Appendices to the 2020 Washington Metropolitan Area Water Supply Study:
Demand and Resource Availability Forecast for the Year 2050

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Table of Contents

Table of Tables

TABLE OF FIGURES

APPENDICES

A.1 SCHEMATICS OF WATER SUPPLY SYSTEMS

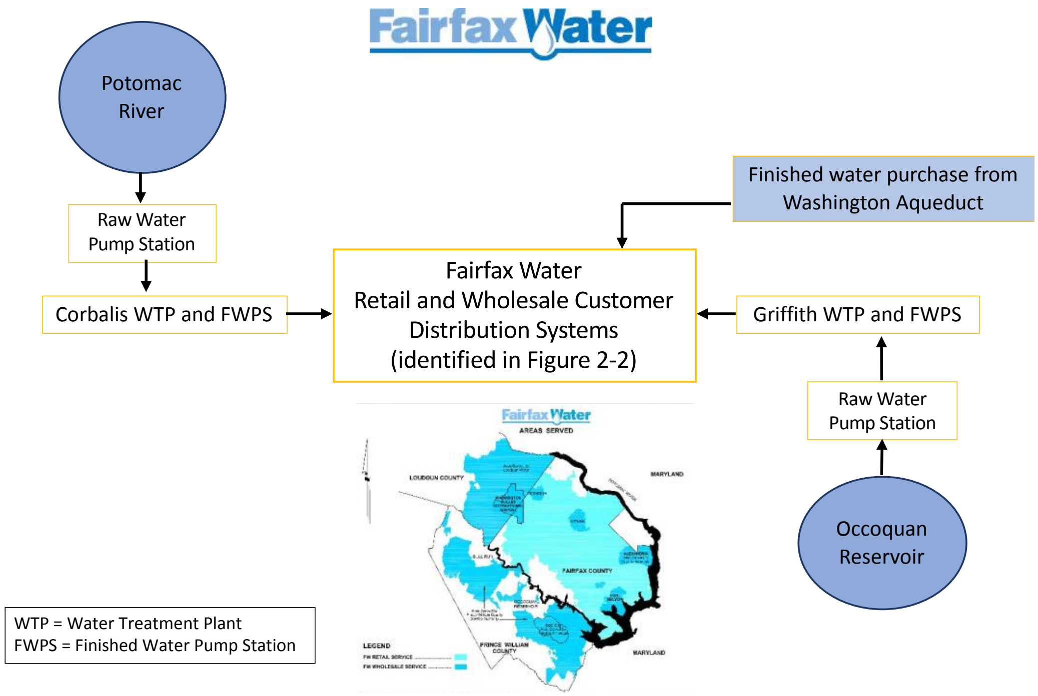

Figure A.1-1: Fairfax Water schematic of water supply system.

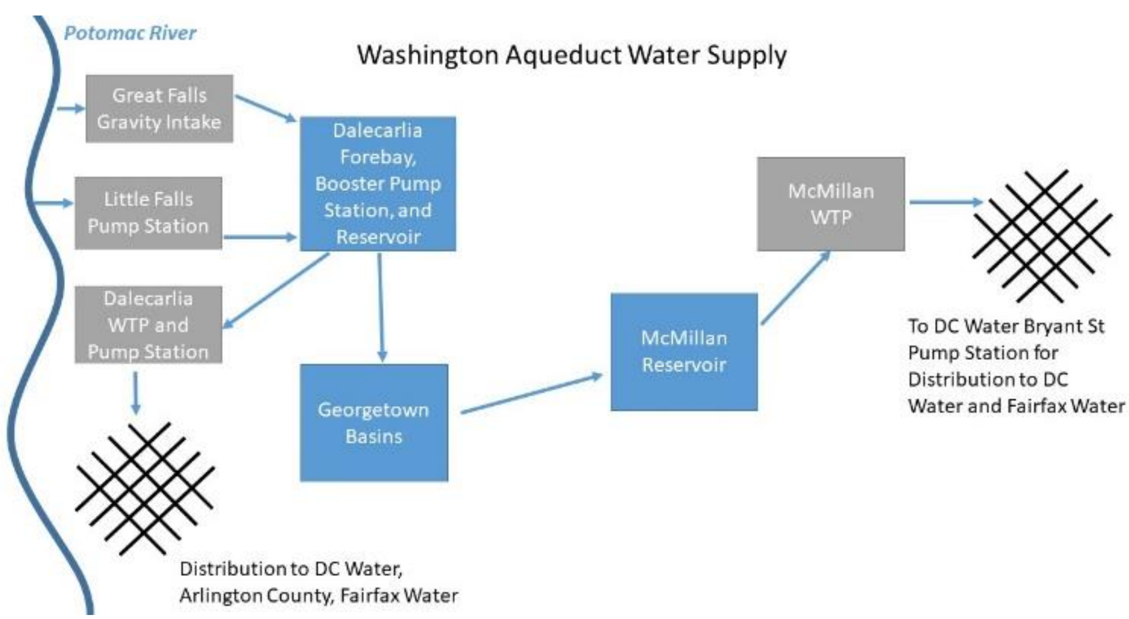

Figure A.1-2: Washington Aqueduct schematic of water supply system.

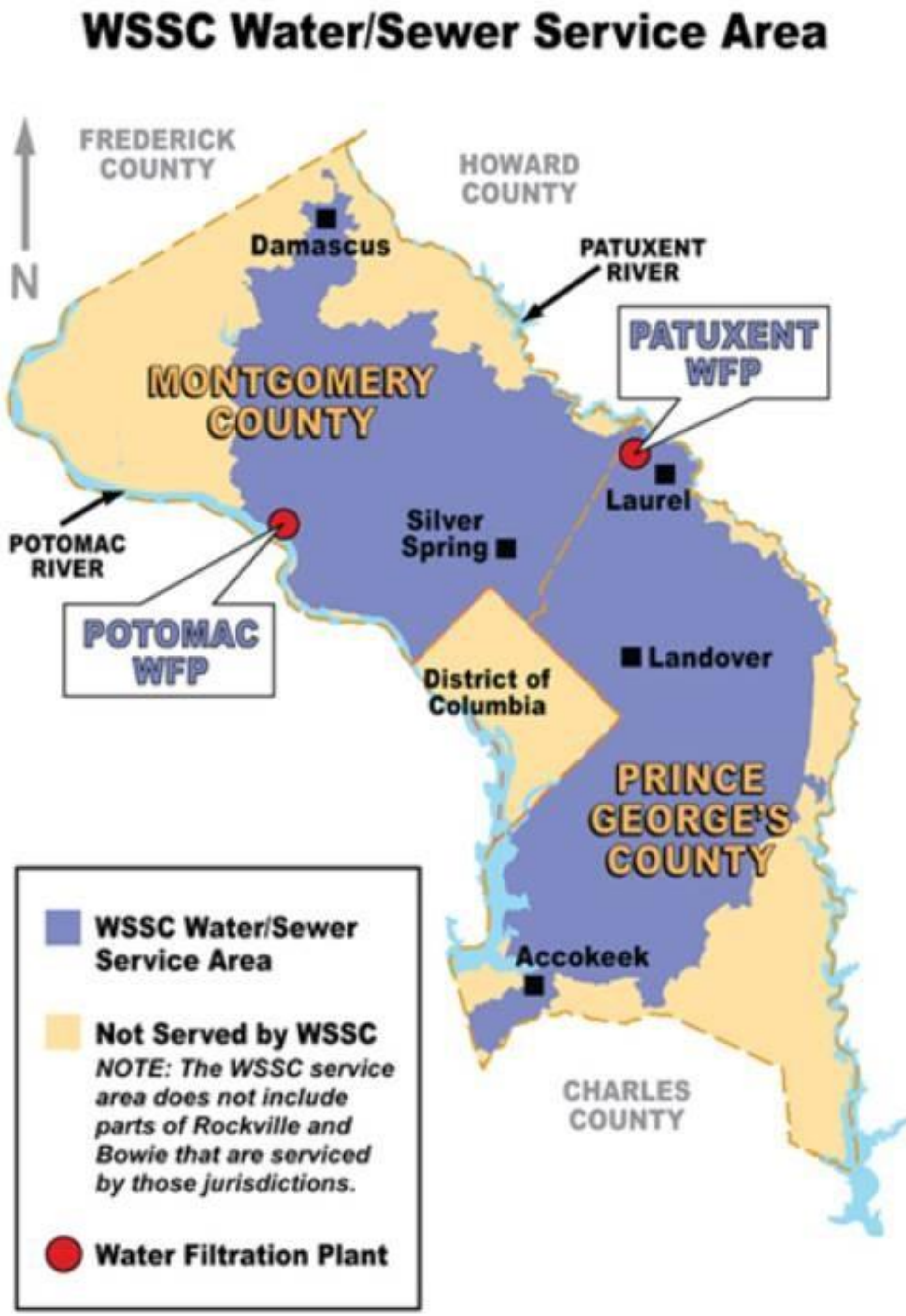

Figure A.1-3: WSSC Water schematic of water supply system.

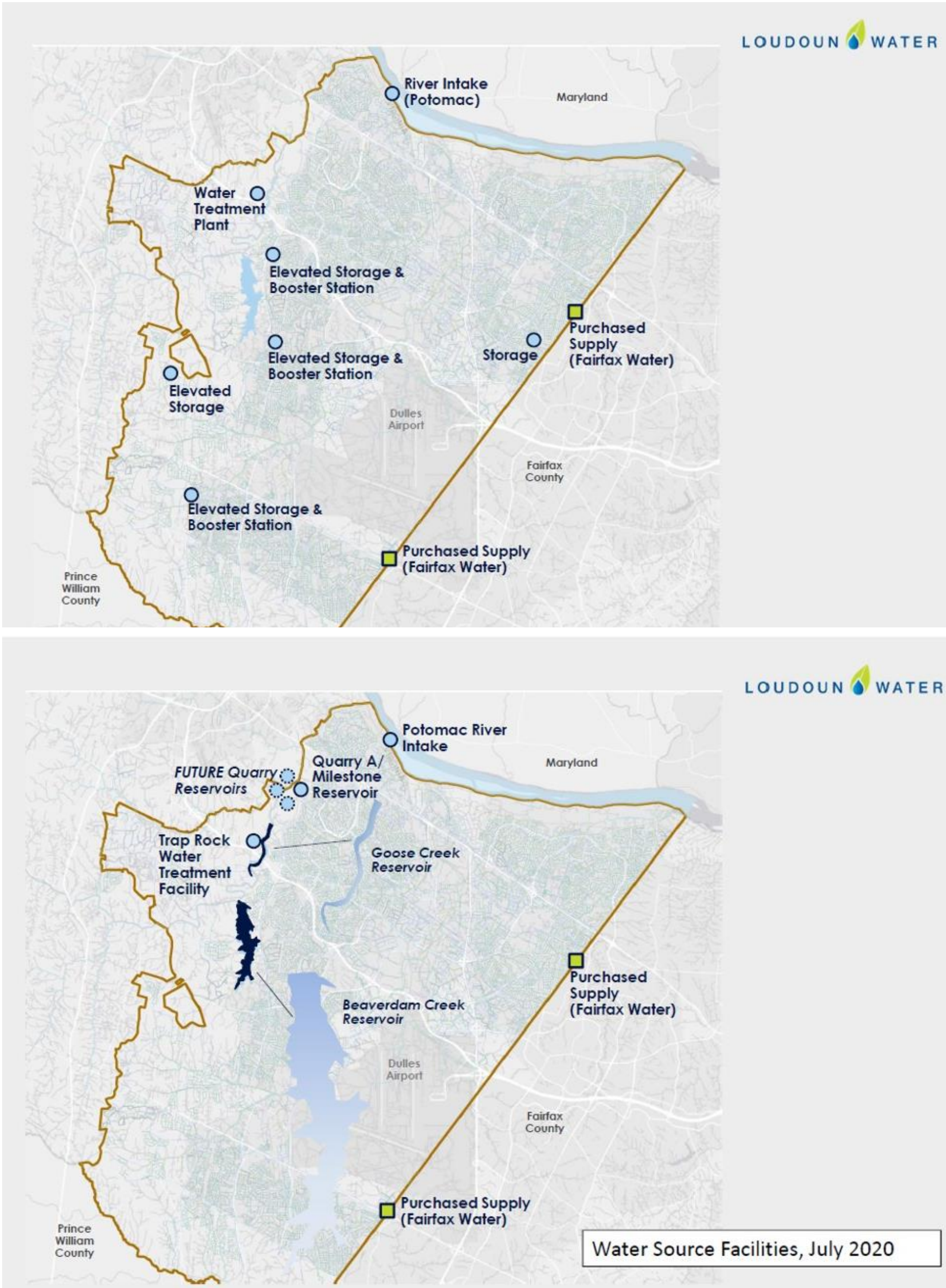

Figure A.1-4: Loudoun Water schematics of water supply system.

A.2 Production Data

Table A.2-1: Fairfax (Total Production).

	2010	2011	2012	2013	2014	2015	2016	2017	2018	Ave.
Ave. annual production, MGD	157	150	151	144	149	150	159	155	151	152
Monthly ave. production, MGD										
January	131	129	128	128	134	130	134	142	147	134
February	129	126	123	125	134	133	134	140	136	131
March	133	126	130	124	133	131	135	137	136	132
April	145	132	148	137	139	135	147	146	145	142
May	163	149	158	149	152	161	148	154	163	155
June	194	191	184	158	170	162	177	183	167	176
July	207	206	202	168	178	165	190	186	189	188
August	183	184	181	164	173	183	191	170	174	178
September	190	153	165	170	166	181	186	169	153	170
October	149	140	142	148	145	146	165	160	144	149
November	127	132	127	129	135	135	156	137	130	134
December	130	127	125	125	128	132	149	137	127	131
Peak 1-day production, MGD										
January	140	138	138	134	143	147	143	150	166	144
February	139	135	134	137	147	158	144	147	143	143
March	143	135	136	137	141	142	144	144	143	141
April	162	146	189	152	150	143	170	165	159	160
May	191	189	176	183	179	190	168	181	184	182
June	235	225	251	183	200	195	209	221	201	213
July	259	239	244	198	207	199	234	222	228	226
August	218	227	204	186	196	212	214	192	201	206
September	223	175	178	198	185	215	216	200	186	197
October	175	160	162	181	162	161	194	190	169	173
November	137	139	137	138	143	148	166	145	139	144
December	141	137	134	135	137	143	162	148	134	141
Ave. Jul.-Oct. production, MGD	182	171	173	162	166	169	183	171	165	171

Note: Includes water sold to Loudoun Water; See Table A.2-5 for Fairfax Water portion of Loudoun Water usage.

Table A.2-2: Washington Aqueduct (Total Production).

	2010	2011	2012	2013	2014	2015	2016	2017	2018	Ave.
Ave. annual production, MGD	156	146	138	134	134	138	135	139	138	140
Monthly ave. production, MGD										
January	147	145	132	124	135	127	123	132	136	133
February	150	142	128	126	132	134	129	132	129	133
March	144	134	133	123	127	129	126	130	128	130
April	148	137	137	127	130	132	131	140	132	135
May	154	144	135	135	136	135	128	142	140	139
June	174	162	147	144	143	148	147	157	146	152
July	184	172	160	151	149	151	152	160	159	160
August	167	168	157	145	140	153	152	150	153	154
September	165	154	144	144	142	157	150	144	147	150
October	149	134	130	131	134	138	133	134	139	136
November	142	131	132	128	122	130	126	124	127	129
December	145	129	118	123	125	119	125	119	123	125
Peak 1-day production, MGD										
January	172	163	146	137	160	145	138	146	163	152
February	174	165	138	148	148	161	153	146	143	153
March	161	167	153	132	135	139	143	142	139	146
April	175	152	157	141	145	141	156	154	143	151
May	170	176	151	150	149	150	141	158	160	156
June	200	198	189	159	157	173	166	175	166	176
July	234	210	189	179	164	165	175	186	195	189
August	205	190	187	159	154	166	171	168	173	175
September	191	176	162	168	155	178	166	158	170	169
October	165	158	149	154	149	149	146	157	156	154
November	184	144	167	137	138	146	140	147	140	149
December	169	146	129	143	144	139	143	130	140	143
Ave. Jul.-Oct. production, MGD	166	157	148	143	141	150	147	147	149	150

Table A.2-3: Washington Suburban Sanitary Commission (WSSC Water, Total Production).

	2010	2011	2012	2013	2014	2015	2016	2017	2018	Ave.
Ave. annual production, MGD	175	169	164	159	162	165	165	163	163	165
Monthly ave. production, MGD										
January	162	164	154	153	165	155	157	154	169	159
February	165	159	151	153	156	161	159	150	152	156
March	160	158	151	149	151	159	154	148	149	153
April	163	163	162	153	152	157	161	155	154	158
May	172	173	168	159	161	170	161	160	167	166
June	194	194	181	167	172	170	172	178	167	177
July	199	201	189	173	177	176	181	182	183	185
August	193	182	178	167	171	182	182	174	177	178
September	195	168	169	169	169	179	173	174	169	174
October	169	161	159	157	158	161	160	166	162	161
November	163	155	153	152	155	157	158	157	154	156
December	165	153	151	151	150	151	158	155	151	154
Peak 1-day production, MGD										
January	181	218	190	181	200	169	186	171	213	190
February	176	173	162	183	176	202	176	162	171	176
March	179	166	163	179	166	172	166	165	164	169
April	180	177	184	169	161	164	176	177	174	174
May	189	200	190	181	184	185	183	182	190	187
June	229	216	216	186	187	195	189	199	202	202
July	233	225	226	206	205	191	209	210	213	213
August	217	206	203	180	188	200	201	191	197	198
September	223	183	179	189	181	200	187	193	189	191
October	182	176	171	185	173	176	176	182	178	178
November	176	173	165	168	169	170	191	175	167	173
December	184	160	161	163	161	166	175	171	164	167
Ave. Jul.-Oct. production, MGD	189	178	174	166	169	174	174	174	173	175

Table A.2-4: Loudoun Water (Total Use).

	2010	2011	2012	2013	2014	2015	2016	2017	2018	Ave.
Ave. annual use, MGD	22	21	23	22	22	23	25	24	23	23
Monthly ave. use, MGD										
January	17	17	17	18	18	17	19	19	20	18
February	17	17	17	17	18	19	19	19	19	18
March	17	17	18	18	18	18	20	19	20	18
April	22	17	23	22	20	20	23	22	22	21
May	24	20	25	24	23	25	23	24	25	24
June	30	32	30	26	27	28	30	32	28	29
July	31	34	33	28	29	27	32	31	32	31
August	27	29	28	27	28	30	33	27	29	29
September	28	21	25	28	27	28	32	27	24	27
October	20	19	21	22	22	22	25	25	22	22
November	17	17	18	19	19	19	20	20	19	19
December	17	17	17	18	18	18	19	18	19	18
Peak 1-day use, MGD										
January	18	19	18	19	20	20	21	22	22	20
February	19	18	18	19	20	22	20	21	22	20
March	19	18	19	21	21	22	22	22	24	21
April	26	21	30	26	23	23	28	26	25	25
May	28	30	28	31	28	32	28	32	31	30
June	35	38	38	31	34	34	37	40	35	36
July	43	39	38	34	33	32	40	38	41	38
August	33	36	32	31	35	36	38	34	37	35
September	33	26	31	33	31	33	38	37	34	33
October	24	21	31	29	25	24	28	32	27	27
November	19	19	19	21	24	21	23	23	21	21
December	18	18	18	20	19	20	21	21	20	20
Ave. Jul.-Oct. use, MGD	27	26	27	26	27	27	30	28	27	27

Note: Trap Rock Water Treatment Facility (Trap Rock WTF) production started on September 4, 2018. The average Potomac River withdrawal has been about 9 MGD, with an average finished water amount of 8 MGD. The Trap Rock WTF has not solidified its operational plan and the total Loudoun Water usage (production plus purchase amount) is a better representation of their water needs.

Table A.2-5: Loudoun Water (FW Portion).

	2010	2011	2012	2013	2014	2015	2016	2017	2018	Ave.
Ave. annual use, MGD	20	19	19	18	19	18	19	19	19	19
Monthly ave. use, MGD										
January	14	15	16	16	14	13	16	19	19	16
February	14	14	14	16	18	14	16	19	19	16
March	14	15	17	15	18	14	17	18	19	16
April	19	14	20	17	20	15	16	16	18	17
May	22	17	20	19	21	20	17	17	22	19
June	25	27	25	21	22	22	24	22	23	23
July	28	29	28	23	23	22	23	21	27	25
August	25	25	24	22	23	24	22	17	23	23
September	25	20	24	23	22	23	23	21	15	22
October	18	19	16	20	18	17	15	20	14	17
November	15	16	13	15	15	16	14	16	12	15
December	14	16	15	15	13	16	19	17	11	15
Peak 1-day use, MGD										
January	16	17	17	18	17	16	18	22	21	18
February	16	15	17	18	20	18	18	20	22	18
March	16	17	18	18	21	18	20	21	21	19
April	23	19	26	21	23	20	21	19	22	22
May	26	25	23	26	24	30	21	25	28	25
June	30	33	33	26	28	28	32	33	30	30
July	40	34	33	29	27	26	32	27	36	32
August	31	33	28	26	29	30	30	23	31	29
September	31	23	29	28	26	27	33	30	23	28
October	22	21	25	27	23	20	22	27	18	23
November	16	18	16	17	20	20	20	19	14	18
December	16	17	16	19	17	17	21	20	13	17
Ave. Jul.-Oct. use, MGD	24	23	23	22	21	22	21	20	20	22

Table A.2-6: CO-OP System (Total Production).

	2010	2011	2012	2013	2014	2015	2016	2017	2018	Ave.
Ave. annual production, MGD	487	465	453	436	445	452	459	457	452	456
Monthly ave. production, MGD										
January	441	437	414	405	434	412	414	428	452	426
February	444	427	402	404	422	429	422	422	417	421
March	436	418	414	396	412	418	415	416	413	415
April	456	433	447	417	421	423	439	440	431	434
May	488	466	461	443	449	467	437	455	471	460
June	561	547	511	468	485	480	497	517	480	505
July	590	579	551	493	505	492	523	528	531	532
August	542	534	516	476	484	519	525	494	503	511
September	550	475	478	484	477	516	509	488	469	494
October	468	435	431	436	436	445	457	461	445	446
November	432	418	413	409	412	422	440	419	411	420
December	440	410	393	399	405	402	432	411	400	410
Peak 1-day production, MGD										
January	476	496	448	441	498	449	465	456	533	474
February	474	455	416	441	458	497	454	438	440	453
March	461	449	427	427	434	442	431	432	428	437
April	507	469	530	447	446	441	492	482	474	476
May	525	562	515	502	498	525	485	516	516	516
June	656	618	645	518	536	549	552	578	559	579
July	697	671	652	568	572	547	597	610	616	614
August	620	618	561	517	531	566	576	537	557	565
September	605	511	505	544	509	569	559	534	532	541
October	503	479	465	511	471	475	501	528	487	491
November	465	439	446	427	436	441	478	453	431	446
December	469	425	409	418	427	421	480	436	425	434
Ave. Jul.-Oct. production, MGD	537	506	494	472	476	493	504	493	487	496

Note: Includes water provided to Loudoun Water by Fairfax Water.

A.3 ANNUAL DEMAND FORECAST

A.3.1 Overview

This appendix details how the historic and forecasted unit use rates are calculated and how these rates are used to generate the average annual demand forecast as discussed in Chapter 3.

A.3.1.1 Historic and Forecast Periods

The historic period covered by the 2020 ICPRB study is 2010-2018. The forecast period is 2020-2050. Available forecast data looks out to 2045. To be consistent with upcoming Virginia water supply planning requirements, the year 2050 is included. These 2050 values are extrapolated at the end of the annual demand forecast calculation.

A.3.1.2 Demographic Data

The Metropolitan Washington Council of Governments (MWCOG) Round 9.1 forecast data (approved October 10, 2018)[1] used by this study includes

1. Households (HH)
2. Employees (EMP)

The MWCOG staff forecast using total occupied household (HH) data (G. Goodwin, personal communication, October 24, 2019). Therefore, no adjustments based on household vacancy rates are made on the Round 9.1 data.

The Round 9.1 data includes values from 2015-2045. To report values back to 2010, Round 8.4 data for 2010 is also collected. Demographic values are then interpolated between 2010-2015 and 2015-2020 for the historic years.

Estimates on the number of households by category come from local jurisdictions for

1. Single family households (SFH)
2. Multi-family households (MFH)

Some jurisdictions provided data as housing units (HU, or SFHU and MFHU) and include vacancy rate estimates to convert to occupied households (HH, or SFH and MFH). This is only useful for those jurisdictions that provided a detailed description of vacancy rates. For most jurisdictions, the vacancy

[1] MWCOG Round 9.1 Forecast: https://www.mwcog.org/documents/2018/10/17/cooperative-forecasts-employment-population-and-household-forecasts-by-transportation-analysis-zone-cooperative-forecast-demographics-housing-population/

rate assumptions are canceled out in the dwelling unit ratio (DUR) calculation (which is a ratio of SFH/MFH).

When local data is unavailable, five-year American Community Survey (ACS) data from the U.S. Census Bureau is used.[2] Data from the ACS is assumed to be for the release date of the five-year period and not the mid-year as previously assumed. The ACS has estimates of the number of HU by unit type and the overall vacancy rate as follows:

1. Total housing units (HU)
    a. 1-unit, detached
    b. 1-unit, attached
    c. 2 units
    d. 3 or 4 units
    e. 5 to 9 units
    f. 10 to 19 units
    g. Mobile home
    h. Boat, RV, van, etc.
2. Occupied households (HH)
3. Vacancy rate

The ACS data is combined into SFHU and MFHU totals by assuming SFHU equals the sum of 1-unit, detached and 1-unit, attached. The MFHU equals the sum of everything else. This is an example where the vacancy rate assumption does not help because the DUR calculations cancel the adjustment.

A.3.1.3 Supplier Data

The CO-OP Suppliers water use data include

1. Service area GIS shape file
2. Billed water use
    a. Retail sales by categories
        i. Single family household (SFH)
        ii. Multi-family household (MFH)
        iii. Employee
    b. Wholesales total and by customer
3. Purchased[3] and/or produced water use by source (e.g., Potomac or off-Potomac)
4. Unmetered use

The wholesale customers of the CO-OP suppliers water use data include

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[2] American Community Survey (ACS) data is collected from "Tables DP04 Selected Housing Characteristics": https://factfinder.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t
[3] Fairfax Water purchases water from Washington Aqueduct to serve the Falls Church service area.

1. Service Area GIS shape file
2. Purchase and/or produced water use by supplier
3. Billed water use[4]
    a. Single family household (SFH)
    b. Multi-family household (MFH)
    c. Employee
4. Unmetered use

The service areas are provided with minimal explanation. In the future it would be useful to know the expected coverage by jurisdictions to help refine MWCOG transportation analysis zone (TAZ) data by either including all of a jurisdiction's data or eliminating those that are not expected to be included in the service area. This change in methods could potentially be more efficient than previous efforts to place KML files in Google Earth to find TAZ areas empty of structures.

The wholesale data is useful to receive by both total and by customer because they sometimes do not match. For example, WSSC Water total wholesales do not equal the sum of the daily average consumption (DAC) by customer for the year 2015. The explanation for this is that the WSSC Water DAC data does not incorporate all the wholesale meters for year 2015. The metered connections with the City of Bowie, Rockville, and DC Water are not included in that year's DAC wholesale roll-up spreadsheet. The amount of water through those connections is likely small but may account for the difference in the two numbers (K. Six, personal communication, November 5, 2019). The total wholesale amount is used in this case. The CO-OP supplier wholesale billed data is also used to compare with wholesale customer purchased data.

The unmetered use is useful to receive, but not always used. Unmetered use is the difference between water produced and water consumed or the water leaving the distribution system without being measured such as water used in fire-fighting, hydrant flushing leaks, main breaks, and under/over-reporting by meters. This water has been referred to as unmetered, unaccounted, unbilled, non-revenue use in various data requests. Generally, the unmetered water use is provided as a percentage of the total produced water. This study reports unmetered use as the amount of produced water minus the amount of billed water.

A.3.1.4 Methods

Step-by-step annual demand forecast methods follow:

1. Service areas are processed and examined
    a. The 3722 TAZ Zone System GIS layer is clipped to each service area
    b. Area ratios are calculated as the clipped area divided by the total area by TAZ
    c. TAZ ratios are examined for

[4] Non-potable water use is not included in this study but should be evaluated in the future. Specifically look at the Broad Run WRF non-potable water use sales.

        i. Unexpected jurisdictional coverage
        ii. Duplicate coverage by neighboring service areas
        iii. Misrepresentation of empty space (e.g., 0.0001 to 0.9999 ratios)
    d. Occasionally a service area is converted to a KML file and examined in Google Maps
2. Total population (POP),[5] employees (EMP), and households (HH) are collected by TAZ and processed for each service area
    a. MWCOG Round 8.4 forecast provides values for 2010
    b. MWCOG Round 9.1 forecast provides values for 2015-2045 for every five-year interval
    c. Service area ratios are multiplied with POP, EMP, and HH values by TAZ, and summed by year
    d. Values for individual years between 2010 and 2018 are interpolated between 2010-2015 and 2015-2020 values
3. Dwelling unit ratios (DURs) are calculated by supplier jurisdiction
    a. Jurisdictional historic and forecast SFH and MFH data by TAZ are assumed as much as possible
    b. Some jurisdictional data is available as a GIS layer and is clipped to service areas, which is believed to improve the DUR estimate
    c. If jurisdictional data is not available, ACS five-year data is used to estimate historic SFH and MFH values
    d. Vacancy rates are applied to data to convert HUs to HHs when possible or as needed
    e. The DUR (ratio of SFH/MFH) for each jurisdiction is estimated and assigned to a service area
    f. If forecasted DUR values are unavailable, a DUR to represent future years is picked
4. The number of SFH and MFH in each service area are estimated
    a. MFH= HH/(1+DUR)
    b. SFH = HH-MFH
5. Historic unit use rate (or factor) by supplier is calculated or estimated
    a. A water use balance is calculated by historic year (2010-2018)
        i. Produced water
        ii. Retail sales
            1. SFH use
            2. MFH use
            3. Employee use
        iii. Wholesales
        iv. Unmetered use = produced water - retail sales – wholesales
    b. A percent unmetered use rate is calculated as produced/purchased water minus billed water, divided by produced/purchased water, times a hundred
    c. Historic unit use factors (2010-2018) for each supplier by year are generated by dividing each supplier’s SFH, MFH, and EMP water use by the respective number of SFH, MFH, and EMP units in their service area

[5] Population is not used for the unit use calculation but collected in every study for plotting purposes.

6. Unit use forecasts by supplier are estimated
    a. Trends in historical unit use (a linear trend is assumed for the 2020 analysis) are reviewed
    b. Unit use rates for the beginning of the forecast period (2018) are calculated based on a trend analysis of 2010-2018 values[6]
    c. Future changes in water use behavior are estimated to calculate end use savings for SFH, MFH and EMP use categories
    d. Future end use savings are applied to the 2018 unit use rate estimates to calculate rates through 2045
    e. End use savings are extrapolated from the 2035, 2040, 2045 years to estimate the 2050 unit use rates (all forecast years are not used to limit effects of non-linear forecasts)
7. Annual demand forecasts are calculated by supplier
    a. The total HH and EMP units collected in step 2b are reviewed for future service area changes (the 2020 demand study did not have any adjustments)
    b. Future DURs are estimated based on data and information from local jurisdictions or the U.S. Census Bureau, in five-year increments through 2045
    c. DUR forecasts are used to divide MWCOG HH data for each service area into SFH and MFH
    d. Unit use rate forecasts are multiplied by the estimates for SFH, MFH, and EMP units for each water supplier and forecast year – this yields annual water use by customer category in each forecast year
    e. The amount of unmetered water use is estimated in each forecast year
        i. Unmetered rates, averaged from the historic period 2010-2018, greater than 10% are used
        ii. Unmetered rates, averaged from the historic period 2010-2018, less than 10% are assumed as 10%
    f. The total amount of SFH, MFH, EMP, unmetered use, and sales to wholesale customers for each supplier in each forecast year is summed to calculate the annual demand forecast [7]

Completing these steps requires data from multiple sources (see Figure 3-1 in Section 3.1 of the main text). In summary, the data sources for the annual demand forecast include billing, produced, and purchased data and service area extents from the water suppliers, including the wholesale customers; demographic information from MWCOG; and additional demographic data from local jurisdictions and the U.S. Census Bureau.

[6] In the past, the average of the historical unit use rates has been used as well.

[7] In some cases, non-calculated assumptions about wholesales or production are made with input by the respective suppliers for the forecast period (e.g., Howard and Charles counties wholesales for WSSC Water, and Trap Rock WTF production for Loudoun Water).

A.3.1.5 Future End Use Savings

The ICPRB efficiency model estimates end use savings, which are used to estimate changes in customer demand patterns for forecast years. This model first appeared in ICPRB's 2000 study (Hagen and Steiner) and is further developed in ICPRB's 2015 study (Ahmed *et al.*). For the purpose of this study, the methods remain the same except 1) literature values are updated, where available, to estimate the reduction in water use from low-flow appliances and fixtures and 2) three estimates of savings (labeled SP1, SP2, and SP3) are developed to bound a range of possible futures. This study, as with ICPRB's 2015 study, considers household toilets, showerheads, clothes washers, dishwashers, and faucets water use for the single-family and multifamily household categories. A simple estimate is also made for savings from low-flow toilets in commercial buildings for the employee category.

The methods include assumptions about the market share for conventional, low-flow (EPAct), and high efficiency (WaterSense or Energy Star) fixtures and appliances. The tables below summarize the assumptions used for the flow rates, natural replacement rates (non-incentivized), frequency of household use, and market share (Table A.3-1 through Table A.3-6). This method is adapted from information and the method described in a 2013 study completed for Tampa Bay Water on demand management (Hazen and Sawyer, 2013). The results from the ICPRB efficiency model used for each fixture or appliance are in Table A.3-7. The end use savings rates that are applied to the 2018 unit use rates are in Table A.3-8. The end use savings are given in gallons per day per unit (gpd/unit), where the unit is either number of households or employees.

In addition, ranges in literature values for market shares (McNeil *et al.*, 2008) and fixture replacement rates are used to develop three different water savings projections. The range in potential reductions is useful for evaluating a range of possible futures as well as sensitivities in this approach. Three savings projections, denoted as SP1, SP2, and SP3, use different assumptions for market shares and replacement rates. SP1 assumes the highest values for replacement rates and market shares of high efficiency fixtures and appliances, SP3 assumes the lowest values, and SP2 falls in the middle.

Table A.3-1: Mechanical efficiency ratings (flow rates) compiled from EPAct and WaterSense, and Hazen and Sawyer (2013).

Fixture	Unit	Flow Rate		
		Conventional (average)	Low-flow	High Efficiency
Residential Toilets	Gallon per flush (gpf)	4.25	1.6	1.28
Commercial Toilets	Gallon per flush (gpf)	3.5	1.6	1.28
Showerheads	Gallon per minute (gpm)	--	2.2	1.15
Faucets	Gallon per minute (gpm)	--	2.2	1.15
Washing machines	Gallon/cycle/cubic feet	40.0 – 15.1	--	29.7 – 12.7
Dishwasher	Gallon/load	8.7 – 6.0	--	4.5

Notes: America's Water Infrastructure Act of 2018 requires the USEPA to review WaterSense performance criteria adopted before January 1, 2012 by the end of 2019. At the time of this publication, the results of that review, including any revised performance criteria, have not been made available.

Table A.3-2: Natural replacement rate of fixtures. Values for washing machines and dishwashers are from Hazen and Sawyer (2013). Values for all other fixtures are from Schein et al. (2017).

Fixture	Expected Life (Years)		
	Minimum	Average	Maximum
Residential Toilets	10	20	30
Commercial Toilets	10	20	30
Showerheads	5	10	15
Residential faucets	5	10	15
Washing machines	12	12	12
Dishwasher	8	8	8

Table A.3-3: Frequency of fixture and appliance use (DeOreo et al., 2016; Hazen and Sawyer, 2013).

Fixture	Event	Event Frequencies	Total Use
Residential Toilets	flushes/person/day	5.0	13 total flushes
Commercial Toilets	flushes/employee/day	3.0	--
Showerheads	minutes/person/day	5.4	14.04 total minutes
Faucets	minutes/person/day	10.0	25.5 total minutes
Washing machines	loads/person/day	0.3	0.78 total loads
Dishwasher	loads/person/day	0.1	0.26 total loads

Note: Assumes 2.26 people per household.

Table A.3-4: Percent market share of EPAct and WaterSense-rated toilets (McNeil et al., 2008).

Year	WaterSense			EPAct		
	SP3	SP2	SP1	SP3	SP2	SP1
2015	13%	35%	53%	87%	65%	47%
2018	21%	55%	83%	79%	45%	17%
2020	28%	75%	99%	72%	25%	1%
2025	47%	99%	99%	53%	1%	1%
2030	66%	99%	99%	34%	1%	1%
2035	66%	99%	99%	34%	1%	1%
2040	66%	99%	99%	34%	1%	1%
2045	66%	99%	99%	34%	1%	1%

Notes: Gray values were assumed equal to the last year of data.

Table A.3-5: Percent market share of EPAct and WaterSense-rated faucets (McNeil et al., 2008).

Year	WaterSense			EPAct		
	SP3	SP2	SP1	SP3	SP2	SP1
2015	24%	30%	30%	76%	70%	70%
2018	36%	45%	50%	64%	55%	50%
2020	44%	55%	65%	56%	45%	35%
2025	64%	80%	99%	36%	20%	1%
2030	84%	99%	99%	16%	1%	1%
2035	84%	99%	99%	16%	1%	1%
2040	84%	99%	99%	16%	1%	1%
2045	84%	99%	99%	16%	1%	1%

Notes: Gray values were assumed equal to the last year of data.

Table A.3-6: Percent of market share of conventional and high efficiency clothes washers (Hazen and Sawyer, 2013).

Year	Conventional	High Efficiency
2015	47%	53%
2020	33%	67%
2025	30%	70%
2030	30%	70%
2035	30%	70%
2040	30%	70%
2045	30%	70%

Notes: Gray values were extrapolated. These rates were also assumed for dishwashers.

Table A.3-7: Low, middle, and high scenario estimates for household fixture and appliance water use (gpd/unit).

Year			2018	2020	2025	2030	2035	2040	2045
Water Use	Toilets	SP3	29.9	28.8	26.5	24.5	22.9	21.7	20.7
		SP2	25.9	24.7	22.1	20.4	19.2	18.4	17.9
		SP1	19.6	18.9	17.7	17.2	16.9	16.8	16.8
	Clothes Washers	SP3	10.1	10.0	10.0	10.0	10.0	9.9	9.9
		SP2	10.1	10.0	10.0	10.0	10.0	9.9	9.9
		SP1	10.1	10.0	10.0	10.0	10.0	9.9	9.9
	Dishwashers	SP3	1.3	1.3	1.2	1.2	1.2	1.2	1.2
		SP2	1.3	1.3	1.2	1.2	1.2	1.2	1.2
		SP1	1.3	1.3	1.2	1.2	1.2	1.2	1.2
	Faucets	SP3	39.6	37.8	34.7	32.8	31.7	31.0	30.6
		SP2	36.0	34.5	32.1	31.0	30.5	30.2	30.1
		SP1	31.5	30.9	30.2	30.1	30.0	30.0	30.0
	Showerheads	SP3	22.5	21.3	19.2	18.0	17.3	17.0	17.3
		SP2	20.5	19.4	17.7	16.9	16.5	16.4	16.4
		SP1	17.6	17.0	16.3	16.2	16.2	16.2	16.2
	Total	SP3	103.4	99.3	91.6	86.5	83.0	80.9	79.8
		SP2	93.9	89.9	83.2	79.4	77.3	76.2	75.5
		SP1	80.1	78.0	75.5	74.6	74.3	74.1	74.1

Table A.3-8: Savings applied to the 2018 unit use rates to estimate the unit use rate in the given forecast year (gpd/unit).

Year	SFH and MFH Savings			EMP Savings		
	SP3	SP2	SP1	SP3	SP2	SP1
2018	--	--	--	--	--	--
2020	4.1	3.9	2.1	0.2	0.2	0.2
2025	11.7	10.7	4.6	0.6	0.8	0.8
2030	16.9	14.4	5.5	1.0	1.1	1.1
2035	20.3	16.5	5.8	1.3	1.4	1.4
2040	22.5	17.7	6.0	1.5	1.6	1.6
2045	23.6	18.4	6.1	1.7	1.8	1.8

A.3.2 Supplier Data: Fairfax Water

Fairfax Water data includes both their retail and wholesale customers. Retail data is provided by Fairfax Water staff. Wholesale data is provided by individual customers except for the Dulles International Airport, Fort Belvoir, City of Alexandria, and Dale City. In 2013 their wholesale customers expanded to include the Town of Vienna. Then in 2014 their retail customers expanded to include the City of Fairfax and the City of Falls Church. Going into the future, wholesale purchases by Loudoun Water will be influenced by operations at their Trap Rock WTF and Goose Creek water treatment plant (D. Geldert, personal communication, December 18, 2019). These potential changes in wholesale purchases are reflected in assumptions used in Loudoun Water's demand forecast. Fairfax Water wholesale customers are

- Dulles International Airport
- Fort Belvoir
- The Town of Herndon
- Loudoun Water
- Prince William County Service Authority
- Virginia American, City of Alexandria
- Virginia American, Dale City
- The Town of Vienna.

A.3.2.1 Fairfax Water – Retail

Fairfax Water retail customers are predominantly in Fairfax County, the City of Falls Church, and Fairfax City. They have some customers from Arlington County as well. Data and calculations are reported in Table A.3-9 and Table A.3-10 below.

A.3.2.1.1 Service Area

An updated shape file of pressure zone coverage for the retail service area is included in this study (N. Saji, personal communication, August 13, 2019). This shape file includes the City of Fairfax and the City of Falls Church (which are modeled with an effective service area change in 2014). The City of Fairfax is a retail customer of Fairfax Water that is included in ICPRB's 2015 study (Ahmed *et al.*). Prior to April 2013, the City of Fairfax was an independent water supplier and was not part of this study. The City of Falls Church is a more recent retail customer, which has effectively made Fairfax Water a wholesale customer of Washington Aqueduct. Washington Aqueduct records still show water being bought by Falls Church after 2014, even though it is actually being bought by Fairfax Water and then distributed to the Falls Church service area through the same infrastructure as previously used (A. Spiesman, personal communication, March 21, 2019). Additionally, an area in the Fort Belvoir service area is corrected from ICPRB's 2015 study (Ahmed *et al.*). No future changes in the service area are reported for this study.

