TECHNICAL EVALUATION OF OPTIONS FOR LONG-TERM AUGMENTATION OF THE COLORADO RIVER SYSTEM

WHITE PAPER ON WATER REUSE

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ACRONYMS

AF	acre-foot
AFY	acre-feet per year
Basin	Colorado River Basin
CRWC	Colorado River Water Consultants
Initiative	Southern California Water Recycling Projects Initiative
mgd	million gallons per day
mg/L	milligrams per liter
MTBE	methyl tertiary butyl ether
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
PCE	tetrachloroethene
RO	reverse osmosis
SCCWRRS	Southern California Comprehensive Water Reclamation and Reuse Study
Seven States	Seven Colorado River Basin States
SNWA	Southern Nevada Water Authority
TCE	trichloroethene
TDS	total dissolved solids
U.S.	United States
USBR	U.S. Bureau of Reclamation
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compounds

1.0 WHITE PAPER ON WATER REUSE

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1.1 SUMMARY AND PURPOSE

This discussion of urban and agricultural water reuse is one of a series of White Papers being prepared for the Seven Colorado River Basin States (Seven States). The purpose of the White Papers is to present evaluations of potential options to provide long-term augmentation of the water supply of the Colorado River system. This White Paper presents background information on the overall evaluation program, followed by a preliminary evaluation of the urban and agricultural water reuse options.

1.2 BACKGROUND

The Seven States have authorized Colorado River Water Consultants (CRWC) to provide a technical evaluation of long-term options. The States will supplement the technical evaluations with legal, administrative, and/or institutional considerations.

The White Papers are the first step in an iterative process to develop, screen, and evaluate options. Evaluation parameters will be applied progressively and will be developed in increasing detail as selected options become more promising. In parallel with White Paper development, the CRWC research team will meet with representatives of the Seven States and will refine the White Papers/develop new White Papers based on their input. White Paper results will be reviewed with a Technical Steering Committee comprised of delegates from the Seven States.

Each White Paper will present a brief overview of the option being evaluated, followed by discussions of history and viability of obtaining additional water from the source, location of supply, quantity of water potentially available, water quality, technical issues, general reliability of supply, environmental issues, permitting issues, and project costs. A list of reference documents for each White Paper will be included, and general findings and conclusions will be provided.

1.3 OVERVIEW OF WATER REUSE OPTION

Water recycling and reuse is one of many effective ways to conserve water. Water recycling reuses water that normally would be discharged as treated wastewater to inland or coastal bodies of water. The development of urban and agricultural reuse projects assists in augmenting water supplies by replacing the need for potable water for nonpotable uses as well as surface or groundwater for agricultural use. For this reason, recycled water is an important component of augmenting potable and agricultural water supplies, thus helping to ensure adequate quantities of water to meet water needs within the Seven States.

This White Paper describes how urban and agricultural reuse can be used as options to extend water resources in the Seven States. The focus is on reuse in large urban areas (e.g., the southern California region, Las Vegas, Nevada, and Phoenix/Tuscon, Arizona) as well as agricultural areas in this same geographic region. Urban reuse in these locations has been practiced for decades, but more can be done as these areas have significant quantities of wastewater which can be reused. In addition, these large urban areas need to augment existing water supplies. Agricultural reuse will provide an opportunity to replace the existing irrigation water source with treated water, and, in theory result in less diversions from the Colorado River upstream of the highly populated southern California area. A major advantage to agricultural reuse is the potential to reuse large quantities of water in controlled environments with limited public access.

1.4 HISTORY/VIABILITY OF OBTAINING WATER FROM THIS SOURCE

The implementation of recycled water projects throughout the world has occurred primarily in areas with large populations and water scarcity issues. This is already occurring in the United States (U.S.), especially in the western states where water scarcity issues and/or large or expanding populations are driving the need for new water sources. To date, California and Arizona are two of the largest users of recycled water in the U.S. with these states supplying an estimated 360 million gallons per day (mgd) and 210 mgd of recycled water in 2000.

