



Financing and Designing PFAS Leachate Treatment



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WIRMC

Wisconsin Integrated
Resource Management
Conference



TETRA TECH

Presentation Outline

Part 1 – Regulatory Overview

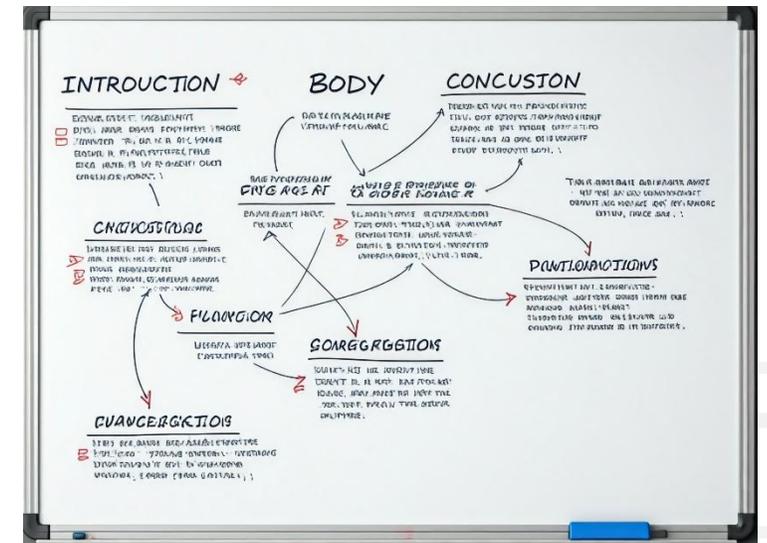
Part 2 – Approaches to Leachate PFAS Management

