Capacity Benefit Calculator Models Cost Savings from Capital Deferment

Tonya Simmons and Max A. Castaneda

Background

In 2012, Simmons Environmental Consulting (SEC) assisted the St. Johns River Water Management District (District) with the development of the Florida Automated Water Conservation Estimation Tool (FAWCET), which estimates water conservation potential across the District. It also estimates daily net benefits of implementing water conservation best management practices (BMPs) from the customer and utility perspectives by estimating daily avoidable costs that are based on water savings to be achieved by implementing BMPs. Further, FAWCET uses property appraiser data (age and size of home, lot size, etc.) to identify BMPs that are most appropriate at the parcel level.

Two crucial questions for the water conservation analyst are: "*Which* BMPs should I implement?" and "For each BMP, *how many* implementations should I do?" The first question is answered by ranking BMPs based on their daily net benefits; the second question is answered by FAWCET's optimization feature, which generates a table of BMPs and the number of implementations recommended for each BMP. Generally, this table is generated by first exhausting the number of available implementations for the highest-ranked (based on daily net benefit) BMP, then the next highest-ranked BMP, and so forth, until the user-defined objective function is met. A common example of an objective function would be to maximize water savings within a monetary budget.

It is important to understand that FAWCET evaluates net benefits of BMPs irrespective of an implementation schedule because all costs and savings are calculated by FAWCET as daily unit costs (costs and savings per day). From the first day that a BMP is implemented, water savings begin to accrue over the life of the BMP. In other words, a BMP that will save 100 gal per day (gpd) will save 100 gpd on day one of its implementation and continue saving 100 gpd throughout its life cycle (assuming savings do not decay).

After FAWCET has selected the optimal mix of BMPs for a particular parcel or service area, the next question the conservation analyst should ask is "*When* should I implement these BMPs?" This is a question that cannot be answered by FAWCET and one that cannot be answered without yearly projections of utility demands with and without conservation, the former of which depends on a yearly BMP implementation schedule. Further, without yearly projections of supply, demand, and BMP implementation, water conservation cannot be properly evaluated as an alternative to developing new capacity.

Economic benefits of conservation are expressed in terms of costs that are avoidable

Tonya Simmons, P.E., is a senior water resources engineer with Greenman-Pedersen Inc. in Tampa and is the former president of Simmons Environmental Consulting. Max A. Castaneda, MPAff, is an independent water resources consultant in Jacksonville and was formerly a water conservation expert with St. Johns River Water Management District.

through BMP implementation. These benefits include cost savings attributed to reduced (by conservation) operation and maintenance (O&M) costs, and cost savings attributed to deferring (or eliminating) the capital cost of future (new or expanded) capacity. Cost savings attributed to deferring (or eliminating) the capital cost of future (new or expanded) capacity is called the capacity benefit of conservation. In 2014, the District hired SEC to develop a stand-alone demonstration model, called a Capacity Benefit Calculator, to demonstrate how FAWCET results could be used by conservation planners and analysts to calculate the capacity benefit of conservation. Intrinsic to this effort was the demonstration of the need to develop and use yearly projections of demand, supply, and BMP implementation to properly evaluate conservation as a supply alternative.

Figure 1. Model Inputs of the Capacity Benefit Calculator

MODEL INPUTS

Period of Analysis (yrs) = 20
Discount Rate (%) = 3.50%

Demand without Conservation

Demand at Year 0 (MG) = 1.00
Demand at End of Period (MGD) = 4.00
Demand Growth (MGD/yr) = 0.15

Water Supply Capacity

Current Capacity (MGD) = 2.00
Capital Cost of Next Increment of Supply = $25,000,000

CONSERVATION BMP YEARLY IMPLEMENTATION SCHEDULE

BMP	WSR	Planning Year 1		Planning Year 2		Planning Year 3		Planning Year 4		Planning Year 5	
Name	(gpd/impl.)	NI_t	Cuml. NI_t	NI_t	Cuml. NI_t	NI_t	Cuml. NI_t	NI_t	Cuml. NI_t	NI_t	Cuml. NI_t
BMP - 1	75	0	0	400	400	400	800	400	1,200	400	1,600
BMP - 2	35	0	0	500	500	500	1,000	500	1,500	500	2,000
BMP - 3	10	0	0	600	600	600	1,200	600	1,800	600	2,400

BMP	Planning Year 6		Planning Year 7		Planning Year 8		Planning Year 9		Planning Year 10		Planning Year 20	
Name	NI_t	Cuml. NI_t	NI_t	Cuml. NI_t	NI_t	Cuml. NI_t	NI_t	Cuml. NI_t	NI_t	Cuml. NI_t	NI_t	Cuml. NI_t
BMP - 1	400	2,000	400	2,400	400	2,800	400	3,200	200	3,400	0	3,600
BMP - 2	500	2,500	500	3,000	500	3,500	500	4,000	250	4,250	0	4,500
BMP - 3	600	3,000	600	3,600	600	4,200	600	4,800	400	5,200	0	5,600

This article describes model inputs and calculations included in the calculator and the impact that BMP implementation *timing* asserts on the economic performance of conservation. Although not presented here (and not included in the model), avoidable O&M costs (another conservation benefit) are similarly sensitive to the timing of BMP implementation.

