

WATER RECYCLING FAQs

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Introduction

Increasing demands on limited water resources have made wastewater recycling (reclamation or reuse) an attractive option for extending water supplies. Treatment technologies have evolved such that recycled water is of sufficient quality to satisfy most non-potable demands, and as such, recycled water has increasingly been used for municipal irrigation, toilet flushing, industrial cooling, and other applications. Many communities are currently engaging in discussions about the possibility of using recycled water to meet potable demands as well. In fact, potable reuse has already been implemented in many communities throughout the United States (U.S.) and the world, but the treatment technologies vary considerably between systems. The use of recycled water is particularly beneficial to extending water supplies in arid climates, areas facing high growth, and regions under water stressed conditions.

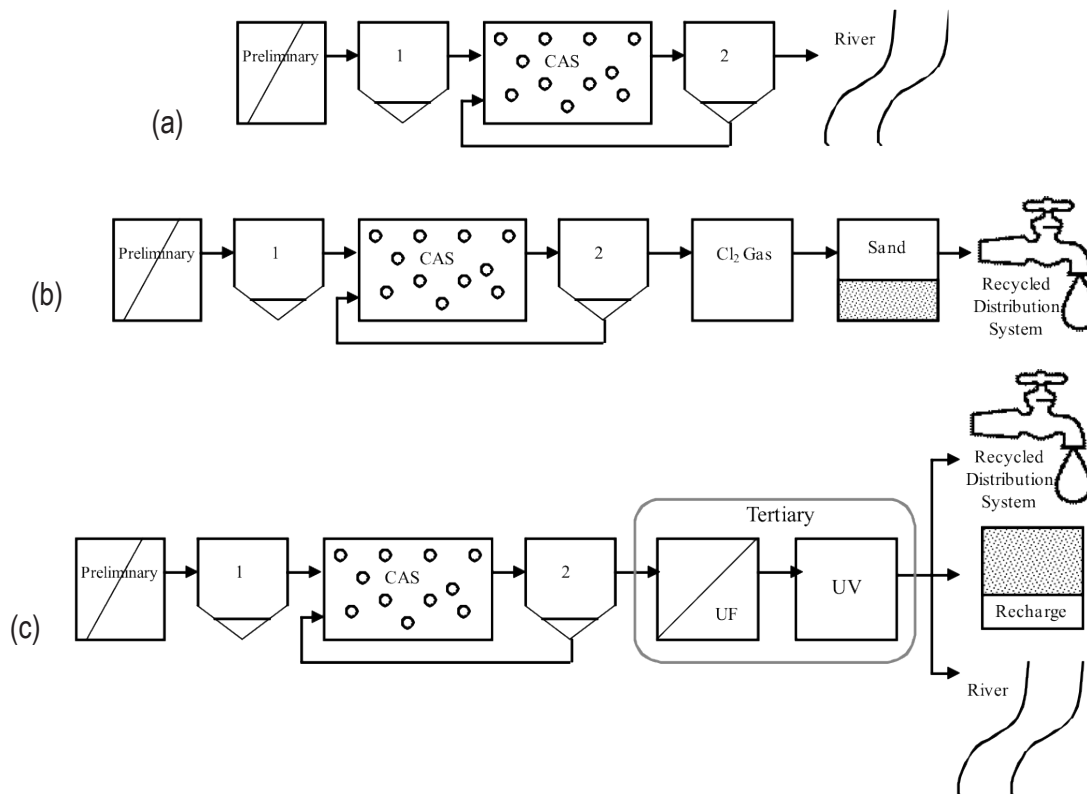
Communities throughout the U.S. have safely used recycled water for many years. In fact, Los Angeles County's sanitation districts have provided treated wastewater for landscape irrigation in parks and golf courses since 1929. The first recycled water facility in California was built at San Francisco's Golden Gate Park in 1932. More recently, advances in treatment technologies have increased the use of recycled water nationwide over the past two decades. In 2006, the U.S. EPA estimated that an average of more than 1.7 billion gallons of wastewater was reused per day (Brandhuber, 2006), representing 5 to 6 percent of the municipal wastewater effluent generated each day in the U.S. (WateReuse Association, 2011a). The states of Florida and California currently have the largest programs, with each reusing an average of more than 500 million gallons per day (MGD), while reuse in Texas and Arizona exceeds an average of 200 MGD (Brandhuber, 2006; U.S. EPA, 2004). Water recycling programs in Arizona, California, Florida, and Texas currently account for about 90% of the water recycled in the country, though recycled water programs are also emerging in many other states: including Washington, Oregon, Nevada, Colorado, New Mexico, Pennsylvania, Virginia, Georgia, and Maryland (WateReuse Association, 2011a).

