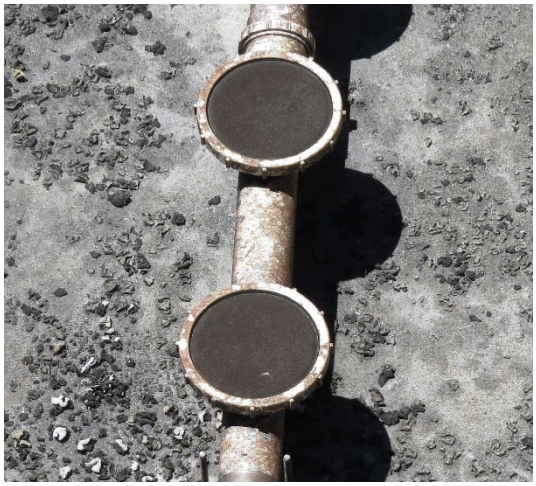
WRF 4973 Fact Sheet: ID 1901

Strategy: Operational Savings

Optimize Operation and Maintenance



Fouled Diffusers Create Loss of Efficiency and High Energy Use.
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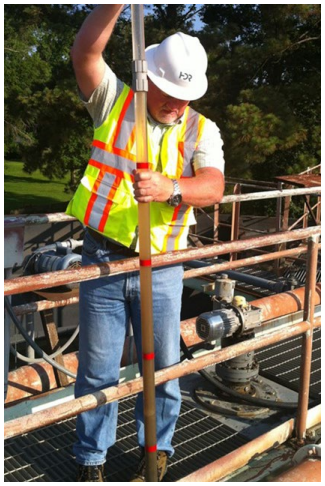

Monitoring Sludge Blanket Depth in a Clarifier.
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This fact sheet focuses on optimizing a water resource recovery facility (WRRF) from an operational standpoint. Opportunities for optimization cover all aspects of the WRRF operations: energy use, chemical use, maintenance, materials, laboratory and administrative support, and labor associated with all activities. Because of the interrelationships connecting various functions of operation at the WRRF, implementing cost-saving and performance-enhancing approaches typically requires collaboration between all WRRF staff, including management. A process analysis can provide insight and direction on how staff can optimize a WRRF's process performance and reduce nutrients in the effluent.

Operational optimization strategies include adjustments or changes in equipment, replacing inefficient or aged facilities, replacing old and fouled diffusers, replacing oversized blowers or pumps, selecting more cost-effective chemicals, fine-tuning the control systems for blowers and chemical feed systems, and implementing many other strategies. All these strategies can reduce the energy, chemical, and maintenance costs of a biological nutrient removal (BNR) process.

Beyond treatment, streamlining administrative functions (e.g., procurement rules) or providing incentives for staff to improve operational efficiency can provide cost savings as well. Laboratory sampling and analysis procedures and requirements can be reviewed to determine sampling needs. Less sampling may not always be the best option though, because special and nutrient species samples can identify avenues to reduce nutrient discharges and potentially reduce the overall operating cost.

The Additional Information section contains more detailed information on potential strategies to optimize operation. Many of these specific strategies are described in related fact sheets.

