Analysis of Potential Water Savings from Residential and Irrigation Accounts in the South Platte Basin Through 2050

Introduction

There are currently approximately 3.5 million persons living in the South Platte River basin. This number is expected to reach up to 6.6 million persons by 2050[1]. If the population grows as anticipated during this period what does this mean with respect to demands for raw water. According to the SP Basin Implementation Plan (SP BIP) demands for M&I water are expected to grow from ~650,000 AF/Yr to approximately 1,150,000 AF/Yr under the low to high growth rate scenarios[2]. In the approach used by the SP BIP, M&I water includes residential, commercial, industrial, irrigation and losses.

In preparation of the SF BIP, water demands were generated by multiplying the number of persons living in the area (the driver) by the average per capita demand. In this method, per capita demands are estimated as the ratio of the total water produced (gpd) to the total population (capita) to generate gallons per capita per day (gpcd). Water savings from various conservation programs are then expressed in terms of reductions in per capita use, and new demand estimates are generated. This approach has the benefit of simplicity, but it is difficult to determine how accurate any reduction in per capita use predicted as the result of a specific conservation program, either passive or active, might be since there is no clear mathematical relationship between the cause and effect to rely upon. For example, it is difficult to determine how replacement of old toilets and clothes washers will affect total per capita use for a given system, given the fact that there are so many components to overall water use that need to be taken into consideration.

A more precise way to assess the impacts of growth and alternative other conditions is to use explicit demand models that deal with the demands in a disaggregated manner. Residential and irrigation demands can be modelled based on the values of key parameters that have been found to best predict demands based on empirical data. For example, indoor residential demands are highly dependent on the number of persons per household and the efficiency class of the fixtures and appliances present. The values of these parameters can be adjusted to capture the effects of changes in household size and efficiency of the fixtures and appliances present in the home. By doing this we can explicitly predict the household water demands for domestic (indoor) uses in gallons per household per day (gphd). The total demands for each category of housing can be estimated in this way for each year of a specific study period. Total demands, and per capita demands can be determined.

The same approach can be used for outdoor (landscape) uses, which are highly influenced by factors such as irrigated area, local net ET, the presence of an in-ground sprinkler system and irrigation habits of the occupants (such as whether they typically over-irrigate their landscapes). Allowances can be made for water use by irrigation only accounts, and an estimate of total water use for residential and irrigation accounts can be prepared over an arbitrary study period, and under a range of conservation scenarios: each based on a unique set of assumptions regarding the factors that affect water use, and how these change over time.

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[1] See Table 2.1 of the South Platte BIP

2 See Table 2.3 of the South Platte BIP. The estimate of 1,150,000 is the average of the three water demand estimates (low, medium and high) presented in the table. None of these include passive savings. The estimated supply is 736,000 AF (from Table 2-13), so the gross gap is ~414,000 AF. This is the amount that needs to be filled from passive and active conservation.

Aquacraft has been studying residential water demands since 1993, when we did the first end use analysis of residential water use in the Heatherwood neighborhood of Boulder, Colorado. Since then we have done end-use analysis on over 4000 homes, most of which have included surveys and landscape analysis. These homes have been highly diverse in terms of their geography, occupancy, levels of efficiency and extent and type of landscape uses. This has provided a large and broad database from which to develop mathematical models of the end uses of water in residences and of water use for landscape irrigation. We have used these models to generate estimates of residential and irrigation demands for the South Platte population over a 40 year time period, which provides estimates out to 2050. Demands have been estimated for indoor and outdoor uses under a range of conservation scenarios. This has provided estimates of the conservation saving potential that are available to bridge gaps between demands and supplies over the planning period, and to identify from where these savings might originate, and the degree to which the savings appear to be achievable without causing undue hardships to the residents of Colorado. This paper explains how this was done, and provides summaries of the demands and savings estimates generated by the process.

Description of the Residential Demand Model

Aquacraft has taken data from several key end use studies and combine them into a single model of indoor and outdoor water use that focuses on the most available and useful parameters as inputs. Individual models were created for each indoor end use (including leakage). The models also dealt with outdoor (landscape) use based on variables found to best predict landscape use. The outputs for the models were gallons per day per household for each end use and thousands of gallons per year per household for landscape uses. Monthly and annual estimates were prorated from the daily and annual demands output by the model.

The seven studies listed in Table 1 were used to develop models of indoor water use specifically for this application. The data available included: water agency, billing data, end use data developed from flow trace analysis, weather information, and survey data provided by the households. A total of 3659 homes are included in the dataset. All data were entered into a statistical program (SPSS) and analyses were done to examine the relationships between household end uses and a range of variables. Variables were chosen to maximize both the predictive ability of the models and the practicality of obtaining the needed data. Table 1shows the end use studies from which the data were derived to construct the household demand models.

Table 1: Studies used for development of indoor use models

Study Name
EPA New Home Study (Standard and High Efficiency)
California Single Family Water Use Efficiency Study
EPA Retrofit Study
Albuquerque Baseline & Retrofit Study
Residential End Uses of Water Study Update (2015)
Residential End Uses of Water Study (1999)
Westminster SF Home Baseline Study

A list of variables that were found to be useful for predicting indoor end uses of water is shown in Table 2, and the variables used for creation of the landscape (outdoor) model are shown in Table 3. These variables were used to create models of the individual uses of water: toilets, showers, clothes washers, faucets, leaks, dishwashers, baths and other indoor uses. The output from these models was gallons per day of household use for the indoor models and kgal of annual use for the landscape model.

