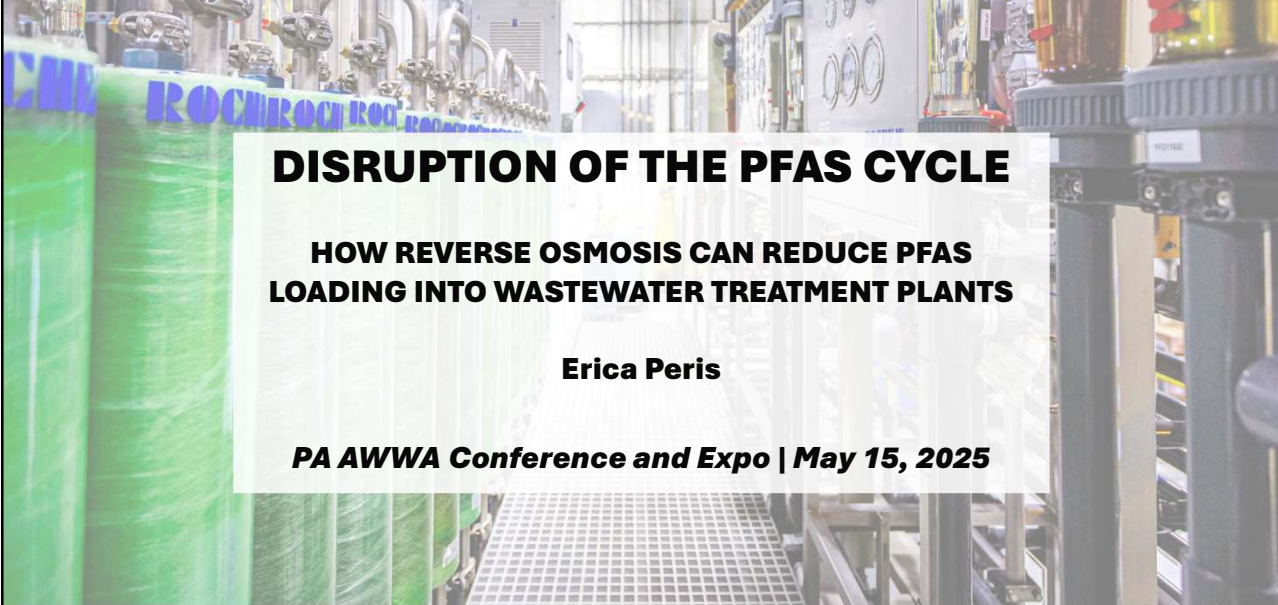




DISRUPTION OF THE PFAS CYCLE

**HOW REVERSE OSMOSIS CAN REDUCE PFAS
LOADING INTO WASTEWATER TREATMENT PLANTS**

Erica Peris

PA AWWA Conference and Expo | May 15, 2025

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1

PRESENTATION SUMMARY

Leachate Treatment Overview

Interdependency of WWTPs and Landfills

The PFAS Cycle

Reverse Osmosis Technology

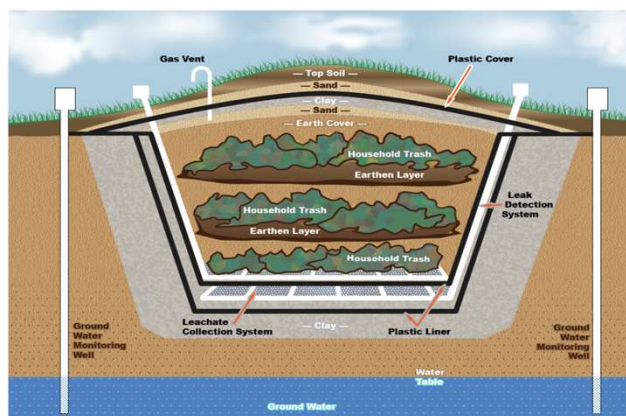
Case Studies



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2

LEACHATE MANAGEMENT



“When [rainwater] comes in contact with buried wastes, it leaches, or draws out, chemicals or constituents from those wastes.” – EPA.gov

