4 Water Requirements

Projections of customer demands serve as the basis for capital improvements planning. Several standard methods were used in this study to project water supply and storage needs based on estimates of population and community growth. This section summarizes the methodology used and the results of these projections.

4.1 Water Consumption History

An analysis was made of past water consumption characteristics by reviewing annual pumpage and water sales records for the period from 2000 to 2016. Average and maximum day water consumption during this period, together with the amount of water sold in each customer category, has been analyzed. Projections of future water requirements are based on the results of this analysis, coupled with estimates of population and community growth discussed in Section 2.

A summary of recent historical water sales and pumpage is provided in Table 4-1. Over the 12 year period of data summarized in the table, average daily water pumpage varied from a low of 4.52 million gallons per day (MGD) in 2015 to a high of 5.87 MGD in 2012 which was a dry and hot year, which may have led to increased outdoor water use. Over the past decade, overall water use, in proportion to population have declined significantly. It is likely that prior to this recent trend, the high water use rates in the early 2000's can be attributed to high growth and building rates. New residential homes, built on sizable lots tend to utilize more water for irrigation, especially when new lawns are being established. With the City now settled into more steady growth patterns, after the previous rescission, a tendency to conserve water can be seen in the resulting data.

4.2 Water Demands By Customer Category

A historical summary of utility customers served is provided in Table 4-2. Residential customers, over the past five years, have accounted for 61 percent of the SPUC's sales. Commercial and Industrial customers, over the past five years, have accounted for 39 percent of the SPUC's sales. Public uses account for approximately 5 percent of total sales. Unaccounted water, either by leak, meter errors, theft, breaks and/or flushing comprised approximately 6.2 percent of total water use over the past five years.

Table 4-1 – Historical Water Use

Year	Population	Average Day (AD) Water Pumped (MGD)	Maximum Day (MD) Water Pumped (MGD)	MD:AD Ratio	AD Per Capita Water Use (gpd)	MD Per Capita Water Use (gpd)
2007	33,022	5.56	14.68	2.64	168	445
2008	33,748	5.09	13.59	2.67	151	403
2009	34,525	5.12	12.83	2.51	148	372
2010	37,366	4.71	10.62	2.26	126	284
2011	38,000	4.81	10.80	2.25	127	284
2012	**38,730**	**5.87**	**16.26**	**2.77**	**152**	**420**
2013	39,167	4.94	13.38	2.71	126	342
2014	39,448	4.59	10.88	2.37	116	276
2015	39,981	4.52	9.94	2.20	113	249
2016	41,657	4.74	11.58	2.44	114	278
5 Year Average (skip 2012)		**4.72**	**11.31**	**2.39**	**119**	**286**
Maximum		*5.87*	*16.26*	*2.77*	*168*	*445*

Table 4-2 – Historical Average Water Sales by Customer Class

Year	Water Sold			Water Pumped	
	Average Day Residential Water Sold (MGD)	Average Day Commercial-Industrial Water Sold (MGD)	Total Average Day Water Sold (MGD)	Average Day Water Pumped (MGD)	Unmetered & Unaccounted Water (%)
2007	3.11	2.10	5.21	5.56	6.3%
2008	2.94	1.88	4.82	5.09	5.2%
2009	3.09	1.82	4.92	5.12	3.9%
2010	2.68	1.72	4.40	4.71	6.5%
2011	2.81	1.80	4.61	4.81	4.1%
2012	**3.25**	**2.06**	**5.31**	**5.87**	**9.5%**
2013	2.85	1.78	4.66	4.94	5.7%
2014	2.64	1.63	4.31	4.59	6.1%
2015	2.50	1.68	4.22	4.52	6.8%
2016	2.68	1.76	4.48	4.74	5.6%
5-Year Average (skip 2012)	**2.69**	**1.73**	**4.45**	**4.72**	**5.7%**
% of Total	**60%**	**40%**	**100%**		

4.3 Unaccounted Water

There is generally a close relationship between the total gallons of water pumped, and the gallons of water metered and sold to water utility customers. Total metered water sales are always less than the amount of pumpage due to several factors, including:

- Unmetered water usage for maintenance purposes such as hydrant flushing and water main repairs
- Unmetered water usage for fire fighting
- Inaccuracies in water metering devices
- Unaccounted-for public water consumption
- Leakage within the distribution system

The difference between total pumpage and total water sales is termed "unaccounted" water. The amount of unaccounted water is an indication of the condition of the water system and is most commonly expressed as a percentage. When a distribution system is very old or poorly maintained, the percentage of water loss often increases dramatically. Unaccounted water was shown in Table 4-2. Since 2012, the commission has averaged 6.7 percent unaccounted water, which is better than many communities throughout the country.

For future planning purposes, the 2012 drought year of **9.5 percent** will be assumed for future unaccounted water. It should be noted that there was a leaking water main discovered during the 2012 water use which led to higher than expected water loss. Nonetheless, this design year water loss figure will still be utilized for planning purposes as the potential for future unforeseen losses can be assumed for a conservative water needs estimate.

4.4 Large Water Customers

The SPUC serves multiple large water customers. The 10 largest customers are shown in Table 4-3, and these customers comprised approximately 15 percent of total sales in 2016. For future planning, the sales to the non-residential customers in Table 3-3 will be assumed constant.

