The St. Johns River Water Management District Comparative Account Water Conservation Linear Programming and Web-Based Implementation Tracking Tool

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The St. Johns River Water Management District staff has been working towards the development of a goal-based water conservation analysis that employs linear programming. The Comparative Account Water Conservation Linear Programming (CAWCLP) tool estimates the potential for water conservation throughout the entire District, attributable to the implementation of best management practices (BMPs). The District's water conservation analysis uses two data sources: utility billing records and standardized county property appraiser (parcel) data.

The District works with utility billing staff to obtain only the fields from the billing data that are necessary. The county appraiser database contains the square footage for all of the parcels within the District, as well as a Department of Revenue (DOR) land use code for each parcel. The DOR codes offer a way to segment a water utility customer market beyond a utility's customer rate categories, which vary across the hundreds of regulated utilities in the District.

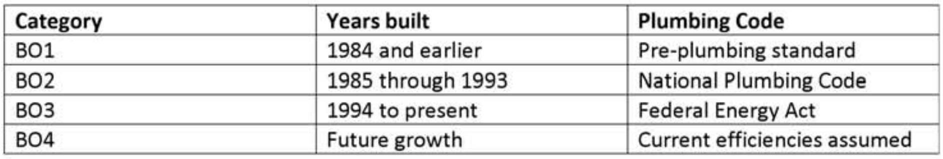
The account level consumption data are joined to county property appraiser parcels, and indoor use and outdoor use are estimated. The account level data often consists of a single potable meter, requiring a calculation to separate the minimum month (i.e., winter average) from the outdoor irrigation months. The result of this calculation is two separate volumes of annual average monthly indoor and outdoor water use. Some utilities provide consumption data for irrigation or reclaimed meters, in addition to potable meters, for some of their accounts. For accounts where outdoor use is metered separately, the metered potable use is considered indoor use, and is averaged.

Each single-family account is classified by the type of irrigation system present, and outdoor use is established. Each single-family account's historical consumption data is evaluated by subtracting the base from the peak use. The difference between the base and peak use determines whether accounts are categorized as either a hose irrigator (small base to peak ratio) or an in-ground irrigator (large base to peak ratio). This separation allows the appropriate BMPs to be applied to each account based on the type of irrigation used.

The conservation savings are represented as percentages of all outdoor use for each of the outdoor BMPs. The BMP costs are estimated to be the average cost of performing a BMP on a typical sized lot. Differences in size, design, and performance make it necessary to avoid attempting to quantify fixtures (sprinkler heads, feet of pipe, etc.) for outdoor BMPs, as is done for indoor BMPs.

To segment indoor use, each end use is represented as a fixed percentage of total indoor use. The percentages are applied to the total indoor consumption for each parcel to determine the volume of each end use. These fixed percentages are stable across the United States for indoor use. There are a number of benefits to using percentages for end use rather than calculating end use as a fixed volume from the number of times a fixture is used per person per day. The use of percentages allows the volume used by each type of fixture to scale up and down according to the billed indoor volume of use. This prevents post-conservation consumption estimates from being extremely low or negative in low-use accounts receiving multiple BMPs.

Table 1. Fixture efficiency classification by plumbing code



Category	Years built	Plumbing Code
BO1	1984 and earlier	Pre-plumbing standard
BO2	1985 through 1993	National Plumbing Code
BO3	1994 to present	Federal Energy Act
BO4	Future growth	Current efficiencies assumed

Fixture counts are estimated using the square footage of indoor area from the county appraisal database, and assumptions on the number of bathrooms per square foot area based on building construction codes. For accounts with more than two of any fixture type, the tool limits the number of replacements to two. This is done for two reasons: 1) The majority of the each end use is assumed to come from the most commonly used fixtures, and 2) A conservation program in practice would not pay to replace more than two of any fixture type because of the small incremental savings beyond the second fixture.

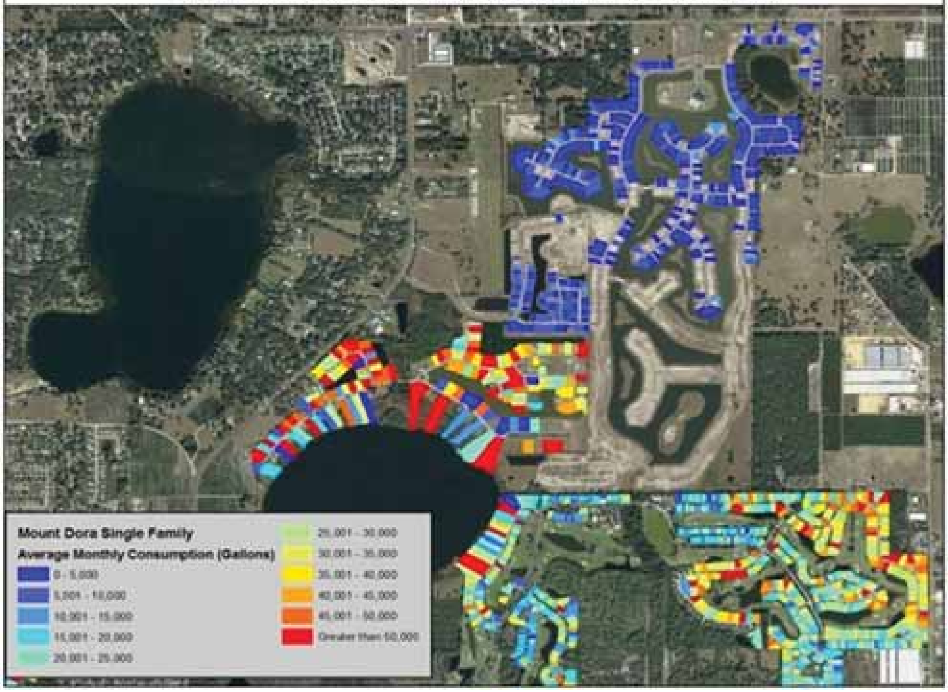
The efficiencies of original fixtures are assumed by aligning the year the property was built to a federal water efficiency plumbing code standard. The analysis breaks accounts out into the several categories in Table 1.

Fixtures are occasionally replaced by property owners over time due to remodeling, malfunction, or simply wearing out. An attempt is made to capture passive-replacement, using the device life of each fixture type. The difference between the current year and the year built is divided by the fixture life, then rounded down to the nearest integer. This calculation conservatively estimates the number of replacements that have occurred since the building was constructed. An effective plumbing code is assigned to each fixture. Water conservation program savings are calculated using the efficiency of each fixture's effective plumbing code.

