Eliminating or Delaying Capital Improvements with Water Conservation: Miami-Dade Water Facilities Master Plan

Jessica R. Fritsche, Bertha M. Goldenberg, and William Y. Davis

The Miami-Dade Water and Sewer Department ("Department" or "MDWASD") is the largest water and sewer utility in the southeastern United States, currently providing drinking water to a service area population of approximately 2.3 million in Miami-Dade County. Figure 1 illustrates the location of the county.

The population in the Miami area is estimated to grow to about 2.8 million by 2030. To adequately provide water for this projected increase, the Department has looked closely at its projected water demand through multiple forecast iterations. Through these iterations, the Department has documented decreasing per capita water use patterns and has initiated investigations into the sources and permanence of the decline.

In 2004, the County submitted a water use permit (WUP) application to the South Florida Water Management District to increase withdrawals from the Biscayne aquifer to meet water demands for a 20-year period. In 2006, the County began to develop an alternative water supply (AWS) plan as part of the permit process. This document established a schedule of milestones and deadlines for the completion of a 20-year consumptive use permit (CUP) application that included alternative water supplies and water conservation measures to meet all additional future drinking water needs for the next 20-year period. The future water demand projections were based on a three-year average per capita use, as required by the District. The WUP was approved in November 2007, and was based on water demand projections of 155 gallons per capita per day.

Jessica R. Fritsche, is a planner, and William Y. Davis is senior economist, with CDM Smith in Denver. Bertha M. Goldenberg, P.E., is assistant director with Miami-Dade Water and Sewer Department..

The 2007 population and water demand projections for the Department's service area for the 20-year period are provided in Table 1. In Table 2, the capital improvements projects necessary to meet the water demands for the 20-year period are listed as estimated in 2007. The cost of these projects, totaling more than $1 billion, is very significant and warrants close attention to the evolving patterns of water customer demands.

Figure 1: Location of Miami-Dade County

Detailed Demand Forecast

The Department contracted with CDM Smith to prepare a computer model-based detailed water use profile and long-term water demand forecast, using 2005 water billing data as a base. This profile was used to confirm or adjust the WUP per capita forecast, and to better inform the Department about the geographic distribution of overall demand within its service area. The retail water use profile detailed single-family, multifamily, and nonresidential water use per unit across more than 1,400 traffic analysis zones (TAZs), which are planning units used by the Miami-Dade Department of Planning and Zoning (DPZ). Wholesale water use and non-revenue water (NRW) were also profiled and included in the forecast.

Demands by water use sector (e.g., single-family) and TAZ were forecasted to 2030 using 2005 billing data as a base year, as well as demographic projections developed by DPZ. Planned conservation from water use saving devices amounting to approximately 15 million gallons per day (mgd) was incorporated into the forecast at the TAZ level by sector.

Continued on page 18

Continued from page 16

Total finished water demand in the base year of 2005 was 347.4 mgd. Considering growth in population, housing, and employment, as well as planned reductions from conservation, 2030 demand was estimated to increase to 401.8 mgd. Figure 2 shows the results of this TAZ-based water demand forecast, along with the per capita demand forecast, the available water, and corresponding capital improvements projects, as identified in the approved WUP. The figure shows that TAZ-based projections were lower by approximately 10 mgd in 2030. In this figure, the timing of future capital improvement projects (and thus the timing of associated water availability increments) is conservatively kept the same as in Figure 2 (namely, based on the 2007 WUP projections), pending further study.

Detailed Reforecast Prompted by Year 2008 Demand Reduction

Between 2007, when the 20-year WUP was issued, and the end of 2008, the Department's water service area experienced a significant reduction in base water demand of approximately 40 mgd. In light of associated potential cost savings, the Department became interested in evaluating the true influences driving the reduction, as well as the likelihood of the reduction's permanence, to consider in the 2008-based demand forecast. Accordingly, in 2009, the Department asked CDM Smith to re-evaluate the water demand forecasts previously prepared, this time using 2008 billing data, which reflected the decline in demand. To the extent possible, the methodology used to develop demand profiles and projections was applied in a fashion consistent with the 2005-based efforts so direct comparisons could be made. Total finished water demand in 2008 was 306.4 mgd, or a 12 percent reduction from 2005.