The models of indoor and landscape water use were used to create a spreadsheet based predictive tool for making projections of indoor and outdoor water demands for residential customers. The demands are estimated on an annual basis for the following categories of customers: single family existing, single family new, multi-family existing, multi-family new, and landscape irrigation accounts. Allowances can also be made for ICI demands, which are estimated based on the historic fraction of residential demands that they comprise.

The model works by increasing or decreasing the values of the individual predictive variables on an annual basis in a way that simulates changes in the population for that variable. The user specifies the starting value of each parameter, the annual change (either + or -), and an upper and lower limit that variable will be allowed. Each year these values are updated (within the specified limits) and the demands are recalculated. The output for each category is placed in tables of monthly demands, which are then summarized on an annual basis. Allowances are made for real losses and treatment and storage losses.

The starting values for the parameters were based on information obtained from the recent Residential End Uses of Water Update Study (REUWS2). Two of the logging sites for that study, Denver and Fort Collins, are located in the South Platte basin, so data on the parameters was available from the logging and survey data collected for that study. Data for the demand projections were also obtained from the U.S. Census for housing and population information.

Annual changes in the values were selected to simulate various water conservation programs. These annual increments or decrements to the parameter values, in combination with the limits allowed gradual changes in things like the percent of homes with high efficiency toilets or clothes washers to be simulated. Changes in price, or irrigated area, or the percent of homes over-irrigating could also be simulated. In this manner household and landscape water demands could be explicitly estimated based on changes to parameters that have been demonstrated to affect each end-use rather than having to rely on estimates based on percent changes or gross changes to average per capita use, which are difficult to explain from empirical data.

Table 2: Variables used for modelling indoor household water demands

	Indoor Variable	Description of Variable
1	Capita	Number of persons per home
2	Adults	Number of adults per home
3	Toilet_Class (-1,0,1)	L=>2.0 gpf (-1), E=1.4-2.0 gpf (0), H=<1.3 gpf (+1)
4	CW_Class (-1,0,1)	L=>30 gpl (-1), E=20-30 gpl (0), H=<20 gpl (+1)
5	Non_Adults_+1	ln of <21 yr olds + 1
6	Shower_Class (-1,0,1)	L=>3 gpm (-1), E=2-3 gpm (0), H=<2 gpm (+1)
7	Shower_Duration	Ln of durations (Avg=8.0 min)
8	% with Outdoor_Spa	0 = no spa; 100% = spa
9	% with swim_pool	0 = no pool, 100% = pool
10	% with HW_OnDemand	0 = no on demand, 100% = on demand
11	Indoor_Use_Excluding Leaks	Ln of indoor use w/o leaks (calculated)
12	% with Softening	0= no; 100% = yes
13	% with IndoorSpa	0 = no spa; 100% = spa
14	Employed_Adults	Ln of employed Adults
15	Adults_Home_in_day	integer
16	Baths_per_week_survey	Estimated value from surveys
17	Income_Percentile	Avg Income as percentile of all study homes
18	% with Disposal	0= no; 100% = yes
19	DW_Class	L=>10 gpl (-1), E=6-10 gpl (0), H=<6 gpl (+1)
20	% of Pop with Active Leak Control	% of population with active leak cntrl.
21	% of Pop with toilet recycle Systems	% of pop. With toilet recycle systems

Table 3: Variables used for construction landscape model

	Outdoor Variable	Description of Variable
1	Intercept	Constant term
2	Irrigated Area (sf)	Average irrigated area per household
3	Net ET (inches)	Average Annual Net ET
4	Ave Cost at 25 kgal ($/kgal)	Avg $/kgal for water + ww at 25 kgal consumption
5	% of HHs w/In-ground sprinklers	
6	% HHs Over-irrigating	% of households that are applying more than the theoretical irrigation requirements for their landscapes

Population and Housing

According to the U.S. Census the total population of the counties located in the South Platte basin as of 2011 was 3,524,704 persons. These individuals resided in a total of 1,343,997 occupied housing units, of which 72% were single family households and 28% were in multi-family residences. According to the demographics used for the SP BIP the population of the basin is expected grow to somewhere around 6.6 million persons by 2050. The two parameters that are of key importance to the demand models used for this analysis are the number of SF and MF households and the average numbers of occupants. As mentioned above, these population projections are in line with the projections contained in the SP BIP. The population and housing projections derived from the Census data and used for the projections in this report are shown in Table 4.

Table 4: Housing and Population Data Use for projections

South Platte Basin	Start Yr: 2010	Yr 40 (2050)
SF HH (2011)	966,230	1,736,623
SF Capita	2.74	2.75
SF Population	2,648,147	4,775,712
MF HH	377,767	678,937
MF Capita	2.32	2.32
MF Population	876,531	1,581,923
Total Population	3,524,680	6,357,635

The projection for single family and multi-family household growth are shown in Figure 1and Figure 2 respectively. These were developed by inserting the starting numbers of housing units and an initial growth rate of 2.5% for each category. An exponential decay factor was used to simulate a gradual deceleration of growth over time as the population growth faces resistance from the environment. This factor was adjusted so that the growth in population and housing reasonably matched the growth scenario of the SP BIP. The average population forecast from the BIP was 6.6 million souls, and the population projection from this analysis was 6.36 million.