What is the difference between recycled water, reclaimed water, and water reuse?

Recycled or reclaimed water is defined as water that is used more than one time before it is returned back into the natural water cycle. Recycled water is generally used for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing, or replenishing a groundwater basin (referred to as groundwater recharge; WateReuse Association, 2011b). These terms are generally used interchangeably, although the preferred term may differ regionally. Recently, public perception studies have indicated that the term "recycled" is often preferred over "reclaimed" based on their connotations (Rock, unpublished data). Water reuse also describes water that has been used more than one time prior to environmental discharge, although the term generally relates to potable uses.

How is recycled/reclaimed water different from raw water?

Through the natural hydrologic cycle, the Earth has recycled water for millions of years. Water utilities use engineered technologies to speed up these natural processes. The Colorado River and the Mississippi River are two common sources of raw water in the United States. Along these rivers, the wastewater discharge of upstream communities ultimately becomes the drinking water source for downstream communities—a concept known as "unplanned indirect potable reuse" (IPR). The water from these rivers has been reused, treated, and piped into the water supply a number of times before the final downstream user withdraws the water. Thus, it is not uncommon for "natural" raw water to be of far poorer quality, containing numerous microbiological and chemical contaminants, than recycled wastewater that has undergone advanced treatment. Regardless of the source, however, water utilities employ multi-barrier processes and follow stringent guidelines to treat water to a quality commensurate with the intended use (WateReuse Association, 2011b).



- (a) Conventional wastewater treatment including preliminary screening of debris and other non-biodegradable materials, primary clarification which allows solids or “sludge” to settle out of the water while floating materials such as grease and oils rise to the surface and be skimmed, aerobic treatment using dissolved oxygen to promote growth of biological floc that help to degrade organic material, secondary clarification to settle out the biological floc and produce water with low levels of organic material and suspended matter, followed by discharge to surface water.
- (b) Treatment processes mentioned above (a) with the addition of disinfection using chlorine gas to inactivate any microorganisms present coupled with sand filtration to “finish” the water by removing small particles prior to distribution for irrigation.
- (c) Treatment processes mentioned above (a) with the addition of ultrafiltration to “finish” the water by removing small particles and residual organic matter coupled with the use of ultraviolet light to inactivate any microorganisms present prior to distribution for irrigation, groundwater recharge, and/or discharge to a surface water.

Figure 1. Common Wastewater Treatment Processes

Table 1. Wastewater Treatment Processes: Purpose and Example Technologies (modified from Wu et al., 2009)

Treatment Stage	Purpose	Technologies
Preliminary	Removal of large solids and grit particles	Screening; settling
Primary	Removal of suspended solids and some organic matter	Screening; sedimentation
Secondary	Biological treatment and removal of common biodegradable organic pollutants as well as inactivation of some microorganisms	Percolating or trickling filter; activated sludge; anaerobic treatment; waste stabilization ponds (oxidation ponds)
Tertiary (or Advanced)	Removal of suspended particles and specific pollutants such as phosphorus, and removal/inactivation of bacteria, parasites, and some viruses	Sand filtration; membrane bioreactor; microfiltration; ultrafiltration; reverse osmosis; chemical coagulation; UV; activated carbon

How is water recycled?

Water utilities use a variety of well-tested and reliable treatment processes to recycle water. Utilities generally describe the various stages of treatment rather than the technologies utilized when referring to water quality, as there are multiple treatment techniques for achieving essentially the same result. Generally speaking, the four core stages of treatment are Preliminary Treatment, Primary Treatment, Secondary Treatment, and Tertiary or Advanced Treatment. The primary objective of conventional wastewater treatment (i.e., the four stages above) is to reduce nutrient loads to the environment, thereby maintaining the health of aquatic ecosystems. In recycled water applications, conventional wastewater treatment can be supplemented with additional processes to achieve a quality that is consistent with the intended use. At a minimum, recycled water will undergo some form of disinfection (WateReuse Association, 2011b). Examples of common treatment processes are presented in Figure 1, while Table 1 outlines wastewater treatment processes and provides the purpose and examples of technologies that are currently used.