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https://www.in.gov/idem/iee/files/lesson_where_landfill.png

3

LEACHATE MANAGEMENT

MSW Landfill Leachate “Typical” Characteristics:

Heavy Metals: typically < 10 mg/L

TDS: 5,000 – 15,000 mg/L

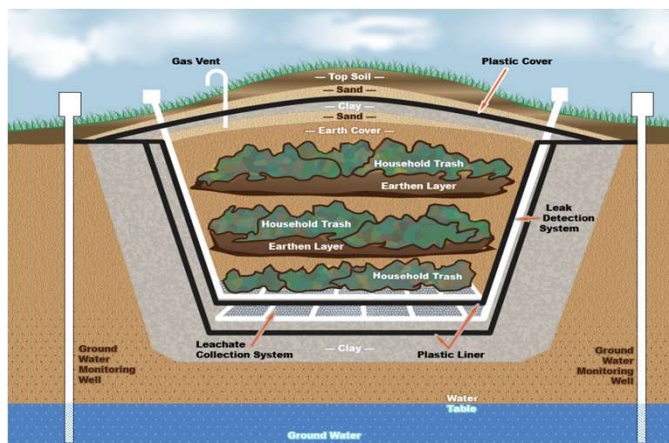
TSS: 50 – 200 mg/L

pH: 7 – 8.5

BOD: 1,000 – 4,000 mg/L

NH₃: 500 – 2,000 mg/L

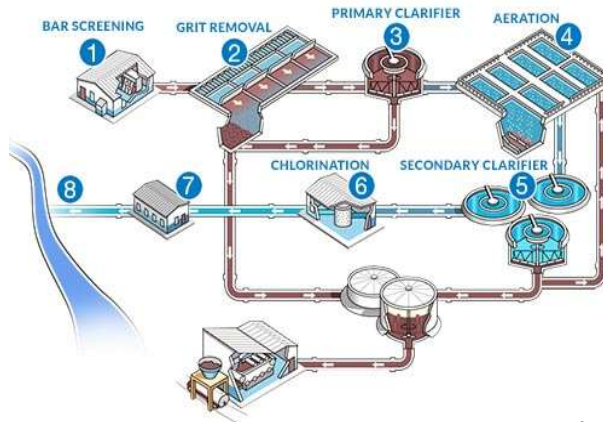
PFAS – highly variable



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WWTP OPERATIONS



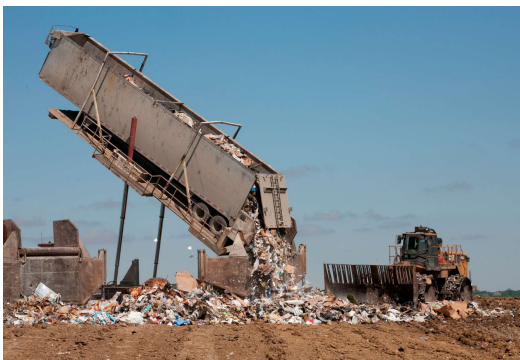
“When sewage...is sent to a wastewater treatment plant, the liquids are separated from the solids, producing a semi-solid, nutrient-rich product known as ‘sewage sludge’ or ‘biosolids’” – EPA.gov

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<https://www.coleparmer.com/tech-article/eight-stages-of-wastewater-treatment-process>