1.4.1 Urban Reuse

Water reuse has evolved from its early use primarily for crop irrigation to include a wide range of urban uses. Urban reuse is defined as the use of recycled or reclaimed water for nonpotable purposes including (U.S. Environmental Protection Agency [USEPA], 2004):

- Irrigation of parks and recreational areas, school facilities (e.g., yards and playing fields), highway medians and shoulders, and landscaped areas surrounding public buildings.
- Irrigation of landscaped areas surrounding single-family and multi-family residences, commercial, office, and industrial developments.
- Irrigation of golf courses.
- Commercial uses such as vehicle washing facilities, laundry facilities, window washing, and mixing water for pesticides, herbicides, and liquid fertilizers.
- Ornamental landscape uses and decorative water features, such as fountains, reflecting pools, and waterfalls.
- Dust control and concrete production for construction projects.
- Fire protection.
- Toilet and urinal flushing in commercial and industrial buildings.

Recycled water is water that has been treated at a wastewater treatment plant. The level of treatment required depends upon location, use, and influent water quality. In California, urban water reuse was used to augment existing water supplies as early as 1929 when the city of Pomona used recycled water to irrigate landscaped areas. The growing use of recycled water in the ensuing 77 years has been summarized by the U.S. Bureau of Reclamation (USBR) in the Southern California Water Recycling Projects Initiative (Initiative) Final Report.

1.4.2 Agricultural Reuse

Agricultural reuse of treated wastewater has been practiced in the U. S. for over a century. Sewage farms were established in the United Kingdom as early as 1865, in the U. S. in 1871, France in 1872, Germany in 1876, India in 1877, Australia in 1893 and Mexico in 1904 (Mara and Cairncross, 1989). In most all of these countries the impetus for sewage farming was to prevent river pollution. However as populations grew and concentrated and more people were connected to sewer systems, the land base was insufficient near the treatment facilities.

In the past four decades, there has been a significant increase in treated wastewater for crop irrigation, especially in the semiarid areas of both developed and developing countries (Mara and Cairncross, 1989). The reason for the increase in irrigation with treated wastewater in these areas occurs due to several factors:

- Scarcity of alternative waters and water in general for irrigation.
- The recognition by respected water resource engineers, scientists and planners as to the value of the practice.
- Increasing cost of artificial fertilizers.
- High costs of advanced wastewater treatment plants.
- The demonstration that health risks and soil damage are minimal if appropriate precautions are taken, including education programs.
- The sociocultural acceptance of the practice.

The viability of obtaining agricultural irrigation water from a wastewater treatment plant is, in many cases in the southern California area, more reliable and consistent than other traditional forms of irrigation water such as groundwater and surface water. The difficulty in using this large volume of water comes in the conveyance of the resource to agricultural areas adjacent to urban areas.

1.5 LOCATION OF SUPPLY

Significant urban and agricultural water reuse supplies are located primarily in large urban areas where reuse of wastewater from centralized wastewater treatment plants is economically feasible. In the Seven States study area, these locations are southern California; Las Vegas, Nevada; and Phoenix and Tucson, Arizona. However, wastewater can be recycled and reused for urban and agricultural reuse purposes in smaller cities as well. For example, the city of Albuquerque, New Mexico is implementing an urban water reuse program. The southern California region, which encompasses the urban areas of Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura Counties, was included in this option because this area relies on imported water from the Colorado River for potable and partial irrigation water supply. Therefore, implementing urban and agricultural water reuse can serve as a source to augment potable water supplies. Figure 1 shows a map of the study area including the large urban areas discussed in this White Paper. From an agricultural perspective, implementation of reuse is difficult when the distance of conveyance of the treated wastewater is not close enough in proximity to economically deliver reclaimed water to the "field edge" for agricultural reuse. As urban centers continue to expand into agricultural land this "proximity issue" actually become more convenient, especially for newly developed treatment facilities.