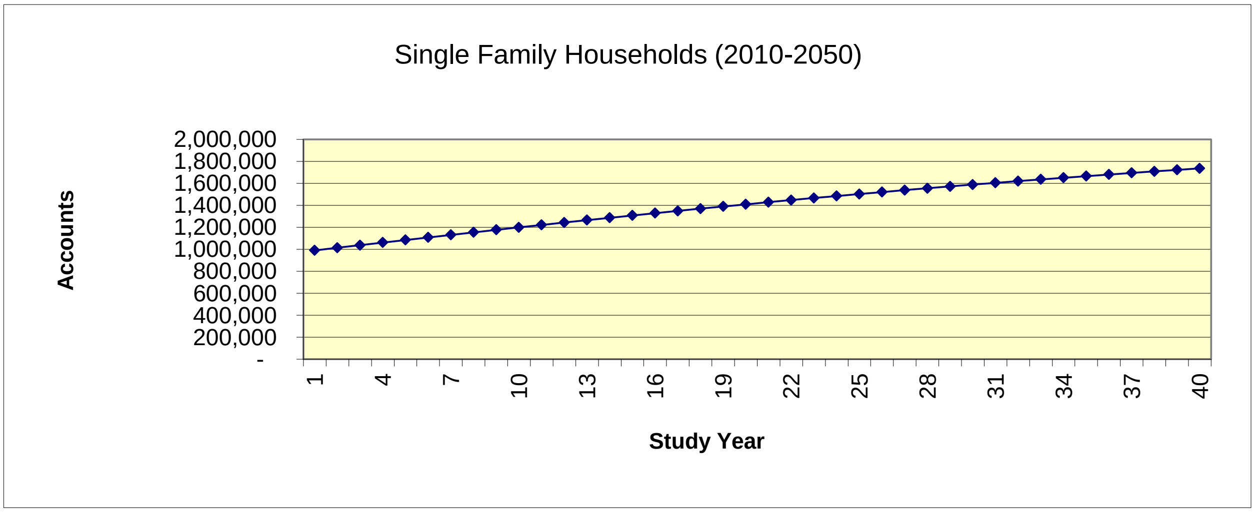

Figure 1: Projection of SF Households used for water demand projections

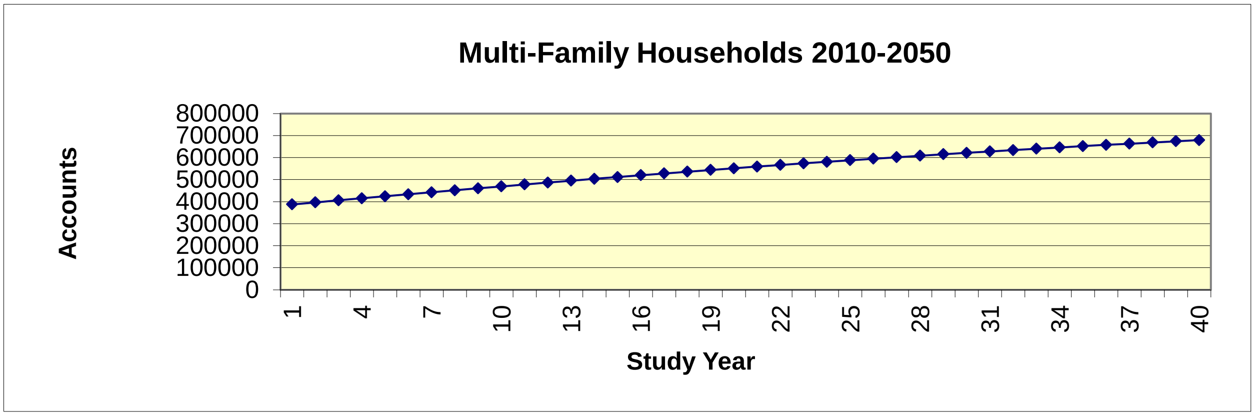

Figure 2: Projection of Multi-family households used for demand projection

The population for the Basin over the 40 year planning period is shown in Figure 3. These projections assume that the same mix of housing between SF and MF that was present in 2010 would prevail over the planning period. This assumption could easily be changed by altering the growth rates for the two categories to shift more of the new population into multi-family housing. But for the present analysis the assumption was that the future mix would remain the same as the current mix.