5

WWTP-LANDFILL RELATIONSHIPS



https://www.in.gov/ide/iee/files/lesson_where_trash.jpg



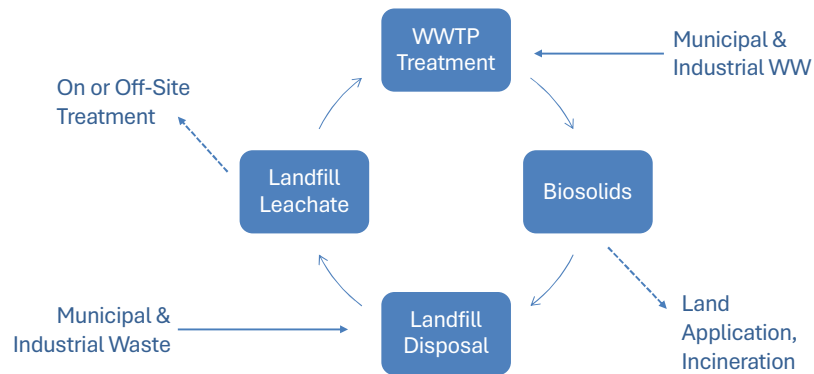
<https://www.walshgroup.com/ourexpertise/water/wastewatertreatmentplants/annarborwastewatertreatmentplant.html>

Wastewater treatment plants and landfills both receive and manage society’s wastes.

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WWTP-LANDFILL RELATIONSHIPS



Common Concerns

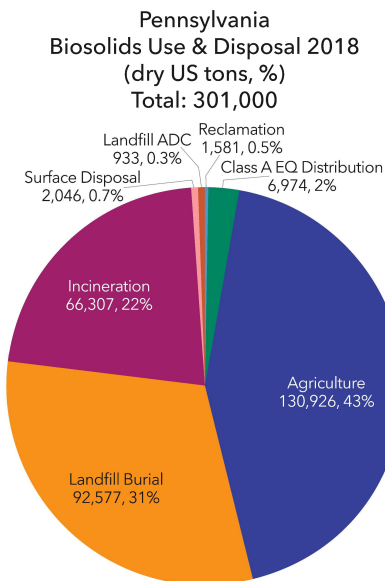
At WWTPs: Constituent loading (Ammonia, TDS, Organics), revenue, public perception

At Landfills: Disposal restrictions, tipping fee increases



7

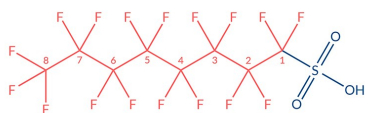
BIOSOLIDS IN PA



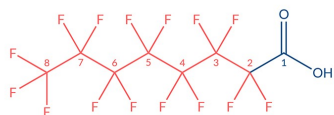
<https://www.biosolidsdata.org/pennsylvania>

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LEACHATE & PFAS



Perfluorooctanesulfonic Acid
PFOS



Pentadecafluorooctanoic Acid
PFOA

Table 8-1 Assumed influent concentrations and treatment goals for target PFAS for mixed MSW landfill leachate (all units in ng/L)

PFAS	Typical Concentrations ⁽¹⁾	High Concentrations ⁽¹⁾
PFBA	950	2,600
PFBS	250	650
PFHxA	1,500	4,000
PFHxS	350	750
PFOA	900	1,900
PFOS	150	300
6:2 FTS	150	350
N-EtFOSAA	150	450

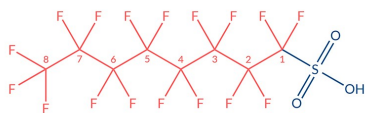
[1] Data from Lang et al.; 2017 data on 87 samples from 18 landfills across the U.S. Typical concentrations reflect the mean of 87 samples, and high concentrations reflect the 90th percentile of 87 samples. These target PFAS generally represented between 60% and 85% of the sum of PFAS analyzed. Values were rounded to the nearest 50 ng/L and two significant digits.

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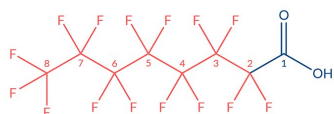
<https://www.caymanchem.com/news/pfas-dilution-is-not-the-solution>
<https://www.pca.state.mn.us/air-water-land-climate/pfas-studies-and-reports>

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LEACHATE & PFAS



Perfluorooctanesulfonic Acid
PFOS



Pentadecafluorooctanoic Acid
PFOA

Recent EPA Actions

- NPDES PFAS Permitting Strategy Issued
- MCLs (6 PFAS compounds)
- CERCLA Haz Substance Designation (PFOS/PFOA)
- Aquatic Surface Water Criteria Issued
- Draft Sewage Sludge Risk Assessment (PFOS/PFOA)