Why should we recycle water?

Water recycling offers a climate-independent water source that is dependable, locally-controlled, and generally beneficial to the environment. Water recycling allows communities to become less reliant on groundwater and surface water sources and can decrease the diversion of water from sensitive ecosystems. In communities where untreated wastewater is typically discharged into waterways, water recycling may reduce nutrient loads to the environment, thereby reducing pollution and the potential for eutrophication (see “Common Terminology of Water Recycling AZ1569” <http://cals.arizona.edu/pubs/water/az1569.pdf>). Finally, this “new” water source may also be used to replenish overdrawn water sources and rejuvenate or reestablish those previously depleted (WateReuse Association, 2011b).

How can recycled water benefit us?

Recycled water can be used in numerous applications to satisfy water demands, but the end use and water quality objectives determine the level of treatment that is required prior to use. At the wastewater treatment facility, the water is treated to meet a variety of regulatory guidelines (state-specific in the U.S.). Those guidelines range from total maximum daily loads on nutrients, specifically the carbon, nitrogen, and phosphorus species responsible for oxygen depletion and algal blooms, to more advanced criteria on microbial pathogens and total dissolved solids, or salt. Once the regulatory requirements are met, the recycled water can be used for the following purposes:

- Surface irrigation of orchards and vineyards
- Landscape impoundments
- Groundwater recharge

- Wetlands, wildlife habitat, and/or stream augmentation
- Industrial cooling processes
- Landscape and golf course irrigation
- Toilet flushing
- Vehicle washing
- Food crop irrigation
- Potable reuse

Typical Recycled Water Applications in the U.S.

In the U.S., the uses listed above, among many others, are broadly classified into the following seven categories:

- Urban Reuse
- Agricultural Irrigation
- Industrial Reuse
- Environmental Reuse
- Recreational Reuse
- Groundwater Recharge
- Indirect/Direct Potable Reuse

Most of these reuse applications are not practiced or regulated in all states. In addition, recycled water quality guidelines may vary from state to state for a particular reuse application. Reuse applications and associated recycled water quality standards, including standards applicable to the State of Arizona, are discussed below.

Urban Reuse

The Arizona urban reuse category covers a wide variety of applications including landscape and golf course irrigation, fire protection, dust control, car washing, toilet flushing, and others. Urban reuse can be both restricted and unrestricted depending on the recycled water quality. Generally, where human contact is likely, the recycled water requires a higher degree of treatment. At a minimum, secondary treatment with disinfection is required for all types of urban reuse.

Agricultural Irrigation

Agricultural irrigation is the oldest practice of recycled water use and the largest end use by volume in Arizona. Depending on the type of crop, agricultural irrigation may be either unrestricted or restricted. Restricted irrigation applies to non-food crops (e.g., cotton, switch grass) and requires less stringent treatment, whereas unrestricted irrigation for food crops (e.g., vegetables that are eaten raw) requires a very high level of treatment and water quality.

Industrial

Over the past decade, industrial reuse in Arizona has increased substantially due to population growth and

Table 5. Indirect Potable Reuse Guidelines

Application	Parameter	FL	WA	CA	AZ
Indirect Potable Reuse	TSS (mg/L)	5	5	N/A	-
	Monthly Average Turbidity (NTU)	N/A ^a	0.1	2/0.2 ^f	-
	Maximum Turbidity (NTU)	N/A	0.5	10/0.5 ^f	-
	Monthly Average TOC (mg/L)	3	N/A	N/A	-
	Maximum TOC (mg/L)	5	1	Calculated	-
	Total Nitrogen (mg/L)	10	10	5	-
	Monthly Average TOX (mg/L)	0.2	N/A	N/A	-
	Indicator Coliform	Total	Total	Total	-
	Median Coliform (MPN/100mL)	N/A	1 ^d	2.2 ^d	-
	Maximum Coliform (MPN/100mL)	ND ^b	5 ^d	240 ^e	-
	Storage Time (months)	N/A	12	6	-
	Minimum Offset Distance (feet)	500	2000	N/A	-

Source: EPA, 2004; CDPH, 2009.

^aN/A = Not Applicable.

^bND = Non-detect.

^cIn 75% of samples over 30-day period.

^dOver a 7-day period.

^eOnly one sample can exceed 23 MPN/100 mL over 30-day period.