Figure 1 Map of Seven States Study Area

1.6 AMOUNT OF WATER

It is estimated that approximately 1.5 million acre-feet per year (AFY) of treated wastewater is discharged to the ocean in the southern California area without reuse. Projects for the reuse of this valuable resource have been developed for both urban and agricultural irrigation systems.

Urban water reuse projections are shown in Table 1. The urban water reuse projections summarized in Table 1 are primarily for urban irrigation reuse; however, industrial, environmental, and miscellaneous uses of recycled water were included in some projections.

Agricultural reuse of the remaining water that is not projected to be used in urban environments could approach 0.9 million AFY. It is not, however, likely economically or logistically feasible to use all of that estimated water volume. For example if only half of that volume (0.4 million AFY) were used for agricultural irrigation, approximately 80,000 to 140,000 acres of irrigable land would be required. The influencing factor on the amount of water that could potentially be reused in an agricultural system is highly dependent on the irrigable land base available and the conveyance infrastructure required to deliver this water. At least initially, it is likely that more water is available than can be delivered both economically and feasibly to agricultural environments. This provides an opportunity for expansion into agricultural lands that is significant and could result in significant water savings for this part of the Colorado River Basin (Basin).

Table 1 Summary of Selected Urban Water Reuse Projections			
Location	Amount of Annual Water Reuse (afy)		Type of Water Reuse included in Projection
	2010	2040	
Southern California[1]	298,100	473,300	
Los Angeles County	134,900	218,600	Environmental, Industrial, Miscellaneous, and Urban Irrigation
Orange County	41,700	61,100	Environmental (2040 only), Industrial, Miscellaneous, and Urban Irrigation
Riverside and San Bernardino Counties	80,400	130,100	Environmental, Industrial, Miscellaneous (2040 only), and Urban Irrigation
San Diego County	28,100	45,500	Industrial, Environmental, and Urban Irrigation
Ventura County	13,000	18,000	Environmental and Urban Irrigation
Phoenix[2]	5,000	61,000	Industrial, Urban Irrigation, and Environmental Uses
Tuscon[3]	11,000	20,200	Industrial and Urban Irrigation
Las Vegas[4]	23,700	62,710	Industrial and Urban Irrigation
Total	337,800	617,210	

Notes:
[1] Data from Southern California Water Recycling Projects Initiative, Table 4.2.
[2] Data from City of Phoenix Water Resources Plan 2005 Update, Appendix B - Water Budget Projection and Details, Scenario A. Projections assume no RID Exchange.
[3] Data from City of Tucson Water Department Water Plan: 2000-2050. Data used is Year 2000 for 2010 and 2050 for 2040 Year projections.
[4] Data Source for 2010 projection: Southern Nevada Water Authority Water Resources Plan 2006. Data is 2004 water use as outlined in Chapter 3. Data for 2040 is based on implementation of the system in the Area Wide Reuse Study for the Las Vegas Valley Study Area, Table ES-2.

1.7 WATER QUALITY

1.7.1 Urban Reuse

Water quality of recycled water varies depending upon the source of potable water, how the potable water was used, and the type of treatment processes at the wastewater treatment plant. In the Seven States region, potable water supplies originate primarily from groundwater, surface water, and stormwater runoff. Potable water quality is dependent upon salt or total dissolved solids (TDS) concentrations, other constituent concentrations (e.g., arsenic, nitrates, phosphorus, sulfites, and volatile organic compounds (VOC)), and contaminants (e.g., tetrachloroethene (PCE), trichloroethene (TCE), and methyl tertiary butyl ether (MTBE)) concentrations and a range of emerging contaminants of concern such as endocrine disrupting compounds. The concentrations and concerns regarding these constituents vary across the region based on the specific groundwater basin or geographic area. For example, acceptable TDS concentrations vary within southern California from 100 milligrams per liter (mg/L) to 1000 mg/L of TDS depending upon the groundwater basin objective. How these constituents are reflected in the final potable water is dependent on the water treatment process employed. Subsequent treatment in the wastewater treatment facility will further impact the quality of the reclaimed water. Due to the location specific nature of these constituents, it is impossible to quantify a range for each constituent. Information describing the major constituents of concern and the sources of and problems associated with these constituents is readily available in the Initiative Final Report.

