Appendix F9
Option Characterization – Municipal and Industrial Water Conservation

Appendix F9 — Option Characterization – Municipal and Industrial Water Conservation

1.0 Introduction

Development of additional municipal and industrial (M&I) water conservation was proposed to further reduce the overall M&I water demand in areas currently relying on water supply from the Colorado River system. A number of M&I conservation options were submitted for consideration in the Colorado River Basin Water Supply and Demand Study (Study). The submittals are summarized in appendix F2 and the original submittals are available via links from the electronic version of appendix F2 on the compact disc that accompanies this report and the version of appendix F2 on the Study website at http://www.usbr.gov/lc/region/programs/crbstudy.html.

Several of the submitted options suggested specific conservation measures, many of which have been implemented at locations in the Study Area. The total potential yield of M&I conservation exceeds 200 kafy, therefore the representative option was characterized in progressive 200 kafy "steps" to represent potential project phasing. Figure F9-1 shows the primary M&I demand locations.

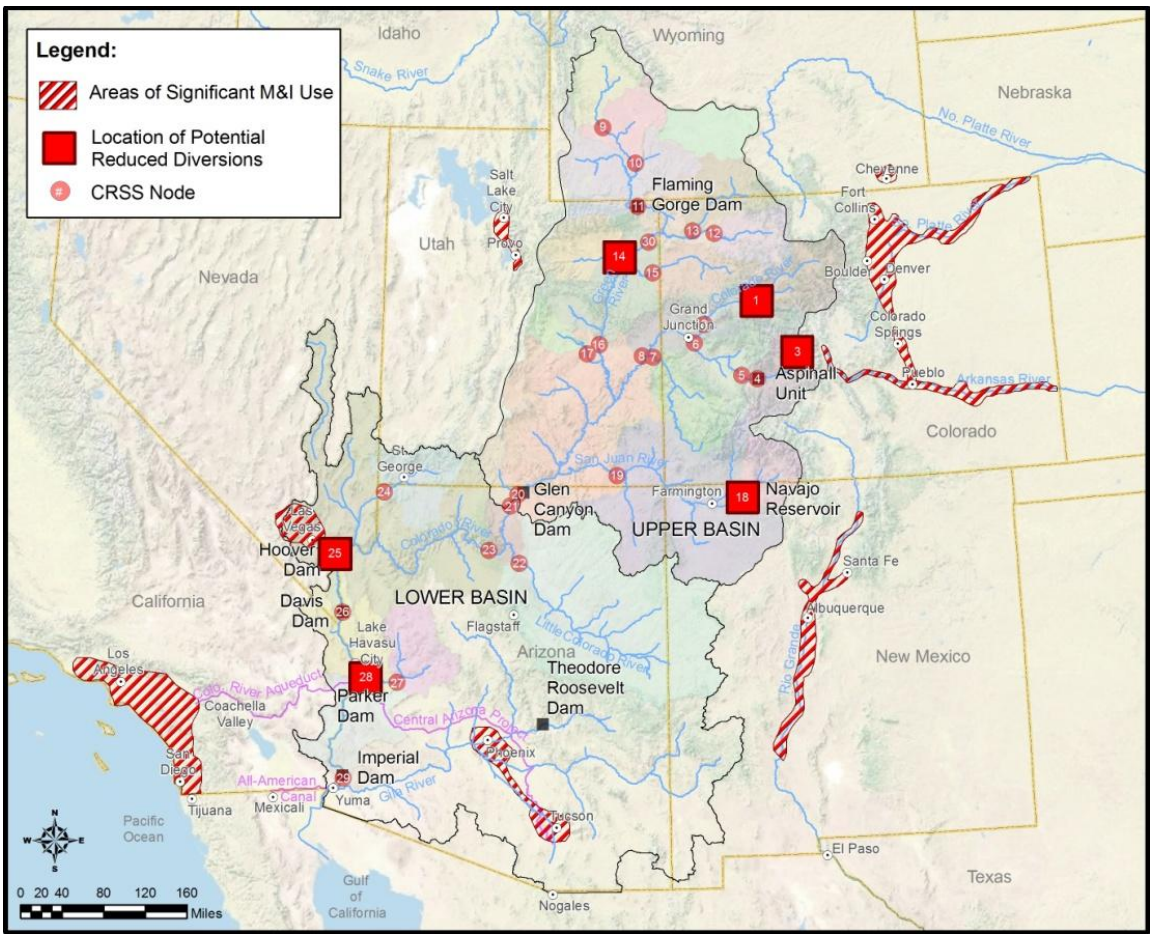
This appendix summarizes the types of options received, the assumptions made and methods used to characterize the options, and the characterization results. Additional detail related to the options characterization is included in appendix F3. Attachment A of appendix F3 contains more detailed descriptions of the ratings. Attachment B provides the methods used for completing the unit cost calculations. Attachment C presents the detailed characterization information and is available on the compact disc that accompanies this report and on the Study website.

2.0 Overall Approach

27 options were submitted that related to additional M&I conservation to reduce demand in areas receiving Colorado River supply. Many of these options were related to specific M&I conservation programs (e.g., water auditing, xeriscaping, inclining block rates, etc.) or targeted specific M&I water use sectors (e.g., golf courses, industrial use) that might provide additional opportunities for M&I conservation in the Colorado River Basin (Basin) as a whole.

