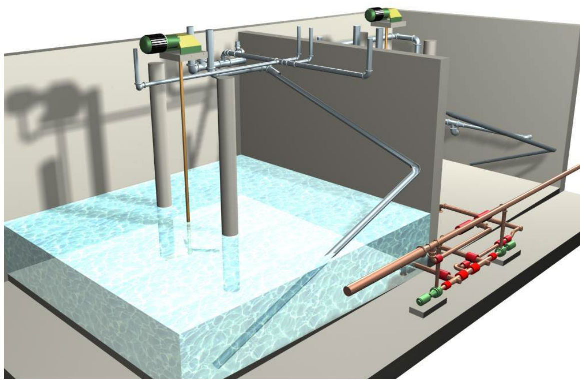
WRF 4973 Fact Sheet: ID 1601

Strategy: Reject Water Management

Reject Water (Sidestream) Management Overview



Dewatering Centrate Equalization.
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Annamox Granules.
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Managing or treating nutrient-rich reject water (sidestreams) includes strategies to attenuate the impact of the load (equalization, scheduled operation, etc.) or to reduce the nutrient load returning to the water resource recovery facility (WRRF) by treating and removing the nutrients from the stream (chemical phosphorus [P] sequestration, nitrification, nitrogen [N] removal, P recovery, N recovery, etc.).

WRRFs that have anaerobic digestion and dewatering processes or sludge storage lagoons with decanting flows produce nutrient-rich reject water streams that are typically returned to the mainstream process. These reject water streams typically increase the influent N load by 10% to 20% and influent P load by 10% to 40% or more. The reject water N concentration increases even more under some conditions. For example, importing organic waste for co-digestion and gas production or thermal hydrolysis sludge treatment processes can increase the influent nitrogen by 60% or more. Similarly, digestion of enhanced biological phosphorus removal (EBPR) waste activated sludge (WAS) biomass can increase the phosphorus in the reject water and can increase the influent P loads by 90% or more.

Managing and treating the reject water reduces the nutrient load and improves the mainstream liquid treatment efficiency of both conventional nutrient removal (CNR) and tertiary nutrient removal (TNR) WRRFs. Treating the reject water nutrient load improves the CNR and TNR process's ability to reduce the effluent nutrient load. Managing the reject water nutrient load makes the CNR and TNR process more reliable and efficient.

The high nutrient concentration in the reject water makes it an optimal location to recover nutrients (N and P). Nutrient recovery will reduce the effluent nutrient load.

The primary reject stream is the reject water from digested sludge dewatering but other reject streams also increase the influent load to a lesser extent. Typical compositions of reject water return streams are shown in Table 1 through Table 4.

Sidestream reject water sources provide a good opportunity for nutrient recovery because of the high ammonia and high phosphate concentrations in the dewatering reject water. The high concentrations also make nutrient removal treatment more efficient.

