

CHAPTER 5

WATER USE CHARACTERIZATION AND FORECASTING

INTRODUCTION

Water use characterization is an important aspect of water system planning. By evaluating the historical trends in the amount of water purchased and consumed, peaking factors, and the customer population, it is possible to provide forecasts of future demands on the water system. This is necessary in order to assess the capacity of the District's existing facilities and design future water system facilities.

Adequate design of the District's water distribution and storage facilities requires a determination of the quantity of water demanded by the various customers. The District's customer base is predominantly residential, but the non-residential customer base is quickly growing.

In this chapter, information from previous reports, water use records, transportation analysis zone (TAZ) data, and master meter flow data are used to estimate unit flow quantities for critical parameters related to population and equivalent residential units (ERUs) within the existing service area. Future demands for the entire service area are estimated through the 20-year planning period and for total build-out scenarios.

WATER USE CHARACTERIZATION

The District's customer base is composed of residential, commercial, and industrial connections. Approximately 66 percent of the District's total water is used by single-family residential customers.

WATER SERVICE CONNECTIONS

The total number of water service connections within the District at the end of 2005 was 20,050. The number of connections is discussed by customer type and location within various municipalities in the following sections.

Service Connections by Customer Class

The District classifies its customers based on various rate codes. For the purposes of this document, water usage has been divided into the following customer types: single-family residential (SFR), multifamily residential (MFR) with individual water meters, MFR with multiple units per meter, non-residential, fire services, and other. SFR is defined as single units with individual water service meters. MFR with individual meters consists of condominiums with individual service meters. MFR with multiple units per meter

consist of residential meters that serve apartment complexes, condominiums, and mobile homes. Non-residential customers include commercial and industrial connections. These connections have meter sizes ranging from 3/4 inch to 6 inches. Fire services are connections reserved for fire lines, with meters ranging from 2 inches to 10 inches. All customers that do not fit into these categories are classified as other.

Table 5-1 provides a summary of the connections for the various types of customers for 2000 - 2005. Values in Table 5-1 indicate the number of connections at the end of each year. Ninety-one percent of the water service connections are for single-family residential homes.

TABLE 5-1

Water Service Connections by Customer Class (2000 – 2005)

Year	Single-Family Residential	Multi-Family Residential		Non-Residential	Total
		Individual Meters	Multiple Units per Meter		
2000	17,315	27	1,032	610	18,984
2001	17,471	28	1,077	621	19,197
2002	17,643	28	1,082	638	19,391
2003	17,862	32	1,092	642	19,628
2004	18,041	32	1,104	648	19,825
2005	18,242	33	1,114	661	20,050

Source: Northshore Utility District billing records.

Service Connections by Municipality within District

The District provides water service to a number of different municipalities within its water service boundary. The percent of water service connections within the District for the Cities of Bothell, Lake Forest Park, Kenmore, Kirkland, and unincorporated King County are based on meter records. Table 5-2 provides an estimate of the number of water service connections in each municipality that the District serves.

TABLE 5-2

Percent of Water Service Connections per Municipal Entity (2005)

Municipality	Percent of Water Service Connections
Bothell	4%
Kenmore	27%
Unincorporated King County	53%
Kirkland	9%
Lake Forest Park	6%
Total	100%

Source: Northshore Utility District billing records.

WATER USE

Water use in the District can be segregated into three elements: master meter flow, customer consumption, and lost and unaccounted for water. These three elements are discussed in the following sections.

Historical Annual Master Meter Flow

The connections to the SPU water supply lines are metered by both SPU and the District. The SPU meters are used to determine the amount of water use that is billed to the District. The District’s master meters are connected to the SCADA system and allow the District to track the amount of water supplied by SPU and determine the total system demand. Table 5-3 provides a summary of the historical annual master meter flow data and the average daily master meter flow based on the SPU end-of-year billing records.