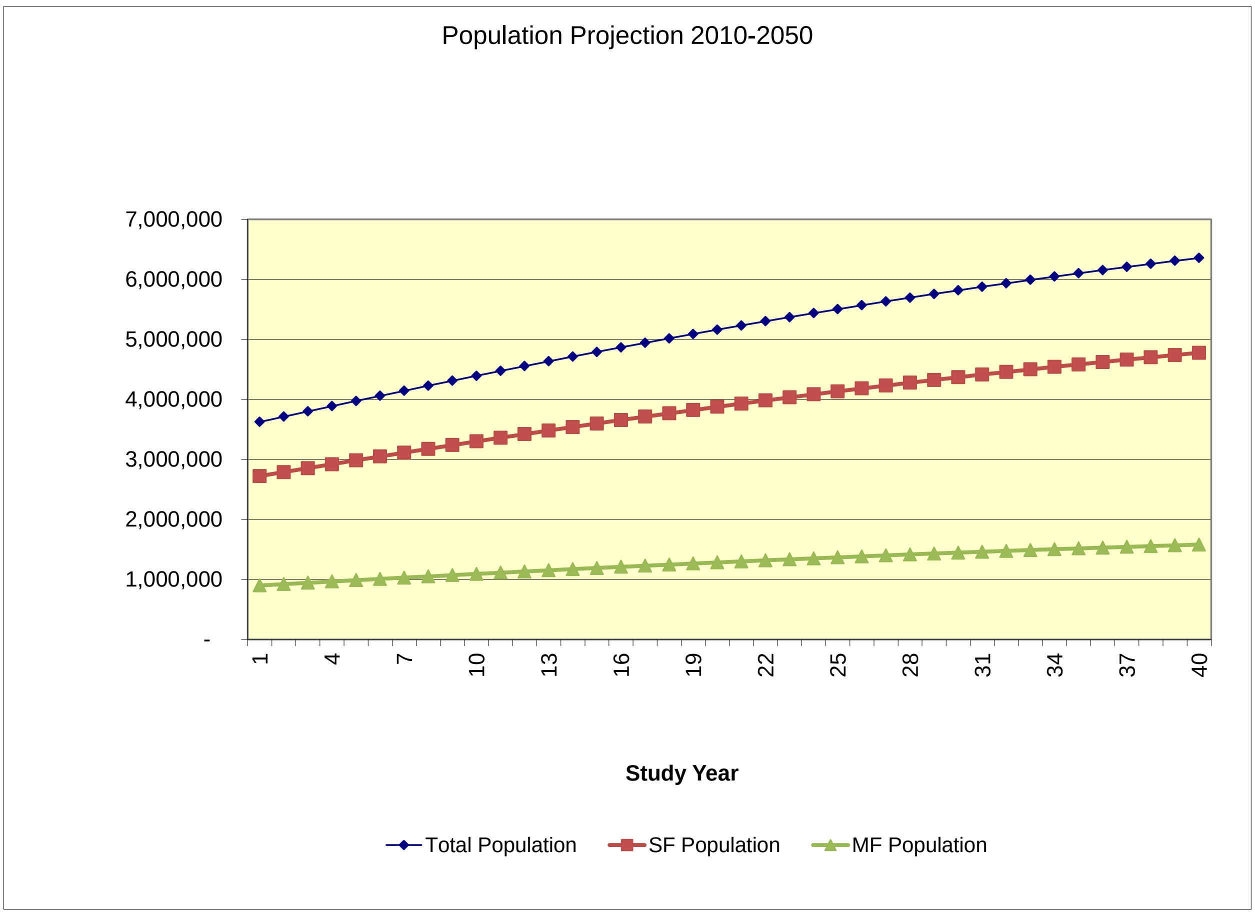

Figure 3: Population projection for SP Basin: 2010-2050

Baseline Water Demands

In order to determine how well the Aquacraft model conforms to the general projections made by the SP BIP the model was run over a 40 year period with parameters set to simply extrapolate the existing conditions estimated for the current population based on the REUWS2 results. The key parameters used are shown in Table 5. Parameters shown in Table 2, but not shown in Table 5 were left unchanged.

Table 5: Values used for baseline analysis for single family households

Parameter for Existing and New Single Family Households	**Starting Value**
Persons per home	2.75
Average efficiency class of toilets	-0.54 -1 = low >2.0 gpf, 0 = medium 1.4-2.0 gpf, 1=high <2.4 gpf
Average efficiency class of clothes washers	-0.24 -1 = low >30 gpl, 0= medium 20-30 gpl, 1= high< 20 gpl
Average efficiency class of showers	0.45 -1=low >3 ppm, 0=medium 2-3 gpm, 1=high <2 gpm
Average efficiency class of dishwashers	0 -1 = low >10 gpl, 0=medium 6-10 gpl, 1=high <6 gpl
% of Population with active leak control	0
% of Population using recycled water for toilet flushing	0
Average irrigated area	6500 sf
Average net ET	32 inches
Average cost of water at the 25 kgal consumption level	5.81
% of households with in-ground irrigation systems	53%
% of Households over-irrigating	30% (existing), 50% new
Parameters for New Single Family Homes	

Table 6: Values used for baseline analysis for multi-family households

Parameter for Existing and New Multi-Family Households	**Starting Value**
Persons per home	2.33
Average efficiency class of toilets	-0.50 -1 = low >2.0 gpf, 0 = medium 1.4-2.0 gpf, 1=high <2.4 gpf
Average efficiency class of clothes washers	-0.50 -1 = low >30 gpl, 0= medium 20-30 gpl, 1= high< 20 gpl
Average efficiency class of showers	0.0 -1=low >3 ppm, 0=medium 2-3 gpm, 1=high <2 gpm
Average efficiency class of dishwashers	0 -1 = low >10 gpl, 0=medium 6-10 gpl, 1=high <6 gpl
% of Population with active leak control	0
% of Population using recycled water for toilet flushing	0
Average irrigated area per account	40,000 sf
Average net ET	32 inches
Average cost of water at the 25 kgal consumption level	5.81
% of households with in-ground irrigation systems	100%
% of Households over-irrigating	20% (existing)

Using these parameters the model was run for a 40 year period in which the numbers of households followed the growth curves shown in Figure 1 and Figure 2 and the parameters for the new households were kept the same as that of the existing households. In addition to the residential demands, the model included allowances for irrigation only accounts and ICI accounts. Since data are not available to permit explicit modelling of these accounts the approach was to use the billed consumption reports submitted by the 26 agencies that participated in the REUWS2 study, and setting the percent of water for irrigation and for ICI to the same proportion of residential use that prevailed in the REUWS2 participants. For irrigation account this was 10% and for ICI the proportion was 50%. The average percent of billed deliveries for the 26 agencies as 6% for irrigation and 62% for residential (SF+MF), so the irrigation use amounted to 10% of the residential consumption. Similarly, the deliveries for ICI accounts amounted to 32% of total deliveries, compared to 62% for residential. So, the ICI allowance was set to

50% (initially). This was reduced to 43% so that the total deliveries for the model matched the estimated deliveries from the SP BIP demands discussed in the Introduction. Using these parameters, the demand model projected total M&I demands, including losses, irrigation and ICI demands that are shown in Figure 4. These start at 675,000 AF and grow to 1,140,000 AF in 2050 (year 40 of the study period). These demands do not include passive savings. According to the SP BIP the total supplies available to the South Platte Basin are 736,000 AF, which implies a total gap between demands and supplies of 404,000 AF of water.3