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<https://www.caymanchem.com/news/pfas-dilution-is-not-the-solution>

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EP1

LEACHATE & PFAS

Many states have advanced regulatory actions

Michigan

- Enacted Industrial Pretreatment Program
- Biosolids Disposal Criteria
- Surface Water Criteria

New York

- PFAS Industrial Permitting Strategy
- Surface Water Criteria
- Biosolids Sampling/Management Requirements

Maine

- Highly Publicized Biosolids Land Application Criteria



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PFAS IN PENNSYLVANIA

Maximum Contaminant Levels – January 2023

	MCLG (ng/L or ppt)	MCL (ng/L or ppt)
PFOA	8	14
PFOS	14	18

Now superseded by EPA MCLs



Pennsylvania
Department of
Environmental Protection



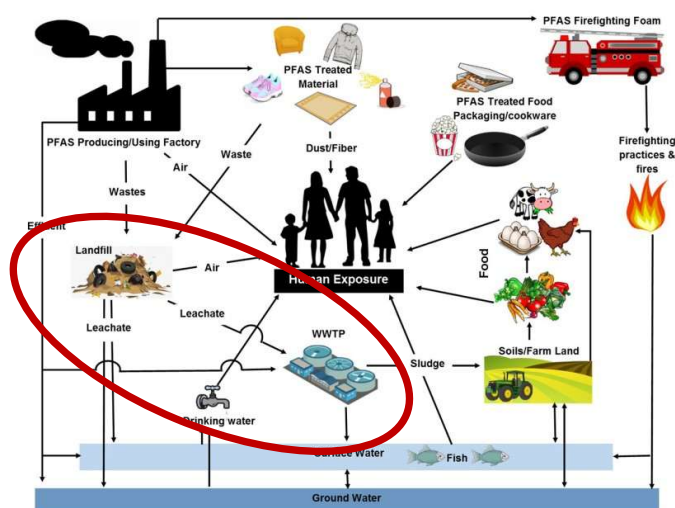
<https://www.pa.gov/agencies/dep/programs-and-services/water/bureau-of-safe-drinking-water/drinking-water-management/drinking-water-regulations/pfas-mcl-rule.html>

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EP1 Include if time

Erica Peris, 2025-05-07T17:27:59.472

THE PFAS CYCLE



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Human Exposure and sources of PFAS
Image: DWP, adapted from Oliaei et al. 2013.

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PFAS – WWTPs

Municipal WWTPs receive PFAS in influent via:

- Landfill leachate (if applicable)
- Industrial wastewater (if applicable)
- Residential wastes

PFAS in wastewater treatment

- Types/concentrations of PFAS vary
- Higher concentrations typical for WWTPs that receive industrial WW or leachate

Biosolids removal/fate

- PFAS accumulation in biosolids
- PFAS distribution in biosolids different than in WW
- High variability (attributed to sources and matrix sampling)

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PFAS – LANDFILL LEACHATE

Landfills receive PFAS in waste via:

- Industrial wastes
- Residential wastes
- Biosolids from WWTPs

PFAS released from landfill via:

- Landfill leachate
- Landfill gas (minor)
- Groundwater (unlined landfills)

“The processes for managing leachate have implications on the ultimate fate and transport of PFAS.”

-ITRC, 2023

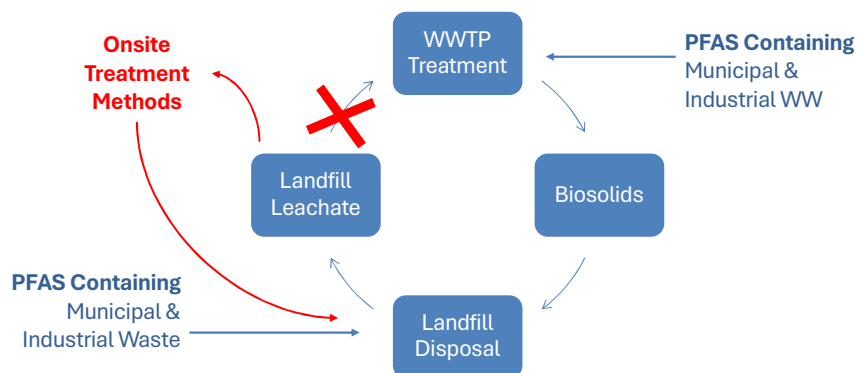
Landfills are the current “best practice” for removing PFAS from the environment.