Table 3 compares 2005 and 2008 demands by component. As shown, the single-family sector experienced the greatest reduction in demand, at 12 percent. The multifamily and nonresidential sectors experienced a 5 and 6.8 percent reduction in demand, respectively. Wholesale demand cannot be directly compared between years, because the Department no longer services a particular wholesale customer, which accounted for 12 mgd of demand in 2005 and because a previous wholesale area was incorporated into its retail system in late 2008. Overall, wholesale demand for ongoing customers was reduced by 9.5 percent from 2005 to 2008. The population served increased by approximately 1.5 percent.

The reduction was thought to be attributed to various influences, such as the Department's 20-year water conservation program that began in 2007, mandatory water irrigation restrictions imposed by the District in response to a severe drought in South Florida during 2007 and 2008, and, possibly, the downturn in the economy which began in late 2007. As before, a profile of water use for the Department's retail and wholesale systems was created using billing data for 2008. Demand projections were prepared to 2030 using updated DPZ demographic projections. Conservation savings were also incorporated into the demand forecast by sector and TAZ. Unfortunately, economic indicators were not available to show the impact of the recession at the time of the analysis due to the lag-time in reporting of economic statistics.

Multivariate Statistical Analysis: Methodology and Data

A component of the reforecast was to conduct an analysis of the Department's historical monthly water use to determine the im-

Table 1: Miami-Dade Water and Sewer Department Population and Water Demand Prepared for 2007 WUP Application

Year	Population	Finished Water Use (gpcd[a])	AADD Finished Water Use[b] (MGD)	Water Conservation[c] Reduction (mgd)	Adjusted Finished Water Demand[d] (mgd)
2007	2,250,944	155	348.90	1.09	347.81
2008	2,230,894	155	345.79	2.24	343.55
2009	2,260,476	155	350.37	3.53	346.84
2010	2,290,058	155	354.96	4.82	350.14
2011	2,319,639	155	359.54	6.34	353.20
2012	2,349,221	155	364.13	7.77	356.36
2013	2,378,803	155	368.71	9.28	359.43
2014	2,408,385	155	373.30	10.09	363.21
2015	2,438,819	155	378.02	10.89	367.13
2016	2,463,169	155	381.79	11.70	370.09
2017	2,487,519	155	385.57	12.51	373.06
2018	2,511,869	155	389.34	13.30	376.04
2022	2,609,268	155	404.44	16.46	387.98
2027	2,731,018	155	423.31	19.62	403.69
2030	2,804,068	155	434.63	19.62	415.01

(a) gpcd = gallons per capita per day
(b) Annual Average Daily Demand (AADD). Finished water projections between 2007 and 2030 assume 155 gpcd total water system demand prior to application of credits (e.g., conservation).
(c) The Department will be undertaking the 20-year water use efficiency plan and expects reductions in per capita water consumption. Water conservation projections were taken from comments the Department submitted to the District in April 2007. Values reflect projections as of April 2007. Real losses in water (e.g., unaccounted-for-water) are assumed to remain at less than 10 percent. Water conservation shall be in accordance with District Water Use Permit No. Re-Issue 13-00017-W, Limiting Condition Nos. 45 and 49 and Exhibit 27.
(d) Adjusted after taking credit in finished water demand projections for reductions in finished water use associated with water conservation.

Table 2: Miami-Dade Water and Sewer Department Capital Improvements Projects and Costs Associated with 2007 WUP

Number	Alternative Water Supply	Flow (mgd)	Capital Cost (SM)
1	Aquifer Storage and Recovery (ASR) Ultraviolet (UV) Disinfection System for West and Southwest Wellfields	7.2	6.4
2	Floridan Aquifer Blending Wellfield at Hialeah/Preston Plants	4.7	13.1
3	Hialeah Floridan Aquifer Reverse Osmosis (RO) Plant Phase 1 Capacity	8.5	116.0
4	South District Water Reclamation Plant (WRP) Groundwater Recharge Phase 1	18.6	359.0
5	Hialeah Floridan Aquifer RO Plant Phase 2	4.5	25.6
6	West District WRP Canal Recharge Phase 2	21.0	632.0
7	West District WRP Canal Recharge Phase 3	16.0	594.0
8	Hialeah Floridan Aquifer RO Plant Phase 3	2.0	12.2
	Totals	82.5	1,758.3

pacts of water use restrictions and weather on retail water consumption. The analysis used regression statistics to evaluate the historical variation in retail water use as a result of changes in weather, water rates, and the effective dates of water use restrictions. The following data were used for the regression analysis:

- Monthly retail and wholesale sales data were obtained from the Department for fiscal years 1980 through 2008 (i.e., October 1979 to September 2008), including both monthly sales and quarterly sales. The monthly and quarterly sales data were adjusted from the month reported (i.e., billed) to the month of consumption.
- The number of retail customers for each fiscal year for the period of September 1980 to September 2008, used to derive an estimated water use per customer in gallons per day, per customer, and per month.
- Monthly weather data were obtained from the National Weather Service for the Miami International Airport. Weather parameters included the monthly average of daily maximum temperature, monthly total precipitation, and the number of days in the month with precipitation greater than 0.01 inch.
- The marginal price of water was determined from Department's rate structures for fiscal years 1992 through 2008 (i.e., October 1991 to September 2008). The dry season surcharge was added to the marginal price when applicable. The reported rates (in nominal dollars) were adjusted for inflation (i.e., converted to real dollars) using the Consumer Price Index from the Bureau of Labor Statistics for the Miami-Fort Lauderdale area.
- Finally, information on when water use restrictions were in effect was obtained from the District Summary Water Shortage Orders from 1980 to 2006, District Water Shortage Orders by region, and Miami Herald archives from 1985 to 2007.

Figure 3 shows the monthly retail water use in mgd, as well as the number of retail customers. Until June 1989, retail water use increased as the number of customers increased. Tiered rate structures, plumbing codes, and watering restrictions were introduced in 1990 and 1991. Starting in the mid-1990s, the number of customers continued to increase, yet the retail water use generally leveled off, and, in fact, dropped from 2005 to 2007. Thus, it is apparent that these other factors came into play.

Figure 3 does not fully include the nationwide economic recession that began in December 2007, as declared by the National

Continued on page 20

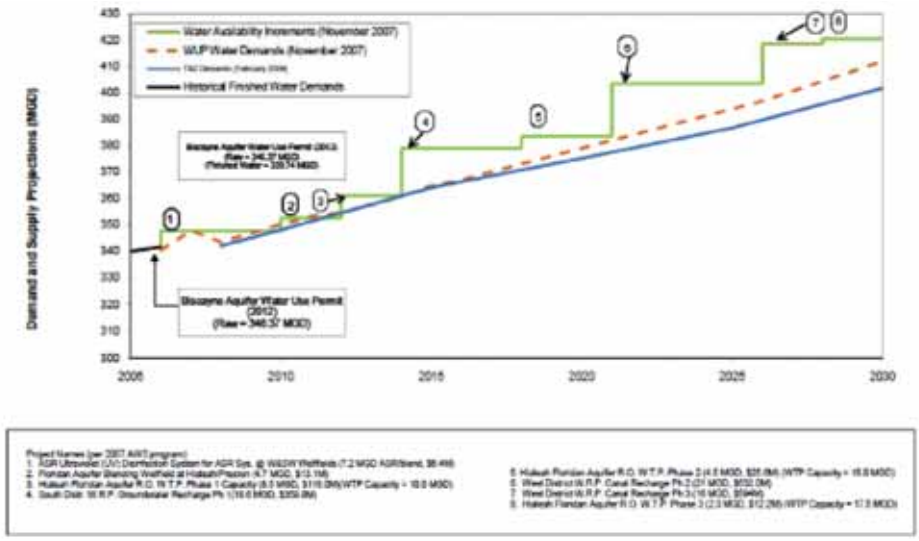

Figure 2: Water Demand Projections, Water Availability Increments, and Capital Improvement Projects

Table 3: Comparison of 2005 and 2008 Demands by Sector (in MG)