Some assumptions on the TAZ ratios within the Fairfax Water retail service area are made to correct for errors in the known inclusion or exclusion of jurisdictions as follows:

- Only Arlington, Fairfax, Fairfax City, and Falls Church county ratios are kept as is
- All service areas that overlap with the Arlington service area are assumed to be served by Fairfax Water because it is known that Fairfax Water serves some of Arlington County
- All Alexandria, Loudoun, Montgomery, Prince George's, and Prince William county ratios are set to zero

A.3.2.1.2 Demographic Data

POP, HH, and EMP data are interpolated between the years 2010 and 2045 using MWCOG Round 8.4 and Round 9.1 forecasts. Because the Fairfax Water retail service area changed in 2014, the following steps are taken to estimate the demographic data during that transition period:

- Round 8.4 and Round 9.1 forecasts between 2010 and 2015 are interpolated
- Pre-2014 TAZ ratios (calculated from 2015 study service area and corrected for Fort Belvoir) are applied to get 2010-2013 estimates
- Post-2014 TAZ ratios (calculated from updated service area) are applied to get 2014 through 2050 estimates

Demographic data are divided into SFH and MFH estimates using dwelling unit ratios calculated from jurisdictional data. Following recommendations from Fairfax County, demographic data from the Fairfax County Geospatial Data page is used (F. Khaja, personal communication, April 30, 2019). Search terms "Households" and "Housing" locate spreadsheet data in the database for current and forecasted HH and HU data. The IPLS Data Dictionary contains information of the available data. Current housing unit data is provided by year built for the following housing unit types:

- SF – single family detached (SFD)
- TH – townhouse unit (SFA)
- MP – multiplex unit (SFA)
- DX – duplex unit (SFA)
- LR – low rise unit (MF)
- MR – mid rise unit (MF)
- HR – high rise unit (MF)

- MH – mobile home

These categories are grouped into SFH and MFH as follows and summed accumulatively by built year to get housing unit totals for the historical years 2010-2018 needed for this study:

- SFH: SF, TH, MP, DX
- MFH: LR, MR, HR,

Forecasted HU data is provided as low, current, and high forecasts. The current forecast is used. These forecasts are separated out by forecast year number, which is added to the VALID_TO field to get the forecast year (i.e., CURRE_YEAR_1_UNIT is the forecast for 2018 for a VALID_TO date of 1-JAN-2018). The data is listed for the following HU types:

- SFD – Single family detached includes SF
- SFA – Single family attached includes TH, MP, and DX
- MF – Multifamily includes LR, MR and HR
- MH – Mobile homes

These categories are grouped into the following two categories to get HU totals for years 2018-2045 needed for this study (forecasts out to 2048 are available):

- SFH: SFD, SFA, MH
- MFH: MH

No vacancy rate information is provided in the HU data. However, HH forecasts are available for the years 2018-2045. This data shows that a 2% vacancy rate had been used throughout the forecast period.

The following two alternative sources for demographic data are available but are not used: (1) the Fairfax County Demographic Reports, and (2) the ACS. Fairfax County compiles "Demographic Reports" of estimated and forecasted population, households, and housing units on an annual basis. The household data includes the number of single family detached, single family attached, and multi-family HUs, as well as the county-wide vacancy rate. Each report provides estimated future number of HUs by unit type. These reports are available to gather 2010-2045 demographic data. The Fairfax County forecasts for 2015-2045 can be taken from the 2018 Annual Demographic Report. Additional HU and HH data are available from the U.S. Census Bureau, ACS. ACS has estimates of the number of HU by unit type and the overall vacancy rate.

Figure A.3-1 compares the DUR results calculated from the Fairfax County Geospatial data set with these two other unused sources. The final DUR calculation is based on data for the entire county; no adjustments are made to match the extent of the Fairfax Water service area. Also, the Town of Herndon and the Town of Vienna housing unit and household numbers are not subtracted from the county totals when estimating the county-side DURs. This is not done because there are no forecasts specific to the towns for SFHU or MHFU. Therefore, for consistency, the county-wide data are used for the Fairfax County DUR. While the City of Falls Church and the City of Fairfax are also within the county boundaries, they are independent jurisdictions and do their own demographic forecasts. In the future, it may be possible to do further analysis on the Fairfax County Geospatial data set to calculate a DUR specific to the Fairfax Water service area.

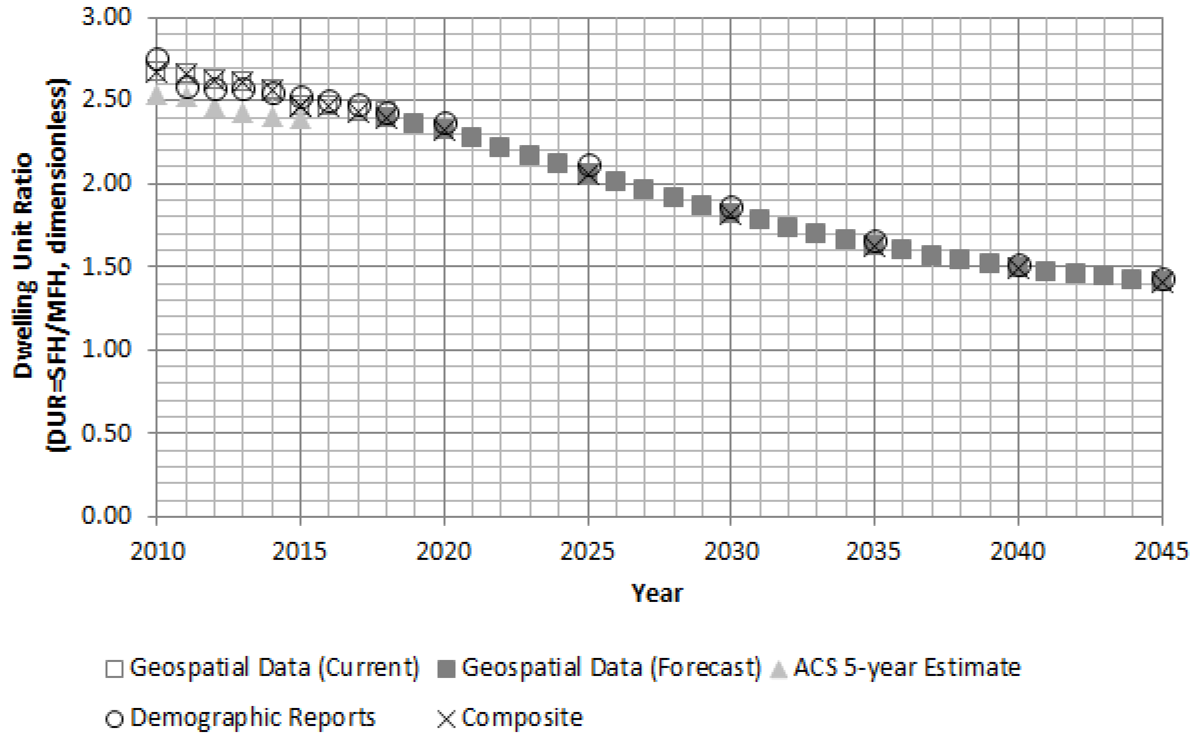

Figure A.3-1: Dwelling unit ratio comparison by data source for Fairfax County (includes the Town of Vienna, the Town of Herndon, and Fort Belvoir). Composite indicates the data points reported in the tables of this report.

A.3.2.1.3 Water Use Data

Production data for 2014-2018 by calendar year is provided by Fairfax Water staff (N. Saji, personal communication, May 31, 2019). Data from 2010-2013 is from the 2015 study (Ahmed et al.), which is also by calendar year.

Water use data is also shared by Fairfax Water staff as the actual amount billed to customers by calendar year from 2014-2018 (N. Saji, personal communication, May 31, 2019). The wholesale amount sold to customers is included in the billing data. The wholesale amount is the sum of Virginia American – Alexandria, Virginia American - Dale City, Prince William County Service Authority, Loudoun Water, Town of Vienna, Town of Herndon, Fort Belvoir, and Dulles Airport customer sales. The City of Fairfax and the City of Falls Church are not included as wholesale sales for this study because they are now part of the retail data. Purchase data is also provided separately for the City of Falls Church. Retail customers from the City of Falls Church, and sometimes wholesale customers from the Town of Vienna, receive purchase water from the McMillan and Dalecarlia treatment plants, which are part of Washington Aqueduct (G. Prelewicz, personal communication, April 6, 2020).

An approximation of unmetered/non-revenue water, which is primarily attributed to distribution system losses, is provided by Fairfax Water staff. The unmetered/non-revenue water is estimated as the "Water Produced (Griffith and Corbalis)" plus the "Water Purchased from Washington Aqueduct" minus "Total Sold," where total sold includes the retail and wholesale sales.[8]

Fairfax Water billing data is reported in the following categories:

- Single Family
- Townhouse
- Apartment
- Commercial and Industrial
- Municipal and Institutional

The Fairfax Water categories are grouped into the categories needed for this study as follows:

- SFH: Single Family, Townhouse
- MFH: Apartment
- EMP: Commercial and Industrial, Municipal and Institutional

[8] Falls Church water is purchased from the Washington Aqueduct, not produced, and included in the Fairfax Water retail sales data. To get an accurate unmetered use, the water purchased from Washington Aqueduct needs to be added to the water produced before water billed is subtracted.

Table A.3-9: Historical data for unit use calculations and results –Fairfax Water – Retail.

			Historic Data								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
Produced (Corbalis + Griffith WTP, MGD)			156.95	149.69	151.6	143.92	149.02	149.59	159.88	155.30	151.10
Purchased (FW Reported, MGD)			--	--	--	--	14.01	14.08	11.44	14.77	15.06
Purchased (WA Reported, MGD)			--	--	--	--	14.24	14.12	11.46	14.79	15.08
Demand (MGD)	Retail Sales	Single Family Household	46.16	44.65	43.07	41.81	47.40	47.18	47.94	46.79	44.54
		Multi-Family Household	13.22	13.81	13.07	13.74	16.92	17.00	17.27	17.50	17.53
		Employee	17.28	17.04	16.06	14.79	19.22	19.56	20.52	19.84	19.22
	Wholesales		65.90	65.13	65.72	63.69	67.14	67.00	69.73	68.87	68.79
	Unmetered/Non-Revenue		14.39	9.06	13.68	9.89	12.36	12.92	15.86	17.07	16.08
	Percent Unmetered/Non-Revenue		9%	6%	9%	7%	8%	8%	9%	10%	10%
	Total Demand		156.95	149.69	151.6	143.92	163.03	163.67	171.32	170.07	166.16
Demographics	Population (units)		853,360	859,134	864,908	870,681	1,063,611	1,071,499	1,079,233	1,086,966	1,094,700
	Employees (units)		424,167	427,305	430,443	433,581	600,391	604,241	612,603	620,966	629,329
	Households (units)		307,049	309,402	311,756	314,109	385,513	388,677	390,986	393,295	395,605
	DUR (dimensionless)		2.67	2.66	2.63	2.61	2.57	2.47	2.46	2.44	2.40
	Single Family Households (units)		223,402	224,777	225,819	227,061	277,474	276,638	278,066	278,806	279,218
	Multi-Family Households (units)		83,647	84,625	85,936	87,048	108,039	112,039	112,920	114,490	116,386
Unit Use (gpd/unit)	Single Family Household		206.6	198.6	190.7	184.1	170.8	170.6	172.4	167.8	159.5
	Multi-Family Household		158.0	163.2	152.1	157.8	156.6	151.7	152.9	152.9	150.6
	Employee		40.7	39.9	37.3	34.1	32.0	32.4	33.5	31.9	30.5

Note: Total demand includes the amount purchased from Washington Aqueduct (Falls Church service area) and the wholesale amount sold to Loudoun Water.

Table A.3-10: Forecast data for unit use calculations and results – Fairfax Water – Retail.

			Forecast Data							
			2018	2020	2025	2030	2035	2040	2045	2050
Produced (Corbalis + Griffith WTP, MGD)			152.41	144.93	148.45	153.46	158.11	162.79	168.67	174.67
Purchased from Washington Aqueduct (MGD)			13.51	13.61	14.45	15.09	15.88	16.69	17.39	18.14
Demand (MGD)	Retail Sales	Single Family Household	44.13	43.11	42.06	41.87	41.74	41.84	42.26	42.07
		Multi-Family Household	17.55	17.71	19.44	21.87	24.32	26.54	28.39	30.80
		Employee	18.74	19.11	19.70	20.46	21.14	22.03	22.72	23.53
	Wholesales		68.90	62.76	65.41	67.50	69.40	71.11	74.08	77.13
	Unmetered/Non-Revenue		16.59	15.85	16.29	16.85	17.40	17.95	18.61	19.28
	Percent Unmetered/Non-Revenue		10%	10%	10%	10%	10%	10%	10%	10%
	Total Demand		165.92	158.55	162.90	168.55	173.99	179.48	186.06	192.81
Demographics	Population (units)		1,094,700	1,110,167	1,163,136	1,225,400	1,279,830	1,328,578	1,372,031	1,419,014
	Employees (units)		629,329	646,054	679,577	713,301	744,639	781,780	812,003	846,838
	Households (units)		395,605	400,223	424,236	451,785	475,935	497,605	517,060	537,991
	DUR (dimensionless)		2.40	2.32	2.06	1.82	1.63	1.49	1.41	1.29
	Single Family Households (units)		279,218	279,620	285,415	291,417	294,824	298,112	302,593	303,478
	Multi-Family Households (units)		116,386	120,603	138,821	160,368	181,111	199,493	214,467	234,513
Unit Use (gpd/unit)	Single Family Household		158.1	154.2	147.4	143.7	141.6	140.4	139.7	138.6
	Multi-Family Household		150.8	146.9	140.1	136.4	134.3	133.1	132.4	131.3
	Employee		29.8	29.6	29.0	28.7	28.4	28.2	28.0	27.8
Total estimated error (MGD)			--	30.0	31.5	33.1	34.8	36.5	38.7	40.8

Note: Loudoun Water's wholesale purchase amount assumes the Trap Rock WTP production rate will be 4.42, 12.00, 13.00, 14.00, 15.00, 16.00, 17.00, and 17.00 MGD for years 2018, 2020, 2025, 2030, 2035, 2040, 2045, and 2050, respectively (P. Kenel, personal communication, April 3, 2020). A 10% unmetered use is assumed.

A.3.2.2 Fairfax Water – Wholesale Customer – Town of Herndon

The Town of Herndon purchases finished water from Fairfax Water. Data and calculations are reported in Table A.3-11 and Table A.3-12 below.

A.3.2.2.1 Service Area

The Town of Herndon service area is updated with a shape file that has minor changes along the town boundary. TAZ ratios are rounded, in some cases, to reduce overlap with Fairfax Water service area.

A.3.2.2.2 Demographic Data

POP, HH, and EMP data are interpolated between the years 2010 and 2045 using MWCOG Round 8.4 and Round 9.1 forecasts. The HH data is split into SFH and MFH using DUR ratios calculated from jurisdictional HU data provided by D. Heiberg (personal communication, April 30, 2019). Memorandums written on "The Annual Population Estimate" detail dwelling unit information for historical years 2010-2019, including vacancy rate assumptions. The 5% vacancy rate for projected years 2020-2045 is from the 2019 memorandum footnote. D. Heiberg data describes the 2020, 2030, and 2040 total HUs split into single family detached, single family attached (townhouses), multifamily (apartments and condominiums) housing types. The single family attached HUs increase 316 units from 2020 to 2030. The 316 townhouses may come along by 2025 based on an application that is in process now, but it is still unknown. Assumptions for estimating 2025, 2035, and 2045 SFHU and MFHU are used (D. Heiberg, personal communication June 7, 2019) as follows: (1) The MFHU estimates are evenly interpolated for years 2025 and 2035, as it is very hard to predict them; (2) The SFHU value is held constant until 2040; (2) The same totals for 2040 are used for 2045 because by 2040 the total HU estimates equal 100% of the projected build-out for the Metrorail Transit Oriented Core and it is unknown if these projects will reach completion.

Two other available data sources include, but are not used, (1) the Town of Herndon 2030 Comprehensive Plan,[9] and (2) the Fairfax County Demographic Reports.[10] Figure A.3-2 compares the DUR estimates from the County planner's memorandum to those estimated from the ACS data.

[9] Town of Herndon 2030 Comprehensive Plan: https://www.herndon-va.gov/home/showdocument?id=1727
[10] Fairfax County Demographic Reports: https://www.fairfaxcounty.gov/demographics/reports

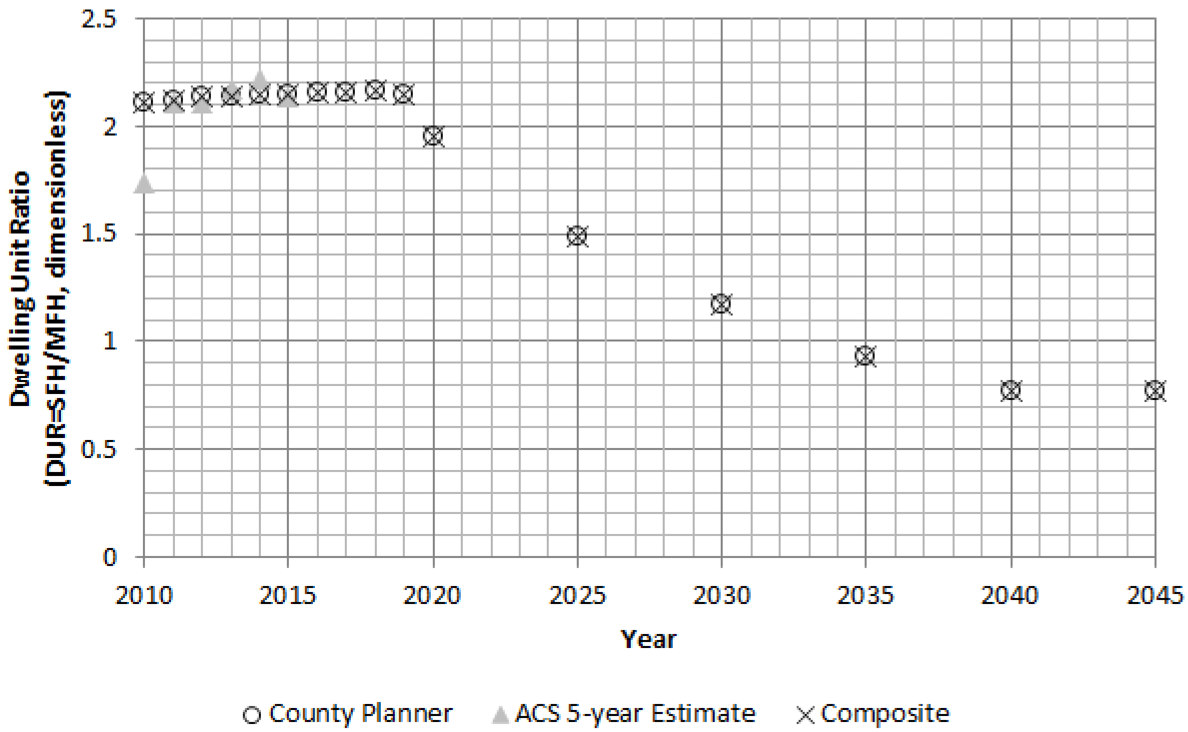

Figure A.3-2: Dwelling unit ratio comparison by data source for Town of Herndon.

A.3.2.2.3 Water Use Data

Water use is updated with billed water data provided by Fairfax Water (N. Saji, personal communication, May 31, 2019) and purchased water data provided by the Town of Herndon (B. Etris, personal communication, July 24, 2019). The Town of Herndon does not have any sold water. The purchase/billing data is not provided by housing category. Instead B. Etris provided a 52% residential, 39% commercial, and 9% unaccounted for estimate for the year 2040 with a future demand estimate of 3.56 MGD for an average day. The 2040 breakdown is recommended for all years (B. Etris, personal communication, Oct 10, 2019). The Town's billing data is unreliable because they switched to a new system about two years ago. Much of the data concerning residential versus commercial is not accurate. The final billing data are grouped into two categories: residential and commercial. They are categorized for this study as:

- Residential (combined SFH and MFH use): Residential
- EMP: Commercial

Therefore, the residential unit use is used instead of SFH and MFH unit use.

Table A.3-11: Historical data for unit use calculations and results – Fairfax Water – Town of Herndon – Wholesale.

			Historic Data								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
Purchased (FW Reported, MGD)			2.16	2.12	2.14	1.97	2.10	2.10	2.22	2.23	2.26
Billed (Town of Herndon Reported, MGD)			2.18	2.12	2.03	1.91	1.87	1.90	1.93	1.93	1.94
Demand (MGD)	Retail Sales	Residential	1.14	1.09	1.05	0.93	1.09	1.09	1.15	1.16	1.17
		Employee	1.04	1.03	0.97	0.98	0.82	0.82	0.87	0.87	0.88
	Unmetered/Non-Revenue		-0.02	0.00	0.12	0.06	0.19	0.19	0.20	0.20	0.20
	Percent Unmetered/Non-Revenue		0%	0%	6%	3%	9%	9%	9%	9%	9%
	Total		2.16	2.12	2.14	1.97	2.10	2.10	2.22	2.23	2.26
Demographics	Population (units)		20,067	20,601	21,170	21,739	22,308	22,911	22,593	22,311	22,028
	Employees (units)		21,138	21,376	21,648	21,920	22,191	22,520	22,943	23,423	23,903
	Occupied Households (units)		7,129	7,195	7,271	7,347	7,423	7,508	7,512	7,526	7,540
	DUR (dimensionless)		2.11	2.12	2.14	2.14	2.15	2.15	2.16	2.16	2.17
	Single Family Households (units)		4,837	4,889	4,955	5,007	5,066	5,125	5,135	5,145	5,162
	Multi-Family Households (units)		2,292	2,306	2,315	2,340	2,356	2,384	2,377	2,382	2,379
Unit Use (gpd/unit)	Residential		159.9	151.5	144.4	126.6	147.0	145.3	153.6	154.0	155.8
	Employee		49.2	48.2	44.8	44.7	36.9	36.4	37.8	37.2	36.9

Note: The residential use category combines SFH and MFH data; Purchased and billed values for 2014-2018 are provided as total amounts. Purchased amounts are disaggregated assuming 52% residential, 39% commercial, and 9% unaccounted for water; Billed values for 2010-2013 are estimated from fiscal year data for July-December 2010, 2011, 2012, and January-June 2013. The Town of Herndon re-grouped these data by calendar year and used typical consumption ratios to fill in the missing months of data (A. Barnes, personal communication, April 1, 2014).

Table A.3-12: Forecast data for unit use calculations and results – Fairfax Water – Herndon – Wholesale.

			Forecast Data							
			2018	2020	2025	2030	2035	2040	2045	2050
Purchased (MGD)			2.17	2.18	2.37	2.48	2.57	2.59	2.68	2.73
Demand (MGD)	Retail Sales	Residential	1.14	1.11	1.09	1.10	1.12	1.14	1.17	1.19
		Employee	0.82	0.85	1.04	1.13	1.19	1.19	1.25	1.27
	Unmetered/Non-Revenue		0.22	0.22	0.24	0.25	0.26	0.26	0.27	0.27
	Percent Unmetered/Non-Revenue		10%	10%	10%	10%	10%	10%	10%	10%
	Total		2.17	2.18	2.37	2.48	2.57	2.59	2.68	2.73
Demographics	Population (units)		22,028	21,494	21,945	22,475	23,002	23,473	23,926	24,392
	Employees (units)		23,903	24,921	30,873	34,063	36,070	36,411	38,289	39,142
	Occupied Households (units)		7,540	7,578	7,823	8,092	8,356	8,592	8,819	9,053
	DUR (dimensionless)		2.17	1.95	1.49	1.17	0.93	0.77	0.77	0.66
	Single Family Households (units)		5,162	5,009	4,681	4,363	4,026	3,738	3,837	3,610
	Multi-Family Households (units)		2,379	2,569	3,142	3,729	4,329	4,854	4,983	5,442
Unit Use (gpd/unit)	Residential		150.5	146.6	139.8	136.1	134.0	132.8	132.1	131.1
	Employee		34.4	34.2	33.6	33.3	33.0	32.8	32.6	32.4
Total estimated error (MGD)			--	1.0	1.1	1.1	1.2	1.2	1.3	1.4

Note: The Town revised its estimate of unmetered use rate from the industry-standard range of 13% to 15% (A. Barnes, personal communication, April 1, 2014) used in ICPRB's 2015 study to 9% (B. Etris, personal communication, Oct 10, 2019). The value used here is rounded up based on our minimum unmetered use rate assumption of 10% for forecast years.

A.3.2.3 Fairfax Water – Wholesale Customer – Vienna

The Town of Vienna purchases finished water from Fairfax Water. Fairfax Water has the capability of supplying the Town of Vienna with water from either a Fairfax Water treated source or from Washington Aqueduct purchased water. When Fairfax Water supplies from the Washington Aqueduct, this is reflected in the reported Fairfax Water purchase total (G. Prelewicz, personal communication, April 6, 2020). Data and calculations are reported in Table A.3-13 and Table A.3-14 below.

A.3.2.3.1 Service Area

The Town of Vienna service area is updated with a shape file dated June 2019 (L. Blandon, personal communication, July 28, 2019). The new service area is slightly different from that provided by Fairfax Water in 2015. The 2015 service area better matches the Town of Vienna profile in the Fairfax Water service area and is used based on a disucssion with Fairfax Water (G. Prelowitzc and N. Sajji, personal communication, August 21, 2019). The 2015 service area still had some overlap with the Fairfax Water service area. One small area overlap is in the middle of the Town of Vienna that is an error. The small area overlaps around the perimeter of the Town of Vienna are assumed to belong to Fairfax Water and most of these areas round to near zero ratios.

A.3.2.3.2 Demographic Data

POP, HH, and EMP data are interpolated between the years 2010 and 2045 using MWCOG Round 8.4 and Round 9.1 forecasts. Demographic HH data is divided into SFH and MFH estimates using dwelling unit ratios calculated from jurisdictional data. The demographic data specific to the town’s service area are from the Fairfax County Geospatial Data page.[11] Search terms “Households” and “Housing” produce results for spreadsheet data for current and forecasted household and housing unit data. Parcel data is also available. The IPLS Data Dictionary contains information of the available data.[12]

Two alternative sources for demographic data include, but are not used, (1) the Fairfax County Demographic Reports, and (2) the American Community Survey (ACS). Figure A.3-3 compares the dwelling unit ratio results calculated from the Fairfax County Geospatial Data with these two other sources. Fairfax County compiles “Demographic Reports” of estimates and forecasts of population, households and housing unit estimates and forecasts on an annual basis.[13] The household data includes the number of single family detached, single family attached, and multi-family housing units, as well as the county-wide vacancy rate. Each report provides estimates of the future number of housing units by unit type. These reports are available to gather 2010-2045 demographic data. The Fairfax County

[11] Fairfax County Geospatial Data: https://www.fairfaxcounty.gov/maps/open-geospatial-data
[12] IPLS Data Dictionary: https://www.fairfaxcounty.gov/demographics/sites/demographics/files/assets/datadictionary/ipls-data-dictionary-gis.pdf
[13] Demographic Reports: https://www.fairfaxcounty.gov/demographics/reports

forecasts for 2015-2045 are taken from the 2018 Annual Demographic Report. Additional housing unit and household data are available from the U.S. Census Bureau, ACS. ACS has estimates of the number of housing units by unit type and the overall vacancy rate.

The water customer service area extends beyond the zoning and ACS shape files of the Town of Vienna. Clipping the Fairfax County GIS housing data to the town zoning shape file produces numbers similar to the 5,600 in town water customers reported in the FY 11-12 Budget.[14] However, when the service area is used to clip the housing data, the numbers better represent the 9,200 total water customers. Because the DUR calculations from the Fairfax County Demographic Reports align better with the town zoning data, the DURs calculated from the Fairfax County GIS housing data clipped to the water customer service area are used.

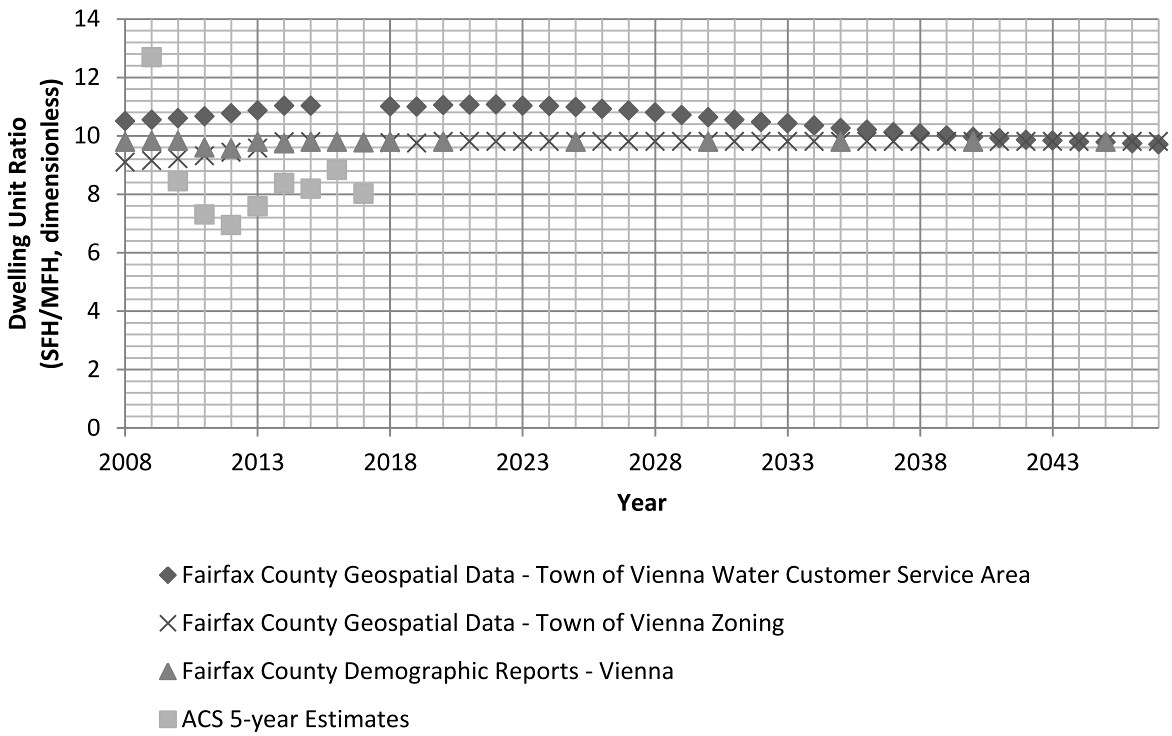

Figure A.3-3: Town of Vienna dwelling unit ratio comparison.

A.3.2.3.3 Water Use Data

Two water use data sets are included: (1) Fairfax Water data on water purchased by Vienna for the years 2010-2018, which is only a portion of the total amount they used prior to 2014; (2) Town of Vienna data

[14] FY 11-12 BUDGET through FY 17-18 BUDGET reports, see https://www.viennava.gov/index.aspx?nid=330

on the water purchased for years 2010-2018 as metered consumption by calendar year (L. Blandon, personal communication, July 29, 2029). The Town also provided water billed data for years 2014-2018.

Figure A.3-4 shows the shift in water source over the historical record. It is documented that the town was an exchange customer through 2012 and then became a Fairfax Water wholesale customer in 2013. The Town billing data is separated out by provider (e.g., Washington Aqueduct – Falls Church (2010-2013), Fairfax Water (2010-2018), and groundwater (none)). It is reported that the town began getting all its water from Fairfax Water in September 2012 (L. Blandon, personal communication, July 29, 2029), but this is not shown in the data. The data shows that all the town's water is purchased from Fairfax Water between the years 2014 and 2018. Also, the Town reports using groundwater in 2007, but it was confirmed by L. Blandon that groundwater is no longer used (personal communication, July 29, 2019).

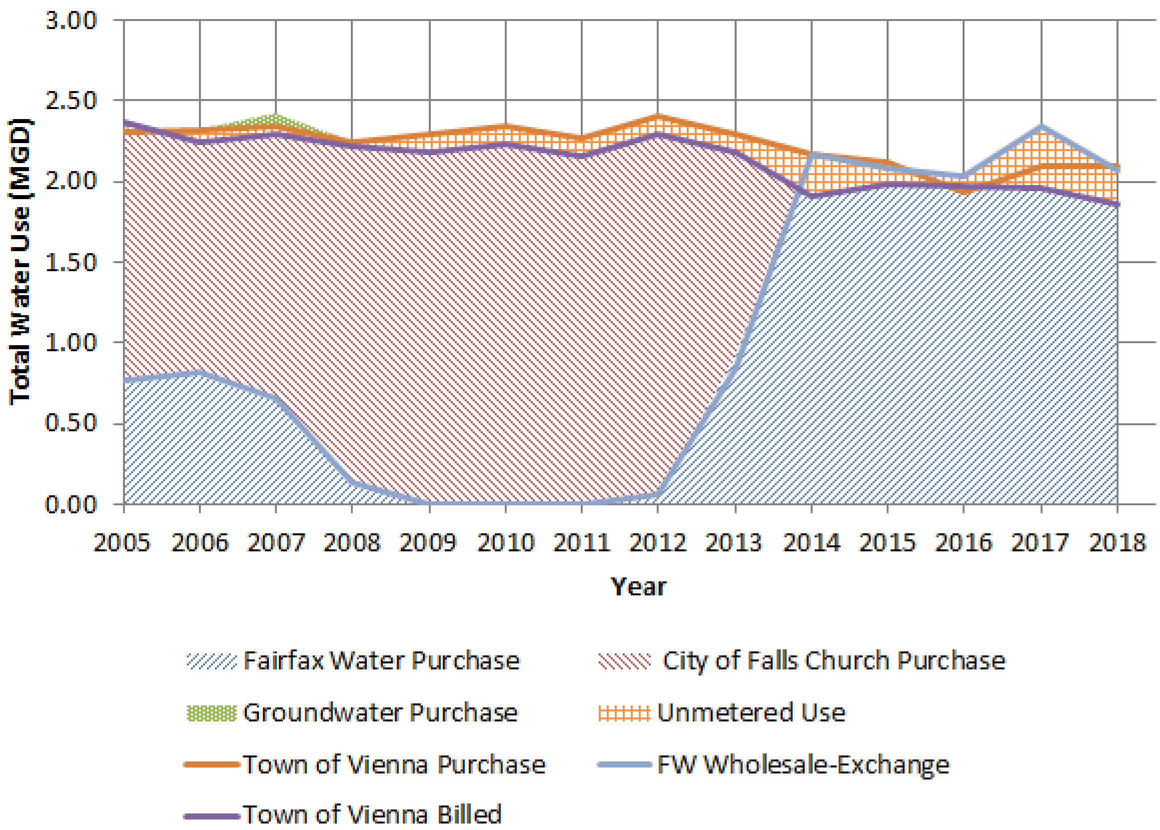

Figure A.3-4: Town of Vienna total water use by source.

Several assumptions about missing data are made. The Town of Vienna value for 2014 Fairfax Water use is missing from the purchase data, but not from billing data, which reports a value of 2.17 MGD. Therefore, a value of 2.17 MGD is assumed for the Town's purchase amount for 2014. Fairfax Water sold data and Town of Vienna purchase data do not match for the years 2015-2018. The sold amount from by Fairfax Water data is assumed for the unit use calculation for years 2014-2018.

Water billed data provided for years 2014-2018 is not separated into single family, multi-family, or employee use. L. Blandon mentioned that they can start tracking and collecting single-family, multi-family, and employee use for the next request (personal communication, July 29, 2019). However, 2005-2008 billed data are available for single family, multi-family, or employee use, along with the corresponding purchase amounts. The 2008 data shows that single family, multi-family, and employee water use make up 79%, 5%, and 16% of the total water billed, respectively. These percentages are very close to those calculated for the 2005-2007 billed data and, therefore, are assumed to be representative of the 2009-2018 years. An unmetered use of 5% is assumed as the average percent difference between thee 2005-2008 and 2014-2018 purchase and billed data. This percent unmetered use is used to estimate the missing 2009-2013 billed amount to get a full set of estimates for the 2009-2018 SF, MF, and EMP water amounts. The percent unmetered use was increased to 10% for forecast years based on the more recent 2014-2018 billed and purchase data.

Table A.3-13: Historical Data for unit use calculations and results – Fairfax Water – Town of Vienna – Wholesale.

			Historic Data								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
Total Purchased (Vienna Reported, MGD)			2.35	2.27	2.41	2.30	2.17	2.12	1.93	2.10	2.09
FW Purchased (Fairfax Water Reported, MGD)			0.00	0.00	0.06	0.84	2.17	2.08	2.03	2.34	2.07
Demand (MGD)	Retail Sales	Single Family Household	1.76	1.70	1.81	1.72	1.51	1.57	1.55	1.54	1.47
		Multi-Family Household	0.10	0.10	0.11	0.10	0.09	0.09	0.09	0.09	0.09
		Employee	0.37	0.36	0.38	0.36	0.31	0.33	0.32	0.32	0.31
	Unmetered/Non-Revenue		0.12	0.11	0.12	0.11	0.26	0.09	0.06	0.39	0.21
	Percent Unmetered/Non-Revenue		5%	5%	5%	5%	12%	5%	3%	17%	10%
	Total		2.35	2.27	2.41	2.30	2.17	2.08	2.03	2.34	2.07
Demographics	Population (units)		26,839	26,978	27,116	27,255	27,394	27,533	27,596	27,659	27,721
	Employees (units)		13,345	13,271	13,197	13,123	13,049	12,976	13,127	13,279	13,430
	Occupied Households (units)		9,039	9,079	9,119	9,159	9,199	9,239	9,238	9,238	9,237
	DUR (dimensionless)		10.60	10.67	10.77	10.87	11.03	11.03	11.02	11.01	11.01
	Single Family Households (units)		8,260	8,301	8,344	8,387	8,434	8,471	8,470	8,469	8,468
	Multi-Family Households (units)		779	778	775	772	765	768	768	769	769
Unit Use (gpd/units)	Single Family Household		212.8	205.0	216.4	205.1	178.5	184.9	183.3	181.9	173.3
	Multi-Family Household		133.6	129.6	138.0	132.0	116.6	120.8	119.6	118.6	112.9
	Employee		27.5	26.8	28.6	27.4	24.1	25.2	24.7	24.2	22.8

Note: 2005-2008 is the most complete set of billed and purchased data. Used the 2005-2008 average SF, MF, and EMP billing ratios (which are close in value between years) to disaggregate the billed data to estimate 2009-2018 data; For years 2009-2013, assumed 5% unmetered use based on average from other years (excluded 2005, 2014 and 2016 data due to missing data or negative unmetered use). For years 2014-2018 estimated unmetered use based on provided purchased and billed amounts.

Table A.3-14: Forecast data for unit use calculations and results – Fairfax Water – Town of Vienna – Wholesale.

			Forecast Data							
			2018	2020	2025	2030	2035	2040	2045	2050
Purchased (MGD)			2.07	2.03	1.96	1.94	1.94	1.94	1.95	1.96
Demand (MGD)	Retail Sales	Single Family Household	1.46	1.43	1.38	1.36	1.36	1.36	1.37	1.38
		Multi-Family Household	0.09	0.08	0.08	0.08	0.08	0.08	0.09	0.09
		Employee	0.31	0.32	0.31	0.31	0.30	0.30	0.30	0.30
	Unmetered/Non-Revenue		0.21	0.20	0.20	0.19	0.19	0.19	0.20	0.20
	Percent Unmetered/Non-Revenue		10%	10%	10%	10%	10%	10%	10%	10%
	Total		2.07	2.03	1.96	1.94	1.94	1.94	1.95	1.96
Demographics	Population (units)		27,721	27,847	27,971	28,342	28,811	29,169	29,570	29,943
	Employees (units)		13,430	13,734	13,827	13,902	13,938	13,985	14,028	14,074
	Occupied Households (units)		9,237	9,236	9,278	9,399	9,552	9,672	9,804	9,928
	DUR (dimensionless)		11.01	11.05	10.98	10.64	10.27	9.96	9.78	9.52
	Single Family Households (units)		8,468	8,470	8,504	8,592	8,704	8,789	8,895	8,984
	Multi-Family Households (units)		769	767	774	808	848	882	909	944
Unit Use (gpd/units)	Single Family Household		172.5	168.6	161.8	158.1	156.0	154.8	154.1	153.1
	Multi-Family Household		113.7	109.8	103.0	99.3	97.2	96.0	95.3	94.3
	Employee		23.3	23.1	22.5	22.2	21.9	21.7	21.5	21.3
Total estimated error (MGD)			--	1.2	1.1	1.1	1.2	1.2	1.2	1.2

Note: A 10% unmetered use is assumed.

A.3.2.4 Fairfax Water – Wholesale Customer – Loudoun Water

Loudoun Water provided water produced data from their Trap Rock Water Treatment Facility (Trap Rock WTF), and water purchased data from Fairfax Water. Additionally, Loudoun Water data shows some use of the Goose Creek facilities, which they purchased from the City of Fairfax in 2014 (D. Geldert, personal communication, December 18, 2019). The Goose Creek Emergency Water Supply Connection Project will provide the infrastructure to transport water from the Goose Creek Reservoir to the Trap Rock WTF for treatment in the event of an emergency. This project will provide resiliency to Loudoun Water customers until the construction of the Milestone Reservoir off-river storage is completed in 2024.

Production at Trap Rock WTF began on September 4, 2018. The 2019 Potomac River withdrawal average is 10 MGD, with a finished water production average of 9 MGD. These early withdrawal records, however, do not reflect TRWTF operations in the future. Data and calculations are reported in Table A.3-17 and Table A.3-18 below.

A.3.2.4.1 Service Area

The same service area shape file provided by Fairfax Water for the 2015 study (Ahmed *et al.*) is displayed in the graphics (D. Geldert, personal communication, July 9, 2019 and July 19, 2019). An updated service area shape file is available, but it includes areas with sewer-only service; therefore, Loudoun Water prefers to display the old shape file as it better represents the water service area. Although, no future changes in the service area are reported for the 2020 study, Loudoun County recently approved a Comprehensive Plan Update that changes some boundaries near Leesburg and adds to Loudoun Water's service area. In addition, the Metropolitan Washington Airport Authority recently sold land that is now under Loudoun County jurisdiction and in the Loudoun Water service area. There are no updates to official projections of employment or population for these new areas.

A.3.2.4.2 Demographic Data

POP, HH, and EMP data are interpolated between the years 2010 and 2045 using MWCOG Round 8.4 and Round 9.1 forecasts. TAZ ratios calculated by Loudoun Water for their service area are used (D. Geldert, personal communication, July 9, 2019 and July 19, 2019). These TAZ ratios include adjustments due to development patterns and so do not equal the strict area ratios calculated from the updated shape file of their service area.

The HH data is divided into SFH and MFH estimates using dwelling unit ratios calculated from Loudoun County demographic data by household type (D. Paul, personal communication, July 3, 2018). The demographic data are sub-divided into the following housing types:

- SFD – Single-family detached
- SFA – Single-family attached
- MFA – Multi-Family attached
- MFST – Multi-Family Stacked

The list of additional demographic data follows:

- "Table A-1 Housing Unit Baseline by Planning Subarea, 2010" includes 2010 Census data that provides the basis of the 2010 baseline calculation for total housing units sub-divided into SFD, SFA, MFA, MFST.
- An online document "Planning Subarea - 2000 to 2017 Annual Series of Population, Households, and Housing Units" provides household estimates for the 2010 planning subareas. This document confirms that data received on July 8, 2014 from demographer J. Kaneff is still valid for 2010 estimates for households sub-divided into SFD, SFA, MFA, MFST.
- A new housing unit estimate sub-divided into SFD, SFA, MFA, MFST for the 2010-2015 period is obtained from the "Loudoun County COG Round 9.0 TAZ Forecasts" using the area ratios provided by Loudoun Water.
- New housing unit estimates for the 2015-2020, 2020-2025, 2025-2030, 2030-2035 periods subdivided into SFD, SFA, MFA, MFST are obtained from the "Loudoun County COG Round 9.1 TAZ Forecasts" using the area ratios provided by Loudoun Water.
- Vacancy rates sub-divided by household type are in "Table A-7(a) New Housing Unit Vacancy Rate Assumptions."

The HU baseline is taken from "Table A-1 Housing Units Baseline by Planning Subarea, 2010." The data is provided by planning subarea. Loudoun Water is assumed to be represented by the planning subareas Ashburn, Dulles, Potomac, and Sterling (J. Kaneff, personal communication, July 8, 2014). The eastern portion of the Leesburg planning area is also in the service area. This area is excluded from the analysis since it includes the Town of Leesburg, which is outside the CO-OP system.