TABLE 5-3

Historical Master Meter Flow

Year	Total SPU Master Meter Flow		Average Day SPU Master Meter Flow (mgd)
	(CCF)⁽¹⁾	(MG)⁽²⁾	
2000	2,828,668	2,116	5.80
2001	2,776,777	2,077	5.69
2002	2,830,016	2,117	5.80
2003	2,897,063	2,167	5.94
2004	2,838,342	2,123	5.82
2005	2,531,502	1,894	5.19
Average	2,783,728	2,082	5.70

Source: Northshore Utility District bills from SPU.

(1) CCF stands for hundred cubic feet and equals 748 gallons.

(2) MG stands for million gallons.

Table 5-4 provides the water service area population, average master meter flow, and average master meter flow per capita (water use per person). Water service area population in Table 5-4 is estimated based on the 2000 Census population of 67,427 and the projected population growth rate of 0.37 percent per year between 2000 and 2010. The per capita master meter flow averaged 83.6 gallons per capita per day (gpcd) between 2000 and 2005. This value includes all water uses, including residential, non-residential, and lost and unaccounted for water.

TABLE 5-4

Historical Per Capita Master Meter Flow

Year	Water Service Area Population⁽¹⁾	Average Daily Master Meter Flow (mgd)	Per Capita Master Meter Flow (gpcd)
2000	67,576	5.80	85.8
2001	67,826	5.69	83.9
2002	68,077	5.80	85.2
2003	68,329	5.94	86.9
2004	68,582	5.82	84.8
2005	68,835	5.19	75.4
Average	68,204	5.71	83.7

(1) Population estimated based on 2000 Census data and an annual growth rate of 0.37%.

Peak Season and Peak Month Water Demand

The District’s contract with SPU contains a maximum average flow rate during the peak season and peak month of each calendar year. The peak season is defined as “June 1 though September 30 of the same calendar year,” and the peak month is defined as “the consecutive 30-day period during a calendar year in which [the District] puts its maximum demand upon the [SPU system].” Per the SPU contract, the peak season flow rate is 11.97 mgd, and the peak month flow rate is 14.96 mgd.

Table 5-5 provides a summary of historical peak season and peak month master meter flow.

TABLE 5-5

Historical Peak Season and Peak Month Master Meter Flow

Year	Peak Season Demand		Peak Month Demand	
	Master Meter Flow (mgd)	Peaking Factor ⁽¹⁾	Master Meter Flow (mgd)	Peaking Factor ⁽¹⁾
2001	6.30	1.11	6.91	1.21
2002	7.44	1.28	9.12	1.57
2003	8.73	1.47	9.73	1.64
2004	7.76	1.33	8.69	1.49
2005	6.46	1.25	8.65	1.67
Average	--	1.29	--	1.52

(1) Peaking factors are equal to the peak demand master meter flow divided by average daily master meter flow.

Maximum Day Water Demand

Maximum day demand is the maximum amount of water used in the highest use 24-hour period for the year. Peak hour demand, or maximum instantaneous demand, is the largest amount of water used in a 1-hour period for the year. Peak day and peak hour demands usually occur during the summer months due to the added demands of irrigation.

The District’s telemetry records were used to determine the historical maximum day demands on the system. The records include all water purchased from SPU through the master meters and any water supplied from the District’s reservoirs. The amount of water drawn from storage is generally not considered when determining the maximum day demand because it is assumed that source of supply is capable of providing the necessary water. Table 5-6 presents the historical maximum day demands and the maximum day to average day peaking factors.