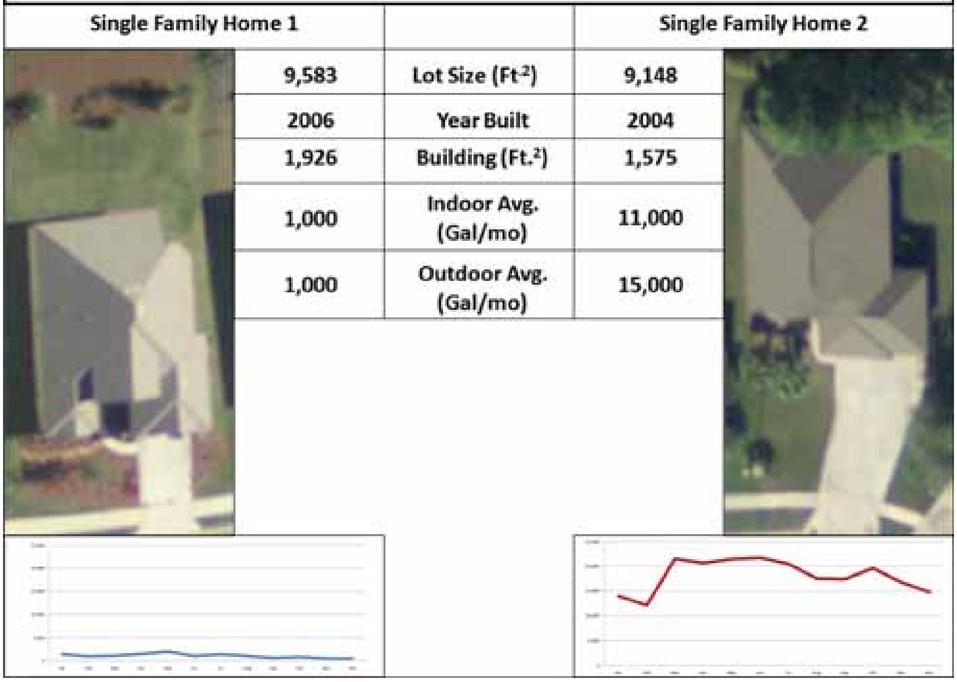
One use of the historical consumption data is to determine how successful a previous conservation effort has been. The developer of Lakes of Mount Dora, an environmentally-friendly neighborhood in the City of Mount Dora, teamed up with the city to employ Florida-Friendly Landscaping (a program using low-maintenance plants and environmentally sustainable practices) on all of its properties, along with a centrally controlled irrigation system. The new homes also feature high-efficiency indoor fixtures. Map 1 below compares the total monthly water use for properties in two different neighborhoods. The environmentally-friendly neighborhood is represented as the blue, low-use parcels in the northeast corner of the map.

A comparison between the low-use neighborhood and one of the high-use areas to the south shows homes with similar home and yard sizes, yet drastically different water use. Map 2 compares the monthly water use among similar homes from each neighborhood. In Map 2, indoor use is less in Home 1 due to water efficiency standards for indoor plumbing that exceed the building code. The yards of the homes in the high-use areas are mostly sod, requiring frequent irrigation. Note the Florida-friendly landscaping in the yard of the low-use home (Home 1).

Map 1. Mount Dora Single Family Average Monthly Consumption



Map 2. Single Family Account Comparison



Single Family Home 1		Single Family Home 2
9,583	Lot Size (Ft.^{2})	9,148
2006	Year Built	2004
1,926	Building (Ft.^{2})	1,575
1,000	Indoor Avg. (Gal/mo)	11,000
1,000	Outdoor Avg. (Gal/mo)	15,000

Linear Programming Tool

The first version of the linear programming tool aggregated accounts by customer class (DOR code), plumbing code, and consumption level. This aggregation allowed accounts to be analyzed in about an hour and a half, regardless of the number of accounts input into the tool.

One of the challenges of aggregating account level billing data is the way in which the number of fixtures are estimated for accounts within a group. The calculation of fixture counts occurs in the aggregate within the tool, using the sum of the square footage of all accounts within a group. While a comparison of calculating fixtures at the aggregate level versus an account-by-account level did not result in much variation in total, it is important to carefully estimate the number of fixtures present in each parcel. When comparing two accounts at the same level of consumption, the account with only one fixture would require half of the investment to save the same volume of water as the account with two fixtures. This aggregate method was featured, beginning on page 49, in the August 2011 *Florida Water Resources Journal*.

Another challenge for the development of the aggregated version of the linear programming tool was the availability of a solver to run the massive account-by-account linear program containing thousands of decision variables and constraints. Since Excel's Solver program has a limit of 200 decision variables, alternative spreadsheet solvers were evaluated, resulting in the implementation of the OpenSolver add-in (www.opensolver.org). When the decision variable issue was resolved by moving to OpenSolver, this brought up a new issue with the solve time due to the size of the linear program. The solver add-in took about 1.5 hours to solve the aggregated version, and several days to generate a result for 30,000 accounts evaluated individually.

District staff began collaborating with staff at opensolver.org, which had the potential