15

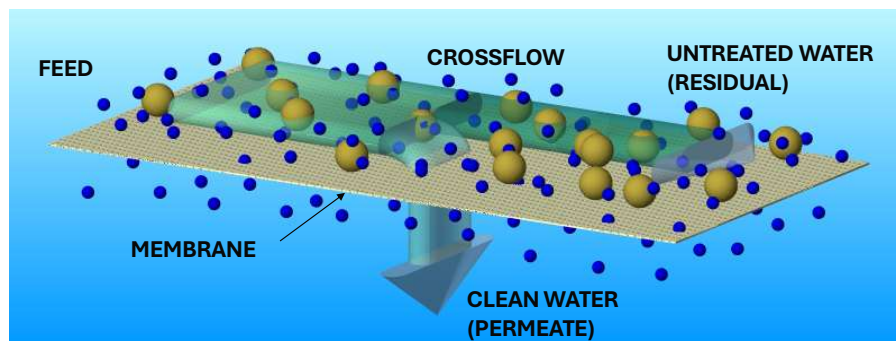
DISRUPTING THE PFAS CYCLE

Landfills can act as an effective repository for PFAS.



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REVERSE OSMOSIS



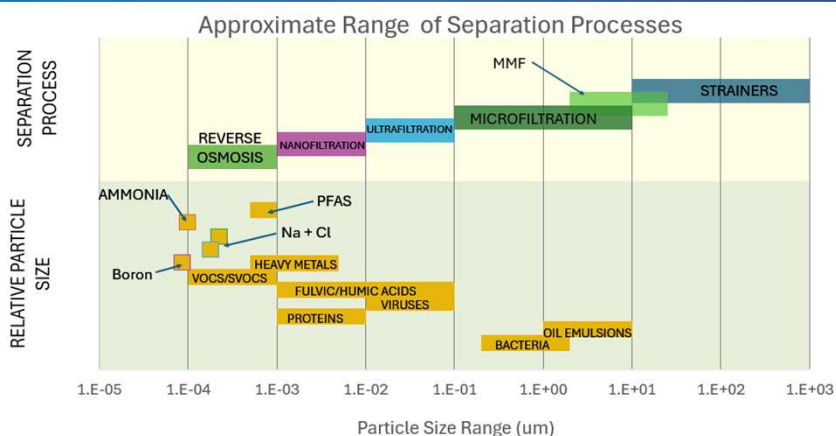
Reverse Osmosis (RO) is a *separation* technology to force clean water (permeate) through a semi-permeable membrane.

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EP1

REVERSE OSMOSIS



Reverse osmosis will effectively remove >99% of all constituents with molecular weight greater than 100, as well as ionic species.

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Slide 18

EP1 Add chart that shows PFAS
Erica Peris, 2025-05-07T17:30:22.420

EP1 0 See Pete's
Erica Peris, 2025-05-07T17:30:42.374

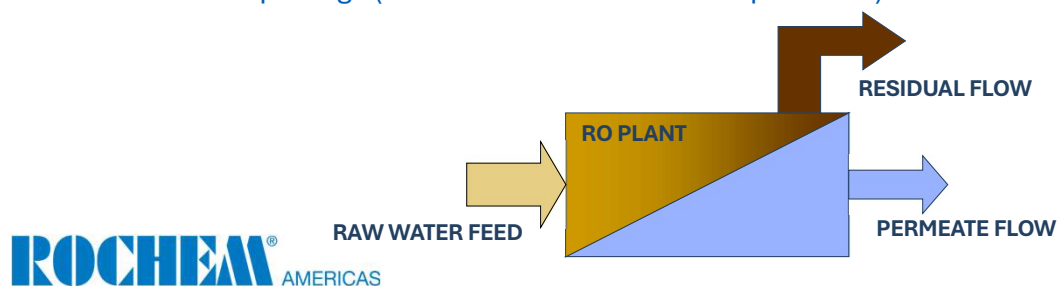
RO TERMS: SYSTEM PERFORMANCE

RECOVERY (%) = Permeate Flow/Raw Water Feed Flow

- Volume basis
- How much clean water is made

REJECTION (%) = (1-(Permeate Concentration/Feed Concentration))