Vacancy rates subdivided into housing types SFD SFA MFA and MFST are available for the period 2010-2045. These vacancy rates are applied to the new housing units subdivided by housing type prior to combining them into SFH and MFH totals (Figure A.3-5). The average vacancy rate for Loudoun Water is back-calculated as about 3.8%. This is consistent with the 4% vacancy rate calculated from the Loudoun County forecasts. The ACS data also shows that the latest vacancy rate is about 4% in 2017.

Table A-7 (a).
New Housing Units Vacancy Rate Assumptions

Year	SFD - Suburban	SFD - Rural	SFA	MFA	MFST
2010*	1.9%	4.9%	3.0%	9.8%	8.4%
2011	1.7%	4.7%	2.8%	7.0%	7.5%
2012	1.5%	4.5%	2.6%	7.0%	6.5%
2013	1.5%	4.4%	2.5%	6.5%	5.6%
2014	1.5%	4.4%	2.5%	6.5%	5.6%
2015	1.5%	4.4%	2.5%	6.5%	5.6%
2016	1.5%	4.4%	2.5%	6.5%	5.6%
2017	1.5%	4.4%	2.5%	6.5%	5.6%
2018	1.5%	4.4%	2.5%	6.5%	5.6%
2019	1.7%	4.6%	2.5%	6.5%	5.6%
2020	1.7%	4.6%	2.5%	6.5%	5.6%
2021 to 2025	1.8%	4.8%	2.5%	6.5%	5.6%
2026 to 2030	2.0%	5.0%	2.5%	6.5%	5.6%
2031 to 2035	2.0%	5.0%	2.5%	6.5%	5.6%
2036 to 2040	2.0%	5.0%	2.5%	6.5%	5.6%
2041 to 2045	2.0%	5.0%	2.5%	6.5%	5.6%

* 2010 estimate based on analysis of 2010 Census data.

Notes:

(1) SFD Rural: Single-Family Detached residential located in the Northwest, Route 15 South, Route 15 North, and Southwest planning subareas.

(2) SFD Suburban: Single-Family Detached located in the Ashburn, Dulles, Leesburg, Potomac, Route 7 West, and Sterling planning subareas.

(3) Group quarter units are not housing units or households. Therefore, they are not displayed in these tables.

Figure A.3-5: Reproduction of Table A-7 (a) for New Housing Unit Vacancy Rate Assumptions.

The HU estimates are made by starting with the 2010 Census numbers, then adding the 2010-2015 numbers for new HUs from Round 9.0, then adding the 2015-2020, 2020-2025, 2025-2030, 2030-2035, 2035-2040, and 2040-2045 new HUs from Round 9.1. The HH, HU, and new HU data are sub-divided into these categories and are grouped into the following two categories to get HH, HU totals for the baseline year 2010 and new HU totals for forecast years 2015-2045:

- SFH: SFD, SFA
- MFH: MFA, MFST

Annual estimates of SFH and MFH totals are obtained by accumulatively adding the new HU totals to the baseline 2010 HH totals obtained from the 2015 study jurisdictional data. The DURs are then estimated for 2010-2045 by taking the ratio between SFH and MFH totals. Table A.3-15 and Table A.3-16 summarize these calculations.

Table A.3-15: Loudoun Water housing unit (HU) estimate for 2010 Baseline.

Housing Units Baseline, 2010	Total	SFD	SFA	MFA	MFST	SF	MF
Potomac Planning Sub Area	15,851	7,689	6,018	2,144	0	13,707	2,144
Sterling Planning Sub Area	11,953	4,962	4,024	2,662	305	8,986	2,967
Dulles Planning Sub Area	13,604	6,823	5,014	938	829	11,837	1,767
Ashburn Planning Sub Area	31,488	13,168	10,325	7,553	442	23,493	7,995
Loudoun Water HU Estimate	72,896	32,642	25,381	13,297	1,576	58,023	14,873
Vacancy Rate	3.7%	2.0%	2.9%	8.8%	7.8%	2.4%	8.7%
Loudoun Water HH Estimate	70,215	32,000	24,635	12,127	1,453	56,635	13,580

Note: SFD, SFA, MFA, and MFST are from Loudoun County COG Round 9.0 Cooperative Forecasts, March 21, 2016; SFD Vacancy rate estimates were divided by SFD Suburban and SFD Rural. The vacancy rate for SFD Suburban is assumed and includes Ashburn, Dulles, Leesburg, Potomac, Route 7 West, and Sterling planning subareas.

Table A.3-16: Loudoun Water household estimates based on planning subareas and assumed new housing unit vacancy rates used to estimate dwelling unit ratios (will be different from the MWCOG Round 8.4 and Round 9.1 data reported in Table A.3-17 and Table A.3-18).

	2010	2011	2012	2013	2014	2015	2020	2025	2030	2035	2040	2045
SFHU Vacancy Rate	0%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
MFHU Vacancy Rate	0%	7%	7%	6%	6%	6%	6%	6%	6%	6%	7%	6%
New SFHH	0	2,198	2,202	2,204	2,204	2,204	2,101	3,911	857	206	67	56
New MFHH	0	624	627	631	631	631	1,137	4,245	4,481	3,663	1,403	510
Total SFHH	56,635	58,833	61,035	63,239	65,443	67,646	72,903	76,814	77,671	77,877	77,944	78,000
Total MFHH	13,580	14,204	14,831	15,462	16,093	16,724	19,567	23,811	28,292	31,955	33,358	33,867

A.3.2.4.3 Water Use Data

The amount sold to Loudoun Water is provided by Fairfax Water data. The same amount purchased (when rounded to the nearest whole MGD) is provided by Loudoun Water data. Loudoun Water data also includes purchased amounts from the City of Fairfax for 2008-2014, produced amounts from Goose Creek WTF for 2014-2018, and produced amounts from Trap Rock WTP for 2018. Unmetered use is calculated as the difference between total water purchased/produced and total water billed.

Loudoun Water's billing data is reported with the following categories:

- Res: SFA/SFD Retail - Retail water sales to single family attached (townhouses) and detached residences within Loudoun County.
- Res: MF Retail - Retail water sales to multi-family residences within Loudoun County.
- Non-Res: Gen Retail - Retail water sales to non-residential (e.g., office, retail, data centers, commercial, etc.) customers within Loudoun County.
- Res: SFA/SFD Other - Retail water sales to single family attached (townhouses) and detached residences outside of Loudoun County.
- Fire Hydrant Meters - Retail water sales to contractors (not directly contracted with Loudoun Water), landscaping companies, swimming pool contractors, etc. The metered values are reported and billed on a monthly or quarterly basis.
- Construction Water - Retail water sales to contractors constructing water mains on behalf of developers (not contracted directly with Loudoun Water). These quantities of water are estimated (not metered) by field personnel and billing is based on the estimated values.
- Loudoun Water Usage - Water used at Loudoun Water owned and operated facilities such as offices and treatment plants; includes an estimate for water main flushing of 100 MG.

The categories are grouped into the following three categories needed for this study:

- SFH: Res: SFA/SFD Retail, Res: SFA/SFD Other
- MFH: Res: MF Retail
- EMP: Non-Res: Gen Retail, Fire Hydrant Meters, Construction Water, Loudoun Water Usage

Table A.3-17: Historical data for unit use calculations and results – Fairfax Water – Loudoun Water – Wholesale (this table reports amounts greater than that used for wholesale under the Fairfax Water Table A.3-9).

			Historic Data								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
Fairfax Water Purchased (MGD)			19.21	19.33	18.73	18.57	19.38	18.44	18.92	19.03	18.85
City OF Fairfax Purchased (MGD)			2.62	2.59	3.38	3.66	0.44	0.00	0.00	0.00	0.00
Trap Rock WTF Produced (MGD)			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.58
Goose Creek WTF Produced (MGD)			0.00	0.00	0.00	0.00	3.17	5.26	6.09	5.05	2.17
Produced/Purchased Total (MGD)			21.83	21.91	22.17	22.23	22.56	23.29	24.74	23.73	23.27
Demand (MGD)	Retail Sales	Single Family Household	12.53	11.96	12.46	12.22	13.16	13.82	14.74	14.17	13.64
		Multi-Family Household	2.00	2.02	2.07	2.19	2.09	2.30	2.50	2.47	2.50
		Employee	5.58	5.43	6.20	5.72	4.77	5.15	5.23	4.82	5.86
	Unmetered/Non-Revenue		1.72	2.50	1.44	2.10	2.54	2.02	2.27	2.27	1.27
	Percent Unmetered/Non-Revenue		8%	11%	6%	9%	11%	9%	9%	10%	5%
	Total		21.83	21.91	22.17	22.23	22.56	23.29	24.74	23.73	23.27
Demographics	Population (units)		211,418	221,257	231,097	240,937	250,777	260,617	269,670	278,723	287,776
	Employees (units)		94,697	98,235	101,772	105,310	108,848	112,386	117,024	121,662	126,300
	Households (units)		70,684	73,518	76,352	79,186	82,019	84,853	87,603	90,353	93,104
	DUR (dimensionless)		4.17	4.14	4.11	4.09	4.07	4.04	3.97	3.90	3.84
	Single Family Households (units)		57,013	59,220	61,425	63,626	65,828	68,030	69,983	71,929	73,870
	Multi-Family Households (units)		13,671	14,298	14,927	15,559	16,191	16,823	17,621	18,424	19,233
Unit Use (gpd/unit)	Single Family Household		219.8	202.0	202.9	192.1	199.9	203.1	210.6	197.0	184.6
	Multi-Family Household		146.3	141.3	138.7	140.8	129.1	136.7	141.9	134.1	130.0
	Employee		58.9	55.3	60.9	54.3	43.8	45.8	44.7	39.6	46.4

Note: Water use between 2009 and 2013 is low compared to other years (T. Lipinski, personal communication, June 8, 2015). Higher use rates are expected in the coming years. The 2014 values are estimated (due to new billing, metering and recording software, some of the data is exceedingly difficult to restore).

Table A.3-18: Forecast data for unit use calculations and results – Fairfax Water – Loudoun Water – Wholesale (this table reports amounts greater than that used for wholesale under the Fairfax Water Table A.3-10).

			Forecast Data							
			2018	2020	2025	2030	2035	2040	2045	2050
Produced/Purchased Total (MGD)			24.36	25.39	26.79	27.86	28.69	29.22	29.59	30.05
Trap Rock WTF Produced (MGD)			4.42	12.00	13.00	14.00	15.00	16.00	17.00	17.00
Demand (MGD)	Retail Sales	Single Family Household	14.24	14.68	14.84	14.65	14.49	14.39	14.34	14.25
		Multi-Family Household	2.54	2.67	3.06	3.52	3.90	4.02	4.06	4.16
		Employee	5.15	5.50	6.20	6.90	7.44	7.88	8.23	8.64
	Unmetered/Non-Revenue		2.44	2.54	2.68	2.79	2.87	2.92	2.96	3.01
	Percent Unmetered/Non-Revenue		10%	10%	10%	10%	10%	10%	10%	10%
	Total		24.36	25.39	26.79	27.86	28.69	29.22	29.59	30.05
Demographics	Population (units)		287,776	305,883	328,501	340,408	348,341	351,339	352,543	354,943
	Employees (units)		126,300	135,577	155,189	173,954	188,830	201,208	211,278	222,887
	Households (units)		93,104	98,604	106,777	112,101	115,963	117,426	117,985	119,147
	DUR (dimensionless)		3.84	3.72	3.23	2.75	2.44	2.34	2.30	2.22
	Single Family Households (units)		73,870	77,735	81,510	82,171	82,224	82,233	82,266	82,202
	Multi-Family Households (units)		19,233	20,869	25,267	29,931	33,739	35,193	35,719	36,945
Unit Use (gpd/units)	Single Family Household		192.7	188.8	182.0	178.3	176.2	175.0	174.3	173.3
	Multi-Family Household		132.0	128.1	121.3	117.6	115.5	114.3	113.6	112.6
	Employee		40.8	40.6	40.0	39.7	39.4	39.2	39.0	38.8
Total estimated error (MGD)			--	5.7	6.1	6.6	7.0	7.3	7.6	7.9

Note: Loudoun Water provided assumptions for Trap Rock WTF produced amounts (P. Kenel, personal communication, April 3, 2020). A 10% unmetered use is assumed.

A.3.2.5 Fairfax Water – Wholesale Customer – Dulles

Metropolitan Washington Airports Authority (Dulles International Airport) is a wholesale customer of Fairfax Water. Instead of contacting Dulles for water use data, Fairfax Water billed data is used. Data and calculations are reported in Table A.3-19 and Table A.3-20 below.

A.3.2.5.1 Service Area

The Dulles service area is provided by Fairfax Water. There is overlap between the Dulles service area and the neighboring water suppliers, which include Loudoun Water and Fairfax Water. Because Loudoun Water provided detailed TAZ ratios that reflect what they believe to be their service area, it is assumed that these Loudoun Water ratios are correct. Many of the overlapping areas are green spaces and it is assumed that they belong to either Loudoun Water or Fairfax Water instead of Dulles airport. For those spaces that are ambiguous, a ratio rounded to the nearest hundredth often resolves the overlap.

A.3.2.5.2 Demographic Data

POP, HH, and EMP data are interpolated between the years 2010 and 2045 using MWCOG Round 8.4 and Round 9.1 forecasts. Dulles is partially within Fairfax County. Fairfax County's DURs are applied to the Dulles service area HH to get SFH and MFH subtotals.

A.3.2.5.3 Water Use Data

The amount sold to Dulles for 2008-2018 by calendar year is from Fairfax Water data (N. Saji, personal communication, May 31, 2019). The SF and MF unit use rates are assumed to be the same as Fairfax Water. These rates are multiplied by the number of SFH and MFH units in the Dulles service area from the MWCOG data. The total amount of HH use is summed, and this is subtracted from the amount Fairfax Water reported selling to them. An assumed 10% unmetered use rate is used. The remaining amount is assumed to be the total amount of EMP water use. This total amount is divided by the number of employees reported by the MWCOG data to estimate the EMP unit use rate.

Table A.3-19: Historic data for unit use calculations and results – Fairfax Water – Dulles – Wholesale.

			Historic Data								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
Purchased (MGD)			0.79	0.82	0.79	0.81	0.81	0.81	0.79	0.77	0.79
Demand (MGD)	Retail Sales	Single Family Household	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
		Multi-Family Household	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003
		Employee	0.70	0.73	0.70	0.72	0.72	0.72	0.70	0.68	0.70
	Unmetered/Non-Revenue		0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
	Percent Unmetered/Non-Revenue		10%	10%	10%	10%	10%	10%	10%	10%	10%
	Total		0.79	0.82	0.79	0.81	0.81	0.81	0.79	0.77	0.79
Demographics	Population (units)		101	103	105	107	109	111	141	172	202
	Employees (units)		17,747	17,363	16,979	16,595	16,211	15,826	15,989	16,152	16,314
	Occupied Households (units)		42	43	44	44	45	46	57	67	78
	DUR (dimensionless)		(2.67)	(2.66)	(2.63)	(2.61)	(2.57)	(2.47)	(2.46)	(2.44)	(2.40)
	Single Family Households (units)		31	31	32	32	32	33	40	48	55
	Multi-Family Households (units)		12	12	12	12	13	13	16	20	23
Unit Use (gpd/units)	Single Family Household		(206.6)	(198.6)	(190.7)	(184.1)	(170.8)	(170.6)	(172.4)	(167.8)	(159.5)
	Multi-Family Household		(158.0)	(163.2)	(152.1)	(157.8)	(156.6)	(151.7)	(152.9)	(152.9)	(150.6)
	Employee		39.6	42.0	41.5	43.4	44.5	45.6	43.9	42.2	42.8

Note: Fairfax Water's DURs and unit use rates in parenthesis are assumed; A 10% unmetered use rate is assumed.

Table A.3-20: Forecast data for unit use calculations and results – Fairfax Water – Dulles – Wholesale.

			Forecast Data							
			2018	2020	2025	2030	2035	2040	2045	2050
Purchased (MGD)			0.81	0.83	0.90	0.97	1.03	1.06	1.08	1.11
Demand (MGD)	Retail Sales	Single Family Household	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
		Multi-Family Household	0.003	0.004	0.007	0.011	0.013	0.014	0.016	0.017
		Employee	0.721	0.732	0.784	0.846	0.896	0.917	0.937	0.957
	Unmetered/Non-Revenue		0.08	0.08	0.09	0.10	0.10	0.11	0.11	0.11
	Percent Unmetered/Non-Revenue		10%	10%	10%	10%	10%	10%	10%	10%
	Total		0.81	0.83	0.90	0.97	1.03	1.06	1.08	1.11
Demographics	Population (units)		202	264	401	540	610	661	701	748
	Employees (units)		16,314	16,640	18,057	19,635	20,926	21,530	22,095	22,685
	Occupied Households (units)		78	100	158	218	248	269	285	305
	DUR (dimensionless)		2.40	2.32	2.06	1.82	1.63	1.49	1.41	1.29
	Single Family Households (units)		55	70	106	141	154	161	167	172
	Multi-Family Households (units)		23	30	52	78	94	108	118	133
Unit Use (gpd/units)	Single Family Household		(158.1)	(154.2)	(147.4)	(143.7)	(141.6)	(140.4)	(139.7)	(138.6)
	Multi-Family Household		(150.8)	(146.9)	(140.1)	(136.4)	(134.3)	(133.1)	(132.4)	(131.3)
	Employee		44.2	44.0	43.4	43.1	42.8	42.6	42.4	42.2
Total estimated error (MGD)			--	0.4	0.5	0.5	0.6	0.6	0.6	0.7

Note: Fairfax Water's DURs and unit use rates in parenthesis are assumed; A 10% unmetered use rate is assumed.

A.3.2.6 Fairfax Water – Wholesale Customer – Prince William County Service Authority

The Prince William County Service Authority (PWCSA) has four distribution systems: East, West, Hoadly Manor, and Bull Run Mountain/Evergreen. The East, West, and Hoadly Manor systems are served by purchase water from Fairfax Water. The West system has an additional source from Lake Manassas. The Bull Run Mountain/Evergreen system is served by six groundwater wells. The PWCSA purchase capacity agreements include: 26.7 MGD from Fairfax Water; and 5 MGD from the City of Manassas. Data and calculations are reported in Table A.3-21 and Table A.3-22 below.

A.3.2.6.1 Service Area

A new service area map based on pressure zone boundaries is provided (M. Knight, personal communication, May 16, 2019). A PWCSA data request and agreement form had to be completed in order to receive the requested data.[15] The new map is very similar to the map provided by Fairfax Water for the 2015 study (Ahmed *et al.*). After confirming with D. Guerra and N. Griffin (personal communication, October 18, 2019), the 2015 study map is used. No changes in the service are expected in the future.

There are multiple versions of the PWCSA service area map on record. One such service area layer includes the eastern system in the Rural Crescent; this is the Prince William Forest and Quantico Marine Corps Base. These older service area maps must have mistakenly included the Rural Crescent area since it is not expected that this area will open to be served by the PWCSA (N. Griffin, October 18, 2019).

A.3.2.6.2 Demographic Data

POP, HH, and EMP data are interpolated between the years 2010 and 2045 using MWCOG Round 8.4 and Round 9.1 forecasts. These values are reported in Table A.3-21 and Table A.3-22 below. In order to calculate DURs, MWCOG Round 9.1 data for POP, HU, and EMP for forecast years 2015-2045 by TAZ are used from Prince William County planning data (R. F. Hunt, personal communication, May 9, 2019). The HU data is disaggregated as follows:

- SF: 1 Unit, Detached (single-family and mobile homes),
- TH: 1 Unit, Attached (townhomes),
- MF: Multi-Unit (includes apartments and condominiums).

The single family and townhomes HUs are combined into one SFHU category.

[15] Prince William County Service Authority Data Request and Agreement: https://www.pwcsa.org/sites/default/files/documents/Development/PWCSA%20-%20Data%20Usage%20Agreement_V2.pdf

The data does not include assumptions on vacancy rates. Information on county HU and HH estimates is available online, where an average vacancy rate of about 3.5% to 4.2% is estimated for the respective period of 2010-2018.[16] An average vacancy rate of 4.9% based on 2019 values is assumed for the forecast years 2020-2045. Additional data could be obtained from archived Quarterly Reports.[17] Figure A.3-6 compares the county planning estimated DURs to the ACS five-year estimate, an alternative data source.

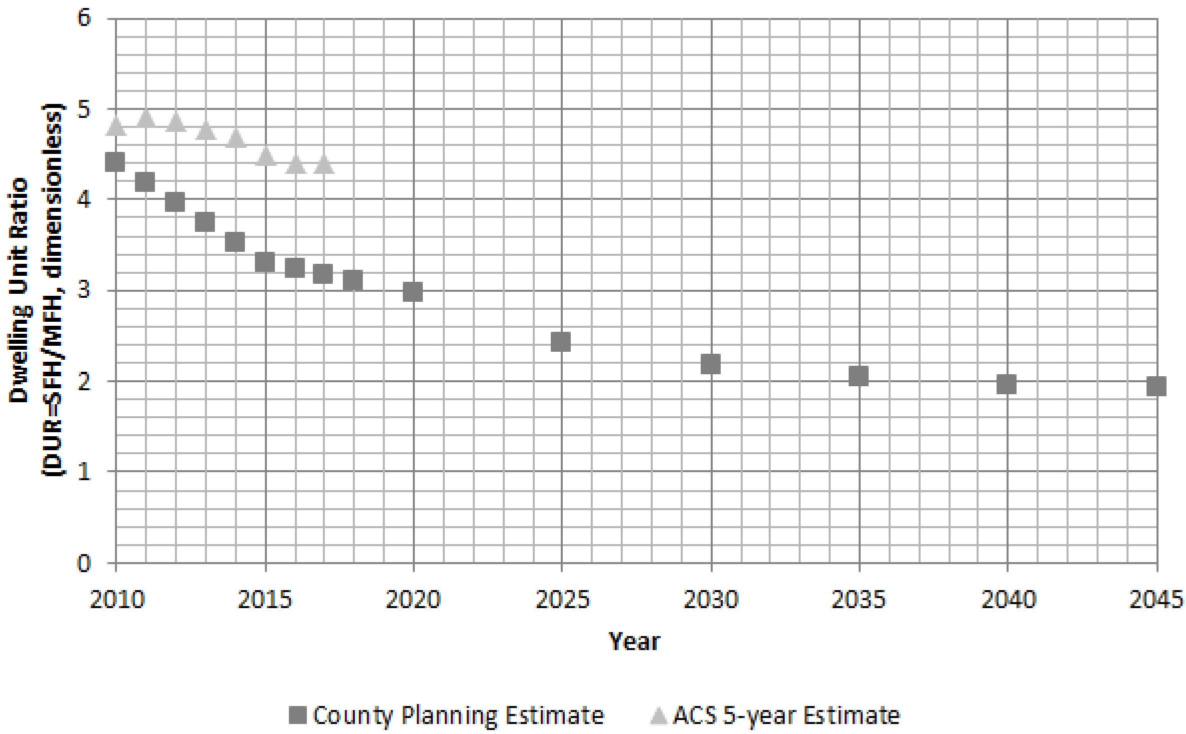

Figure A.3-6: Dwelling unit ratio comparison for Prince William County Service Authority (PWCSA).

A.3.2.6.3 Water Use Data

Fairfax Water is one data source for the amount sold to PWCSA by calendar year. The PWCSA Finance Department also provided the amount purchased and billed by fiscal year for 2014-2018 (D. Guerra, personal communication, July 3, 2019). The purchased and billed amounts for years 2010-2013 are obtained from the 2015 study raw data sets. The amount PWCSA reports as purchased is higher than the amount Fairfax Water reports selling to PWCSA. This is because PWCSA also purchases approximately

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[16] Online sources: https://www.pwcgov.org/government/dept/doit/gis/Pages/Quarterly-Estimates.aspx and https://www.pwcgov.org/government/dept/doit/gis/pages/annual-population-estimates.aspx

[17] Quarterly Reports: https://www.pwcgov.org/government/dept/doit/gis/Pages/Archives-Quarterly-Reports.aspx

4.7 MGD from the City of Manassas, which is included in the total purchase amount. Not accounted for in this amount is the water supplied to customers from groundwater wells. The PWCSA customers still on wells are in the far north hydraulically isolated portion of their service area and account for less than 0.1 MGD. Since this is a small portion of their service area, it is not thought to have a significant impact on the unit use calculations. PWCSA reports selling the City of Manassas Park about 0.1 MGD from 2011-2013 and 0.9 MGD from 2014-2018. That 0.9 MGD is included in the water they purchase from Fairfax Water. However, this amount is not considered a wholesale and is included in the retail sales reported in their billed data.

The sum of the purchase numbers reported in Table A.3-21, and for the purpose of calculating the unit use rates, are from PWCSA. It is assumed that the Fairfax Water reported purchase amount is the Fairfax Water portion of the PWCSA data. The remainder is assumed to be the City of Manassas portion of the PWCSA purchase data. The retail sales by category are the combination of both.

The amount of unmetered water by fiscal year was calculated as the difference between the amount purchased minus the amount billed, which gives an average unmetered use of 10% over the years 2010-2018. PWCSA reported having about 6% to 7% non-revenue water, which includes water loss through leaks, any illegal connections, and faulty meters.

An incomplete billed data set is available for the years 2010-2018. The billed data is not disaggregated into retail sales categories of SFH, MFH, and EMP for the years 2010-2013. Therefore, the Fairfax Water unit use rate are assumed for the SFH and MFH categories to estimate sales. The EMP sales are then calculated from the remaining data and used to estimate an employee unit use rate. For the years 2014-2018, detailed billing data by use category is available and used to calculate PWCSA specific unit use rates for all sale categories.

Table A.3-21: Historic data for unit use calculations and results – Fairfax Water – Prince William County Service Authority – Wholesaler.

			Historic Data								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
Fairfax Water Purchased (MGD)			21.02	20.55	21.43	20.18	21.01	21.20	23.36	22.75	23.05
City of Manassas Purchased (MGD)			5.38	6.05	5.47	5.12	4.71	4.74	3.78	5.51	4.63
Demand (MGD)	Retail Sales[4]	Single Family Household	16.36	15.94	15.49	15.12	15.17	15.28	16.04	15.93	15.43
		Multi-Family Household	2.84	3.13	3.11	3.46	3.57	3.66	3.84	3.88	3.85
		Employee	5.50	5.93	6.59	5.92	4.83	5.09	5.26	5.13	4.89
	Manassas Park Sales		0.00	0.10	0.10	0.10	0.90	0.90	0.89	0.91	0.89
	Unmetered/Non-Revenue		1.70	1.60	1.70	0.80	2.15	1.91	2.00	3.32	3.51
	Percent Unmetered/Non-Revenue		6%	6%	6%	3%	8%	7%	7%	12%	13%
	Total		26.40	26.60	26.90	25.30	25.72	25.94	27.14	28.26	27.68
Demographics	Population (units)		292,953	300,546	308,138	315,730	323,322	330,914	334,353	337,791	341,229
	Employees (units)		89,961	93,477	96,993	100,510	104,026	107,542	111,024	114,506	117,988
	Occupied Households (units)		97,140	99,429	101,718	104,006	106,295	108,584	110,228	111,872	113,515
	DUR (dimensionless)		4.4	4.2	4.0	3.7	3.5	3.3	3.2	3.2	3.1
	Single Family Households (units)		79,184.24	80,266	81,241	82,093	82,804	83,353	84,210	85,042	85,848
	Multi-Family Households (units)		17,956	19,162	20,477	21,914	23,491	25,231	26,017	26,829	27,668
Unit Use (gpd/unit)	Single Family Household		(206.6)	(198.6)	(190.7)	(184.1)	183.2	183.3	190.5	187.3	179.7
	Multi-Family Household		(158.0)	(163.2)	(152.1)	(157.8)	152.0	145.1	147.6	144.6	139.2
	Employee		61.1	63.4	68.0	58.9	46.4	47.3	47.4	44.8	41.4

Note: Fairfax Water unit use rates are assumed as shown in parenthesis; Data excludes the well systems in the far northwest corner of the county, which is not considered part of the general service area (D. Guerra, personal communication, Jul 19, 2019); "Fairfax Water Purchased" data is reported by Fairfax Water as the amount sold to Prince William County Service Authority; "City of Manassas Purchased" data is estimated as the difference between Prince William County Service Authority purchase amount and Fairfax Water sold amount; "Manassas Park Sales" is included in the retail water sales amount and not technically a wholesale customer (D. Guerra, personal communication, Jul 19, 2019).

Table A.3-22: Forecast data for unit use calculations and results – Fairfax Water – Prince William County Service Authority – Wholesaler.

			Forecast Data							
			2018	2020	2025	2030	2035	2040	2045	2050
Fairfax Water Purchased (MGD)			22.12	22.48	23.99	25.41	26.77	28.06	29.19	30.38
City of Manassas Purchased (MGD)			4.70	4.70	4.70	4.70	4.70	4.70	4.70	4.70
Demand (MGD)	Retail Sales	Single Family Household	15.44	15.37	15.31	15.43	15.66	15.95	16.25	16.51
		Multi-Family Household	3.90	4.03	4.87	5.43	5.85	6.17	6.38	6.67
		Employee	4.80	5.06	5.64	6.24	6.81	7.37	7.87	8.39
	Manassas Park Sales		0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
	Unmetered/Non-Revenue		2.68	2.72	2.87	3.01	3.15	3.28	3.39	3.51
	Percent Unmetered/Non-Revenue		10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
	Total		26.82	27.18	28.69	30.11	31.47	32.76	33.89	35.08
Demographics	Population (units)		341,229	348,106	377,546	398,834	416,445	430,930	442,735	456,327
	Employees (units)		117,988	124,953	141,367	157,554	173,152	188,353	202,141	216,871
	Occupied Households (units)		113,515	116,803	127,942	136,196	142,968	148,465	152,777	157,879
	DUR (dimensionless)		3.1	3.0	2.4	2.2	2.0	2.0	1.9	1.9
	Single Family Households (units)		85,848	87,374	90,499	93,277	95,890	98,359	100,664	102,907
	Multi-Family Households (units)		27,668	29,429	37,443	42,919	47,078	50,106	52,113	54,972
Unit Use (gpd/unit)	Single Family Household		179.8	175.9	169.1	165.4	163.3	162.1	161.4	160.4
	Multi-Family Household		140.9	137.0	130.2	126.5	124.4	123.2	122.5	121.4
	Employee		40.7	40.5	39.9	39.6	39.3	39.1	38.9	38.7
Total estimated error (MGD)			--	8.4	9.1	9.7	10.2	10.8	11.3	11.9

Note: Data excludes the well systems in the far northwest corner of the county, which is not considered part of the general service area (D. Guerra, personal communication, Jul 19, 2019); "Fairfax Water Purchased" data is estimated as the remainder of forecast amount after assuming a 4.70 MGD purchase from the City of Manassas (average of 2014-2018); "City of Manassas Sales" assumed 0.9 MGD but is already included in the retail water sales forecast and so is not added into the total demand (D. Guerra, personal communication, Jul 19, 2019).

A.3.2.7 Fairfax Water – Wholesale Customer – Fort Belvoir

The U.S. Government (Fort Belvoir) is a wholesale customer of Fairfax Water. Data and calculations are reported in Table A.3-23 and Table A.3-24 below.

A.3.2.7.1 Service Area

The Fort Belvoir service area is provided by Fairfax Water. Overlap between the Fairfax Water and Fort Belvoir service areas are assumed to belong to Fairfax Water retail. It is not the goal, but this helps adjust the large household forecast to values more in line with the ACS five-year estimate of 2,044 housing units in 2017. There is a service area error in the map of the Fort Belvoir service area in the 2015 study (Ahmed *et al.*), where an upper portion of the service area is not included in published maps. This error did not affect the actual calculations of the study as it is not included in the TAZ ratios.

A.3.2.7.2 Demographic Data

POP, HH, and EMP data are interpolated between the years 2010 and 2045 using MWCOG Round 8.4 and Round 9.1 forecasts. Fort Belvoir is within Fairfax County. Fairfax County's DUR are applied to the Fort Belvoir service area households. An alternative source of household data is the ACS five-year data; however, it is not used (Figure A.3-7).

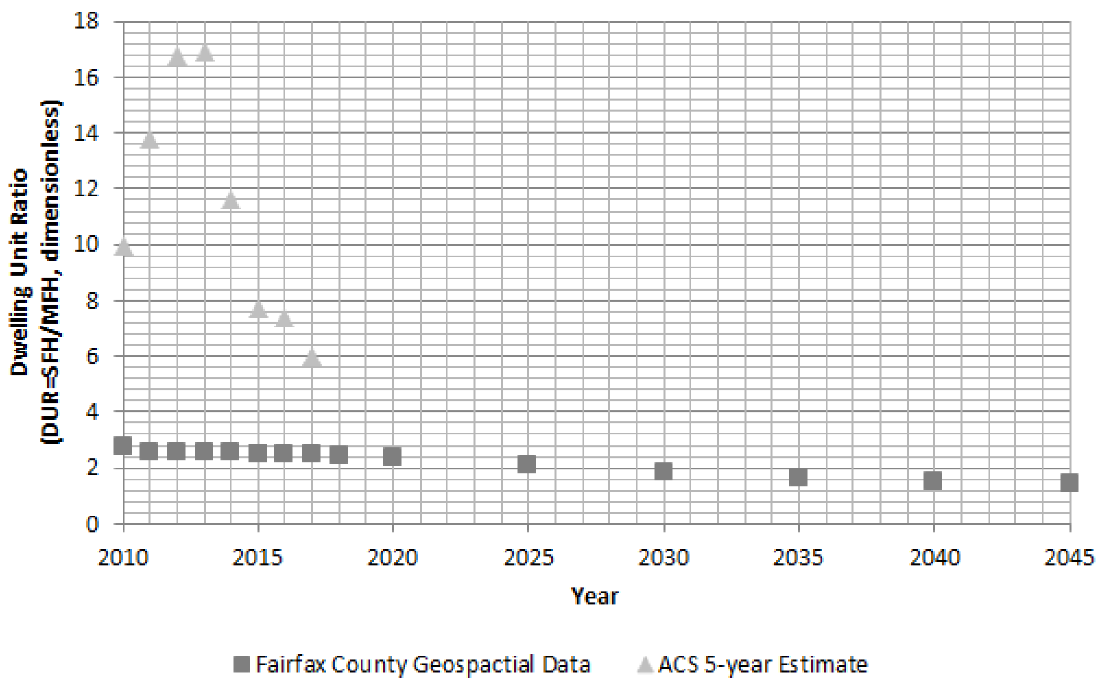

Figure A.3-7: Dwelling unit ratio comparison for Fort Belvoir.

A.3.2.7.3 Water Use Data

No billed or purchased data is obtained from Fort Belvoir. Instead, Fairfax Water provided the amount sold to Fort Belvoir for 2008-2018 by calendar year (N. Saji, personal communication, May 31, 2019). To calculate household usage, SFH and MFH unit use rates are assumed to be the same as Fairfax Water's unit use rates. These rates are multiplied by the number of households in the Fort Belvoir service area from the MWCOG data. The total amount of household use is summed, and this is subtracted from the amount Fairfax Water reported selling to them. A 10% unmetered use is assumed. The remaining amount is assumed to be the total amount of EMP water use. This total amount is divided by the number of EMPs reported by MWCOG to estimate the EMP unit use rate.

Table A.3-23: Historic data for unit use calculations and results – Fairfax Water – Fort Belvoir – Wholesale.

			Historic Data								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
Purchased (MGD)			1.82	1.83	1.95	1.66	1.54	1.92	1.78	1.93	1.75
Demand (MGD)	Retail Sales	Single Family Household	0.32	0.32	0.32	0.33	0.32	0.33	0.34	0.33	0.31
		Multi-Family Household	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.12	0.12
		Employee	1.23	1.22	1.33	1.06	0.96	1.28	1.15	1.28	1.14
	Unmetered/Non-Revenue		0.18	0.18	0.19	0.17	0.15	0.19	0.18	0.19	0.18
	Percent Unmetered/Non-Revenue		10%	10%	10%	10%	10%	10%	10%	10%	10%
	Total		1.82	1.83	1.95	1.66	1.54	1.92	1.78	1.93	1.75
Demographics	Population (units)		7,060	7,520	7,980	8,440	8,900	9,360	9,427	9,494	9,561
	Employees (units)		28,462	30,348	32,233	34,118	36,003	37,888	38,629	39,370	40,110
	Occupied Households (units)		2,098	2,221	2,344	2,467	2,590	2,713	2,737	2,761	2,785
	DUR (dimensionless)		(2.7)	(2.7)	(2.6)	(2.6)	(2.6)	(2.5)	(2.5)	(2.4)	(2.4)
	Single Family Households (units)		1,527	1,614	1,698	1,784	1,864	1,931	1,947	1,957	1,965
	Multi-Family Households (units)		572	608	646	684	726	782	791	804	819
Unit Use (gpd/unit)	Single Family Household		(206.6)	(198.6)	(190.7)	(184.1)	(170.8)	(170.6)	(172.4)	(167.8)	(159.5)
	Multi-Family Household		(158.0)	(163.2)	(152.1)	(157.8)	(156.6)	(151.7)	(152.9)	(152.9)	(150.6)
	Employee		43.2	40.3	41.3	31.0	26.6	33.7	29.7	32.6	28.5

Note: DURs and unit use rates in parenthesis are assumed from Fairfax Water. A 10% unmetered use is assumed.

Table A.3-24: Forecast data for unit use calculations and results – Fairfax Water – Fort Belvoir – Wholesale.

			Forecast Data							
			2018	2020	2025	2030	2035	2040	2045	2050
Purchased (MGD)			1.70	1.73	1.85	2.00	1.99	1.98	1.97	1.97
Demand (MGD)	Retail Sales	Single Family Household	0.31	0.31	0.28	0.27	0.26	0.25	0.25	0.24
		Multi-Family Household	0.12	0.13	0.13	0.14	0.15	0.16	0.17	0.18
		Employee	1.09	1.13	1.25	1.39	1.38	1.37	1.36	1.35
	Unmetered/Non-Revenue		0.17	0.17	0.18	0.20	0.20	0.20	0.20	0.20
	Percent Unmetered/Non-Revenue		10%	10%	10%	10%	10%	10%	10%	10%
	Total		1.70	1.73	1.85	2.00	1.99	1.98	1.97	1.97
Demographics	Population (units)		9,561	9,694	9,720	9,841	9,982	10,098	10,215	10,332
	Employees (units)		40,110	41,592	47,291	53,235	53,241	53,314	53,358	53,421
	Occupied Households (units)		2,785	2,832	2,844	2,897	2,956	3,006	3,056	3,106
	DUR (dimensionless)		(2.40)	(2.32)	(2.06)	(1.82)	(1.63)	(1.49)	(1.41)	(1.29)
	Single Family Households (units)		1,965	1,979	1,913	1,869	1,831	1,801	1,789	1,752
	Multi-Family Households (units)		819	854	931	1,028	1,125	1,205	1,268	1,354
Unit Use (gpd/unit)	Single Family Household		(158.1)	(154.2)	(147.4)	(143.7)	(141.6)	(140.4)	(139.7)	(138.6)
	Multi-Family Household		(150.8)	(146.9)	(140.1)	(136.4)	(134.3)	(133.1)	(132.4)	(131.3)
	Employee		27.3	27.1	26.5	26.2	25.9	25.7	25.5	25.3
Total estimated error (MGD)			--	0.9	1.0	1.1	1.1	1.1	1.1	1.1

Note: DURs and unit use rate forecasts in parenthesis are assumed from Fairfax Water.

A.3.2.8 Fairfax Water – Wholesale Customer – Virginia - American Water – Alexandria District

The City of Alexandria's Central System Customers are served by Virginia American Water (VAW), which is a subsidiary of American Water, a U.S. publicly traded water and wastewater utility company.[18] The VAW in Alexandria is a private company that purchases water from Fairfax Water which provides treated drinking water. Data and calculations are reported in Table A.3-25 and Table A.3-26 below.

A.3.2.8.1 Service Area

The City of Alexandria service area is provided by Fairfax Water. All jurisdictional areas of the City of Alexandria that overlap with the Fairfax Water service area are assumed to belong to the City of Alexandria's service area. Ratios for jurisdictional areas in the District of Columbia, Arlington County, Fairfax County, and Prince George's County are near zero and, therefore, rounded to zero. Many of these areas are small border sections along the outer perimeter of the City of Alexandria service area and some are confirmed to have zero structures within them and to overlap with the Potomac River.

A.3.2.8.2 Demographic Data

POP, HH, and EMP data are interpolated between the years 2010 and 2045 using MWCOG Round 8.4 and Round 9.1 forecasts. The Alexandria Department of Planning and Zoning provided SFH and MFH data to calculate DURs for the period 2014-2045. This data is based on Alexandria's information for the MWCOG Round 9.1 forecast (S. Latham, personal communication, May 20, 2019). Values estimated from the 2015 study (Ahmed *et al.*) are used for the years 2010-2013. Alternatively, the ACS five-year values for 2010-2013 could have been used to extend the DUR values, which modifies the baseline EMP unit use estimates for 2018 from 23.5 gpd/unit to 24 gpd/unit and increases the total demand forecast for that year by less than 0.1 MGD. The SFH and MFH unit uses are unaffected because they are assumed from Fairfax Water. Therefore, the choice to use either DUR set for the 2010-2013 years is acceptable. See Figure A.3-8 for the DUR comparison.

[18] Source: http://www.amwater.com/ccr/alexandria.pdf.

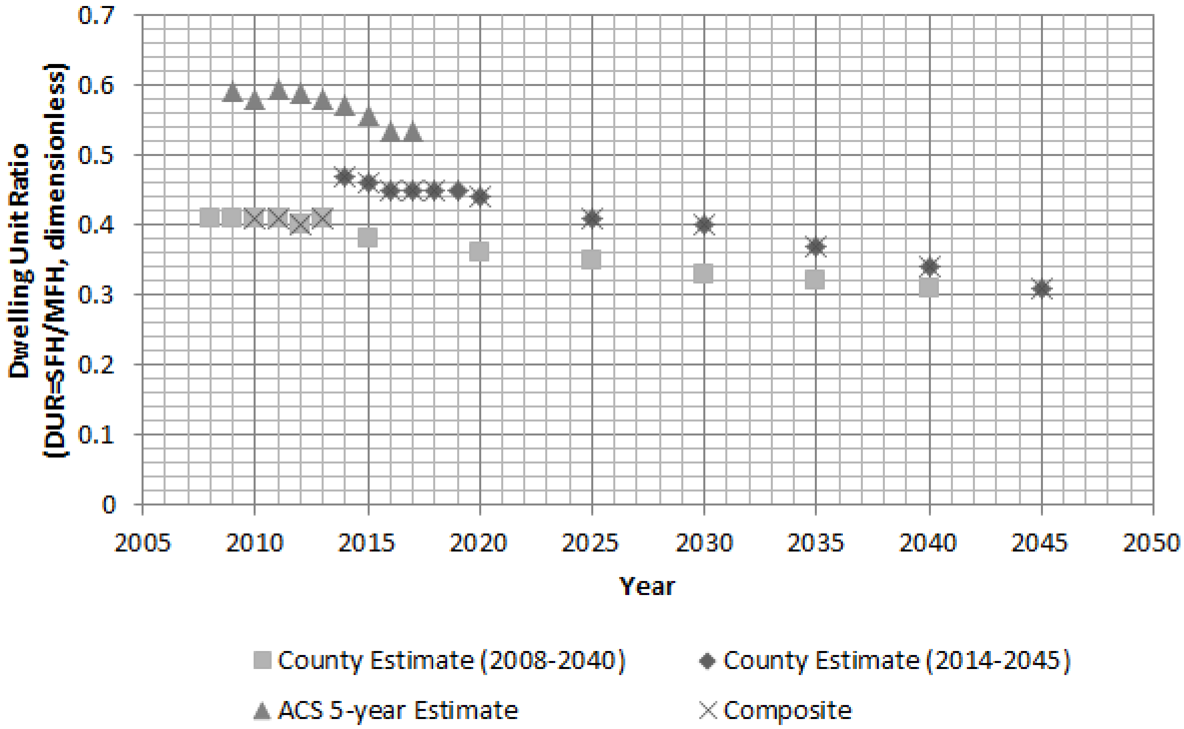

Figure A.3-8: Dwelling unit ratio comparison for Virginia - American Water – Alexandria District.