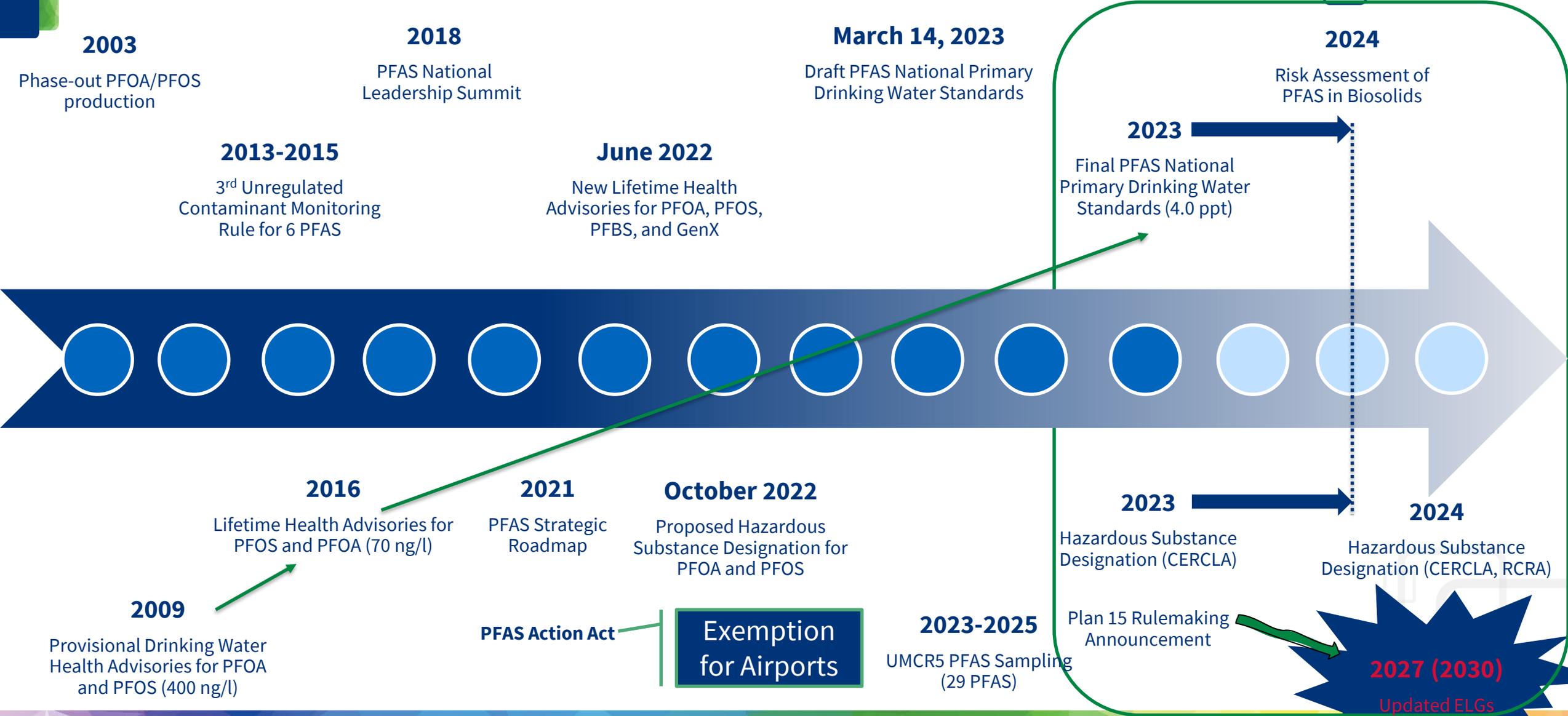
Part 3 – Case Study

Part 4 – Beyond Leachate

Part 5 – Summary

Part 6 – Q&A





✓ Hazardous Substance Designation under CERCLA (April 2024)

✓ Drinking Water Standards (April 2024) Effluent Limitations Guidelines (ELG)

- USEPA rulemaking intent: Effluent Limitations Guidelines (ELG a/k/a “Plan 15”)
 - Landfill Study - approx. 3-5 years
 - Rule Promulgation - approx. 1-2 years
 - Implementation Schedule - approx. 3 years
 - Systems operational - approx. 7-10 years (est. 2030-2033)

Biosolids

- ✓
 - Risk Assessment
 - National Sewage Sludge Survey (ongoing)

• Interim PFAS Destruction and Disposal Guidance

Facilities potentially subject to CERCLA Rule

- Abandoned waste facilities
- Non-operational facilities
 - Clarifications needed
 - post-closure care period
 - Custodial care
- Operating facilities pre-dating RCRA Subtitle D
- Potentially Responsible Parties
 - Facility owners
 - Waste generators
 - Facility operators

Current USEPA Guidance Policy

- Leverage NPDES permitting (USEPA, 2018)
- Delegate responsibility to States and Territories

- Facility monitoring
- Source reduction
- Require permittees to

- Eliminate or use substitutes where “*reasonable alternatives exist*”
- Require BMPs w/r/t firefighting foams
- Enhanced public notification and engagement

Not an option for SW Industry

- **Protect WWTP discharges & Biosolid applications**

- **Pre-treatment Programs**
- Source Control
- Best Management Practices

- Drinking Water standards akin to a “Race to the Bottom”
 - USEPA MCL Goals ZERO
 - CA Health Advisory: PFOA **7 pg/l** (pico 10^{-12} , parts per quadrillion)
- Approach
 1. Derive discharge requirements from Drinking Water standards
 2. Specify limits based upon receiving water classification
 1. Wisconsin - Chapters NR 102, 105, 106, 219, and other related regulations
 2. Michigan - Rule #57
 3. North Carolina - Title 15A Subchapter 02B
 3. Discharge reductions to WWTP
 4. Source Reduction
 1. California - Central Coast Water Quality Control Board first to propose leachate PFAS limits

How are MSW Landfills affected?

INDIRECT DISCHARGE (to WWTP)

- Industrial Pretreatment Program
- Local Limits Analysis
- Discharge criteria subject to WWTP headworks mass loading

DIRECT DISCHARGE (to SW or GW)

- NPDES permit
- Water Quality Values applicable to receiving waters
- State and local rulemaking

EFFLUENT LIMITATIONS

| Regulated parameter | Maximum daily ¹ | Maximum monthly avg. ¹ |
|---------------------------|----------------------------|-----------------------------------|
| BOD | 140 | 37 |
| TSS | 88 | 27 |
| Ammonia (as N) | 10 | 4.9 |
| α -Terpineol | 0.033 | 0.016 |
| Benzoic acid | 0.12 | 0.071 |
| <i>p</i> -Cresol | 0.025 | 0.014 |
| Phenol | 0.026 | 0.015 |
| Zinc | 0.20 | 0.11 |
| pH | (²) | (²) |

¹ Milligrams per liter (mg/L, ppm)

² Within the range 6 to 9.