Another factor that impacts reclaimed water quality is the type of potable use. As water is diverted from streams or groundwater and is used for irrigation or municipal/industrial uses, chemicals are added to the water stream. Many of these chemicals include high concentrations of salts, especially effluent streams from irrigation activities with chemical applications and municipal activities that discharge water from cooking, cleaning, manufacturing, and/or water softener backwash streams. Each time water is used, a potential exists for significant increases in constituent concentrations. For example, municipal uses can increase TDS from the water supply to the wastewater effluent by 200 to 400 mg/L (U.S. Department of the Interior, Bureau of Reclamation [Reclamation], 2006). The level of wastewater treatment can also impact the water quality of recycled water. In the Seven States region, the level of treatment for reclaimed water ranges from wastewater treatment with disinfection to advanced treatment processes (i.e., secondary treatment followed by filtration, reverse osmosis, and ultraviolet disinfection). The level of treatment required is dependent on the use type, influent water quality, and state regulation. For example, the West Basin Municipal Water District operates an advanced treatment plant to serve an industrial client that requires consistent high-quality water. The level of treatment in this case is based on the need of the end user.

1.7.2 Agricultural Reuse

Perhaps the most influential factors in determining whether or not an agricultural reuse system is appropriate, depends on the quality of water produced from the wastewater treatment facility and the crops and soils this water is intended to irrigate. Water quality varies from one treatment facility to another, however, is greatly influenced by the initial source water quality. Plentiful research has been conducted and reliable values have been determined for a whole variety of water quality parameters as related to specific crops. It should be clearly noted that different agricultural crops have very different tolerances to various constituents of concern. For example, avocados and strawberries (a portion of many crops grown in southern California) are some of the most susceptible crops to salinity and chloride in the irrigation water (CH2M HILL, 2006). That being said, forage crops such as grass hay, alfalfa, wheat, barley, etc. are much more tolerant. In most cases salinity is the main constituent of concern with some individual ions (e.g. chloride, boron, sodium, etc.) being of specific concern for certain crops. Reclaimed water quality constituents of concern for irrigation have been well documented in the literature. Issues can vary according to the tolerance of the individual crop, soil type, climate, irrigation method, etc.

1.8 TECHNICAL ISSUES

Key technical issues that impact the level of urban and agricultural water reuse are initial planning activities, water supply/availability, public perception/water quality concerns, treatment requirements, regulatory requirements, seasonal storage, potential environmental impacts, and economics. Water reuse is most economic, accepted, and feasible when it is used to supply users either located near the wastewater treatment plant or where one large user makes supplying water economical. This is based on the infrastructure requirements to serve users that have to be developed. Moving recycled water across regions was studied by Reclamation and 12 other agencies in the Southern California Comprehensive Water Reclamation and Reuse Study (SCCWRRS, Reclamation 2003) and was found to be difficult due to institutional issues, geographic issues, and economic costs. It is more viable to reuse water within its area of origin. With that said, there are emerging treatment technologies that allow "satellite" plants to be constructed at the point of use for reclaimed water which can significantly reduce the amount of reuse water distribution system infrastructure.

The success of any urban or agricultural reuse program is significantly dependent on the initial planning, science and engineering activities required to establish a viable reuse program. Without thoughtful planning, including public education, the potential for marginal success or poor performance in a reuse system exists. It is crucial that the sizing of the irrigation facilities are conducted in a scientifically sound manner relative to the influence of the climate, crop rotation, soils, irrigation method, etc. The engineering behind the irrigation system is important to ensure containment of tail water where necessary and efficient irrigation and conveyance facilities.

Adequate water quality is one of the keys to the success of water reuse projects because public acceptance is associated closely with the belief that the water is safe to use. As discussed in the previous section, water quality is dependent upon geographic location and treatment method. However, salinity is a constituent that is emerging across the Seven States region as a significant limitation for water reuse. Salinity-associated issues include corrosion, environmental impacts, and limitations on many types of beneficial reuse. . Blending saline recycled water with higher quality water or applying reverse osmosis (RO) or membrane filtration might be used to reduce salinity concentrations and gain beneficial uses. Desalination treatment is described in more detail in the White Papers on Brackish Water Desalination and Ocean Water Desalination.