Component	2005 Billing Data	2008 Billing Data	Percent Change
Single-family	78.99	69.14	-12.0%
Multifamily	53.29	50.40	-5.0%
Nonresidential	61.98	57.75	-6.8%
Total Retail	194.26	177.29	-9.0%
Wholesale	76.33	62.39	-18.0%
Total Water Sold	270.60	239.68	-11.0%
NRW Volume	76.77	66.67	-13.0%
Total Finished Water	347.36	306.36	-12.0%
Population Served	2,190,625	2,222,932	1.5%
Per Capita (gpcd)	158.6	137.8	-13.0%

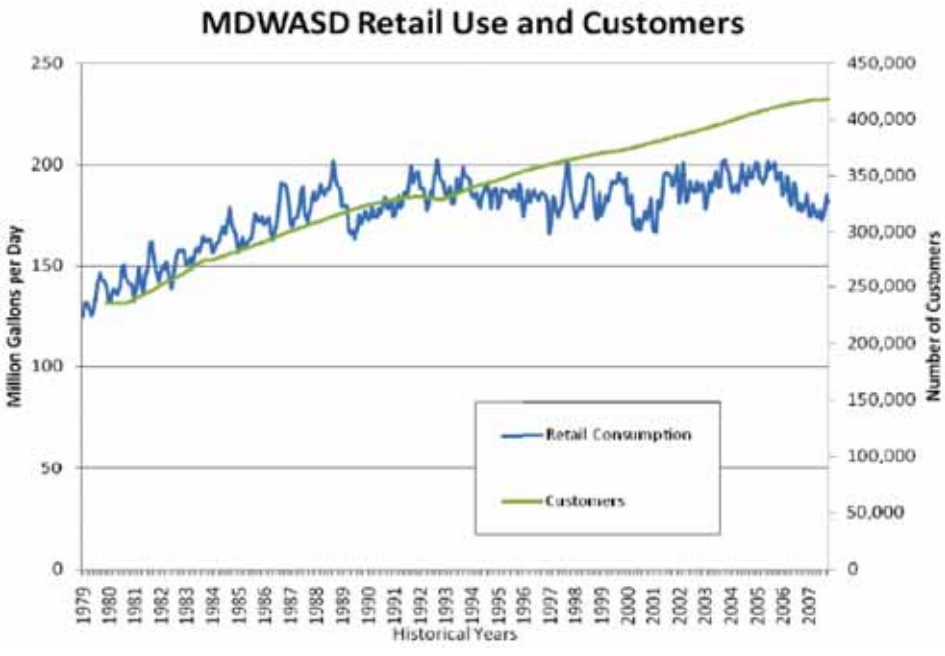

Figure 3: Retail Use and Number of Customers

Continued from page 19

Bureau of Economic Research (NBER), and is now over, according to NBER. In defining a recession, NBER looks at several economic variables, including the gross domestic product (GDP), which is the reading most typically associated with a recession by the general public. Unfortunately, at the time the analysis was being conducted, local GDP data were not up to date, making an economic analysis difficult.

Figure 4 shows the average water use per customer during fiscal years 1980 through 2008. Up until the early 1990s, water use per customer remained relatively steady, averaging about 575 gallons per day (gpd) and often exceeding 600 gpd per customer. After about 1991, the average use per customer began to decline, and, during FY 2008, the data show an average of about 425 gpd. The variations in monthly water use seen in both Figures 3 and 4 are due to the combined effects of weather, seasonal water use behaviors, and watering restrictions.

A subset of the database was created representing 17 years of data (October 1991 to September 2008). The average water use in gallons per day, per customer, and by month ranges from October, with an average of 489 gpd per customer, to June, with 520 gpd per customer. It is important to remember that this average use per retail customer is a blend of single-family, multifamily, and nonresidential sector customers, and not the average water use of any one sector. In FY 2008, October water use was 420 gpd per customer, and June water use was 444 gpd per customer.

Regression analysis was used to determine the relationship between the monthly gallons per day per customer (i.e., the dependent variable) and the other variables within the database of monthly data from October 1991 to September 2008. Variables in the database that are statistically significant in relation to monthly retail water use per customer include (a) the number of days with precipitation greater than 0.01 inches in the preceding month, (b) the marginal price of water in the third tier of the rate structure, and (c) implementation of Phase I and Phase II water use (i.e., irrigation) restrictions. These three variables are discussed below.