Source: 40 CFR P445.20, RCRA Subtitle D Non-Hazardous Landfills

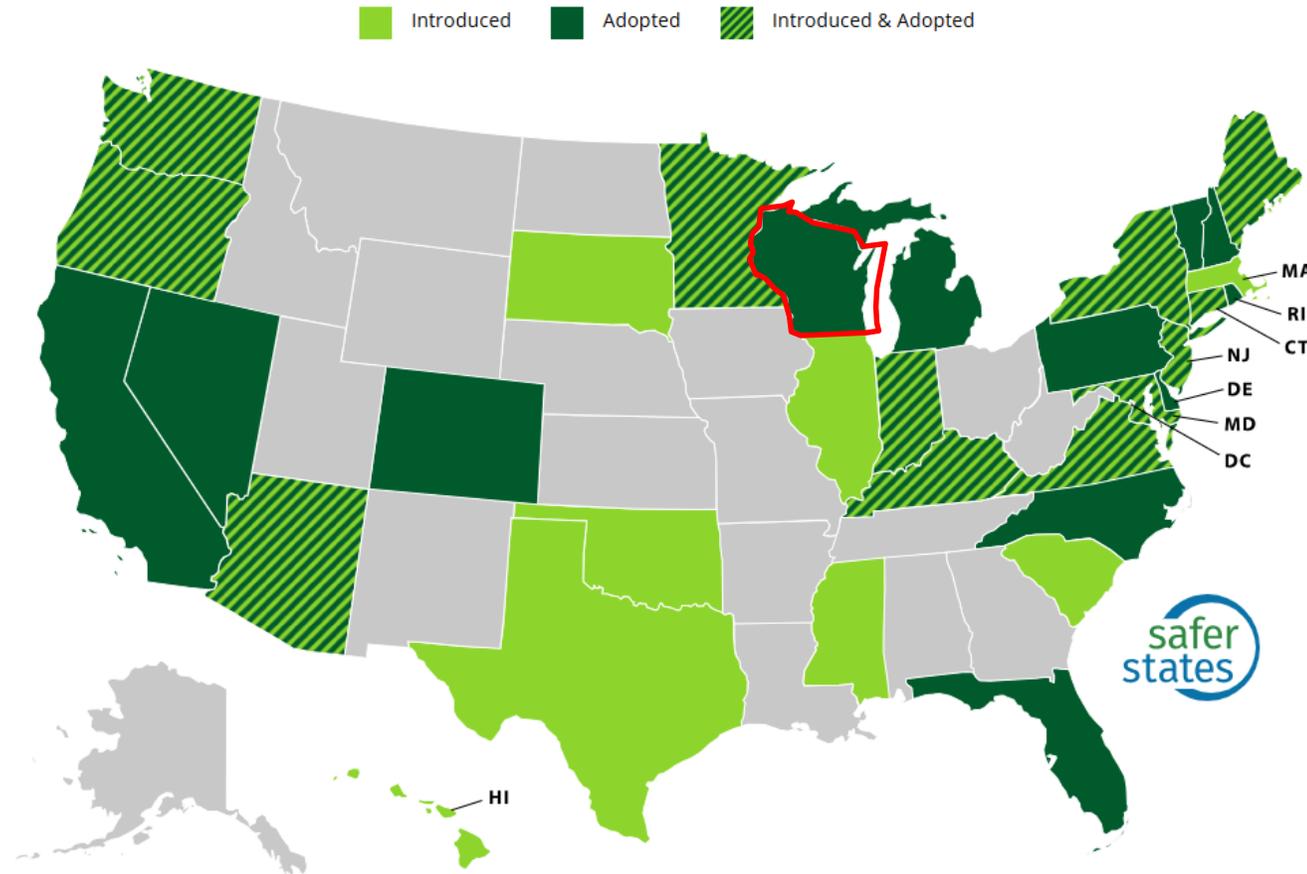
Where are we heading?

