Facts & Information About Groundwater Recharge of Recycled Water

What is Planned Potable Reuse?

- Water has always been reused through the global hydrologic cycle.
- Most people in the United States make use of water resources that include some amount of water that has been used at least once before. For example, many cities take water from rivers or lakes that receive treated wastewater discharges or use groundwater that comes in contact with septic tanks. In California, both the Colorado River and the San Francisco Delta receive treated wastewater. Both of these water supplies are sources of drinking water for many Californians.
- This practice is often called “incidental” or “unplanned” potable reuse.
- In contrast, planned potable reuse is the consequence of thoroughly considering the applicable and interrelated technical, economic, regulatory, and public policy issues prior to using highly treated wastewater (known as recycled water) for pre-defined beneficial purposes, such as replenishing groundwater that will eventually be used for potable supply.

How is Recycled Water Produced From Wastewater?

- A multi-barrier approach is used to ensure that only high quality water that meets or exceeds established standards, and thus is safe, is reused. The first line of protection is aggressive use of source control to minimize the introduction of pollutants in the wastewater before it even is treated. Source control programs involve an extensive regulatory system to manage industries and commercial facilities that discharge wastewater into community sewerage systems. These programs also address ways to control and limit discharges of pollutants of concern from residences.
- The next barriers are provided by a high degree of treatment at water reclamation plants, including at least four stages of purification. The different stages of purification at a water reclamation plant are just a speeded-up version of what is done in nature and can be as good as or even better than the natural process.
- In the first stage of purification, the wastewater entering a water reclamation plant flows into large tanks where the flow is slowed down. The heavier materials in the wastewater settle to the bottom of the tanks and lighter materials, like oil and grease, float to the top. These heavier and lighter materials are removed for further treatment. The water, which still contains dissolved and suspended organic material, goes on to the next stage of processing.
- In the second stage of purification, the water from the first stage of the process flows into large tanks where microbes are added to consume the dissolved and suspended organic material. Air is bubbled through the tanks to supply the microbes with oxygen. After the microbes have done their job, the water is sent to large tanks where the flow is slowed down again, the microbial materials settle to the bottom of the tank, and are removed for further treatment.
- The third stage of the purification process is designed to further clean the water, using filters that contain granular materials such as coal and sand. The filtration process is similar to that used at facilities that produce drinking water. The filters remove the very small particles remaining in the water after the second stage of purification.

- The fourth state of the purification process is designed to kill any harmful microorganisms. This process typically uses chlorine, similar to the process used for swimming pools. At this point the water meets California's water recycling regulatory requirements for a wide variety of reuse applications, including landscape irrigation and industrial manufacturing. Water that is used for planned potable reuse through groundwater recharge undergoes even more treatment, as described below.

What is Groundwater Recharge?

- Groundwater recharge is a category of planned potable reuse. The two main types of groundwater recharge are called surface spreading and direct injection.
- For surface spreading, after leaving the water reclamation plant, recycled water is delivered to earthen basins called spreading or percolation basins where it can soak into the ground.
- When the recycled water enters the spreading basin it starts to soak into the soil, which consists of layers of dirt, sand, gravel, and clay. These layers allow the recycled water to undergo further physical, biological, and chemical purification as it filters through the soil and ultimately becomes part of the groundwater system (this process is called Soil Aquifer Treatment or SAT).
- Recycled water that has undergone additional processing such as advanced treatment, which uses processes similar to those used to desalinate sea water, can also be directly injected into groundwater. This method is often used as a means of forming a fresh water barrier to prevent salt water along parts of the California coast from infiltrating groundwater resources. These projects are known as direct injection.
- Groundwater recharge is regulated by two state agencies, the California Department of Public Health (CDPH) and the Regional Water Quality Control Board (RWQCB).
- CDPH regulates projects to protect public health by establishing requirements for chemicals, microorganisms, and constituents of emerging concern, such as personal care products, pharmaceuticals, and compounds that impact human growth and reproduction. CDPH also requires that agencies maintain comprehensive industrial wastewater pretreatment and source control programs to prevent undesirable compounds from entering wastewater treatment systems.
- RWQCB regulates projects to protect and maintain the quality of surface waters and groundwater and their beneficial uses, such as drinking water, aquatic life, and recreation.
- CDPH and RWQCB require extensive monitoring of the recycled water used for groundwater recharge as well as monitoring of groundwater quality.
- The process for receiving authorization from CDPH and RWQCB to operate a groundwater recharge project is complex, and projects are carefully evaluated and subject to several public hearings. It can take ten or more years to complete the process, based on the experience of recent projects that have been approved in California.

