An Overview of Water Recycling in the United States

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1. Introduction

Water recycling is a growing practice in many regions of the world. Countries and regions in which water reuse is on the rise include the United States (U.S.), Western Europe, Australia, and Israel. In the U.S., the practice of recycling water is a large and growing industry. An estimated 3.4 billion gallons per day (bgd) (13 million m^3/d) is reused in the U.S. However, this is but a small fraction of the total volume of wastewater generated. According to the U.S. Environmental Protection Agency's (EPA) 2000 Watershed Needs Survey, a total of 34.9 bgd (132 million m^3/d) of municipal wastewater effluent is produced. Thus, the proportion currently reused amounts to only 9.7%, suggesting that future potential for recycling treated wastewater is enormous.

2. Discussion

There are a number of factors that drive water reuse in the U.S., including that recycled water is a drought-resistant and reliable local supply, the increasing demand for water as the population grows, preservation of limited potable water supplies for drinking, that recycled water is a method for wastewater disposal, the economic feasibility of recycled water projects with well-established technology, and that recycled water is an integrated part of public policy particularly in states with limited water supplies.

Recycled water use on a volume basis is growing at an estimated 15% per year in the U.S. All evidence suggests that water recycling will play an expanded role in water management in the 21st century, not only in the semi-arid western states and "sunbelt" states, but perhaps in all 50 states. At a compound annual growth rate of 15%, the volume of recycled water would amount to 12 bgd (45 million m^3/d) by the year 2015.

The early applications of water reuse were for irrigation of landscaping; this is no longer the case, however. Other applications include industrial reuse, irrigation of edible and non-edible agricultural crops, commercial uses such as toilet flushing in high-rise office buildings, groundwater recharge, and indirect potable reuse. Industrial reuse applications include use in cooling towers and for boiler feedwater. In Sonoma and Monterey Counties in California, lettuce, artichokes, strawberries, and grapes are irrigated with recycled water. There are several well known examples of indirect potable reuse around the world, including a facility in Orange County, California.

Water recycling represents a viable, long-term solution to the challenges presented by growing demands for water. Recycled water has numerous benefits, including a local, dependable water supply that is drought-resistant and under local control, reduction of treated wastewater discharge to sensitive or impaired surface waters, reduction of imported water and avoided costs associated with importing water, environmental benefits, and that it represents a sustainable water resource.

Recycled water regulations vary across the U.S. from state to state. There are no national standards. In general, the highest treatment is required for the highest use to ensure adequate level of protection of public heath. California has the most stringent

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regulations (Title 22 as set by the Department of Health Services) in the U.S. In Title 22, Chapter 4, of the California Code of Regulations, bacteriological water quality standards are established based on the expected degree of public contact with recycled water.

The technologies used most frequently in California for treatment prior to groundwater recharge are microfiltration (MF), reverse osmosis (RO), and ultraviolet disinfection (UV). Many California experts believe that in the future, virtually all wastewater treatment plants, especially those that discharge into the Bay-Delta surface waters, will feature filtration of some type. Groundwater recharge requires that a municipal utility purify water to a higher quality than most natural water resources. Clear, treated wastewater is subjected to three purification processes in order to produce clean water that is allowed to filter through the ground by natural filtration processes (e.g., the path that rainwater takes) into deep aquifers in an underground basin, where it will be extracted by wells for drinking water after mixing with exiting groundwater supplies for at least a year. The first of these three purification processes is MF, which uses a low-pressure membrane that takes small suspended particles and other materials out of the water. MF efficiently prepares water for the RO process.

Technologies employed to treat recycled water in the U.S. depend almost entirely on the application, which is called “highest treatment for highest use.” For example, if the primary application is irrigation or cooling tower water, sand or dual media filtration after secondary treatment is sufficient to achieve a state’s water quality criteria. If, on the other hand, the intended application is indirect potable reuse, sophisticated technologies such as MF, RO, and UV disinfection must be employed to ensure chemical and microbiological safety of the recycled water. Although membranes are not required for all applications of water reuse, it is becoming the technology of choice as the pricing becomes more competitive.