| PFAS | | Maximum Contaminant Level Goal | Maximum Contaminant Level |
|----------------------|-------|--------------------------------|------------------------------|
| PFOA | | 0 | 4.0 ppt |
| PFOS | | 0 | 4.0 ppt |
| PFNA | | 10 ppt | 10 ppt |
| PFHxS | | 10 ppt | 10 ppt |
| GenX | | 10 ppt | 10 ppt |
| Mixture of 2 or more | PFNA | 1 (unitless) Hazard Index | 1 (unitless) Hazard Index |
| | PFHxS | | |
| | GenX | | |
| | PFBS | | |

$$Hazard\ Index = \frac{[GenX]}{10} + \frac{[PFBS]}{2,000} + \frac{[PFNA]}{10} + \frac{[PFHxS]}{9}$$

Hazard Index for Typical Leachate >>> 1

State Actions



Wisconsin:

Appropriations Bill (SB70, 2023): Transfers \$110 million from the general fund to the PFAS fund. Transfer \$15 million from the environmental management fund to the PFAS fund.

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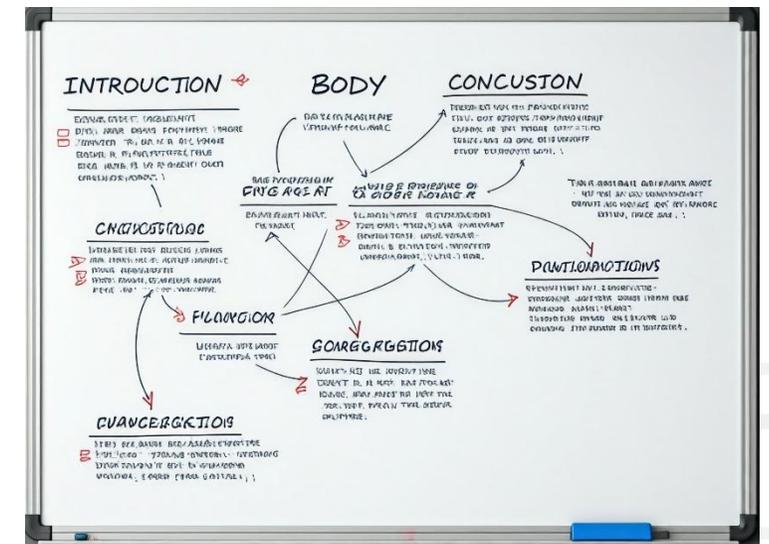
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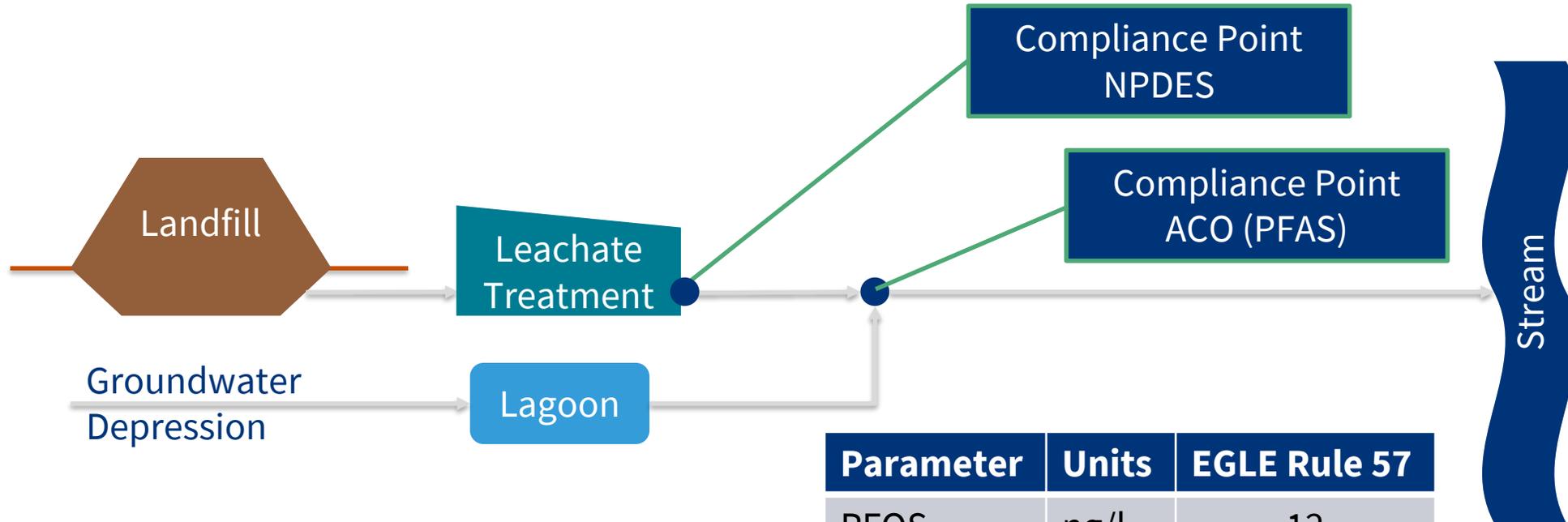
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Considerations: Technologies