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
	R	Chemical addition
	R	Carbon management
	R	I&C strategies
	PR	Sidestream mgmt.
	R	Energy savings
	R	Chemical savings
	R	Operational savings
		Other means of NutRem
Nutrient	R	Ammonia
	R	NOx
	R	TN
	R	Ortho-P
	R	TP
Scale (design flow)	PR	Small (<1 mgd)
	R	Medium (1–10 mgd)
	R	Large (>10 mgd)
Goal	R	Improve reliability
	R	Reduce nutrient
	R	Reduce O&M cost
Group	R	Optimize existing CNR
	R	Optimize existing TNR
	PR	NutRem in secondary plant
Process		Small
		Pond
		Fixed film (secondary)
		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	3	Compared to conventional (1 = much smaller; 3 = conventional; 5 = much larger)
Development status*	4–5	Technology ranking based (LIFT) see below*
Energy use	1	Scale 1–5: 1 = use much less; 3 = use similar to conventional; 5 = use much more
O&M cost	1	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	Reduce costs and nutrient discharge from WRRF by optimizing operations
Description	This fact sheet provides an overview of strategies that operations, maintenance, and other staff can initiate to improve nutrient removal and/or reduce operational costs at a WRRF. Cost categories include items such as energy, process, chemical, automation and control, maintenance, and other strategies.
Application	Opportunities to optimize operational improvements and savings at WRRFs are typically recognized first by the staff of that WRRF. This includes everyone that works at the WRRF, including administrative, management, process analysis, and laboratory staff. Cost savings and performance enhancements can often be recognized by engaging and empowering staff members to propose and implement optimization strategies. The enhancements can be in the form of new process ideas, new approaches, addressing administrative barriers, and other opportunities.
Constituents removed	All nutrients
Development status*	Most operational improvement strategies will fall within LIFT TDLs 4–5. However, some newer approaches and equipment could be appropriate to test at a bench, pilot, or demonstration scale. Most strategies are built and developed from experiences at the WRRF, or other similar WRRFs, and can often be tested and evaluated at the WRRF to ensure their success.
O&M considerations	Depends on the strategy. Changes in the labor skill required to operate and maintain a process may require additional training. Typically, this can be achieved with on-the-job field pilot/demonstration testing.
Benefits	Benefits depend on the strategy, but cover improved process performance, reduced operational cost, improved staff engagement, and better morale.
Limitations	Institutional procedures and rules may pose a barrier for some strategies.
Design considerations	Depends on strategy, but generally none to some minor design is required
Potential fatal flaws	None
Footprint requirements	None
Residuals	Depends on strategy, but typically similar to existing operations
Cost considerations	Depends on strategy
Past experience	City of Henderson, Nevada: biological process, operations and maintenance (O&M) Hampton Roads Sanitation District (HRSD), Virginia: energy, process, chemical, O&M, automation Clean Water Services, Oregon: energy, process, chemical, O&M, automation Central Contra Costa Sanitary District, Martinez, California: diffuser testing/cleaning
Publications	Reardon, D. 1998. “Energy Usage Wastewater treatment plants.” Waterworld, August 31. U.S. Department of Energy. 2019. “Energy Data Management Manual Wastewater Treatment.” DOE/EE-1700 Better Buildings, U.S. Department of Energy, December 2017. WEF. 2017. “Operation of Water Resource Recovery Facilities, MOP 11.” Water Environment Federation (WEF).
Related fact sheets	Many of the fact sheets are referenced below in Additional Information. The overview fact sheets are listed here (additional ones listed below): 1101: Process Intensification Overview 1301: Overview of Chemical Addition 1501: Overview of Instrumentation and Controls Strategies

	1601: Reject Water (Sidestream) Management Overview 1701: Reduce Energy Consumption Overview 1801: Overview Chemical Saving Strategies 1901: Optimize Operation and Maintenance
Date updated	9/10/2022
Contributors	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)

Additional Information

Opportunities for optimization cover all areas of the WRRF operations. The tables below contain information on potential O&M optimization strategies and references to fact sheets or other publications where additional information on these strategies can be found. These tables are:

- Table 1. Energy Optimization Operational Strategies
- Table 2. Process Optimization Operational Strategies
- Table 3. Chemical Optimization Operational Strategies
- Table 4. Automation and Control Operational Strategies
- Table 5. Maintenance Optimization Operational Strategies
- Table 6. Other Optimization Operational Strategies

Table 1. Energy Optimization Operational Strategies.

Sort	Energy Reduction Strategy	Description	Related Fact Sheets
1	Optimize blower operation	• Add jockey blower to provide efficient turndown capability • Lower header pressure • Optimize blower controls	1701, 1710
2	Reduce aeration/optimize dissolved oxygen (DO) control	• Reduce operation DO • Automate DO control • Implement ammonia-based aeration control (ABAC) or other control strategies • Manage air distribution through basins to avoid over-aeration • Reduce mixing aeration in channels	1450, 1501, 1510, 1560, 1701, 1710, 1740
3	Optimize pump operation	• Raise wet well level to reduce pump head • Add jockey pump to provide efficient turndown capability • Optimize internal recirculation (for denitrification)	1501, 1510, 1560, 1701, 1710, 1740
4	Clean diffusers	• Conduct off-gas testing to determine standard oxygen transfer efficiency (SOTE) and assess value of cleaning • Establish schedule to clean aeration diffusers	1701, 1710, 1740

Table 2. Process Optimization Operational Strategies.

Sort	Process Strategy	Description	Related Fact Sheets
1	Optimize BNR process	• Improve carbon use with shortcut nitrogen (N) removal, simultaneous nitrification and denitrification (SND), ABAC • Improve carbon use by limiting DO and nitrate return in anoxic and anaerobic zones • Eliminate/reduce short circuiting in zones	1101, 1110, 1130, 1140, 1401, 1450, 1601, 1620, 1630
2	Optimize secondary clarifiers	• Improve hydraulics with baffling • Add flocculation zones	1101, 1160
3	Treat and manage reject water (sidestreams)	• Manage reject water return flows to avoid shock loading to WRRF • Remove and/or recover nutrient (N and phosphorus [P]) in reject water	1601, 1610, 1620, 1630
4	Track individual process and WRRF wide key performance indicators (KPIs)	• Determine KPIs for unit process and for WRRF as a whole • Use past performance as starting point/base • Establish goal for KPI • Track progress and adjust	See Section 4.1.4 in Report

Table 3. Chemical Optimization Operational Strategies.