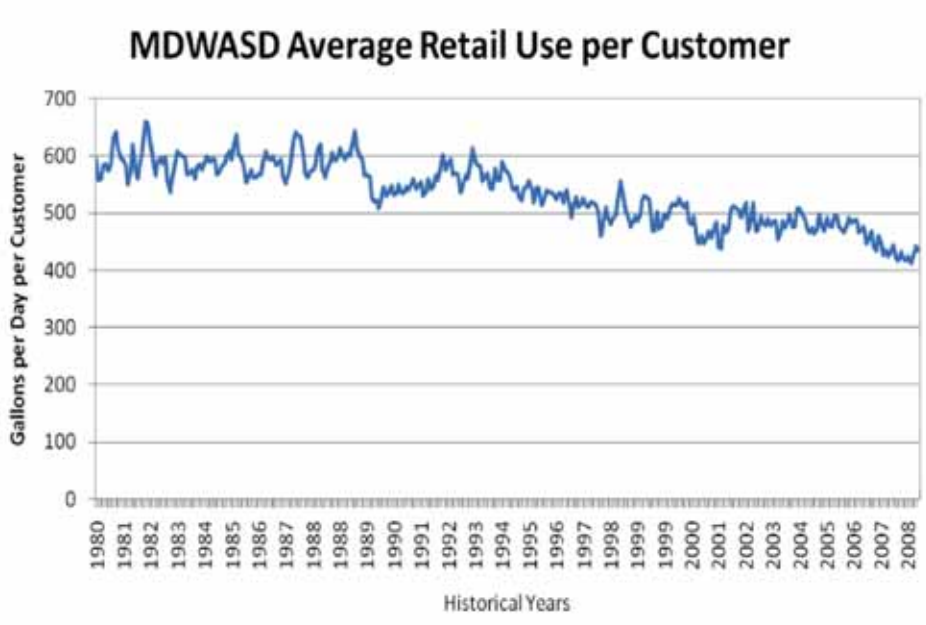

Figure 4: Miami-Dade Water and Sewer Department's Historical Average Retail Water Use per Customer

Table 4: System-wide Water Demand Forecasts Summary (mgd)

Forecasts Based on 2008 Data*	2010	2015	2020	2025	2030
Demand After Conservation	320.2	334.4	349.3	364.3	383.2
Forecasts Based on 2005 Data					
Demand After Conservation	348.1	364.1	375.2	386.7	401.8
Percent Change (2008 Relative to 2005)					
Demand After Conservation	-8%	-8%	-7%	-6%	-5%

Number of Days with Precipitation Variable

Analysis of historical water demand and historical weather data shows that the number of rainy days (i.e., the number of days with precipitation greater than 0.01 inch) has a statistically significant impact on water use. As the number of rainy days increases, water use decreases. The coefficient for the lagged number of rainy days indicates that a 10 percent increase in the number of days with precipitation greater than 0.01 inch in the preceding month is associated with a 2.6 percent decrease in monthly water use per customer. This lagged effect can be a result of psychological memory (i.e., "we are in a rainy period") or a reflection of soil moisture conditions that require less irrigation.

Weather data for FY2008 show that this time period had a total of 140 rainy days. The10-year average (i.e., 1999 to 2008) shows an annual average of 122.3 rainy days per year. Thus, FY2008 had 14.5 percent more rainy days than the annual average of the last ten years.

Marginal Price for Water Variables

The coefficient for nonresidential sector marginal price indicates that, as the volumetric rate in the third tier (plus the dry season surcharge) increases by 10 percent, the monthly water use per non-residential customer decreases by almost 35 percent.

Watering Restriction Variables

The coefficients for the binary (watering restriction) variables account for changes in the water use per customer during the months in which the water use restrictions were in effect. The Phase I (three-day per week irrigation) restrictions reduce average monthly water use per customer by about 7.5 percent, while the Phase II (two-day per week irrigation) restrictions reduce average monthly water use per customer by about an additional 3.1 percent, for total reduction of 10.6 percent from restrictions.