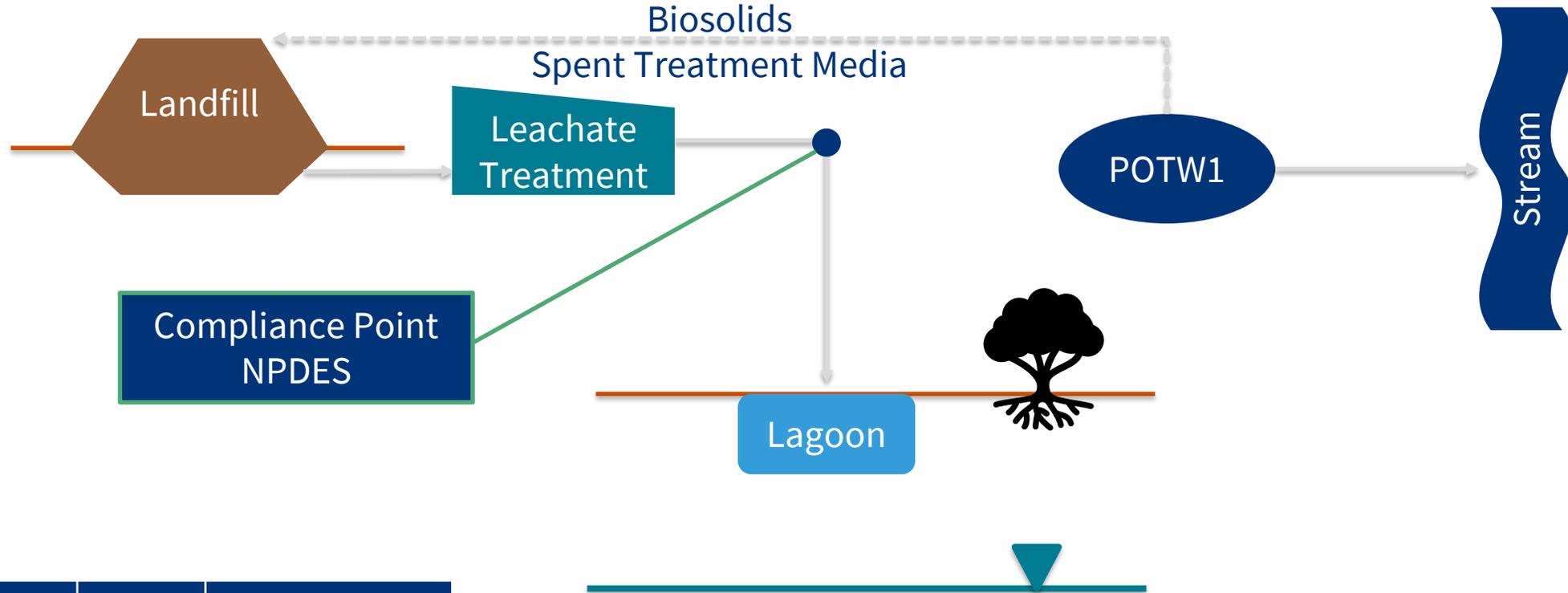
| | GAC | IX | FF | RO |
|-------------|---|---|--|---|
| Pros | <ul style="list-style-type: none"> GAC is readily available Relatively low capital cost | <ul style="list-style-type: none"> Slower breakthrough for short-chained PFAS than GAC Relatively low capital cost Some selectivity | <ul style="list-style-type: none"> PFAS selective Relatively low O&M cost Ease of operations Low residual volume (~1%) | <ul style="list-style-type: none"> Not selective, but effective at treating most contaminants Can discharge on-site Concentrate can be recirculated on-site Simple operations |
| Cons | <ul style="list-style-type: none"> Not selective, other contaminants interfere with PFAS removal Quicker breakthrough for short-chain PFAS than IX Relatively high O&M cost | <ul style="list-style-type: none"> IX resin is more expensive than GAC Relatively high O&M cost | <ul style="list-style-type: none"> Relatively high capital cost Less effective on short-chain PFAS | <ul style="list-style-type: none"> Relatively high capital cost High residual volume (~10-15%) |