A.3.2.8.3 Water Use Data

Fairfax Water provided the amount sold to the City of Alexandria. No billed or purchased data was requested from the VAW. To estimate water use, the SFH and MFH unit use rates are assumed to equal those of Fairfax Water. These rates are multiplied by the number of households in the Alexandria service area from the MWCOG data. The total amount of household use is summed, and this is subtracted from the amount Fairfax Water reported selling to them. A 10% unmetered use is assumed. The remaining amount is assumed to be the total amount of EMP water use. This total amount is divided by the number of EMPs reported by MWCOG to estimate the EMP unit use rate.

Table A.3-25: Historic data for unit use calculations and results – Fairfax Water – Virginia American Water, City of Alexandria – Wholesale.

			Historic Data								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
Purchased (MGD)			15.79	15.47	15.57	14.90	15.42	15.72	15.87	15.13	15.35
Demand (MGD)	Retail Sales	Single Family Household	4.09	3.97	3.78	3.74	3.85	3.82	3.86	3.80	3.66
		Multi-Family Household	7.63	7.95	7.53	7.83	7.52	7.40	7.60	7.69	7.67
		Employee	2.49	2.00	2.71	1.84	2.51	2.93	2.82	2.13	2.48
	Unmetered/Non-Revenue		1.58	1.55	1.56	1.49	1.54	1.57	1.59	1.51	1.53
	Percent Unmetered/Non-Revenue		10%	10%	10%	10%	10%	10%	10%	10%	10%
	Total		15.79	15.47	15.57	14.90	15.42	15.72	15.87	15.13	15.35
Demographics	Population (units)		139,989	141,516	143,042	144,569	146,096	147,622	149,924	152,226	154,528
	Employees (units)		102,882	103,550	104,219	104,888	105,557	106,225	107,002	107,778	108,554
	Occupied Households (units)		68,085	68,702	69,320	69,938	70,556	71,174	72,068	72,961	73,855
	DUR (dimensionless)		0.41	0.41	0.40	0.41	0.47	0.46	0.45	0.45	0.45
	Single Family Households (units)		19,798	19,977	19,806	20,337	22,559	22,425	22,366	22,643	22,921
	Multi-Family Households (units)		48,287	48,725	49,515	49,602	47,997	48,749	49,702	50,318	50,935
Unit Use (gpd/unit)	Single Family Household		(206.6)	(198.6)	(190.7)	(184.1)	(170.8)	(170.6)	(172.4)	(167.8)	(159.5)
	Multi-Family Household		(158.0)	(163.2)	(152.1)	(157.8)	(156.6)	(151.7)	(152.9)	(152.9)	(150.6)
	Employee		24.2	19.3	26.0	17.5	23.7	27.6	26.4	19.8	22.9

Note: Unit use rates in parenthesis are assumed from Fairfax Water. A 10% unmetered use is assumed.

Table A.3-26: Forecast data for unit use calculations and results – Fairfax Water – Virginia American Water, City of Alexandria – Wholesale.

			Forecast Data							
			2018	2020	2025	2030	2035	2040	2045	2050
Purchased (MGD)			15.39	15.38	15.83	16.10	16.61	17.39	19.69	20.93
Demand (MGD)	Retail Sales	Single Family Household	3.62	3.56	3.46	3.45	3.36	3.31	3.54	3.49
		Multi-Family Household	7.68	7.71	8.02	8.19	8.61	9.22	10.82	11.81
		Employee	2.55	2.56	2.76	2.85	2.99	3.12	3.36	3.53
	Unmetered/Non-Revenue		1.54	1.54	1.58	1.61	1.66	1.74	1.97	2.09
	Percent Unmetered/Non-Revenue		10%	10%	10%	10%	10%	10%	10%	10%
	Total		15.39	15.38	15.83	16.10	16.61	17.39	19.69	20.93
Demographics	Population (units)		154,528	159,132	167,479	172,745	180,427	190,787	208,413	221,196
	Employees (units)		108,554	110,106	121,759	127,253	135,241	142,721	155,081	164,189
	Occupied Households (units)		73,855	75,642	80,756	84,095	87,825	92,875	107,057	115,151
	DUR (dimensionless)		0.45	0.44	0.41	0.40	0.37	0.34	0.31	0.28
	Single Family Households (units)		22,921	23,113	23,482	24,027	23,719	23,565	25,334	25,189
	Multi-Family Households (units)		50,935	52,529	57,274	60,068	64,106	69,310	81,723	89,962
Unit Use (gpd/unit)	Single Family Household		(158.1)	(154.2)	(147.4)	(143.7)	(141.6)	(140.4)	(139.7)	(138.63)
	Multi-Family Household		(150.8)	(146.9)	(140.1)	(136.4)	(134.3)	(133.1)	(132.4)	(131.32)
	Employee		23.5	23.3	22.7	22.4	22.1	21.9	21.7	21.49
Total estimated error (MGD)			--	7.8	8.1	8.2	8.6	9.0	10.3	11.0

Note: Unit use rate forecasts in parenthesis are assumed from Fairfax Water.

A.3.2.9 Fairfax Water – Wholesale Customer – Virginia - American Water – Prince William District (Dale City)

Dale City is a Planned Residential Community within Prince William County. The Dale City water system is owned and operated by the VAW. The VAW in Dale City is a private company that purchases water from Fairfax Water and sells the water in Dale City. Data and calculations are reported in Table A.3-27 and Table A.3-28 below.

A.3.2.9.1 Service Area

The service area is provided by Fairfax Water for the 2015 study (Ahmed *et al.*). No changes are made to the service area.

A.3.2.9.2 Demographic Data

POP, HH, and EMP data are interpolated between the years 2010 and 2045 using MWCOG Round 8.4 and Round 9.1 forecasts. Jurisdictional data for Dale City household information is included in the data received from Prince William County (R. F. Hunt, personal communication, May 9, 2019). The method used to calculate the Prince William County DURs is also used for Dale City. Since the data is provided by TAZ, only the data in Dale City TAZs are pulled out to calculate the DURs. SFH are estimated by summing “SF HH” and “TH HH” categories. The “MF HH” is used for MFH. See Figure A.3-9 for the DUR comparison.

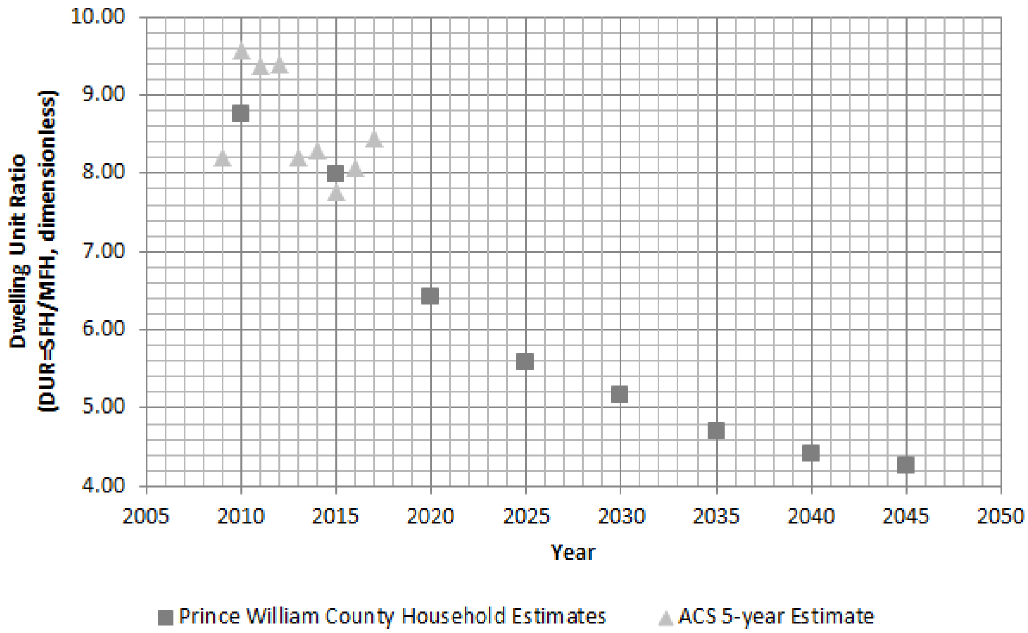

Figure A.3-9: Dwelling unit ratio comparison for Virginia - American Water – Prince William District (Dale City).

A.3.2.9.3 Water Use Data

Fairfax Water provided the amount sold to them. No water use data was received from VAW. It is assumed that the SFH and MFH rates are the same as Fairfax Water. These rates are multiplied by the number of households in the Dale City service area from the MWCOG data. The total amount of household use is summed, and this is subtracted from the amount Fairfax Water reported selling to them. A 10% unmetered use is assumed. The remaining amount is assumed to be the total amount of EMP water use. This total amount is divided by the number of EMPs reported by the MWCOG to estimate the EMP unit use rate.

Table A.3-27: Historic data for unit use calculations and results – Fairfax Water – Virginia - American Water – Prince William District (Dale City) – Wholesale.

			Historic Data								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
Purchased (MGD)			4.95	4.77	4.87	4.60	4.73	4.73	4.76	4.68	4.67
Demand (MGD)	Retail Sales	Single Family Household	3.94	3.79	3.65	3.53	3.29	3.29	3.36	3.31	3.18
		Multi-Family Household	0.34	0.36	0.34	0.37	0.37	0.37	0.39	0.41	0.43
		Employee	0.18	0.14	0.39	0.24	0.60	0.60	0.53	0.49	0.60
	Unmetered/Non-Revenue		0.50	0.48	0.49	0.46	0.47	0.47	0.48	0.47	0.47
	Percent Unmetered/Non-Revenue		10%	10%	10%	10%	10%	10%	10%	10%	10%
	Total		4.95	4.77	4.87	4.60	4.73	4.73	4.76	4.68	4.67
Demographics	Population (units)		66,658	67,144	67,629	68,115	68,600	69,086	69,852	70,617	71,383
	Employees (units)		10,099	10,342	10,584	10,827	11,069	11,312	11,518	11,724	11,930
	Occupied Households (units)		21,219	21,313	21,408	21,502	21,597	21,691	22,044	22,397	22,751
	DUR (dimensionless)		8.76	8.61	8.45	8.30	8.14	7.99	7.68	7.37	7.06
	Single Family Households (units)		19,045	19,095	19,143	19,190	19,235	19,278	19,504	19,720	19,926
	Multi-Family Households (units)		2,174	2,219	2,265	2,313	2,362	2,413	2,540	2,677	2,824
Unit Use (gpd/unit)	Single Family Household		(206.6)	(198.6)	(190.7)	(184.1)	(170.8)	(170.6)	(172.4)	(167.8)	(159.5)
	Multi-Family Household		(158.0)	(163.2)	(152.1)	(157.8)	(156.6)	(151.7)	(152.9)	(152.9)	(150.6)
	Employee		17.9	13.8	36.6	22.3	54.0	53.1	46.3	41.7	50.0

Note: Unit use rates in parenthesis are assumed from Fairfax Water. A 10% unmetered use is assumed.

Table A.3-28: Forecast data for unit use calculations and results – Fairfax Water – Virginia - American Water – Prince William District (Dale City)– Wholesale.

			Forecast Data							
			2018	2020	2025	2030	2035	2040	2045	2050
Purchased (MGD)			4.70	4.74	4.72	4.74	4.80	4.87	4.93	5.00
Demand (MGD)	Retail Sales	Single Family Household	3.15	3.13	3.03	2.99	2.97	2.97	2.98	2.97
		Multi-Family Household	0.43	0.46	0.52	0.55	0.60	0.64	0.66	0.70
		Employee	0.65	0.67	0.70	0.73	0.75	0.78	0.80	0.82
	Unmetered/Non-Revenue		0.47	0.47	0.47	0.47	0.48	0.49	0.49	0.50
	Percent Unmetered/Non-Revenue		10%	10%	10%	10%	10%	10%	10%	10%
	Total		4.70	4.74	4.72	4.74	4.80	4.87	4.93	5.00
Demographics	Population (units)		71,383	72,914	75,041	76,569	78,126	79,395	80378	81552
	Employees (units)		11,930	12,342	12,948	13,545	14,118	14,641	15094	15594
	Occupied Households (units)		22,751	23,457	24,248	24,832	25,451	25,947	26319	26774
	DUR (dimensionless)		7.06	6.43	5.59	5.16	4.69	4.42	4.26	4.03
	Single Family Households (units)		19,926	20,301	20,570	20,798	20,979	21,158	21,319	21,451
	Multi-Family Households (units)		2,824	3,156	3,678	4,034	4,472	4,789	5,000	5,322
Unit Use (gpd/unit)	Single Family Household		(158.1)	(154.2)	(147.4)	(143.7)	(141.6)	(140.4)	(139.7)	(138.6)
	Multi-Family Household		(150.8)	(146.9)	(140.1)	(136.4)	(134.3)	(133.1)	(132.4)	(131.3)
	Employee		54.8	54.6	54.0	53.7	53.4	53.2	53.0	52.8
Total estimated error (MGD)			--	2.7	2.8	2.8	2.9	3.0	3.1	3.2

Note: Unit use rate forecasts in parenthesis are assumed from Fairfax Water.

A.3.3 Supplier Data: Washington Aqueduct

The Washington Aqueduct does not own its own distribution system. Instead, finished drinking water is distributed through Washington Aqueduct wholesale customers, which include: The District of Columbia Water and Sewer Authority; Arlington County, Virginia; and Fairfax Water, Virginia. On January 3, 2014, the ownership of Falls Church Water Utility transferred to Fairfax Water. At that time the Falls Church Water Utility, which had been a wholesale customer of Washington Aqueduct, became a retail customer of Fairfax Water and in turn Fairfax Water became a wholesale customer of the Washington Aqueduct. The Washington Aqueduct records still show water purchased by Falls Church after 2014, but it is actually purchased by Fairfax Water and then distributed to Falls Church through the same infrastructure used prior to 2014 (A. Speisman, personal communication, August 23, 2019).

A.3.3.1 Washington Aqueduct Wholesale Customer – DC Water

DC Water purchases treated drinking water from the Washington Aqueduct and distributes it to their customers. Data and calculations are reported in Table A.3-29 and Table A.3-30 below.

A.3.3.1.1 Service Area

The service area boundary is the same as in the 2015 study (Ahmed *et al.*). The service area boundary does not completely match the TAZ layer for the District of Columbia jurisdiction. However, all TAZ data is included in the DC Water demographic information because it is assumed that all District of Columbia households and employees are served by DC Water. TAZ areas that represent Montgomery, Prince George's, Arlington, Alexandria, and Fairfax jurisdictions are excluded from the DC Water analysis.

A.3.3.1.2 Demographic data

POP, HH, and EMP data are interpolated between the years 2010 and 2045 using MWCOG Round 8.4 and Round 9.1 forecasts. Dwelling unit ratios are calculated as the ratio of SFH to MFH using housing unit and household data available from the U.S. Census Bureau, American Community Survey (ACS). Data for projections of the future number of SFH versus MFH are made using two assumptions recommended by the Associate Director of the DC State Data Center/GIS/IT (J. Phillips, personal communication, June 5, 2019):

1. For all past data years, the average proportions for MFH is 60% and the other 40% for SFH (attached and detached)
2. For years 2020 and onward, any net new households are forecasted to be proportioned at 5% SFH and 95% MFH

The ACS data used for the years 2009-2017 shows an average of 38% SFH, therefore this number is used instead of the 40% recommended in the first assumption in order to minimize a break in the ACS historic data and the MWCOG forecast data (Figure A.3-10).

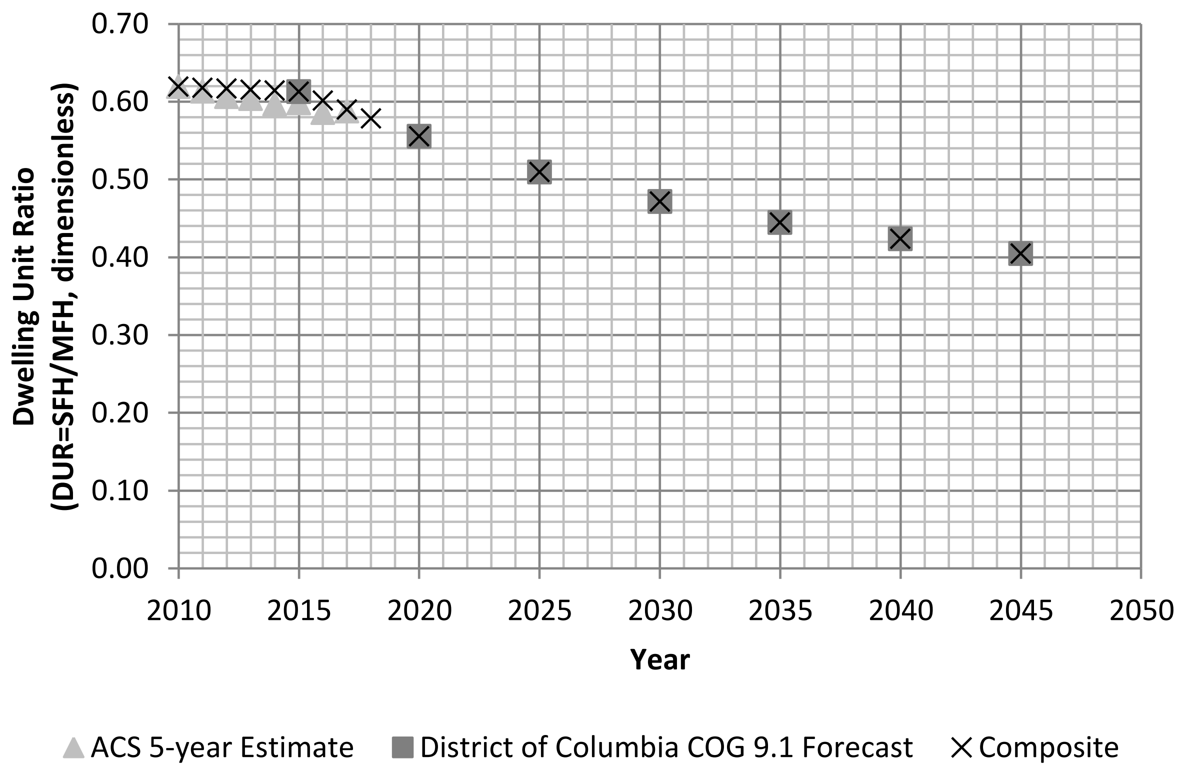

Figure A.3-10: Dwelling unit ratios using ACS data to approximate a 38% single family assumption for the year 2015. Additional households after 2015 assumed to be split 5% single family and 95% multi-family and were applied to MWCOG Round 9.1 data.

A.3.3.1.3 Water Use Data

Purchased data is assumed from the amount Washington Aqueduct sold to DC Water by calendar year between 2014 and 2018 (A. Speisman, personal communication, August 23, 2019). Billed data is provided by DC Water by fiscal year (October 1-September 30) (R. Lipscomb, personal communication, April 2, 2019 and March 6, 2020). To estimate the amount billed for this study, data from fiscal year 2014-2018 is used. The numbers reported represent the net amount billed to customers after corrections and does not include fire hydrant use (L. Preston, personal communication, May 1, 2014). DC Water's billing data are reported in the following categories for the years 2014-2018:

- Residential – buildings with one to three dwelling units
- Commercial
- Multi-family – buildings with 4 or more dwelling units
- District Government – combines previous categories labeled Exempt and Municipal, which includes meters exempt from billing and DC Government, excluding housing, respectively
- Federal Government
- DC Housing – DC Housing Authority

- DC Water – DC Water's own use, previously labeled WASA
- Washington Aqueduct

The DC Water categories are grouped into the categories needed for this study as follows:

- SFH: Residential
- MFH: DC Housing, Multi-family
- EMP: Commercial, District Government, Federal Government
- Other: DC Water and Washington Aqueduct

Purchase and billing data for years 2010-2013 came from the 2015 study (Ahmed *et al.*).

Table A.3-29: Historic data for unit use calculations and results – Washington Aqueduct Wholesale Customer - DC Water.

			Historic Data								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
Purchased (MGD)			104.43	102.96	99.46	95.50	95.89	104.13	100.95	94.83	95.12
Demand (MGD)	Retail Sales	Single Family Household	16.99	16.82	16.03	15.65	15.51	15.23	14.88	14.57	14.27
		Multi-Family Household	18.31	17.91	17.10	16.86	16.84	16.87	19.78	20.04	19.21
		Employee	42.51	43.43	42.37	39.22	36.67	40.34	36.42	35.40	35.70
		Other	1.60	1.28	1.05	0.37	0.51	0.84	1.03	0.81	0.76
	Unmetered		25.02	23.52	22.91	23.40	26.36	30.85	28.84	24.01	25.18
	Percent Unmetered		24%	23%	23%	25%	27%	30%	29%	25%	26%
	Total		104.43	102.96	99.46	95.50	95.89	104.13	100.95	94.83	95.12
Demographics	Population (units)		601,764	615,857	629,950	644,044	658,137	672,230	683,684	695,138	706,593
	Employees (units)		783,282	786,280	789,278	792,275	795,273	798,271	807,827	817,383	826,940
	Households (units)		266,707	272,788	278,869	284,950	291,031	297,112	301,548	305,983	310,419
	DUR (dimensionless)		0.62	0.62	0.62	0.62	0.61	0.61	0.60	0.59	0.58
	Single Family Households (units)		101,974	104,171	106,363	108,549	110,729	112,903	113,245	113,529	117,959
	Multi-Family Households (units)		164,733	168,617	172,506	176,401	180,302	184,209	188,302	192,454	192,460
Unit Use (gpd/unit)	Single Family Household		166.6	161.5	150.7	144.2	140.1	134.9	131.4	128.3	121.0
	Multi-Family Household		111.1	106.2	99.1	95.6	93.4	91.6	105.0	104.1	99.8
	Employee		54.3	55.2	53.7	49.5	46.1	50.5	45.1	43.3	43.2

Table A.3-30: Forecast data for unit use calculations and results – Washington Aqueduct Wholesale Customer - DC Water.

			Forecast Data							
			2015	2020	2025	2030	2035	2040	2045	2050
Purchased (MGD)			93.07	93.31	95.00	97.77	100.61	103.29	106.19	108.82
Demand (MGD)	Retail Sales	Single Family Household	14.16	13.25	12.59	12.28	12.13	12.07	12.06	11.95
		Multi-Family Household	18.81	19.27	19.67	20.53	21.41	22.28	23.27	24.19
		Employee	35.20	35.84	37.35	38.86	40.24	41.42	42.59	43.74
		Other	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
	Unmetered		23.97	24.03	24.47	25.18	25.91	26.61	27.35	28.03
	Percent Unmetered		26%	26%	26%	26%	26%	26%	26%	26%
	Total		93.07	93.31	95.00	97.77	100.61	103.29	106.19	108.82
Demographics	Population (units)		706,593	729,501	787,116	842,154	893,898	940,687	987,213	1,033,914
	Employees (units)		826,940	846,052	894,385	937,119	977,488	1,011,071	1,044,655	1,078,238
	Households (units)		310,419	319,290	341,019	362,524	380,594	396,233	411,872	427,511
	DUR (dimensionless)		0.58	0.56	0.51	0.47	0.44	0.42	0.40	0.38
	Single Family Households (units)		117,959	114,011	115,098	116,173	117,077	117,859	118,641	118,705
	Multi-Family Households (units)		192,460	205,279	225,921	246,351	263,517	278,374	293,231	308,806
Unit Use (gpd/unit)	Single Family Household		120.1	116.2	109.4	105.7	103.6	102.4	101.7	100.6
	Multi-Family Household		97.8	93.9	87.1	83.4	81.3	80.1	79.4	78.3
	Employee		42.6	42.4	41.8	41.5	41.2	41.0	40.8	40.6
Total estimated error (MGD)			--	13.3	15.0	16.9	18.8	20.7	22.7	24.7

A.3.3.2 Washington Aqueduct Wholesale Customer – Arlington County DES

The Arlington County Department of Environmental Services' Water, Sewers, and Streets Bureau (or Arlington County DES) purchases its treated water from the Washington Aqueduct and distributes it to their customers. Additionally, the Willston Water Distribution System serves approximately 2,000 citizens (or 1% of residents) and is located on the western edge of the County. Arlington purchases water for the Willston area from Fairfax Water. Fairfax Water receives its water for this service area from the Dalecarlia and McMillan Water Treatment Plants, which is also run by the Washington Aqueduct. Data and calculations are reported in Table A.3-31 and Table A.3-32 below.

A.3.3.2.1 Service Area

No change from the 2015 study service area boundary is made by Arlington County DES. The service area boundary does not match the TAZ layer for the Arlington jurisdiction. This is, at least in part, because some households located on the same street can be served by either Arlington County DES or Fairfax Water, the neighboring water supplier. Arlington County DES has about 300 accounts served in Falls Church for Fairfax Water and Fairfax Water has about 300 accounts served in Arlington County for Arlington County DES (K. Abele, personal communication, September 5, 2019). The following assumptions are made in adjusting TAZ area ratios:

- A portion of TAZs 1437 and 1405 are clearly part of Fairfax Water and therefore the Fairfax Water TAZ ratio is kept and the Arlington DES ratio is adjusted to have the full TAZ represented between the two suppliers
- TAZs 1476, 1486, 1489, 1495, 1488, plus 3% of 1487 are excluded because they are assumed to be part of the Fort Myer service area, which is reported separately as a wholesale customer of Arlington County DES
- All remaining TAZ areas located in the Arlington are set to an area ratio of one
- TAZs marked as the District of Columbia are excluded because they are in non-populated areas along the Potomac River
- TAZs marked as Alexandria are excluded because they overlap with the Alexandrea service area

Historically, the Arlington County DES reports that it has served National Airport for extended periods of time, and they have made a demand assumption of 1.0 MGD in some of the County's demand analyses.[19]

[19] See Addendum-9-20-14-S-Water_Distribution_Master_Plan.pdf on page 31.

A.3.3.2.2 Demographic Data

POP, HH, and EMP data are interpolated between the years 2010 and 2045 using MWCOG Round 8.4 and Round 9.1 forecasts. Historical years of SFH and MFH unit data, as well as the vacancy rates, for the county are available online through the Arlington County Profile, which is an annual report providing statistical information including demographics, development tracking, employment, transportation and community resources.[20] HUs, HHs, and vacancy rates are also available from the U.S. Census Bureau, ACS data. Data for projections of the future number of SFH and MFH are provided by the Arlington County Urban Planner/Demographer in a file called, “Arlington County Forecasts of Major Statistics, 2010 to 2045,” which is updated to reflect COG 9.1 for years 2015 through 2045 (E. Hardy, personal communication, May 31, 2019). The DURs selected for the unit use calculation are shown as the “Composite” DURs in Figure A.3-11 and are obtained by interpolated historical values using the “Major Statistics COG 9.1 Forecast.” Arlington’s DURs are also used for the Fort Myer service area.

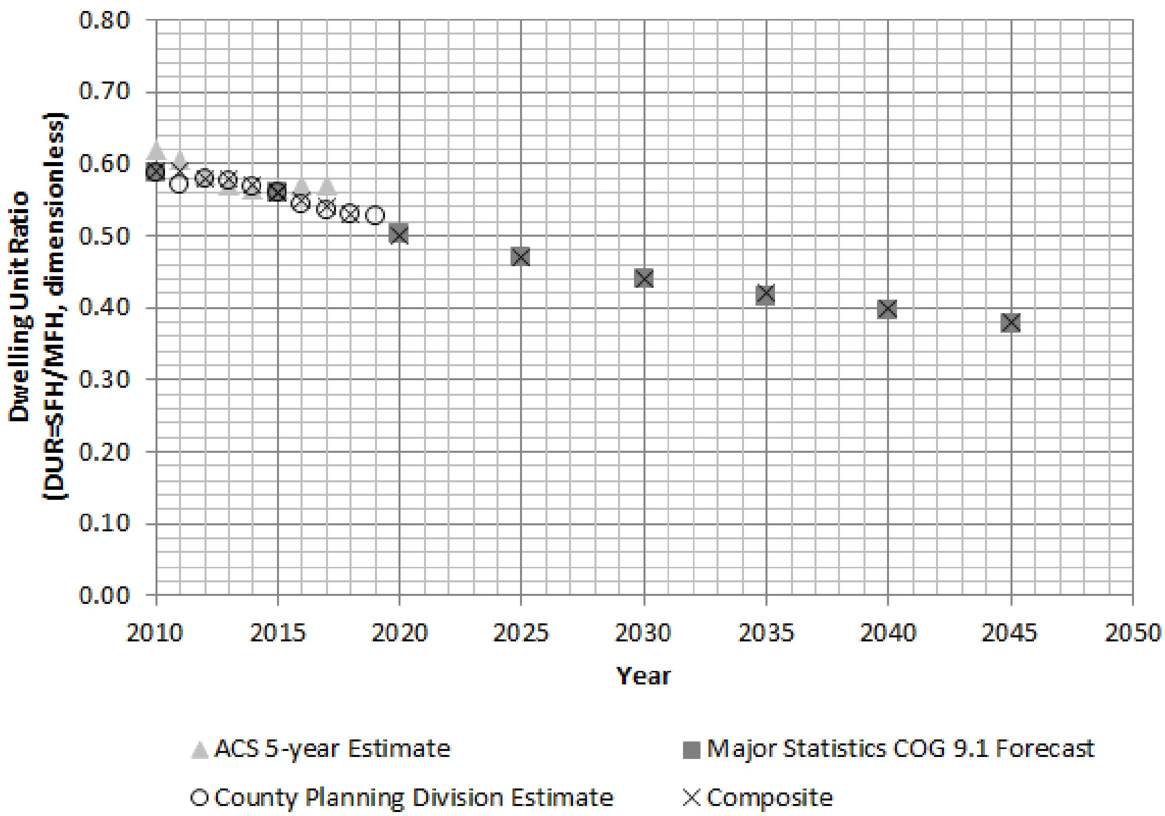

Figure A.3-11: Comparing dwelling unit ratios (DUR) for Arlington County. The “Composite” DUR is the “Major Statistics COG 9.1 Forecast” interpolated for historical years and is what is reported.

[20] See https://www.arlingtonva.us/profile/

A.3.3.2.3 Water Use Data

Two matching sets of purchased data are obtained for the years 2014-2018. The first data set is provided as the amount the Washington Aqueduct sold to Arlington County DES. The second data set is provided as the amount Arlington County DES purchased from the Washington Aqueduct.

The actual amount billed to customers by calendar year 2014-2018 is provided by Arlington County DES (K. Abele, personal communication, March 29, 2019). The amount sold to Fort Myer for 2014-2018 is included in the billed information. Arlington County billed data are reported in the following categories:

- Residential – single family homes
- Apartments – multifamily duplexes and apartment buildings
- Commercial and large apartments – commercial and large apartments, county agencies

The Arlington County categories are grouped into the categories needed for this study as follows:

- SFH: Residential
- MFH: Apartments
- EMP: Commercial

Purchased and billed data for years 2010-2013 are from the 2015 study (Ahmed *et al.*).

Arlington County data includes unaccounted water estimates. The unaccounted water estimates shown below are calculated by subtracting the amount sold to retail customers and Fort Myer from the amount purchased from Washington Aqueduct and is reported as unmetered demand.

Table A.3-31: Historic data for unit use calculations and results – Washington Aqueduct Wholesale Customer – Arlington County Department of Environmental Services' Water, Sewers, and Streets Bureau (or Arlington County DES).

			Historic Data								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
Purchased (MGD)			23.78	22.46	22.76	22.15	22.13	21.97	21.41	21.28	21.83
Demand (MGD)	Retail Sales	Single Family Household	5.65	5.50	5.40	5.27	5.22	5.23	5.23	5.12	4.91
		Multi-Family Household	5.65	5.57	5.49	5.50	5.39	5.47	5.63	5.45	5.33
		Employee	8.86	8.31	8.19	8.30	8.25	8.55	8.80	8.40	8.49
	Wholesales		0.30	0.26	0.28	0.55	0.27	0.30	0.26	0.21	0.34
	Unmetered		3.32	2.82	3.40	2.53	3.00	2.42	1.49	2.10	2.76
	Percent Unmetered		14%	13%	15%	11%	14%	11%	7%	10%	13%
	Total		23.78	22.46	22.76	22.15	22.13	21.97	21.41	21.28	21.83
Demographics	Population (units)		206,475	209,132	211,789	214,445	217,102	219,759	223,235	226,710	230,186
	Employees (units)		216,467	214,250	212,040	209,830	207,620	205,417	206,851	208,292	209,734
	Households (units)		97,821	98,963	100,105	101,247	102,389	103,531	105,188	106,845	108,502
	DUR (dimensionless)		0.59	0.59	0.58	0.58	0.57	0.56	0.55	0.54	0.53
	Single Family Households (units)		36,298	36,722	36,747	37,167	37,173	37,165	37,325	37,465	37,586
	Multi-Family Households (units)		61,523	62,241	63,358	64,081	65,216	66,366	67,863	69,380	70,916
Unit Use (gpd/unit)	Single Family Household		155.7	149.8	146.9	141.8	140.4	140.7	140.1	136.7	130.6
	Multi-Family Household		91.8	89.5	86.7	85.8	82.6	82.4	83.0	78.6	75.2
	Employee		40.9	38.8	38.6	39.6	39.7	41.6	42.5	40.3	40.5

Note: The wholesale values are also reported in the Fort Myer Table as "Purchased" since they are a wholesale customer of Arlington County.

Table A.3-32: Forecast data for unit use calculations and results – Washington Aqueduct Wholesale Customer – Arlington County Department of Environmental Services' Water, Sewers, and Streets Bureau (or Arlington County DES).

			Forecast Data							
			2018	2020	2025	2030	2035	2040	2045	2050
Purchased (MGD)			21.96	21.81	21.56	22.10	22.63	23.36	24.01	24.66
Demand (MGD)	Retail Sales	Single Family Household	4.97	4.78	4.57	4.45	4.43	4.42	4.43	4.39
		Multi-Family Household	5.43	5.42	5.27	5.34	5.48	5.69	5.96	6.19
		Employee	8.63	8.70	8.85	9.37	9.72	10.15	10.39	10.74
	Wholesales		0.32	0.31	0.31	0.31	0.31	0.32	0.38	0.41
	Unmetered		2.61	2.59	2.56	2.63	2.69	2.77	2.85	2.93
	Percent Unmetered		12%	12%	12%	12%	12%	12%	12%	12%
	Total		21.96	21.81	21.56	22.10	22.63	23.36	24.01	24.66
Demographics	Population (units)		230,186	237,138	248,304	260,633	273,403	285,811	299,313	312,086
	Employees (units)		209,734	212,623	219,288	234,127	244,649	256,722	264,003	274,479
	Households (units)		108,502	111,815	117,635	123,625	129,536	135,146	141,352	147,160
	DUR (dimensionless)		0.53	0.5	0.47	0.44	0.42	0.40	0.38	0.36
	Single Family Households (units)		37,586	37,272	37,611	37,774	38,314	38,613	38,923	38,954
	Multi-Family Households (units)		70,916	74,544	80,024	85,851	91,223	96,533	102,429	108,206
Unit Use (gpd/unit)	Single Family Household		132.3	128.4	121.6	117.9	115.8	114.6	113.9	112.8
	Multi-Family Household		76.6	72.7	65.9	62.2	60.1	58.9	58.2	57.2
	Employee		41.1	40.9	40.3	40.0	39.7	39.5	39.3	39.1
Total estimated error (MGD)			--	4.9	5.1	5.4	5.8	6.2	6.6	7.1

Note: The wholesale values are also reported in the Fort Myer Table as "Purchased" since they are a wholesale customer of Arlington County.

A.3.3.3 Washington Aqueduct Wholesale Customer – Arlington County Department of Environmental Services WSS – Fort Myer

Fort Myer is in Arlington County, Virginia, and receives treated water through the Arlington County DES, which is a wholesale customer of Washington Aqueduct. Data and calculations are reported in Table A.3-33 and Table A.3-34 below.

A.3.3.3.1 Service Area

While no changes are made to the Fort Myer service area, some adjustments are made to the TAZ ratio assumptions. The MWCOG demographic data is collected for TAZs 1476, 1486, 1487, 1488, 1489, 1494, 1495, and 1525. A Google Maps analysis shows that the portion of the TAZ segments 1476, 1486, 1488, 1489, and 1495, that extended beyond the provided service area included highways, roads, and open land. Therefore, demographic data is not reduced by area ratios to correct for the service area boundary in those identified TAZs. A ratio of 0.03 was applied to TAZ 1487 because a building is included in the selected area. Including 0.03 of TAZ 1487 increased the number of employees accounted for in Fort Myer and, therefore, changed the EMP unit use rate from that used in the 2015 study (Ahmed *et al.*). Finally, a ratio of zero is applied to TAZs 1494 and 1525 because they only include roads and highways with no other structures.

A.3.3.3.2 Demographic data

POP, HH, and EMP data are interpolated between the years 2010 and 2045 using MWCOG Round 8.4 and Round COG 9.1 forecasts. Data on SFH and MFH is unavailable for Fort Myer. Therefore, the dwelling unit ratios for Arlington County, Virginia are assumed.

A.3.3.3.3 Water Use Data

Purchased data is provided by Arlington County DES as the amount sold to Fort Myer for 2014-2018. No billed or purchased data separated by use is obtained from Fort Myer. Therefore, Arlington County DES SFH and MFH unit use rates are assumed. These rates are multiplied by the number of HHs in the Fort Myer service area from the amount Arlington reported selling to them. An unmetered use rate of 10% is assumed. The remaining amount is assumed to be the total amount of EMP water use. This total amount is divided by the number of EMPs reported by MWCOG to estimate the EMP unit use rate.

Table A.3-33: Historic data for unit use calculations and results – Washington Aqueduct Wholesale Customer – Arlington County DES – Fort Myer.

			Historic Data								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
Purchased (MGD)			0.30	0.26	0.28	0.55	0.27	0.30	0.26	0.21	0.34
Demand (MGD)	Retail Sales	Single Family Household	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
		Multi-Family Household	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
		Employee	0.25	0.21	0.23	0.48	0.22	0.25	0.22	0.17	0.29
	Unmetered		0.03	0.03	0.03	0.06	0.03	0.03	0.03	0.02	0.03
	Percent Unmetered		10%	10%	10%	10%	10%	10%	10%	10%	10%
	Total		0.30	0.26	0.28	0.55	0.27	0.30	0.26	0.21	0.34
Demographics	Population (units)		1,003	1,003	1,003	1,003	1,003	1,003	1,003	1,003	1,003
	Employees (units)		25,219	21,024	16,830	12,635	8,441	4,246	4,246	4,246	4,246
	Households (units)		175	175	175	175	175	175	175	175	175
	DUR (dimensionless)		(0.59)	(0.59)	(0.58)	(0.58)	(0.57)	(0.56)	(0.55)	(0.54)	(0.53)
	Single Family Households (units)		65	65	64	64	64	63	62	61	61
	Multi-Family Households (units)		110	110	111	111	111	112	113	114	114
Unit Use (gpd/unit)	Single Family Household		(155.7)	(149.8)	(146.9)	(141.8)	(140.4)	(140.7)	(140.1)	(136.7)	(130.6)
	Multi-Family Household		(91.8)	(89.5)	(86.7)	(85.8)	(82.6)	(82.4)	(83.0)	(78.6)	(75.2)
	Employee		9.9	10.2	13.8	37.7	26.6	59.3	50.9	40.4	68.2

Note: Arlington County's DURs and unit use rates in parenthesis are assumed. Fairfax Water's Unit use rates are assumed in the 2015 study (Ahmed *et al.*). A 10% unmetered use is assumed.

Table A.3-34: Forecast data for unit use calculations and results – Washington Aqueduct Wholesale Customer – Arlington County DES – Fort Myer.

			Forecast Data							
			2018	2020	2025	2030	2035	2040	2045	2050
Purchased			0.32	0.31	0.31	0.31	0.31	0.32	0.38	0.41
Demand (MGD)	Retail Sales	Single Family Household	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
		Multi-Family Household	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
		Employee	0.27	0.27	0.26	0.26	0.26	0.26	0.31	0.33
	Unmetered		0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
	Percent Unmetered		10%	10%	10%	10%	10%	10%	10%	10%
	Total		0.32	0.31	0.31	0.31	0.31	0.32	0.38	0.41
Demographics	Population		1,003	1,003	1,003	1,003	1,003	1,594	1,695	2,123
	Employees		4,246	4,246	4,246	4,247	4,248	4,248	5,053	5,322
	Households		175	175	175	175	175	396	434	594
	DUR		(0.53)	(0.50)	(0.47)	(0.44)	(0.42)	(0.40)	(0.38)	(0.36)
	Single Family Households		61	58	56	53	52	113	120	157
	Multi-Family Households		114	117	119	122	123	283	315	437
Unit Use (gpd)	Single Family Household		(132.3)	(128.4)	(121.6)	(117.9)	(115.8)	(114.6)	(113.9)	(112.8)
	Multi-Family Household		(76.6)	(72.7)	(65.9)	(62.2)	(60.1)	(58.9)	(58.2)	(57.2)
	Employee		63.2	63.0	62.4	62.1	61.8	61.6	61.4	61.2
Total estimated error (MGD)			--	0.08	0.08	0.09	0.09	0.10	0.12	0.14

Note: Arlington County's DURs and unit use rates in parenthesis are assumed. Fairfax Water's unit use rates are assumed in the 2015 study (Ahmed *et al.*).

A.3.3.4 Washington Aqueduct Wholesale Customer – Fairfax Water-Retail - Falls Church

On January 3, 2014, the ownership of Falls Church Water Utility transferred to Fairfax Water. At that time the Falls Church Water Utility, which had been a wholesale customer of Washington Aqueduct, became a retail customer of Fairfax Water and in turn Fairfax Water became a wholesale customer of the Washington Aqueduct. The Washington Aqueduct records still show water purchased by Falls Church after 2014, but it is actually purchased by Fairfax Water and then distributed to Falls Church through the same infrastructure used prior to 2014 (A. Speisman, personal communication, August 23, 2019). When discussing the demand forecast, Falls Church water use after 2014 is included with the Fairfax Water retail estimates. However, when discussing the production forecast, Falls Church water use is included with the Washington Aqueduct estimates. Data and calculations are reported in Table A.3-35 and Table A.3-36 below.

A.3.3.4.1 Service Area

The Falls Church service area is now part of the larger Fairfax Water retail service area. To estimate produced water sold by Washington Aqueduct, the same Falls Church service area from the 2015 study (Ahmed *et al.*) is assumed.