Table 4-3 – 10 Largest Customers in 2016

Rank	Customer Name	Customer Category	Average Day Sales (MGD)	% of Water Sold (MGD)
1	Valley Fair	Commercial	0.131	2.9%
2	Metro Council Environmental Services	Commercial	0.105	2.3%
3	Canterbury Park	Institutional	0.072	1.6%
4	Certainteed Corporation	Commercial	0.068	1.5%
5	Women's Correctional Facility	Institutional	0.067	1.5%
6	Providence Pointe Townhomes	Residential	0.051	1.2%
7	Seagate Technology LLC	Commercial	0.051	1.1%
8	ISD #720	Institutional	0.043	1.0%
9	St. Francis Regional Medical	Commercial	0.041	0.9%
10	Amazon.com.nvdc, INC	Commercial	0.031	0.7%
		Total (Sold By SPUC)	**0.660**	14.8%

4.5 Variations in Water Use

4.5.1 Seasonal Variations

Seasonal fluctuations in water usage are important factors in the design and sizing of water supply and storage facilities. The seasonal nature of water consumption in SPUC can be demonstrated by an analysis of monthly pumpage variations. The SPUC's monthly pumpage variations in 2016 are presented in Figure 4-1. In 2016, the maximum monthly pumpage occurred in July, while the minimum monthly pumpage occurred November through March.

Figure 4-1 revealed an interesting trend of the 2016 water use. During the cold-season months the average day pumpage was almost constant, at an average of 3.06 mgd. In Table 4-2, the 2016 average day pumpage was 4.74 mgd. Thus, the warm months raised the annual average day pumpage from 3.06 mgd to 4.74 mgd. In Figure 4-2, approximately 54 percent of pumpage occurred in four months, the months of May through August. Shakopee experiences a substantial warm-season water demand compared to the cold-season. A portion of this increased summer water consumption can be attributed to some of the largest water users in the City including Valley Fair and Canterbury Park which operate at peak capacity during the summer months.

Figure 4-1: 2016 Monthly Water Use

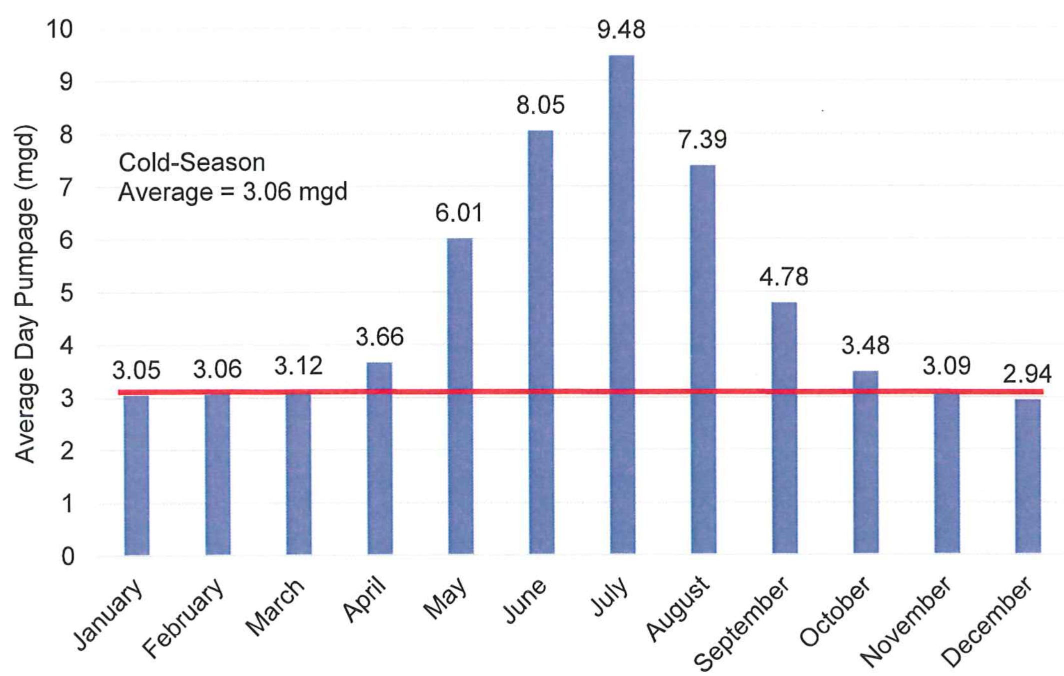
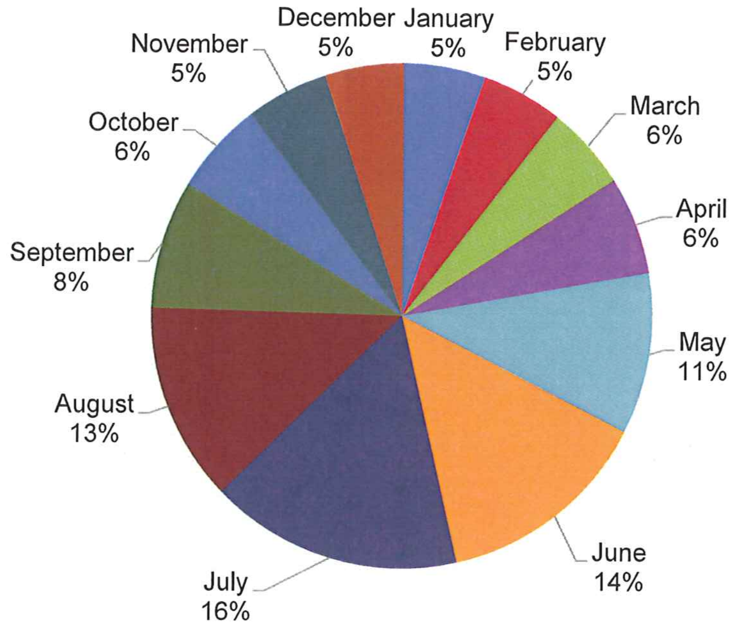


Figure 4-2: Distribution of 2016 Monthly Water Use



4.5.2 Effect of Drought

In addition large seasonal water users, Shakopee experiences high water use in the warm months due to irrigation and lawn watering. Information from Table 4-1 was compared with climate data in Table 4-4. Of the ten years in the table, year 2012 had the highest average summer daily high temperature and had the second lowest summer rainfall. Year 2012 had the highest average day and maximum day demands in the past 10 years. The combination of high temperatures and low rainfall, substantiates summer water demand, and in-turn, the maximum day demand. During a drought year, such as 2012, the maximum day demand increases to a very high value not generally observed in normal years with more typical rainfall.