TABLE 5-6

Historical Maximum Day Demand

Year	Average Day Demand⁽¹⁾ (mgd)	Maximum Day Master Meter Flow⁽²⁾ (mgd)	Maximum Day Demand⁽³⁾ (mgd)	Peaking Factor (MDD/ADD)
2000 ⁽⁴⁾	5.80	12.53	12.39	2.14
2001	5.69	9.39	8.24	1.45
2002	5.80	12.77	7.98	1.38
2003	5.94	10.05	12.16	2.05
2004	5.82	11.44	10.68	1.84
2005	5.19	N/A	N/A	N/A
Average	5.70	11.24	10.29	1.77

- (1) Average day demand from Table 5-3.
- (2) Maximum day master meter flow is the highest total flow through the SPU master meters.
- (3) Maximum day demand is the highest system demand (consumption plus lost and unaccounted for water) and equals the master meter flow minus the change in reservoir storage.
- (4) Maximum day master meter flow and maximum day demand for year 2000 is believed to be incorrect and has not been considered when evaluating the average peaking factor.

The average peaking factor shown in Table 5-6 is 1.77. However, a conservative maximum day to average day peaking factor of 2.0 is used to project future maximum day demands on the system discussed later in this Chapter.

Peak Hour Water Demand

Data collected in the District’s telemetry system was used to determine peak hour demand. The SCADA system divides the District into four areas, based on reservoir service or source: Inglemoor, Westhill, Lake Forest Park, and Norway Hill/Kingsgate. Telemetry graphs showing the varying hourly demands in each of these four areas were evaluated for the peak 24-hour period of water use. The peak hour demand was calculated as the maximum total demand of the system in a given hour on that peak day. The historical peak hour demand estimated from the District’s telemetry system is shown in Table 5-7. “Demand” is defined as the total amount of water being used by District customers and lost water provided from a combination of master meters and District water storage reservoirs.

TABLE 5-7

Historical Peak Hour Demand

Date	Maximum Day Demand (mgd)	Peak Hour Demand		Peaking Factor (PHD/MDD)
		(mgd)	(gpm)	
7/7/00	12.39	40.98	28,460	3.31
8/12/01	8.24	16.34	11,350	1.98
8/11/02	7.98	11.32	7,860	1.42
7/27/03	12.16	22.60	15,695	1.86
8/9/04	10.68	16.04	11,140	1.50
2005	N/A	N/A	N/A	N/A
Average⁽¹⁾	9.77	16.58	11,511	1.69

Source: Northshore Utility District SCADA data.

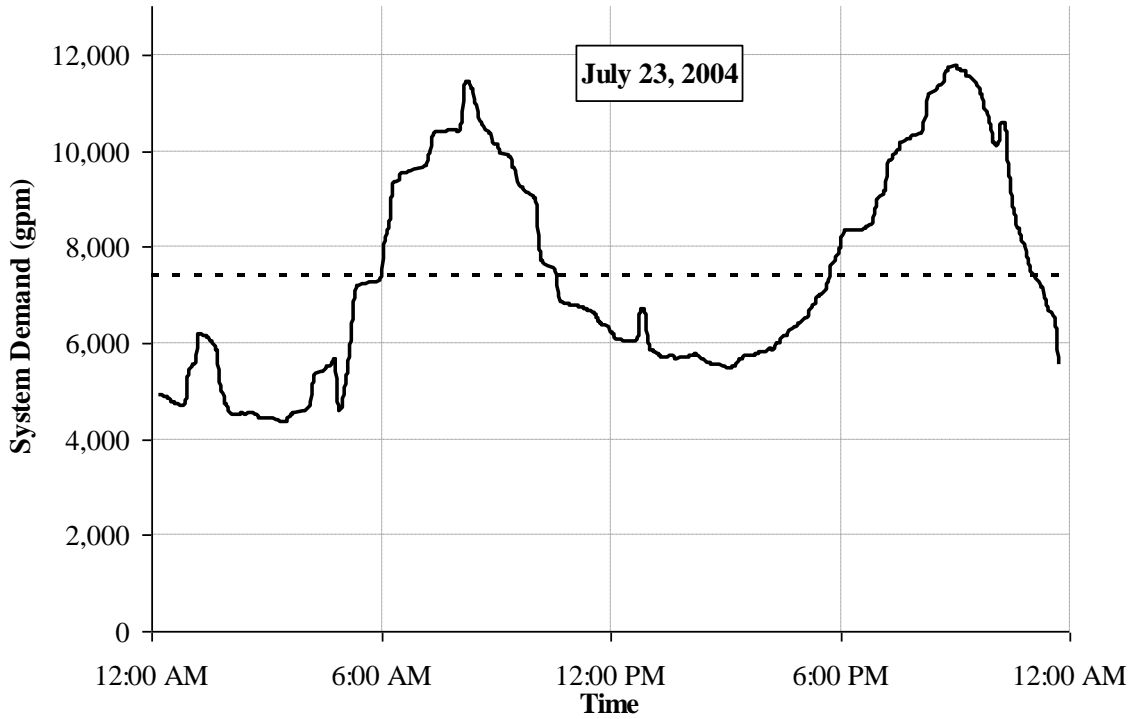
(1) Average does not include year 2000 data because it is believed to be incorrect.