- Concentration basis
- How much contaminant remains behind in reject/residual
- Inverse is salt passage (how much contaminant is in permeate)



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BENEFITS OF RO FOR LEACHATE TREATMENT

The inherent nature of RO as a separation process offers several significant advantages:

High rejection rates → Large reduction in concentrations

Physical/chemical process → More resistant to concentration swings

“Simpler” to Operate

- No biomass to maintain
- Mechanical system with limited chemistry
- Larger pool of operators (compared to biological)

Consolidated footprint

Rapid startup/deployment

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DRAWBACKS OF TRADITIONAL RO SYSTEMS

When conventional RO Systems are used:

Designed for cleaner water/maximum efficiency

Thinner feed spacer → Prone to fouling

Lower pressure rating → Limited recovery rate

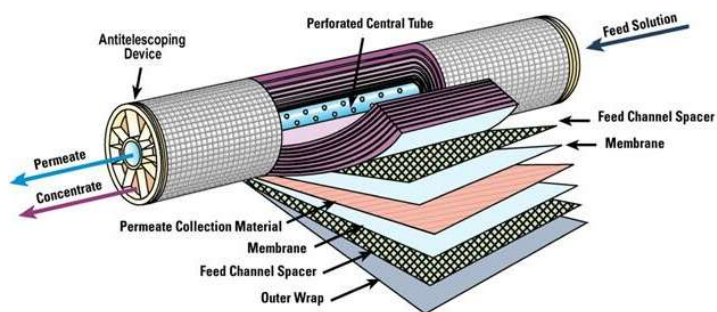
Cleaning-in-place not readily incorporated into design

High strength wastewater requires lower flux/membrane and high cross-flow velocities – Balance of flux against internal flows



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FOULING IN TRADITIONAL RO



Traditional RO module construction results in areas of low flow where solids may collect, resulting in membrane fouling.



<http://www.esep.co/en/products/MembraneFiltration.aspx>

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PROCESS ENHANCEMENTS FOR LEACHATE

Multiple Passes

1. Polishing stage: > 99% removal
2. High pressure stage: residuals volume reduction

Module Design

1. Higher pressure → up to 1300 psi for first pass, 1740 psi for residuals
2. Open channel feed spacer
3. Accessible for removal/maintenance

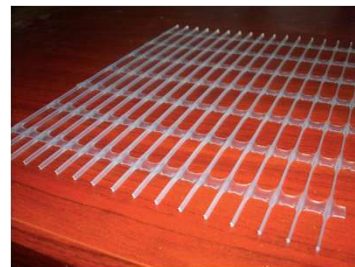
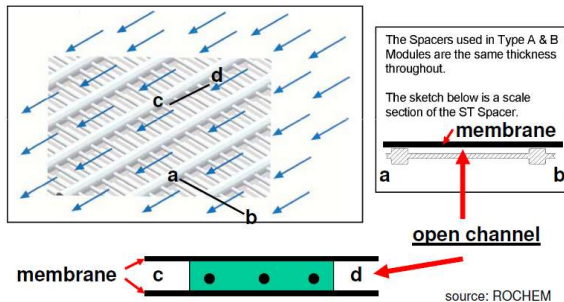
CIP inherent to operations