The cost for a water agency to implement recycled water projects vary across the U.S. from minimal to over $2,000 per acre-ft ($1,5/m^3). Variable factors include proximity to users, federal and state funding availability, subsidies offered, and retrofit users or new development. Projects are more cost effective where there is a large user located in close proximity to the source of recycled water, as compared to projects where an extensive distribution system is needed to reach a number of smaller users. Federal and state funding can help offset project costs. For example, some types of federal funding can offset up to 75% of project costs. Some water wholesalers offer subsidies to water retailers to encourage implementation of recycled water projects in order to offset demand for imported potable water supplies. The Metropolitan Water District of southern California offers the West Basin Municipal Water District $250 per acre-ft ($0.2/m^3) for recycled water produced. Another variable involves whether a new development is mandated to use recycled water. In this case, the water agency can often negotiate with the developer to pay for a substantial portion of the recycled water project costs. With retrofit customers, a large industrial user may have more incentive and capital available to help jointly fund a recycled water project than smaller, irrigation users.

Some of the principal issues, barriers, and impediments to widespread water reuse include the need for further public education, lack of available funding, better documentation of the economics of water reuse, consistent regulations that enable protection of public health, and the need for additional research.

As for public perception and acceptance, while non-potable reuse applications (e.g., landscape irrigation) are generally acceptable, as reuse moves toward indirect potable reuse, the reaction from the public – usually in the form of negative publicity in the media – becomes more negative. More focus and consideration should be given to the psychological factors that lead to the public's resistance to indirect potable reuse.

A survey of municipalities in California several years ago revealed that the major constraint to water recycling is lack of funds. Although many larger municipalities have constructed recycled water projects, smaller utilities have not, often due to lack of funding support from Federal and/or state governments.

There is the need for additional research on water recycling issues, including development of innovative and emerging technologies that could lower projects costs, testing and monitoring methods, and emerging issues relating to public and environmental heath such as the emergence of endocrine disrupting compounds and pharmaceutically active compounds.

3. Conclusion

Water recycling already represents an important water supply in many areas of the world. Reuse is growing in importance in the U.S., Australia, Europe and other regions. Its potential is largely untapped, however, due to a number of barriers. Water reuse should not be viewed as simply the reuse of wastewater effluents. Rather, water reuse should be viewed as one of several alternative sources of new water, all of which will be important tools in the toolkit of the water manager of the 21^{st} century.

Both water professionals and the consuming public will need to view water differently in the 21^{st} century. It is incumbent upon the consuming public that they develop more trust in the ability of water utilities to treat any poor quality (impaired) water to drinking water or higher standard. Similarly, water professionals must earn that trust. Water will finally be recognized for its inherent great value in the 21^{st} century as demand grows and readily available and inexpensive supplies remain at virtually the same level. The water community should strive to convey the value of water through a variety of means, including education of the public and elected officials.

References

Miller, G. Wade, "Integrated Concepts in Water Reuse: Managing Global Water Needs," 2005

Talley, Pick, Presentation at the American Water Works Association Annual Conference in San Antonio, TX, June 14, 2006

Overview of Water Recycling in the United States

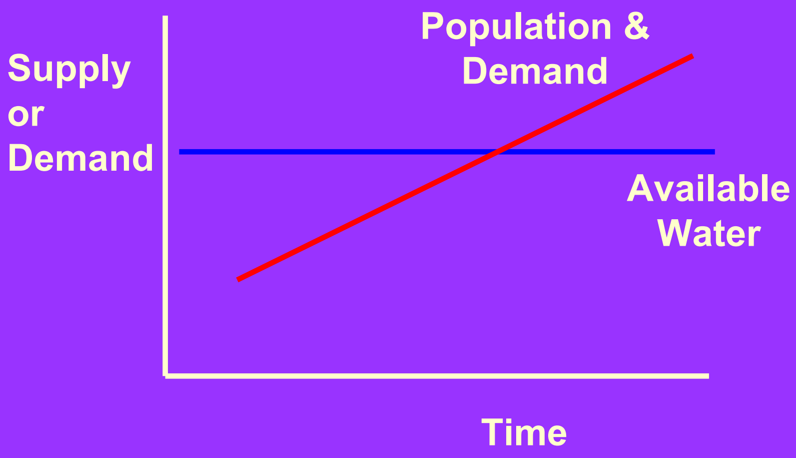
Japan-U.S. Conference on Drinking Water Quality and Wastewater Control

January 22, 2007

Outline

- Background – global water supply
- Water recycling in the U.S.
  - Driving factors
  - Projected increase
  - Applications
  - Benefits
  - Regulations
  - Treatment technologies
  - Costs
  - Areas of increased emphasis needed