Salinity mitigation is expensive and could even lead to a decision not to use reclaimed water. Additionally, where membrane filtration can be applied to remove the salinity, these treatment processes produce a highly concentrated brine solution, which results in significant disposal issues, such as the need for extensive pipeline systems to convey the brine/concentrate to the ocean for discharge, or the implementation of costly brine management processes.

Regulatory issues facing water reuse are primarily based on water quality regulation and source water protection. In the Seven States region, water reuse regulations vary based upon requirements of the individual States. Under the current regulations, urban and agricultural water reuse is an economically feasible option to augment water supplies; however, if regulations become more stringent in regard to water quality then water reuse may not be a viable option due to the treatment and associated costs required to meet new regulations.

Managing and distributing reclaimed water is different than the management of traditional irrigation sources. For example, a water utility currently drawing from groundwater or surface impoundments uses the resource as source and storage facility. If all of the yield of the source is not required, the water is simply left for use at a later date. In the case of reuse, reclaimed water is continuously generated and what cannot be used immediately must be stored or disposed of in some manner. Storage requirements can become a significant component of the reuse system. This is especially true in California whereby a very low proportion of the irrigation demand occurs in the winter months, yet wastewater production in ongoing. Conversely, if the irrigation system is sized correctly, the demand during the growing season will likely be much more than the rate of supply. Therefore, some form of storage will likely be necessary in the development of a reuse program. These facilities can be large regional storage areas or individual, on-farm storage ponds in the case of agricultural reuse.

Environmental impacts can influence a water reuse system and need to be considered during the planning process. For example, use of reclaimed water can have beneficial or detrimental influence on land use, stream flows, and hydrogeologic characteristics of the surrounding environment (USEPA, 1992).

Key economic components that can limit the potential for reuse of water in an area are cost and existence of adequate infrastructure. Recycled water needs to be conveyed from the water reclamation plant to the user; therefore, the infrastructure costs are the additional treatment and conveyance costs as well as the cost for storage. The cost of infrastructure as well as the economics of developing recycled water projects can limit the potential for project implementation.

Recycled water pricing historically has been at reduced levels to attract users. However, recycled water has become more valued as a mechanism to assist in conserving potable water as well as an alternative water supply. The true economics of water reuse are not derived solely from cost recovery. In general, water used in agricultural settings needs to be priced at 50-75 percent of the grower's normal water costs. This, however, is influenced by water quality and the crops being grown. The value of water reuse is also dependent on avoided costs for water supply, wastewater disposal, environmental degradation, and energy usage. Additionally, extensive values are associated with reliable water supplies during dry periods. These values appear as community income and employment based on the availability of water supplies. Although recycled water systems are costly to implement, the implementation of a recycled water system can offset a number of other costs that face water or wastewater agencies. In general, the cost of existing irrigation water in southern California is, in some circumstances, very high (e.g., $350-500 per acre-foot [AF]). A consistent supply and lower cost recycled water source can be attractive to certain agricultural settings. In the end, development of a recycled water project depends on the value assigned by the local agency and whether or not the project is feasible under the set of circumstances that the agency is facing.

1.9 GENERAL RELIABILITY OF SUPPLY

Recycled water is a reliable, locally controlled source of water with a long history of use. In addition, recycled water is regulated by the State and Federal government to protect and ensure public health and safety. The availability of recycled water is predicated upon the amount of potable water used and discharged to the sewer system. Table 2 provides a summary of the total amount of wastewater projected to be available in 2010 and 2040 for selected large urban areas in California, Arizona, and Nevada. Recycled water is susceptible to the same types of disruptions as potable water supplies during natural events such as floods and earthquakes. Supply disruptions are mainly due to damage to treatment processes, breaks in pipelines, and damage to storage facilities.