Inputs to the Capacity Benefit Calculator

Figure 1 includes a screenshot of model inputs, which include the following sets of variables:

Economic Planning

- *Period of Analysis (years)* – This is the period over which the economic analysis will occur. Typically, in Florida water management, 20 years is used.
- *Discount Rate (percentage)* – The Federal Water Resources Discount Rate published yearly in the Federal Register is an appropriate planning-level discount rate to use.

Water Supply and Demand Projections

- *Demand at Year 0 (mil gal per day [mgd])* – This is the utility's water demand at planning year 0 (one year prior to analysis start date).
- *Demand at End of Period (mgd)* – If the period of analysis is 20 years, this input would be the utility's demand at year 20.
- *Current Capacity (mgd)* – This is the total current capacity of the water utility (supply, treatment, and storage). Many utilities have various plants or storage facilities serving distinct zones in their overall service areas; in this case, demand and BMP implementation should be evaluated at the zone level and current capacity should reflect the capacity of the individual zones.
- *Capital Cost of Next Increment of Supply* – This is the capital cost of building the next increment of supply, expressed in year-1 constant dollars, which is the cost to build new or expand the existing water supply (withdrawal, treatment, and storage facilities).

Conservation Best Management Practices Yearly Implementation Schedule

- *BMP Description* – The analyst would enter each BMP here; FAWCET is an excellent tool to use to identify the best BMPs to implement for a utility service area.
- *Water Savings Rate (WSR)* – The amount of water saved by one implementation (i.e., retrofitting one fixture), expressed in gpd per implementation.
- *NI_t* – This is the number of BMP implementations at each year, t. The user enters a number of implementations for each BMP, and for each year. If FAWCET is used to select BMPs, the analyst should consider using the FAWCET-recommended total number of implementations for each BMP. The task for the analyst is then to apply the total number of implementations across the planning horizon in a manner that suits the utility's conservation budget or other planning goals.

Model Calculations and Outputs

Calculations and resulting outputs from the calculator are described as follows:

Conservation Best Management Practices Yearly Implementation Schedule

Using the number of BMPs implemented each year (*NIt*), the model calculates the cumulative number of implementations per year (*Cuml. NIt*), as shown in Figure 1.

Continued on page 30

CONSERVATION BMP YEARLY IMPLEMENTATION SCHEDULE

BMP Name	WSR (gpd/impl.)	Planning Year 1		Planning Year 2		Planning Year 6		Planning Year 7		Planning Year 8		Planning Year 9		Planning Year 10		Planning Year 20	
		NI_t	Cuml. NI_t	NI_t	Cuml. NI_t	NI_t	Cuml. NI_t	NI_t	Cuml. NI_t	NI_t	Cuml. NI_t	NI_t	Cuml. NI_t	NI_t	Cuml. NI_t	NI_t	Cuml. NI_t
BMP - 1	75	0	0	400	400	400	2,000	400	2,400	400	2,800	400	3,200	200	3,400	0	3,600
BMP - 2	35	0	0	500	500	500	2,500	500	3,000	500	3,500	500	4,000	250	4,250	0	4,500
BMP - 3	10	0	0	600	600	600	3,000	600	3,600	600	4,200	600	4,800	400	5,200	0	5,600

BMP YEARLY CUMULATIVE WATER SAVINGS

	Planning Year 1	Planning Year 2	Planning Year 6	Planning Year 7	Planning Year 8	Planning Year 9	Planning Year 10	Planning Year 20
BMP - 1	0	10,950	54,750	65,700	76,650	87,600	93,075	98,550
BMP - 2	0	6,388	31,938	38,325	44,713	51,100	54,294	57,488
BMP - 3	0	2,190	10,950	13,140	15,330	17,520	18,980	20,440
Program Yearly Totals (Kgal)	0	19,528	97,638	117,165	136,693	156,220	166,349	176,478

WATER DEMAND PROJECTIONS AND CAPACITY DEFERMENT

	Planning Year 1	Planning Year 2	Planning Year 6	Planning Year 7	Planning Year 8	Planning Year 9	Planning Year 10	Planning Year 20
Can New Capacity be Deferred?	Not Needed	Not Needed	Not Needed	Yes	Yes	Yes	No	No
Without Conservation (MGD)	1.15	1.30	1.90	2.05	2.20	2.35	2.50	4.00
With Conservation (MGD)	1.15	1.25	1.63	1.73	1.83	1.92	2.04	3.52

CAPACITY BENEFIT

$1,926,804

Continued from page 29

Best Management Practices Yearly Cumulative Water Savings

The calculator computes yearly BMP cumulative water savings (*Cumulative* WS_t) at the BMP level for each year of the planning horizon (period of analysis) as follows:

$$\text{Cumulative } WS_t = \text{Cumulative } NI_t \times WSR \times ((365 \text{ days/year}) \div (1{,}000 \text{ gal/Kgal}))$$

Where:

- Cumulative WS_t = Cumulative water savings at year t, expressed in Kgal
- Cumulative NI_t = Cumulative number of planned implementations in year t
- WSR = Water savings rate expressed as gpd per implementation

Note that in the preceding equation, yearly savings attributed to a BMP accumulate over time. It is precisely this cumulative effect that necessitates evaluating BMPs and programs temporally (implementations per year over the period of analysis). Yearly cumulative water savings are shown in Figure 2.