Rural Michigan Direct Discharge to Surface Water



| Parameter | Units | EGLE Rule 57 |
|-----------|-------|--------------|
| PFOS | ng/l | 12 |
| PFOA | ng/l | 170 |
| PFBS | ng/l | 670,000 |
| PFHxS | ng/l | 210 |
| PFNA | ng/l | 30 |

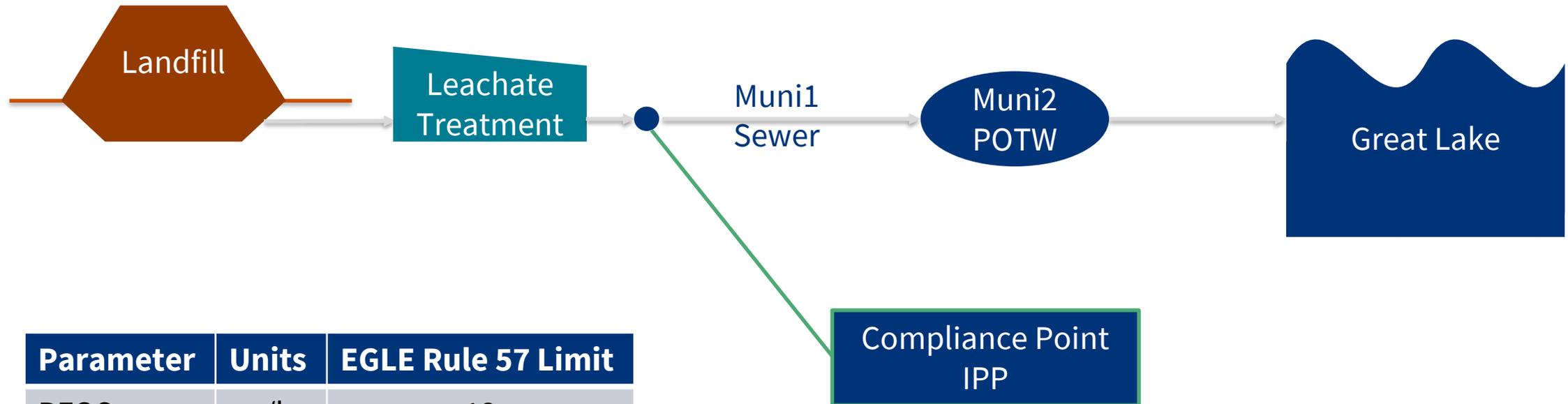
Rural Wisconsin Direct Discharge to Groundwater



| Parameter | Units | WPDES* |
|-----------|-------|--------|
| PFOS | ng/l | 8 |
| PFOA | ng/l | 20 |