What is Soil Aquifer Treatment (SAT) and is it Effective?

- SAT is a purification process that provides an additional safety barrier for indirect potable reuse projects. Three different parts of the soil underlying a spreading basin provide additional purification: the top few inches of soil (called the infiltration zone), the area just below the surface and between the top layer of groundwater (called the vadose zone), and the soil layers where groundwater is present (called the aquifer). SAT relies on natural

physical, biological, and chemical processes that occur in these layers. It is a robust process that does not require inputs of chemicals or electricity.

- As part of a SAT research program, studies were conducted from 1996 to 2004 to evaluate the sustainability and effectiveness of SAT, specifically looking at the fate and transport of organic carbon, nitrogen species, pathogens, and trace constituents such as pharmaceuticals and endocrine disruptors.
- These studies included comparative investigations of the effectiveness of SAT at four primary sites in Arizona and California (Sweetwater wetlands/recharge facility in Tucson, Mesa Northwest water reclamation facility in Mesa, Tres Rios Cobble site in Phoenix, and Montebello Forebay recharge project in Los Angeles County).
- The following agencies and academic institutions participated in the SAT research program: Arizona State University, the Colorado School of Mines, Stanford University, the University of Arizona, the University of Colorado at Boulder, the cities of Glendale, Mesa, Phoenix, Scottsdale, Tempe, Tolleson, and Tucson, Arizona, the City of Riverside, California, the Los Angeles Department of Water and Power, the Metropolitan Water District of Southern California, the Sanitation Districts of Los Angeles County, the United States Bureau of Reclamation, the United States Environmental Protection Agency (USEPA), the United States Geological Survey, the Water Replenishment District of Southern California, and the Water Research Foundation (formerly American Water Works Association Research Foundation).
- Additionally, the SAT research program included a Project Advisory Committee composed of technical experts appointed by the Water Research Foundation and a Regulatory Advisory Committee composed of public health and water resource experts from Arizona and California.
- The study concluded that the removal of organic material in recycled water through SAT is a sustainable process. The organic material remaining after SAT is almost indistinguishable from natural organics found in drinking water sources. Additionally, the majority of trace organic compounds were removed to below levels of detection after SAT. Special tests that look at the ability of compounds to impact the human hormone system, known as endocrine-disrupting chemicals, were run. The results of these tests showed that SAT efficiently removes estrogenicity. The study showed that no human viruses were present in groundwater following SAT of disinfected filtered recycled water. In addition, the study used bacterial virus as a surrogate to measure human virus removal rates in the subsurface. The results showed that a 7-log reduction (99.9999%) of bacteria virus should occur within 100 feet of subsurface travel.

Will there be Microorganisms in the Groundwater Supply Because of the Recharge Project?

- No. Harmful microorganisms such as viruses and bacteria are removed during the recycled water purification process.
- Added safety barriers are provided by the soil (through SAT) as the recycled water percolates into the ground and by storing the groundwater containing recycled water underground for at least six months before being pumped out by a municipal water supply well.
- A final barrier is provided when the groundwater pumped from a municipal well is disinfected prior to being supplied for drinking.

Are Trace Contaminants a Concern for Groundwater that is Recharged with Recycled Water through Surface Spreading?

- Trace contaminants include constituents such as metals, fertilizers, pesticides, and other non-volatile and/or volatile organic compounds that are found at very low levels in surface water, ground water, and drinking water, even in areas not recharged with recycled water.
- The significance of trace contaminants in water has been extensively evaluated. Findings suggest there is a substantial margin of safety between the maximum concentrations found in groundwater recharged with recycled water and concerns for human health.

Trace Metals

- USEPA and CDPH have established drinking water standards, known as maximum contaminant levels, for trace metals.
- The concentrations of trace metals in the recycled water used for groundwater recharge are monitored to ensure that groundwater meets established standards.