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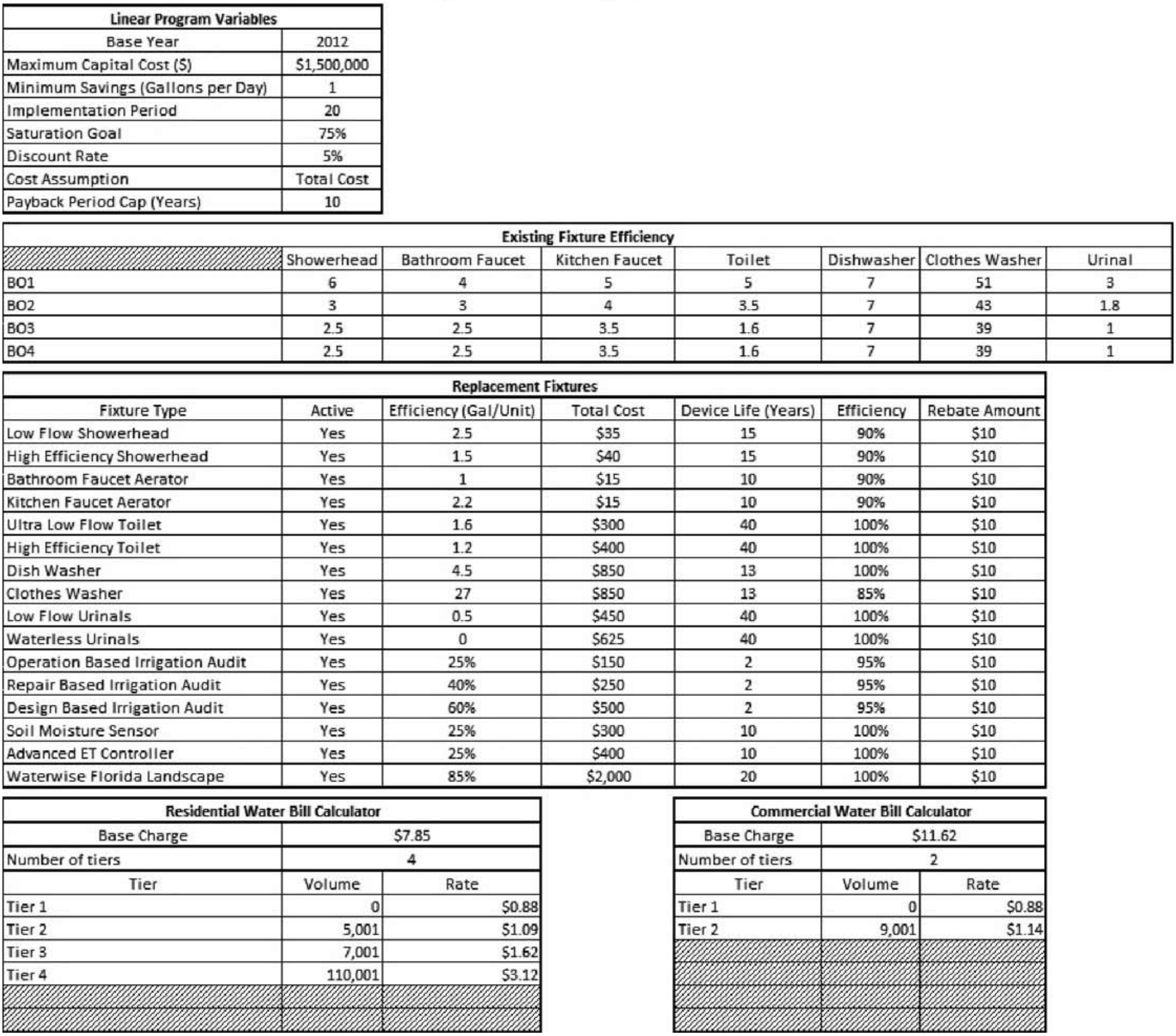
Figure 1. Assumptions Tables



Linear Program Variables	
Base Year	2012
Maximum Capital Cost ($)	$1,500,000
Minimum Savings (Gallons per Day)	1
Implementation Period	20
Saturation Goal	75%
Discount Rate	5%
Cost Assumption	Total Cost
Payback Period Cap (Years)	10

Existing Fixture Efficiency

▨	Showerhead	Bathroom Faucet	Kitchen Faucet	Toilet	Dishwasher	Clothes Washer	Urinal
BO1	6	4	5	5	7	51	3
BO2	3	3	4	3.5	7	43	1.8
BO3	2.5	2.5	3.5	1.6	7	39	1
BO4	2.5	2.5	3.5	1.6	7	39	1

Replacement Fixtures

Fixture Type	Active	Efficiency (Gal/Unit)	Total Cost	Device Life (Years)	Efficiency	Rebate Amount
Low Flow Showerhead	Yes	2.5	$35	15	90%	$10
High Efficiency Showerhead	Yes	1.5	$40	15	90%	$10
Bathroom Faucet Aerator	Yes	1	$15	10	90%	$10
Kitchen Faucet Aerator	Yes	2.2	$15	10	90%	$10
Ultra Low Flow Toilet	Yes	1.6	$300	40	100%	$10
High Efficiency Toilet	Yes	1.2	$400	40	100%	$10
Dish Washer	Yes	4.5	$850	13	100%	$10
Clothes Washer	Yes	27	$850	13	85%	$10
Low Flow Urinals	Yes	0.5	$450	40	100%	$10
Waterless Urinals	Yes	0	$625	40	100%	$10
Operation Based Irrigation Audit	Yes	25%	$150	2	95%	$10
Repair Based Irrigation Audit	Yes	40%	$250	2	95%	$10
Design Based Irrigation Audit	Yes	60%	$500	2	95%	$10
Soil Moisture Sensor	Yes	25%	$300	10	100%	$10
Advanced ET Controller	Yes	25%	$400	10	100%	$10
Waterwise Florida Landscape	Yes	85%	$2,000	20	100%	$10

Residential Water Bill Calculator

Base Charge	$7.85	
Number of tiers	4	
Tier	Volume	Rate
Tier 1	0	$0.88
Tier 2	5,001	$1.09
Tier 3	7,001	$1.62
Tier 4	110,001	$3.12
▨	▨	▨
▨	▨	▨

Commercial Water Bill Calculator

Base Charge	$11.62	
Number of tiers	2	
Tier	Volume	Rate
Tier 1	0	$0.88
Tier 2	9,001	$1.14
▨	▨	▨
▨	▨	▨
▨	▨	▨
▨	▨	▨

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to solve the larger account level problem in much less time by moving to their SolverStudio platform, which uses modeling language PuLP-Python to build optimization problems. The staff at opensolver.org made improvements to their solver in order for it to accommodate the larger problem. District staff continued to work collaboratively with staff at opensolver.org and have successfully transitioned from OpenSolver to SolverStudio for the District's water conservation tool.

District staff began to develop a method to use the raw form of the joined consumption and parcel data, allowing the results of the analysis to be linked back to individual parcels. This is key to targeting parcels in the development of an implementation plan. Analyzing the data account-by-account resulted in being able to pre-process the account-level data more efficiently by eliminating the need to aggregate the accounts at the kilo-gallon level of consumption, customer class, and year built.

Additional benefits of moving to an account-by-account approach include fixture counts performed at the parcel level, the calculation of a water utility bill before and after the water conservation BMPs are applied, and a payback period calculated for customers based on their BMP investment, consumption, and utility water rate schedule. The CAWCLP tool has functionality built in, which allows a payback period threshold to be established and considered as a goal in the optimization process.

The tool consists of three tabs within Excel: the assumptions, the linear program (LP), and the summary table. The assumptions tab is where all of the customizable water use assumptions are stored and can be adjusted by the user. This tab includes the linear program variables, the end-use proportions by customer class, existing fixture efficiency, the replacement fixture list (including cost, savings, device life, efficiency, and rebate amount), fixture counts, and water bill calculator. The analysis is typically run with the default values; however, the values can be

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adjusted by the water utility before it runs the analysis. For example, if the cost shown in the assumptions table is high and a utility (and its buying power) can purchase the fixture at a lower cost, that cost could be adjusted in the assumptions table. Figure 1 shows the assumptions tab.