Three representative options were developed from the submitted options, reflecting different degrees of additional M&I conservation. The representative options consist of three "levels" of conservation, with progressively ambitious goals (Level 1, Level 2, and Level 3) that would be implemented sequentially. The representative options reflect conservation in addition to that already included in the demand scenarios in the Study.

FIGURE F9-1
Primary M&I Demand Locations



3.0 Overall Approach

Approximately 50 options were submitted that related to additional M&I conservation to reduce demand in areas receiving Colorado River supply. Many of these options were related to specific M&I conservation programs (e.g., water auditing, xeriscaping, inclining block rates, etc.) or targeted specific M&I water use sectors (e.g., golf courses, industrial use) that might provide additional opportunities for M&I conservation in the Basin as a whole.

Three representative options were developed from the submitted options, reflecting different degrees of additional M&I conservation. The representative options consist of three "levels" of conservation, with progressively ambitious goals (Level 1, Level 2, and Level 3) that would be implemented sequentially. The representative options reflect conservation in addition to that already included in the demand scenarios in the Study.

These levels of additional M&I demand reduction would likely be implemented through use of progressively ambitious water conservation best management practices (BMP) and adoption rates targeting residential indoor; commercial, institutional, and industrial (CII); outdoor landscaping; and water loss demand.

Because levels of current and projected future conservation vary throughout the Study Area, different levels of potential savings are possible for a given conservation measure. These savings range from essentially no savings where measures have been fully implemented to significant savings where measures have not been implemented or where adoption rates are relatively low. Disaggregating the savings potential by conservation measure and individual location was beyond the scope of the Study. Instead, M&I conservation measures were considered for the entire Study Area with the acknowledgement that, despite state and regional differences in current levels of conservation and potential for future conservation, additional conservation is achievable on a Study Area-wide basis. Likewise, it was assumed that additional conservation is due to an "active" incentive-based program, such as paying for conversion of turf to xeriscape, toilet replacement, etc.

Table F9-1 presents a list of the types of urban water conservation BMPs included in several guidance and water planning documents produced for the Study Area. These include BMPs in guidance documents from California, Colorado, and the U.S. Environmental Protection Agency (EPA). In addition, table F9-2 presents a list of BMPs considered in the conservation planning aspects of the Metropolitan Water District (MWD) of Southern California's Integrated Resources Plan (2010). These lists include BMPs that are considered in many M&I water conservation plans and are consistent with the BMPs included in statewide and regional documents and studies by the California Urban Water Conservation Council (CUWCC) (2005), Colorado Water Conservation Board (CWCB) (2010), and CALFED (2006).

Many of these BMPs have already been enacted throughout the Study Area, resulting in significant conservation savings. For example, a recent study of municipal deliveries of Colorado River water (Pacific Institute, 2010) found that most of the municipalities receiving Colorado River water had produced significant reductions in per capita water deliveries for the period 1990 to 2008. A number of states, including California and Utah, have programs in place that require a certain amount of reduction over time, such as California's 20x2020 program (California Department of Water Resources, 2010). Arizona has a statewide conservation plan and specific conservation requirements associated with individual Active Management Areas (Arizona Department of Water Resources, 2008). Likewise, a number of individual communities, including Albuquerque, Denver, Las Vegas, Phoenix, and Tucson, have specific M&I conservation goals. The associated conservation programs employ many of the BMPs shown in tables F9-1 and F9-2.

TABLE F9-1
Example Urban BMPs for Water Conservation

California Urban Water Conservation Council (2005, 2011)	Colorado Statewide Water Supply Initiative (CWCB, 2010)	EPA Water Conservation Plan Guidelines (EPA,1998)
Residential Survey Programs	Metering	Universal Metering
Residential Plumbing Retrofit	Plumbing Codes and Fixture Standards	Water Accounting and Loss Control
System Water Audits	Public Education	Costing and Pricing
Metering w/Commodity Rates	Leak Detection	Information and Education
Large Landscape Conservation	Water Audits (indoor, commercial, and landscape)	Water Use Audits
High Efficiency Clothes Washers	Irrigation Efficiency Evaluations	Retrofits
Public Information Programs	High-efficiency Fixture and Appliance Replacement	Pressure Management
School Education Programs	Rebates for Toilets and Washers	Landscape Efficiency
Commercial Industrial Institutional	Turf Replacement and Restrictions	Replacements and Promotions
Wholesaler Agency Assistance Programs	Pricing and Surcharges	Water Use Regulation
Conservation Pricing	Fixture Retrofit on Sale of Property	Reuse and Recycling
Conservation Coordinator	Eliminate High-Water Use Landscape	Integrated Resource Management
Water Waste Prohibitions	Elimination of Single-Pass Cooling	
Residential Ultra-Low Flush Toilet Replacement Programs	Non-water Using Urinals in Non-Residential	

Note that an amended Memorandum of Understanding was signed on 9/14/2011 that revised the list shown for the CUWCC. The revision included a re-categorization of the above broad BMPs, as found at http://www.cuwcc.org/mou/exhibit-1-bmp-definitions-schedules-requirements.aspx.