The purpose of this run was just to show that the model predictions for total M&I demand matched the predictions of the SF BIP. ICI demands were not included in the runs that estimated savings from residential and irrigation accounts. The reason for this is that the ICI demands were pegged at a specific percentage of residential demands (43%). This meant that as residential demands dropped in response to conservation programs the ICI demands would fall proportionally. While it is reasonable to assume that ICI demands will drop as residential demands fall, we have no reason to expect them to fall in a constant proportion. Therefore, to avoid possibly over-estimating savings from ICI account, we simply did not include them in the model runs that were used for prediction of savings. The setting aside of ICI demands had no bearing on the outcome of the study, however, since our objective was to obtain estimates of the savings available from the residential and irrigation accounts. Savings from ICI customers can be the subject of a separate study.

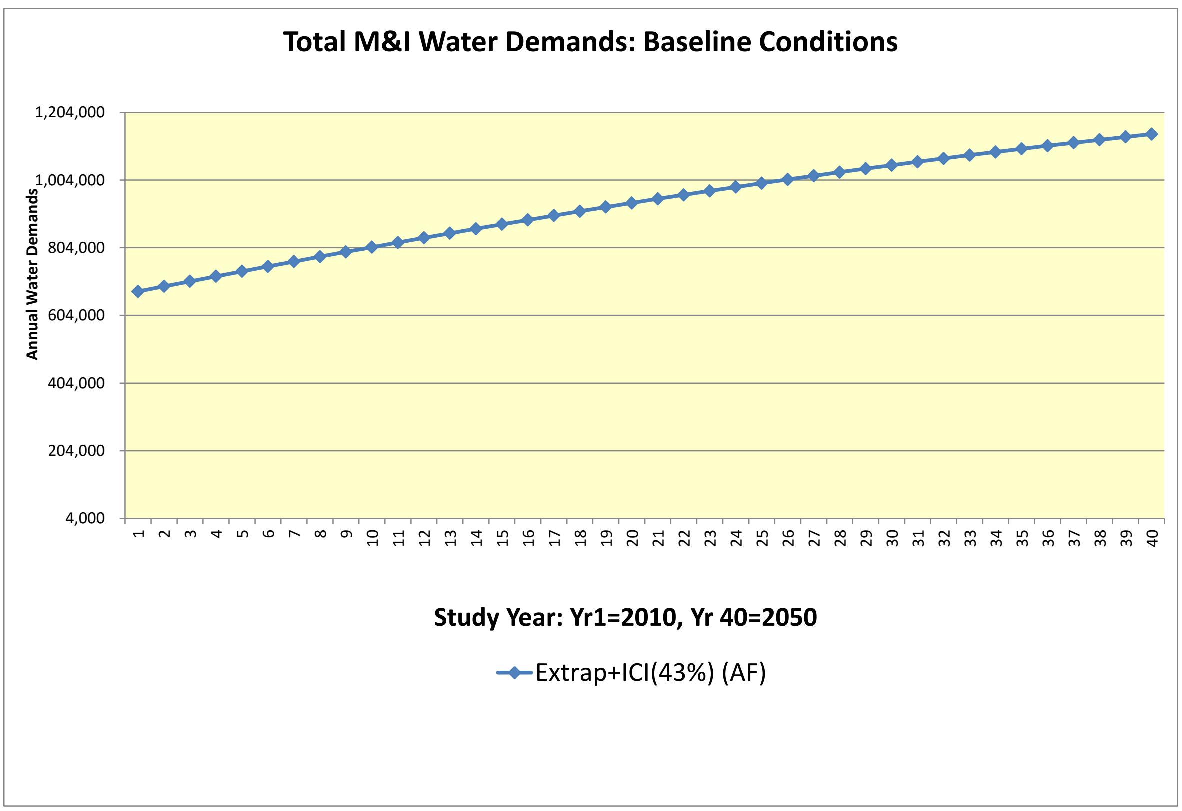

Figure 4: Projected total M&I Demands using extrapolation from existing conditions and no passive conservation

3 The SP BIP estimated that the M&I demands with passive savings to be exactly 10% of the gross demands; suggesting that the passive savings were estimated as a simple percent of the gross demands.

Savings from Passive Changes

Rather than assume that passive savings can be estimated as a flat percentage of gross demands the demand model was run to simulate passive savings as the first scenario studied. By definition, passive savings are those reductions in residential water demands that are expected to occur due to changes in building codes and standards, and are expected to occur irrespective of any actions on the part of the water agency. In our case, we assumed that the passive savings would be derived from the changes outlines in Table 7. For this study no other indoor residential conservation programs were studied since the focus of our investigation was on the potential savings from landscape uses, after passive savings were taken into account.