The raw data and linear program resides in the LP tab. The objective function calculates the amount of water conservation that can be obtained with a given budget, subject to the number of fixtures available in total. User can also specify the amount of savings desired in gallons per day. The payback period can be specified for each account through a constraint. Once the linear program is executed, the result is the number of fixtures selected for replacement for each parcel subject to the budget and fixture constraints. The geo-location of the parcel from the county appraisal information allows the model result for each account to be linked to its location on a map. Figure 2 shows the global constraints and objective function along with input data for a handful of accounts. The account data extends down thousands of rows, with one row for each account.

The last-tab summary sheet summarizes all of the fixtures selected by the CAWCLP and lists them by BMP. It also projects the amount of future use and savings over any desired planning horizon. The total number of estimated passive replacement fixtures is summarized using passive replacement assumptions, which are a part of the assumptions table. The number of available fixtures is adjusted by the passive replacement assumptions, before savings are calculated. This represents a conservative approach and the passive replacement savings is only summarized over the period of the selected planning horizon. The summary page includes a cost per 1,000 gallons using the amortized cost over the planning horizon divided by the annual savings estimated by the CAWCLP tool. Figure 3 shows the summary sheet for a sample run of residential properties at a cost threshold of $1.5 million.

The BMPs (see Figure 4) are sorted by cost/kgal to develop an implementation schedule. This relegates the more expensive BMPs to the latter years and allows for changes in the plan as costs for BMPs decrease or future technology allows for an improved list of alternative cost-effective BMPs. The tool also attempts to account for the energy savings from not having to treat and deliver the water that is conserved.

There are several options for estimating the future use over the planning horizon for

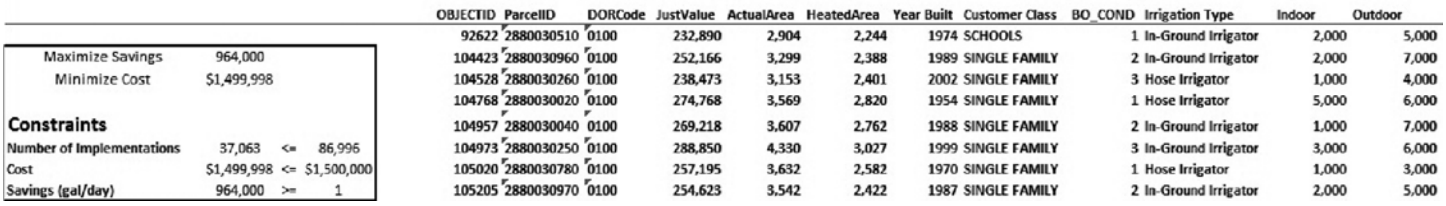

Figure 2. Linear Program Inputs

Maximize Savings	964,000		
Minimize Cost	$1,499,998		
Constraints			
Number of Implementations	37,063	<=	86,996
Cost	$1,499,998	<=	$1,500,000
Savings (gal/day)	964,000	>=	1

OBJECTID	ParcelID	DORCode	JustValue	ActualArea	HeatedArea	Year Built	Customer Class	BO_COND	Irrigation Type	Indoor	Outdoor
92622	2880030510	0100	232,890	2,904	2,244	1974	SCHOOLS	1	In-Ground Irrigator	2,000	5,000
104423	2880030960	0100	252,166	3,299	2,388	1989	SINGLE FAMILY	2	In-Ground Irrigator	2,000	7,000
104528	2880030260	0100	238,473	3,153	2,401	2002	SINGLE FAMILY	3	Hose Irrigator	1,000	4,000
104768	2880030020	0100	274,768	3,569	2,820	1954	SINGLE FAMILY	1	Hose Irrigator	5,000	6,000
104957	2880030040	0100	269,218	3,607	2,762	1988	SINGLE FAMILY	2	In-Ground Irrigator	1,000	7,000
104973	2880030250	0100	288,850	4,330	3,027	1999	SINGLE FAMILY	3	In-Ground Irrigator	3,000	6,000
105020	2880030780	0100	257,195	3,632	2,582	1970	SINGLE FAMILY	1	Hose Irrigator	1,000	3,000
105205	2880030970	0100	254,623	3,542	2,422	1987	SINGLE FAMILY	2	In-Ground Irrigator	2,000	5,000