Hydraulics designed for high cross flow to decrease fouling



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OPEN CHANNEL FEED SPACER



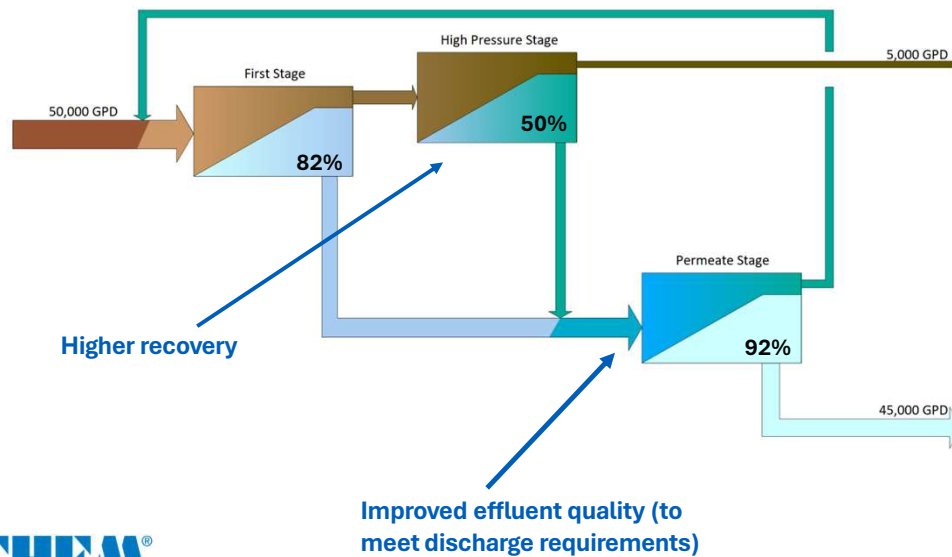
Open feed channels minimize fouling and maximize cross flow velocity

- Requires internal loops to maintain high velocity
- This allows for higher achievable recovery rates



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RO SYSTEM – 3 STAGES

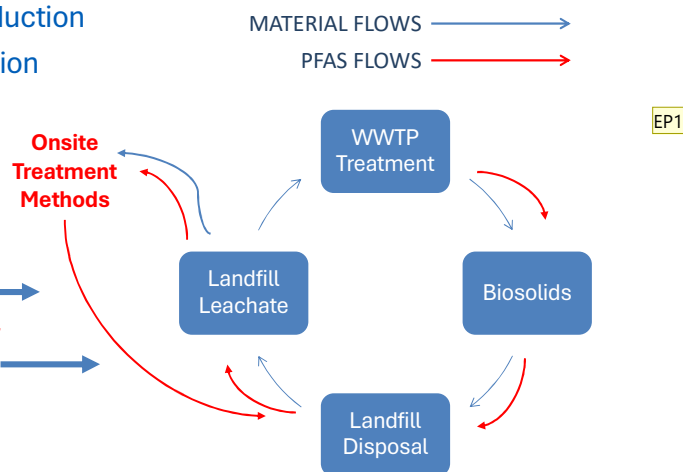


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RESIDUALS MANAGEMENT

Options Include

- Further volume reduction
 - Foam fractionation
 - Evaporation
 - Additional RO stages
- Off-site disposal
- **Stabilization**
- **Recirculation to LF working face**



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EP1 unclear
Erica Peris, 2025-05-07T17:35:57.438