A.3.3.4.2 Demographic Data

POP, HH, and EMP data are interpolated between the years 2010 and 2045 using MWCOG Round 8.4 and Round 9.1 forecasts. Demographic data is divided into SFH and MFH estimates using DURs calculated from demographic provided by the Principal Planner/West Falls Church Project Manager and the Principal Planner for the Falls Church Economic Development Office (C. Aubrey and G. Fuller, personal communication, June 28, 2019). The data includes total number of households for 2010-2040, and the number of additional households by unit type expected between 2005-2040. Since an initial number of households by unit type is not available, ACS data is used. The 2006-2010 ACS survey for the city is used to estimate the percentage of SFH and MFH in 2010. These percentages are applied to the 2010 total household numbers from Falls Church and the number of households by type is estimated through 2040, and the DUR is calculated. Figure A.3-12 compares the Falls Church Economic Development DUR values with those estimated from the ACS data.

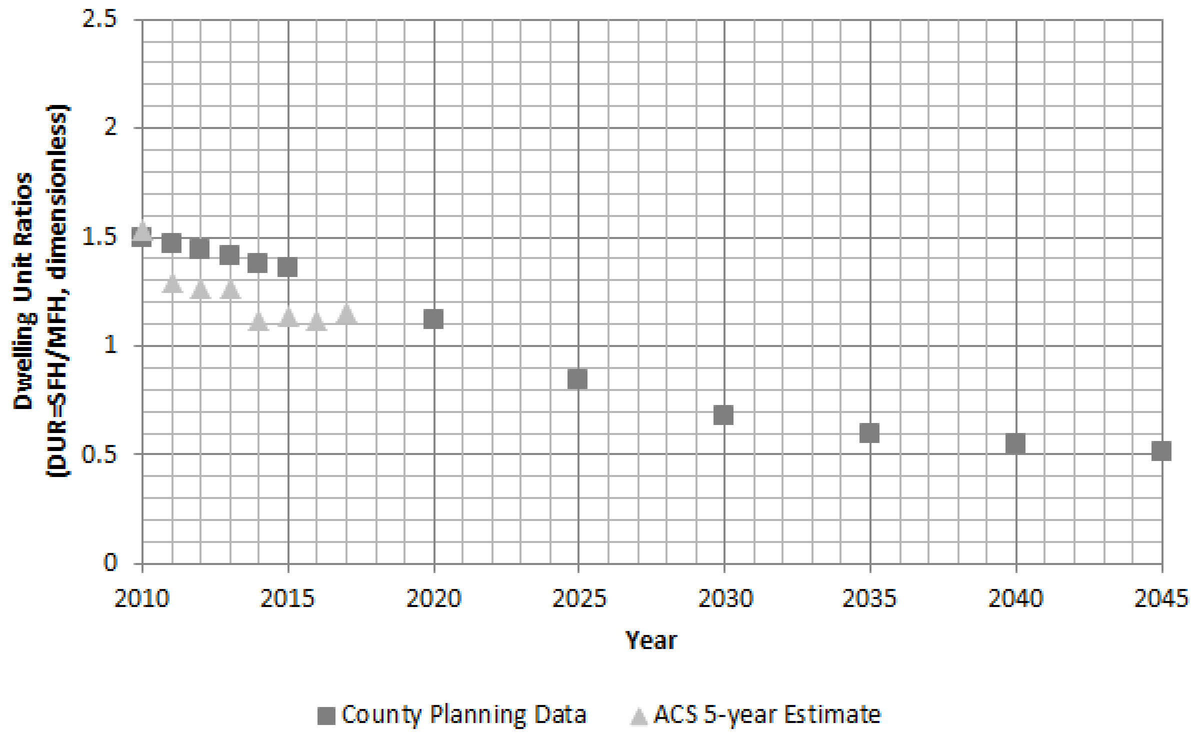

Figure A.3-12: Falls Church dwelling unit ratios.

A.3.3.4.3 Water Use Data

Purchased data is provided by the Washington Aqueduct as the amount sold to Fairfax Water for the Falls Church service area. Fairfax Water lumps the Falls Church water use by category into the entire retail serve area and does not report it individually. Therefore, unit use is assumed to equal the SFH and MFH rates calculated for Fairfax Water. These rates are multiplied by the number of households in the Falls Church service area from the MWCOG data. The total amount of household use is summed, and this is subtracted from the amount the Washington Aqueduct and Fairfax Water report sold to them. A 10% unmetered use is assumed. The remaining amount is assumed to be the total amount of EMP water use. This total amount of EMP water use is divided by the number of EMPs reported by MWCOG to estimate the EMP unit use rate.

Table A.3-35: Historic data for unit use calculations and results – Washington Aqueduct Wholesale Customer – Fairfax Water-Retail - Falls Church.

			Historic Data								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
Purchased from Washington Aqueduct (MGD)			16.55	15.64	15.57	14.29	--	--	--	--	--
Purchase from Fairfax Water (MGD)			0.10	0.10	0.10	0.05	14.24	14.12	11.46	14.79	15.08
Demand (MGD)	Retail Sales	Single Family Household	6.29	6.08	5.86	5.69	5.30	5.32	5.38	5.23	4.96
		Multi-Family Household	3.21	3.40	3.25	3.46	3.52	3.48	3.64	3.77	3.85
		Employee	5.49	4.70	4.99	3.77	4.00	3.90	1.29	4.32	4.77
	Unmetered		1.67	1.57	1.57	1.43	1.42	1.41	1.15	1.48	1.51
	Percent Unmetered		10%	10%	10%	10%	10%	10%	10%	10%	10%
	Total		16.65	15.74	15.67	14.35	14.24	14.12	11.46	14.79	15.08
Demographics	Population (units)		131,080	132,715	134,349	135,983	137,618	139,252	141,272	143,292	145,312
	Employees (units)		128,344	128,756	129,168	129,580	129,993	130,405	132,542	134,679	136,815
	Households (units)		50,703	51,394	52,085	52,776	53,467	54,158	54,978	55,799	56,619
	DUR (dimensionless)		1.50	1.47	1.44	1.41	1.38	1.36	1.31	1.26	1.22
	Single Family Households (units)		30,422	30,587	30,739	30,877	31,002	31,210	31,199	31,153	31,069
	Multi-Family Households (units)		20,281	20,807	21,346	21,899	22,465	22,948	23,780	24,646	25,550
Unit Use (gpd/unit)	Single Family Household		(206.6)	(198.6)	(190.7)	(184.1)	(170.8)	(170.6)	(172.4)	(167.8)	(159.5)
	Multi-Family Household		(158.0)	(163.2)	(152.1)	(157.8)	(156.6)	(151.7)	(152.9)	(152.9)	(150.6)
	Employee		42.8	36.5	38.7	29.1	30.8	29.9	9.8	32.1	34.9

Note: Unit use rates in parenthesis are assumed from Fairfax Water. A 10% unmetered use is assumed. Fairfax Water purchased amount is assumed insignificant for years 2010-2013. Then starting in 2014, Falls Church became a retail customer to Fairfax Water, but the water still comes from the Washington Aqueduct.

Table A.3-36: Forecast data for unit use calculations and results – Washington Aqueduct Wholesale Customer – Fairfax Water-Retail - Falls Church.

			Forecast Data							
			2018	2020	2025	2030	2035	2040	2045	2050
Purchased from Washington Aqueduct (MGD)			--	--	--	--	--	--	--	--
Purchase from Fairfax Water (MGD)			13.51	13.61	14.45	15.09	15.88	16.69	17.39	18.14
Demand (MGD)	Retail Sales	Single Family Household	4.91	4.74	4.44	4.15	4.05	4.02	4.02	3.93
		Multi-Family Household	3.85	4.04	5.03	5.80	6.41	6.93	7.46	8.04
		Employee	3.39	3.47	3.54	3.63	3.83	4.07	4.17	4.36
	Unmetered		1.35	1.36	1.44	1.51	1.59	1.67	1.74	1.81
	Percent Unmetered		10%	10%	10%	10%	10%	10%	10%	10%
	Total		13.51	13.61	14.45	15.09	15.88	16.69	17.39	18.14
Demographics	Population (units)		145,312	149,352	164,309	175,316	185,648	194,808	203,687	212,753
	Employees (units)		136,815	141,089	147,305	153,239	163,669	175,224	181,306	191,036
	Households (units)		56,619	58,261	66,030	71,414	76,351	80,759	85,137	89,535
	DUR (dimensionless)		1.22	1.12	0.84	0.68	0.6	0.55	0.51	0.46
	Single Family Households (units)		31,069	30,779	30,144	28,906	28,631	28,656	28,755	28,349
	Multi-Family Households (units)		25,550	27,481	35,886	42,508	47,719	52,102	56,382	61,186
Unit Use (gpd/unit)	Single Family Household		(158.1)	(154.2)	(147.4)	(143.7)	(141.6)	(140.4)	(139.7)	(138.6)
	Multi-Family Household		(150.8)	(146.9)	(140.1)	(136.4)	(134.3)	(133.1)	(132.4)	(131.3)
	Employee		24.8	24.6	24.0	23.7	23.4	23.2	23.0	22.8
Total estimated error (MGD)			--	7.2	7.8	8.4	9.1	9.7	10.3	11.0

Note: Unit use rates in parenthesis are assumed from Fairfax Water. Falls Church is a retail customer to Fairfax Water, but water still comes from the Washington Aqueduct.

A.3.4 Supplier Data: Washington Suburban Sanitary Commission (WSSC Water)

The Washington Suburban Sanitary Commission (WSSC Water) finished drinking water is distributed to their retail customers in Prince George's and Montgomery counties, and are included in the WSSC Water demand forecast. In addition to their retail customers, WSSC Water has formal water system interconnections with five wholesale customers. Table A.3-37 details the allowable withdrawal limits with these customers. A constant total wholesale amount of 6.8 MGD is assumed for forecast years.

Table A.3-37: Wholesale customers of WSSC Water and their water usage replicated from Table 6 in Carpio (2016).

Wholesale Customer	Max Allowable (MGD)	Average (MGD)	Forecast (MGD)
City of Bowie	Not specified – emergency only	Negligible	--
Charles County[1]	1.4	1.8	1.8
Howard County[2]	5.0	4.0	5.0
City of Rockville[3]	8.0	Negligible	--
DC Water	Not specified	Negligible	--
Total Wholesale[4]	14.4	5.8	6.8

[1] The 1.4 MGD withdrawal is from a 1987 Agreement. Not included is a request to increase their capacity allocation by 5 MGD, but no agreement currently exists.
[2] Howard County wholesales may increase by 10 MGD by 2030, but no agreement currently exists.
[3] Emergency water connection for three and a half months (late June 2010-mid-October 2010).
[4] Not included is Anne Arundel County's request for an emergency interconnection (early 2016 request, but no formal agreement has been made). This request would be sending water outside of the Potomac Basin.

A.3.4.1 WSSC Water – Retail

WSSC Water finished drinking water is distributed to their retail customers in Prince George's and Montgomery counties. Data and calculations are reported in Table A.3-38 and Table A.3-39 below.

A.3.4.1.1 Service Area

The WSSC Water service area is updated with a new shape file (P. Flores, personal communication, July 23, 2020). Only two small adjacent areas are added in Montgomery and Prince George's counties. The transmission pipeline in southern Prince George's County is not taken into account because that pipe is built for redundancy purposes and it does not have customers attached to it.[21] The service area is based on a combination of the existing pipelines and the pressure zone boundaries of the water system. The service area excludes parts of Rockville and Bowie, which are serviced by those jurisdictions. Rockville has been reported as a separate entity. The retail service area is within the Montgomery and Prince George's county boundaries and only those TAZs are selected using the WSSC Water current service

[21] The two counties (Water Supply & Wastewater Unit, Intergovernmental Affairs Division, Montgomery Co. Dept. of Environmental Protection and Prince George's Site/Road Plan Review Division) and MNCPCC regulate the service area based on the water and sewer category maps (K. Six, personal communication, February 19, 2020). P. Flores from WSSC Water provided the final shape files.

area. Other jurisdictions including Charles, District of Columbia, Howard, and Anne Arundel are also included in the service area TAZ selection. However, these other jurisdictions make up about 3% of the service area and are not included in the TAZ analysis.

A.3.4.1.2 Demographic Data

POP, HH, and EMP data are interpolated between the years 2010 and 2045 using MWCOG Round 8.4 and Round 9.1 forecasts. Demographic data is divided into SFH and MFH estimates using DURs that are calculated from data provided by Montgomery and Prince George's counties. Montgomery County provided SFH and MFH by TAZ from the county's submission to the MWCOG Round 9.1 forecast for the five-year intervals between 2015 and 2045 (C. Blackford, personal communication, June 12, 2019). Additionally, five-year ACS data is collected for the years 2009-2019. The DURs calculated as SFH divided by MFH matched well between the county data and the five-year ACS as shown in Figure A.3-13. Therefore, a composite set of DURs is created and values are interpolated between 2015 and 2020 to better follow the trend given by Montgomery County.

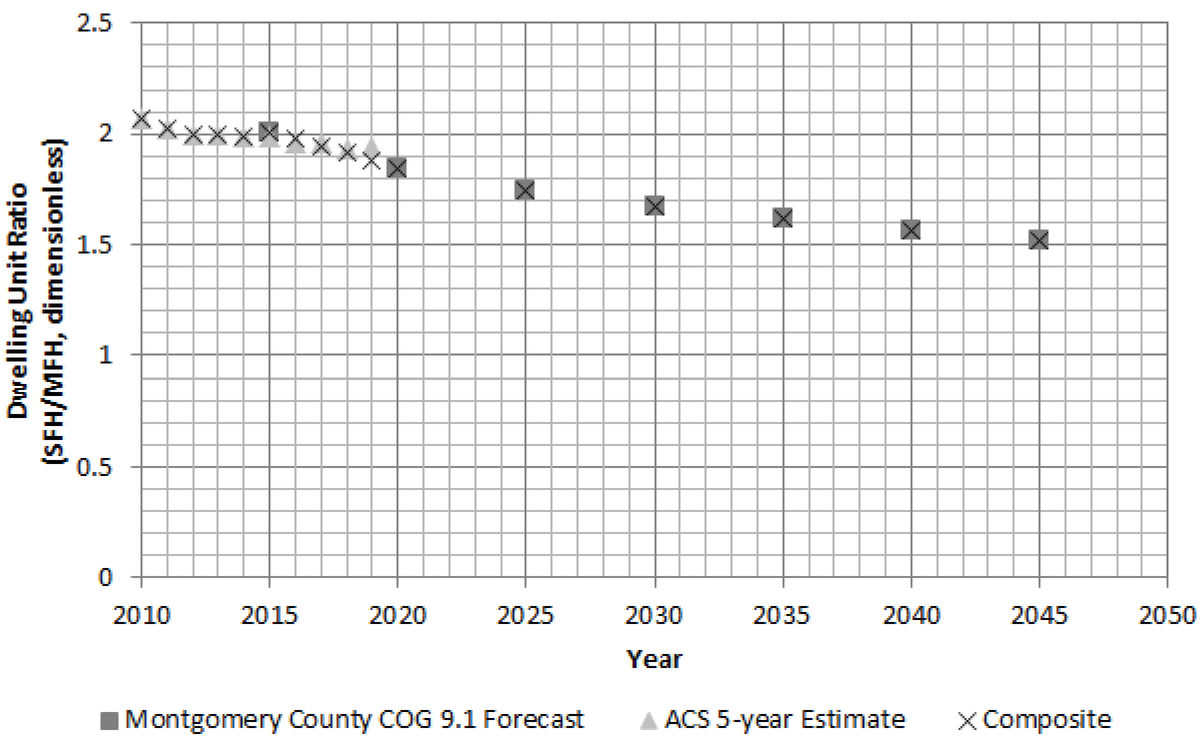

Figure A.3-13: Montgomery County dwelling unit ratio comparison for different data sets.

Prince George's County provided MWCOG Round 9.1 forecasts with a breakout between SFH and MFH units by TAZ for the five-year intervals for 2010-2045 (T. Kowaluk, personal communication, April 10, 2019). A set of vacancy rates are estimated from the provided annual housing unit and annual household data to estimate occupied households. However, because of the DUR calculation, the vacancy rate assumptions do not make a difference. Also available is the ACS five-year estimates. In general, the census data tends to underestimate the actual number of dwelling units in the county (T. Kowaluk, personal communication, April 10, 2019). As an example, in 2011 the county estimated 331,306 dwelling units from tax accessor records and the Census reported 329,855 (one-year ACS). For 2017 the county estimated 346,201 dwelling units and the Census reported 332,156 (one-year ACS). This discrepancy in county and Census data is shown in Figure A.3-14.

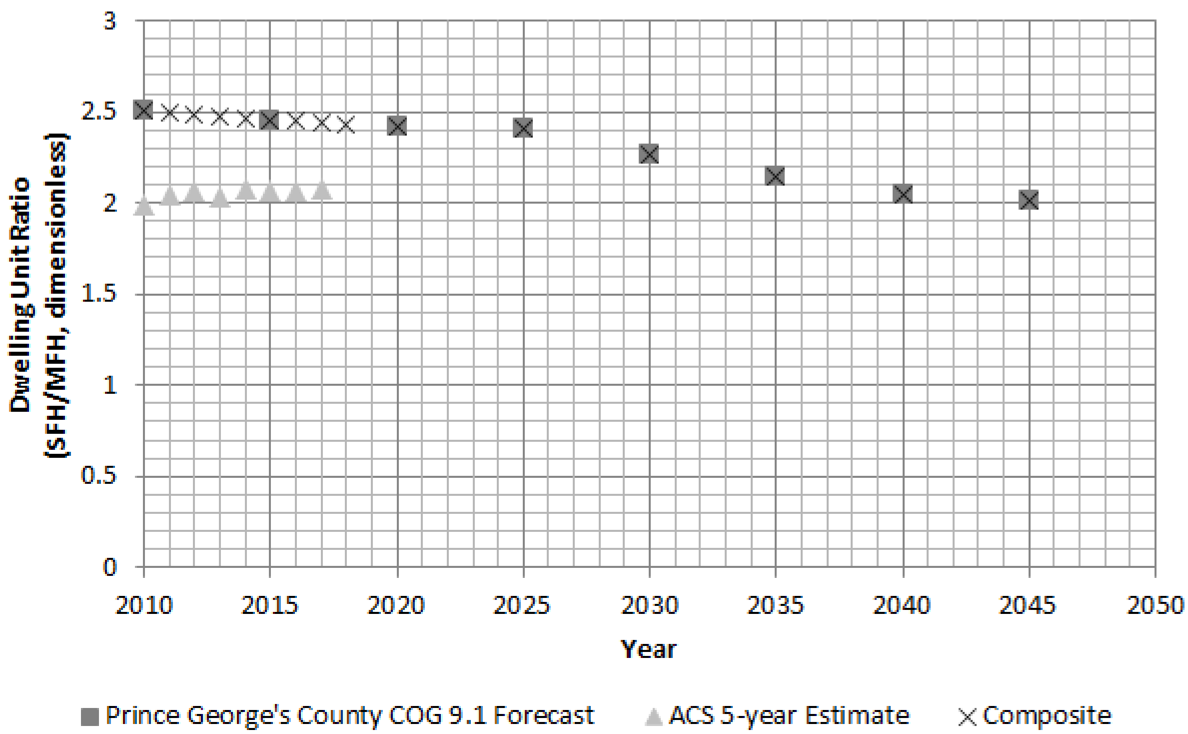

Figure A.3-14: Prince George's County dwelling unit ratio comparison for different data sets.

A.3.4.1.3 Water Use Data

The produced data for 2014-2018 by calendar year is provided by WSSC Water (T. Supple, personal communication, May 29, 2019). Years 2010-2013 are available from the 2015 study (Ahmed *et al.*).

The actual billed data details the water use for each customer account but does not contain information on the number of units served by the account. Most customers are billed quarterly. Large water users and wholesale customers are generally billed monthly. Some customers are billed semi-annually or bi-monthly. More information on the billing methods is contained in the FY*2017 Water Loss Reduction Plan* (K. Six, personal communication, March 25, 2019).

In the place of actual billing data, data from the daily average consumption (DAC) is provided as a gauge of water use for EMP, MF, SF, wholesale, and grand total (K. Six, personal communication, March 25, 2019). The DAC acts as a rolling average of water consumption by account, maintained by WSSC Water. Most WSSC Water retail customers are metered and billed on a quarterly basis. Their consumption for each billing cycle is recorded and the average daily consumption (ADC) for each account is calculated. The ADC is the current meter reading less the previous meter reading divided by the number of days between readings. The DAC is calculated as shown in Equation A-1.

$$DAC = (\text{previous } DAC + ADC)/2 \qquad \textit{Equation A-1}$$

The DAC data for years 2014-2018 is summarized by month and to calculate the annual use, an average of the DAC over 12 months is taken.

WSSC Water data also provided DAC data for the individual wholesale water customers – DC Water, City of Rockville, City of Bowie, Howard County, and Charles County. Many of WSSC Water's wholesale customers do not buy water on a regular basis. Since the DAC is a rolling average of water consumption, the DAC for wholesale customers is variable. Howard County is the only wholesale customer to purchase water on a consistent basis. Their DAC numbers most closely represent a true DAC. For the other customers, the DAC was used in conjunction with the total wholesale data provided. DAC data is not available for the City of Bowie. Charles County started making meter readings monthly in October 2009, previously meter readings were done quarterly.

WSSC Water provided the FY 2017 Water Loss Reduction Plan as submitted to the Maryland Department of the Environment (K. Six, personal communication, March 25, 2019). Since 2010, the percentage of lost water in WSSC Water's system has varied from 15.7% to 20.9%. This report says that for the fiscal year 2017, the unaccounted water losses equal 15.7%. A calculated unmetered use rate (production minus retail and wholesale sales) is used in analysis, where the average unmetered use rate over the years 2010-2018 is 17.8%.

Table A.3-38: Historic data for unit use calculations and results – WSSC Water.

			Historic Data								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
Produced (MGD)			174.92	169.36	163.87	158.63	161.65	164.89	164.68	162.80	163.05
Demand (MGD)	Retail Sales	Single Family HH	70.85	69.52	68.39	67.83	71.73	70.91	76.92	64.99	64.36
		Multi-Family HH	30.39	29.87	26.44	27.88	27.7	29.17	28.58	28.60	29.20
		Employee	30.59	31.44	35.56	32.37	32.17	35.68	34.34	33.07	32.82
	Wholesale Sales		6.69	5.67	4.43	3.39	3.06	2.9	2.9	4.4	4.4
	Unmetered		36.40	32.86	29.05	27.16	26.99	26.25	21.91	31.71	32.30
	Percent Unmetered		21%	19%	18%	17%	17%	16%	13%	19%	20%
	Total		174.92	169.36	163.87	158.63	161.65	164.89	164.68	162.80	163.05
Demographics	Population (units)		1,709,535	1,724,704	1,739,874	1,755,043	1,770,213	1,785,382	1,795,480	1,805,578	1,815,675
	Employees (units)		769,321	769,364	769,408	769,452	769,496	769,539	775,992	782,445	788,897
	Households (HH, units)		618,459	624,164	629,868	635,572	641,277	646,981	652,384	657,787	663,189
	HH - Montgomery (units)		328,039	330,650	333,261	335,872	338,483	341,094	344,024	346,954	349,883
	HH - Prince George's (units)		290,420	293,513	296,607	299,700	302,794	305,887	308,360	310,833	313,306
	DUR- Montgomery (dimensionless)		2.07	2.03	2.00	1.99	1.99	2.01	1.98	1.94	1.91
	DUR- Prince George's (dimensionless)		2.51	2.50	2.49	2.48	2.47	2.45	2.45	2.44	2.43
	Single Family HH (units)		428,754	431,000	433,713	437,195	440,749	445,111	447,394	449,624	451,799
	Multi-Family HH (units)		189,705	193,163	196,155	198,378	200,528	201,870	204,990	208,163	211,391
Unit Use (gpd/unit)	Single Family HH		165.2	161.3	157.7	155.1	162.7	159.3	171.9	144.5	142.5
	Multi-Family HH		160.2	154.6	134.8	140.5	138.1	144.5	139.4	137.4	138.1
	Employee		39.8	40.9	46.2	42.1	41.8	46.4	44.3	42.3	41.6

Table A.3-39: Forecast data for unit use calculations and results – WSSC Water.

			Forecast Data							
			2018	2020	2025	2030	2035	2040	2045	2050
Produced (MGD)			164.59	166.65	166.24	168.75	171.11	173.88	176.80	179.51
Demand (MGD)	Retail Sales	Single Family HH	68.02	66.88	65.10	64.59	64.48	64.45	64.87	64.85
		Multi-Family HH	28.46	28.50	28.52	29.70	30.83	32.08	33.07	34.30
		Employee	34.39	34.79	36.21	37.61	38.53	39.59	40.58	41.60
	Wholesale Sales		4.4	6.8	6.8	6.8	6.8	6.8	6.8	6.8
	Unmetered		29.31	29.68	29.60	30.05	30.47	30.96	31.48	31.97
	Percent Unmetered		17.8%	17.8%	17.8%	17.8%	17.8%	17.8%	17.8%	17.8%
	Total		164.59	166.65	166.24	168.75	171.11	173.88	176.80	179.51
Demographics	Population (units)		1,815,675	1,835,870	1,879,743	1,930,457	1,976,873	2,016,316	2,051,587	2,089,640
	Employees (units)		788,897	801,802	846,196	884,997	913,028	942,700	970,923	1,000,113
	Households (HH, units)		663,189	673,995	695,606	721,386	741,971	759,386	775,327	792,251
	HH - Montgomery (units)		349,883	355,743	368,241	382,518	395,597	406,407	415,694	425,996
	HH - Prince George's (units)		313,306	318,252	327,365	338,868	346,374	352,979	359,634	366,255
	DUR- Montgomery (dimensionless)		1.91	1.85	1.75	1.67	1.62	1.56	1.52	1.46
	DUR- Prince George's (dimensionless)		2.43	2.42	2.41	2.26	2.15	2.05	2.01	1.94
	Single Family HH (units)		451,799	455,976	465,446	474,332	480,978	485,043	490,819	494,534
	Multi-Family HH (units)		211,391	218,019	230,160	247,054	260,993	274,343	284,509	297,716
Unit Use (gpd/unit)	Single Family HH		150.6	146.7	139.9	136.2	134.1	132.9	132.2	131.1
	Multi-Family HH		134.6	130.7	123.9	120.2	118.1	116.9	116.2	115.2
	Employee		43.6	43.4	42.8	42.5	42.2	42.0	41.8	41.6
Total estimated error (MGD)			--	23.9	24.7	26.0	27.2	28.6	30.0	31.6

A.3.4.2 Rockville – Retail and WSSC Water-Wholesale Customer

The City of Rockville's Water Treatment Plant, with a 4 MGD production capacity, began service in 1958. The plant was upgraded in 1965 to increase production to 8 MGD. In the mid-1990's additional upgrades to the plant were carried out to meet U.S. Environmental Protection Agency and Maryland Department of the Environment regulations. Since that time, an average of 5 MGD of raw (untreated) water has been withdrawn from the Potomac River, treated by the water plant, and then distributed to the City's water customers.

The city serves 70% of the city, while the WSSC Water serves the remainder of the city. When Rockville's water plant is not operating because of necessary improvements or maintenance activities, or in cases of regional drought, Rockville purchases water from the WSSC Water. In 2018, Rockville purchased about 188 MG of water (approximately 11% of their annual production) from WSSC Water.

Data and calculations are reported in Table A.3-40 and Table A.3-41 below.

A.3.4.2.1 Service Area

No change is made to the service area from the 2015 study (Ahmed *et al.*). However, some adjustments to the TAZ area ratios are made to account for gaps and overlaps in the city's service area and the WSSC Water service area. Overlapping service areas are assumed to be served by WSSC Water. Areas not included in either the City of Rockville or the WSSC Water service areas are assumed to be served by the city.

A.3.4.2.2 Demographic Data

POP, HH, and EMP data are interpolated between the years 2010 and 2045 using MWCOG Round 8.4 and Round 9.1 forecasts. Demographic data is divided into SFH and MFH estimates using DURs. The DURs are calculated from jurisdictional data. Principal Planner for The Department of Planning and Development Services (PDS) for the City of Rockville provided Round 9.1 city SFH and MFH data for forecast years 2015-2045 (M. Tewari, personal communication, April 30, 2019). The data includes assumptions on vacancy rates, and therefore the occupied household totals are used as provided. The DUR value for 2010 is calculated from five-year ACS data. Linear interpolation is done between 2010 (ACS data) and 2015 (Round 9.1 data) occupied households prior to calculating DUR values for missing historical years (Figure A.3-15).

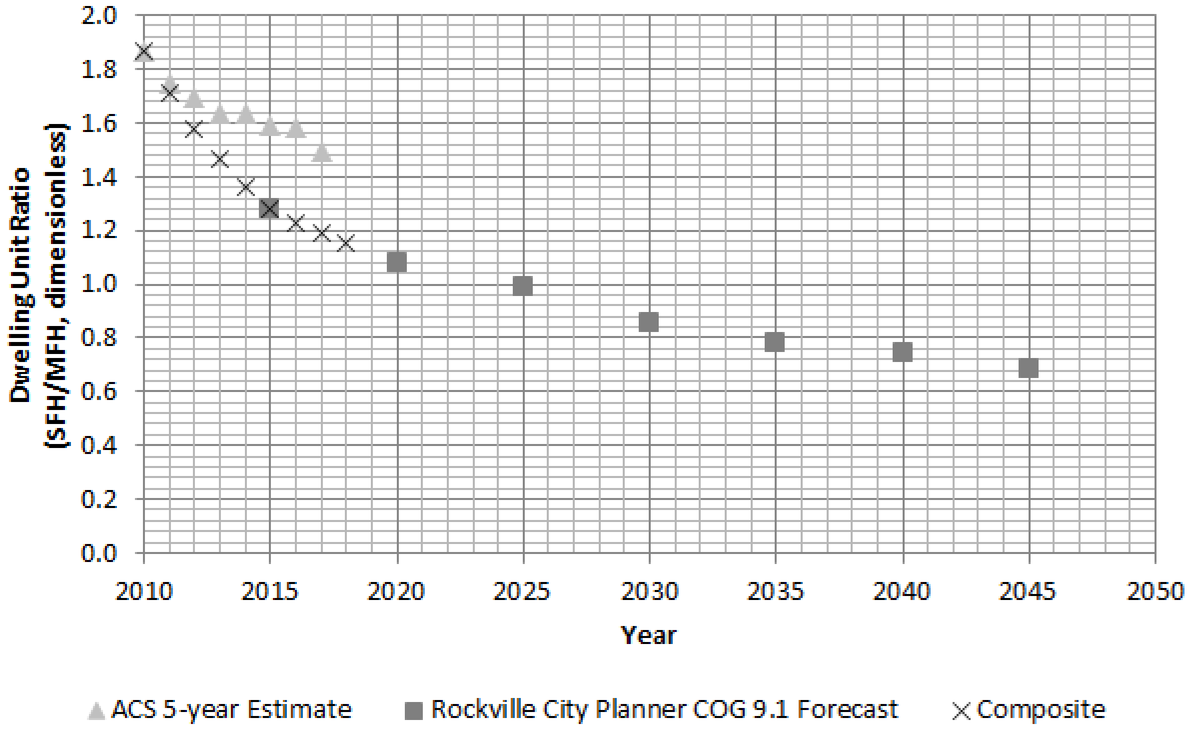

Figure A.3-15: The City of Rockville's dwelling unit ratio comparison for different data sets.

A.3.4.2.3 Water Use Data

Data on total water produced, purchased, and billed to customers is provided by the City of Rockville by calendar year 2010-2018 (I. Lish, personal communication, May 29, 2019). A set of Water Audit Reports for 2010-2018 are also included, which report on the amount produced and the water loss amount (equal to unbilled/unmetered authorized consumption, water meter malfunction, theft, main breaks, storage overflow, other). There are metering inaccuracy adjustments made to 2011 and 2012 production data and so some of the numbers did not match earlier files (I. Lish, personal communication, May 30, 2019).

Rockville's billed data are reported in the following categories:

- Residential (account type 01): single family households
- Commercial (account type 02): business as well as apartments and condos
- Tax exempt (account type 03): church, schools, and government buildings

The categories are grouped into the three categories needed for this study as follows:

- SFH: residential
- MFH_EMP: commercial and tax exempt

The estimated percent water loss provided by the City of Rockville and reported in the Water Audit Reports did not follow the same unmetered use assumptions used in this study (see Water Audit Worksheet for Treated Water—CY 2017 for the City of Rockville's calculation methods) and therefore is not used. Instead, the unmetered water use is estimated from the distributed water amount minus the billed amount. In this case the distributed water amount is the Rockville produced water plus the WSSC Water purchased water. For forecast years 2020-2045, an unmetered water use of 14% is assumed based on the average of calculated historical values.

Unit use rates for MFH are assumed to equal a 10% reduction in the unit uses rates for SFH. MFH billed amounts are then back-calculated by taking the product of the unit use rates for MFHs and the number of MFHs in Rockville to get the total MFH billed amount for each year. The EMP billed amount is then estimated by subtracting the sum of the SFH and MFH billed amounts, plus the unmetered water amount assumption. The unit use rate for employees is then estimated by taking the calculated EMP billed amount divided by the number of EMPs. Although there may be some inaccuracies in the MFH and EMP billed amounts, the total billed amount by use is maintained.

Table A.3-40: Historic data for unit use calculations and results – Rockville - Retail and WSSC Water-Wholesale Customer.

			Historic Data								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
Produced (MGD)			3.48	4.65	4.87	4.48	4.59	4.71	4.61	4.48	4.03
Purchased (MGD)			1.56	0.01	0.12	0.08	0.01	0.00	0.16	0.10	0.51
Demand (MGD)	Retail Sales	Single Family Household	1.91	1.89	1.80	1.80	1.70	1.73	1.67	1.63	1.61
		Multi-Family Household	0.92	1.00	1.03	1.11	1.12	1.22	1.22	1.23	1.26
		Employee	1.49	1.53	1.41	1.14	1.03	1.05	0.96	0.90	0.92
	Unmetered		0.72	0.24	0.75	0.51	0.74	0.71	0.92	0.81	0.75
	Percent Unmetered		14%	5%	15%	11%	16%	15%	19%	18%	17%
	Total		5.04	4.66	4.99	4.56	4.60	4.71	4.77	4.57	4.54
Demographics	Population (units)		46,749	47,355	47,961	48,567	49,173	49,779	50,465	51,151	51,837
	Employees (units)		60,262	61,019	61,776	62,534	63,291	64,048	64,301	64,554	64,807
	Households (units)		19,154	19,236	19,317	19,398	19,479	19,560	19,857	20,153	20,449
	DUR (dimensionless)		1.87	1.71	1.58	1.46	1.36	1.28	1.23	1.19	1.15
	Single Family Households (units)		12,470	12,136	11,819	11,520	11,236	10,967	10,955	10,944	10,934
	Multi-Family Households (units)		6,684	7,100	7,497	7,878	8,243	8,593	8,901	9,208	9,515
Unit Use (gpd/unit)	Single Family Household		153.2	155.7	152.3	156.2	151.3	157.7	152.4	148.9	147.2
	Multi-Family Household		137.8	140.2	137.1	140.6	136.2	142.0	137.2	134.0	132.5
	Employee		24.7	25.2	22.9	18.3	16.3	16.4	14.9	13.9	14.2

Note: Produced values for 2011 and 2012 are adjusted for metering errors (I. Lish, personal communication, May 30, 2019); Multi-family household retail sales are calculated from the assumption that multi-family unit use is equal to 90% of single-family household unit use; Employee retail sales are calculated as the difference between the amount distributed (produced plus purchased) and the sum of single family, multi-family, and unmetered use; The percent unmetered use is calculated from the percent difference between the amount distributed (produced plus purchased) and the amount billed (single family, multi-family, and employee retail demands).

Table A.3-41: Forecast data for unit use calculations and results – Rockville - Retail and WSSC Water-Wholesale Customer.

			Forecast Data							
			2018	2020	2025	2030	2035	2040	2045	2050
Produced (MGD)			4.35	4.34	4.36	4.52	4.69	4.93	5.14	5.35
Demand (MGD)	Retail Sales	Single Family Household	1.64	1.59	1.55	1.52	1.51	1.54	1.54	1.55
		Multi-Family Household	1.28	1.33	1.41	1.58	1.71	1.84	1.99	2.14
		Employee	0.80	0.79	0.77	0.77	0.79	0.82	0.85	0.88
	Unmetered		0.63	0.63	0.63	0.66	0.68	0.71	0.74	0.78
	Percent Unmetered		14%	14%	14%	14%	14%	14%	14%	14%
	Total		4.35	4.34	4.36	4.52	4.69	4.93	5.14	5.35
Demographics	Population (units)		51,837	53,208	57,110	60,901	63,929	67,611	70,707	74,194
	Employees (units)		64,807	65,314	66,719	68,684	72,735	77,019	81,339	85,635
	Households (units)		20,449	21,041	22,488	24,299	25,742	27,398	28,837	30,420
	DUR (dimensionless)		1.15	1.08	0.99	0.85	0.78	0.74	0.69	0.64
	Single Family Households (units)		10,934	10,917	11,165	11,190	11,308	11,674	11,737	11,876
	Multi-Family Households (units)		9,515	10,125	11,324	13,108	14,435	15,724	17,100	18,544
Unit Use (gpd/unit)	Single Family Household		150.0	146.1	139.3	135.6	133.5	132.3	131.6	130.5
	Multi-Family Household		135.0	131.1	124.3	120.6	118.5	117.3	116.6	115.5
	Employee		12.3	12.1	11.5	11.2	10.9	10.7	10.5	10.3
Total estimated error (MGD)			--	1.3	1.4	1.4	1.5	1.6	1.7	1.8

A.3.5 Independent Forecast Comparison

The annual demand forecasts presented in Chapter 3 follow a systemwide methodology for projecting future water demands for the aggregate WMA region. While some suppliers included in this study create independent demand forecasts for multiple purposes (e.g., infrastructure planning, finance budgeting, or supply planning) they often use varying data sources and methodologies that are not always comparable with those of other WMA suppliers. This section outlines some differences between the annual demand forecast presented in Section 3.6 and the annual demand forecasts created by the suppliers themselves.

WSSC Water, through its Planning Group, generates their own water production projections every five years. The last water production projection report was completed in 2016 (Carpio, 2015) and informs the Montgomery County 2018-2027 Comprehensive Water Supply and Sewerage System Plan (MCDEP, 2018) and the Prince George's County 2018 Water & Sewer Plan (PGDPIE, 2019), all of which are publicly available online. These water use forecasts are reviewed and found to differ both in data and methodologies from the forecast in the current study, as detailed in Table A.3-42.

Table A.3-42: Comparison of methodologies for 2016 WSSC Water Production Projections (Carpio, 2016) versus ICPRB's 2020 study annual average demand forecasts.

Forecast Component	ICPRB	WSSC Water Planning Group
Demographic Projections	MWCOG Round 9.1	MWCOG Round 8.0/8.1 blend
Single Family and Multi-Family Households	Included all existing households; Used Montgomery and Prince George's County jurisdictional data to estimate dwelling unit ratios to disaggregate total households.	Limited to newer households (post-1993); Used an older MWCOG forecast because the household disaggregation step was already done.
Daily Average Consumption	2010-2018 period	2005-2015 period
Baseline Unit Use Rate	Used a 2018 estimate from a linear trendline analysis through the 2010-2018 historic rates	Used the 2010 historic rate because it is almost identical to the 50th percentile of the 2005-2015 rates
Water Use Savings	High, Mid-range, and Low scenarios all assume a reduction in unit use rates, with differences in showers, toilet, and faucet use assumptions (Section 3.3.2 and Appendix A.3.1.5)	High: 0 savings; Mid-Range: decrease following three-year trend rate; Low: equivalent to ICPRB 2015 study.
Wholesale Projections	6.8 MGD for Charles and Howard Counties	6.8 MGD for Charles and Howard Counties

Figure A.3-16 compares the ICPRB and WSSC Water average annual water demands. In this figure, you can see that the ICPRB 2015 study projection for 2040 is not expected to occur until around 2050 in the current study. Both these ICPRB demand projections are lower than the WSSC High Planning Scenario and follow different trends. However, the ICPRB 2020 demand projection and the WSSC Low scenario projection match closely in 2040, with respective values of 174 MGD and 175 MGD. ICPRB demonstration (1) shows that if the ICPRB water use saving assumptions that reduce the baseline unit use rates are eliminated, the remaining ICPRB demand forecasting assumptions more closely resemble the WSSC Mid-Range forecast. To further demonstrate comparability between ICPRB and the WSSC studies, demonstration (2) tests what happens if the WSSC High unit use projection assumptions are applied to the ICPRB 2020 demographic data assumptions. The lesson is that Round 9.1 demographic forecasts are less than Round 8.0/8.1 demographic forecasts. The diverging forecasts between the WSSC High forecast and the ICPRB 2020 demonstration (2) using equivalent unit use assumptions are not unreasonable for different forecast iterations based on previous ICPRB experience demonstrated in Figure 3-9 in Section 3.6 of this report.

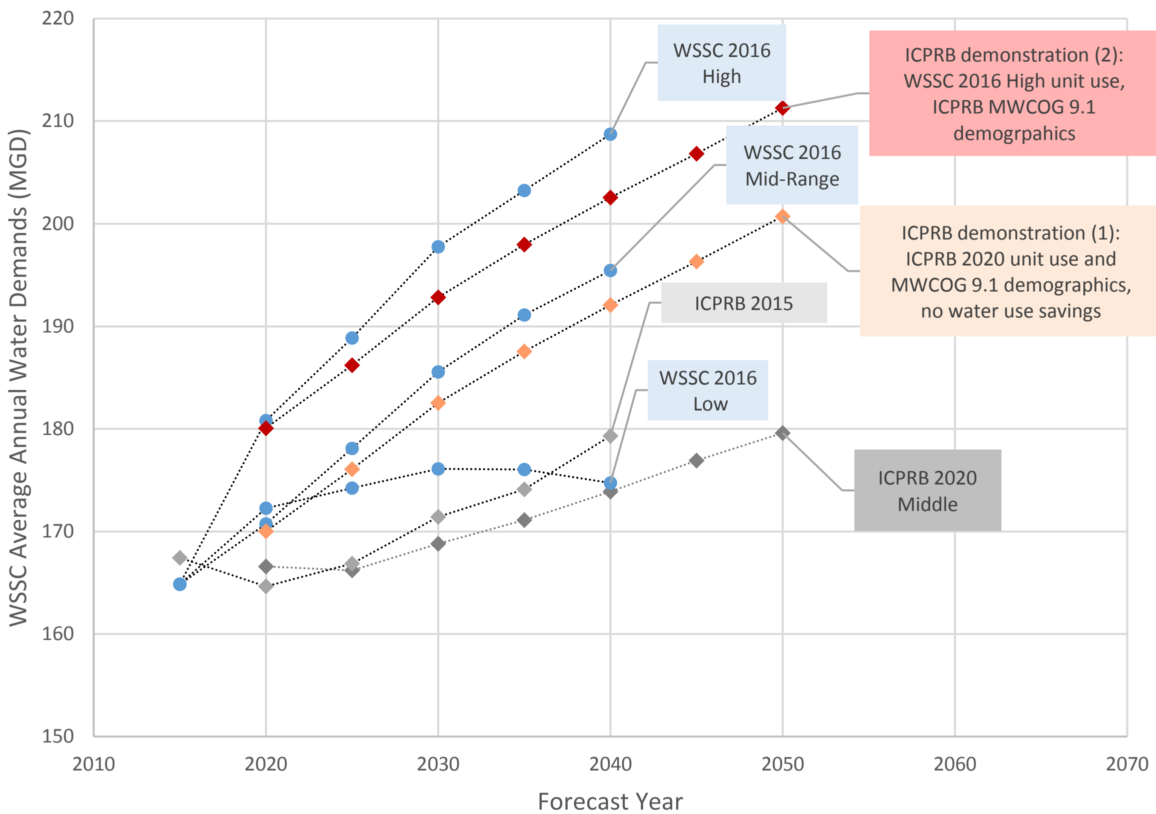

Figure A.3-16: Demonstration of differences between the 2016 Water Production Projections by WSSC (WSSC 2016) and the ICPRB 2015 and 2020 studies.