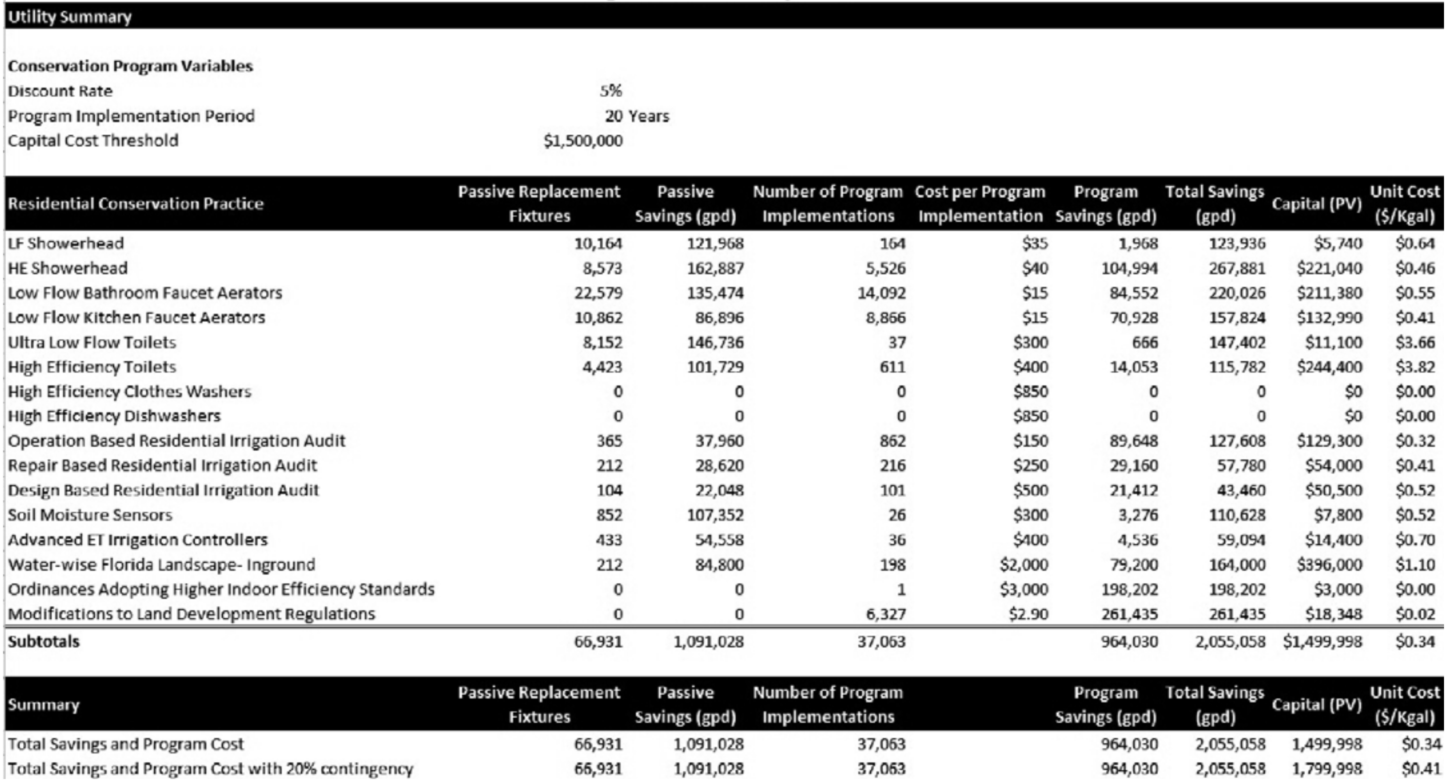

Figure 3. Summary Sheet

Utility Summary

Conservation Program Variables

Discount Rate	5%	
Program Implementation Period	20	Years
Capital Cost Threshold	$1,500,000	

Residential Conservation Practice	Passive Replacement Fixtures	Passive Savings (gpd)	Number of Program Implementations	Cost per Program Implementation	Program Savings (gpd)	Total Savings (gpd)	Capital (PV)	Unit Cost ($/Kgal)
LF Showerhead	10,164	121,968	164	$35	1,968	123,936	$5,740	$0.64
HE Showerhead	8,573	162,887	5,526	$40	104,994	267,881	$221,040	$0.46
Low Flow Bathroom Faucet Aerators	22,579	135,474	14,092	$15	84,552	220,026	$211,380	$0.55
Low Flow Kitchen Faucet Aerators	10,862	86,896	8,866	$15	70,928	157,824	$132,990	$0.41
Ultra Low Flow Toilets	8,152	146,736	37	$300	666	147,402	$11,100	$3.66
High Efficiency Toilets	4,423	101,729	611	$400	14,053	115,782	$244,400	$3.82
High Efficiency Clothes Washers	0	0	0	$850	0	0	$0	$0.00
High Efficiency Dishwashers	0	0	0	$850	0	0	$0	$0.00
Operation Based Residential Irrigation Audit	365	37,960	862	$150	89,648	127,608	$129,300	$0.32
Repair Based Residential Irrigation Audit	212	28,620	216	$250	29,160	57,780	$54,000	$0.41
Design Based Residential Irrigation Audit	104	22,048	101	$500	21,412	43,460	$50,500	$0.52
Soil Moisture Sensors	852	107,352	26	$300	3,276	110,628	$7,800	$0.52
Advanced ET Irrigation Controllers	433	54,558	36	$400	4,536	59,094	$14,400	$0.70
Water-wise Florida Landscape- Inground	212	84,800	198	$2,000	79,200	164,000	$396,000	$1.10
Ordinances Adopting Higher Indoor Efficiency Standards	0	0	1	$3,000	198,202	198,202	$3,000	$0.00
Modifications to Land Development Regulations	0	0	6,327	$2.90	261,435	261,435	$18,348	$0.02
Subtotals	66,931	1,091,028	37,063		964,030	2,055,058	$1,499,998	$0.34

Summary	Passive Replacement Fixtures	Passive Savings (gpd)	Number of Program Implementations	Program Savings (gpd)	Total Savings (gpd)	Capital (PV)	Unit Cost ($/Kgal)
Total Savings and Program Cost	66,931	1,091,028	37,063	964,030	2,055,058	1,499,998	$0.34
Total Savings and Program Cost with 20% contingency	66,931	1,091,028	37,063	964,030	2,055,058	1,799,998	$0.41

each customer class. The appraisal data contain the year built, which can be used to calculate an annual growth rate of new accounts over the planning horizon using the historical growth rate of each customer class in the latest plumbing code and their estimated water use. Since the load profile for each of the utility's existing customer classes is known, water use can be assigned to each of the projected accounts using the load profile from the existing customer classes.

The results of the estimated growth rate can be calibrated to the permitted amount over the planning horizon or calibrated to other municipal population and development services planning efforts.

The calculation of gallons per capita per day (GPCD) is much improved, since the water use data can be directly applied to an average household population by census block. This additional information can be brought back into the linear programming tool to assist in the prioritization of selected parcels for water conservation, or the information can be used to develop a logistical plan with the goal of targeting and reducing water use in those areas with particularly high GPCDs.

The linear programming tool estimates conservation savings for residential indoor and outdoor use and commercial, industrial, institutional (CII) domestic use. In addition to conservation savings as a result of a formal water conservation program, the tool also calculates passive savings. Each fixture is assumed to have its own passive replacement rate, based on the device life. Assumptions can be made regarding passive replacement depending on the year a structure was built. Passive replacement savings can be grouped into two categories: historical savings, which is calculated by comparing the original fixture efficiencies at the time the structure was built to the present fixture efficiencies; and future passive replacement over the planning horizon. For example, if a 20-year planning horizon is selected, all fixtures with device lives less than 20 years would likely be replaced by the customer at least once during that period.

Through the use of OpenSolver's Quick-Solve feature, once the solver is initialized, inputs can be changed and new scenarios run in seconds. Incremental changes to the total budget result in varying program savings. Graphing the output of these iterations results in a diminishing returns curve, which assists the utility in the goal setting process. The most cost-effective program savings on the diminishing returns curve results from ordinances adopting higher indoor efficiency standards and modifications to land development regulations limiting outdoor use. These two ordinances are very similar to the construction standards in the low-use neighborhood in Mount Dora previously shown in Map 1.

All of the assumptions made in the linear programming tool were developed using a conservative approach. The assumptions, documented in the BMP library, contain references to the origin of the information. It is expected that when the BMPs are implemented on the recommended parcels, the implementation will result in additional savings not accounted for by the tool due to the conservative approach taken.

Water Conservation Vision

A few forward-thinking utilities are running their conservation programs using automated meter reading or advanced metering infrastructure data, which can be fed into sophisticated utility operations software and work order management software packages typically used by distribution personnel within the utility. The CAWCLP tool, used in conjunction with a web-based implementation and tracking tool, is an alternative for utilities that lack the necessary resources to be able to develop or implement advanced work-order management systems.