Table 7: Changes to Baseline case to model passive savings

Parameter	Category	Passive Change
Toilets	SF Existing	Gradual retrofit to HET standards in 40 years, with maximum penetration at 90% of existing SF households.
	SF New	All new SF households come in at HET standards
	MF Existing	Retrofit all existing MF units to HET in 40 years
	MF New	All new MF units come in with HET toilets.
Clothes Washers	SF Existing	Retrofit to high efficiency standard (<20 gpl) over 40 years in 90% of homes.
	SF New	All new homes come in at high efficiency status
	MF Existing	Replacement of all units to high efficiency standard over 40 years
	MF New	All new MF units come in at high efficiency
Showers	SF Existing	Upgrade to high efficiency over 40 years in 90% of homes
	SF New	All new SF units come in at high efficiency
	MF Existing	Replacement of all showers to high efficiency over 40 years
	MF New	All new MF units come in with high

		efficiency showers
Dishwashers	SF Existing	Replacement of dishwashers to high efficiency units in 90% of homes over 40 year period
	SF New	All new SF units come in with high efficiency dishwashers.
	MF Existing	Replacement of all dishwashers to high efficiency over 40 years

Effects of Reducing Rates of Over Irrigation

After analyzing the impacts of passive conservation, the next option studied was to reduce the percentages of households that were over-irrigating. The model of landscape water us showed a strong relationship between the average landscape water use and the percentage of households that were applying more than their theoretical irrigation requirements (TIR). In the baseline and passive cases the percentage of SF homes that were over-irrigating was 30% and the rate of over-irrigation in the multi-family properties was 20%. In the reduced excess irrigation case these rates were assumed to be brought down to 10% at 1% per year. In this case there was no change to the irrigated areas or types of irrigation systems employed. The only change was that by whatever means necessary the percentage of customers that were applying more than their theoretical requirements was reduced from 30% or 20% to 10%. This simulated the savings that can be obtained through better irrigation management rather than changes to plant materials or irrigated areas.

Effects of Reducing Irrigated Areas

The third option studied was to reduce the average irrigated areas of the customers by 10% over the 40 year study period. This meant that the average irrigated areas of the SF homes dropped from 6529 to 5876 at 1% per year. The new SF homes were assumed to be limited to no more than 5000 sf of irrigated area. The existing multi-family properties reduced their irrigated area by 10% from 40,000 sf to 36,000 sf at 1% per year, and the new multi-family properties were assumes to have not more than 36,000 sf of irrigated area. A fourth option was included, which was to reduce irrigated area by 25% for existing and new residences. The difficulty of reduction of the average irrigated areas should not be under-estimated. Many homes may already be well under the average area, and not able to reduce their areas easily. Reductions of 10% are thought to be challenging, and reduction of 25% for the average area would be a difficult task.

Results

The results of the baseline plus four conservation scenarios are shown in the following figures and tables. Figure 5 shows a graph of annual residential and irrigation demands that are projected for the baseline case and each conservation scenario. Figure 6 shows the estimated savings relative to the baseline case for each scenario. Table 8 provides the estimated total M&I and Residential/Irrigation demands for each of the 40 years in the study period and the savings from the passive case, the case with less excess irrigation and the two cases with reduced irrigated areas.

The figures show that the largest savings are expected to come from the passive replacement of the existing toilets, clothes washer, showers and dishwashers over the next 40 years with new, high efficiency devices. As shown in Table 8 the savings in year 40 from the passive case (177,745 AF) are expected to equal 15.5% of the gross M&I demands (1,150,020 AF) and 21.7% of the gross residential and irrigation demands.(819,622 AF).

The three additional conservation programs all involve changes only to landscape water use rather than any additional changes to indoor uses from leak control or recycling of gray water for toilet flushing. If the percentage of the residential and irrigation properties that are over-irrigating could be brought down to no more than 10% then another 87,000 AF of additional water could be saved. These additional savings could be increased to 115,000 AF if irrigated areas could be reduced by 10%, and the savings could be brought up to 146,000 AF with a reduction of 25% in irrigated areas. These reductions can either be in straight area, or in a reduction in the water use intensity of the landscape that mimics the equivalent area reduction. All of these savings are projected to occur from only the residential and irrigation accounts, and do not include any savings from ICI uses, which are certainly available, but have not been quantified here.

According to the SP BIP the gross water supply gap equals 414,000 AF. This is the difference between the gross demands and the supplies without taking passive conservation savings into account. By our analysis the available savings from the options evaluated for this report, as shown in Table 9, could equal from between 43% to 78% of this gap.