* Final Guidance

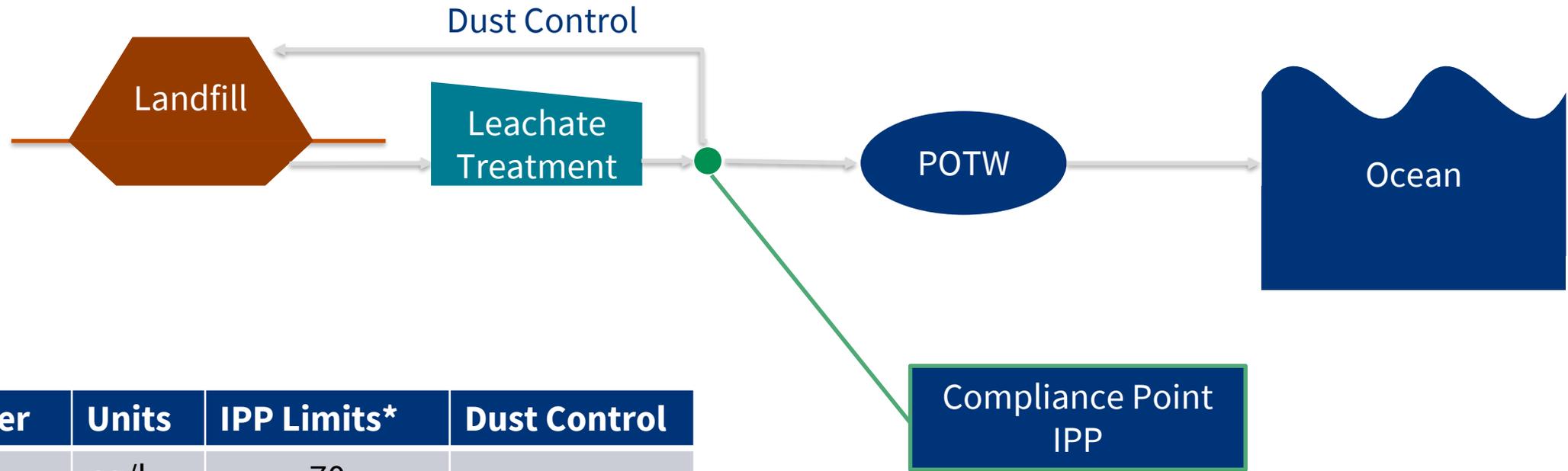
Suburban Michigan Significant Indirect User



| Parameter | Units | EGLE Rule 57 Limit |
|-----------|-------|--------------------|
| PFOS | ng/l | 12 |
| PFOA | ng/l | 170 |
| PFBS | ng/l | 670,000 |
| PFHxS | ng/l | 210 |
| PFNA | ng/l | 30 |