Loudoun Water uses an independent average day demand forecast created by Hazen and Sawyer for their Water Distribution System Master Plan (Hazen and Sawyer, 2018a; 2018b). Loudoun Water has refined a methodology for projecting future water demands that differs from the ICPRB as summarized in Table A.3-43. The Loudoun Water methodology was selected by their Hazen and Sawyer consultants to ensure adequate system capacity for the growth allowed in Loudoun County's Comprehensive Plan, and their water demand projections provide some planning buffer to ensure they do not underestimate needed infrastructure.

Table A.3-43: Comparison of methodologies Loudoun Water 2018 Water Distribution System Master Plan by Hazen and Sawyer versus ICPRB 2020 study annual average demand forecasts.

Forecast Component	ICPRB	Loudoun Water
Demographic Projections	MWCOG Round 9.1 with Loudoun Water estimated TAZ ratios	MWCOG Round 9.0 with Loudoun Water estimated TAZ ratios
Units	Used single family and multi-family households, and employee population (decreased approximately 1% from Round 9.0)	Used residential population and employee population (increased approximately 2% in Round 9.1)
Billing data	2010 through 2018	2015, 2016
Baseline Unit Use Rate	Used a 2018 estimate from a linear trendline analysis through the 2010-2018 historic rates, scale of analysis is average service area	Used 2015 and 2016 data; included non-revenue water of 11% for the unit demands; scale of analysis was TAZ level, where they isolated TAZs almost completely residential and TAZs almost complete employee to get conservative estimates for residential and employee unit water demands, respectively
Water Use Savings	High, Mid-range, and Low scenarios all assume a reduction in unit use rates, with differences in showers, toilet, and faucet use assumptions (Section 3.3.2 and Appendix A.3.1.5)	Not considered.
Unmetered use	Assumed 10%	Calculated as 11%, and incorporating in the unit demand estimates
Growth Potential above the COG 9.0 projections	Unknown if these growth potentials are included in Round 9.1	Increased development near Silver Line Metro, Dulles Airport Property development
Emergency Water Demand	Not considered.	Town of Leesburg Emergency Water Supply, Panda Stonewall Facility Emergency Supply, Reclaimed Water System Outage, Town of Herndon Emergency Supply, Prince William County Service Authority Emergency Supply

The ICPRB Loudoun Water forecast for average annual water demand is less than Loudoun Water's forecast from their Water Distribution System Master Plan (Hazen and Sawyer, 2018). It was considered that Loudoun Water's efforts to increase the size of their service area and the allowed development density could have caused this difference. An update to Loudoun County's Comprehensive Plan was completed in June 2019. As a result, Loudoun Water's service area increased, and increased development densities were approved. These changes are not captured in MWCOG Round 9.1 (P. Kenel, personal communication, July 7, 2020; D. Geldert, personal communication July 14, 2020). This is true, but the TAZ ratios used by ICPRB are provided by Loudoun Water (D. Geldert, personal communication, December 18, 2019) to convert the Round 9.1 projections to the existing service area and are able to replicate the demographic data provided in Table 3-2 in the Master Plan (Hazen and Sawyer, 2018). One major difference that creates the lower demand is the fact that ICPRB methods use average systemwide unit water demand estimates rather than evaluating the variations within the traffic analysis zones. For example, when Hazen and Sawyer looked at systemwide demands they reported an approximate residential unit demand of 60 gpd/unit and an approximate employee unit demand of 50 gpd/unit. In

Figure A.3-17, ICPRB demonstration (1) shows that a systemwide unit water demand assumption used with Loudoun Water data inputs produces a lower Loudoun Water demand forecast that is closer to that reported in this study. Demonstration (1) is calculated using all Loudoun Water data summarized in their input for systemwide unit water demands, multiplied by Round 9.0 residential and employee population numbers, and adjusted by a non-revenue water factor. A second major difference is that Loudoun Water does not consider water use savings and when ICPRB assumes a constant baseline unit use rate the ICPRB forecast becomes more like the Loudoun Water forecast as shown in ICPRB demonstration (2). A third major difference is the baseline unit use selection process. ICPRB looked at trends between 2010 and 2018 and then estimates a 2018 trendline adjusted unit water demands. Loudoun Water only looked at 2015 and 2016. ICPRB demonstration (3) shows that when the ICPRB method is modified using average 2015 and 2016 unit water demands and no water use savings, the forecast begins to line up with the lower systemwide Loudoun Water Forecast in ICPRB demonstration (1). Finally, the water demand unit type is shown in ICPRB demonstration (4) to not contribute to differences in the average water demand forecast, which uses ICPRB calculated unit water demands in residential and employee populations units instead of single family, multi-family households, and employee population.

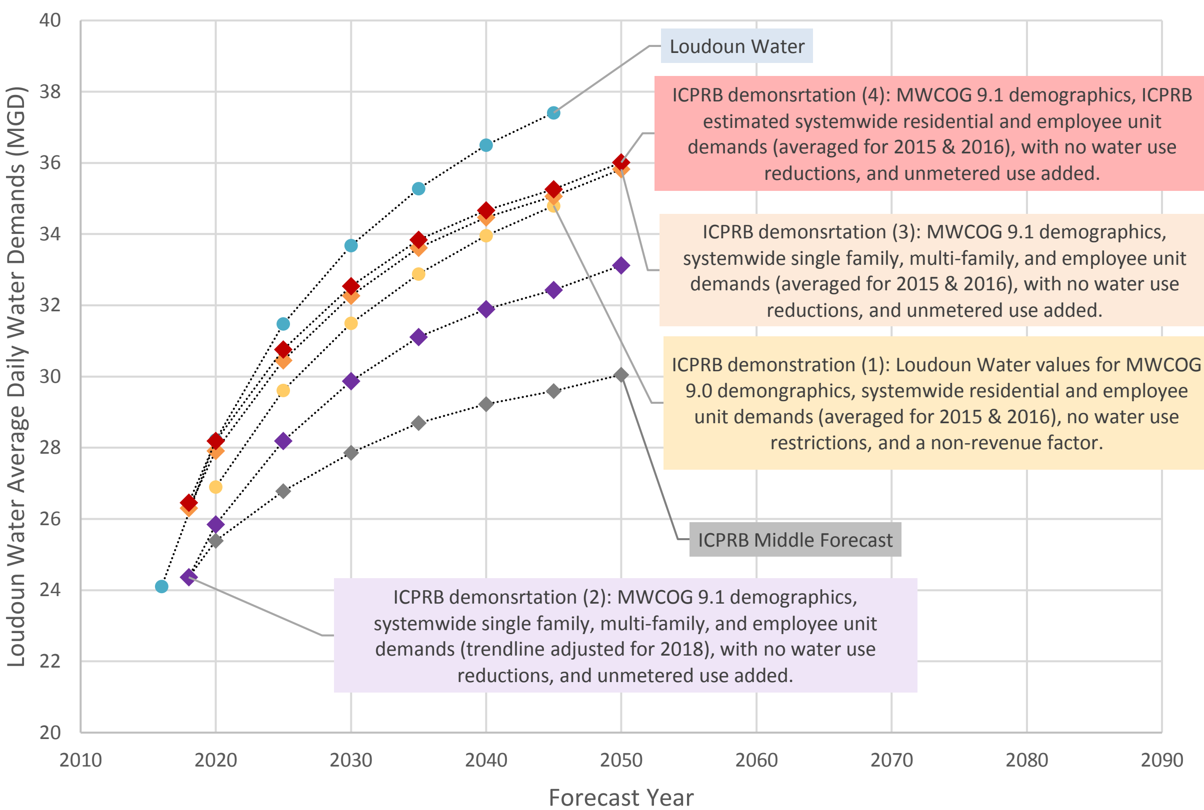

Figure A.3-17: Demonstration of differences between the 2018 Water Distribution System Master Plan by Hazen and Sayer for Loudoun Water and the ICPRB 2015 and 2020 studies.

An additional area that may affect future correlation of water demand and finished water production is Loudoun Water's non-potable reclaimed water system (P. Kenel, personal communication, July 7, 2020).

ICPRB's long-term water demand forecasts for commercial and industrial uses assume potable water supply. Over the last five years, the expansion of the data center segment in Loudoun County has resulted in many connections to the reclaimed water system, although some customers have selected potable water supply for their cooling needs. In 2019, Loudoun Water served an annual average of 1.75 MGD of reclaimed water to industrial and commercial customers representing 7% of total water supplied to Loudoun Water customers.

A Washington Aqueduct and Fairfax Water comparison with ICPRB demand forecasts is not provided in this section. Washington Aqueduct relies on the ICPRB water demands forecasts and does not conduct their own independent forecasts. Fairfax Water produces independent demand forecasts for internal use. Like WSSC Water and the ICPRB studies, Fairfax Water forecasts water demands for infrastructure planning using historical unit use rates and MWCOG household and employment forecasts.

This review of individual supplier demand forecasts shows the similarities and differences between supplier forecasts and the forecasts in the current study. The current study uses the same demographic forecasts (MWCOG 9.1) for all suppliers. It also applies the same future water use savings estimates to all suppliers, based on ICPRB's regional end use efficiency model. The current study makes use of billing data at the service area level because ICPRB does not have access to TAZ level billing data for all retail and wholesale customers in the WMA, and thus some of the variations accounted for in individual supplier service areas cannot be incorporated in detail by this study. Finally, the unit demand estimates for this study are based on trends in the most recent historical data. In contrast, the individual suppliers may select specific historical years to represent future unit demands. By applying the same methodology to all WMA suppliers, the current study produces a consistent set of forecasts for use in the PRRISM evaluations of future system reliability.

A.4 Climate Models and Runs Used

The 231 bias corrected and spatially downscaled (BCSD) climate projections used in this study, from the Coupled Model Intercomparison Project Phase 5 (CMIP5) multi-model ensemble,[22] are derived from 36 global climate models (GCMs) constructed by 22 climate modeling groups from around the world. Table A.4-1 shows the number of runs in the BSCD ensemble that were available for the Potomac River drainage area about Little Falls, by GCMs and RCP. In cases where there are multiple runs available for a given GCM and RCP, each run is associated with a different set of initial climate conditions.

Table A.4-1: Number of BCSD projections, by GCM and RCP, available for the Potomac basin above Little Falls.

WCRP CMIP5 Climate Modeling Group	WCRP CMIP5 Climate Model ID	RCP 2.6 runs	RCP 4.5 runs	RCP 6.0 runs	RCP 8.5 runs
Commonwealth Scientific and Industrial Research Organization and Bureau of Meteorology, Australia	ACCESS1-0	--	1	--	1
	ACCESS1-3	--	1	--	1
Beijing Climate Center, China Meteorological Administration	BCC-CSM1-1	1	1	1	1
	BCC-CSM1-1-M	--	1	--	1
Canadian Centre for Climate Modelling and Analysis	CanESM2	5	5	--	5
National Center for Atmospheric Research	CCSM4	5	5	5	5
Community Earth System Model Contributors	CESM1-BGC	--	1	--	1
	CESM1-CAM5	3	3	2	3
Centro Euro-Mediterraneo per I Cambiamenti Climatici	CMCC-CM	--	1	--	1
Centre National de Recherches Météorologiques/ Centre Européen de Recherche et Formation Avancée en Calcul Scientifique	CNRM-CM5	--	1	--	5
Commonwealth Scientific and Industrial Research Organization, Queensland Climate Change Centre of Excellence	CSIRO-Mk3-6-0	10	10	10	10
EC-Earth consortium, representing 22 academic institutions and meteorological services from 10 countries in Europe	EC-EARTH	2	3	--	3

[22] Downscaled CMIP3 and CMIP5 Climate Projections: Release of Downscaled CMIP5 Climate Projections, Comparison with Preceding Information, and Summary of User Needs. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado, 116 p., available at: http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/techmemo/downscaled_climate.pdf.

WCRP CMIP5 Climate Modeling Group	WCRP CMIP5 Climate Model ID	RCP 2.6 runs	RCP 4.5 runs	RCP 6.0 runs	RCP 8.5 runs
Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics, Institute of Atmospheric Physics, Chinese Academy of Sciences, and Center for Earth System Science, Tsinghua University	FGOALS-g2	1	1	--	1
Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics, Institute of Atmospheric Physics, Chinese Academy of Sciences	FGOALS-s2	--	1	--	2
The First Institute of Oceanography, State Oceanic Administration, China	FIO-ESM	3	3	3	3
NOAA Geophysical Fluid Dynamics Laboratory	GFDL-CM3	1	1	1	1
	GFDL-ESM2G	1	1	1	1
	GFDL-ESM2M	1	1	1	1
NASA Goddard Institute for Space Studies	GISS-E2-H-CC	--	1	--	--
	GISS-E2-R	1	5	1	1
	GISS-E2-R-CC	--	1	--	--
Met Office Hadley Centre (additional HadGEM2 ES realizations contributed by Instituto Nacional de Pesquisas Espaciais)	HadGEM2-AO	1	1	1	1
	HadGEM2-CC	--	1	--	1
	HadGEM2-ES	4	4	4	4
Institute for Numerical Mathematics	INM-CM4	--	1	--	1
Institut Pierre-Simon Laplace	IPSL-CM5A-LR	3	4	1	4
	IPSL-CM5A-MR	1	1	1	1
	IPSL-CM5B-LR	--	1	--	1
Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies	MIROC-ESM	1	1	1	1
	MIROC-ESM-CHEM	1	1	1	1
Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	MIROC5	1	1	1	1
Max-Planck-Institut für Meteorologie (Max Planck Institute for Meteorology)	MPI-ESM-LR	3	3	--	3
	MPI-ESM-MR	1	1	--	1
Meteorological Research Institute	MRI-CGCM3	1	1	--	1
Norwegian Climate Centre	NorESM1-M	1	1	1	1
	NorESM1-ME	1	1	1	1

A.5 PRRISM Simulation Output

A.5.1 Overview and Measures of Performance (Metrics)

Each PRRISM run simulates daily flows, demands, and system operations over an 80-year period (October 1, 1929 through December 31, 2009). As discussed in Chapter 4, the simulated water supply demands include a randomly generated component of demand; therefore, each model run is based on a slightly different time series of daily WMA demands. These demand time series represent the potential variation of demand for a given set of meteorological conditions, incorporating the randomness inherent in the original demand data set. (Section 4.6 and Section 4.7 provide more detail on the random component of demand.) Since demands and corresponding results are slightly different in each PRRISM simulation, the model is run 100 times and results are represented in terms of the average over the 100 runs. PRRISM output metrics are described as follows:

- Percentage years with no Potomac deficits: reports the percentage of years in the simulation period in which flow in the Potomac River at Little Falls is above 100 MGD (the Little Falls flow-by) on every day of the year, that is, in which combined WMA Potomac water supply needs and the environmental flow-by at Little Falls is always met.
- Maximum number of days in a row of Potomac deficits: reports a maximum number of consecutive days over the 80-year period in which combined WMA Potomac water supply needs and the environmental flow-by at Little Falls cannot be met (that is, a Potomac shortfall exists).
- Number of days in which Potomac deficits must be allocated: reports the total number of days over the 80-year period in which combined WMA Potomac water supply needs and the environmental flow-by at Little Falls cannot be met (that is, a Potomac shortfall exists).
- Maximum amount of deficit allocated in a single day, MGD: reports the maximum amount by which combined WMA Potomac water supply needs and the environmental flow-by at Little Falls is not met (maximum Potomac shortfall) for any single day over the simulation period.
- Total amount of deficit allocated full simulation period, MG: reports the daily amount by which the combined WMA Potomac water supply needs and the environmental flow-by at Little Falls is not met (or daily Potomac shortfall), summed over the course of the entire 80-year period.
- Number of Patuxent water supply shortfalls over simulation period: reports the total number of days over the 80-year period with zero storage and/or the total number of days where the Patuxent release is below the emergency storage request of 20 MGD (or 0 MGD if Travilah Quarry is available).
- Number of Occoquan water supply shortfalls over simulation period: reports the total number of days over the 80-year period where the Occoquan release is below the minimum demand of 43 MGD for Occoquan's service area.
- Number of days in which Patuxent plant production is less than 30 MGD: reports the total number of days over the 80-year period that the Patuxent plant must be shut down to reduce its withdrawal amount.
- Percentage of years with restrictions: reports the percentage of years over the 80-year period during which either voluntary and/or emergency water use restrictions are implemented. For single year runs this is reported as percentage of days.

- Minimum reservoir storage, BG: reports the single-day lowest usable water volume identified over the 80-year period for each individual reservoir (*i.e.*, Little Seneca Reservoir, Jennings Randolph water supply account, Jennings Randolph water quality account, Patuxent Reservoir, Occoquan Reservoir, Savage Reservoir, Milestone Reservoir, Luck Stone (Quarry B), Vulcan Quarry, Travilah Quarry, or Beaverdam Reservoir).
- Little Seneca Reservoir and Jennings Randolph water supply account (combined), BG: reports the single-day minimum usable water volume of the combined water supply storage in the two shared reservoirs.
- Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply (combined), BG: reports the single-day minimum usable water volume of the combined water supply storage in both the shared reservoirs and water supplier owned off-Potomac reservoirs.
- Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply (combined), BG: reports the single-day minimum usable water volume of the combined water supply storage in both the shared reservoirs, water supplier owned off-Potomac reservoirs, Loudoun Water owned reservoirs, and additional alternative resources.
- WMA average annual demand, no restrictions, with climate change impact, MGD: reports the sum of the daily demand for a specific forecast year (e.g., 2040 or 2050) for Fairfax Water, Washington Aqueduct, WSSC Water, Rockville, and Loudoun Water accumulated over the simulation period, and divided by the number of simulation days; this annual average demand total is modified by the daily demand variation model and is influenced by temperature and precipitation inputs; this annual average demand total is unmodified by a percent reductions in water use due to restriction status.
- WMA July average demand, no restrictions, with climate change impact, MGD: reports the sum of the daily demand for a specific forecast year (e.g., 2040 or 2050) for Fairfax Water, Washington Aqueduct, WSSC Water, Rockville, and Loudoun Water accumulated over the month of July, and divided by the number of simulation days in July; this monthly average demand total is modified by the daily demand variation model and is influenced by temperature and precipitation inputs; this monthly demand total is unmodified by a percent reductions in water use due to restriction status.
- WMA average annual demand, no restrictions, no climate change impact, MGD: reports the sum of the average annual demand for a specific forecast year (e.g., 2040 or 2050) for Fairfax Water, Washington Aqueduct, WSSC Water, Rockville, and Loudoun Water; this annual average demand total is unmodified by daily variation based on climate inputs, or percent reductions in water use due to restriction status.
- WMA July average demand, no restrictions, no climate change impact, MGD: reports the sum of the average annual demand for a specific forecast year (e.g., 2040 or 2050) for Fairfax Water, Washington Aqueduct, WSSC Water, Rockville, and Loudoun Water, where each supplier's annual average demand is multiplied by its respective July monthly factor in order estimate the monthly average demand; this July average demand total is unmodified by daily variation based on climate inputs, or percent reductions in water use due to restriction status.
- Minimum average natural flow late summer, MGD: reports the minimum average flow for July and August over the 80-year period, and is the flow that would have occurred without upstream

reservoir releases, return flows from CO-OP supplier wastewater treatment plants, or WMA withdrawals.

- Minimum average natural flow fall, MGD: reports the same flow as described above, but averaged over the months of September, October, and November.
- Minimum average late summer flow downstream of intakes, MGD: reports the minimum average of flow downstream of the water supply intakes in July and August over the 80-year period and represents the simulated flow after all upstream augmentation, withdrawals, and consumptive use.
- Minimum average fall flow downstream of intakes, MGD: reports the same flow as described above, but averaged over the months of September, October, and November.
- System mass balance, MGD: reports a zero if all system components are simulating correctly.
- Number of years where reservoirs refill to 90% full by June 1 (percent probability): reports the number of years accumulated over the 80-year period, where the current usable storage is above 90% of the storage capacity by June 1 for each individual reservoir (i.e., Little Seneca Reservoir, Jennings Randolph water supply account, Jennings Randolph water quality account, Patuxent Reservoir, Occoquan Reservoir, Savage Reservoir); the percent probability is the number of years where this storage volume criteria is met divided by the total number of simulation years times a hundred.

A.5.2 Result Tables

Table A.5-1: 2040 Baseline: Higher Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	60	0	1
Number of Occoquan water supply shortfalls over simulation period	594	6	7
Number of days in which Patuxent plant production is less than 30 MGD	4,064	199	309
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.10%	0.70%	0.03%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.29	2.61	2.33
Jennings Randolph water supply account	8.72	9.39	8.93
Jennings Randolph water quality account	2.87	5.28	3.49
Patuxent Reservoir	0.69	1.93	2.05
Occoquan Reservoir	2.30	3.91	3.50
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.96	0.96	0.99
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.11	0.11	0.23
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.11	1.11	1.16
Little Seneca Reservoir and Jennings Randolph water supply account, combined	11.0	12.00	11.27
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	18.1	18.32	19.17
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	20.3	20.55	21.32
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	457	448	439
WMA July demand, no restrictions, with climate change impact, MGD	554	28	27
WMA annual demand, no restrictions, without climate change impact, MGD	452	--	--
WMA July demand, no restrictions, without climate change impact, MGD	532	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	680	720	680
Minimum average natural flow fall, MGD	582	582	3,931
Minimum average late summer flow downstream of intakes, MGD	390	450	390
Minimum average fall flow downstream of intakes, MGD	322	322	3,673
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	80 (100)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	70 (87)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-2: 2040 Baseline: Higher Flows and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	0	0	--
Number of Occoquan water supply shortfalls over simulation period	7	0	0
Number of days in which Patuxent plant production is less than 30 MGD	3,285	197	349
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.04%	26.65%	4.27%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.75	1.91	1.87
Jennings Randolph water supply account	6.37	6.83	6.75
Jennings Randolph water quality account	2.87	5.37	3.49
Patuxent Reservoir	0.68	1.97	1.97
Occoquan Reservoir	1.82	3.18	3.05
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.96	0.97	0.98
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.11	1.11	1.16
Little Seneca Reservoir and Jennings Randolph water supply account, combined	8.1	8.74	8.62
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	14.2	14.26	16.15
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	16.4	16.49	18.30
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	505	492	486
WMA July demand, no restrictions, with climate change impact, MGD	611	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	501	--	--
WMA July demand, no restrictions, without climate change impact, MGD	590	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	680	720	680
Minimum average natural flow fall, MGD	582	582	3,931
Minimum average late summer flow downstream of intakes, MGD	366	427	366
Minimum average fall flow downstream of intakes, MGD	292	292	3,620
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	68 (86)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-3: 2040 Baseline: Higher Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,409	199	353
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.75%	36.29%	11.98%
Emergency restrictions	0.01%	0.13%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.10	1.26	1.39
Jennings Randolph water supply account	3.85	4.37	4.71
Jennings Randolph water quality account	2.87	5.37	3.55
Patuxent Reservoir	0.71	2.04	1.96
Occoquan Reservoir	1.60	2.69	2.87
Savage Reservoir	0.62	0.64	0.66
Milestone Reservoir	0.99	1.00	0.99
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.11	1.11	1.16
Little Seneca Reservoir and Jennings Randolph water supply account, combined	5.0	5.63	6.10
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	10.7	10.77	13.52
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	12.9	13.00	15.67
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	554	537	531
WMA July demand, no restrictions, with climate change impact, MGD	668	33	32
WMA annual demand, no restrictions, without climate change impact, MGD	550	--	--
WMA July demand, no restrictions, without climate change impact, MGD	647	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	680	720	680
Minimum average natural flow fall, MGD	583	583	3,931
Minimum average late summer flow downstream of intakes, MGD	341	408	341
Minimum average fall flow downstream of intakes, MGD	270	270	3,580
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78.99 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	68.29 (85)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-4: 2040 Baseline: Medium Flows and Low Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	90	1	1
Number of Occoquan water supply shortfalls over simulation period	619	9	8
Number of days in which Patuxent plant production is less than 30 MGD	4,756	208	352
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.54%	37.08%	4.14%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.00	1.01	1.86
Jennings Randolph water supply account	4.38	4.40	6.93
Jennings Randolph water quality account	2.85	4.78	3.42
Patuxent Reservoir	0.00	1.50	1.78
Occoquan Reservoir	2.23	3.26	3.02
Savage Reservoir	0.60	0.62	0.65
Milestone Reservoir	0.47	0.47	0.98
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.10	1.10	1.16
Little Seneca Reservoir and Jennings Randolph water supply account, combined	5.4	5.41	8.78
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	10.5	10.54	15.26
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	12.4	12.38	17.40
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	456	442	437
WMA July demand, no restrictions, with climate change impact, MGD	554	27	27
WMA annual demand, no restrictions, without climate change impact, MGD	452	--	--
WMA July demand, no restrictions, without climate change impact, MGD	532	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	576	576	608
Minimum average natural flow fall, MGD	471	471	3,541
Minimum average late summer flow downstream of intakes, MGD	349	378	349
Minimum average fall flow downstream of intakes, MGD	255	255	3,281
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	68 (84)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	79 (99)	0	1

Table A.5-5: 2040 Baseline: Medium Flows and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	30	--	0
Number of Occoquan water supply shortfalls over simulation period	9	0	0
Number of days in which Patuxent plant production is less than 30 MGD	3,668	150	356
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.76%	31.35%	13.30%
Emergency restrictions	0.85%	8.12%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.15	0.15	1.33
Jennings Randolph water supply account	1.18	1.19	4.75
Jennings Randolph water quality account	2.85	4.87	3.41
Patuxent Reservoir	0.00	1.41	1.70
Occoquan Reservoir	1.92	2.49	2.92
Savage Reservoir	0.43	0.43	0.65
Milestone Reservoir	0.54	0.54	0.98
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.10	1.10	1.16
Little Seneca Reservoir and Jennings Randolph water supply account, combined	1.3	1.34	6.08
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	5.5	5.57	12.36
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	7.5	7.51	14.51
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	505	487	487
WMA July demand, no restrictions, with climate change impact, MGD	611	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	501	--	--
WMA July demand, no restrictions, without climate change impact, MGD	590	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	576	576	608
Minimum average natural flow fall, MGD	471	471	3,541
Minimum average late summer flow downstream of intakes, MGD	317	361	317
Minimum average fall flow downstream of intakes, MGD	237	237	3,241
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	79 (99)	0	1

Table A.5-6: 2040 Baseline: Medium Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	99.68%	0.12%	0.00%
Maximum number of days in a row of Potomac deficits	0	0	--
Number of days in which Potomac deficits must be allocated	0	0	--
Maximum amount of deficit allocated in a single day, MGD	(6.9)	(7)	--
Total amount of deficit allocated full simulation period, MG	(10)	(10)	--
Number of Patuxent water supply shortfalls over simulation period	30	--	--
Number of Occoquan water supply shortfalls over simulation period	0	0	0
Number of days in which Patuxent plant production is less than 30 MGD	3,637	66	357
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	5.26%	13.83%	28.24%
Emergency restrictions	2.54%	26.89%	0.10%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	0.71
Jennings Randolph water supply account	0.01	0.01	2.47
Jennings Randolph water quality account	2.85	5.06	3.46
Patuxent Reservoir	0.00	1.06	1.70
Occoquan Reservoir	1.31	1.42	2.71
Savage Reservoir	0.27	0.27	0.65
Milestone Reservoir	0.61	0.61	0.98
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.10	1.10	1.16
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.01	3.17
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	2.9	2.92	9.48
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	4.8	4.84	11.64
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	554	533	531
WMA July demand, no restrictions, with climate change impact, MGD	668	32	32
WMA annual demand, no restrictions, without climate change impact, MGD	550	--	--
WMA July demand, no restrictions, without climate change impact, MGD	647	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	576	576	608
Minimum average natural flow fall, MGD	471	471	3,541
Minimum average late summer flow downstream of intakes, MGD	296	338	296
Minimum average fall flow downstream of intakes, MGD	203	203	3,190
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (97)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	79 (99)	0	1

Table A.5-7: 2040 Baseline: Lower Flows and Low Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	98.79%	1.28%	0.00%
Maximum number of days in a row of Potomac deficits	2	2	--
Number of days in which Potomac deficits must be allocated	5	5	--
Maximum amount of deficit allocated in a single day, MGD	(54.8)	(55)	--
Total amount of deficit allocated full simulation period, MG	(158)	(158)	--
Number of Patuxent water supply shortfalls over simulation period	141	2	1
Number of Occoquan water supply shortfalls over simulation period	615	9	6
Number of days in which Patuxent plant production is less than 30 MGD	5,229	106	365
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	5.00%	13.21%	13.42%
Emergency restrictions	2.50%	27.87%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	1.40
Jennings Randolph water supply account	0.00	0.00	5.11
Jennings Randolph water quality account	2.76	3.56	3.38
Patuxent Reservoir	0.00	0.29	1.35
Occoquan Reservoir	1.86	2.19	2.78
Savage Reservoir	0.22	0.22	0.65
Milestone Reservoir	0.17	0.17	0.97
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.10	1.10	1.16
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	6.50
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	2.8	2.81	11.20
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	4.1	4.15	13.34
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	457	439	437
WMA July demand, no restrictions, with climate change impact, MGD	554	27	27
WMA annual demand, no restrictions, without climate change impact, MGD	452	--	--
WMA July demand, no restrictions, without climate change impact, MGD	532	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	426	426	534
Minimum average natural flow fall, MGD	352	352	3,143
Minimum average late summer flow downstream of intakes, MGD	300	301	307
Minimum average fall flow downstream of intakes, MGD	174	174	2,895
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	64.75 (81)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	75 (94)	0	1

Table A.5-8: 2040 Baseline: Lower Flows and Medium Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	98.75%	6.51%	0.00%
Maximum number of days in a row of Potomac deficits	14	14	--
Number of days in which Potomac deficits must be allocated	24	24	--
Maximum amount of deficit allocated in a single day, MGD	(106.9)	(107)	--
Total amount of deficit allocated full simulation period, MG	(1,214)	(1,214)	--
Number of Patuxent water supply shortfalls over simulation period	128	22	--
Number of Occoquan water supply shortfalls over simulation period	9	1	0
Number of days in which Patuxent plant production is less than 30 MGD	4,612	139	298
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	5.83%	9.03%	30.73%
Emergency restrictions	2.53%	33.03%	0.01%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	0.70
Jennings Randolph water supply account	0.00	0.00	2.61
Jennings Randolph water quality account	2.76	3.66	3.34
Patuxent Reservoir	0.00	0.00	1.28
Occoquan Reservoir	0.71	0.75	2.69
Savage Reservoir	0.10	0.10	0.65
Milestone Reservoir	0.22	0.22	0.97
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.10	1.10	1.16
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	3.31
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.8	0.77	7.84
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	2.1	2.13	9.98
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	505	481	483
WMA July demand, no restrictions, with climate change impact, MGD	611	29	29
WMA annual demand, no restrictions, without climate change impact, MGD	501	--	--
WMA July demand, no restrictions, without climate change impact, MGD	590	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	426	426	534
Minimum average natural flow fall, MGD	352	352	3,143
Minimum average late summer flow downstream of intakes, MGD	278	281	284
Minimum average fall flow downstream of intakes, MGD	136	136	2,835
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (97)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	75 (94)	0	1

Table A.5-9: 2040 Baseline: Lower Flows and High Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	98.31%	16.38%	0.10%
Maximum number of days in a row of Potomac deficits	32	32	0
Number of days in which Potomac deficits must be allocated	60	60	0
Maximum amount of deficit allocated in a single day, MGD	(176.7)	(177)	(13)
Total amount of deficit allocated full simulation period, MG	(4,213)	(4,191)	(19)
Number of Patuxent water supply shortfalls over simulation period	144	38	--
Number of Occoquan water supply shortfalls over simulation period	35	33	0
Number of days in which Patuxent plant production is less than 30 MGD	4,571	161	109
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	8.83%	7.62%	38.48%
Emergency restrictions	3.45%	35.32%	2.37%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	0.10
Jennings Randolph water supply account	0.00	0.00	0.36
Jennings Randolph water quality account	2.76	3.78	3.43
Patuxent Reservoir	0.00	0.00	1.63
Occoquan Reservoir	0.01	0.01	2.40
Savage Reservoir	0.01	0.01	0.65
Milestone Reservoir	0.29	0.29	0.97
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.10
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.10	1.10	1.16
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	0.46
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.0	0.01	5.05
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	1.4	1.43	7.19
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	554	524	527
WMA July demand, no restrictions, with climate change impact, MGD	668	32	32
WMA annual demand, no restrictions, without climate change impact, MGD	550	--	--
WMA July demand, no restrictions, without climate change impact, MGD	647	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	426	426	534
Minimum average natural flow fall, MGD	352	352	3,143
Minimum average late summer flow downstream of intakes, MGD	259	261	268
Minimum average fall flow downstream of intakes, MGD	80	80	2,782
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	77.14 (96)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	75 (94)	0	1

Table A.5-10: 2040 Baseline + Operations (Ops): Higher Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	60	0	1
Number of Occoquan water supply shortfalls over simulation period	607	6	8
Number of days in which Patuxent plant production is less than 30 MGD	4,023	191	264
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.00%	0.00%	0.00%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.62	3.00	2.64
Jennings Randolph water supply account	10.49	10.58	11.29
Jennings Randolph water quality account	2.87	4.74	3.49
Patuxent Reservoir	0.61	1.71	2.08
Occoquan Reservoir	2.33	3.92	3.59
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.83	0.90	0.84
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.11	0.11	0.62
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.91	0.99	0.92
Little Seneca Reservoir and Jennings Randolph water supply account, combined	13.3	13.58	13.93
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	19.6	19.67	21.85
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	21.7	21.79	23.64
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	456	446	438
WMA July demand, no restrictions, with climate change impact, MGD	553	27	27
WMA annual demand, no restrictions, without climate change impact, MGD	452	--	--
WMA July demand, no restrictions, without climate change impact, MGD	532	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	680	720	680
Minimum average natural flow fall, MGD	581	581	3,930
Minimum average late summer flow downstream of intakes, MGD	377	442	377
Minimum average fall flow downstream of intakes, MGD	323	323	3,681
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	80 (100)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	70 (88)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-11: 2040 Baseline + Operations (Ops): Higher Flows and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	0	--	--
Number of Occoquan water supply shortfalls over simulation period	6	0	0
Number of days in which Patuxent plant production is less than 30 MGD	3,161	195	325
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.24%	3.32%	0.02%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.19	2.40	2.24
Jennings Randolph water supply account	8.33	8.37	9.39
Jennings Randolph water quality account	2.87	5.37	3.49
Patuxent Reservoir	0.65	1.90	1.96
Occoquan Reservoir	1.82	3.08	3.19
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.81	0.91	0.81
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.19
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.73	0.79	0.76
Little Seneca Reservoir and Jennings Randolph water supply account, combined	10.6	10.78	11.62
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	16.1	16.14	19.21
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	18.1	18.06	20.81
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	505	495	489
WMA July demand, no restrictions, with climate change impact, MGD	611	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	501	--	--
WMA July demand, no restrictions, without climate change impact, MGD	590	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	680	720	680
Minimum average natural flow fall, MGD	582	582	3,931
Minimum average late summer flow downstream of intakes, MGD	347	413	347
Minimum average fall flow downstream of intakes, MGD	279	279	3,620
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	68 (85)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-12: 2040 Baseline + Operations (Ops): Higher Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,231	195	352
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.05%	30.10%	3.53%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.71	1.90	1.82
Jennings Randolph water supply account	6.41	6.46	7.53
Jennings Randolph water quality account	2.87	5.37	3.49
Patuxent Reservoir	0.69	1.99	1.96
Occoquan Reservoir	1.60	2.59	2.78
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.79	0.89	0.79
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.54	0.60	0.59
Little Seneca Reservoir and Jennings Randolph water supply account, combined	8.2	8.36	9.35
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	13.5	13.50	16.63
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	15.2	15.22	18.04
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	554	537	538
WMA July demand, no restrictions, with climate change impact, MGD	669	33	33
WMA annual demand, no restrictions, without climate change impact, MGD	550	--	--
WMA July demand, no restrictions, without climate change impact, MGD	647	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	680	720	680
Minimum average natural flow fall, MGD	582	582	3,931
Minimum average late summer flow downstream of intakes, MGD	316	391	316
Minimum average fall flow downstream of intakes, MGD	254	254	3,563
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	68 (85)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-13: 2040 Baseline + Operations (Ops): Medium Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	89	1	1
Number of Occoquan water supply shortfalls over simulation period	612	8	7
Number of days in which Patuxent plant production is less than 30 MGD	4,685	197	343
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	2.26%	29.27%	0.05%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.75	1.77	2.20
Jennings Randolph water supply account	6.61	6.61	9.34
Jennings Randolph water quality account	2.85	4.76	3.42
Patuxent Reservoir	0.00	1.45	1.78
Occoquan Reservoir	2.17	2.98	3.30
Savage Reservoir	0.62	0.64	0.65
Milestone Reservoir	0.71	0.73	0.80
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.12
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.52	0.52	0.73
Little Seneca Reservoir and Jennings Randolph water supply account, combined	8.4	8.38	11.54
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	13.3	13.28	18.28
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	14.9	14.93	19.84
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	457	444	440
WMA July demand, no restrictions, with climate change impact, MGD	554	27	27
WMA annual demand, no restrictions, without climate change impact, MGD	452	--	--
WMA July demand, no restrictions, without climate change impact, MGD	532	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	576	576	608
Minimum average natural flow fall, MGD	471	471	3,541
Minimum average late summer flow downstream of intakes, MGD	329	357	329
Minimum average fall flow downstream of intakes, MGD	235	235	3,269
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	68 (84)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	79 (99)	0	1

Table A.5-14: 2040 Baseline + Operations (Ops): Medium Flows and Medium Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	30	--	--
Number of Occoquan water supply shortfalls over simulation period	6	0	--
Number of days in which Patuxent plant production is less than 30 MGD	3,628	125	355
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.41%	37.73%	3.53%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.75	0.75	1.75
Jennings Randolph water supply account	3.33	3.33	7.58
Jennings Randolph water quality account	2.58	4.11	3.42
Patuxent Reservoir	0.00	1.39	1.70
Occoquan Reservoir	1.48	1.81	2.81
Savage Reservoir	0.56	0.57	0.65
Milestone Reservoir	0.56	0.56	0.77
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.15	0.15	0.55
Little Seneca Reservoir and Jennings Randolph water supply account, combined	4.1	4.09	9.32
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	8.0	7.96	15.48
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	9.2	9.19	16.83
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	505	490	488
WMA July demand, no restrictions, with climate change impact, MGD	611	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	501	--	--
WMA July demand, no restrictions, without climate change impact, MGD	590	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	576	576	608
Minimum average natural flow fall, MGD	471	471	3,541
Minimum average late summer flow downstream of intakes, MGD	304	344	304
Minimum average fall flow downstream of intakes, MGD	228	228	3,224
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	79 (99)	0	1

Table A.5-15: 2040 Baseline + Operations (Ops): Medium Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	99.95%	0.01%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	0	0	--
Maximum amount of deficit allocated in a single day, MGD	(0.2)	(0)	--
Total amount of deficit allocated full simulation period, MG	(0)	(0)	--
Number of Patuxent water supply shortfalls over simulation period	30	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,521	57	358
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.75%	32.15%	10.93%
Emergency restrictions	0.90%	7.72%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.16	0.16	1.29
Jennings Randolph water supply account	1.06	1.06	5.76
Jennings Randolph water quality account	0.73	1.24	3.40
Patuxent Reservoir	0.00	1.37	1.70
Occoquan Reservoir	1.19	1.45	2.54
Savage Reservoir	0.33	0.33	0.65
Milestone Reservoir	0.70	0.71	0.80
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.02	0.02	0.41
Little Seneca Reservoir and Jennings Randolph water supply account, combined	1.2	1.23	7.05
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	4.5	4.54	12.97
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	5.7	5.66	14.21
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	554	535	536
WMA July demand, no restrictions, with climate change impact, MGD	669	33	33
WMA annual demand, no restrictions, without climate change impact, MGD	550	--	--
WMA July demand, no restrictions, without climate change impact, MGD	647	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	576	576	608
Minimum average natural flow fall, MGD	471	471	3,541
Minimum average late summer flow downstream of intakes, MGD	276	324	276
Minimum average fall flow downstream of intakes, MGD	231	231	3,186
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	79 (99)	0	1

Table A.5-16: 2040 Baseline + Operations (Ops): Lower Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	99.11%	0.25%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	1	1	--
Maximum amount of deficit allocated in a single day, MGD	(16.8)	(17)	--
Total amount of deficit allocated full simulation period, MG	(19)	(19)	--
Number of Patuxent water supply shortfalls over simulation period	120	1	0
Number of Occoquan water supply shortfalls over simulation period	620	5	6
Number of days in which Patuxent plant production is less than 30 MGD	5,151	81	365
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	4.40%	26.49%	2.36%
Emergency restrictions	1.66%	13.05%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	1.83
Jennings Randolph water supply account	0.57	0.57	7.88
Jennings Randolph water quality account	0.20	0.72	3.39
Patuxent Reservoir	0.00	0.75	1.35
Occoquan Reservoir	1.80	1.97	2.80
Savage Reservoir	0.24	0.24	0.65
Milestone Reservoir	0.37	0.37	0.76
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.00	0.00	0.57
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.6	0.58	9.71
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	3.6	3.63	14.42
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	4.3	4.35	15.78
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	456	440	439
WMA July demand, no restrictions, with climate change impact, MGD	554	27	27
WMA annual demand, no restrictions, without climate change impact, MGD	452	--	--
WMA July demand, no restrictions, without climate change impact, MGD	532	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	426	426	534
Minimum average natural flow fall, MGD	352	352	3,143
Minimum average late summer flow downstream of intakes, MGD	280	283	285
Minimum average fall flow downstream of intakes, MGD	208	208	2,885
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	65 (81)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	75 (94)	0	1

Table A.5-17: 2040 Baseline + Operations (Ops): Lower Flows and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	98.75%	2.10%	0.00%
Maximum number of days in a row of Potomac deficits	3	3	--
Number of days in which Potomac deficits must be allocated	8	8	--
Maximum amount of deficit allocated in a single day, MGD	(83.1)	(83)	--
Total amount of deficit allocated full simulation period, MG	(325)	(325)	--
Number of Patuxent water supply shortfalls over simulation period	86	2	--
Number of Occoquan water supply shortfalls over simulation period	12	4	--
Number of days in which Patuxent plant production is less than 30 MGD	4,507	111	345
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	5.00%	17.87%	9.81%
Emergency restrictions	2.50%	23.16%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	1.40
Jennings Randolph water supply account	0.00	0.00	6.17
Jennings Randolph water quality account	0.00	0.03	3.36
Patuxent Reservoir	0.00	0.25	1.27
Occoquan Reservoir	0.42	0.43	2.49
Savage Reservoir	0.16	0.16	0.65
Milestone Reservoir	0.04	0.04	0.77
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.00	0.00	0.42
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	7.57
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.9	0.89	11.87
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	1.0	1.04	13.09
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	505	485	486
WMA July demand, no restrictions, with climate change impact, MGD	611	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	501	--	--
WMA July demand, no restrictions, without climate change impact, MGD	590	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	426	426	534
Minimum average natural flow fall, MGD	352	352	3,143
Minimum average late summer flow downstream of intakes, MGD	257	268	258
Minimum average fall flow downstream of intakes, MGD	181	181	2,841
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	75 (94)	0	1

