WRF 4973 Fact Sheet: ID 2010

Strategy: Nutrient Reduction outside WRRF

Water Reuse

Purple Pipe to Distribute Reuse Water.
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Reclaimed Water Used for Irrigating Gardens.
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Water reuse is well established in the United States. Individual states have set reuse criteria for various reuse applications that prescribe the water quality and reliability requirements for treatment facilities. These requirements are geared toward protecting public health in the application and use of reclaimed water. Many water resource recovery facilities (WRRFs) that reduce nutrients to low levels are producing water that meets the requirements for unrestricted water reuse. In these cases, the additional investment for a reuse program is drastically reduced, making it an attractive strategy.

The demand for reuse-quality water has increased in recent years, and droughts have accelerated the adoption of indirect potable reuse (IPR) and even direct potable reuse (DPR) to supplement low water supplies. This is only expected to accelerate, as climate change is expected to increase the frequency of droughts (and floods) and heighten the need for a reliable and safe water supply.

Irrigation is another major reuse strategy. Reclaimed irrigation water is used in public spaces, such as parks, recreation fields, highway medians, and many others. Dual-pipe systems have been used in many areas to distribute irrigation water to individual homes.

Industrial reuse is another major use of reclaimed water. Industrial water often requires additional treatment, but the specific treatment requirements are determined by the industrial application. Treatment can take place at the WRRF or at the reuse site. Special agreements between the WRRF providing the water and the organization taking that water are recommended and may be needed. These applications commonly require limits on the total dissolved solids (TDS) of the reuse water, as it impacts the suitability of the reclaimed water for use in irrigation and many industrial applications.

Groundwater replenishment is another potential application for reclaimed water, which is commonly done to provide aquifer water storage for later withdrawal and/or a hydraulic barrier to protect an aquifer (from salt seawater intrusion, for example). Reuse water is often used to replenish groundwater sources by being spread on land to percolate into the ground or injected into the aquifer. Another driver for groundwater injection is to stabilize the ground and prevent ground-level subsidence caused by overdrawing of groundwater from the aquifer.

Fact Sheet Application Checklist

R = fact sheet relevant to item
PR = fact sheet is potentially relevant to item depending on application, existing conditions, etc.

Category		Intensification
		Chemical addition
		Carbon management
		I&C strategies
		Sidestream mgmt.
		Energy savings
		Chemical savings
		Operational savings
	R	Other means of NutRem
Nutrient	R	Ammonia
	R	NOx
	R	TN
	R	Ortho-P
	R	TP
Scale (design flow)	R	Small (<1 mgd)
	R	Medium (1–10 mgd)
	R	Large (>10 mgd)

Goal		Improve reliability
	R	Reduce nutrient
		Reduce O&M cost
Group	R	Optimize existing CNR
	R	Optimize existing TNR
	R	NutRem in secondary Plant
Process	R	Small
	R	Pond
	R	Fixed film (secondary)
	R	Conventional act. sludge (CAS)
	R	Nitrifying act. sludge (NAS)
	R	Conventional NutRem (CNR)
	R	Tertiary NutRem (TNR)
		Other

CAS = conventional activated sludge (BOD only)
NAS = nitrifying activated sludge (without denitrification)
CNR = conventional nutrient removal no chemical/no filter, etc.
TNR = tertiary nutrient removal with chemical, filter, etc.

Technology Summary Evaluation

Footprint	1	Compared to conventional (1 = much smaller; 3 = conventional; 5 = much larger)
Development status*	5	Technology ranking based (LIFT) see below*
Energy use	2	Scale 1–5: 1 = use much less; 3 = use similar to conventional; 5 = use much more
O&M cost	2	Scale 1–5: 1 = cost much less; 3 = cost similar to conventional; 5 = cost much more
Material/consumables	1	Scale 1–3: minimal = 1; some = 2; significant = 3 (e.g., UV lamps/membranes)
Chemical use	1	Scale 1–3: minimal/none = 1; some = 2; significant = 3 (e.g., chemical process)

* Technology ranking based on Leaders Innovation Forum for Technology (LIFT) Water Research Foundation (WRF) Technology Development Level (TDL) definitions:
1 = bench research and development
2 = small-scale pilot
3 = full-scale pilot (demonstration)
4 = pioneer stage (production and implementation)
5 = conventional