The peak hour demand from July 7, 2000, is believed to be incorrectly recorded data and is disregarded for determining the peak hour peaking factor. Based on the maximum peak hour factor for years 2001 through 2004, a conservative peak hour to peak day peaking factor of 2.0 will be used to project peak hour demands on the system discussed later in this Chapter.

Figure 5-1 provides a diurnal curve as measured on July 23, 2004, which was the date of the maximum day demand in 2004.

FIGURE 5-1

Water Demand Diurnal Curve



Consumption History

District water consumption is measured at individual service meters. Customers are billed for water service every two months. The District's water consumption by customer class is presented in Table 5-8.

TABLE 5-8

Historical Consumption by Customer Class

Year	Single-Family Residential (MG)	Multi-Family Residential		Non-Residential (MG)	Total (MG)
		One Unit per Meter (MG)	Multiple Units per Meter (MG)		
2000	1,331	4	406	240	1,981
2001	1,264	4	400	213	1,881
2002	1,308	5	401	236	1,950
2003	1,396	4	415	254	2,069
2004	1,343	4	406	243	1,996
2005	1,224	5	388	224	1,841

Source: Purchased water bills from SPU to the District.

Per Capita Consumption

Table 5-9 identifies the total residential water consumption, total population, and the average daily water consumption per capita. During the previous six years, the average water consumption was 69 gallons per day per capita (gpcd).

TABLE 5-9

Historical Per Capita Water Consumption

Year	Total Residential Water Use (MG)	Population	Average Daily Water Consumption per Capita (gpcd)
2000	1,741	67,576	70.6
2001	1,668	67,826	67.4
2002	1,714	68,077	69.0
2003	1,816	68,329	72.8
2004	1,753	68,582	70.0
2005	1,617	68,835	64.4
Average			69.0

Per Employee Consumption

Table 5-10 identifies the total non-residential water consumption, total employment of the businesses that make up the non-residential customers, and the average daily water consumption per employee. During the previous 6 years, the average water consumption was 39.9 gallons per day per employee (gped).

TABLE 5-10

Historical Per Employee Water Consumption

Year	Total Non-Residential Water Use (MG)	Employment	Average Daily Water Consumption per Employee (gped)
2000	240	15,542	42.4
2001	213	15,774	37.0
2002	236	16,009	40.4
2003	254	16,247	42.8
2004	243	16,489	40.3
2005	224	16,735	36.7
Average			39.9

Lost and Unaccounted for Water

Lost and unaccounted for water is defined as the difference between the amount of water purchased from SPU through the master meters and the metered consumption by the customers of the District. “Lost water” includes any water loss due to leaks or unauthorized uses, such as illegal service connections. “Unaccounted for water” results from accounting error, inaccurate master meters and customer meters, and water leaving the system for unmetered uses, such as flushing of mains and fire flows. Table 5-11 provides the historical lost and unaccounted for water for 2000 through 2005. As shown in Table 5-11, the District has a relatively low percentage of lost and unaccounted for water.