Table 4-4 – Historical Water Use

Year	Summer Precipitation (inches)	Average Summer High Temperature (°F)	Average Day (AD) Water Pumped (MGD)	Maximum Day (MD) Water Pumped (MGD)	MD:AD Ratio
2007	18.7	80.2	5.56	14.68	2.64
2008	7.3	80.4	5.09	13.59	2.67
2009	9.1	77.8	5.12	12.83	2.51
2010	13.5	80.3	4.71	10.62	2.26
2011	8.6	81.0	4.81	10.80	2.25
2012	**6.6**	**82.8**	**5.87**	**16.26**	**2.77**
2013	6.9	81.8	4.94	13.38	2.71
2014	6.1	78.3	4.59	10.88	2.37
2015	15.0	79.4	4.52	9.94	2.20
2016	18.4	80.0	4.74	11.58	2.44
5 Year Average (skip 2012)			**4.72**	**11.31**	**2.39**
Maximum (2012)			*5.87*	*16.26*	*2.77*

Source: NOAA Online Data

It is recommended that the commission plan for drought conditions, however, drought conditions may be handled using multiple approaches. These approaches are briefly discussed later in the "Water Conservation" section.

4.6 Hourly Demand Fluctuations

The hour-to-hour variation of customer demands is also an important characteristic used to evaluate water supply and storage requirements. As with maximum day demands, peak hour is often expressed as a ratio to the average demand of any particular day. The peak hour demand is the hour of maximum demand that occurs on the maximum day, and is thus assumed to be the peak hour of the year.

The peak hourly rate for Shakopee was estimated to be approximately 160 percent of the maximum day rate. This estimate is based on a typical AWWA diurnal curve in residential communities. This diurnal curve will be used to determine storage equalization needs of the community.

4.7 Per Capita Usage

Water use is often proportional, and is therefore correlated with a community's population. An analysis of per capita water consumption for the SPUC water system for the two customer classifications was made from the available sales records and is summarized in Table 4-5.

SPUC's residential per capita sales have varied over the previous 5 years, averaging approximately 68 gallons per capita per day (gpcd) over the recent 5-year period (skip 2012). Likewise, SPUC's commercial and industrial per capita sales have varied over the previous 5 years, averaging approximately 44 gallons per capita per day (gpcd) over the recent 5-year period (skip 2012). Water conservation will be considered as part of future planning in the following section.

From Table 4-3, nine of the ten largest customers were non-residential. These nine customers comprised 0.61 mgd of the 1.76 mgd average day non-residential sales (35 percent). For future planning purposes, 35 percent of existing non-residential sales will be assumed constant and 65 percent of sales will be attributed to population.

Table 4-5 – Historical Per Capita Water Use by Customer Class

Year	Sales			
	Residential Daily Per Capita Water Use (gpcd)	Commercial-Industrial Daily Per Capita Water Use (gpcd)	Total Average Day Water Sold (gpcd)	Total Average Day Water Pumped (gpcd)
2007	94	64	158	168
2008	87	56	143	151
2009	90	53	142	148
2010	72	46	118	126
2011	74	47	121	127
2012	**84**	**53**	**137**	**152**
2013	73	45	118	126
2014	67	41	108	116
2015	62	42	104	113
2016	64	42	106	114
5-Year Average	**68**	**44**	**112**	**119**
% of Total	**61%**	**39%**	**100%**	

4.8 Water Conservation

Water conservation occurs in two different forms, active conservation and passive conservation. Active conservation efforts include mechanisms such as educational programs, customer incentives and conservation ordinances while passive conservation results are a product of the installation of water efficient fixtures (toilets, showerheads and washers) implemented by manufacturing standards and plumbing codes which may or may not be a result of intended conservation efforts.

Research has indicated that individual conservation efforts including educational programs, public information, school programs, retrofit programs, conservation ordinances, and/or regulations can reduce water use about 1%-4% per program. It should be also noted that indoor residential water use has decreased about 15.4 percent from 69.3 GPCD in 1999 to 58.6 GPCD in recent years nationwide. Furthermore, homes built according to EPA's water sense specification use 37 percent less water than the average home and 47 percent less water than an average home in 1999. In summary, when estimating projected water use, both active and passive water conservation should be accounted for.

As previously noted, nationwide per capita indoor water use has been trending downward. The Water Research Foundation previously published an executive report profiling the Residential End Use of Water in 1999 and followed up with a second version of the report in 2016. In Table 3-6, the report profiled water use trends across the country and found that per capita average water use has decreased from 69.3 gpcd in 1999 (REU 1999) to 58.6 gpcd in 2016 (REU 2016). The improved efficiency of clothes washers and toilets account for most of the water savings.

Table 4-6 – Indoor Conservation Potential - Per Capita Water Use

Water Use	REU 1999[1]	REU 2016[2]	2007 MWCP[3]	High Efficiency[4]
Showers	11.6	11.1	8.8	8.4
Clothes Washers	15	9.6	10	4.7
Dishwashers	1	0.7	0.7	0.4
Toilets	18.5	14.2	8.2	6.1
Baths	1.2	1.5	1.2	5.8
Leaks	9.5	7.9	4	3.2
Faucets	**10.9**	**11.1**	**10.8**	**6.5**
Other Domestic Uses	1.6	2.5	1.6	1.6
TOTAL	**69.3**	**58.6**	**45.3**	**36.7**

[1] 1999 report, Residential end use of water (REU 1999)

[2] 2016 report, Residential end use of water, Version 2 (REU 2016)

[3] 2007 Madison Water Conservation Plan (Vickers, Amy. 2002. Handbook of Water Use and Conservation: Homes, Landscapes, Industries, Businesses, Farms.