Descriptions/Evaluation

Strategy	Water reuse as a means to reduce nutrient discharge from WRRF
Description	Water reuse strategies include the following: • Send treated effluent to consumptive uses, such as landscaping, parks, highway medians, golf courses, agricultural uses, and residential uses. This is typically a seasonal application. • Send treated effluent to various industrial users. • Add advanced water treatment to use water for IPR or DPR. • Groundwater supplementation to stabilize water table. • Groundwater injection to create a hydraulic barrier for protection against saltwater intrusion, for example.
Application	Water reuse is a sustainable solution to water management. It provides a renewable resource to the public. The water sent to reuse carries nutrients in the treated effluent and reduces the amount of nutrients being discharged by the WRRF. Creating reuse-quality water may require the implementation of additional treatment, which requires both capital investment and additional operational costs. WRRF effluent meeting conventional nutrient removal (CNR) or tertiary nutrient removal (TNR) WRRF water quality requirements will typically meet reuse quality requirements for certain applications. The amount of nutrient reduction is tied to the amount of water sent to reuse applications. A reuse strategy is attractive under the following circumstances: • Landscape irrigation near the WRRF is available • Industrial use with nearby industries • Areas where reuse distribution pipes (purple pipes) are installed during land development • Areas where droughts can cause severe disruption to the water supply • WRRFs that have a seasonal (summer only) nutrient reduction requirement
Constituents removed	All nutrients in the effluent are removed when directed away for consumptive use.
Development status*	LIFT TDLs 4–5, depending on the application. Most states allow water reuse for use with and without public contact. Water quality criteria and application rules vary. IPR and DPR have been used inside and outside the United States.
O&M considerations	Operations and maintenance (O&M) requirements depend highly on the reuse application. Irrigation applications require additional O&M requirements for pumping and distribution. Reuse with and without public contact will increase O&M requirements. Applications that require advanced water treatment (AWT) could require advanced oxidation, biofiltration, membrane treatment, and other processes.
Benefits	Water reuse has many community benefits: • Reduced water demand on potable systems • Landscape irrigation can benefit from nutrients in the effluent • Reduced nutrient discharge into the environment • Makes community water resources more resilient to droughts and disruptions • Satellite water reclamation plants can provide additional sewer conveyance capacity
Limitations	Infrastructure required to bring water to the use point is expensive when constructed after development is in place. New communities could plan for water reuse within the community. Irrigation demand is seasonal—it cannot provide nutrient reduction year round. However, in many cases nutrient reduction is most critical in hot summer months, coinciding with high reuse demand. Some industrial reuse applications return concentrated, reject water to the WRRF or receiving water, which can be difficult to treat. Some nutrients may be lost in the industrial application. Reuse applications that return concentrated reject waters include: • Cooling water, which typically relies on evaporation and returns a concentrated reject stream that needs to be managed elsewhere

	• Waste brine streams resulting from industrial reuse applications that use desalination to prevent salt buildup
Design considerations	States provide guidance for reuse water design criteria. The guidance most commonly referenced is the California Title 22 reuse criteria.
Potential fatal flaws	A distribution system is needed to convey the reuse water. May need to manage/dispose of brine (if desalting is required) from industrial reuse applications.
Footprint requirements	Varies depending on the specific reuse application
Residuals	A small amount of new residuals is typically generated (compared to TNR). Reuse applications that require additional TDS reduction will require treatment that generates a brine.
Cost considerations	Varies based on application, but can require slightly more O&M cost (for irrigation applications) to substantially higher O&M cost for applications that require AWT. Reuse projects may require additional treatment (including filtration and advanced treatment) and conveyance facilities for various reuse water quality requirements.
Past experience	Irvine Ranch Water District (IRWD), Irvine, California: 100% reclamation, Title 22 reuse Orange County Water District (OCWD), Fountain Valley, California: IPR, groundwater recharge Hampton Roads Sanitation District (HRSD), Sustainable Water Initiative for Tomorrow (SWIFT), Virginia: reduce nutrient discharge into Chesapeake Bay, groundwater storage stabilization settling Cities of Lacey, Olympia, and Tumwater and Thurston County (LOTT) Clean Water Alliance, Olympia, Washington: water reuse Delta Diablo, California: power plant El Paso Water Utilities, Texas: DPR
Publications	Bell, M., E. Lozon, H. Netto, T. Haug, K. Redd, S. Hammond, and W. Hartnett. 2010. “Nutrient Removal Treatment Practices Implemented at the City of Los Angeles Upstream Water Reclamation Plants.” WEF’s 83rd Annual Technical Exhibition and Conference. New Orleans, Louisiana: WEFTEC. California Water Boards. 2018. “Regulations Related to Recycled Water.” from Titles 22 and 17 California Code of Regulations State Board, Division of Drinking Water, Recycled Water Regulations. https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/lawbook/RWregulations_20181001.pdf. Date accessed February 12, 2022. Olson, D., I. Venner, and D. Ornelas. 2016. “Upstream Biological Treatment for Total Nitrogen Removal in a Direct Potable Reuse Application.” WEF’s 89th Annual Technical Exhibition and Conference. New Orleans, Louisiana: WEFTEC.
Related fact sheets	2001: Manage Nutrients outside the WRRF 2020: Nature-Based Solutions
Date updated	5/18/2022
Contributors	Mike Falk, JB Neethling, Anand Patel

Note

* Technology ranking based on LIFT WRF TDL definitions:
1 = bench research and development
2 = small-scale pilot
3 = full-scale pilot (demonstration)
4 = pioneer stage (production and implementation)
5 = conventional (https://www.waterrf.org/sites/default/files/file/2019-07/LIFT%20Scan%20Application-LIFT%20Link%2BHub_0.pdf : accessed September 2020)

Abbreviations

AWT	Advanced water treatment: to produce IPR and DPR water
BOD	Biochemical oxygen demand
CAS	Conventional activated sludge: BOD removal only
CNR	Conventional nutrient removal
DPR	Direct potable reuse
HRSD	Hampton Roads Sanitation District
I&C	Instrumentation and controls
IPR	Indirect potable reuse
IRWD	Irvine Ranch Water District
LIFT	Leaders Innovation Forum for Technology (now RIC and RISE)
LOTT	Cities of Lacey, Olympia, and Tumwater and Thurston County (Clean Water Alliance)
mgd	Million gallons per day
NAS	Nitrifying activated sludge
NbS	Nature-based solutions
NO_x	Oxidized nitrogen (nitrate + nitrite)
NutRem	Nutrient removal
OCWD	Orange County Water District
O&M	Operations and maintenance
RIC	Research & Innovation Committee
RISE	Research and Innovation for Strengthening Engagement
TDL	Technology Development Level
TDS	Total dissolved solids
TN	Total nitrogen
TNR	Tertiary nutrient removal
TP	Total phosphorus
UV	Ultraviolet
WRF	The Water Research Foundation
WRRF	Water resource recovery facility