TABLE F9-2
Example BMPs Considered in MWD's Integrated Resource Planning (MWD, 2010)

Residential	*Landscape*	*CII*
Aerators	Audits	Analyst S ELWRF Phase Va Survey I
Flappers Replaced w/Survey	Calif-Friendly Landscape	Analyst Survey II
High-Efficiency Clothes Washer (WF 4)	Central Controllers	Connectionless Food Steamer
High-Efficiency Clothes Washer (WF 5)	Education - Member Agency	Cooling Tower Conductivity Meter
High-Efficiency Clothes Washer (WF 6)	ET Controllers	Dry Vacuum Pump
High-Efficiency Toilet - Melded Rate	Irrigation Controllers	Engineer Survey
High-Efficiency Toilet - Upgrade	Large Rotors - HE Nozzles	Flush Valve Kit
High-Efficiency Toilet	Moisture Sensors	HE Urinal - Upgrade
High-Efficiency Washers	Protector del Agua Class	High-Efficiency Toilet - Melded Rate
Irrigation Eval with Timers	Research and Development	High-Efficiency Toilet - Upgrade
Irrigation Eval without Timers	Synthetic Turf	High-Efficiency Toilet
Multi-Family Surveys	Water Use Accountability	High-Efficiency Urinal
Research and Development	Weather-Based Controllers	High-Efficiency Washers
Rotating Nozzles		Industrial Process Improve
Shower heads		pH Cooling Tower Controllers
Shower heads - Distributed		Pre-Rinse Spray Head
Surveys, Single Family		Recycled Water Hook-Up
Surveys, Single Family-Old		Research and Development
Toilet Displacement		Rotating Nozzles
ULF Toilets - Distribution		Steam Sterilizer
ULF Toilets - Rebate		ULF Toilets - Dual Flush
ULF Toilet - Dual Flush Upgrade		ULF Toilets - Flush Valve
ULF Toilets - Dual Flush		ULF Toilets - Tank Type
WBIC for Large Residential		ULF Urinals
WBIC Large Site (Station)		Walkthru Survey
Weather-Based Controller		Water Broom
		Water Management Study
		WBIC by Station
		Weather-Based Controller
		X-Ray Processor
		Zero Water Urinal
		Zero Water Urinal -Upgrade

In order to examine the potential for additional M&I conservation and to explore the range of costs and other factors, three levels of conservation were considered based on assumed levels of reductions and adoption (or penetration) rates for residential indoor, CII, landscape, and water loss. Table F9-3 presents the assumptions for Level 1, Level 2, and Level 3 conservation. The levels of reduction in table F9-3 are based on estimates of the use rates by demand type in 2015 (e.g., ~69 gallons per capita per day [gpcd] Study Area indoor water use). The assumptions in table F9-3 were derived from state of Colorado (Colorado Water Conservation Board, 2011) and California (CALFED, 2006) approaches and applied to Study Area projected demand to result in a Basin-wide estimate of potential water savings. The assumptions were derived for purposes of the Study and do not necessarily reflect realistic or achievable local conservation goals.

TABLE F9-3
Municipal and Industrial Water Conservation Assumptions

	Level 1	Level 2	Level 3
Residential Indoor			
Indoor gpcd	60	50	40
Adoption rates	50%	60%	70%
Example types of BMPs: Public education programs, conservation-oriented plumbing and building codes, residential water surveys, high-efficiency showerheads and faucets, ultra low-flow toilets, efficient clothes washers, meter retrofits.			
Commercial, Institutional, and Industrial			
Target reduction in demand	15%	25%	30%
Adoption rates	50%	60%	70%
Example types of BMPs: Public education programs, conservation-oriented plumbing and building codes, green building codes, CII surveys and audits, high-efficiency faucets and fixtures, ultra low-flow toilets, high efficiency clothes waters, dishwasher high-efficiency pre-rinse spray valves, meter retrofits, efficiency in industrial processes and cooling .			
Outdoor Landscaping			
Target reduction in demand	15%	25%	35%
Adoption rates	50%	60%	70%
Example types of BMPs: Public education programs, conservation-oriented pricing, large landscape water surveys and audits, evapotranspiration-based irrigation controllers, large landscape separate metering, irrigation efficiency improvements, conversion of turf to lower water use landscaping.			
Water Loss			
Target water loss	7%	7%	7%
Adoption rates	50%	60%	70%
Example types of BMPs: Utility water loss control, supply system audits and leak detection programs.			

Conservation levels from estimated use rates by demand type in 2015.

4.0 Potential M&I Conservation Measures

4.1 Residential Indoor Conservation Measures

The minimum indoor residential water use was assumed to be about 45 gpcd for "existing homes", based on research from the American Water Works Association (1999) and recent analysis of residential water use performed for EPA (Aquacraft, 2011). "New homes" were

assumed to potentially achieve a minimum 35.6 gpcd based on EPA research of "high efficiency" new homes under the WaterSense program specifications. These data were assumed to bracket a minimum "potential" for residential indoor gpcd. Residential indoor yield was calculated for a given level of conservation based on a per capita use target and an assumed adoption rate.