[4] High Eff from 2016 report, Residential end use of water, Version 2 (REU 2016)

Even without an intentional conservation program and or effort to switch to more efficient fixtures, reductions in total water use will be expected as old toilets and washers wear out. Per capita water use has the potential to be reduced to 36.7 gpcd in the future (REU 2016). For purposes of this report, Table 4-6 will be considered the maximum water use reduction potential used in the most optimal conservation effort.

4.8.2 Residential Water Conservation

Table 4-5 showed residential water use to be approximate 84 gpcd in 2012. Table 4-6 reported that, nation-wide, communities could reduce residential demands to as low as 36.7 gpcd. However, with each step to decrease average day residential demand, the next step becomes increasingly more difficult. Challenges include 1) recruiting customer participation, 2) costs of incentive programs, 3) public relations when conservation disagrees with customer interests, and/or 4) maintaining adequate water utility revenues with decreasing sales. It is recommended that the utility devise and initiate a public outreach program to learn what methods should be used to reduce residential water demand.

For the purpose of future planning, the rate of residential sales in 2012 of approximately **84 gpcd** will be projected into the future. If the utility promotes conservation during drought seasons, this value should reduce.

4.8.3 Non-Residential Water Conservation

Table 4-5 showed non-residential water use to be approximate 53 gpcd in 2012, with large customers excluded. Conservation for non-residential customers can become challenging, as each non-residential customer has to be individually examined for their ability to conserve water. The waterpark, for instance, must use increased water for the summer months. Restaurants and hotels must wash dishes, cook, and clean. Seasonal drivers determine when some of these businesses are required to use water, and summer tourism amplifies the summer water needs of businesses in Shakopee. It is recommended that the utility devise and initiate a public outreach program to learn what methods should be used to reduce non-residential water demand.

For the purpose of future planning, the non-residential sales in 2012 of approximately 2.06 mgd will be projected into the future, of which 35 percent will be assumed constant and 65 percent assumed to relate to population. Thus, **a fixed 0.72 mgd** (2.06 mgd x 35 %) will be assumed for large customers **with an additional 35 gpcd** (53 gpcd x 65 %) for population based non-residential water use. If the utility promotes conservation during drought seasons, these values should reduce.

4.8.4 Maximum Day Water Use Conservation

Conservation with regards to the Maximum day demand may provide more immediate benefit to SPUC, and SPUC is required to provide sufficient supply and storage for the maximum day demand. Conserving on the maximum day is usually connected to outdoor water use, such as lawn watering. Indoor water use is usually constant throughout the year, as people generally do not change their domestic hygiene habits from summer to winter. Conservation of outdoor water use, however, is challenging to achieve because it usually requires some degree of authority action, either by increasing rates (charging higher fees for excess water use) or by enforcement (writing citations). Alternate day lawn watering is used by many utilities; however, the water reduction of alternate day lawn watering is often offset (or even reversed) by excessive watering when watering occurs.

For the purposes of future planning, the design maximum day from 2012 will be used, corresponding to a **maximum day to average day ratio of 2.77** during a drought year.

4.9 Water Consumption & Pumpage Projections

Population growth, development, customer water needs, conservation, and climate all affect future water needs. This section provides a projection of water needs to year 2040 based on these factors. One projection is based on anticipated population growth and conservation. A second projection is based on buildout of all service areas.

4.9.1 System Wide Water Needs Projections

4.9.1.1 Projected Water Use By Population

Table 4-7 summarizes the population based water needs projections, first for current water use in a drought year, and then for a drought year if more aggressive conservation were pursued. Projects were solely based on the values from year 2012, as 2012 represents a hot and dry year when the system will be stressed for water. With the assumptions shown in the table, by 2040, SPUC could experience a maximum day demand of 24 mgd if year 2040 were a drought year. If aggressive conservation were pursued, the 2040 drought year maximum day could be reduced to around 17.7 mgd.

At the time of this report, the SPUC did not pursue further conservation efforts. Thus, **24 mgd by year 2040** will be the design basis of this report based on population. Appendix A provides a breakdown of each pressure zone. Table 4-8 summarizes each pressure zone.

4.9.1.2 Projected Water Use By Future Land Use

Apart from anticipated population growth, SPUC must be aware of all future potential water needs as development occurs and the City expands into new areas. The potential for future development exists as the City expands and grows to the South. The City of Shakopee plans to annex portions of the Jackson Township which have been outlined in this report. Understanding the potential water needs for these areas is imperative for proper City and utility planning. The hypothetical water needs for these areas are represented in Table 3-9. Based on drought year 2012, average day water demand with full buildout could reach a potential 13 mgd, with a maximum day demand of approximately 36 mgd (ratio of 2.77).

While the long term prospects expansion into Louisville Township are unknown, portion of Jackson Township are either being scheduled for annexation or are currently in the process. The City has divided Jackson into six planning areas, designated A through F. Area A is anticipated to be annexed within the next 0-5 years, B within 5-10 years, C within 10-15 years, D within 15-20 years, and E and F beyond 20-25 years. Table 4-9 develops a basis for projected water needs within the townships, assuming all half-acre single family lots.