TABLE 5-11

Lost and Unaccounted For Water

Year	Total Master Meter Flow⁽¹⁾ (MG)	Total Metered Consumption⁽²⁾ (MG)	Lost and Unaccounted for Water	
			(MG)	(%)
2000	2,116	1,981	135	6.4%
2001	2,077	1,881	196	9.4%
2002	2,117	1,950	166	7.9%
2003	2,167	2,069	98	4.5%
2004	2,123	1,996	127	6.0%
2005	1,894	1,841	53	2.8%
Average⁽³⁾	2,061	1,969	93	4.4%

- (1) Total Master Meter Flow from Table 5-3.
- (2) Total Metered Consumption from Table 5-8.
- (3) Average is based on years 2003, 2004, and 2005.

The volume of lost and unaccounted for water has decreased from 196 MG in 2001 to 53 MG in 2005. During this time, the District has removed nearly 14,000 lineal feet of cast iron, asbestos cement, permastran, and class 200 PVC water main. These types of piping have historically exhibited frequent breaks and are believed to be a major contributor to the lost and unaccounted for water of the system.

The average rate of lost and unaccounted for water over the previous three years is 4.4 percent. The District plans to further reduce lost and unaccounted for water by systematically replacing aging and problematic water mains. However, the Plan uses 5 percent per year of the total master meter flow for purposes of projecting future lost and unaccounted for water. This percentage is below the current DOH standard of 20 percent and also below the future standard of 10 percent required by the water use efficiency rule.

EQUIVALENT RESIDENTIAL UNITS

The conversion of total water use to equivalent residential units (ERUs) provides a way to express water use by non-residential and multi-family residential customers as an equivalent number of single-family residential customers. The average volume of water used per residential connection is calculated by dividing the total volume of water used in the single-family residential customer class by the total number of single-family residential connections. This number (the ERU value) defines the average single-family residential water use per connection. The volume of water used by the other customer classes can then be converted to an equivalent number of single-family residential services. ERUs for other customer classes are calculated by dividing the total consumption for other customer classes by the average single-family residential water use per connection.

The ERU value varies each year depending on the consumption patterns of the single-family customer class. Table 5-12 provides the number of single-family residential connections, single-family consumption, and the ERU value for the years 2000 through 2005. During this period, the average ERU value was 202 gallons per day (gpd). The Plan uses 202 gpd for purposes of projecting future water use.

TABLE 5-12

Historical Equivalent Residential Unit Value

Year	No. of Single-Family Residential Connections⁽¹⁾	Total Single-Family Residential Consumption⁽²⁾ (MG)	ERU Value (gpd/ERU)
2000	17,315	1,331	211
2001	17,471	1,264	198
2002	17,643	1,308	203
2003	17,862	1,396	214
2004	18,041	1,343	204
2005	18,242	1,224	184
Average	17,762	1,311	202

(1) Number of Single-Family Residential Connections from Table 5-1.

(2) Total Single-Family Residential Consumption from Table 5-7.

Table 5-13 identifies the number of ERUs for each customer class and the total number of ERUs. As of the end of 2005, the District provides water service to 27,445 ERUs.

TABLE 5-13

Historical Equivalent Residential Units by Customer Class

Year	ERU Value (gpd/ERU)	Single-Family Residential ERUs	Multi-Family Residential ERUs		Non-Residential ERUs	Total ERUs
			One Unit per Meter	Multiple Units per Meter		
2000	211	17,315	5,281	58	3,127	25,781
2001	198	17,471	5,534	57	2,946	26,008
2002	203	17,643	5,414	71	3,189	26,316
2003	214	17,862	5,314	54	3,245	26,475
2004	204	18,041	5,450	59	3,260	26,810
2005	184	18,242	5,787	77	3,339	27,445

WATER USE FORECASTING

The following sections provide 20-year forecasts of ERUs, average day demands, and peak demands. These projections are based on the anticipated growth within the water service area and the historical water usage patterns presented in this Chapter. These demand forecasts will be used as the basis for evaluating the capacity of the system.