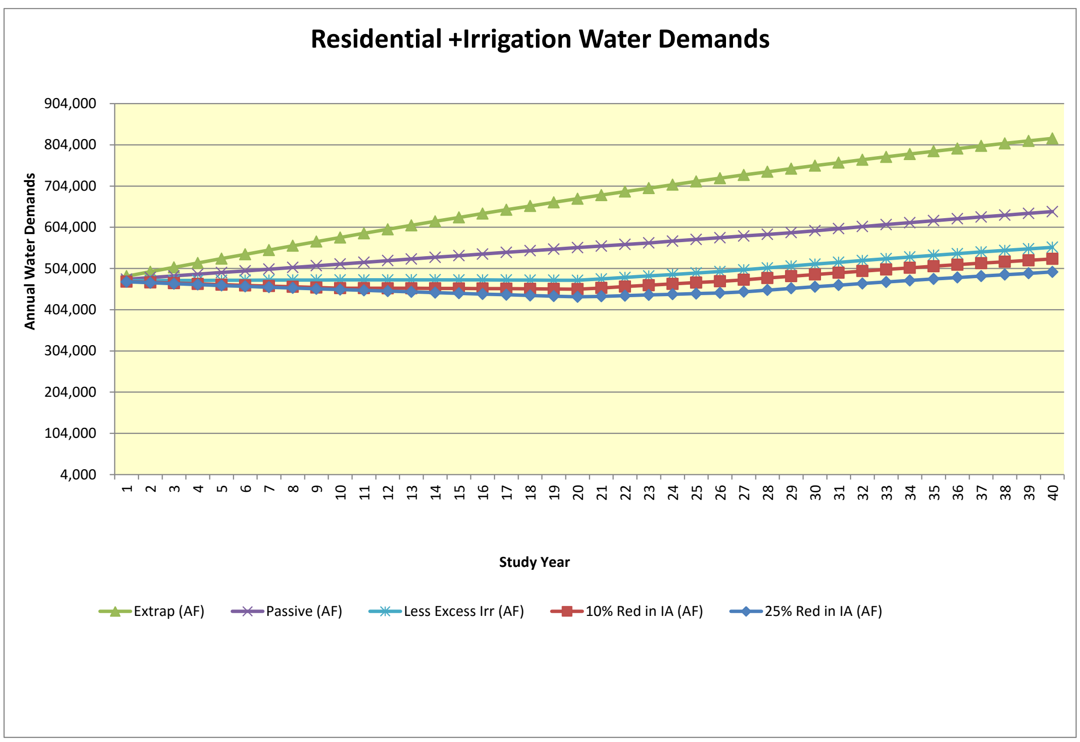

Figure 5: Projected residential and irrigation demands under five scenarios

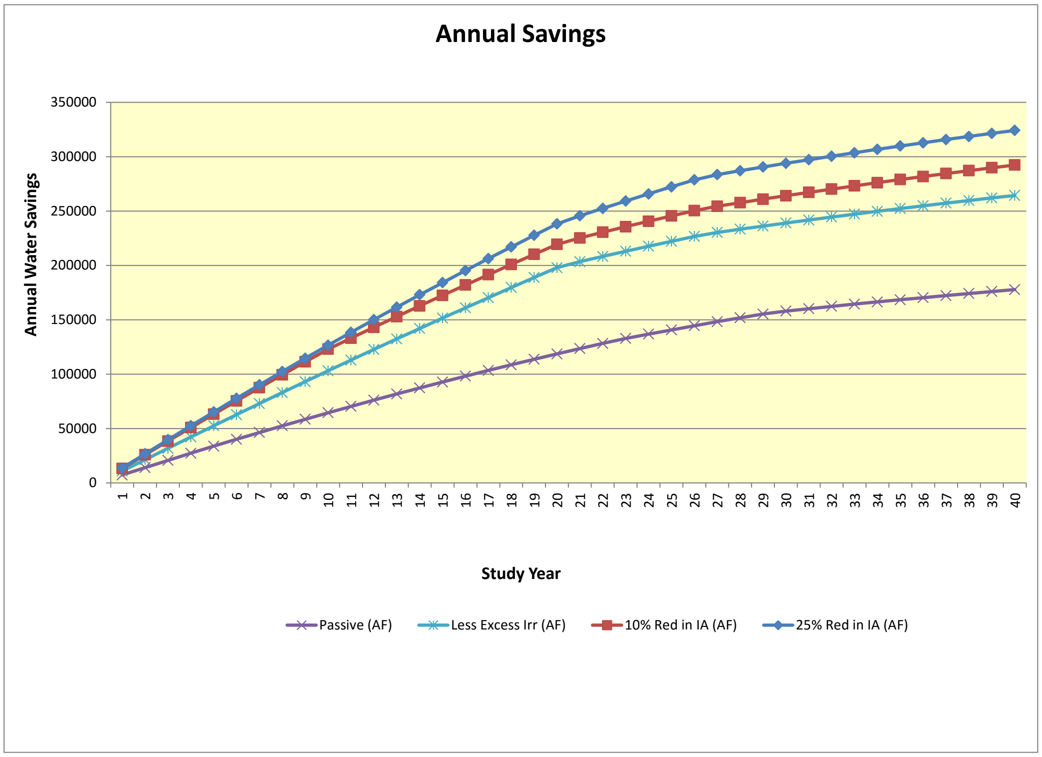

Figure 6: Projected saving relative to baseline for four scenarios

Table 8: Projected total and incremental water savings from three water conservation options

	Baseline M&I Demands	**Baseline Residential and Irrigation demands**	**Total Savings relative to Baseline case**			
Year			Passive (AF)	Passive + Excess Irrigation on no more than 10% of landscapes (AF)	Passive + Reduce Irrigated Area by 10% (AF)	Passive + 25% Reduction in Irrigated Area
2011	674,909	485,229	7265	10854	13128	13556
2012	689,885	495,996	14025	21327	25808	26648
2013	704,771	506,698	20684	31751	38374	39611
2014	719,557	517,329	27243	42124	50824	52444
2015	734,234	527,881	33700	52442	63156	65144
2016	748,793	538,348	40057	62703	75369	77710
2017	763,226	548,724	46312	72904	87461	90142
2018	777,525	559,005	52467	83033	99431	102432
2019	791,682	569,183	58521	93095	111276	114584
2020	805,691	579,255	64475	103086	122997	126595
2021	819,545	589,216	70328	112925	133058	138392

2022	833,239	599,061	76082	122691	143027	150049
2023	846,768	608,787	81737	132380	152905	161564
2024	860,125	618,391	87292	141991	162689	172938
2025	873,307	627,868	92749	151520	172378	184169
2026	886,310	637,216	98108	160967	181970	195256
2027	899,129	646,433	103370	170329	191463	206199
2028	911,762	655,515	108535	179605	200855	216997
2029	924,206	664,461	113604	188791	210145	227650
2030	936,457	673,270	118579	197887	219332	238157
2031	948,515	681,939	123459	203386	225220	245624
2032	960,377	690,467	128246	208217	230435	252418
2033	972,042	698,854	132832	212958	235553	259117
2034	983,508	707,097	136787	217609	240575	265721
2035	994,775	715,198	140665	222171	245501	272230
2036	1,005,842	723,154	144466	226644	250332	278606
2037	1,016,709	730,967	148192	230326	254365	283503
2038	1,027,375	738,636	151843	233266	257649	287014
2039	1,037,841	746,160	155264	236151	260872	290460
2040	1,048,108	753,542	157994	238980	264034	293839
2041	1,058,175	760,780	160159	241755	267134	297153
2042	1,068,045	767,875	162281	244475	270173	300402
2043	1,077,717	774,829	164360	247141	273151	303586
2044	1,087,193	781,642	166397	249753	276069	306705
2045	1,096,474	788,315	168393	252311	278927	309761
2046	1,105,562	794,849	170346	254816	281726	312752
2047	1,114,459	801,245	172259	257268	284466	315681
2048	1,123,166	807,505	174131	259668	287147	318547
2049	1,131,686	813,630	175963	262016	289770	321352
2050	1,150,020	819,622	177754	264313	292337	324095