^fMedia filtration/membrane filtration

the passage of legislation promoting increased water conservation and environmental compliance. In order to meet the increased demand, many major industrial facilities are using recycled water for cooling water, process/boiler-feed requirements, and flue-gas scrubber requirements.

Environmental

Environmental reuse includes natural wetland enhancement and restoration, creation of artificial wetlands to serve as wildlife habitat and refuges, and stream augmentation. No regulations for environmental reuse currently exist in Arizona; a review of existing reuse regulations shows only two states (Florida and Washington) that currently have regulations for environmental reuse.

Recreational

Recreational reuse includes landscape impoundments, water hazards on golf courses, water-based recreational impoundments, water bodies with incidental human contact (fishing and boating), and water bodies where full human body contact (swimming and wading) occurs. Recreational reuse can be both restricted and unrestricted, depending on the recycled water quality. Generally, where public access is likely, the recycled water requires a higher degree of treatment.

Groundwater Recharge

The main objectives of groundwater recharge using recycled water are to replenish aquifer water reserves, establish saltwater intrusion barriers in coastal aquifers, provide storage of recycled water for subsequent withdrawal and use, and to prevent ground subsidence that may occur after large-scale groundwater withdrawals (U.S.EPA, 2004).

A review of existing reuse regulations shows that four states (California, Florida, Hawaii, and Washington) currently have regulations for groundwater recharge for non-potable purposes.

Indirect Potable Reuse

Indirect potable reuse is a term applied to recycled water that has been used to augment surface water supplies or to recharge groundwater targeted for domestic water supplies. Indirect potable reuse involves the introduction of recycled water into the raw water supply (surface water or groundwater) for the purposes of increasing the volume of water available for potable use. This, in effect, “blends” the recycled water with raw water supplies that can then be utilized for agricultural irrigation or transported to drinking water treatment facilities. A review of existing reuse regulations shows that three states (California, Florida, and Washington) have regulations for indirect potable reuse. Although rare, direct potable reuse also augments drinking water supplies but eliminates the environmental buffer characteristic of indirect potable reuse applications. Currently, there are no regulations specifically addressing direct potable reuse. However, existing drinking water regulations must always be achieved. Some states have also identified specific storage times that must be demonstrated in the environmental buffer prior to using recycled water as a drinking water source, effectively eliminating the possibility of direct potable reuse (Table 5).

Who regulates water reuse?

Several states consider recycled water viable as a water source alternative and have developed regulations with specific water quality requirements and/or treatment

Table 2. Summary of Water Quality Parameters of Concern for Water Reuse

Parameter	Range in Secondary Effluents	Treatment Goal in Recycled Water	US EPA Guideline
Suspended Solids	5 mg/L – 50 mg/L	<5 mg/L – 30 mg/L	–
Turbidity	1 NTU – 30 NTU	<0.1 NTU – 30 NTU	2 NTU
BOD5	10 mg/L – 30 mg/L	<10 mg/L – 45 mg/L	10 mg/L
COD	50 mg/L – 150 mg/L	<20 mg/L – 90 mg/L	–
TOC	5 mg/L – 20 mg/L	<1 mg/L – 10 mg/L	–
Total Coliform	<10 cfu/100mL – 107 cfu/100mL	<1 cfu/100mL – 200 cfu/100mL	–
Fecal Coliform	<1-106 cfu/100mL	<1 cfu/100mL – 10 ³ cfu/100mL	14 for any sample, 0 for 90%
Helminth Eggs	<1/L – 10/L	<0.1/L – 5/L	–
Viruses	<1/L – 100/L	<1/50L	–
Heavy Metals	–	<0.001 mg/L <0.01 mg/L <0.1 mg/L – 0.02 mg/L	–
Inorganic	–	<450 mg/L	–
Chlorine Residual	–	0.5 mg/L – <1 mg/L	1 mg/L
Nitrogen (as N)	10 mg/L – 30 mg/L	<1 mg/L – 30 mg/L	–
Phosphorus (as P)	0.1 mg/L – 30 mg/L	<1 mg/L – 20 mg/L	–
pH	–	–	6 – 9

Source: U.S. EPA. 2004. *Guidelines for Water Reuse*.

processes for a variety of reuse applications. In other states, water reuse regulations have been developed with the primary intent of providing a disposal alternative to surface water discharge. A few states have no specific regulations or guidelines on water reclamation and reuse, although programs may still be permitted with approval on a case-by-case basis.