4.2 CII Conservation Measures

CII water use is highly variable in the Study Area and is heavily dependent on the mixture and type of industry in the community. Without further characterization and study, a "minimum" CII rate estimate would be highly speculative. Instead, it was assumed that a CII demand could be reduced by a percentage of total CII demand through the implementation of standard BMPs, as outlined in programs by CUWCC (2005, 2011), CWCB (2010), and others. CII demand reduction was calculated for a given level of conservation based on a reduction target and an assumed adoption rate. Reductions in CII demand were consistent with the range of CII reductions contemplated in Colorado's *SWSI 2010 Municipal and Industrial Water Conservation Strategies* (CWCB, 2011).

4.3 Outdoor Landscaping Conservation Measures

Outdoor water use within an M&I service area is primarily for lawn irrigation and landscaping at single-family homes, neighborhood/community parks, golf courses, commercial building landscaping, and median landscaping. The estimated minimum outdoor water use in a community is based on assumptions related to levels of landscape area and percent of turf that may exist in the future, while maximizing the water efficiency of the required irrigation.

It was assumed that outdoor use could be reduced by a percentage of total outdoor use through the implementation of standard BMPs as outlined in programs by CUWCC, CWCB, and others. Outdoor use reduction was calculated for a given level of conservation based on a reduction target and an assumed adoption rate. Reductions in outdoor demand were consistent with the range of outdoor reductions contemplated in Colorado's *SWSI 2010 Municipal and Industrial Water Conservation Strategies* (CWCB, 2011). However, as documented in the Metropolitan Round Table Conservation Paper, Colorado Front Range municipalities agree that, although 15 percent is reasonable, higher levels may be hard to achieve.

4.4 Water Loss Reductions

Water loss occurs in water utilities' distribution systems and represents an opportunity for water conservation. Distribution system auditing, leak detection and repair, replacement of aging infrastructure, and recurring maintenance activities can reduce the loss between diversion and the meter at the house or business. These water loss reduction measures are applied at the municipality or utility level and reflect an increase in the accounting and control over water distribution. Water loss reduction was calculated based on a target water loss percentage of 7 percent and an assumed adoption rate that varies by level of conservation.

5.0 Regional Considerations

The potential M&I water conservation measures are assumed to apply to the overall Study Area, but significant differences in potential water savings exist between geographies based on the

current level of conservation adoption, commercial and industrial base, and climate. In addition, because return flows augment river flow for in-Basin locations, indoor conservation has little to no net effect on water demand. For in-Basin locations, only reductions in consumptive use will reduce overall Colorado River system demand as the return flows from the urban areas is returned to the Colorado River. In addition, the amount of reduction in Colorado River demand varies by location.

In many of the major urban areas receiving Colorado River water, the overall water supply provided to communities consists of a significant portion of other supplies (other surface supplies, groundwater supplies, reuse, etc.) in addition to Colorado River water. In most of these out-of-Basin areas, the supplies are comingled in the water supply and distribution systems before delivery to the consumer. Because the conservation measures are end-use water demand reductions, the water savings result in a net demand reduction. In these areas, the net M&I demand reductions may not result in the same amount of demand reduction for Colorado River water. This is the result of the distributed nature of conservation efforts and the inability of conservation to target one type of supply in regions that have diverse water supply portfolios. For example, MWD's service area receives approximately 40 percent of its total water supply portfolio from the Colorado River, as noted in *Technical Report C – Water Demand Assessment*, whereas northern California supplies via the State Water Project, Los Angeles Aqueduct supplies, local surface and groundwater supplies, and reuse contribute the remaining supply. Water conservation will reduce the overall demand on these supplies collectively, but is not likely to result in a one-for-one reduction in Colorado River demand. However, an overall reduction in demand could potentially reduce demands on each supply source, resulting in an overall benefit. Alternatively, reductions in consumptive use in Nevada result in an equal potential reduction in Colorado River demand.

In many adjacent areas, including the Front Range of Colorado, water exported from the Basin is reused essentially to extinction. Municipal conservation in these areas reduces the amount of water available for reuse, and does not result in a one-for-one reduction in Colorado River demand.

In many areas, the marginal cost of water from the Colorado River is lower than for other new supplies, and it is likely that M&I water conservation may result in the deferral of the development of new supplies rather than direct reductions in Colorado River system demand. However, for the purposes of the Study it was assumed that water conservation savings would be allocated to the supply sources in proportion to their contribution to the overall water supply portfolio. For the entire Study Area, the average Colorado River system M&I demand is about 40 percent of the total Study Area M&I demand. However, because these demand reductions benefit more than just Colorado River water users, the costs of achieving these reductions was assumed to be shared by the beneficiaries.

6.0 Implementation Approaches

The primary implementation approach under consideration for M&I water conservation is an incentive-based program. M&I water conservation programs are typically implemented through adoption and verification of a broad suite of BMPs such as those described previously. Public education programs, regulations dictating standard practices for new development, and incentive-based programs encouraging more efficient water use are typically implemented. These

programs provide the necessary incentives (financial or otherwise) to achieve the levels of conservation. Financial incentives provide a cost share for implementation of BMPs and have been widely used to facilitate conversion to higher-efficiency fixtures and toilets. These types of mechanisms are anticipated to continue to be widely used to achieve higher levels of conservation in areas served by Colorado River system water. Non-incentive based approaches are considered as well, consistent with the BMP examples shown in table F9-3. Both approaches are effective and contribute to market transformation, which provides reliable long-term water savings.