The biggest supply reliability issue facing the urban use of recycled water is the seasonal variability of the use (e.g. the water is used during peak conditions in the hot summer months and not used in cooler winter months). To address seasonal use variability, seasonal storage facilities will need to be developed to store water for peak demand periods or treatment. Another approach to avoiding the cost for implementation of seasonal storage is to assume a factor that approximates the peaking requirements of the recycled water systems' urban or agricultural irrigation use. For example, the SCCWRRS report assumed a peaking factor of 2 that although not exact for all landscape irrigation users, was a good approximation of what can occur on a systemwide basis for nonpotable systems (Reclamation 2002). Using a peaking factor of 2 means that flow from the treatment plants is allocated at a rate that was twice the landscape irrigation user's annual average flow. This results in treatment plants having an excess flow available in the winter months, which goes unused, and does not maximize the use of this water supply resource. With even small supplemental storage, a greater portion of this valuable resource can be used.

Table 2 Wastewater Availability in Selected Urban Regions		
	Wastewater Availability (mgd)	
Area	**2010**	**2040**
Southern California[1]	1,005	1,437
Phoenix[2]	161	161
Tuscon[3]	27	59
Las Vegas[4]	112	161
Total	1,306	1,818

Notes:
[1] Data from Southern California Water Recycling Projects Initiative, Table 4.6. This data is based on tertiary treated water at WWTP with capacities greater than 1 mgd.
[2] Data from City of Phoenix website at http://phoenix.gov/WATER/wtrfacts.html. 250 mgd of WWTP effluent available less the 100,000 afy allotment for Arizona Nuclear Power Plant.
[3] Data from City of Tucson Water Department Water Plan: 2000-2050. Data used is Year 2000 for 2010 and 2050 for 2040 Year projections.
[4] Data Source for 2010 projection is based on implementation of the system in the Area Wide Reuse Study for the Las Vegas Valley Study Area, Table ES-1. Data for 2040 projection based on full WWTP flow as summarized on website: http://www.cleanwatercoalition.com/whoweare/WhoWeAreFrame.htm.

1.10 ENVIRONMENTAL ISSUES

The use of reclaimed water affects the environment by disturbing the environment during construction of facilities and by removing water that is discharged to streams or rivers. The impacts on the environment from construction of facilities are dependent upon the location of the project, type of construction, and the environment that exists. This will need to be investigated on a site by site basis. Construction can have short-term effects such as disturbing the soil or longer term effects that require mitigation measures to protect or reestablish habitat in another location.

The second environmental effect of recycled water use is the removal of water from the stream or river where wastewater was previously discharged. In southern California, the Los Angeles, Santa Ana, Santa Clara and San Gabriel Rivers are all effluent dominated streams during most of the year. Therefore, removal of the significant quantities of effluent from these streams or rivers could impact habitat that has been established or has flourished as a result of the discharged wastewater. The city of Los Angeles is currently working on a study to determine what is the low flow capability of the Los Angeles River that would still support habitat that has been established as a result of the effluent discharges. Colorado River water use in the southern California, Tucson and Phoenix areas result in water being removed from the river system and either reused, recharged, or discharged in the region of use. However, in Nevada the Southern Nevada Water Authority (SNWA) returns the flow used to the Colorado River. The SNWA receives credits for these return flows to the Colorado River.

1.11 PERMITTING

Permitting of urban recycled water projects consists of State and Federal National Environmental Policy Act (NEPA) requirements (Record of Decision), National Pollutant Discharge Elimination System (NPDES) permitting under the Federal Water Pollution Control Act, and adherence to local and state environmental health requirements.
For agricultural reuse projects in California, permitting is mostly regulated by the State Water Resources Control Board and the Regional Water Quality Control Boards and many times does not involve NEPA or NPDES requirements. These permits are approved on the basis of both agronomic nutrient and hydraulic loadings, soil conditions and crop removal. Basically, both a nutrient and hydraulic loadings balance needs to be developed and strictly adhered to. Also, tail water management, up to recovery and reuse is usually necessary for systems that produce tail water. Annual or seasonal soil, crop and groundwater sampling are usually required throughout the life of an agricultural reuse site.