4.9.2 Projected Water Use By Pressure Zone

Similar to the system wide water needs projection, each supply service area was projected for its individual water needs. This analysis was based on population and also by land use. 2016 meters were used to distribute existing demand between each service area. Existing and planned land use was determined for each pressure zone and was used to allocate demands based on land area.

The planned pressure zones were shown in Figure 3-3. The pressure zones were shaped in a manner consistent with utility planning, but in a manner where zones could be reasonably connected by water mains. The east zone, for instance, was separated from the 2nd High Zone due to its distance from the 2nd High Zone.

Table 4-7 – Future Water Needs Projections

	Year	2020	2030	2040
	Population	*43,000*	*51,500*	*60,000*
	Current Practices for Drought Year (Based on Drought Year 2012)			
Demand Type	Assumption	Demand (mgd)		
Residential	84 gpcd	3.61	4.33	5.04
Non-Residential				
Largest Customers	0.72 mgd	0.72	0.72	0.72
Other Population Based	35 gpcd	1.51	1.80	2.10
Average Day Sales		5.84	6.85	7.86
Unaccounted Water	9.5%	0.62	0.72	0.83
Projected Average Day Demand		**6.45**	**7.57**	**8.69**
Projected Maximum Day Demand	**277%**	**17.9**	**21.0**	**24.0**

Table 4-8 – Summary of Water Needs Projections Per Service Zone

Zone	Average Day Demand (MGD)	Maximum Day Demand (MGD)	Portion of Total Demand
Main Zone	4.6	12.6	70.6%
1st High Zone	1.5	4.2	23.8%
2nd High Zone Central	0.0	0.1	0.4%
2nd High Zone West	0.2	0.7	3.8%
2nd High Zone East	0.1	0.3	1.5%
Total	6.5	17.9	100%
Main Zone	5.0	13.8	65.9%
1st High Zone	1.8	4.9	23.4%
2nd High Zone Central	0.1	0.2	0.9%
2nd High Zone West	0.6	1.7	8.2%
2nd High Zone East	0.1	0.3	1.6%
Total	7.6	21.0	100%
Main Zone	5.4	15.0	62.4%
1st High Zone	2.0	5.6	23.1%
2nd High Zone Central	0.1	0.3	1.3%
2nd High Zone West	1.0	2.8	11.5%
2nd High Zone East	0.2	0.4	1.7%
Total	8.7	24.0	100%

4.9.2.2 Projected Water Use By Pressure Zone Population

A breakdown of the anticipated water needs of each pressure zone is shown in Appendix A. The following terms were calculated for each pressure zone:

- Portion of existing residential demand, based on 2016 water meters.
- Portion of future residential demand, based on land use area.
- Water used by top ten largest customers within pressure zone, based on if the customers exist in the zone or not.
- Portion of existing non-residential demand, based on 2016 water meters.
- Portion of future population-based non-residential demand, based on land use area.

Table 4-7 summarizes each of the pressure zones. Growth is anticipated to occur mostly in the 1st and 2nd High Zones where land is more available.

4.9.2.3 Projected Water Use By Future Land Use

Due to the uncertainty with population growth projections and water use projections, it is useful to estimate future water system demands from multiple perspectives to find a range of potential outcomes. In addition to the population-based method used in the previous section, projected land uses were also examined for this plan, and water demands projected based on an assumed unit demand per area for varying land uses. A breakdown of the full buildout water needs of each pressure zone is shown in Appendix B. Based on GIS land use in Figure 3-1 and the planned pressure zones in Figure 2-2, land areas were determined for each pressure zone.

Results of the land used base water demand projections are presented in Table 4-9. The time at which this expected development occurs will be strongly dependent on market forces, therefore the yearly water use projections provide a reasonable estimate of planning period demand while the land use projections help to understand the total ultimate water system needs independent of time.

Table 4-10 summarizes each of the pressure zones. Growth is anticipated to occur in the 1st and 2nd High Zones where vacant land is available. As time progresses, the 1st and 2nd High Zones are anticipated to contribute to additional water system demand.

Table 4-9 – Projected Water Consumption By Land Use

Land Use[1]	Existing Acres	Full Buildout Acres[1]	Estimated 2012 AD Water Use (gpd/acre)	Estimated 2012 AD Water Use (MGD)	Projected Full Buildout AD Water Use (MGD)	Projected Full Buildout MD Water Use (gpd)
Residential Sales						
Low Density Residential	2,644	7,118	660	1.75	4.70	13.00
Medium Density Residential	517	621	2,000	1.03	1.24	3.44
High Density Residential	88	94	5,400	0.47	0.51	1.40
All Residential	**3,248**	**7,833**	--	**3.25**	**6.4**	**17.8**
Non-Residential Sales						
Business Park	108	129	675	0.07	0.09	0.24
Commercial	547	625	675	0.37	0.42	1.17
Entertainment	356	543	500	0.18	0.27	0.75
Industrial	1,136	1,541	675	0.77	1.04	2.88
Institutional	344	368	675	0.23	0.25	0.69
Mix Use	68	99	675	0.05	0.07	0.19
Open Space	124	1,700	0	0.00	0.00	0.00
Parks	222	483	100	0.02	0.05	0.13
All Non-Residential	**2,905**	**5,489**	--	**1.69**	**2.2**	**6.0**
Future Service Area[2]						
Jackson Township	Not Yet Included			Not Yet Included		
Area A - Low Density Residential		242	490		0.12	0.33
Area B - Low Density Residential		327	490		0.16	0.44
Area C - Low Density Residential		1,304	490		0.64	1.77
Area D - Low Density Residential		412	490		0.20	0.56
Area E - Low Density Residential		828	490		0.41	1.12
Jackson Township		**3,113**	--		**1.5**	**4.2**
All Land Use	**6,153**	**16,435**	--	**4.94**	**10.2**	**28.1**

*Estimates based on typical historical usage.