7.0 Quantity of Yield

As described in *Technical Report C – Water Demand Assessment*, M&I water conservation measures have been implemented at locations throughout the Basin, resulting in significant reductions from historical per capita use. Demand scenarios developed for the Study include, to varying degrees, by both scenario and location, some portion of passive conservation (resulting from outside entities/programs, such as federal standards) and active conservation (resulting from active state and local programs). In general, consideration of active programs was limited to those already in place or logically following the storyline for a given demand scenario (e.g., social values of the Enhanced Environment scenario).

Considerable conservation is included in these demand scenarios. Table F9-4 provides an estimate of the conservation savings included in each of the six water demand scenarios. The conservation savings is calculated based on estimates of what future Colorado River system water demand would be in these scenarios at 2060 in the absence of decreasing per capita water use rates (*Technical Report C – Water Demand Assessment* provides a complete description of the demand scenarios). As shown in the table, the conservation considered in the demand scenarios ranges from 300 thousand acre-feet per year (kafy) to more than 1.1 million acre-feet per year (mafy) depending on the assumptions within each scenario regarding degree of per capita water demand reductions.

TABLE F9-4
Estimated M&I Conservation Savings by 2060 (afy) Included in Demand Scenarios

	Current Projected (A)	Economic Slowdown (B)	Expansive Growth (C1)	Expansive Growth (C2)	Enhanced Environment (D1)	Enhanced Environment (D2)
Estimated Savings from 2015 Level Use Rates	478,000	296,000	621,000	1,048,000	1,052,000	1,114,000

Additional conservation beyond that included in the demand scenarios was considered in the three additional conservation levels (Level 1, 2, and 3). The demand reductions from each of these levels were computed using the assumptions in table F9-3 applied to the M&I demand over the entire Study Area. Estimates of level of demand and conservation potential in residential, CII, outdoor landscaping, and water loss were developed based on regional and Study Area estimates. The potential conservation was assumed to apply proportional to all M&I demands within the Study Area. However, the areas of greatest M&I demand are outside of the hydrologic basin and generally include a portfolio of water supplies (groundwater, local supplies,

other imports, etc.) including Colorado River water. The supplies each have their own cost, reliability, water quality, and other factors that lead to agency preferences related to which supply (current or future) would be reduced under lower demand scenarios. Under purely financial considerations, it is unlikely that the Colorado River supply is the marginal supply in the portfolio. Given the complexity of regional and local water management decisions, it was assumed that reductions in Study Area M&I water demand as part of these options are distributed proportionally to the magnitude of supplies from the Colorado River and non-Colorado River sources.

Table F9-5 presents the estimated M&I water conservation savings associated with the Level 1, 2, and 3 assumptions. These values represent the sum of the potential conservation in the Study Area for residential, CII, outdoor landscaping, and water loss measures compared to the scenario demand at 2060. The last row shows the potential reduction that might accrue to the Colorado River demand. The Basin demand reduction is substantially lower because the major urban areas are located outside of the hydrologic basin and have diversified portfolios of supplies to which the benefits would likely accrue. This aspect is an important consideration in Basin water planning. Water conservation in the areas served by Colorado River or tributary water would likely have benefits for reducing demand on all supplies in the service areas, but may have a less than one-for-one benefit for reducing Colorado River system demands.

The areas of greatest potential for savings are residential indoor and outdoor landscaping water conservation measures. Conservation measures within these two categories represent almost 80 percent of the total M&I water conservation potential estimated in this evaluation.

TABLE F9-5
M&I Conservation Savings (afy) for the Current Projected Scenario by 2060

	Level 1	Level 2	Level 3
Study Area			
Residential	94,000	532,000	1,110,000
CII	77,000	237,000	362,000
Landscape	164,000	509,000	958,000
Loss	125,000	149,000	174,000
Total	459,000	1,428,000	2,604,000
Colorado River System			
Estimated Colorado River System Demand Reduction	185,000	576,000	1,051,000

The M&I conservation options included here are based on conservation in addition to that already included in the demand scenarios. However, because the Study considers six distinct water demand scenarios that have different levels of both passive and active conservation, the conservation levels may generate a different magnitude of savings when compared to different scenarios. Table F9-6 shows the cumulative potential reduction in Colorado River system demand for each of the six water demand scenarios and for each conservation level. For all

options, these values represent the additional demand reduction by 2060. The actual demand reduction would ramp up over time as conservation measures are applied more aggressively and adoption rates are expanded.