Water Demand Projections and Capacity Deferment

The calculator uses analysis start-year and end-year demands to calculate a constant demand growth rate (displayed in the model directly under the user-entered demands, as shown in Figure 1). The model uses the growth rate to calculate a linear yearly demand schedule with and without conservation (Figure 2). This is an oversimplified approach to projecting demands, but is provided for ease of use. It is recommended instead that the analyst manually enter yearly demand projections in the row "Demand without Conservation" (Figure 2).

The model calculates yearly demand with conservation by subtracting program yearly cumulative water savings from "Demand without Conservation" (Figure 2).

Based on demand projections with and without conservation, the calculator models projected capacity deferment potential and answers the following question: "Can New Capacity be Deferred?" (Figure 2). The capacity deferment potential for each year is defined as:

- *Not needed* = Demand without conservation is less than the current capacity.
- *Yes* = Demand without conservation exceeds current capacity, but demand with conservation is less than current capacity, meaning that the utility would not need the new capacity in that year.
- *No* = Demand with conservation exceeds current capacity.

Capacity Benefit

The objective of the model is to calculate the capacity benefit of conservation. The capacity benefit is the final value calculated by the model (bottom of Figure 2) and is calculated as follows:

Capacity Benefit = PV of New Capacity without Conserv.-PV of New Capacity with Conserv.

$$PV_{New\ Capacity} = C_{supply} \div (1+d)^n$$

Where:

- $PV_{New\ Capacity}$ = Present value (PV) cost of next increment of supply (new capacity), expressed in analysis start-year constant dollars
- $C_{New\ Capacity}$ = Capital cost of the next increment of supply (new capacity), expressed in analysis start-year (constant) dollars
- d = Real discount rate
- n = Number of years new capacity is discounted

The capital cost of the next increment of supply ($C_{New\ Capacity}$) and discount rate is the same, irrespective of the BMP implementation schedule. With respect to the capacity benefit, the only difference between the PV with conservation and the PV without conservation is "*n*," or the number of years the new capacity is discounted. New capacity can be deferred when conservation reduces demand ahead of the year that the new capacity would be needed if conservation were not implemented (or its effect was not sufficient to defer new capacity). Yearly demand with conservation is based on yearly cumulative water savings, which are based on the yearly BMP implementation schedule. As such, the capacity benefit cannot be calculated without a yearly BMP implementation schedule.

Using the Calculator to Demonstrate the Importance of Yearly Projections in Conservation Planning

The impact of yearly implementation schedules was demonstrated by exploring two conservation plan scenarios using the calculator. For both scenarios, every model input, including the total number of implementations for each BMP, were held constant and are the same as the inputs shown in Figure 1. The only difference between the two scenarios was the timing of BMP implementation (the BMP implementation schedule).

In scenario 1, BMP implementation began at planning year 2, and was rather 'front loaded' across the planning horizon, meaning the BMPs were planned for implementation in the first 12 years and then discontinued after year 12. For this scenario, the next increment of supply was deferred three years, namely years 7, 8, and 9. This implementation schedule resulted in a capacity benefit of approximately $1.9 million.

In scenario 2, the total number of BMPs implemented in the period of analysis was the same as for scenario 1; however, the total number of BMPs was equally distributed over the 20-year planning horizon. For this scenario, similar to scenario 1, the next increment of supply was deferred at year 7; however, supply was deferred for year 7 only. This resulted in a capacity benefit of approximately $664,000.

Summary

Florida water conservation planning tools, such as FAWCET, do a fine job of answering the following question: "*Which* BMPs should I implement?" Some tools, including FAWCET, answer this question for the analyst by ranking BMPs by their unit costs ($/Kgal saved) or, as in the case of FAWCET, by daily net savings. However, FAWCET, and most other Florida-based tools, do not answer this question: "*When* should I implement the BMPs?"

The Capacity Benefit Calculator helps the water conservation analyst model the impact that planned BMP-implementation timing may have on both demand projections and the timing of new capacity.

Although not explicitly discussed, the calculator can also be used to evaluate the ability of conservation to reduce the size of the next increment of supply. As previously mentioned, the calculator was developed for demonstration purposes; further developing the calculator into a holistic net-benefit calculator is recommended. This would include providing calculations of yearly avoidable O&M costs of current and future supplies as a function of yearly cumulative water savings. It is also recommended to use linear programming to automatically generate an optimized implementation schedule that maximizes the net benefit using budget constraints.