Microconstituents

- With recent advances in analytical capability and focused attention on monitoring studies of surface water and drinking water that utilize these new methods, pharmaceuticals, personal care products, and endocrine disrupting chemicals have come to the public's attention because they have been detected in drinking water.
- As a group, these chemicals are often called "microconstituents," which is a term applied to describe the vast array of substances found in water, typically in very small concentrations.
- Studies have been conducted on the effectiveness of wastewater purification processes for removing microconstituents. These studies found that compounds were partially or completely removed (greater than 80%) in tertiary treated recycled water.
- Additional studies have been conducted to evaluate the effectiveness of SAT purification processes as the recycled water passes through the soil. These studies found that tertiary treated recycled water contains very low concentrations of microconstituents and those compounds detected were partially or completely removed (greater than 90%) through SAT.
- The types of compounds still detected included anti-epileptic drugs and flame-retardants, measured at very low levels - parts per trillion. To put this into perspective, a part per trillion is equivalent to one cent in ten billion dollars.
- However, simply detecting a compound does not mean that the amount present is of any significance to human health.
- For pharmaceuticals, some studies have looked at the concentration of a compound that would have to be present in water to cause a health effect.
- For anti-epileptic drugs, the concentration to cause a health effect is one thousand times higher than the concentration found in recycled water after it has gone through SAT.
- These same studies show that for other pharmaceuticals, a person would have to drink thousands of gallons of water each day for a drug present in such low concentrations to have an adverse effect.
- The significance of such low concentrations of microconstituents in recycled water is the subject of ongoing research. Current findings continue to support that there is a substantial margin of safety between the maximum concentrations found in groundwater and concerns for human health.

What Health Studies Have Been Done for Groundwater Recharge Projects?

- Groundwater recharge with recycled water has been on-going in California for about 45 years. The oldest and best characterized project in the state is the Montebello Forebay Groundwater Recharge Project. This project is the joint responsibility of the Sanitation Districts of Los Angeles County, the Water Replenishment District of Southern California, and the Los Angeles County Department of Public Works.
- Several extensive studies have been done for this project to determine impacts on human health. The Sanitation Districts of Los Angeles County's Health Effects Study, conducted from 1978-84, evaluated the health effects of using recycled water for groundwater recharge. The study looked at recycled water and groundwater quality, evaluated the toxicity of recycled water and groundwater, and conducted human health studies (called epidemiology studies) of people drinking groundwater containing recycled water. A State Scientific Advisory Panel reviewed the results of the study and concluded that the health risks, if any, were similar to those for commonly used surface waters such as rivers and lakes.
- The Rand Corporation also conducted two large epidemiology studies on the health of people consuming groundwater containing recycled water from this project for the time period 1982-93. The results showed that after almost 30 years of recharge with recycled water, there was no association between recycled water and higher rates of cancer, mortality, infectious disease, or adverse birth outcomes.
- The Montebello Forebay Project also has an extensive ongoing monitoring program that looks at the quality of groundwater and recycled water. Based on over 40 years of data, the groundwater is safe and meets all drinking water standards.
- Additional health studies examining recycled water have been conducted for a number of other types of planned potable reuse projects, including: the Denver Potable Water Reuse Demonstration Project; the Tampa Water Resources Recovery Project; the San Diego Total Resource Recovery Project; the Potomac Estuary Experimental Wastewater Treatment Plant; and the Singapore Water Reclamation Study. No effects of concern were found.

Groundwater Recharge Projects in California.

- Using recycled water to replenish groundwater via surface spreading has been successfully applied in California for about 45 years.
- Additionally, a number of projects use recycled water to create sea-water intrusion barriers.
- The tables below show the history and status of groundwater recharge projects in California. Projects that did not go forward faced public opposition or lacked political support. Successful projects included strategic planning, public education and outreach efforts, and political support.

Groundwater Recharge Projects Using Recycled Water in California

Successful Projects			
Name	**Type**	**Amount Recycled (Acre-Feet/Year)**	**Operational Date**
Montebello Forebay Groundwater Recharge	Spreading	50,000	1962
Water Factory 21 Saltwater Barrier[1]	Injection	Not Applicable	1976 to 2007
West Coast Basin Saltwater Barrier	Injection	14,000	1994
Chino Basin Groundwater Recharge	Spreading	21,000	Phase I 2005 Phase II 2007
Alamitos Saltwater Barrier	Injection	3,360	2005
Dominguez Gap Saltwater Barrier	Injection	5,600	2006
Orange County Groundwater Replenishment System	Spreading/ Injection	72,000	2008

Projects Underway		
Name	**Type**	**Status**
City of Los Angeles East Valley Water Reclamation	Spreading	Being reconsidered
San Gabriel Valley Groundwater Recharge	Spreading	In development
Monterey Peninsula Water Management District Seaside Basin Groundwater Replenishment	Spreading	In development
Warren Sub-basin Artificial Recharge	Spreading	In development

Unsuccessful Projects		
Name	**Type**	**Termination Date**
Dublin San Ramon Clean Water Revival	Injection	1998
Livermore Groundwater Recharge	Injection	1998

[1] This project was replaced by the Orange County Groundwater Recharge and Saltwater Barrier project.