EP1 0 Pfas mass loading to wwtps - michigan
Erica Peris, 2025-05-07T17:37:25.047

MULTIMEDIA FILTERS



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1ST / 2ND PASS



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HIGH PRESSURE SYSTEM



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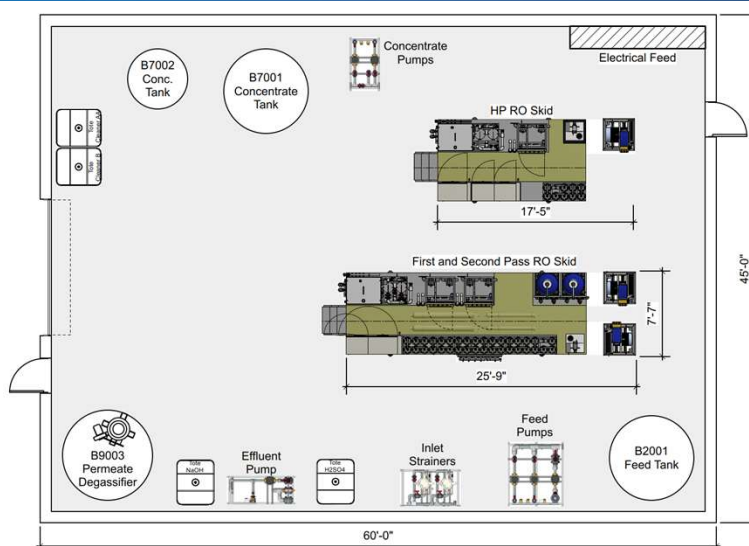
TYPICAL CONFIGURATION



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EXAMPLE BUILDING LAYOUT – 50,000 GPD



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RO & LEACHATE - PFAS

Rochem Systems have been operating for decades in US

Originally designed for removal of conventional wastewater constituents

- BOD/COD
- NH₃
- TSS
- TDS
- Heavy Metals

Late 2010s → Increased scrutiny on PFAS in leachate

Sampling demonstrated effectiveness of PFAS removal using RO – specifically 2-pass systems for >> 99% removal

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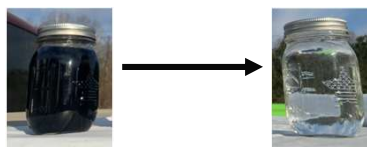
34

TYPICAL LEACHATE TREATMENT RESULTS

Parameter	Units	Leachate	Final Pass Effluent
Volumetric Flow	GPD	100,000	87,500
Total Dissolved Solids	mg/L	7,890	25
Total Suspended Solids	mg/L	90	ND
Biological Oxygen Demand	mg/L	1,560	36
Chemical Oxygen Demand	mg/L	4,670	29
Total Organic Carbon	mg/L	2,020	8
Ammonia-Nitrogen	mg/L	1,050	21
PFAS Compounds*	ng/L	44,130	ND

*USEPA Method 1633

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REDUCTION IN PFAS LOADING

Example:

2,200 ng/L PFOA + PFOS in typical leachate

100,000 GPD discharged to POTW prior to RO system install

NO TREATMENT
100,000 GPD DISCHARGED

0.00184 lbs/day
PFOA+PFOS

RO EFFLUENT
87,500 GPD DISCHARGED

<0.000004 lbs/day
PFOA+PFOS

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OHSL – NPDES PERMIT (PFAS ADDITION)

2021: Addition of PFOS & PFOA to NPDES Permit

4 ng/L limit

2 outfalls monitored 1/month

- No exceedances
- All ND values



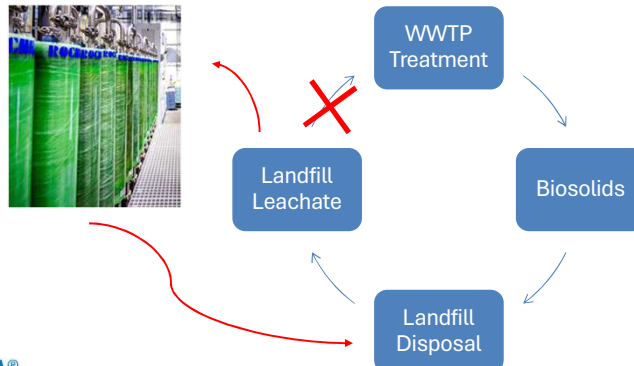
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Source: EPA ECHOES → <https://echo.epa.gov/effluent-charts#MI0058853>
 NPDES Individual Permit No. MI0058853
 PFAS/PFOA Added to NPDES Permit in 2021 → Monthly Monitoring → No Action Level

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IN CONCLUSION

Reverse osmosis is an effective technology for the containment of PFAS and other contaminants within landfills.



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EP1 Insert summary table

Erica Peris, 2025-05-07T17:58:56.971

QUESTIONS?

Erica Peris

Rochem Americas, Inc.

ericap@rochemamericas.com

Thank you!

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