PROJECTED EQUIVALENT RESIDENTIAL UNITS (ERUS)

Table 5-14 provides ERU projections for the residential (single-family and multi-family) and non-residential customer classes. The annual growth rates used for the residential and non-residential classes correspond to the average annual growth rates for population and employment presented in Table 3-5. The District’s water system is projected to expand from 27,445 ERUs in 2005 to 30,803 in 2026, an increase of 12 percent.

TABLE 5-14

Water Service Area ERU Projections

Year	Residential			Non-Residential			Total ERUs
	Population	Annual Growth	ERUs	Employment	Annual Growth	ERUs	
2005	68,861	--	24,106	16,778	--	3,339	27,445
2006	69,108	0.37%	24,195	16,980	1.49%	3,389	27,584
2007	69,366	0.37%	24,285	17,232	1.49%	3,439	27,724
2008	69,625	0.37%	24,375	17,488	1.49%	3,490	27,865
2009	69,885	0.37%	24,465	17,748	1.49%	3,542	28,007
2010	70,146	0.37%	24,556	18,013	1.49%	3,595	28,151
2011	70,483	0.48%	24,674	18,319	1.70%	3,656	28,330
2012	70,821	0.48%	24,792	18,630	1.70%	3,718	28,510
2013	71,161	0.48%	24,911	18,946	1.70%	3,781	28,692
2014	71,503	0.48%	25,031	19,268	1.70%	3,845	28,876
2015	71,846	0.48%	25,151	19,595	1.70%	3,910	29,061
2016	72,191	0.48%	25,272	19,928	1.70%	3,976	29,248
2017	72,537	0.48%	25,393	20,267	1.70%	4,044	29,437
2018	72,885	0.48%	25,515	20,611	1.70%	4,113	29,628
2019	73,235	0.48%	25,637	20,961	1.70%	4,183	29,820
2020	73,586	0.48%	25,760	21,318	1.70%	4,254	30,014
2021	73,799	0.29%	25,835	21,590	1.28%	4,308	30,143
2022	74,012	0.29%	25,910	21,865	1.28%	4,363	30,273
2023	74,226	0.29%	25,985	22,144	1.28%	4,419	30,404
2024	74,440	0.29%	26,060	22,426	1.28%	4,476	30,536
2025	74,655	0.29%	26,136	22,712	1.28%	4,533	30,669
2026	74,871	0.29%	26,212	23,002	1.28%	4,591	30,803
Buildout	118,584	--	40,506	24,199	--	4,780	45,286

The number of residential ERUs projected at buildout is based on the average flow per capita (69 gpcd) and average ERU value (202 gpd/ERU). The number of non-residential ERUs projected at buildout is based on the average flow per employee (39.9 gped) and average ERU value (202 gpd/ERU). Using these assumptions, a total of 40,506 residential ERUs and 4,780 non-residential ERUs are projected at buildout.

PROJECTED AVERAGE DAY DEMAND

Table 5-15 provides projections for the annual consumption, lost and unaccounted for water, and average day demands for the 20-year planning period and at buildout. Lost and unaccounted currently is projected to remain at five percent of the total master meter flow. Projections presented in this Chapter do not assume any additional conservation savings. The District’s conservation program, presented in Chapter 9, identifies water saving measures that will reduce the total system demands.