Feedback to both the utility and the Dis-

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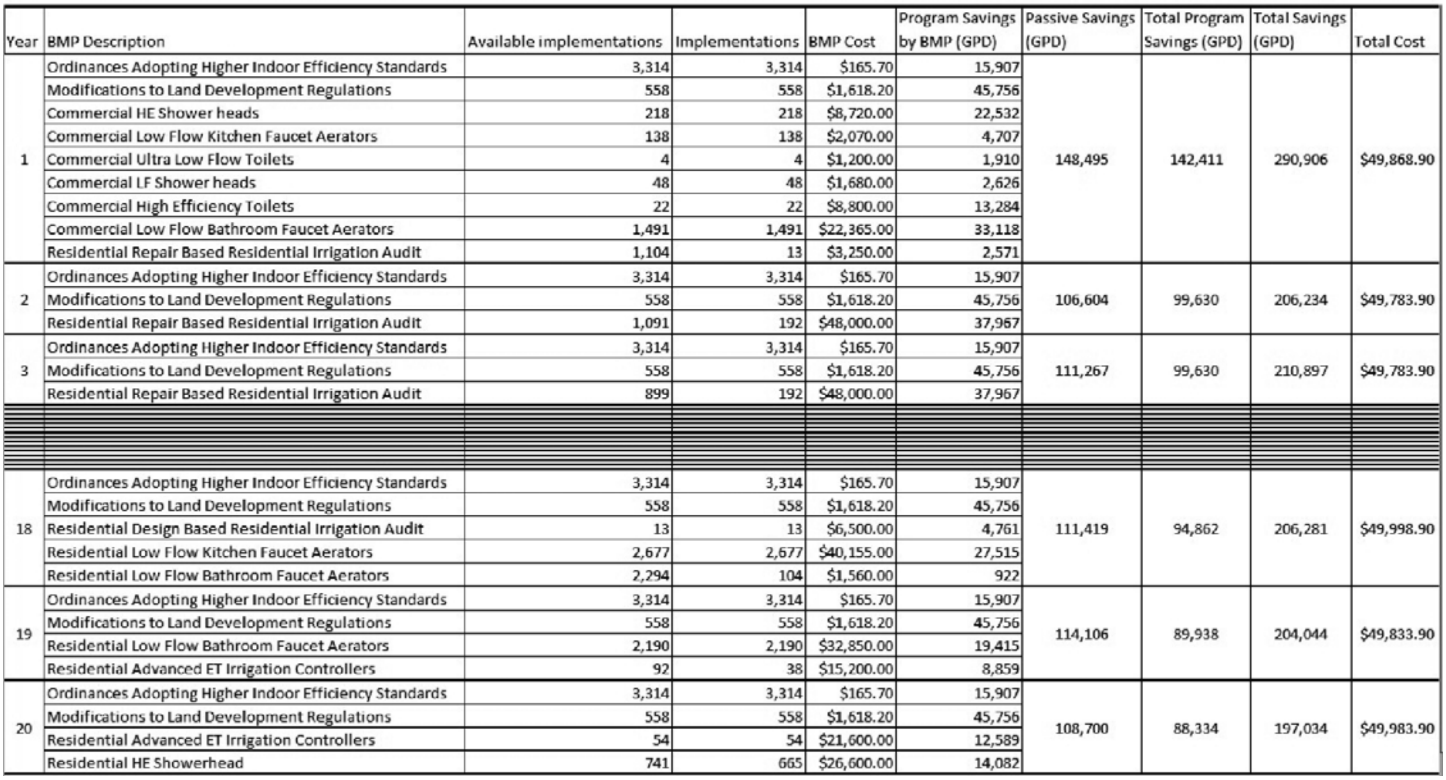
Figure 4. Implementation Schedule



Year	BMP Description	Available implementations	Implementations	BMP Cost	Program Savings by BMP (GPD)	Passive Savings (GPD)	Total Program Savings (GPD)	Total Savings (GPD)	Total Cost
1	Ordinances Adopting Higher Indoor Efficiency Standards	3,314	3,314	$165.70	15,907	148,495	142,411	290,906	$49,868.90
	Modifications to Land Development Regulations	558	558	$1,618.20	45,756				
	Commercial HE Shower heads	218	218	$8,720.00	22,532				
	Commercial Low Flow Kitchen Faucet Aerators	138	138	$2,070.00	4,707				
	Commercial Ultra Low Flow Toilets	4	4	$1,200.00	1,910				
	Commercial LF Shower heads	48	48	$1,680.00	2,626				
	Commercial High Efficiency Toilets	22	22	$8,800.00	13,284				
	Commercial Low Flow Bathroom Faucet Aerators	1,491	1,491	$22,365.00	33,118				
	Residential Repair Based Residential Irrigation Audit	1,104	13	$3,250.00	2,571				
2	Ordinances Adopting Higher Indoor Efficiency Standards	3,314	3,314	$165.70	15,907	106,604	99,630	206,234	$49,783.90
	Modifications to Land Development Regulations	558	558	$1,618.20	45,756				
	Residential Repair Based Residential Irrigation Audit	1,091	192	$48,000.00	37,967				
3	Ordinances Adopting Higher Indoor Efficiency Standards	3,314	3,314	$165.70	15,907	111,267	99,630	210,897	$49,783.90
	Modifications to Land Development Regulations	558	558	$1,618.20	45,756				
	Residential Repair Based Residential Irrigation Audit	899	192	$48,000.00	37,967				
18	Ordinances Adopting Higher Indoor Efficiency Standards	3,314	3,314	$165.70	15,907	111,419	94,862	206,281	$49,998.90
	Modifications to Land Development Regulations	558	558	$1,618.20	45,756				
	Residential Design Based Residential Irrigation Audit	13	13	$6,500.00	4,761				
	Residential Low Flow Kitchen Faucet Aerators	2,677	2,677	$40,155.00	27,515				
	Residential Low Flow Bathroom Faucet Aerators	2,294	104	$1,560.00	922				
19	Ordinances Adopting Higher Indoor Efficiency Standards	3,314	3,314	$165.70	15,907	114,106	89,938	204,044	$49,833.90
	Modifications to Land Development Regulations	558	558	$1,618.20	45,756				
	Residential Low Flow Bathroom Faucet Aerators	2,190	2,190	$32,850.00	19,415				
	Residential Advanced ET Irrigation Controllers	92	38	$15,200.00	8,859				
20	Ordinances Adopting Higher Indoor Efficiency Standards	3,314	3,314	$165.70	15,907	108,700	88,334	197,034	$49,983.90
	Modifications to Land Development Regulations	558	558	$1,618.20	45,756				
	Residential Advanced ET Irrigation Controllers	54	54	$21,600.00	12,589				
	Residential HE Showerhead	741	665	$26,600.00	14,082				