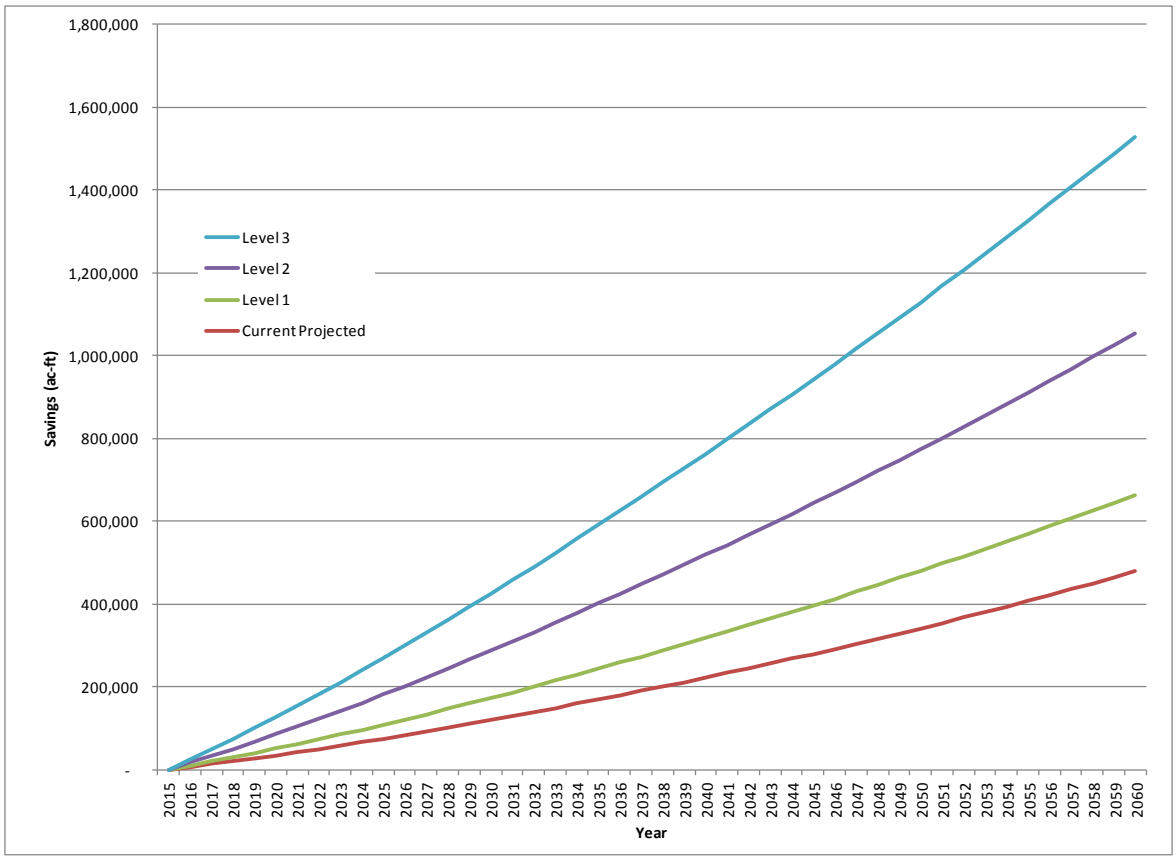
TABLE F9-6
Reductions in Colorado River System Demand (afy) for Each Demand Scenario and Conservation Level at 2060

Conservation Level	Current Projected (A)	Slow Growth (B)	Rapid Growth (C1)	Rapid Growth (C2)	Enhanced Environment (D1)	Enhanced Environment (D2)
Level 1	185,000	187,000	207,000	56,000	44,000	55,000
Level 2	576,000	504,000	681,000	427,000	238,000	383,000
Level 3	1,051,000	888,000	1,258,000	960,000	654,000	908,000

Significant water conservation has occurred in the recent decades through most urban centers in the Study Area. The M&I water conservation savings realized in the demand scenarios and potential additional measures will likely occur at a lower annual rate than what has been observed in recent historical periods due to differing types of conservation measures and greater adoption rates that will need to be included. As noted for other options, in order to represent the challenges associated with increasing scale, when options exceed a 200 kafy yield, they are generally assumed to be implemented in 200-kafy steps. For example, for the Current Projected (A) scenario, M&I conservation options would be available in six steps, at 200 kafy each for the first five steps and at 51 kafy for the final step. These steps are assumed to proportionally implement progressive amounts of the individual levels noted in the table. For example the first step of conservation will implement 185 kafy of "Level 1" practices and 15 kafy of "Level 2" practices.

Figure F9-2 shows the resulting Basin-wide savings for the Level 1, 2, and 3 conservation levels compared to the Current Projected scenario.

FIGURE F9-2
Estimated Water Conservation Savings (af) in Current Projected Scenario and Additional Conservation Levels