Summary of Savings

Table 9 shows a summary of the projected South Platte gap and the potential savings that the Aquacraft analysis indicates could be met from passive savings and three progressively more aggressive landscape programs. These do not include savings from ICI uses or savings from more advanced domestic conservation programs such as leak control and recycling. It is interesting to note that over 40% of the gap could be met with the passive replacement of interior retrofits, and strict building codes that require all new residences to use the best available fixtures and appliances. While not included here, the model shows that if 50% of new residences were required to employ active leak detection devices and use recycled gray water for toilet flushing an additional 25,000 AF of water could be saved not included in Table 9 over the 40 year planning period.

Table 9 also shows that of the three landscape programs, the biggest savings are expected to be derived not from reductions in irrigated areas, but from better management of irrigation, and reductions in the percentage of homes that are over-irrigating. The additional savings from reductions in irrigated areas are also substantial. The combination of the passive indoor savings and the three landscape programs examined in this report could amount to 78% of the anticipated gap in M&I supplies, and this is without resorting to more aggressive programs or ICI conservation.

Table 9: Summary of Total Water Savings from Residential and Irrigation Accounts

Total Available Supply	736,000 AF	Total Savings (AF)
Gross M&I Demands	1,150,000 AF	
Total Gap	(414,000) AF	
Passive Savings	177,751 AF	177,751 (43% of gap)
Saving from reduction in Excess Irrigation	86,558 AF	264,313 (64% of gap)
Savings from 10% Reduction in Irrigated Area	28,024 AF	292,334 (71% of gap)
Savings from 25% reduction in irrigated area	59,782 AF	324,095 (78% of gap)

The SP BIP makes estimates of landscape savings as a percentage reduction in landscape use.[4] These savings ranged from a low of 15% of landscape use in the Low Strategy to a high of 35% reduction in the High Strategy. In order to allow a comparison in percent reductions in landscape use for the three scenarios investigated I this report the water savings were determined for just the landscape use and are shown in Table 10. This table show that in order to achieve the savings hoped for in the High Strategy, of 35%, will require the types of changes included in our most aggressive program, namely that no more than 10% of the properties are applying more than their theoretical irrigation requirements, and that the average irrigated areas be reduced by 25%. Our medium case, where irrigated areas are reduced by an average of 10%, is equivalent to the Medium Strategy of the SP BIP.

Table 10: Summary in Landscape Water Use and Savings (AF/%)

Case	SFex	SFnew	MFex	MFnew	Irr	Total
Passive	203420	99362	5294	2469	55425	365970
Less Excess	150216	73374	4549	2220	47851	278210
Savings	53204 (26%)	25988 (26%)	745 (14%)	249 (10%)	7576 (13.7%)	87760 (24%)
-10% Area	139756	61120	4232	1103	45436	251647
Savings	63664 (31.3%)	38240 (38.5%)	1062 (20%)	1366 (55%)	9989 (18%)	114321 (31%)
-25% Area	121678	52458	3735	973	42699	221543
Savings	81742 (40%)	46904 (47%)	1559 (29%)	1496 (61%)	12726 (23%)	147427 (40%)

Source: these figures were derived from the monthly demands tables for landscape uses in year 2050 by scenario

[4] See table 5.2 on page 84 of the Second Draft of the SP BIP.

Suggestions for Improving Predictions

The water demand projections in this report are based on empirically derived relationships between the explanatory variables shown in Table 5 and water use. These values were based on survey information obtained as part of the Residential End Uses of Water Study Update (REUWS2) with emphasis on Denver and Fort Collins, but including results from all 26 of the participating agencies across the U.S. and Canada that participated in that study. Data for the new homes was obtained primarily from the EPA New Home Study and various retrofit studies conducted by Aquacraft since 2000. Data for the multi-family properties and irrigation only accounts is far less reliable and could be improved by obtaining better information on the multi-family sector and the areas of irrigated landscape served in the communities of the South Platte Basin. Much of this information could come from the self-reported information required by the Colorado legislature in HB 1051. Ultimately, however, the most beneficial action would be to organize a large, systematic study of residential water use and landscape irrigation based on sampling from all of the large water providers in the basin, similar to the end use studies on which the models have been based upon. This would be a major undertaking, but the work would provide a wealth of details on the parameters needed to make accurate predictions of water use, and would greatly improve the accuracy of the predictive tools such as the model used for this analysis. This would allow water demand projections to be made in a more explicit and mathematically satisfying manner.

Relationship of Landscape Programs to Landscape BMPs

The landscape programs investigated in this report are not explicitly tied to any particular landscape best management practice, but there is clearly a relationship between achieving the water savings associated with the landscape programs included in the models and the BMP’s. The BMP’s will not only make achieving the conservation goals possible, but will allow them to the done in a way the minimizes the negative impacts on the urban environment….