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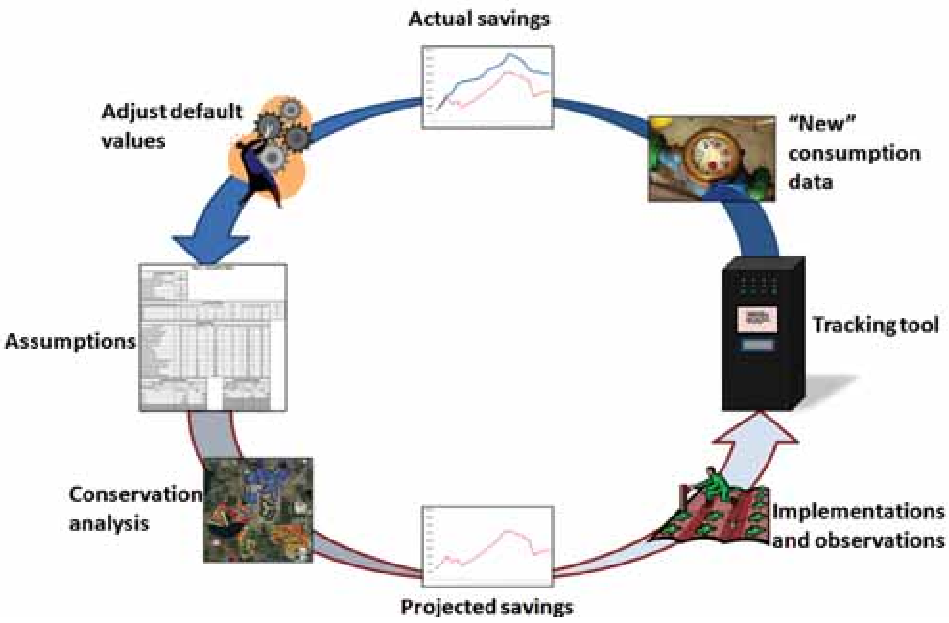
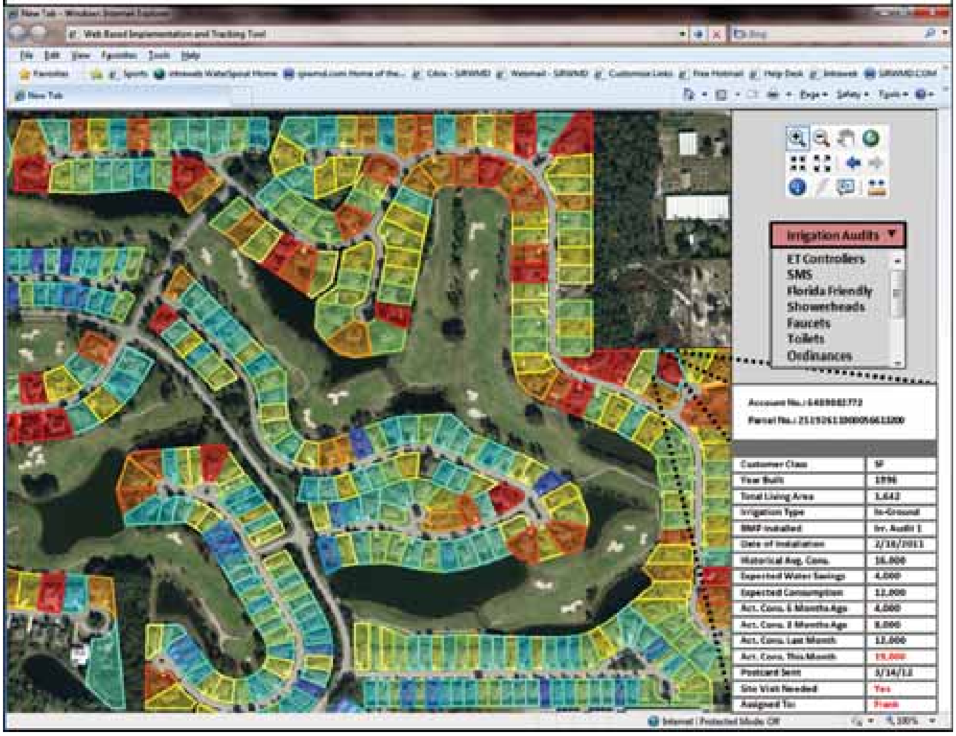
trict on the success of implemented best management practices, provides information necessary for decision-making regarding continued funding of projects and specific BMPs. Utilities with an existing continuous improvement workflow are able to tailor their conservation program to their customer base in order to maximize its effectiveness. The District is currently developing a Web-based Implementation and Tracking Tool (WBITT), which will track the performance of implemented BMPs. Figure 5 shows how the tool incorporates billing data through a live link, to track consumption and monitor the performance of BMPs. The process starts with the beginning assumptions, and continues with the adjustment of default values from the implementation process resulting in a continuous loop.

Figure 5. Web-Based Implementation Tracking Tool



Map 3. Web-Based Implementation Tracking Tool



Account No.: 6489882772

Parcel No.: 25192611000056611200

Customer Class	SF
Year Built	1996
Total Living Area	1,642
Irrigation Type	In-Ground
BMP Installed	Irr. Audit 1
Date of Installation	2/18/2011
Historical Avg. Cons.	16,000
Expected Water Savings	4,000
Expected Consumption	12,000
Act. Cons. 6 Months Ago	4,000
Act. Cons. 3 Months Ago	8,000
Act. Cons. Last Month	12,000
Act. Cons. This Month	19,000
Postcard Sent	3/14/12
Site Visit Needed	Yes
Assigned To:	Frank

The development of a goal-based approach to water conservation planning should be considered prior to investing in large alternative or traditional water supply projects, and as a companion to large water supply projects. A tool for implementing the plan and providing a feedback loop mechanism for actual on-the-ground observations through audits is also needed. Development of a WBITT will test the initial assumptions used in the linear programming tool and automatically adjust those assumptions from observed data in the field. An example of this may be estimated (rated) vs. actual flow rates of showerheads. The tool will be linked with current and future data, to compare the use before and after BM's have been installed. It will also notify utility water conservation staff when accounts where the BMPs were installed may need additional adjustment in order to remain effective (an irrigation controller, for example).