Results of Detailed Reforecast Based on Billing Data

For the updated demand forecast based on 2008 data, it was desirable to estimate future demands under normal weather conditions, but with permanent irrigation restrictions. The base year of the forecast was therefore normalized to account for reduced 2008 demands attributable to weather. Table 4 shows the estimated demands for the 2005-based and 2008-based detailed forecasts. As shown, the 2008-based forecast shows a 5 percent reduction in 2030.

Table 5: Miami-Dade Water and Sewer Department Population and Water Demand from WUP

Year	Population	Finished Water Use (gpcd)	AADD Finished Water Use[a](mgd)	Water Conservation[b] (mgd)	Adjusted Finished Water Demand[c](mgd)
2010	2,263,566	145.4	329.12	1.75	327.37
2011	2,288,432	145.4	332.74	2.64	330.10
2012	2,321,552	145.4	337.55	3.91	333.64
2013	2,347,030	145.4	341.26	5.18	336.08
2014	2,372,509	145.4	344.96	5.96	339.00
2015	2,401,027	145.4	349.11	6.74	342.37
2016	2,426,789	145.4	352.86	7.51	345.35
2017	2,452,550	145.4	356.60	8.29	348.31
2018	2,478,312	145.4	360.35	9.06	351.29
2022	2,581,358	145.4	375.33	12.12	363.21
2027	2,710,166	145.4	394.06	15.19	378.87
2030	2,787,451	145.4	405.30	15.19	390.11

(a) –AADD finished water projections between 2010 and 2030 assume 145.4 gpcd total water system demand prior to application of credits (e.g., conservation).
(b) The Department will be undertaking the 20-year water use efficiency plan and expects reductions in per capita water consumption. Water conservation projections were taken from comments the Department submitted to the District in April 2007. Values reflect projections as of April 2007. Real losses in water (e.g., unaccounted-for-water) are assumed to remain at less than 10 percent. Water conservation shall be in accordance with District Water Use Permit No. Re-Issue 13-00017-W, Limiting Condition Nos. 45 and 49 and Exhibit 27.
(c) Adjusted after taking credit in finished water demand projections for reductions in finished water use associated with water conservation.

Updating of Water Demands for Water Use Permit

Based on the results of the extensive work completed by the Department and CDM Smith to profile past water use, and to prepare updated water demand forecasts on a TAZ basis for use in the Water Facilities Master Plan Update, it was evident that a modification to the WUP was necessary and desirable. A modification to the WUP would establish updated reduced water demands and the revised list of projects and schedule necessary to provide the decreased water allocation. For consistency with previous WUPs, the methodology used to prepare the updated water demand forecast was the system-wide per capita methodology,

Continued on page 22

Continued from page 21
while keeping in mind the detailed 2008-based reforecast.

Review of water use during 2007 and 2008 revealed reductions as reflected in the TAZ-based methodology. Updating of the historical water per capita use to include the recent reductions in water usage yielded a revised per capita water demand of 145.4 gpcd. The updated population and water demand projections for the Department's service area for the 20-year period are provided in Table 5. Table 6 lists the updated capital improvements projects necessary to provide the water demands for the 20-year period. Figure 5 shows the updated water demand projections, available water, and corresponding capital improvements projects included in the WUP modification request submitted to the District in December 2009 (the "pending" WUP) and in the current WUP.

Capital Improvements Plan Implications

Figure 5 highlights the reduced water demand projection (dashed lines) and the reduced and delayed water availability projects. Two projects are no longer planned because of the demand reductions, eliminating more than $21 million of capital expenditures. The remaining six projects have been rescheduled to come on line when needed to meet the updated water demand projections. Two projects are delayed by one year. While this may not appear to be a significant delay, when consideration is given to the overall project amounts, a one-year delay could save several million dollars. One project has been delayed until 2027, allowing an additional nine years to obtain funding of the additional $25.6 million . Projects 5 and 6 are currently scheduled to come on line in 2027. The WUP will be reevaluated in 2017 and additional project modifications may occur.