Sort	Chemical Use Strategy	Description	Related Fact Sheets
1	Add carbon to improve N removal	• Add external carbon to anoxic zone	1301, 1310
2	Add carbon to improve P removal	• Add external carbon to anaerobic zone	1301, 1310
3	Generate carbon through fermentation for N and P	• Primary sludge fermentation to produce volatile fatty acids (VFAs) • Activated primary treatment: operate primary with high blanket, recycle sludge to elutriate VFAs • Use sidestream enhanced biological phosphorus removal (EPBR) fermentation process	1401, 1410
4	Improve carbon use efficiency	• Operate in shortcut N removal mode: SND • Avoid DO return to unaerated zone	1101, 1130, 1401, 1450
5	Optimize chemical dose/cost	• Conduct jar tests to find optimal dose • Study alternative chemical for P removal • Study alternative carbon sources for N/P removal (denitrification or EBPR)	1301, 1801, 1820
6	Evaluate industrial “waste chemicals”	• Use readily degradable organic waste for carbon (denitrification or EPBR): e.g., beer waste, soda bottling, etc.	1401, 1801, 1820
7	Improve chemical dose efficiency	• Improve mixing at chemical injection point	1801, 1820
8	Use chemical sludge for P removal	• Recycle chemical sludge from tertiary process to headworks to reduce P • Rely on water treatment chemical sludge to remove P in sewer/conveyance	1801, 1850
9	Reduce returned P load in reject water	• Add chemical to dewatering operation to reduce P in reject water • Recover P in reject water	1601, 1630

Table 4. Automation and Control Operational Strategies.

Sort	Automation and Control Strategy	Description	Related Fact Sheets
1	Automate process controls	• Automate DO control • Automate chemical dose	1501, 1510, 1560
2	Improve equipment operation	• Tune, adjust, replace equipment to improve ability to control within required operating range	1501, 1510, 1560
3	Select/install self-cleaning sensors	• Use self-cleaning sensors to reduce staff probe maintenance effort	1501, 1560

Table 5. Maintenance Optimization Operational Strategies.

Sort	Maintenance Strategies	Description	Related Fact Sheets
1	Select/install self-cleaning sensors	• Use self-cleaning sensors to reduce staff probe maintenance effort	1501, 1560
2	Replace inefficient equipment	• Replace fouled diffusers in aeration basin. • Replace high-energy-use pumps: ▪ Internal recycle pumps operating at high pressure ▪ Reroute recycle stream to reduce pump pressure	1701, 1710
3	Schedule maintenance	• Maintain routine maintenance to avoid emergency maintenance work	1710
4	Limit fouling/debris of equipment components	• Install fine screens to remove debris that accumulates in the WRRF • Optimize cleaning as needed: e.g., membranes, filters, diffusers, etc.	1710

Table 6. Other Optimization Operational Strategies.

Sort	Other Strategies	Description	Related Fact Sheets
1	Provide incentives to staff for ideas and suggestion	• WRRF staff knows the WRRF best and can spot opportunities for improvements • Provide mechanism to make suggestions/propose ideas • Incentivize staff	1901
2	Conduct strategic evaluations and studies	• Conduct no-risk bench-, pilot-, and full-scale tests as appropriate to evaluate strategies • Engage internal and external subject matter experts to conduct tests/studies to assess the potential for specific optimization. For example, conduct off-gas testing to evaluate the efficiency of an aeration system.	1901
3	Assess data needs/samples	• Identify the need and use of data (samples, analytical work, etc.) to determine appropriate level for WRRF. ▪ Eliminate data needs/samples that are not used. ▪ Add data needs/samples that are not currently tracked but needed. This could be a short-term event.	1901
4	Automate data analysis and trending	• Combine all WRRF performance data in a single platform for operators and others to review daily • Use online data to track trends, note changes, and identify causes to process variability	1901
5	Streamline red tape	• Review procurement rules to simplify and reduce paperwork • Limit staffing rules to provide flexibility	1901

Abbreviations

ABAC	Ammonia-based aeration control
BNR	Biological nutrient removal
BOD	Biochemical oxygen demand
CAS	Conventional activated sludge: BOD removal only
CNR	Conventional nutrient removal
DO	Dissolved oxygen
EBPR	Enhanced biological phosphorus removal
HRSD	Hampton Roads Sanitation District
I&C	Instrumentation and controls
KPI	Key performance indicator
LIFT	Leaders Innovation Forum for Technology (now RIC and RISE)
mgd	Million gallons per day
N	Nitrogen
NAS	Nitrifying activated sludge
NO_x	Oxidized nitrogen (nitrate + nitrite)
NutRem	Nutrient removal
O&M	Operations and maintenance
P	Phosphorus
RIC	Research & Innovation Committee
RISE	Research and Innovation for Strengthening Engagement
SND	Simultaneous nitrification and denitrification
SOTE	Standard oxygen transfer efficiency
TDL	Technology Development Level
TN	Total nitrogen
TNR	Tertiary nutrient removal
TP	Total phosphorus
UV	Ultraviolet
VFA	Volatile fatty acid
WRF	The Water Research Foundation
WRRF	Water resource recovery facility