8.0 Timing of Option Availability

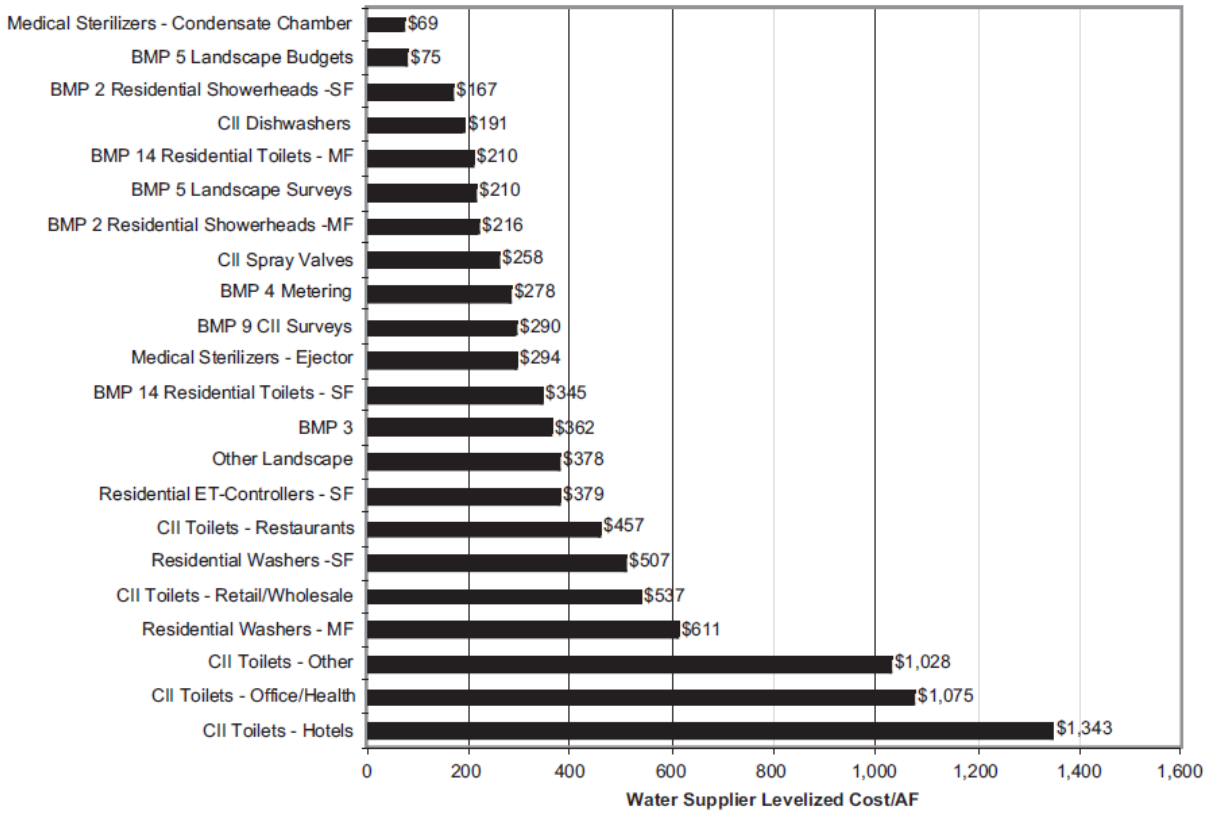
Because the M&I water conservation options would be ramped over time, each of the options could begin implementation with benefits starting to accrue within 5 years. The conservation program would need to be established, commitments of Basin-wide BMPs, and measures to assess per capita water use baselines and performance would be agreed upon before implementation. The potential savings of the options would be small in the early years of implementation and grow over time.

Ultimate savings for each level are assumed to occur in 2060, with the savings progressively ramping from 2015 through 2060. However, it is possible that adoption rates could be slower or faster than those included in the conservation level assumptions. In addition, Conservation Level 2 would in all likelihood need to have adopted all Conservation Level 1 measures, and Conservation Level 3 would need to have adopted most of the measures and achieved adoption rates from Conservation Level 2.

9.0 Costs

Costs for implementing M&I water conservation vary by measure, location, and timing. The BMPs shown in figure F9-3 are intended to represent a range of potential measures for cost considerations. This figure presents representative BMPs and their associated costs from the *Water Use Efficiency Comprehensive Evaluation,* (CALFED, 2006). Costs for the options were amalgamated by demand type (residential indoor, CII, outdoor, and water loss). It was generally assumed that the most cost-effective BMPs would be implemented first, followed by progressively more-costly measures. However, suites of BMPs are generally implemented when an agency is implementing water conservation programs. For this reason, an average cost of various BMP suites was assumed. Based on historical conservation levels within the Study Area, it was assumed that foundational BMPs related to education and staffing were largely embedded in the demand scenarios and these costs were not included. Conservation Level 1 was assumed to be the average cost of available BMPs within the demand type (residential, CII, outdoor landscaping, and water loss). Conservation Level 3 costs were assumed to be the average of the more-expensive BMPs within the M&I demand type, and Conservation Level 2 costs were assumed to be between these costs.

FIGURE F9-3
Average Costs of Various M&I Water Conservation BMPs (dollar per afy)
SF=single family, MF=multi-family Source: CALFED, 2006



These BMPs were grouped by demand type and used to assign costs to the conservation levels. In addition, a landscape replacement cost was developed based on a $2 per square foot rebate for

xeriscaping 1,500 square feet of turf using the range of information from the Southern Nevada Water Authority (2005), the City of Peoria, Arizona (2012) the City of San Diego (2012), and Albuquerque Bernalillo County Water Utility Authority (2012) turf conversion programs. These costs were amortized at 4.125 percent over 20 years, consistent with other option cost estimates.

Table F9-7 presents the estimated costs per af of water conservation savings to implement the suite of BMPs for each conservation level. The unit annual costs range from roughly $350 to $1,400 per afy reduction in demand. CII and outdoor landscaping water conservation measures represent the most cost-intensive measures. Based on the assumption that the water conservation savings result in proportional savings to all supplies contributing to Study Area delivery, the demands for Colorado River system water may only be reduced by about 40 percent of the total Study Area demand reduction. However, it was assumed that the cost to Colorado River system water users is solely for the reduction (benefit) that they achieved and that "other" beneficiaries would pay for their portion of the overall benefit. It is quite possible that M&I water conservation in some regions outside of the hydrologic basin may result in little to no reduction in Colorado River demand due to cost considerations within the region's water supply portfolio.