Environmental requirements (i.e. NEPA /California Environmental Quality Act [CEQA] for a recycled urban water project are similar to those for construction for water supply projects. To implement a recycled water project, a NPDES permit is required. These permits are issued by the State for the USEPA and are based on water quality requirements (i.e., total dissolved solids [TDS], nitrate, phosphorous) set on a local water basin level. In addition to NPDES permitting, other local regulations that protect health and safety also must be met. Examples of local regulations are: requiring purple pipe and other signs denoting recycled water is in use; requiring cross connection control of dual plumbing systems, and regulating water quality to protect the water quality in the area where recycled water is used. In addition, local regulators may implement requirements to protect surface and groundwater sources in an area by requiring specific water quality requirements be met.

1.12 COST

Costs associated with implementation of urban reuse projects vary by geography, level of treatment required, user requirements, and available uses. Table 3 provides an overview of potential costs to implement recycled water projects as developed by local agencies. Due to the variability of the cost based on locality, no costs for reuse were developed.

Costs associated with agricultural systems should be considered to be on the same order of magnitude as urban systems, since the bulk of the cost is usually associated with conveyance facilities to deliver the water to the user. These costs are similar in nature, regardless of the end use (urban or agriculture). It should be noted, however, that for agricultural systems the cost ends there and the grower is usually responsible for all costs starting at the field edge including filtration systems, irrigation systems, blending systems, pumping facilities, on site storage, and tail water recovery and reuse.

Unit costs of reuse are estimated to be between $900/AF and $1,700/AF based on amortization of the capital costs for Southern California and Las Vegas from Table 3 plus an O&M cost ranging from $2 to $4 per thousand gallons.

Table 3
Costs to Fund Recycled Water Projects in Selected Areas

Area	Amount of Recycled Water (afy)	Cost ($)	Uses
Southern California[1]	451,500	$ 2,252,800,000	All use types
Phoenix[2]	180,000	N/A	No future costs because water will most likely be recharged
Tuscon[3]	66,000	N/A	After 2014 planned reuse is for potable use.
Las Vegas[4]	62,710	$ 223,000,000	Industrial and Urban Irrigation
Total	760,210	$ 2,475,800,000	

Notes:
[1] Data from Southern California Comprehensive Water Reclamation and Reuse Study, Table ES-2.
[2] Data from City of Phoenix website at http://phoenix.gov/WATER/wtrfacts.html.
[3] Data from City of Tucson Water Department Water Plan: 2000-2050.
[4] Data Source is based on implementation of the system in the Area Wide Reuse Study for the Las Vegas Valley Study Area, Table ES-2.

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1.14 CONCLUSION

Urban recycled water use is locally controlled and a reliable water supply that can be implemented to augment existing potable water supply sources. Implementation of recycled water projects are site specific based on local geography and environment, local water quality, and local and state regulations. Findings are summarized in Table 4.

Table 4 Summary of Findings Related to Urban and Agricultural Reuse Option	
Parameter	**Findings**
Location of Supply	Large urban areas or any locality where wastewater is available, particularly Southern California.
Quantity of Water Potentially Available	Availability ranges from 20,000 to 760,000 AFY.
Water Quality	Site specific
Technical Issues	Planning activities, water supply/availability, public perception/water quality concerns, treatment requirements, regulatory requirements, seasonal storage, potential environmental impacts and economics
General Reliability of Supply	Extremely reliable and constant supply
Environmental Issues	Site specific, primarily related to construction activities.
Permitting Issues	Site specific for urban, however, mostly driven by the Regional Water Quality Control Board in Southern California
Cost	$2.5 billion for large urban areas. Not quantified for entire region. Likely a similar cost with agricultural settings for 400,000 AFY usage – mostly contained in the conveyance requirements to the field edge. Unit costs are estimated to range from $900/AF to $1,700/AF