1 20 percent of future areas assumed to be streets and open areas. Calculated by [(Future - Existing) x 0.8] + Existing.

2 20 percent of Township areas assumed to be streets and open areas and 80 percent as 1/2 acre single-family lots; water not included; (2.9 persons per household x 2 households per acre x 84 gpcd = 490 gpd/acre).

Table 4-10 – Summary of Full Buildout Water Needs Projections Per Service Zone

Zone	HGL	Average Day Demand (MGD)	Maximum Day Demand (MGD)	Portion of Total Demand
Main Zone	933'	5.8	16.0	57.0%
1st High Zone	1015'	2.0	5.7	20.2%
2nd High Zone Central	1115'	0.7	2.0	7.2%
2nd High Zone West		1.4	4.0	14.1%
2nd High Zone East		0.2	0.4	1.5%
Total		**10.2**	**28.1**	100%

4.10 Water Needs for Fire Protection

In addition to the water supply requirements for residential, public, commercial, and industrial consumption, water system planning for fire protection needs is an important consideration. In most instances, water main sizes are designed specifically to supply needed fire flow requirements.

Benefits of providing adequate fire protection for SPUC include the reduction of insurance rates for residential homes and commercial business in the community. In the United States, guidelines for determining fire flow requirements are developed based on recommendations offered by the Insurance Services Office (ISO), which is responsible for evaluating and classifying municipalities for fire insurance rating purposes.

When a community evaluation is conducted by ISO, the water system is evaluated for its capacity to provide needed fire flow at a specific location and will depend on land use characteristics and the types of properties to be protected. The ISO has developed a method for design and evaluation of a municipal system which will indicate the Needed Fire Flow (NFF). For residential buildings the NFF is determined by the distance between structures as shown below:

Distance between Structures (ft)	***Fire Flow (gpm)***
More than 100	500
31-100	750
11-30	1,000
Less than 11	1,500

Fire protection needs vary with the physical characteristics of each building that is to be protected. For example, needed fire flows for a specific building can vary from 500 gpm to as high as 12,000 gpm, depending on habitual classifications, separation distances between buildings, height, materials of construction, size of the building, and the presence or absence of building sprinklers. Municipal fire insurance ratings are partially based on the Village's ability to provide needed fire flows up to 3,500 gpm. If a specific building has a needed fire flow greater than this amount, the community's fire insurance rating will only be based on the water system's ability to provide 3,500 gpm.

However, in high value districts containing commercial and industrial buildings, fire flow requirements of up to 3,500 gpm or more can be expected. These values can be reduced if existing buildings have sprinklers. Below is a formula that has been established for determining the NFF for commercial and industrial structures and is documented in the *Fire Protection Rating System* and AWWA M31:

$$NFF = 18 \times F \times A^{0.5} [O \times (X+P)]$$

Where:

NFF = needed fire flow (gpm)
F = class of construction coefficient
A = effective area (ft^2)
O = occupancy factor
X = exposure factor
P = communication factor

Based on current insurance classification guidelines, base fire flow requirements are not expected to change over the planning period. The base fire flow used in this study of 3,500 gpm for 3 hours is based on typical ISO recommendations.

Table 4-11 shows typical fire flow requirements for various land uses. These requirements were used as a basis for evaluating the Shakopee water system. The requirements shown in the table are only intended as a general guideline. The actual needed fire flow for a specific building can vary considerably, as discussed above.

Table 4-11 – Typical Fire Flow Requirements

Land Use	Approximate Needed Fire Protection (gpm)
Single & Two-Family	
Over 100 feet Building Separation	500
31 to 100 feet Building Separation	750
11 to 30 feet Building Separation	1,000
10 feet or Less Building Separation	1,500
Multiple Family Residential Complexes	2,000 to 3,000+
Average Density Commercial	1,500 to 2,500+
High Value Commercial	2,500 to 3,500+
Light Industrial	2,000 to 3,500
Heavy Industrial	2,500 to 3,500+
Other Commercial, Industrial & Public Buildings	Up to 12,000

5 Water System Evaluation

Water systems are analyzed, planned, and designed primarily through the application of basic hydraulic principles. A schematic of the water system was shown in Figure 2-1. A map of the existing water system was shown in Figure 2-3. Figure 2-1 and Figure 2-3 provide the basis of understanding of the water system layout and operation. The existing water system contains multiple tanks, wells, booster stations and pressure zones. When analyzing the various components of a water system, important factors that must be considered when performing this analysis include:

- The location and capacity of supply facilities
- The location, sizing, and design of storage facilities
- The location, magnitude, and variability of customer demands
- Water system geometry and geographic topography
- Minimum and maximum pressure requirements
- Land use characteristics with respect to fire protection needs
- Other operational criteria which define the manner in which the system can most efficiently be operated

For this study, an evaluation of the Shakopee water system was performed to determine the adequacy of the system to supply existing and future water needs, and to supply water for fire protection purposes.

The system was evaluated based on the following criteria:

- Reliable Supply Capacity of Entire System
- Reliable Pumping Capacity into each Zone
- Storage Volume in each Zone
- Pressures
- Fire Projection
- Reliability

The water system evaluation was based on compliance with Minnesota state code requirements and standard water industry engineering practice.

5.1 Water Supply Sources

The City utilizes three different aquifers as the water source for their public water supply. These aquifers are the Prairie du Chien-Jordan Sandstone, Franconia-Ironton-Galesville bedrock, and Mt. Simon/Hinckley bedrock.