TABLE F9-7
Estimated Costs per af Demand Reduction for Each Conservation Level at 2060

Costs (afy) for Demand Reduction by Category			
	Level 1	**Level 2**	**Level 3**
Residential Indoor	$ 350	$ 450	$ 550
CII	$ 550	$ 900	$ 1,200
Outdoor Landscape	$ 700	$ 1,050	$ 1,400
Water Loss	$ 350	$ 350	$ 350
Total	$ 500	$ 750	$ 950

Per capita water use varies widely across the states and across planning areas within states because of differences in climate conditions, economic and demographic conditions, industry and recreation composition, and level of historical conservation efforts. The conservation options described here are applied as a Basin-wide percent reduction in M&I demand. It should be recognized that in reality some regions could achieve the targets more cost- effectively than regions that have had active conservation programs in place for several decades.

10.0 Other Key Criteria

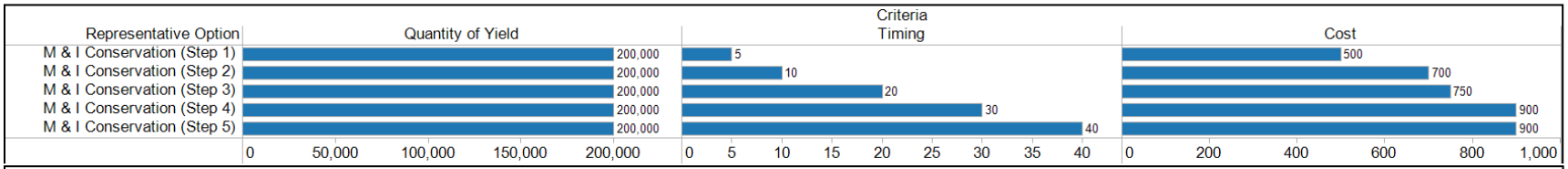
In addition to yield, timing, and cost, the M&I conservation options were characterized for several other criteria. A summary of the findings for all criteria is shown in table F9-8. In general, these options are highly feasible, with existing examples in areas of the Southwest and in other arid regions of the world. Programs of this scale are underway at state levels, but have not been demonstrated on basins of the scale of the Colorado River in North America. Based on the targeted BMPs and quantity of yield, these options are likely to become progressively more difficult to implement moving from Level 1 to Level 3. Likewise, as conservation becomes more successful, the ability to reliably maintain a given level becomes somewhat more difficult

through the result of demand hardening – less discretionary use. It is not anticipated that permitting or legal changes will be required to implement most conservation measures, but agreements will be required on the methodology and institutional structure to implement in this multi-jurisdictional Basin. Some policy changes may be required to fully implement the Level 3 assumptions depending on implementation, in that large-scale landscape conversion to xeriscape will be required. There is some implementation risk in that yields will fluctuate over time, and programs will require continuous funding to maintain overall results. Many conservation measures are based on achieving behavior changes in the way water is valued and used. The realized conservation savings associated with these measures may depend on future economic, social, and political conditions that maintain and strengthen these behavior changes. In general, however, once savings are realized through most measures they can be maintained, resulting in long-term viability of the options. These options were rated high with respect to operational flexibility because the programs can be stopped at any time without incurring significant debt service or resulting in stranded assets. There are no inherent energy needs for the M&I conservation options in that they result in reduced demand and reduced need to treat and deliver water. For the highest levels of conservation there could be some socioeconomic issues as turf is replaced by xeriscaping.

11.0 Characterization Results

A summary of the characterization findings are shown in table F9-8. The top portion of the table shows the estimated quantity of yield, earliest timing of implementation, and estimated cost. The bottom portion of the table shows the 17 criteria and associated ratings ("A" through "E") for each option. As noted previously, for implementation purposes, some large options, were broken into 200-kafy yield steps to reflect increasing complexity as project size increases. For conservation, the three conservation levels resulted in demand reduction (yield) from about 600,000 afy to 1.2 mafy. These resulting yields were implemented in 200-kafy steps. These steps are denoted numerically with "1" being the first 200-kafy step, followed by subsequent steps. In general, a "C" rating is typically designated as mostly neutral (yellow), "A" is largely positive (green), or easier to accomplish, and "E" is largely negative (red) or more difficult to accomplish. Refer to appendix F3 for specific criteria descriptions and rating scales.

TABLE F9-8
Summary Characterization Ratings for M&I Conservation Options



Criteria

Representative Option	Quantity of Yield	Timing	Cost	Technical Feasibility	Implementation Risk	Long-Term Viability	Operational Flexibility	Permitting	Energy Needs	Energy Source	Other Environmental	Recreation	Socioeconomics	Policy	Legal	Hydropower	Water Quality
M & I Conservation (Step 1)	D	A	A	A	A	B	A	A	A	A	A	A	B	A	A	B	B
M & I Conservation (Step 2)	D	B	A	A	B	B	A	A	A	A	A	A	B	B	A	B	B
M & I Conservation (Step 3)	D	C	A	A	B	B	A	A	A	A	A	A	B	B	A	B	B
M & I Conservation (Step 4)	D	D	A	B	C	C	A	A	A	A	A	A	C	B	A	B	B
M & I Conservation (Step 5)	D	E	A	B	C	C	A	A	A	A	A	A	C	B	A	B	B

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