Supply vs. Demand



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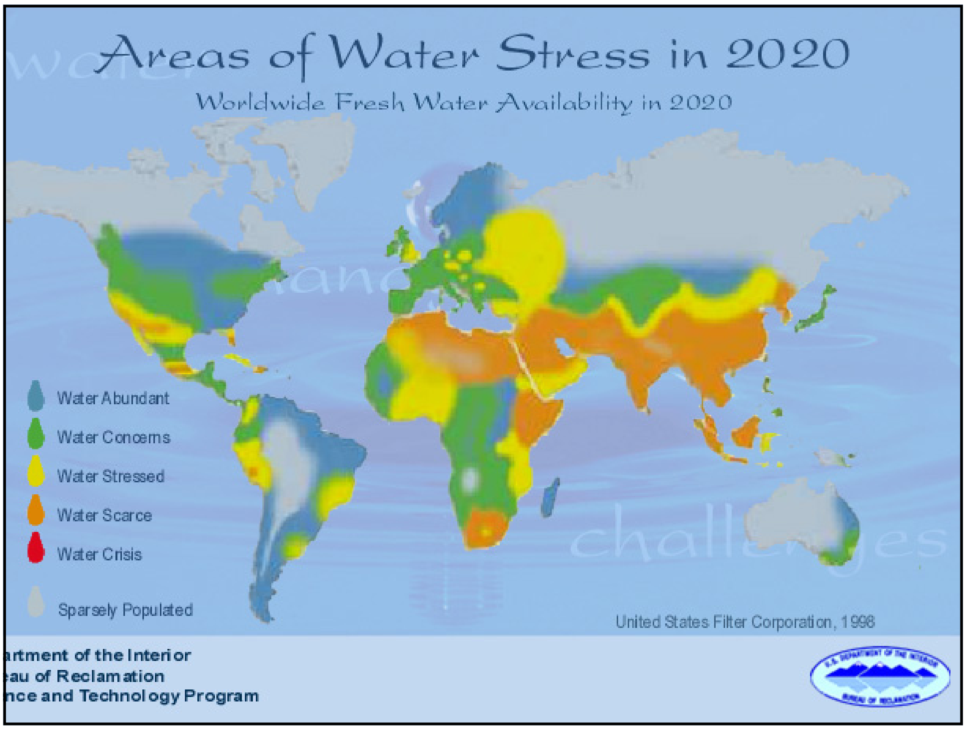

Factors Driving Water Recycling in the U.S.

- Drought-resistant/reliable supply
- Population growth/increasing demand for water
- Preserving limited potable water supplies for drinking
- Wastewater disposal
- Ecosystem and environmental protection
- Economically feasible
- Well-established technology
- Public policy and integrated water planning

