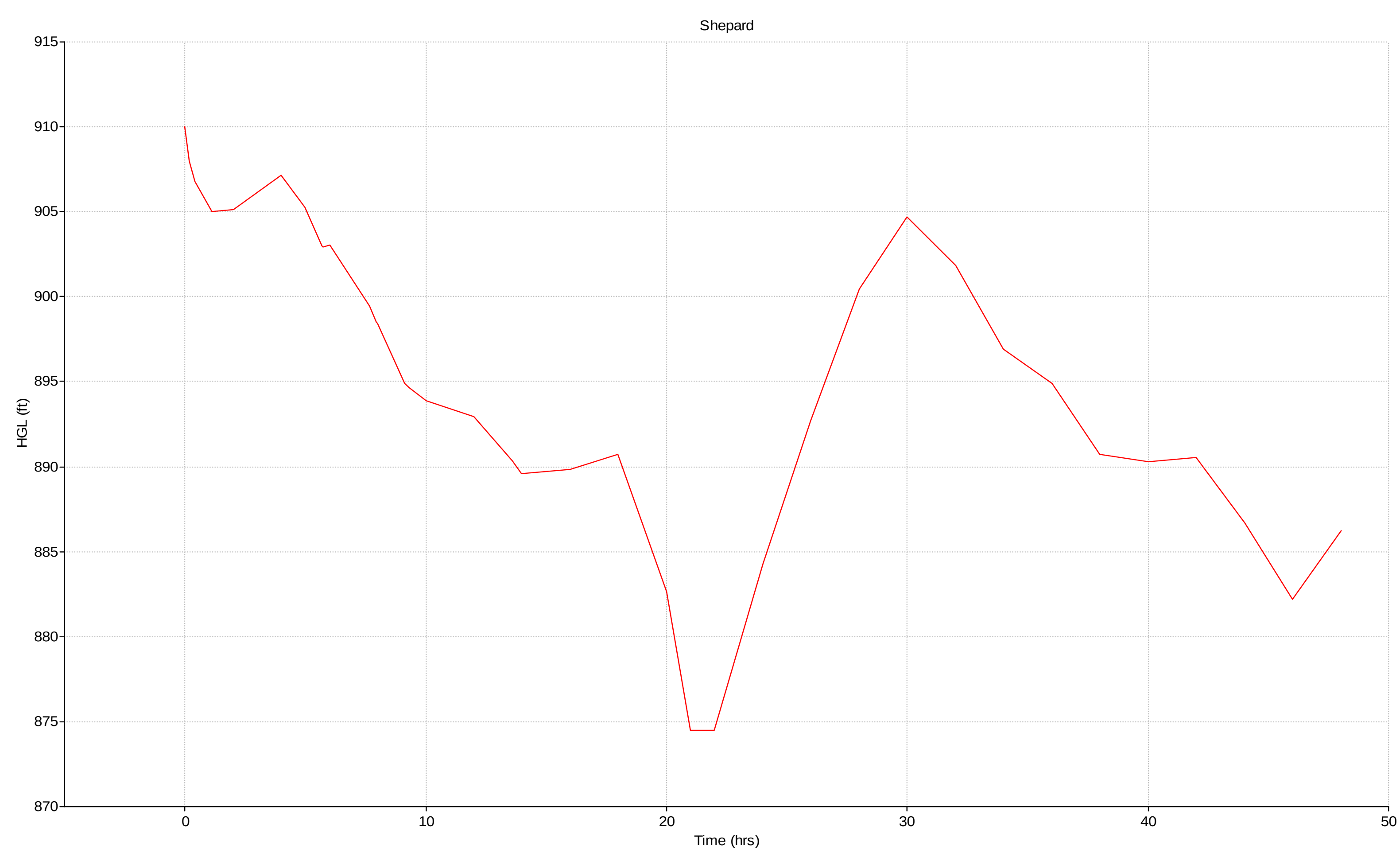




2023 Demands - 300 Residential Users plus 2,000 GPM Fire Flow







2023 Demands - 300 Residential Users plus 800 GPM Fire Flow