Table A.5-18: 2040 Baseline + Operations (Ops): Lower Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	98.71%	11.95%	0.01%
Maximum number of days in a row of Potomac deficits	21	21	--
Number of days in which Potomac deficits must be allocated	44	44	0
Maximum amount of deficit allocated in a single day, MGD	(167.5)	(167)	(0)
Total amount of deficit allocated full simulation period, MG	(2,657)	(2,656)	(0)
Number of Patuxent water supply shortfalls over simulation period	131	25	--
Number of Occoquan water supply shortfalls over simulation period	33	31	0
Number of days in which Patuxent plant production is less than 30 MGD	4,396	147	128
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	5.64%	12.22%	25.42%
Emergency restrictions	2.50%	30.04%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	0.79
Jennings Randolph water supply account	0.00	0.00	4.13
Jennings Randolph water quality account	0.00	0.00	3.33
Patuxent Reservoir	0.00	0.00	1.27
Occoquan Reservoir	0.00	0.00	2.20
Savage Reservoir	0.03	0.03	0.65
Milestone Reservoir	0.00	0.00	0.79
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.00	0.00	0.24
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	4.92
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.0	0.01	8.99
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.0	0.01	10.06
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	554	531	534
WMA July demand, no restrictions, with climate change impact, MGD	668	32	32
WMA annual demand, no restrictions, without climate change impact, MGD	550	--	--
WMA July demand, no restrictions, without climate change impact, MGD	647	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	426	426	534
Minimum average natural flow fall, MGD	352	352	3,143
Minimum average late summer flow downstream of intakes, MGD	239	255	239
Minimum average fall flow downstream of intakes, MGD	129	129	2,788
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (97)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	75 (94)	0	1

Table A.5-19: 2040 Baseline + Operations (Ops) + Travilah Quarry: Higher Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	0	--	--
Number of Occoquan water supply shortfalls over simulation period	615	7	7
Number of days in which Patuxent plant production is less than 30 MGD	3,951	169	213
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.00%	0.00%	0.00%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.90	3.26	2.90
Jennings Randolph water supply account	11.24	11.27	11.96
Jennings Randolph water quality account	2.87	4.11	3.49
Patuxent Reservoir	0.91	1.46	2.11
Occoquan Reservoir	2.32	3.91	3.51
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.87	0.98	0.88
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.17	0.18	1.04
Travilah Quarry	7.73	7.73	7.74
Beaverdam Reservoir	1.01	1.06	1.02
Little Seneca Reservoir and Jennings Randolph water supply account, combined	14.3	14.54	14.86
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	20.4	20.38	22.61
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	30.3	30.33	32.27
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	456	447	440
WMA July demand, no restrictions, with climate change impact, MGD	554	27	27
WMA annual demand, no restrictions, without climate change impact, MGD	452	--	--
WMA July demand, no restrictions, without climate change impact, MGD	532	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	680	720	680
Minimum average natural flow fall, MGD	580	580	3,930
Minimum average late summer flow downstream of intakes, MGD	370	427	370
Minimum average fall flow downstream of intakes, MGD	327	327	3,688
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	80 (100)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	70 (88)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-20: 2040 Baseline + Operations (Ops) + Travilah Quarry: Higher Flows and Medium Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	7	0	0
Number of days in which Patuxent plant production is less than 30 MGD	3,017	185	219
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.04%	0.69%	0.00%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.51	2.77	2.56
Jennings Randolph water supply account	9.35	9.41	10.49
Jennings Randolph water quality account	2.87	5.30	3.49
Patuxent Reservoir	0.91	1.78	1.97
Occoquan Reservoir	1.82	3.10	3.32
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.83	0.94	0.83
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.11	0.11	0.51
Travilah Quarry	7.73	7.73	7.74
Beaverdam Reservoir	0.87	0.93	0.90
Little Seneca Reservoir and Jennings Randolph water supply account, combined	12.0	12.18	13.06
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	17.4	17.44	20.60
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	27.3	27.25	30.10
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	505	496	486
WMA July demand, no restrictions, with climate change impact, MGD	611	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	501	--	--
WMA July demand, no restrictions, without climate change impact, MGD	590	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	680	720	680
Minimum average natural flow fall, MGD	582	582	3,930
Minimum average late summer flow downstream of intakes, MGD	334	397	334
Minimum average fall flow downstream of intakes, MGD	270	270	3,638
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	80 (100)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	68 (85)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-21: 2040 Baseline + Operations (Ops) + Travilah Quarry: Higher Flows and High Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,010	165	232
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.89%	10.76%	0.21%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.17	2.34	2.25
Jennings Randolph water supply account	7.62	7.65	8.92
Jennings Randolph water quality account	2.87	5.37	3.49
Patuxent Reservoir	0.92	1.92	1.96
Occoquan Reservoir	1.61	2.68	2.96
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.81	0.94	0.81
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.20
Travilah Quarry	7.72	7.72	7.74
Beaverdam Reservoir	0.73	0.78	0.78
Little Seneca Reservoir and Jennings Randolph water supply account, combined	9.9	9.99	11.17
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	15.0	15.02	18.46
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	24.7	24.68	27.81
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	553	542	537
WMA July demand, no restrictions, with climate change impact, MGD	668	33	33
WMA annual demand, no restrictions, without climate change impact, MGD	550	--	--
WMA July demand, no restrictions, without climate change impact, MGD	647	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	680	720	680
Minimum average natural flow fall, MGD	582	582	3,931
Minimum average late summer flow downstream of intakes, MGD	291	365	291
Minimum average fall flow downstream of intakes, MGD	234	234	3,578
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	68 (85)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-22: 2040 Baseline + Operations (Ops) + Travilah Quarry: Medium Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	0	--	--
Number of Occoquan water supply shortfalls over simulation period	621	5	7
Number of days in which Patuxent plant production is less than 30 MGD	4,586	173	293
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.80%	10.40%	0.00%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.20	2.23	2.59
Jennings Randolph water supply account	7.90	7.90	10.49
Jennings Randolph water quality account	2.85	4.75	3.42
Patuxent Reservoir	0.82	1.37	1.77
Occoquan Reservoir	2.17	3.20	3.62
Savage Reservoir	0.62	0.65	0.65
Milestone Reservoir	0.82	0.88	0.83
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.39
Travilah Quarry	7.72	7.72	7.73
Beaverdam Reservoir	0.71	0.71	0.90
Little Seneca Reservoir and Jennings Randolph water supply account, combined	10.1	10.14	13.08
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	15.1	15.07	20.09
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	24.7	24.67	29.57
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	456	448	438
WMA July demand, no restrictions, with climate change impact, MGD	553	27	27
WMA annual demand, no restrictions, without climate change impact, MGD	452	--	--
WMA July demand, no restrictions, without climate change impact, MGD	532	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	576	576	608
Minimum average natural flow fall, MGD	471	471	3,540
Minimum average late summer flow downstream of intakes, MGD	311	330	312
Minimum average fall flow downstream of intakes, MGD	215	215	3,279
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	67 (85)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	79 (99)	0	1

Table A.5-23: 2040 Baseline + Operations (Ops) + Travilah Quarry: Medium Flows and Medium Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	8	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,692	134	321
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	2.54%	34.57%	0.08%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.68	1.69	2.20
Jennings Randolph water supply account	5.90	5.90	8.88
Jennings Randolph water quality account	2.85	4.83	3.42
Patuxent Reservoir	0.82	1.33	1.70
Occoquan Reservoir	1.55	2.37	3.12
Savage Reservoir	0.62	0.64	0.65
Milestone Reservoir	0.74	0.77	0.80
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.13
Travilah Quarry	7.71	7.71	7.73
Beaverdam Reservoir	0.50	0.50	0.74
Little Seneca Reservoir and Jennings Randolph water supply account, combined	7.6	7.59	11.08
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	11.8	11.85	17.53
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	21.2	21.25	26.82
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	505	492	487
WMA July demand, no restrictions, with climate change impact, MGD	611	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	501	--	--
WMA July demand, no restrictions, without climate change impact, MGD	590	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	576	576	608
Minimum average natural flow fall, MGD	471	471	3,541
Minimum average late summer flow downstream of intakes, MGD	279	308	279
Minimum average fall flow downstream of intakes, MGD	192	192	3,223
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	79 (99)	0	1

Table A.5-24: 2040 Baseline + Operations (Ops) + Travilah Quarry: Medium Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,813	137	346
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.69%	38.84%	6.47%
Emergency restrictions	0.04%	0.13%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.61	0.61	1.66
Jennings Randolph water supply account	2.31	2.31	6.80
Jennings Randolph water quality account	1.67	2.55	3.41
Patuxent Reservoir	0.82	1.40	1.70
Occoquan Reservoir	1.31	1.78	2.65
Savage Reservoir	0.46	0.46	0.66
Milestone Reservoir	0.68	0.69	0.79
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	7.71	7.71	7.74
Beaverdam Reservoir	0.12	0.12	0.54
Little Seneca Reservoir and Jennings Randolph water supply account, combined	2.9	2.95	8.47
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	6.8	6.82	14.48
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	15.8	15.82	23.58
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	554	536	535
WMA July demand, no restrictions, with climate change impact, MGD	668	33	32
WMA annual demand, no restrictions, without climate change impact, MGD	550	--	--
WMA July demand, no restrictions, without climate change impact, MGD	647	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	576	576	608
Minimum average natural flow fall, MGD	471	471	3,541
Minimum average late summer flow downstream of intakes, MGD	257	303	257
Minimum average fall flow downstream of intakes, MGD	205	205	3,182
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	79 (99)	0	1

Table A.5-25: 2040 Baseline + Operations (Ops) + Travilah Quarry: Lower Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	0	--	--
Number of Occoquan water supply shortfalls over simulation period	608	5	4
Number of days in which Patuxent plant production is less than 30 MGD	5,328	161	339
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	2.60%	37.24%	0.01%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.76	0.76	2.33
Jennings Randolph water supply account	3.38	3.38	9.34
Jennings Randolph water quality account	2.27	3.00	3.39
Patuxent Reservoir	0.75	0.87	1.34
Occoquan Reservoir	1.74	1.88	3.44
Savage Reservoir	0.43	0.43	0.65
Milestone Reservoir	0.43	0.43	0.81
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.12
Travilah Quarry	7.5	7.54	7.67
Beaverdam Reservoir	0.22	0.22	0.79
Little Seneca Reservoir and Jennings Randolph water supply account, combined	4.3	4.30	11.68
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	7.4	7.42	17.00
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	16.2	16.21	26.29
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	457	442	442
WMA July demand, no restrictions, with climate change impact, MGD	554	27	27
WMA annual demand, no restrictions, without climate change impact, MGD	452	--	--
WMA July demand, no restrictions, without climate change impact, MGD	532	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	426	426	534
Minimum average natural flow fall, MGD	352	352	3,143
Minimum average late summer flow downstream of intakes, MGD	241	243	251
Minimum average fall flow downstream of intakes, MGD	157	157	2,878
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	65 (81)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	75 (94)	0	1

Table A.5-26: 2040 Baseline + Operations (Ops) + Travilah Quarry: Lower Flows and Medium Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	7	0	0
Number of days in which Patuxent plant production is less than 30 MGD	4,540	191	265
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	2.56%	37.88%	0.00%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.89	0.89	2.46
Jennings Randolph water supply account	3.29	3.29	9.29
Jennings Randolph water quality account	2.37	3.21	3.38
Patuxent Reservoir	0.74	0.85	1.23
Occoquan Reservoir	1.04	1.20	3.12
Savage Reservoir	0.45	0.45	0.65
Milestone Reservoir	0.50	0.50	0.81
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.19
Travilah Quarry	4.31	4.31	6.89
Beaverdam Reservoir	0.26	0.26	0.86
Little Seneca Reservoir and Jennings Randolph water supply account, combined	4.3	4.33	11.75
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	6.4	6.40	16.60
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	11.9	11.89	25.19
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	505	488	488
WMA July demand, no restrictions, with climate change impact, MGD	611	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	501	--	--
WMA July demand, no restrictions, without climate change impact, MGD	590	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	426	426	534
Minimum average natural flow fall, MGD	352	352	3,143
Minimum average late summer flow downstream of intakes, MGD	200	209	202
Minimum average fall flow downstream of intakes, MGD	132	132	2,838
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	75 (94)	0	1

Table A.5-27: 2040 Baseline + Operations (Ops) + Travilah Quarry: Lower Flows and High Demands

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	1	1	--
Number of days in which Patuxent plant production is less than 30 MGD	4,604	205	263
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.46%	37.80%	1.00%
Emergency restrictions	0.26%	1.53%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.46	0.46	2.22
Jennings Randolph water supply account	1.65	1.65	8.05
Jennings Randolph water quality account	0.83	1.50	3.29
Patuxent Reservoir	0.74	0.82	1.20
Occoquan Reservoir	0.52	0.55	2.68
Savage Reservoir	0.30	0.30	0.66
Milestone Reservoir	0.57	0.57	0.80
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.12
Travilah Quarry	1.62	1.62	5.65
Beaverdam Reservoir	0.12	0.12	0.77
Little Seneca Reservoir and Jennings Randolph water supply account, combined	2.3	2.25	10.27
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	3.6	3.64	14.67
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	6.3	6.32	21.92
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	554	536	538
WMA July demand, no restrictions, with climate change impact, MGD	669	33	33
WMA annual demand, no restrictions, without climate change impact, MGD	550	--	--
WMA July demand, no restrictions, without climate change impact, MGD	647	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	426	426	534
Minimum average natural flow fall, MGD	352	352	3,143
Minimum average late summer flow downstream of intakes, MGD	170	191	171
Minimum average fall flow downstream of intakes, MGD	129	129	2,798
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	75 (94)	0	1

Table A.5-28: 2040 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Lower Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	3	2	0
Number of days in which Patuxent plant production is less than 30 MGD	4,599	204	263
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	2.89%	38.46%	0.29%
Emergency restrictions	0.05%	0.23%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.70	0.70	2.33
Jennings Randolph water supply account	2.42	2.42	8.34
Jennings Randolph water quality account	1.64	2.41	3.30
Patuxent Reservoir	0.74	0.82	1.20
Occoquan Reservoir	0.28	0.28	2.67
Savage Reservoir	0.34	0.34	0.66
Milestone Reservoir	0.18	0.18	0.77
Luck Stone (Quarry B)	0.76	0.76	1.88
Vulcan Quarry	0.10	0.11	0.13
Travilah Quarry	2.1	2.05	5.90
Beaverdam Reservoir	0.26	0.26	0.86
Little Seneca Reservoir and Jennings Randolph water supply account, combined	3.2	3.24	10.67
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	4.4	4.36	15.06
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	8.0	8.04	24.49
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	554	536	539
WMA July demand, no restrictions, with climate change impact, MGD	668	33	33
WMA annual demand, no restrictions, without climate change impact, MGD	550	--	--
WMA July demand, no restrictions, without climate change impact, MGD	647	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	426	426	534
Minimum average natural flow fall, MGD	352	352	3,143
Minimum average late summer flow downstream of intakes, MGD	170	188	170
Minimum average fall flow downstream of intakes, MGD	128	128	2,789
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	75 (94)	0	1

Table A.5-29: 2040 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Higher Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	0	--	--
Number of Occoquan water supply shortfalls over simulation period	622	7	6
Number of days in which Patuxent plant production is less than 30 MGD	3,969	174	217
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.00%	0.00%	0.00%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.96	3.20	3.00
Jennings Randolph water supply account	11.10	11.10	11.93
Jennings Randolph water quality account	2.87	4.27	3.49
Patuxent Reservoir	0.91	1.52	2.07
Occoquan Reservoir	2.32	3.90	3.52
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.85	0.93	0.88
Luck Stone (Quarry B)	2.24	2.36	2.26
Vulcan Quarry	0.12	0.12	1.13
Travilah Quarry	7.73	7.73	7.74
Beaverdam Reservoir	1.03	1.04	1.05
Little Seneca Reservoir and Jennings Randolph water supply account, combined	14.2	14.31	14.93
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	20.2	20.17	22.67
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	32.6	32.59	34.61
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	456	449	441
WMA July demand, no restrictions, with climate change impact, MGD	554	28	27
WMA annual demand, no restrictions, without climate change impact, MGD	452	--	--
WMA July demand, no restrictions, without climate change impact, MGD	532	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	680	720	680
Minimum average natural flow fall, MGD	580	580	3,930
Minimum average late summer flow downstream of intakes, MGD	371	429	371
Minimum average fall flow downstream of intakes, MGD	322	322	3,691
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	80 (100)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	70 (88)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-30: 2040 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Higher Flows and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	7	0	0
Number of days in which Patuxent plant production is less than 30 MGD	3,060	188	255
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.00%	0.00%	0.00%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.57	2.83	2.62
Jennings Randolph water supply account	9.52	9.56	10.37
Jennings Randolph water quality account	2.87	5.29	3.49
Patuxent Reservoir	0.91	1.77	1.97
Occoquan Reservoir	1.81	3.11	3.33
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.81	0.91	0.82
Luck Stone (Quarry B)	2.05	2.21	2.08
Vulcan Quarry	0.11	0.11	0.55
Travilah Quarry	7.73	7.73	7.74
Beaverdam Reservoir	0.92	0.96	0.94
Little Seneca Reservoir and Jennings Randolph water supply account, combined	12.2	12.39	12.99
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	17.6	17.64	20.58
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	30.0	29.98	32.19
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	505	493	490
WMA July demand, no restrictions, with climate change impact, MGD	611	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	501	--	--
WMA July demand, no restrictions, without climate change impact, MGD	590	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	680	720	680
Minimum average natural flow fall, MGD	582	582	3,930
Minimum average late summer flow downstream of intakes, MGD	330	403	330
Minimum average fall flow downstream of intakes, MGD	271	271	3,632
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	80 (100)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	68 (86)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-31: 2040 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Higher Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	0
Number of days in which Patuxent plant production is less than 30 MGD	2,991	164	222
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.38%	4.99%	0.00%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.36	2.50	2.46
Jennings Randolph water supply account	8.10	8.13	9.53
Jennings Randolph water quality account	2.87	5.37	3.49
Patuxent Reservoir	0.92	1.88	1.96
Occoquan Reservoir	1.60	2.67	2.98
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.81	0.89	0.81
Luck Stone (Quarry B)	1.91	2.03	1.97
Vulcan Quarry	0.11	0.11	0.38
Travilah Quarry	7.72	7.72	7.74
Beaverdam Reservoir	0.85	0.88	0.90
Little Seneca Reservoir and Jennings Randolph water supply account, combined	10.5	10.63	11.99
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	15.7	15.68	19.23
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	27.9	27.92	30.67
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	553	542	537
WMA July demand, no restrictions, with climate change impact, MGD	668	33	33
WMA annual demand, no restrictions, without climate change impact, MGD	550	--	--
WMA July demand, no restrictions, without climate change impact, MGD	647	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	680	720	680
Minimum average natural flow fall, MGD	582	582	3,931
Minimum average late summer flow downstream of intakes, MGD	288	365	288
Minimum average fall flow downstream of intakes, MGD	228	228	3,580
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	68 (85)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-32: 2040 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Medium Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	0	--	--
Number of Occoquan water supply shortfalls over simulation period	610	4	5
Number of days in which Patuxent plant production is less than 30 MGD	4,580	181	279
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.23%	2.93%	0.00%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.39	2.42	2.69
Jennings Randolph water supply account	8.46	8.46	10.64
Jennings Randolph water quality account	2.85	4.75	3.42
Patuxent Reservoir	0.82	1.35	1.78
Occoquan Reservoir	2.18	3.25	3.59
Savage Reservoir	0.62	0.65	0.65
Milestone Reservoir	0.78	0.82	0.83
Luck Stone (Quarry B)	1.87	1.89	2.12
Vulcan Quarry	0.10	0.11	0.54
Travilah Quarry	7.72	7.72	7.73
Beaverdam Reservoir	0.82	0.82	0.96
Little Seneca Reservoir and Jennings Randolph water supply account, combined	10.9	10.89	13.34
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	15.8	15.83	20.33
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	28.0	28.02	31.99
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	457	449	442
WMA July demand, no restrictions, with climate change impact, MGD	554	28	27
WMA annual demand, no restrictions, without climate change impact, MGD	452	--	--
WMA July demand, no restrictions, without climate change impact, MGD	532	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	576	576	608
Minimum average natural flow fall, MGD	471	471	3,540
Minimum average late summer flow downstream of intakes, MGD	305	327	306
Minimum average fall flow downstream of intakes, MGD	209	209	3,278
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	68 (85)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	79 (99)	0	1

Table A.5-33: 2040 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Medium Flows and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	8	0	0
Number of days in which Patuxent plant production is less than 30 MGD	3,681	146	303
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	2.38%	29.48%	0.00%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.84	1.85	2.37
Jennings Randolph water supply account	6.46	6.46	9.33
Jennings Randolph water quality account	2.85	4.83	3.42
Patuxent Reservoir	0.82	1.32	1.70
Occoquan Reservoir	1.54	2.32	3.26
Savage Reservoir	0.62	0.65	0.65
Milestone Reservoir	0.60	0.60	0.80
Luck Stone (Quarry B)	1.48	1.48	1.91
Vulcan Quarry	0.10	0.11	0.18
Travilah Quarry	7.70	7.70	7.73
Beaverdam Reservoir	0.63	0.63	0.86
Little Seneca Reservoir and Jennings Randolph water supply account, combined	8.3	8.30	11.70
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	12.6	12.57	18.27
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	24.0	23.99	29.60
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	505	492	487
WMA July demand, no restrictions, with climate change impact, MGD	611	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	501	--	--
WMA July demand, no restrictions, without climate change impact, MGD	590	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	576	576	608
Minimum average natural flow fall, MGD	471	471	3,541
Minimum average late summer flow downstream of intakes, MGD	276	307	276
Minimum average fall flow downstream of intakes, MGD	189	189	3,223
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	79 (99)	0	1

Table A.5-34: 2040 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Medium Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,671	139	285
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.16%	36.54%	1.50%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.23	1.23	2.02
Jennings Randolph water supply account	4.25	4.25	7.88
Jennings Randolph water quality account	2.84	5.02	3.42
Patuxent Reservoir	0.82	1.33	1.70
Occoquan Reservoir	1.12	1.23	2.72
Savage Reservoir	0.62	0.64	0.65
Milestone Reservoir	0.37	0.37	0.75
Luck Stone (Quarry B)	1.04	1.04	1.64
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	7.67	7.67	7.73
Beaverdam Reservoir	0.40	0.40	0.73
Little Seneca Reservoir and Jennings Randolph water supply account, combined	5.5	5.48	9.90
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	8.7	8.66	15.97
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	18.9	18.92	26.84
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	554	536	535
WMA July demand, no restrictions, with climate change impact, MGD	668	33	33
WMA annual demand, no restrictions, without climate change impact, MGD	550	--	--
WMA July demand, no restrictions, without climate change impact, MGD	647	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	576	576	608
Minimum average natural flow fall, MGD	471	471	3,541
Minimum average late summer flow downstream of intakes, MGD	243	285	243
Minimum average fall flow downstream of intakes, MGD	179	179	3,173
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	79 (99)	0	1

Table A.5-35: 2040 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Lower Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	0	--	--
Number of Occoquan water supply shortfalls over simulation period	610	5	6
Number of days in which Patuxent plant production is less than 30 MGD	5,350	158	355
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	2.51%	36.43%	0.00%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.83	0.83	2.30
Jennings Randolph water supply account	3.71	3.71	9.22
Jennings Randolph water quality account	2.61	3.36	3.39
Patuxent Reservoir	0.75	0.89	1.35
Occoquan Reservoir	1.38	1.42	3.43
Savage Reservoir	0.47	0.47	0.65
Milestone Reservoir	0.04	0.04	0.78
Luck Stone (Quarry B)	0.72	0.72	1.82
Vulcan Quarry	0.10	0.11	0.12
Travilah Quarry	7.7	7.65	7.73
Beaverdam Reservoir	0.28	0.28	0.82
Little Seneca Reservoir and Jennings Randolph water supply account, combined	4.7	4.67	11.52
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	7.3	7.34	16.85
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	16.6	16.64	28.02
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	456	440	440
WMA July demand, no restrictions, with climate change impact, MGD	554	27	27
WMA annual demand, no restrictions, without climate change impact, MGD	452	--	--
WMA July demand, no restrictions, without climate change impact, MGD	532	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	426	426	534
Minimum average natural flow fall, MGD	352	352	3,143
Minimum average late summer flow downstream of intakes, MGD	250	253	257
Minimum average fall flow downstream of intakes, MGD	171	171	2,873
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	65 (81)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	75 (94)	0	1

Table A.5-36: 2040 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Lower Flows and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	6	0	--
Number of days in which Patuxent plant production is less than 30 MGD	4,610	175	343
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	2.63%	37.72%	0.01%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.73	0.73	2.29
Jennings Randolph water supply account	2.96	2.96	8.73
Jennings Randolph water quality account	2.18	2.99	3.38
Patuxent Reservoir	0.74	0.86	1.22
Occoquan Reservoir	0.63	0.66	3.10
Savage Reservoir	0.42	0.42	0.65
Milestone Reservoir	0.09	0.09	0.77
Luck Stone (Quarry B)	0.70	0.70	1.84
Vulcan Quarry	0.10	0.11	0.12
Travilah Quarry	6.6	6.58	7.50
Beaverdam Reservoir	0.25	0.25	0.84
Little Seneca Reservoir and Jennings Randolph water supply account, combined	3.8	3.83	11.02
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	5.4	5.39	15.88
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	13.4	13.38	26.85
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	505	485	489
WMA July demand, no restrictions, with climate change impact, MGD	611	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	501	--	--
WMA July demand, no restrictions, without climate change impact, MGD	590	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	426	426	534
Minimum average natural flow fall, MGD	352	352	3,143
Minimum average late summer flow downstream of intakes, MGD	207	215	209
Minimum average fall flow downstream of intakes, MGD	142	142	2,828
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	75 (94)	0	1

Table A.5-37: 2040 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Lower Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	3	2	0
Number of days in which Patuxent plant production is less than 30 MGD	4,599	204	263
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	2.89%	38.46%	0.29%
Emergency restrictions	0.05%	0.23%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.70	0.70	2.33
Jennings Randolph water supply account	2.42	2.42	8.34
Jennings Randolph water quality account	1.64	2.41	3.30
Patuxent Reservoir	0.74	0.82	1.20
Occoquan Reservoir	0.28	0.28	2.67
Savage Reservoir	0.34	0.34	0.66
Milestone Reservoir	0.18	0.18	0.77
Luck Stone (Quarry B)	0.76	0.76	1.88
Vulcan Quarry	0.10	0.11	0.13
Travilah Quarry	2.1	2.05	5.90
Beaverdam Reservoir	0.26	0.26	0.86
Little Seneca Reservoir and Jennings Randolph water supply account, combined	3.2	3.24	10.67
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	4.4	4.36	15.06
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	8.0	8.04	24.49
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	554	536	539
WMA July demand, no restrictions, with climate change impact, MGD	668	33	33
WMA annual demand, no restrictions, without climate change impact, MGD	550	--	--
WMA July demand, no restrictions, without climate change impact, MGD	647	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	426	426	534
Minimum average natural flow fall, MGD	352	352	3,143
Minimum average late summer flow downstream of intakes, MGD	170	188	170
Minimum average fall flow downstream of intakes, MGD	128	128	2,789
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	75 (94)	0	1

Table A.5-38: 2050 Baseline: Higher Flows and Low Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	19	0	0
Number of Occoquan water supply shortfalls over simulation period	72	1	0
Number of days in which Patuxent plant production is less than 30 MGD	3,647	204	343
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	2.14%	19.77%	2.73%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.84	2.05	1.95
Jennings Randolph water supply account	6.79	7.34	7.19
Jennings Randolph water quality account	2.64	5.11	3.26
Patuxent Reservoir	0.57	1.87	2.00
Occoquan Reservoir	2.10	3.53	3.09
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.90	0.90	0.96
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.12
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.09	1.09	1.15
Little Seneca Reservoir and Jennings Randolph water supply account, combined	8.6	9.39	9.14
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	15.1	15.21	16.74
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	17.3	17.43	18.85
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	479	466	462
WMA July demand, no restrictions, with climate change impact, MGD	582	28	28
WMA annual demand, no restrictions, without climate change impact, MGD	473	--	--
WMA July demand, no restrictions, without climate change impact, MGD	557	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	671	704	671
Minimum average natural flow fall, MGD	571	571	3,928
Minimum average late summer flow downstream of intakes, MGD	376	434	376
Minimum average fall flow downstream of intakes, MGD	301	301	3,641
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	71 (88)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-39: 2050 Baseline: Higher Flows and Medium Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	0	0	--
Number of days in which Patuxent plant production is less than 30 MGD	3,369	202	353
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.73%	36.39%	11.10%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.20	1.34	1.40
Jennings Randolph water supply account	4.22	4.70	4.80
Jennings Randolph water quality account	2.64	5.11	3.24
Patuxent Reservoir	0.58	1.92	1.96
Occoquan Reservoir	1.73	2.79	2.90
Savage Reservoir	0.62	0.64	0.66
Milestone Reservoir	0.96	0.97	0.96
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.09	1.09	1.15
Little Seneca Reservoir and Jennings Randolph water supply account, combined	5.4	6.04	6.20
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	11.1	11.12	13.64
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	13.3	13.34	15.76
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	534	514	513
WMA July demand, no restrictions, with climate change impact, MGD	647	31	31
WMA annual demand, no restrictions, without climate change impact, MGD	528	--	--
WMA July demand, no restrictions, without climate change impact, MGD	622	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	671	704	671
Minimum average natural flow fall, MGD	571	571	3,928
Minimum average late summer flow downstream of intakes, MGD	349	412	349
Minimum average fall flow downstream of intakes, MGD	274	274	3,593
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	70 (88)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-40: 2050 Baseline: Higher Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	-	-	-
Number of days in which Potomac deficits must be allocated	-	-	-
Maximum amount of deficit allocated in a single day, MGD	-	-	-
Total amount of deficit allocated full simulation period, MG	-	-	-
Number of Patuxent water supply shortfalls over simulation period	-	-	-
Number of Occoquan water supply shortfalls over simulation period	0	-	-
Number of days in which Patuxent plant production is less than 30 MGD	3,282	163	357
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.88%	26.36%	26.16%
Emergency restrictions	1.40%	13.40%	0.07%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.18	0.23	0.73
Jennings Randolph water supply account	0.59	0.74	2.35
Jennings Randolph water quality account	2.64	5.11	3.25
Patuxent Reservoir	0.61	1.97	1.96
Occoquan Reservoir	1.66	2.57	2.85
Savage Reservoir	0.41	0.41	0.65
Milestone Reservoir	0.96	0.96	0.97
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.09	1.09	1.15
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.8	0.97	3.08
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	5.9	5.97	10.62
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	8.1	8.19	12.75
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	589	567	564
WMA July demand, no restrictions, with climate change impact, MGD	712	34	33
WMA annual demand, no restrictions, without climate change impact, MGD	583		
WMA July demand, no restrictions, without climate change impact, MGD	687		
Minimum average flow			
Minimum average natural flow late summer, MGD	671	704	671
Minimum average natural flow fall, MGD	571	571	3,928
Minimum average late summer flow downstream of intakes, MGD	323	394	323
Minimum average fall flow downstream of intakes, MGD	250	250	3,548
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78.54 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	70 (88)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-41: 2050 Baseline: Medium Flows and Low Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	99.99%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	0	0	--
Maximum amount of deficit allocated in a single day, MGD	(0.0)	(0)	--
Total amount of deficit allocated full simulation period, MG	(0)	(0)	--
Number of Patuxent water supply shortfalls over simulation period	58	0	0
Number of Occoquan water supply shortfalls over simulation period	78	1	1
Number of days in which Patuxent plant production is less than 30 MGD	4,056	82	356
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.75%	27.55%	11.43%
Emergency restrictions	1.25%	12.11%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.03	0.03	1.39
Jennings Randolph water supply account	0.77	0.77	5.05
Jennings Randolph water quality account	2.56	4.30	3.20
Patuxent Reservoir	0.00	1.19	1.60
Occoquan Reservoir	2.05	2.57	2.79
Savage Reservoir	0.32	0.32	0.65
Milestone Reservoir	0.32	0.32	0.96
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.09	1.09	1.15
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.8	0.80	6.44
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	4.9	4.88	12.37
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	6.6	6.56	14.49
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	479	462	460
WMA July demand, no restrictions, with climate change impact, MGD	582	28	28
WMA annual demand, no restrictions, without climate change impact, MGD	473	--	--
WMA July demand, no restrictions, without climate change impact, MGD	557	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	535	535	589
Minimum average natural flow fall, MGD	440	440	3,487
Minimum average late summer flow downstream of intakes, MGD	325	350	325
Minimum average fall flow downstream of intakes, MGD	234	234	3,211
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	67 (84)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	78 (98)	0	1

Table A.5-42: 2050 Baseline: Medium Flows and Medium Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	99.29%	0.23%	0.00%
Maximum number of days in a row of Potomac deficits	0	0	--
Number of days in which Potomac deficits must be allocated	1	1	--
Maximum amount of deficit allocated in a single day, MGD	(21.4)	(21)	--
Total amount of deficit allocated full simulation period, MG	(29)	(29)	--
Number of Patuxent water supply shortfalls over simulation period	37	--	--
Number of Occoquan water supply shortfalls over simulation period	0	0	--
Number of days in which Patuxent plant production is less than 30 MGD	3,764	69	358
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	5.29%	12.24%	26.09%
Emergency restrictions	2.51%	28.84%	0.01%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	0.81
Jennings Randolph water supply account	0.00	0.00	2.81
Jennings Randolph water quality account	2.56	4.50	3.18
Patuxent Reservoir	0.00	0.80	1.56
Occoquan Reservoir	1.32	1.36	2.90
Savage Reservoir	0.20	0.20	0.65
Milestone Reservoir	0.35	0.35	0.96
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.09	1.09	1.15
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	3.62
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	2.6	2.57	9.64
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	4.2	4.15	11.76
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	533	510	509
WMA July demand, no restrictions, with climate change impact, MGD	646	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	528	--	--
WMA July demand, no restrictions, without climate change impact, MGD	622	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	535	535	589
Minimum average natural flow fall, MGD	440	440	3,487
Minimum average late summer flow downstream of intakes, MGD	301	328	301
Minimum average fall flow downstream of intakes, MGD	192	192	3,160
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	78 (98)	0	1

Table A.5-43: 2050 Baseline: Medium Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	98.32%	3.09%	0.14%
Maximum number of days in a row of Potomac deficits	4	4	0
Number of days in which Potomac deficits must be allocated	12	11	1
Maximum amount of deficit allocated in a single day, MGD	(127.4)	(127)	(14)
Total amount of deficit allocated full simulation period, MG	(525)	(504)	(21)
Number of Patuxent water supply shortfalls over simulation period	40	3	--
Number of Occoquan water supply shortfalls over simulation period	15	14	0
Number of days in which Patuxent plant production is less than 30 MGD	3,962	108	312
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	8.36%	8.27%	37.43%
Emergency restrictions	3.54%	33.77%	3.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	0.09
Jennings Randolph water supply account	0.00	0.00	0.23
Jennings Randolph water quality account	2.56	4.59	3.18
Patuxent Reservoir	0.00	0.22	1.73
Occoquan Reservoir	0.08	0.08	2.64
Savage Reservoir	0.12	0.12	0.65
Milestone Reservoir	0.39	0.39	0.97
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.09	1.09	1.15
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	0.31
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.5	0.54	6.41
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	2.1	2.08	8.53
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	589	559	559
WMA July demand, no restrictions, with climate change impact, MGD	712	33	33
WMA annual demand, no restrictions, without climate change impact, MGD	583	--	--
WMA July demand, no restrictions, without climate change impact, MGD	687	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	535	535	589
Minimum average natural flow fall, MGD	440	440	3,487
Minimum average late summer flow downstream of intakes, MGD	287	300	287
Minimum average fall flow downstream of intakes, MGD	156	156	3,100
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	78 (98)	0	1

Table A.5-44: 2050 Baseline: Lower Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	98.61%	16.35%	0.00%
Maximum number of days in a row of Potomac deficits	31	31	--
Number of days in which Potomac deficits must be allocated	60	60	--
Maximum amount of deficit allocated in a single day, MGD	(143.0)	(143)	--
Total amount of deficit allocated full simulation period, MG	(3,631)	(3,629)	--
Number of Patuxent water supply shortfalls over simulation period	192	40	0
Number of Occoquan water supply shortfalls over simulation period	76	3	1
Number of days in which Patuxent plant production is less than 30 MGD	5,405	163	310
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	6.06%	7.82%	32.04%
Emergency restrictions	2.54%	34.95%	0.05%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	0.66
Jennings Randolph water supply account	0.00	0.00	2.49
Jennings Randolph water quality account	2.08	2.81	3.03
Patuxent Reservoir	0.00	0.00	1.13
Occoquan Reservoir	0.83	0.87	2.56
Savage Reservoir	0.00	0.00	0.65
Milestone Reservoir	0.01	0.01	0.95
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.08	1.08	1.14
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	3.15
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.9	0.90	7.02
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	2.1	2.06	9.12
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	479	452	456
WMA July demand, no restrictions, with climate change impact, MGD	582	27	27
WMA annual demand, no restrictions, without climate change impact, MGD	473	--	--
WMA July demand, no restrictions, without climate change impact, MGD	557	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	355	355	501
Minimum average natural flow fall, MGD	297	297	3,014
Minimum average late summer flow downstream of intakes, MGD	254	254	282
Minimum average fall flow downstream of intakes, MGD	84	84	2,733
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (97)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	79 (99)	0	1
Patuxent Reservoir	64 (80)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	74 (93)	0	1

Table A.5-45: 2050 Baseline: Lower Flows and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	97.49%	24.49%	0.13%
Maximum number of days in a row of Potomac deficits	60	60	0
Number of days in which Potomac deficits must be allocated	92	89	0
Maximum amount of deficit allocated in a single day, MGD	(220.3)	(220)	(15)
Total amount of deficit allocated full simulation period, MG	(9,162)	(9,115)	(20)
Number of Patuxent water supply shortfalls over simulation period	199	57	--
Number of Occoquan water supply shortfalls over simulation period	52	50	0
Number of days in which Patuxent plant production is less than 30 MGD	5,110	208	125
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	8.95%	6.92%	38.17%
Emergency restrictions	3.66%	36.90%	3.33%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	0.04
Jennings Randolph water supply account	0.00	0.00	0.10
Jennings Randolph water quality account	2.25	2.98	3.09
Patuxent Reservoir	0.00	0.00	1.44
Occoquan Reservoir	0.00	0.00	2.50
Savage Reservoir	0.00	0.00	0.65
Milestone Reservoir	0.01	0.01	0.95
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.10
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.08	1.08	1.14
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	0.13
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.0	0.00	4.18
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	1.1	1.13	6.28
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	534	505	506
WMA July demand, no restrictions, with climate change impact, MGD	646	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	528	--	--
WMA July demand, no restrictions, without climate change impact, MGD	622	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	355	355	501
Minimum average natural flow fall, MGD	297	297	3,014
Minimum average late summer flow downstream of intakes, MGD	226	226	267
Minimum average fall flow downstream of intakes, MGD	16	16	2,671
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	77 (96)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	79 (99)	0	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	74 (93)	0	1

Table A.5-46: 2050 Baseline: Lower Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	96.00%	28.99%	1.87%
Maximum number of days in a row of Potomac deficits	66	66	4
Number of days in which Potomac deficits must be allocated	118	106	7
Maximum amount of deficit allocated in a single day, MGD	(287.3)	(287)	(109)
Total amount of deficit allocated full simulation period, MG	(16,860)	(16,252)	(478)
Number of Patuxent water supply shortfalls over simulation period	205	63	--
Number of Occoquan water supply shortfalls over simulation period	73	70	1
Number of days in which Patuxent plant production is less than 30 MGD	5,148	212	23
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	11.45%	6.03%	39.97%
Emergency restrictions	4.54%	38.46%	6.30%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	0.00
Jennings Randolph water supply account	0.00	0.00	0.00
Jennings Randolph water quality account	2.30	3.02	4.73
Patuxent Reservoir	0.00	0.00	1.62
Occoquan Reservoir	0.00	0.00	2.09
Savage Reservoir	0.00	0.00	0.65
Milestone Reservoir	0.01	0.01	0.96
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.10
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.08	1.08	1.14
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	0.00
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.0	0.00	3.71
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	1.1	1.10	5.82
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	589	553	555
WMA July demand, no restrictions, with climate change impact, MGD	711	33	33
WMA annual demand, no restrictions, without climate change impact, MGD	583	--	--
WMA July demand, no restrictions, without climate change impact, MGD	687	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	355	355	501
Minimum average natural flow fall, MGD	297	297	3,014
Minimum average late summer flow downstream of intakes, MGD	187	187	238
Minimum average fall flow downstream of intakes, MGD	-47	-47	2,613
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	76.29 (95)	1	0
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	79 (99)	0	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	74 (93)	0	1