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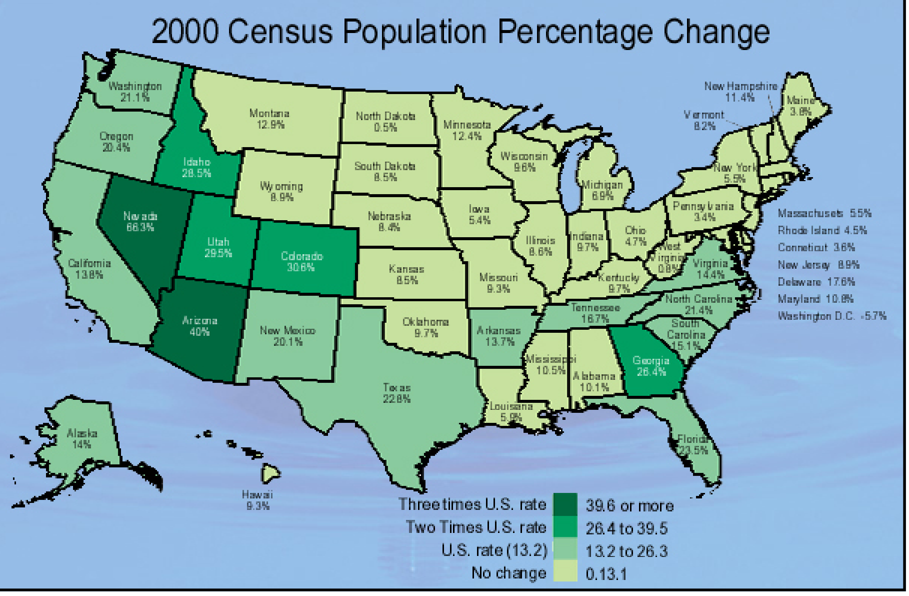
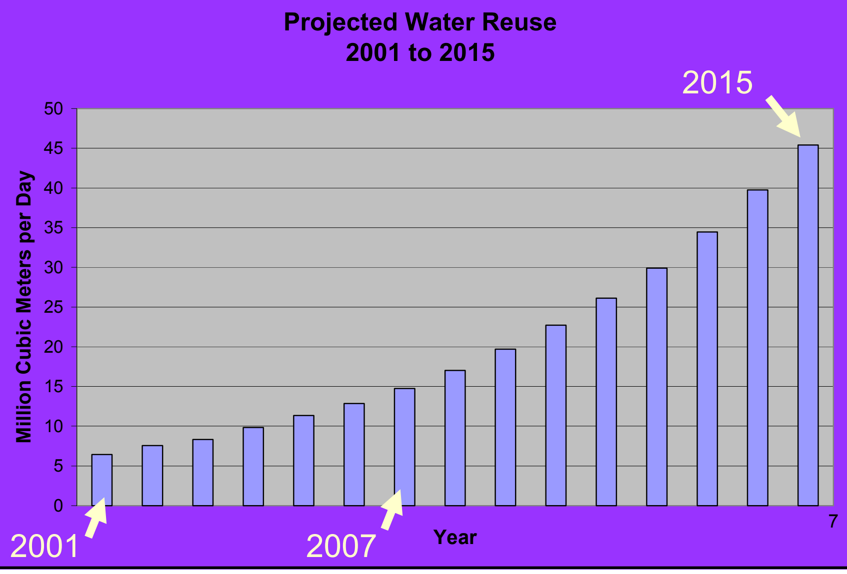
Population Growth in the U.S.

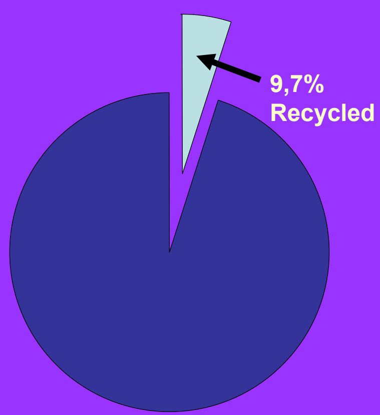


Projection of Water Recycling in the U.S.



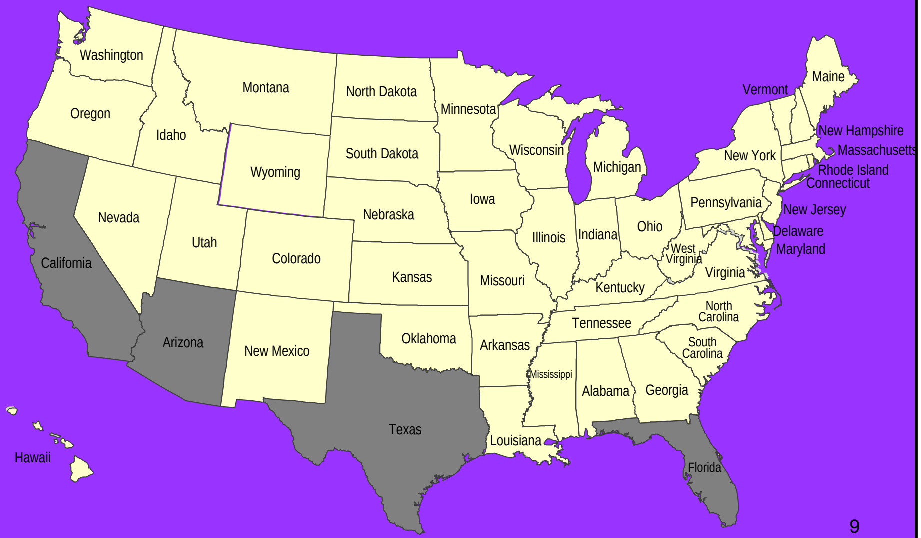
Potential for Water Recycling

- Approximately 9,7% of municipal wastewater effluent in the U.S. is currently recycled or reused