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
	PR	Chemical addition
	R	Carbon management
		I&C strategies
	R	Sidestream mgmt.
	R	Energy savings
		Chemical savings
	R	Operational savings
	R	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
	R	NutRem in secondary plant
Process		Small
		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	1–5	Compared to conventional (1 = much smaller; 3 = conventional; 5 = much larger)
Development status*	5	Technology ranking based (LIFT) see below*
Energy efficiency	2	Compared to conventional (1 = much less; 3 = conventional; 5 = much more)
O&M impact	1–3	Compared to conventional (1 = much less; 3 = conventional; 5 = much more)
Material/consumables	1–3	Scale 1–3: minimal = 1; some = 2; significant = 3 (e.g., UV lamps/membranes)
Chemical use	2	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	Reject water (also called sidestream) control is aimed to reduce the impact of high nutrient loads from in-plant sources such as dewatering and sludge storage basin.
Description	Managing or treating nutrient-rich reject water includes strategies to attenuate the impact of the load (equalization, scheduled operation, etc.) or to reduce the nutrient load returning to the WRRF by treating and removing the nutrients from the stream (chemical P sequestration, nitrification, N removal, P recovery, N recovery, etc.).
Application	Manage nutrient loads from various treatment processes in the WRRF. The primary load comes from reject water when dewatering anaerobic digested sludge or decant water from sludge storage lagoons. Other sources include thickeners, filter backwash, etc.
Constituents removed	Nitrogen and phosphorus
Development status*	LIFT TDLs: 1–5 Many sidestream management strategies and treatment technologies are well established with many full-scale installations but new approaches and technologies are still emerging.
O&M considerations	Most sidestream nutrient control approaches will add equipment, tanks, and conveyance that require maintenance and control. Chemicals are sometimes added. Most sidestream treatment processes run fully automated but require periodic maintenance, especially instrumentation that is critical for the automated control.
Benefits	Reduce operating cost Reduce effluent nutrients Improve treatment efficiency and reliability Eliminate struvite nuisance precipitants Improve dewaterability (percent cake) Flow equalization can also provide liquid storage space for plant operations Sidestream treatment reduces carbon, oxygen, and alkalinity demand in liquid treatment Biomass from sidestream processes can be used to seed the mainstream process (bioaugmentation) Nutrient recovery provides a sustainable solution to generate fertilizer by-product
Limitations	Continuous flow is required for some processes. Smaller plants may be unable to dewater 24/7. Sidestream treatment technologies require capital investment. Their operational savings and process improvements should be evaluated to determine the overall benefits. Cases where solids are stored seasonally and dewatered in short periods should be evaluated to ensure compatibility with nutrient limits. P recovery economics may not justify a cost-based investment; a non-cost factor can inform the decision to implement.
Design considerations	Sidestream management or treatment facility should be in close proximity of the dewatering operation. Sidestream equalization may be required for reliable and constant performance. The design should consider and mitigate the potential for unintentional struvite formation.
Potential fatal flaws	Some processes (such as deammonification) may require warm liquid and consistent flows. The water quality should be evaluated for suitability to the selected treatment process (especially sludge storage lagoon return flows, which may be cold).
Footprint requirements	Small to moderate, depending on the strategy (management vs. treatment).

Residuals	For equalization there is no change in residuals. Solids from biological sidestream treatment do not increase the total solids yield. Biomass generated in a reject water treatment process can be directed to the mainstream for bioaugmentation. Chemical P removal will generate a chemical sludge. Harvested struvite from P recovery.
Cost considerations	The economic analysis for cost should include the following: • Capital and operating costs for the sidestream nutrient control strategy • Reduction in cost of treatment in the mainstream • Benefits of sidestream nutrient control for meeting permit • Potential revenues from N and P recovery
Past experience	Durham Advanced Wastewater Treatment Plant (WWTP), Clean Water Services, Portland, Oregon: centrate equalization and phosphorus recovery R.W. Hite Water Reclamation Facility, Denver, Colorado, Metro Water Recovery: deammonification and sludge conditioning with MagPrex DC Water: deammonification Howard County, Maryland, Little Patuxent Water Reclamation Plant: centrate equalization, deammonification, sludge condition with MagPrex Tres Rios Water Reclamation Facility, Pima County, Arizona: sludge conditioning with NuReSys and deammonification
Publications	Kasi, M., W. Wehner, M. Benisch, A. Perreira, and J. Wodrich. 2017. “Paradigm Shift if Dewatering Operations Moved to the Center of the Plant Universe.” Nutrient Symposium. Fort Lauderdale Florida: WEF. Wilson, C.A., C. Watson, R. Natarajan, W. Horton, and L.A. Zuravnsky. 2014. “Articulating the Case for Sidestream Nutrient Removal to Enhance WRRF Capacity: One Year of Full-Scale Operating Experience.” WEF’s 87th Annual Technical Exhibition and Conference. New Orleans, Louisiana: WEFTEC.
Related fact sheets	1301: Use of Chemicals to Improve Nutrient Removal 1320: Chemical Phosphorus Removal 1610: Sidestream Return Flow Management 1620: Sidestream Ammonia/TN Treatment and Control 1630: Sidestream Phosphorus Treatment, Recovery, and Control 1820: Chemical Testing and Selection 1901—Optimize Operation and Maintenance
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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

Typical compositions and load contribution for common recycle streams are shown in Table 1 through Table 4 below.

Table 1. Typical Primary Sludge Thickening Return Composition Example.