TABLE 5-15

Water Service Area Average Day Demand Projections

Year	Total ERUs ⁽¹⁾	Projected Consumption ⁽²⁾ (mgd)	Lost and Unaccounted For Water		Average Day Demand (mgd)
			Percent	Total (mgd)	
2005	27,445	5.54	5%	0.29	5.83
2006	27,584	5.57	5%	0.29	5.86
2007	27,724	5.60	5%	0.29	5.89
2008	27,865	5.63	5%	0.30	5.93
2009	28,007	5.66	5%	0.30	5.96
2010	28,151	5.69	5%	0.30	5.99
2011	28,330	5.72	5%	0.30	6.02
2012	28,510	5.76	5%	0.30	6.06
2013	28,692	5.80	5%	0.31	6.11
2014	28,876	5.83	5%	0.31	6.14
2015	29,061	5.87	5%	0.31	6.18
2016	29,248	5.91	5%	0.31	6.22
2017	29,437	5.95	5%	0.31	6.26
2018	29,628	5.98	5%	0.31	6.29
2019	29,820	6.02	5%	0.32	6.34
2020	30,014	6.06	5%	0.32	6.38
2021	30,143	6.09	5%	0.32	6.41
2022	30,273	6.12	5%	0.32	6.44
2023	30,404	6.14	5%	0.32	6.46
2024	30,536	6.17	5%	0.32	6.49
2025	30,669	6.20	5%	0.33	6.53
2026	30,803	6.22	5%	0.33	6.55
Buildout	45,286	9.15	5%	0.48	9.63

(1) Total ERUs calculated in Table 5-14.

(2) Projected consumption based on the ERU value of 202 gpd/ERU.

PROJECTED PEAK DEMANDS

Table 5-16 provides projections for the average day, maximum day, and peak hour demand. Maximum day demands are equal to 2.0 times the average day demands and peak hour demands are equal to 2.0 times the maximum day demand as discussed previously in this Chapter. Peak month demand is estimated to equal 1.52 times the average day demand, and peak season demand is estimated to equal 1.29 times the average day demand.

TABLE 5-16

Water Service Area Peak Demand Projections

Year	Average Day Demand, ADD⁽¹⁾ (mgd)	Maximum Day Demand, MDD⁽²⁾ (mgd)	Peak Hour Demand, PHD⁽³⁾ (gpm)	Peak Month Demand⁽⁴⁾ (mgd)	Peak Season Demand, PHD⁽⁵⁾ (gpm)
2005	5.83	11.66	16,200	8.86	7.52
2006	5.86	11.72	16,300	8.91	7.56
2007	5.89	11.78	16,400	8.95	7.60
2008	5.93	11.86	16,500	9.01	7.65
2009	5.96	11.92	16,600	9.06	7.69
2010	5.99	11.98	16,600	9.10	7.73
2011	6.02	12.04	16,700	9.15	7.77
2012	6.06	12.12	16,800	9.21	7.82
2013	6.11	12.22	17,000	9.29	7.88
2014	6.14	12.28	17,100	9.33	7.92
2015	6.18	12.36	17,200	9.39	7.97
2016	6.22	12.44	17,300	9.45	8.02
2017	6.26	12.52	17,400	9.52	8.08
2018	6.29	12.58	17,500	9.56	8.11
2019	6.34	12.68	17,600	9.64	8.18
2020	6.38	12.76	17,700	9.70	8.23
2021	6.41	12.82	17,800	9.74	8.27
2022	6.44	12.88	17,900	9.79	8.31
2023	6.46	12.92	17,900	9.82	8.33
2024	6.49	12.98	18,000	9.86	8.37
2025	6.53	13.06	18,100	9.93	8.42
2026	6.55	13.10	18,200	9.96	8.45
Buildout	9.63	19.26	26,800	14.64	12.42

- (1) Average day demand from Table 5-15.
- (2) Maximum day demand equals 2.0 times the average day demand. See Table 5-6.
- (3) Peak hour demand equals 2.0 times the maximum day demand. See Table 5-7.
- (4) Peak month demand equals 1.52 times the average day demand. See Table 5-5.
- (5) Peak season demand equals 1.29 times the average day demand. See Table 5-5.