In the Shakopee area the Prairie du Chien-Jordan sandstone aquifer is close to the ground surface and is soft in structure. Wells constructed in this area have removed sandstone surrounding the well to prevent large quantities of sand from entering the well with the water. The Prairie du Chien-Jordan sandstone aquifer supplies a significant quantity of water to the City's water system, and is expected to provide the majority of the water in the future. Wells #4 - #9, #11 - #17, #20, #21 utilize water from the Prairie du Chien-Jordan sandstone aquifer.

Wells #2 #3, and #14 utilize water from the Franconia-Ironton-Galesville bedrock aquifer. This aquifer also supplied water to Well #1 before it was abandoned and sealed.

Water use restrictions have been placed on the Mt. Simon/Hinckley bedrock aquifer. These restrictions only allow usage of the Mt. Simon/Hinckley bedrock aquifer when there is no alternate water supply available, and the water may only be used for drinking water purposes. Wells #3 and #10 are supplied with water from this aquifer. Well #10 has low nitrate concentrations and was established to dilute the high concentration of nitrates in water from Wells #6 and #7.

Multiple aquifer wells are wells that utilize water from multiple aquifers. These types of wells are no longer allowed to be constructed in Minnesota because of the increased potential for spreading contamination to multiple aquifers. Wells #3 is a multiple aquifer well and was once supplied with water from all three aquifers. Eventually the Prairie du Chien-Jordan sandstone aquifer was cased off due to the large quantity of sand that was entering into #3. Well #2 was also a multiple aquifer well that received water from all three wells. Two of the aquifers have been cased off and it currently only receive water from the Franconia-Ironton-Galesville bedrock aquifer

5.2 Source Water Quality

Desirable water quality implies water that is clear, tasteless, odorless, and free of chemical and microbiological contaminants. The quality of water delivered by the community water supplier must meet legislated water quality standards, and should meet other standards recognized as desirable by the water industry. A sound source of municipal supply must reliably yield raw water quality that is economically treated. SPUC and all public utilities are required to meet water quality rules and regulations under the Safe Drinking Water Act. SPUC must meet all regulations and participate in required programs established the governing bodies, the U.S. Environmental Protection Agency (U.S. EPA) and the Minnesota Health Department (MDH).

5.2.1 Safe Drinking Water Act (SDWA) Regulations

In 1974 the Safe Drinking Water Act (SDWA) was established to protect the public's heath by establishing water quality rules and regulations for public water supplies. In 1986 and 1996 the law was amended to add protection to drinking water sources and groundwater wells. Under the SDWA governing bodies, such as the U.S. EPA and state organizations, establish water quality standards to protect the public's drinking water against both natural and manmade contaminants.

At the national level the U.S. EPA creates National Primary Drinking Water Regulations (NPDWR) and National Secondary Drinking Water Regulations (NSDWR) to protect drinking water and water sources. In addition to rules and regulations, the U.S. EPA has developed a list of Drinking Water Contaminants. The U.S. EPA has the power to hold public utilities responsible for meeting all rules and regulations established under the SDWA.

At the state level the MDH adopts standards established by the U.S. EPA and implements their own standards for water quality within the state. Like the U.S. EPA, the MDH has the power to hold public utilities operating in Minnesota responsible for meeting all rules and regulations established under the SDWA.

5.2.1.1 National Primary Drinking Water Regulations (NDPWR)

The National Primary Drinking Water Regulations (NPDWR) are legally enforceable primary standards and treatment techniques that apply to public water systems. Primary standards and treatment techniques protect public health by limiting the levels of contaminants in drinking water.

The NDPWRs are standards enforceable by law established to protect drinking water and public health. These standards create limits, referred to as the Maximum Concentration Levels (MCL), on the concentrations of contaminants present in drinking water and water sources. Levels are also established within the regulation to indicate at what concentrations and length of exposure a contaminant can impact human health. Governing bodies can take legal actions against utilities if public water supplies are not in compliance with the MCLs.

5.2.1.2 National Secondary Drinking Water Regulations (NSDWR)

The NSDWRs are non-enforceable standards for contaminants that impact the aesthetic of drinking water. It is recommended that public water supplies meet these drinking water standards even though they are not legally enforceable.

5.2.1.3 Drinking Water Contaminant Candidate List (CCL)

Every five years the U.S. EPA publishes the CCL, which is a list of contaminants known to be found in drinking water. Currently the contaminants on the CCL are not regulated, however, future regulations may be established under the SDWA.

5.2.2 Minnesota Department of Health Requirements

All regulations established by the U.S. EPA are adopted by the MDH. The MDH also develops their own health standards to indicate at what concentrations a contaminant may be impacting human health. Along with adopting rules and regulations, the MDH implements a Drinking Water Protection Program to help public utilities stay in compliance and protect water sources. Through the program water sampling is performed, public water contamination problems are address, training is given to water operators, and grants are administered for infrastructure improvements and water protection.

5.2.3 Existing Drinking Water Quality

Under existing operating conditions the City receives their drinking water from eighteen groundwater wells. At each well house chlorine and fluoride are added to the water for disinfection and public health purposes. The City monitors their wells to insure they stay in compliance with the NPDWRs, NSEWRs and other water quality standards. Water from these wells is considered a good quality, however, there are some elements present in the water which require monitoring.

5.2.3.1 Existing National Primary Drinking Water Regulations (NPDWR) Review

Some of the wells have a history of containing elevated concentrations of nitrate, radon and radium 226/228 . The increased concentrations are close to NPDWR maximum contaminant levels and could have potential health risks associated with them. The Utility will continue to sample and monitor water production wells to ensure they are staying under the NPDWR maximum contaminant levels.