The WBITT will feature an online mapping interface, accessible by authorized users, with multiple data views and permissions. Authorized users may include District staff, utility directors, or conservation coordinators, contractors, or account holders. Different users have different viewing permissions. For example, account holders may only be able to view their own account, while a conservation coordinator may be able to view all accounts. If a utility chooses to make the mapping feature available to the public, users could view the utility's accounts in several different "views." The most common viewing option is consumption-by-account. Other options include optimized BMP selection, payback period, fixtures by unit cost, and possible clustering options for similar BMPs. A savvy contractor could use this information to identify potential business opportunities for both residential and commercial customers. After performing an on-site audit, some contractors may finance the BMPs and guarantee the water savings for a percentage of the cost savings over a set period of time.

After a BMP is implemented, each account is automatically assigned a "threshold" of expected use, calculated by the linear programming tool (Some BMP savings will be too small to be detected using a monthly billing system). Over time, if an account's consumption exceeds their expected use, the account is flagged for follow up. Utility staff will be able to pull up information on all of the accounts exceeding their expected use. An account's "threshold" may be tripped for several reasons, including: tampering, malfunctioning, or broken equipment; increased need for irrigation due to dry/hot weather; and leaks. A postcard could be automatically generated and sent to the account holder to identify the reason, or at least verify that a follow-up visit may be needed.

Map 3 shows a mocked-up version of an interface for the WBITT.

The staff is currently working on improving the cost-benefit calculations in the tool. The goal is to include cost savings from each BMP due to in-home energy savings and reduced in-home operations and maintenance costs. The calculations will include the dollars saved by a utility putting off the expansion of treatment and storage capacity due to water conservation savings and may require additional operations data from the utility.

Another future development of the tool is to include site-specific industrial BMPs for cooling and limited process water. These assumptions and estimates will be included in the tool when this study is completed.

Figure 6 shows multiple mobile platforms that approved field personnel including contractors, utility staff, or LEED certified auditors use to deploy the WBITT. The mobile web map retains the full functionality of the desktop version, and allows edits to update instantaneously to the database.

Work is also underway to improve the performance of the solver in the District's CAWCLP tool. District staff continues to collaborate with developers at OpenSolver to produce a PuLP-Python based code from which the solver will run. Initial results using the PuLP-Python code show a reduction in solve-time from the current OpenSolver platform ranging from 60 to 90 percent, depending on the number of accounts that are run through the tool. Another benefit to using the PuLP-Python code is that the end user will not need to define constraints, changing cells, or the objective function when the tool is run.

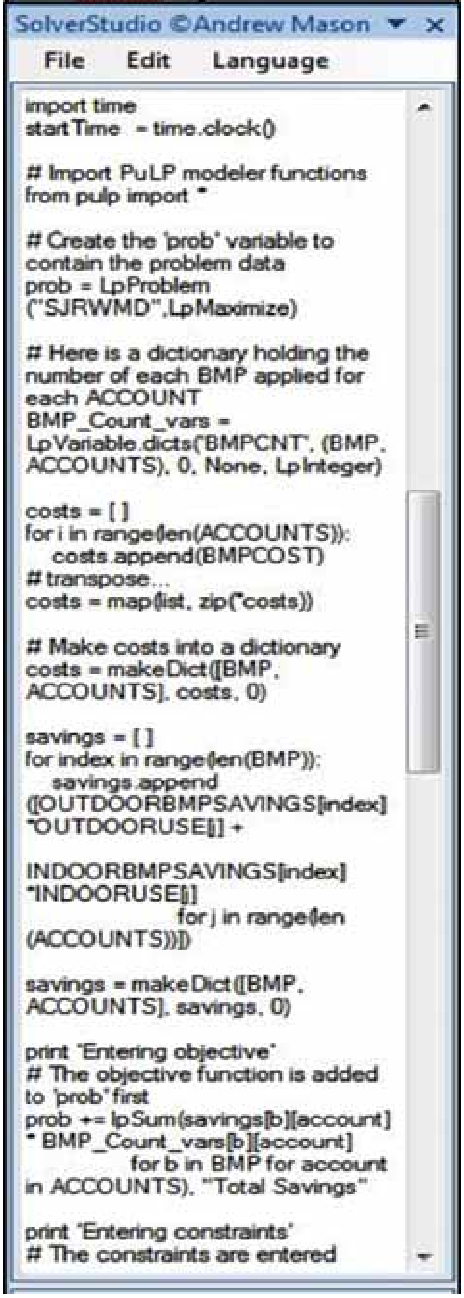
Figure 7 shows some sample of the PuLP-Python code being developed.

The PuLP-Python code also retains the full functionality of the calculations and cell references in the Excel spreadsheet. This means that the user can still make an adjustment on any assumption within the tool, and understand exactly how that change impacts the optimized selection when the solver is run again.

Conclusion

It is important to incentivize water conservation. As discussions between regulatory agencies and regulated utilities regarding incentives continue in earnest, there will be a need to quantify, and more importantly, verify the amount of savings estimated by the goal-based plan versus the savings actually obtained in the implementation of the plan. The CAWCLP tool and the WBITT are a system that will track BMPs that are proven to work in the short term, as well as the long term. If utilities and their customers are going to commit themselves to water conservation efforts, a dependable savings must be calculated for a variety of utility sizes, customer makeups, and regional differences in weather. This information will take time to generate. The sooner the necessary data is collected through the feedback loop described, the sooner the incentives that can be proven can be developed and funded.

Figure 7.
PuLP-Python Code



```
import time
startTime  = time.clock()

# Import PuLP modeler functions
from pulp import *

# Create the 'prob' variable to
contain the problem data
prob = LpProblem
("SJRWMD",LpMaximize)

# Here is a dictionary holding the
number of each BMP applied for
each ACCOUNT
BMP_Count_vars =
LpVariable.dicts('BMPCNT', (BMP,
ACCOUNTS), 0, None, LpInteger)

costs = [ ]
for i in range(len(ACCOUNTS)):
    costs.append(BMPCOST)
# transpose...
costs = map(list, zip(*costs))

# Make costs into a dictionary
costs = makeDict([BMP,
ACCOUNTS], costs, 0)

savings = [ ]
for index in range(len(BMP)):
    savings.append
([OUTDOORBMPSAVINGS[index]
*OUTDOORUSE[j] +

INDOORBMPSAVINGS[index]
*INDOORUSE[j]
                for j in range(len
(ACCOUNTS))])

savings = makeDict([BMP,
ACCOUNTS], savings, 0)

print 'Entering objective'
# The objective function is added
to 'prob' first
prob += lpSum(savings[b][account]
* BMP_Count_vars[b][account]
            for b in BMP for account
in ACCOUNTS), "Total Savings"

print 'Entering constraints'
# The constraints are entered
```

Figure 6. Multi-Platform Compatibility of WBITT Tool