Parameter	Concentration (mg/L)	Fraction of Influents Load (%)
TSS	400–600	2.0–3.0
BOD	350–550	4.0–8.0
TKN	40–70	3.0–7.0
NH_4-N	20–40	4.0–8.0
NO_x	0.0	2.0–3.0
TP	5–20	0.0
PO_4-P	4–10	3.0–5.0

Table 2. Typical WAS Thickening Return Composition Example.

Parameter	Concentration (mg/L)	Fraction of Influents Load (%)
TSS	1,000–1,400	0.4–0.6
BOD	200–400	2.5–3.5
TKN	70–90	0.5–1.5
NH_4-N	1.0–5.0	1.0–2.0
NO_x	3.0–6.0	0.0–0.1
TP	50–70	0.0–0.2
PO_4-P	0.1	5.0–8.0

Table 3. Typical Primary Sludge Fermenter Return Composition Example.

Parameter	Concentration (mg/L)	Fraction of Influents Load (%)
TSS	700–900	8–13
BOD	2,000–2,500	25–35
sBOD	1,600–2,200	10–50
VFA	500–700	10–50
TKN	80–120	9–12
NH_4-N	60–100	9–12
NO_x	0	0
TP	10–20	7–9
PO_4-P	5–15	6–8

Table 4. Typical Composition of Dewatering Recycle from Anaerobic Digestion.

Parameter	Concentration (mg/L)	Fraction of Influents Load (%)
TSS	1,200–1,600	2–3
BOD	400–500	0.7–1.0
TKN	1,100–1,300	12–18
NH_4-N	1,000–1,200	15–22
NO_x	0	0
TP	300–400	30–40
PO_4-P	250–500	15–50

Table 5. Sidestream Processes.

Strategy/Technology	Load Equalization	NH_4 Removal	PO_4 Removal	PO_4 Recovery	N Recovery	Mainstream Reliability	Nuisance Control	Reduce Effluent N	Reduce Effluent P	Comment
Equalize flow	✓					Y		P	P	
Continuous dewatering operation	✓					Y		P	P	
Off-peak return	✓					Y		P	P	
Nitrification activated sludge		Y				Y		P	P	
Nitrification/ denitrification activated sludge		Y				Y		P	P	
Post-aerobic digestion		Y				Y		P	P	
Deammonification		Y				Y		Y	P	
Shortcut N removal		Y				Y		Y	P	
Ammonia stripping		Y			P	Y				
N recovery	*									Required
P sequestration			Y	P		Y	Y		Y	
P recovery	*	Y	Y	Y		Y	Y		Y	
WASStrip				P		P				
Struvite recovery			Y	Y	Y	Y	Y		Y	
NuReSys			Y	Y	Y		Y	Y	Y	

Note: Y = yes; P = potentially; * = equalization required for this strategy/technology

Abbreviations

BOD	Biochemical oxygen demand
CAS	Conventional activated sludge: BOD removal only
CNR	Conventional nutrient removal
EBPR	Enhanced biological phosphorus removal
I&C	Instrumentation and controls
L	Liter(s)
LIFT	Leaders Innovation Forum for Technology (now RIC and RISE)
mg	Milligram(s)
mgd	Million gallons per day
N	Nitrogen
NAS	Nitrifying activated sludge
NH_4	Ammonium
NH_4-N	Ammonium-nitrogen
NO_x	Oxidized nitrogen (nitrate + nitrite)
NutRem	Nutrient removal
O&M	Operations and maintenance
P	Phosphorus
PO_4	Phosphate
PO_4-P	Orthophosphate
RIC	Research & Innovation Committee
RISE	Research and Innovation for Strengthening Engagement
sBOD	Soluble biochemical oxygen demand
TDL	Technology Development Level
TKN	Total Kjeldahl nitrogen
TN	Total nitrogen
TNR	Tertiary nutrient removal
TP	Total phosphorus
TSS	Total suspended solids
UV	Ultraviolet
VFA	Volatile fatty acid
WAS	Waste activated sludge
WRF	The Water Research Foundation
WRRF	Water resource recovery facility
WWTP	Wastewater treatment plant