Municipal effluent in the U.S. = 132 million m^3/d

90% of Water Reuse Occurs in Four States



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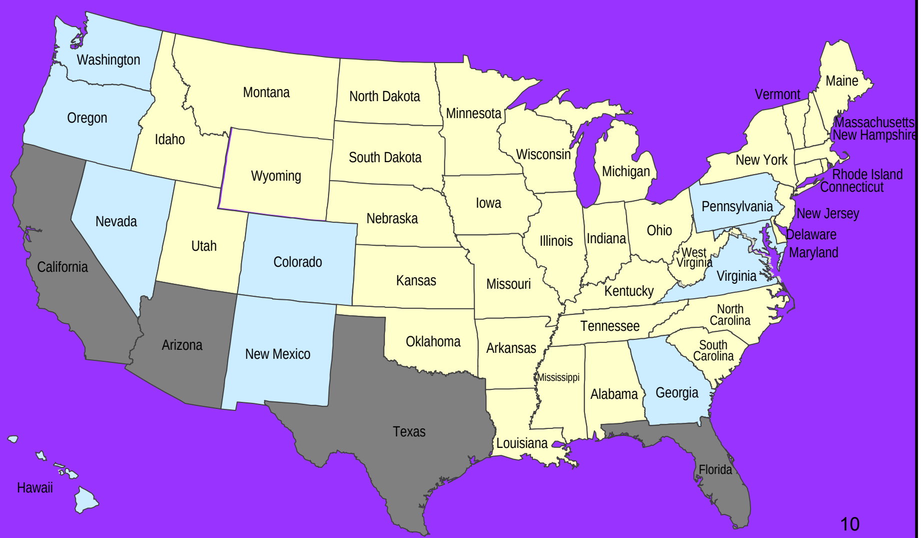
However, Water Reuse is Growing in Other States



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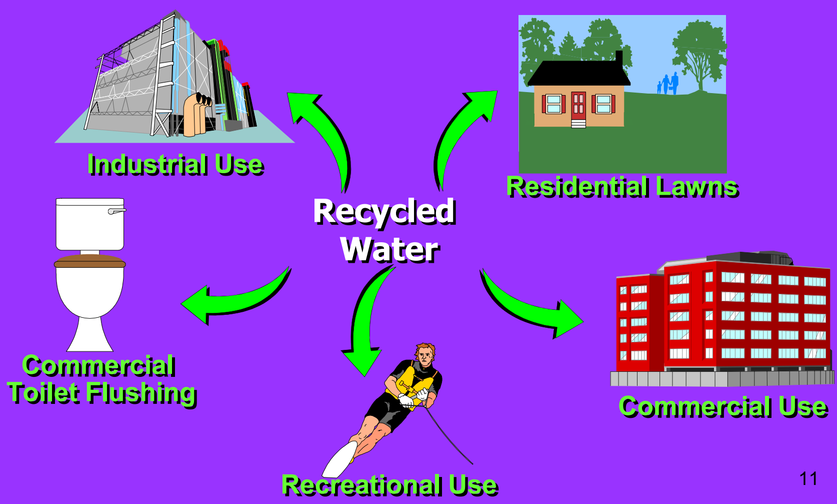
Water Recycling
Not Just for Irrigation



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Applications of Recycled Water

- Landscape irrigation
- Agricultural irrigation
- Industrial and commercial
- Non-potable urban uses (toilet flushing in high-rise commercial buildings)
- Environmental uses
- Groundwater recharge
- Potable water supply augmentation

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Benefits of Recycled Water

- Local, dependable water supply
- Drought-resistant
- Reduces wastewater discharge to surface waters
- Reduces uses of imported water
- Benefits the environment
- Sustainable supply

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Recycled Water Regulations

- Regulations vary across the U.S.
- No national standards in the U.S.
- In general, highest treatment required for highest use
- California has the most stringent regulations (Title 22), as set by the Department of Health Services