Recycled Water Regulations and Water Quality Standards

To date, no federal regulations exist that govern water recycling in the U.S.; such standards have been developed and implemented at the state government level. The lack of federal regulations and coordination between states has resulted in differing standards for recycled water across the country. Despite the differing standards, the process of recycling water always involves a multi-barrier approach (i.e., physical, chemical, and biological treatment processes). In 1992, the U.S. EPA first developed the Guidelines for Water Reuse, a comprehensive, technical document to encourage states to develop their own regulations. Recognizing the tremendous growth in reuse, the U.S. EPA released its updated Guidelines for Water Reuse in September 2004.

The main purpose of federal guidelines and state regulations is to protect the health of the public and the environment. Recycled water standards and guidelines vary with the type of application, the regional context, and the overall risk perception. The types and concentrations of constituents in recycled water depend upon the following (U.S. EPA, 2004):

- Initial quality of the municipal water supply
- Sources of the influent waste streams (i.e., the composition of domestic wastewater differs significantly from the composition of industrial contributions)
- Amount and composition of infiltration in the wastewater collection system
- Wastewater treatment processes
- Type of storage facilities.

The fundamental precondition for water recycling is that applications will not cause unacceptable public health risks (UNEP, 2004). Therefore, microbiological parameters have historically received the most attention in water reuse regulations and guidelines. Recently, the focus on microbiological parameters has shifted slightly to address contaminants of emerging concern, including pharmaceuticals and potential endocrine disrupting compounds (EDCs). However, microbial pathogens still pose the greater demonstrated risk in water recycling applications. Since monitoring for all pathogens is not practical, specific indicator organisms are monitored to minimize health risks (U.S. EPA, 2004). Indicator organisms (e.g., total coliform, fecal coliform) are generally not pathogenic, but their presence in a water sample signals the possible presence of fecal contamination, though recycled water guidelines may also mandate screening for disease-causing organisms (e.g., enteric viruses) (Table 2).

Updated in 2006, the World Health Organization (WHO) introduced guidance for the safe use of wastewater in 1971. The WHO guidelines are relatively less restrictive than water

Table 3. Summary of State Reuse Regulations and Guidelines

State	Regulations	Guidelines	None	State	Regulations	Guidelines	None
Alabama		■		Montana	■		
Alaska	■			Nebraska	■		
Arizona	■			Nevada	■		
Arkansas		■		New Hampshire			■
California	■			New Jersey		■	
Colorado	■			New Mexico		■	
Connecticut			■	New York		■	
Delaware	■			North Carolina	■		
Florida	■			North Dakota		■	
Georgia		■		Ohio		■	
Hawaii		■		Oklahoma	■		
Idaho	■			Oregon	■		
Illinois	■			Pennsylvania		■	
Indiana	■			Rhode Island			■
Iowa	■			South Carolina	■		
Kansas		■		South Dakota		■	
Kentucky			■	Tennessee	■		
Louisiana			■	Texas	■		
Maine			■	Utah	■		
Maryland		■		Vermont	■		
Massachusetts		■		Virginia			■
Michigan	■			Washington		■	
Minnesota			■	West Virginia	■		
Mississippi			■	Wisconsin	■		
Missouri	■			Wyoming	■		

Source: U.S. EPA. 2004. *Guidelines for Water Reuse*.

reuse regulations and guidelines adopted by the various states in the U.S. (Metcalf & Eddy, 2007). The main intent of the WHO guideline is to introduce some level of treatment of wastewater and interrupt transmission of diseases prior to food crop irrigation. Table 2 provides a summary of water quality parameters of concern with approximate ranges in secondary treated sewage and recycled water as suggested in the U.S. EPA water reuse guideline.

State-Level Recycled Water Regulations

Since the U.S. EPA views it as a regional issue, regulations for water recycling have been developed and implemented at the state government level. According to U.S. EPA's 2004 Guidelines for Water Reuse, 26 states have adopted water recycling regulations, 15 states have guidelines or design standards, and 9 states have no regulations or guidelines. Table 3 shows the summary of state reuse regulations and guidelines.

The lack of federal regulations has resulted in varying regulations and guidelines. Among the states, Arizona,

California, Colorado, Florida, Hawaii, Nevada, Oregon, Texas, Utah, and Washington have developed regulations or guidelines specifying recycled water quality and treatment requirements, and the full spectrum of reuse applications that strongly encourage water reuse as a sustainable water conservation and management strategy.