Table A.5-47: 2050 Baseline + Operations (Ops): Higher Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	17	0	0
Number of Occoquan water supply shortfalls over simulation period	66	1	0
Number of days in which Patuxent plant production is less than 30 MGD	3,553	200	318
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.11%	1.42%	0.05%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.23	2.45	2.27
Jennings Randolph water supply account	8.55	8.64	9.61
Jennings Randolph water quality account	2.64	5.10	3.26
Patuxent Reservoir	0.53	1.79	1.99
Occoquan Reservoir	2.11	3.39	3.26
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.79	0.89	0.80
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.11	0.11	0.20
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.74	0.80	0.78
Little Seneca Reservoir and Jennings Randolph water supply account, combined	10.9	11.10	11.89
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	16.6	16.66	19.58
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	18.5	18.59	21.18
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	479	466	461
WMA July demand, no restrictions, with climate change impact, MGD	582	28	28
WMA annual demand, no restrictions, without climate change impact, MGD	473	--	--
WMA July demand, no restrictions, without climate change impact, MGD	557	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	671	704	671
Minimum average natural flow fall, MGD	571	571	3,928
Minimum average late summer flow downstream of intakes, MGD	364	426	364
Minimum average fall flow downstream of intakes, MGD	291	291	3,647
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	71 (88)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-48: 2050 Baseline + Operations (Ops): Higher Flows and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	0	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,256	200	351
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.06%	31.68%	2.89%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.66	1.77	1.81
Jennings Randolph water supply account	6.16	6.19	7.57
Jennings Randolph water quality account	2.64	5.11	3.26
Patuxent Reservoir	0.55	1.87	1.96
Occoquan Reservoir	1.71	2.59	2.84
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.76	0.83	0.77
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.51	0.54	0.59
Little Seneca Reservoir and Jennings Randolph water supply account, combined	7.9	7.96	9.38
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	13.0	13.03	16.73
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	14.7	14.69	18.12
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	534	518	515
WMA July demand, no restrictions, with climate change impact, MGD	647	31	31
WMA annual demand, no restrictions, without climate change impact, MGD	528	--	--
WMA July demand, no restrictions, without climate change impact, MGD	622	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	671	704	671
Minimum average natural flow fall, MGD	571	571	3,928
Minimum average late summer flow downstream of intakes, MGD	332	399	332
Minimum average fall flow downstream of intakes, MGD	259	259	3,586
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	70 (88)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-49: 2050 Baseline + Operations (Ops): Higher Flows and High Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	99.99%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	0	0	--
Maximum amount of deficit allocated in a single day, MGD	(0.1)	(0)	--
Total amount of deficit allocated full simulation period, MG	(0)	(0)	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,124	165	356
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.75%	38.25%	10.54%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.84	0.90	1.26
Jennings Randolph water supply account	3.07	3.07	5.58
Jennings Randolph water quality account	2.33	4.01	3.25
Patuxent Reservoir	0.60	1.95	1.96
Occoquan Reservoir	1.63	2.11	2.69
Savage Reservoir	0.54	0.55	0.66
Milestone Reservoir	0.73	0.74	0.79
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.22	0.22	0.41
Little Seneca Reservoir and Jennings Randolph water supply account, combined	4.0	3.98	6.83
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	8.9	8.90	14.12
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	10.2	10.25	15.35
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	588	571	569
WMA July demand, no restrictions, with climate change impact, MGD	711	34	34
WMA annual demand, no restrictions, without climate change impact, MGD	583	--	--
WMA July demand, no restrictions, without climate change impact, MGD	687	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	671	704	671
Minimum average natural flow fall, MGD	571	571	3,928
Minimum average late summer flow downstream of intakes, MGD	301	378	301
Minimum average fall flow downstream of intakes, MGD	246	246	3,536
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	70 (88)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-50: 2050 Baseline + Operations (Ops): Medium Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	99.99%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	-	-	-
Number of days in which Potomac deficits must be allocated	0	0	-
Maximum amount of deficit allocated in a single day, MGD	(0.0)	(0)	-
Total amount of deficit allocated full simulation period, MG	(0)	(0)	-
Number of Patuxent water supply shortfalls over simulation period	30	-	-
Number of Occoquan water supply shortfalls over simulation period	0	-	-
Number of days in which Patuxent plant production is less than 30 MGD	3,606	62	357
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.75%	34.63%	8.93%
Emergency restrictions	0.58%	5.03%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.28	0.28	1.41
Jennings Randolph water supply account	1.44	1.44	6.18
Jennings Randolph water quality account	0.85	1.38	3.17
Patuxent Reservoir	0.00	1.34	1.58
Occoquan Reservoir	1.41	1.98	2.68
Savage Reservoir	0.31	0.31	0.65
Milestone Reservoir	0.65	0.66	0.76
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.04	0.04	0.44
Little Seneca Reservoir and Jennings Randolph water supply account, combined	1.7	1.74	7.59
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	5.7	5.67	13.53
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	6.8	6.81	14.76
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	533	513	513
WMA July demand, no restrictions, with climate change impact, MGD	646	31	31
WMA annual demand, no restrictions, without climate change impact, MGD	528		
WMA July demand, no restrictions, without climate change impact, MGD	622		
Minimum average flow			
Minimum average natural flow late summer, MGD	566	566	599
Minimum average natural flow fall, MGD	465	465	3,534
Minimum average late summer flow downstream of intakes, MGD	284	329	284
Minimum average fall flow downstream of intakes, MGD	234	234	3,201
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78.24 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66.01 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	77 (96)	0	1

Table A.5-51: 2050 Baseline + Operations (Ops): Medium Flows and Medium Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	99.95%	0.01%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	0	0	--
Maximum amount of deficit allocated in a single day, MGD	(0.3)	(0)	--
Total amount of deficit allocated full simulation period, MG	(0)	(0)	--
Number of Patuxent water supply shortfalls over simulation period	37	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,647	55	358
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.75%	26.61%	9.81%
Emergency restrictions	1.60%	13.58%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.06	0.06	1.35
Jennings Randolph water supply account	0.60	0.60	5.91
Jennings Randolph water quality account	0.22	0.70	3.20
Patuxent Reservoir	0.00	1.16	1.56
Occoquan Reservoir	1.22	1.40	2.67
Savage Reservoir	0.24	0.24	0.65
Milestone Reservoir	0.57	0.58	0.77
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.01	0.01	0.42
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.7	0.66	7.26
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	3.7	3.70	13.02
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	4.7	4.71	14.24
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	534	512	512
WMA July demand, no restrictions, with climate change impact, MGD	646	31	30
WMA annual demand, no restrictions, without climate change impact, MGD	528	--	--
WMA July demand, no restrictions, without climate change impact, MGD	622	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	535	535	589
Minimum average natural flow fall, MGD	440	440	3,487
Minimum average late summer flow downstream of intakes, MGD	281	314	281
Minimum average fall flow downstream of intakes, MGD	227	227	3,158
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	78 (98)	0	1

Table A.5-52: 2050 Baseline + Operations (Ops): Medium Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	98.99%	1.33%	0.00%
Maximum number of days in a row of Potomac deficits	2	2	--
Number of days in which Potomac deficits must be allocated	5	5	--
Maximum amount of deficit allocated in a single day, MGD	(53.7)	(54)	--
Total amount of deficit allocated full simulation period, MG	(188)	(188)	--
Number of Patuxent water supply shortfalls over simulation period	37	0	--
Number of Occoquan water supply shortfalls over simulation period	13	11	0
Number of days in which Patuxent plant production is less than 30 MGD	3,840	81	357
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	5.48%	15.09%	26.25%
Emergency restrictions	2.50%	26.27%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	0.61
Jennings Randolph water supply account	0.00	0.00	3.58
Jennings Randolph water quality account	0.00	0.04	3.19
Patuxent Reservoir	0.00	0.60	1.58
Occoquan Reservoir	0.07	0.07	2.51
Savage Reservoir	0.11	0.11	0.65
Milestone Reservoir	0.16	0.16	0.80
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.00	0.00	0.23
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	4.19
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	1.0	0.99	9.95
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	1.3	1.26	11.02
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	589	564	563
WMA July demand, no restrictions, with climate change impact, MGD	711	34	33
WMA annual demand, no restrictions, without climate change impact, MGD	583	--	--
WMA July demand, no restrictions, without climate change impact, MGD	687	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	535	535	589
Minimum average natural flow fall, MGD	440	440	3,487
Minimum average late summer flow downstream of intakes, MGD	264	296	265
Minimum average fall flow downstream of intakes, MGD	198	198	3,104
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	78 (98)	0	1

Table A.5-53: 2050 Baseline + Operations (Ops): Lower Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	98.75%	10.80%	0.00%
Maximum number of days in a row of Potomac deficits	20	20	--
Number of days in which Potomac deficits must be allocated	39	39	--
Maximum amount of deficit allocated in a single day, MGD	(134.5)	(135)	--
Total amount of deficit allocated full simulation period, MG	(2,081)	(2,081)	--
Number of Patuxent water supply shortfalls over simulation period	179	26	0
Number of Occoquan water supply shortfalls over simulation period	71	4	1
Number of days in which Patuxent plant production is less than 30 MGD	5,333	166	342
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	4.99%	12.80%	11.23%
Emergency restrictions	2.50%	29.15%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	1.34
Jennings Randolph water supply account	0.00	0.00	5.90
Jennings Randolph water quality account	0.00	0.00	3.04
Patuxent Reservoir	0.00	0.00	1.13
Occoquan Reservoir	0.68	0.69	2.43
Savage Reservoir	0.00	0.00	0.65
Milestone Reservoir	0.00	0.00	0.72
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.00	0.00	0.40
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	7.24
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.7	0.74	10.98
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.7	0.74	12.13
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	479	454	457
WMA July demand, no restrictions, with climate change impact, MGD	582	27	27
WMA annual demand, no restrictions, without climate change impact, MGD	473	--	--
WMA July demand, no restrictions, without climate change impact, MGD	557	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	355	355	501
Minimum average natural flow fall, MGD	297	297	3,014
Minimum average late summer flow downstream of intakes, MGD	253	254	264
Minimum average fall flow downstream of intakes, MGD	134	134	2,741
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	79 (99)	0	1
Patuxent Reservoir	64.12 (80)	0	0
Occoquan Reservoir	79.83 (100)	1	1
Savage Reservoir	74 (93)	0	1

Table A.5-54: 2050 Baseline + Operations (Ops): Lower Flows and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	98.71%	21.21%	0.01%
Maximum number of days in a row of Potomac deficits	45	45	--
Number of days in which Potomac deficits must be allocated	77	77	0
Maximum amount of deficit allocated in a single day, MGD	(248.1)	(248)	(0)
Total amount of deficit allocated full simulation period, MG	(7,494)	(7,494)	(0)
Number of Patuxent water supply shortfalls over simulation period	186	45	--
Number of Occoquan water supply shortfalls over simulation period	51	49	0
Number of days in which Patuxent plant production is less than 30 MGD	5,043	203	120
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	6.79%	10.05%	30.90%
Emergency restrictions	2.50%	33.12%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	0.57
Jennings Randolph water supply account	0.00	0.00	3.49
Jennings Randolph water quality account	0.00	0.00	2.99
Patuxent Reservoir	0.00	0.00	1.17
Occoquan Reservoir	0.01	0.01	2.18
Savage Reservoir	0.00	0.00	0.65
Milestone Reservoir	0.00	0.00	0.75
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.00	0.00	0.18
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	4.06
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.0	0.01	7.66
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.0	0.01	8.65
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	534	508	510
WMA July demand, no restrictions, with climate change impact, MGD	646	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	528	--	--
WMA July demand, no restrictions, without climate change impact, MGD	622	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	355	355	501
Minimum average natural flow fall, MGD	297	297	3,014
Minimum average late summer flow downstream of intakes, MGD	240	243	243
Minimum average fall flow downstream of intakes, MGD	59	59	2,678
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (97)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	79 (99)	0	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	74 (93)	0	1

Table A.5-55: 2050 Baseline + Operations (Ops): Lower Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	97.89%	27.04%	0.25%
Maximum number of days in a row of Potomac deficits	64	64	0
Number of days in which Potomac deficits must be allocated	100	99	1
Maximum amount of deficit allocated in a single day, MGD	(312.5)	(312)	(19)
Total amount of deficit allocated full simulation period, MG	(14,178)	(14,155)	(24)
Number of Patuxent water supply shortfalls over simulation period	195	53	--
Number of Occoquan water supply shortfalls over simulation period	71	68	1
Number of days in which Patuxent plant production is less than 30 MGD	5,119	210	30
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	7.50%	8.64%	36.11%
Emergency restrictions	2.50%	35.38%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	0.05
Jennings Randolph water supply account	0.00	0.00	2.41
Jennings Randolph water quality account	0.00	0.00	3.78
Patuxent Reservoir	0.00	0.00	1.77
Occoquan Reservoir	0.00	0.00	1.77
Savage Reservoir	0.00	0.00	0.65
Milestone Reservoir	0.00	0.00	0.64
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.10
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.00	0.00	0.09
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	2.47
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.0	0.00	6.53
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.0	0.00	7.35
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	589	558	561
WMA July demand, no restrictions, with climate change impact, MGD	712	33	33
WMA annual demand, no restrictions, without climate change impact, MGD	583	--	--
WMA July demand, no restrictions, without climate change impact, MGD	687	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	355	355	501
Minimum average natural flow fall, MGD	297	297	3,014
Minimum average late summer flow downstream of intakes, MGD	227	237	228
Minimum average fall flow downstream of intakes, MGD	-28	-28	2,613
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	77 (96)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	79 (99)	0	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	74 (93)	0	1

Table A.5-56: 2050 Baseline + Operations (Ops) + Travilah Quarry: Higher Flows and Low Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	76	1	1
Number of days in which Patuxent plant production is less than 30 MGD	3,432	183	215
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.00%	0.00%	0.00%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.65	2.86	2.70
Jennings Randolph water supply account	9.72	9.74	10.95
Jennings Randolph water quality account	2.64	4.94	3.26
Patuxent Reservoir	0.90	1.66	2.01
Occoquan Reservoir	2.10	3.49	3.33
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.83	0.91	0.84
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.11	0.11	0.67
Travilah Quarry	7.73	7.73	7.74
Beaverdam Reservoir	0.91	0.95	0.95
Little Seneca Reservoir and Jennings Randolph water supply account, combined	12.5	12.61	13.65
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	18.1	18.15	21.22
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	28.0	27.99	30.76
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	479	467	461
WMA July demand, no restrictions, with climate change impact, MGD	582	28	28
WMA annual demand, no restrictions, without climate change impact, MGD	473	--	--
WMA July demand, no restrictions, without climate change impact, MGD	557	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	671	704	671
Minimum average natural flow fall, MGD	570	570	3,927
Minimum average late summer flow downstream of intakes, MGD	344	404	344
Minimum average fall flow downstream of intakes, MGD	288	288	3,665
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	80 (100)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	71 (88)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-57: 2050 Baseline + Operations (Ops) + Travilah Quarry: Higher Flows and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,085	188	274
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.95%	12.87%	0.18%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.11	2.28	2.22
Jennings Randolph water supply account	7.50	7.55	8.85
Jennings Randolph water quality account	2.64	5.11	3.26
Patuxent Reservoir	0.91	1.81	1.96
Occoquan Reservoir	1.72	2.76	3.01
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.80	0.92	0.80
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.18
Travilah Quarry	7.73	7.73	7.74
Beaverdam Reservoir	0.70	0.75	0.76
Little Seneca Reservoir and Jennings Randolph water supply account, combined	9.7	9.82	11.07
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	14.8	14.78	18.46
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	24.4	24.42	27.78
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	534	522	515
WMA July demand, no restrictions, with climate change impact, MGD	647	31	31
WMA annual demand, no restrictions, without climate change impact, MGD	528	--	--
WMA July demand, no restrictions, without climate change impact, MGD	622	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	671	704	671
Minimum average natural flow fall, MGD	571	571	3,928
Minimum average late summer flow downstream of intakes, MGD	308	373	308
Minimum average fall flow downstream of intakes, MGD	244	244	3,594
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	70 (88)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-58: 2050 Baseline + Operations (Ops) + Travilah Quarry: Higher Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	--	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,032	134	281
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.58%	36.01%	5.14%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.54	1.62	1.77
Jennings Randolph water supply account	5.14	5.16	6.92
Jennings Randolph water quality account	2.64	5.09	3.24
Patuxent Reservoir	0.91	1.88	1.96
Occoquan Reservoir	1.66	2.29	2.69
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.78	0.86	0.78
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	7.73	7.73	7.74
Beaverdam Reservoir	0.48	0.51	0.60
Little Seneca Reservoir and Jennings Randolph water supply account, combined	6.7	6.78	8.70
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	11.7	11.75	15.88
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	21.2	21.15	25.02
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	588	569	568
WMA July demand, no restrictions, with climate change impact, MGD	711	34	34
WMA annual demand, no restrictions, without climate change impact, MGD	583	--	--
WMA July demand, no restrictions, without climate change impact, MGD	687	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	671	704	671
Minimum average natural flow fall, MGD	571	571	3,928
Minimum average late summer flow downstream of intakes, MGD	275	351	275
Minimum average fall flow downstream of intakes, MGD	215	215	3,535
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	70 (88)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-59: 2050 Baseline + Operations (Ops) + Travilah Quarry: Medium Flows and Low Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	0	--	--
Number of Occoquan water supply shortfalls over simulation period	76	1	1
Number of days in which Patuxent plant production is less than 30 MGD	4,177	145	295
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	2.43%	33.16%	0.00%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.71	1.71	2.34
Jennings Randolph water supply account	5.99	5.99	9.32
Jennings Randolph water quality account	2.56	4.26	3.20
Patuxent Reservoir	0.80	1.12	1.60
Occoquan Reservoir	1.85	2.50	3.28
Savage Reservoir	0.61	0.62	0.66
Milestone Reservoir	0.67	0.68	0.80
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.17
Travilah Quarry	7.69	7.70	7.71
Beaverdam Reservoir	0.51	0.51	0.81
Little Seneca Reservoir and Jennings Randolph water supply account, combined	7.7	7.71	11.67
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	11.9	11.87	18.07
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	21.3	21.27	27.41
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	479	465	461
WMA July demand, no restrictions, with climate change impact, MGD	582	28	28
WMA annual demand, no restrictions, without climate change impact, MGD	473	--	--
WMA July demand, no restrictions, without climate change impact, MGD	557	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	535	535	589
Minimum average natural flow fall, MGD	440	440	3,487
Minimum average late summer flow downstream of intakes, MGD	278	293	280
Minimum average fall flow downstream of intakes, MGD	184	184	3,200
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	67 (84)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	78 (98)	0	1

Table A.5-60: 2050 Baseline + Operations (Ops) + Travilah Quarry: Medium Flows and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,841	136	344
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.44%	38.29%	4.04%
Emergency restrictions	0.03%	0.17%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.88	0.88	1.80
Jennings Randolph water supply account	3.11	3.11	7.26
Jennings Randolph water quality account	2.28	3.86	3.18
Patuxent Reservoir	0.82	1.31	1.58
Occoquan Reservoir	1.40	1.79	2.77
Savage Reservoir	0.51	0.52	0.65
Milestone Reservoir	0.61	0.61	0.76
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	7.70	7.70	7.74
Beaverdam Reservoir	0.20	0.20	0.59
Little Seneca Reservoir and Jennings Randolph water supply account, combined	4.0	4.00	9.06
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	7.8	7.82	15.06
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	16.9	16.87	24.17
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	534	517	515
WMA July demand, no restrictions, with climate change impact, MGD	647	31	31
WMA annual demand, no restrictions, without climate change impact, MGD	528	--	--
WMA July demand, no restrictions, without climate change impact, MGD	622	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	566	566	599
Minimum average natural flow fall, MGD	465	465	3,534
Minimum average late summer flow downstream of intakes, MGD	259	302	259
Minimum average fall flow downstream of intakes, MGD	192	192	3,193
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	77 (96)	0	1

Table A.5-61: 2050 Baseline + Operations (Ops) + Travilah Quarry: Medium Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,660	146	218
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.65%	38.67%	6.34%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.94	0.94	1.81
Jennings Randolph water supply account	2.72	2.72	6.63
Jennings Randolph water quality account	1.90	3.18	3.18
Patuxent Reservoir	0.82	0.89	1.58
Occoquan Reservoir	1.34	1.73	2.56
Savage Reservoir	0.48	0.48	0.65
Milestone Reservoir	0.69	0.69	0.78
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	7.3	7.35	7.51
Beaverdam Reservoir	0.26	0.26	0.62
Little Seneca Reservoir and Jennings Randolph water supply account, combined	3.7	3.67	8.44
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	7.0	7.02	14.11
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	15.8	15.83	23.06
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	588	568	567
WMA July demand, no restrictions, with climate change impact, MGD	711	34	34
WMA annual demand, no restrictions, without climate change impact, MGD	583	--	--
WMA July demand, no restrictions, without climate change impact, MGD	687	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	566	566	599
Minimum average natural flow fall, MGD	465	465	3,534
Minimum average late summer flow downstream of intakes, MGD	206	252	206
Minimum average fall flow downstream of intakes, MGD	154	154	3,148
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	77 (96)	0	1

Table A.5-62: 2050 Baseline + Operations (Ops) + Travilah Quarry: Lower Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	74	1	1
Number of days in which Patuxent plant production is less than 30 MGD	5,324	207	316
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	2.78%	37.03%	0.00%
Emergency restrictions	0.13%	0.73%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.78	0.78	2.75
Jennings Randolph water supply account	2.59	2.59	9.96
Jennings Randolph water quality account	1.21	1.92	3.08
Patuxent Reservoir	0.68	0.74	1.12
Occoquan Reservoir	1.23	1.35	3.19
Savage Reservoir	0.08	0.08	0.66
Milestone Reservoir	0.42	0.42	0.81
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.47
Travilah Quarry	0.8	0.85	5.85
Beaverdam Reservoir	0.23	0.23	0.96
Little Seneca Reservoir and Jennings Randolph water supply account, combined	3.5	3.51	12.71
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	5.7	5.66	17.20
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	7.6	7.62	24.85
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	479	460	460
WMA July demand, no restrictions, with climate change impact, MGD	582	28	28
WMA annual demand, no restrictions, without climate change impact, MGD	473	--	--
WMA July demand, no restrictions, without climate change impact, MGD	557	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	355	355	501
Minimum average natural flow fall, MGD	297	297	3,014
Minimum average late summer flow downstream of intakes, MGD	180	180	194
Minimum average fall flow downstream of intakes, MGD	129	129	2,744
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	79 (99)	0	1
Patuxent Reservoir	64 (80)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	74 (93)	0	1

Table A.5-63: 2050 Baseline + Operations (Ops) + Travilah Quarry: Lower Flows and Medium Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	99.49%	1.06%	0.00%
Maximum number of days in a row of Potomac deficits	2	2	--
Number of days in which Potomac deficits must be allocated	4	4	--
Maximum amount of deficit allocated in a single day, MGD	(69.3)	(69)	--
Total amount of deficit allocated full simulation period, MG	(377)	(377)	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	32	31	--
Number of days in which Patuxent plant production is less than 30 MGD	5,273	208	365
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	4.99%	14.98%	8.74%
Emergency restrictions	2.50%	26.70%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	1.67
Jennings Randolph water supply account	0.00	0.00	6.20
Jennings Randolph water quality account	0.00	0.00	3.00
Patuxent Reservoir	0.64	0.77	1.08
Occoquan Reservoir	0.00	0.00	2.56
Savage Reservoir	0.00	0.00	0.65
Milestone Reservoir	0.00	0.00	0.75
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	1.01	1.01	7.44
Beaverdam Reservoir	0.00	0.00	0.54
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	7.87
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.8	0.80	11.68
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	1.9	1.90	20.46
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	534	513	513
WMA July demand, no restrictions, with climate change impact, MGD	646	31	31
WMA annual demand, no restrictions, without climate change impact, MGD	528	--	--
WMA July demand, no restrictions, without climate change impact, MGD	622	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	355	355	501
Minimum average natural flow fall, MGD	297	297	3,014
Minimum average late summer flow downstream of intakes, MGD	175	179	180
Minimum average fall flow downstream of intakes, MGD	134	134	2,689
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	79 (99)	0	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	74 (93)	0	1

Table A.5-64: 2050 Baseline + Operations (Ops) + Travilah Quarry: Lower Flows and High Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	98.75%	10.52%	0.00%
Maximum number of days in a row of Potomac deficits	19	19	--
Number of days in which Potomac deficits must be allocated	38	38	--
Maximum amount of deficit allocated in a single day, MGD	(263.0)	(263)	--
Total amount of deficit allocated full simulation period, MG	(5,044)	(5,044)	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	53	52	--
Number of days in which Patuxent plant production is less than 30 MGD	5,279	215	363
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	5.09%	11.52%	18.76%
Emergency restrictions	2.50%	30.88%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	1.30
Jennings Randolph water supply account	0.00	0.00	4.70
Jennings Randolph water quality account	0.00	0.00	2.97
Patuxent Reservoir	0.63	0.73	1.07
Occoquan Reservoir	0.00	0.00	2.25
Savage Reservoir	0.00	0.00	0.65
Milestone Reservoir	0.00	0.00	0.77
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	6.81
Beaverdam Reservoir	0.00	0.00	0.43
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	6.00
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.8	0.75	9.55
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.8	0.75	17.60
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	589	561	565
WMA July demand, no restrictions, with climate change impact, MGD	712	33	33
WMA annual demand, no restrictions, without climate change impact, MGD	583	--	--
WMA July demand, no restrictions, without climate change impact, MGD	687	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	355	355	501
Minimum average natural flow fall, MGD	297	297	3,014
Minimum average late summer flow downstream of intakes, MGD	153	164	153
Minimum average fall flow downstream of intakes, MGD	84	84	2,640
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (97)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	79 (99)	0	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	74 (93)	0	1

Table A.5-65: 2050 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Lower Flows and High Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	98.77%	8.75%	0.00%
Maximum number of days in a row of Potomac deficits	16	16	--
Number of days in which Potomac deficits must be allocated	32	32	--
Maximum amount of deficit allocated in a single day, MGD	(239.1)	(239)	--
Total amount of deficit allocated full simulation period, MG	(4,150)	(4,150)	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	49	48	--
Number of days in which Patuxent plant production is less than 30 MGD	5,299	220	363
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	5.00%	16.55%	9.32%
Emergency restrictions	2.50%	24.92%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	1.77
Jennings Randolph water supply account	0.00	0.00	5.99
Jennings Randolph water quality account	0.00	0.01	2.99
Patuxent Reservoir	0.63	0.70	1.07
Occoquan Reservoir	0.00	0.00	2.15
Savage Reservoir	0.00	0.00	0.65
Milestone Reservoir	0.00	0.00	0.67
Luck Stone (Quarry B)	0.00	0.00	1.48
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.02	0.02	6.11
Beaverdam Reservoir	0.00	0.00	0.65
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	7.77
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.7	0.72	11.16
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.8	0.75	20.10
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	588	565	567
WMA July demand, no restrictions, with climate change impact, MGD	712	34	34
WMA annual demand, no restrictions, without climate change impact, MGD	583	--	--
WMA July demand, no restrictions, without climate change impact, MGD	687	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	355	355	501
Minimum average natural flow fall, MGD	297	297	3,014
Minimum average late summer flow downstream of intakes, MGD	145	157	146
Minimum average fall flow downstream of intakes, MGD	89	89	2,634
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	79 (99)	0	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	74 (93)	0	1

Table A.5-66: 2050 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Higher Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	0	--	--
Number of Occoquan water supply shortfalls over simulation period	66	0	0
Number of days in which Patuxent plant production is less than 30 MGD	3,451	192	233
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.00%	0.00%	0.00%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.68	2.83	2.76
Jennings Randolph water supply account	9.67	9.69	10.87
Jennings Randolph water quality account	2.64	4.96	3.26
Patuxent Reservoir	0.90	1.67	1.99
Occoquan Reservoir	2.09	3.41	3.36
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.80	0.86	0.82
Luck Stone (Quarry B)	2.09	2.18	2.14
Vulcan Quarry	0.11	0.11	0.71
Travilah Quarry	7.73	7.73	7.74
Beaverdam Reservoir	0.94	0.96	0.98
Little Seneca Reservoir and Jennings Randolph water supply account, combined	12.4	12.53	13.63
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	18.0	18.00	21.23
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	30.3	30.31	32.93
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	479	470	460
WMA July demand, no restrictions, with climate change impact, MGD	582	28	28
WMA annual demand, no restrictions, without climate change impact, MGD	473	--	--
WMA July demand, no restrictions, without climate change impact, MGD	557	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	671	704	671
Minimum average natural flow fall, MGD	571	571	3,927
Minimum average late summer flow downstream of intakes, MGD	346	407	346
Minimum average fall flow downstream of intakes, MGD	281	281	3,664
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	80 (100)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	71 (88)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-67: 2050 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Higher Flows and Medium Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,121	193	304
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	0.79%	10.52%	0.04%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.14	2.28	2.28
Jennings Randolph water supply account	7.59	7.61	8.98
Jennings Randolph water quality account	2.64	5.11	3.26
Patuxent Reservoir	0.91	1.80	1.96
Occoquan Reservoir	1.72	2.67	3.03
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.76	0.83	0.78
Luck Stone (Quarry B)	1.73	1.83	1.84
Vulcan Quarry	0.10	0.11	0.22
Travilah Quarry	7.73	7.73	7.74
Beaverdam Reservoir	0.76	0.80	0.83
Little Seneca Reservoir and Jennings Randolph water supply account, combined	9.8	9.89	11.26
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	14.9	14.89	18.68
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	27.0	26.96	29.89
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	534	522	518
WMA July demand, no restrictions, with climate change impact, MGD	647	31	31
WMA annual demand, no restrictions, without climate change impact, MGD	528	--	--
WMA July demand, no restrictions, without climate change impact, MGD	622	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	671	704	671
Minimum average natural flow fall, MGD	571	571	3,928
Minimum average late summer flow downstream of intakes, MGD	307	377	307
Minimum average fall flow downstream of intakes, MGD	237	237	3,589
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	70 (88)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-68: 2050 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Higher Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	-	-	-
Number of days in which Potomac deficits must be allocated	-	-	-
Maximum amount of deficit allocated in a single day, MGD	-	-	-
Total amount of deficit allocated full simulation period, MG	-	-	-
Number of Patuxent water supply shortfalls over simulation period	-	-	-
Number of Occoquan water supply shortfalls over simulation period	-	-	-
Number of days in which Patuxent plant production is less than 30 MGD	3,150	162	346
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.48%	34.27%	4.26%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.64	1.74	1.84
Jennings Randolph water supply account	5.59	5.61	7.16
Jennings Randolph water quality account	2.64	5.11	3.24
Patuxent Reservoir	0.91	1.89	1.96
Occoquan Reservoir	1.62	1.97	2.58
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.66	0.69	0.74
Luck Stone (Quarry B)	1.37	1.43	1.52
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	7.73	7.73	7.74
Beaverdam Reservoir	0.58	0.61	0.67
Little Seneca Reservoir and Jennings Randolph water supply account, combined	7.3	7.36	9.00
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	12.1	12.10	16.10
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	23.3	23.36	26.79
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	588	570	568
WMA July demand, no restrictions, with climate change impact, MGD	711	34	34
WMA annual demand, no restrictions, without climate change impact, MGD	583		
WMA July demand, no restrictions, without climate change impact, MGD	687		
Minimum average flow			
Minimum average natural flow late summer, MGD	671	704	671
Minimum average natural flow fall, MGD	571	571	3,928
Minimum average late summer flow downstream of intakes, MGD	276	354	276
Minimum average fall flow downstream of intakes, MGD	215	215	3,529
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	70 (88)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	80 (100)	1	1

Table A.5-69: 2050 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Medium Flows and Low Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	72	1	1
Number of days in which Patuxent plant production is less than 30 MGD	4,118	146	249
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	1.85%	22.91%	0.00%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	2.03	2.03	2.56
Jennings Randolph water supply account	6.94	6.94	9.83
Jennings Randolph water quality account	2.56	4.25	3.20
Patuxent Reservoir	0.80	1.05	1.59
Occoquan Reservoir	1.84	2.62	3.33
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.59	0.59	0.80
Luck Stone (Quarry B)	1.60	1.60	2.03
Vulcan Quarry	0.10	0.11	0.34
Travilah Quarry	7.65	7.65	7.68
Beaverdam Reservoir	0.69	0.69	0.92
Little Seneca Reservoir and Jennings Randolph water supply account, combined	9.0	8.97	12.40
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	13.1	13.12	18.83
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	24.8	24.84	30.29
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	479	464	462
WMA July demand, no restrictions, with climate change impact, MGD	582	28	28
WMA annual demand, no restrictions, without climate change impact, MGD	473	--	--
WMA July demand, no restrictions, without climate change impact, MGD	557	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	535	535	589
Minimum average natural flow fall, MGD	440	440	3,487
Minimum average late summer flow downstream of intakes, MGD	269	287	270
Minimum average fall flow downstream of intakes, MGD	176	176	3,201
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	67 (84)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	78 (98)	0	1

Table A.5-70: 2050 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Medium Flows and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	3,858	153	353
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.20%	36.78%	2.08%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.11	1.11	1.94
Jennings Randolph water supply account	3.99	3.99	7.64
Jennings Randolph water quality account	2.60	4.72	3.18
Patuxent Reservoir	0.82	1.33	1.58
Occoquan Reservoir	1.11	1.20	2.76
Savage Reservoir	0.61	0.62	0.66
Milestone Reservoir	0.20	0.20	0.72
Luck Stone (Quarry B)	0.90	0.90	1.55
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	7.71	7.71	7.74
Beaverdam Reservoir	0.33	0.33	0.69
Little Seneca Reservoir and Jennings Randolph water supply account, combined	5.1	5.10	9.59
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	8.3	8.27	15.59
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	18.1	18.09	26.30
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	534	516	513
WMA July demand, no restrictions, with climate change impact, MGD	646	31	31
WMA annual demand, no restrictions, without climate change impact, MGD	528	--	--
WMA July demand, no restrictions, without climate change impact, MGD	622	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	566	566	599
Minimum average natural flow fall, MGD	465	465	3,534
Minimum average late summer flow downstream of intakes, MGD	264	304	264
Minimum average fall flow downstream of intakes, MGD	197	197	3,188
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	77 (96)	0	1

Table A.5-71: 2050 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Medium Flows and High Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	1	1	--
Number of days in which Patuxent plant production is less than 30 MGD	3,746	143	252
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.71%	38.45%	7.15%
Emergency restrictions	0.08%	0.69%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.67	0.67	1.75
Jennings Randolph water supply account	2.03	2.03	6.51
Jennings Randolph water quality account	1.20	1.88	3.18
Patuxent Reservoir	0.78	0.99	1.56
Occoquan Reservoir	0.60	0.60	2.34
Savage Reservoir	0.38	0.38	0.66
Milestone Reservoir	0.29	0.29	0.71
Luck Stone (Quarry B)	0.66	0.66	1.45
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	7.57	7.57	7.65
Beaverdam Reservoir	0.20	0.20	0.64
Little Seneca Reservoir and Jennings Randolph water supply account, combined	2.7	2.74	8.26
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	4.9	4.88	13.66
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	14.4	14.37	24.15
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	588	568	568
WMA July demand, no restrictions, with climate change impact, MGD	711	34	34
WMA annual demand, no restrictions, without climate change impact, MGD	583	--	--
WMA July demand, no restrictions, without climate change impact, MGD	687	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	535	535	589
Minimum average natural flow fall, MGD	440	440	3,487
Minimum average late summer flow downstream of intakes, MGD	209	245	209
Minimum average fall flow downstream of intakes, MGD	160	160	3,092
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	78 (98)	0	1

Table A.5-72: 2050 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Lower Flows and Low Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	77	1	1
Number of days in which Patuxent plant production is less than 30 MGD	5,326	203	323
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	2.73%	37.33%	0.00%
Emergency restrictions	0.03%	0.13%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.78	0.78	2.65
Jennings Randolph water supply account	2.80	2.80	9.65
Jennings Randolph water quality account	1.57	2.28	3.08
Patuxent Reservoir	0.68	0.76	1.11
Occoquan Reservoir	0.86	0.88	3.22
Savage Reservoir	0.07	0.07	0.66
Milestone Reservoir	0.06	0.06	0.79
Luck Stone (Quarry B)	0.71	0.71	2.07
Vulcan Quarry	0.10	0.11	0.33
Travilah Quarry	2.84	2.84	6.57
Beaverdam Reservoir	0.28	0.28	0.95
Little Seneca Reservoir and Jennings Randolph water supply account, combined	3.7	3.69	12.30
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	5.4	5.36	16.82
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	9.5	9.47	27.22
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	479	463	462
WMA July demand, no restrictions, with climate change impact, MGD	582	28	28
WMA annual demand, no restrictions, without climate change impact, MGD	473	--	--
WMA July demand, no restrictions, without climate change impact, MGD	557	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	355	355	501
Minimum average natural flow fall, MGD	297	297	3,014
Minimum average late summer flow downstream of intakes, MGD	179	180	195
Minimum average fall flow downstream of intakes, MGD	129	129	2,736
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	79 (99)	0	1
Patuxent Reservoir	64 (80)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	74 (93)	0	1

Table A.5-73: 2050 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Lower Flows and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	99.93%	0.20%	0.00%
Maximum number of days in a row of Potomac deficits	0	0	--
Number of days in which Potomac deficits must be allocated	1	1	--
Maximum amount of deficit allocated in a single day, MGD	(12.0)	(12)	--
Total amount of deficit allocated full simulation period, MG	(74)	(74)	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	24	23	--
Number of days in which Patuxent plant production is less than 30 MGD	5,255	219	361
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	4.08%	24.68%	0.88%
Emergency restrictions	2.34%	15.56%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.02	0.02	2.23
Jennings Randolph water supply account	0.11	0.11	7.89
Jennings Randolph water quality account	0.01	0.33	3.01
Patuxent Reservoir	0.64	0.71	1.08
Occoquan Reservoir	0.00	0.00	2.79
Savage Reservoir	0.01	0.01	0.66
Milestone Reservoir	0.01	0.01	0.71
Luck Stone (Quarry B)	0.10	0.10	1.79
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	1.92	1.92	6.29
Beaverdam Reservoir	0.01	0.01	0.82
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.2	0.15	10.12
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.9	0.89	14.18
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	3.1	3.07	23.81
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	534	513	514
WMA July demand, no restrictions, with climate change impact, MGD	646	31	31
WMA annual demand, no restrictions, without climate change impact, MGD	528	--	--
WMA July demand, no restrictions, without climate change impact, MGD	622	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	355	355	501
Minimum average natural flow fall, MGD	297	297	3,014
Minimum average late summer flow downstream of intakes, MGD	163	167	166
Minimum average fall flow downstream of intakes, MGD	130	130	2,687
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	79 (99)	0	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	74 (93)	0	1

Table A.5-74: 2050 Baseline + Operations (Ops) + Travilah + Luck Stone Quarries: Lower Flows and High Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	98.77%	8.75%	0.00%
Maximum number of days in a row of Potomac deficits	16	16	--
Number of days in which Potomac deficits must be allocated	32	32	--
Maximum amount of deficit allocated in a single day, MGD	(239.1)	(239)	--
Total amount of deficit allocated full simulation period, MG	(4,150)	(4,150)	--
Number of Patuxent water supply shortfalls over simulation period	--	--	--
Number of Occoquan water supply shortfalls over simulation period	49	48	--
Number of days in which Patuxent plant production is less than 30 MGD	5,299	220	363
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	5.00%	16.55%	9.32%
Emergency restrictions	2.50%	24.92%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.00	0.00	1.77
Jennings Randolph water supply account	0.00	0.00	5.99
Jennings Randolph water quality account	0.00	0.01	2.99
Patuxent Reservoir	0.63	0.70	1.07
Occoquan Reservoir	0.00	0.00	2.15
Savage Reservoir	0.00	0.00	0.65
Milestone Reservoir	0.00	0.00	0.67
Luck Stone (Quarry B)	0.00	0.00	1.48
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.02	0.02	6.11
Beaverdam Reservoir	0.00	0.00	0.65
Little Seneca Reservoir and Jennings Randolph water supply account, combined	0.0	0.00	7.77
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.7	0.72	11.16
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	0.8	0.75	20.10
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	588	565	567
WMA July demand, no restrictions, with climate change impact, MGD	712	34	34
WMA annual demand, no restrictions, without climate change impact, MGD	583	--	--
WMA July demand, no restrictions, without climate change impact, MGD	687	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	355	355	501
Minimum average natural flow fall, MGD	297	297	3,014
Minimum average late summer flow downstream of intakes, MGD	145	157	146
Minimum average fall flow downstream of intakes, MGD	89	89	2,634
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	78 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	79 (99)	0	1
Patuxent Reservoir	63 (79)	0	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	74 (93)	0	1

Table A.5-75: 2040 Baseline: No Climate Change and Medium Demands.

Historical period for simulation of variability	**1929-2009**	**1930**	**1966**
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	17	--	--
Number of Occoquan water supply shortfalls over simulation period	4	0	0
Number of days in which Patuxent plant production is less than 30 MGD	4,304	198	356
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.70%	35.18%	10.81%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.26	1.38	1.47
Jennings Randolph water supply account	4.61	5.08	5.15
Jennings Randolph water quality account	2.81	5.23	3.42
Patuxent Reservoir	0.00	1.72	1.65
Occoquan Reservoir	1.85	2.83	2.84
Savage Reservoir	0.62	0.65	0.66
Milestone Reservoir	0.80	0.80	0.98
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.10	1.10	1.16
Little Seneca Reservoir and Jennings Randolph water supply account, combined	5.9	6.47	6.62
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	11.2	11.34	12.80
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	13.4	13.57	14.95
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	503	486	484
WMA July demand, no restrictions, with climate change impact, MGD	602	30	29
WMA annual demand, no restrictions, without climate change impact, MGD	503	--	--
WMA July demand, no restrictions, without climate change impact, MGD	602	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	610	651	610
Minimum average natural flow fall, MGD	529	529	3,551
Minimum average late summer flow downstream of intakes, MGD	324	397	324
Minimum average fall flow downstream of intakes, MGD	259	259	3,254
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (82)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	78 (98)	1	1

Table A.5-76: 2050 Baseline: No Climate Change and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	17	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	4,289	188	358
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.91%	37.01%	20.81%
Emergency restrictions	0.14%	1.33%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	0.59	0.67	1.02
Jennings Randolph water supply account	2.36	2.63	3.46
Jennings Randolph water quality account	2.56	4.98	3.18
Patuxent Reservoir	0.00	1.70	1.55
Occoquan Reservoir	1.87	2.56	2.84
Savage Reservoir	0.53	0.53	0.65
Milestone Reservoir	0.64	0.64	0.96
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	1.09	1.09	1.15
Little Seneca Reservoir and Jennings Randolph water supply account, combined	2.9	3.29	4.48
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	7.8	7.92	10.60
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	10.0	10.12	12.72
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	530	511	506
WMA July demand, no restrictions, with climate change impact, MGD	634	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	530	--	--
WMA July demand, no restrictions, without climate change impact, MGD	634	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	601	641	601
Minimum average natural flow fall, MGD	524	524	3,545
Minimum average late summer flow downstream of intakes, MGD	309	382	309
Minimum average fall flow downstream of intakes, MGD	248	248	3,221
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (98)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	78 (98)	1	1

Table A.5-77: 2050 Baseline + Operations (Ops): No Climate Change and Medium Demands.

Historical period for simulation of variability	1929-2009	1930	1966
Reliability, Vulnerability, Resiliency			
Percentage years with no Potomac deficits	100.00%	0.00%	0.00%
Maximum number of days in a row of Potomac deficits	--	--	--
Number of days in which Potomac deficits must be allocated	--	--	--
Maximum amount of deficit allocated in a single day, MGD	--	--	--
Total amount of deficit allocated full simulation period, MG	--	--	--
Number of Patuxent water supply shortfalls over simulation period	17	--	--
Number of Occoquan water supply shortfalls over simulation period	0	--	--
Number of days in which Patuxent plant production is less than 30 MGD	4,225	184	357
Percentage of years with restrictions (Percentage of days for 1930 and 1966)			
Voluntary restrictions	3.74%	36.21%	7.73%
Emergency restrictions	0.00%	0.00%	0.00%
Minimum reservoir storage, BG			
Little Seneca Reservoir	1.24	1.32	1.49
Jennings Randolph water supply account	4.66	4.68	6.44
Jennings Randolph water quality account	2.55	4.90	3.19
Patuxent Reservoir	0.00	1.67	1.55
Occoquan Reservoir	1.46	2.07	2.71
Savage Reservoir	0.61	0.64	0.66
Milestone Reservoir	0.61	0.61	0.76
Luck Stone (Quarry B)	0.00	0.00	0.00
Vulcan Quarry	0.10	0.11	0.11
Travilah Quarry	0.00	0.00	0.00
Beaverdam Reservoir	0.34	0.36	0.47
Little Seneca Reservoir and Jennings Randolph water supply account, combined	5.9	6.00	7.93
Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	10.5	10.56	13.89
Milestone Reservoir, Quarry B, Vulcan, Travilah, Beaverdam, Patuxent, Occoquan, Little Seneca reservoirs and Jennings Randolph water supply, combined	12.0	12.03	15.14
Miscellaneous			
Number of years in simulation	80	1	1
WMA annual demand, no restrictions, with climate change impact, MGD	530	511	511
WMA July demand, no restrictions, with climate change impact, MGD	633	30	30
WMA annual demand, no restrictions, without climate change impact, MGD	530	--	--
WMA July demand, no restrictions, without climate change impact, MGD	633	--	--
Minimum average flow			
Minimum average natural flow late summer, MGD	601	641	601
Minimum average natural flow fall, MGD	524	524	3,545
Minimum average late summer flow downstream of intakes, MGD	290	372	290
Minimum average fall flow downstream of intakes, MGD	237	237	3,211
System mass balance, MGD	0	0	0
Number of years where reservoirs refill to 90 percent full by June 1 (percent probability)			
Little Seneca Reservoir	79 (99)	1	1
Jennings Randolph water supply account	80 (100)	1	1
Jennings Randolph water quality account	80 (100)	1	1
Patuxent Reservoir	66 (83)	1	0
Occoquan Reservoir	80 (100)	1	1
Savage Reservoir	78 (98)	1	1