Nitrates: Nitrate contamination is often attributed to runoff from fertilizer use; leaking from septic tanks, sewage; erosion of natural deposits and livestock waste. The U.S. EPA set the MCL for nitrate to be 10 ppm. Wells utilizing water from the Jordan Sandstone aquifer have experienced an increased level of nitrates over the years. This is especially predominant in areas of the City lower elevations due to the decrease in soil cover between the ground surface and the aquifer. Blending is used to reduce the concentration of nitrates in the City's water.

Radon: Radon is a naturally-occurring radioactive gas that emits ionizing radiation. National and international scientific organizations have concluded that radon causes lung cancer in humans. Most of the radon in indoor air comes from the breakdown of uranium in soil beneath homes.

Radon from tap water is a smaller source of radon in indoor air. Only about 1-2 percent of radon in indoor air comes from drinking water. (US EPA) However breathing radon released to air from household water uses may increases the risk of lung cancer over the course of a lifetime. Ingestion of drinking water containing radon also presents a risk of internal organ cancers, primarily stomach cancer. This risk is smaller than the risk of developing lung cancer from radon released to air from tap water

This contaminant is not on the NPDWR list of contaminants, however, it is does have a negative impact on human health as it is associated with an increased risk of cancer. The Proposed Rule for Radon in Drinking Water states that two different methods can be used for reducing the impact of radon. The first method is to implement the Multimedia Mitigation (MMM) program which limits the MCL of radon to be 4000 pCi/L. The second method is the state will set what the MCL for radon should be. Like nitrates, blending is used to reduce the concentration of radon in the City's water.

Radium 226/228: Radium becomes an issues when naturally occurring deposits erode. Certain rock types have naturally occurring trace amounts of "mildly radioactive" elements (radioactive elements with very long half-lives) that serve as the "parent" of other radioactive contaminants ("daughter products"). These radioactive contaminants, depending on their chemical properties, may accumulate in drinking water sources at levels of concern. The "parent radionuclide" often behaves very differently from the new element, the "daughter radionuclide" in the environment.

A federal law called the Emergency Planning and Community Right to Know Act (EPCRA) requires facilities in certain industries, which manufacture, process, or use significant amounts of toxic chemicals, to report annually on their releases of these chemicals. The Final Radionuclides Rule was established to reduce the public's exposure to radium. The U.S. EPA set the MCL for Radium 226/228 to be 5 pCi/L.

5.2.3.2 Existing National Secondary (NSDWS) Review

The Utility also monitors the aesthetic conditions of the water they are supplying. EPA believes that if these contaminants are present in your water at levels above these standards, the contaminants may cause the water to appear cloudy or colored, or to taste or smell bad. This may cause a great number of people to stop using water from their public water system even though the water is actually safe to drink. Secondary standards are set to give public water systems some guidance on removing these chemicals to levels that are below what most people will find to be noticeable.

The problems associated with NSDWS include:

- Aesthetic effects — undesirable tastes or odors;
- Cosmetic effects — effects which do not damage the body but are still undesirable
- Technical effects — damage to water equipment or reduced effectiveness of treatment for other contaminants

Monitoring indicates that total hardness is the most common nuisance for NSDWSs. Impacts from total hardness can be offset by implementing hardness removal at the well house, which ultimately may be very costly or the addition of an in-home water softener.

A few of the wells also had elevated levels of manganese. Manganese is associated with aesthetic issues which include taste and water coloring. If manganese was moved from the NSDWS to the NPDWR it is likely that the Utility would not meet regulations, and additional treatment would be required. However, there is no known indication that Manganese would be considered a primary contaminant as manganese poses as an aesthetic nuisance rather than a health risk.

5.2.4 Summary of Water Quality Review

The SPUC water system currently has a quality water Supply. SPUC continues to monitor system water quality to assure compliance with the SDWA and SPUC intends on being in compliance with all rules and regulations established under the SDWA.

Contaminant levels of nitrates, radon, and radium should be continued to be monitored closely as some wells have a history of elevated levels close to the MCL. Additionally, if MCL change or contaminants listed on the NSDWR are transferred to the NPDWR some contaminants may no longer be in compliance and additional treatment need to be pursued.

5.3 Total System Reliable Supply Capacity

The reliable supply capacity of a water system is the total available delivery rate with the largest pumping unit(s) out of service. The reliable supply capacity is less than the total supply capacity because well and other supply pumps must be periodically taken out of service for maintenance. These water supply pumps can be off-line for periods of several days to several weeks, depending on the nature of the maintenance being performed. For a system as large as Shakopee with 18 high capacity wells, it is somewhat likely for two wells to be offline at the same time, comprising approximately 10 percent of the total supply capacity. Because of this, system wide well supply requirements will assume that the SPUC water supply system should be capable of meeting maximum day demands with the Utilities' largest two wells out of service.

The current reliable water supply capacity is given in Table 5-1. Under present operating conditions, the existing wells have a combined total capacity of about 24.4 mgd when operating 24 hours per day. However, the reliable capacity of the supply wells is approximately 20.3 mgd with the two highest yielding wells out of service. The availability of this reliable supply capacity assumes that there will be no significant declines or changes in the water supply capacity over the next 20 years.

To determine if SPUC should plan for additional supply, the demands of the system can be compared to supply capacity. The projected drought-year average day and maximum day demands are set against total and reliable supply capacities in Figure 5-1, assuming the growth projections discussed in Table 3-2 and Table 4-7. The results in Figure 5-1 indicated a potential need for approximately 4.0 MGD or more in reliable supply capacity to meet projected water system demand growth. This would equate to roughly three new wells. The suggested location for these wells on a zone by zone basis is discussed later in this section. It should also be noted that future demands are estimated projections (not records) and thus should be re-evaluated frequently (every five years ±) as water use trends can change over time.

Figure 5-1
Historical & Projected Demands
Versus Total & Reliable Supply Capacity