Table 6: Miami-Dade Water and Sewer Department
Revised Capital Improvements Projects and Costs

Number	Alternative Water Supply (AWS) Project	Flow (mgd)	Costs ($M)
-	ASR UV Disinfection System for West and Southwest Wellfields	Cancelled	
-	Floridan Aquifer Blending Wellfield at Hialeah/Preston Plants	Cancelled	
1	Hialeah Floridan Aquifer RO Plant Phase 1 Capacity	10.0	116.0
2	South Miami Heights Water Treatment Plant (WTP)	20.0	359.0
4	Hialeah Floridan Aquifer RO Plant Phase 2	5.0	25.6
3	West District WRP Canal Recharge Phase 1	21.0	632.0
5	West District WRP Canal Recharge Phase 2	16.0	594.0
6	Hialeah Floridan Aquifer RO Plant Phase 3	2.5	12.2
	Total	74.5	1,738.8

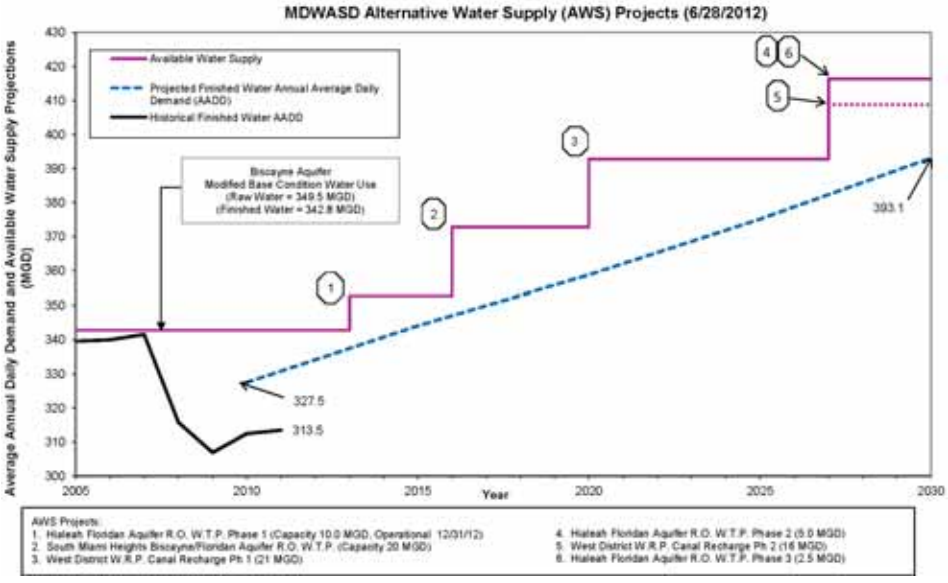

Figure 5: Updated Water Demand Projections,
Water Availability Increments, and Capital Improvement Projects

Summary

The County and the Department have committed to balancing the need for providing water to accommodate developmental growth in the County with meeting regulatory requirements and being fiscally responsible. Through diligent operational modifications and specific water conservation programs and requirements, the Department has successfully reduced and delayed capital improvements and necessary funding costs. To do this, it used two methodologies to study past water use and project future water demands. The two methodologies were utilized in the 20-year Water Facilities Master Plan Update, which was recently finalized.

Keeping track of water use patterns on a yearly or periodic basis and reacting to changes in water use has the potential for justifiably delaying funding commitments and the burdens they place on water utilities and their customers.

Acknowledgements

The authors would like to acknowledge the following contributors:
- Victor J. Pujals, P.E., BCEE, CDM Smith
- Armando I. Perez, P.E., PhD, CDM Smith

References

- CDM Smith (2008) Evaluation of Future Demands Reflecting Reduction in Unaccounted for Water and Conservation; Prepared for MDWASD.
- CDM Smith (2009) Task Authorization No. 10 – Water Demand Forecast Revisions/Update; Prepared for MDWASD.
- CDM Smith (2007) *Alternative Water Supply Plan*; Prepared for MDWASD.
- MDWASD (2009) Alternative Water Supply Plan and Reuse Feasibility Plan Annual Progress Report for January 1, 2008 through December 31, 2008.
- CDM Smith and MSA (2008) *Water Supply Facilities Work Plan*; Prepared for MDWASD.
- MDWASD (2009) Aquifer Storage and Recovery Implementation Plan.
- MDWASD Water Efficiency Section (March 2009); 2008 Annual Water Conservation Plan Conserve Florida Report.