Recycled Water Regulations in Arizona

The Arizona Department of Environmental Quality (ADEQ) regulates recycled water use in the State of Arizona. Local (county) management programs have also been developed, specifically in Maricopa County. The Arizona Legislature has established recycled water quality standards under the Arizona Administrative Code (AAC) Title 18, Chapter 11, Article 3 and reuse applications under the AAC, Title 18, Chapter 9, Article 7. Arizona's Reclaimed Water Quality Standards established five classes of recycled water with minimum treatment requirements and water quality criteria. Table 4 shows the recycled water quality standards as specified in the AAC.

Table 4. Recycled Water Quality Standards in Arizona

Recycled Water Class	Treatment Process (Minimum)	Recycled Water Standards							
		BOD5 (mg/L)	TSS (mg/L)	Turbidity		Microbial			Total Nitrogen (mg/L)
				24 Hr Avg (NTU)	Any Time (NTU)	Fecal Coliform (FC)		Enteric Virus	
						Daily conc. (cfu/100mL)	Max conc. (cfu/100mL)	Blended water	
Class A+	Secondary treatment + Filtration + Nitrogen Removal + Disinfection	NS	NS	≤ 2	≤ 5	No detectable FC in 4 of last 7 daily samples	≤ 23/100 mL	No detectable enteric virus in 4 of last 7 monthly samples	5-sample geometric mean conc. Less than 10 mg/L
Class A	Secondary treatment + Filtration + Disinfection	NS	NS	≤ 2	≤ 5	No detectable FC in 4 of last 7 daily samples	≤ 23/100 mL	No detectable enteric virus in 4 of last 7 monthly samples	NS
Class B+	Secondary treatment + Nitrogen Removal + Disinfection	NS	NS	NS	NS	≤ 200/100 mL in 4 of last 7 daily samples	≤ 800/100 mL	NS	5-sample geometric mean conc. Less than 10 mg/L
Class B	Secondary treatment + Disinfection	NS	NS	NS	NS	≤ 200/100 mL in 4 of last 7 daily samples	≤ 800/100 mL	NS	NS
Class C	Secondary treatment (stabilization pond + aeration) + With or w/o disinfection [Retention time in stabilization pond >20 days]	NS	NS	NS	NS	≤ 1000/100 mL in 4 of last 7 daily samples	≤ 4000/100 mL	NS	NS

NS = Not Specified

Source:

Arizona Administrative Code (AAC) Title 18 – Environmental Quality - http://www.azsos.gov/public_services/Title_18/18_table.htm

Chapter 9, Article 7: Direct Reuse of Reclaimed Water: http://www.azsos.gov/public_services/Title_18/18-09.htm

Chapter 11, Article 3: Reclaimed Water Quality Standards: http://www.azsos.gov/public_services/Title_18/18-11.htm

How is recycled water kept separate from other water?

Although recycled water is highly treated in many applications, it is not always intended for potable applications so it may not comply with the water quality standards mandated by the Safe Drinking Water Act (SDWA). As a result, non-potable recycled water goes through a completely separate pipeline system to the customers. In the U.S., recycled water is always distributed in purple pipes to distinguish it from potable water. Periodic cross-connection tests ensure that the non-potable recycled water pipelines are not accidentally connected to the drinking water system. In addition, there is ongoing monitoring and testing of the non-potable recycled water and drinking water systems to protect the public’s health (WaterReuse Association, 2011b).

Is recycled water safe?

Recycled water is highly engineered for safety and reliability so that the quality of water is more predictable than many existing surface and groundwater sources. Recycled water is considered safe when appropriately used. Although recycled water is of very high quality, it is only tested for its intended use so not all recycled water is suitable for potable reuse. Recycled water intended for indirect potable reuse, whether through aquifer recharge or surface water discharge, receives extensive, multi-barrier treatment. The states of Florida, California, and Washington have implemented additional guidelines specifically related to Indirect Potable Reuse applications (Table 5). To date, Arizona has not followed suit. Once treated the water is then discharged to the environment where it undergoes natural

restoration processes. This water eventually becomes part of our drinking water supply so it is subjected to further treatment and testing to demonstrate compliance with the stringent regulations mandated by the SDWA (WaterReuse Association, 2011b).

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