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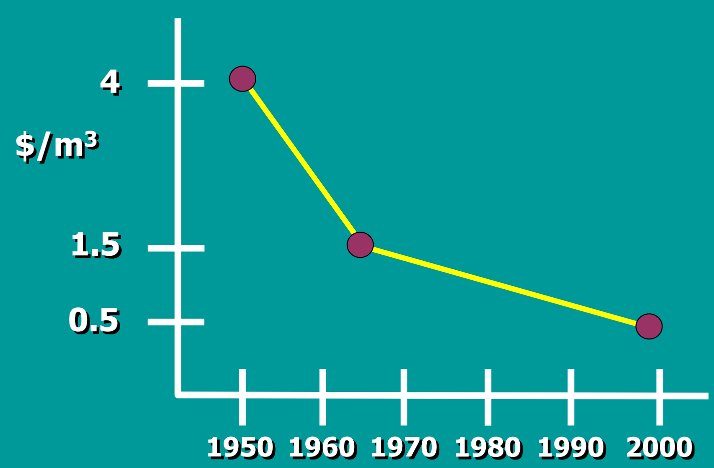
Treatment Technologies for Recycled Water

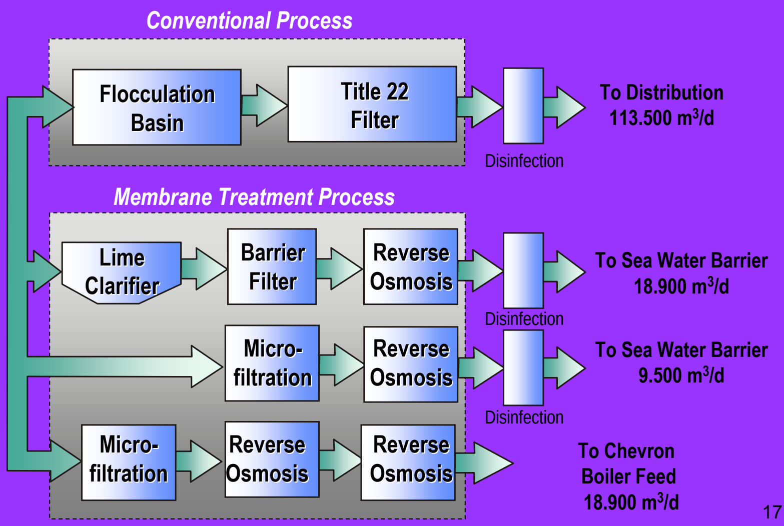
- Conventional treatment
  - Media (sand) filtration
  - Chlorination or ultraviolet (UV) disinfection
- Advanced treatment
  - Microfiltration and reverse osmosis (RO) membranes
  - Membrane bioreactor
  - UV disinfection
- Membranes are becoming the technology of choice around the world as the best available technology for water purification

Good News: RO Technology Costs Fall



AWWARF Study, 2001

West Basin Water Recycling Plant El Segundo, California

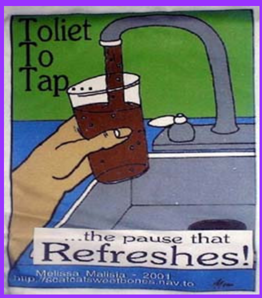


Costs of Recycled Water Projects

- Costs for a water agency to implement recycled water projects vary across the U.S. (minimal to over $1,5/m^3)
- Variable factors:
  - Proximity to users
  - Federal and state funding availability
  - Subsidies offered
  - Retrofit or new development

Areas of Increased Emphasis Needed for Water Reuse

- Further public education
- Funding assistance from federal and state governments
- Better documentation of economics
- Consistent regulations that enable protection of public health
- Additional research



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Conclusion

- Water recycling is growing in the U.S.
- Water recycling is also increasing in Australia, Europe and other regions of the world
- Opportunities for water recycling are numerous in the future as population and demand increase

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Thank You

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Title 22 Regulations

Treatment Level	Treatment Required	Total Coliform (MPN) Limit	Turbidity Limit
Disinfected Tertiary (Unrestricted Use)	Filtration & chlorine disinfection or other forms of disinfection to inactivate 99.999% virus	Median <= 2.2 per 100 mL (7 days), Max <= 23 per 100 mL (30 days), Max <=240 per 100 mL	Conventional filtration (2 NTU avg, <= 5 NTU 5% of time, <= 10 NTU max) Membrane (<= 0.2 NTU 5% of time, <= 0.5 NTU max)
Disinfected Secondary 2.2 (Restricted Use)	Secondary, oxidized, disinfected	Median <= 2.2 per 100 mL (7 days), Max <= 23 per 100 mL (30 days)	None
Disinfected Secondary 23 (Restricted Use)	Secondary, oxidized, disinfected	Median <= 23 per 100 mL (7 days), Max <= 240 per 100 mL (30 days)	None