Urban California

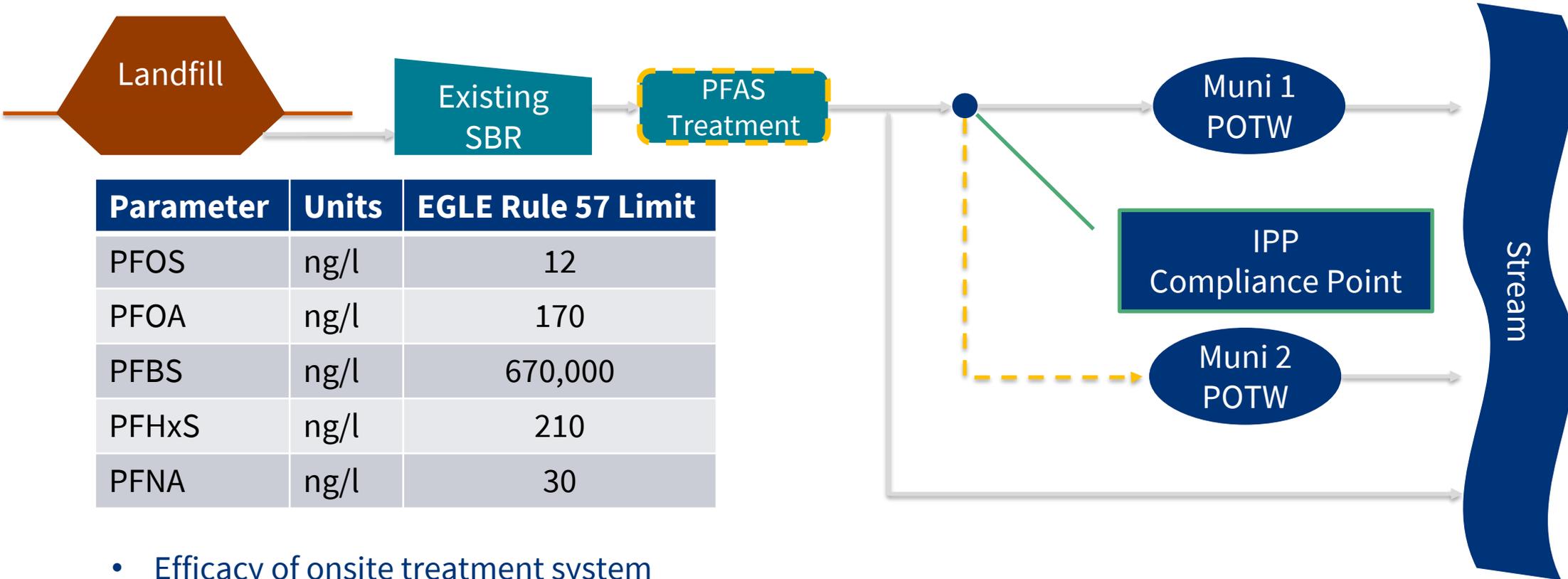
Onsite Use, Significant Indirect User



| Parameter | Units | IPP Limits* | Dust Control |
|-----------|-------|-------------|--------------|
| PFAS | ng/l | 70 | --- |

* Subject to Local Limits negotiation (ongoing)

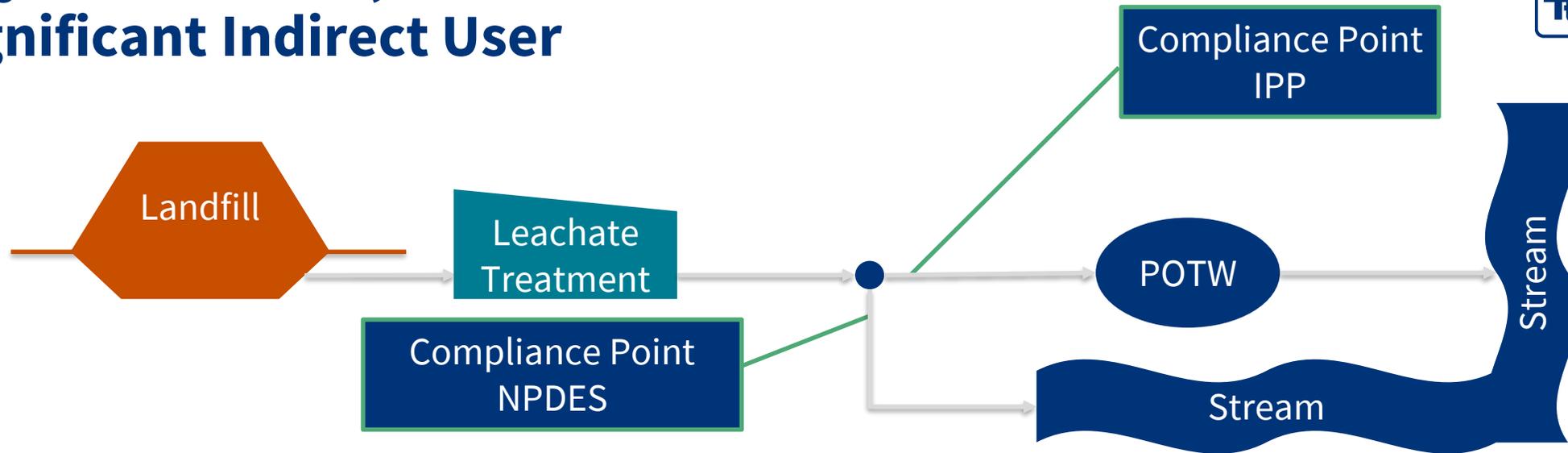
Rural Michigan Significant Indirect User or Direct Discharge?



| Parameter | Units | EGLE Rule 57 Limit |
|-----------|-------|--------------------|
| PFOS | ng/l | 12 |
| PFOA | ng/l | 170 |
| PFBS | ng/l | 670,000 |
| PFHxS | ng/l | 210 |
| PFNA | ng/l | 30 |

- Efficacy of onsite treatment system
- Additionally required capital investments
- POTW actual and permitted capacity
- POTW treatment process

City of Riverview, MI Significant Indirect User



Compliance Point
NPDES

| Parameter | Units | EGLE Rule 57 Limit |
|-----------|-------|--------------------|
| PFOS | ng/l | 11 |
| PFOA | ng/l | 66 |
| PFBS | ng/l | 8,300 |
| PFHxS | ng/l | 59 |
| PFNA | ng/l | 19 |

| Parameter | Units | IPP Limits |
|-----------|-------|------------|
| PFOS | ng/l | >11 |
| PFOA | ng/l | >66 |
| PFBS | ng/l | >8,300 |
| PFHxS | ng/l | >59 |
| PFNA | ng/l | >19 |

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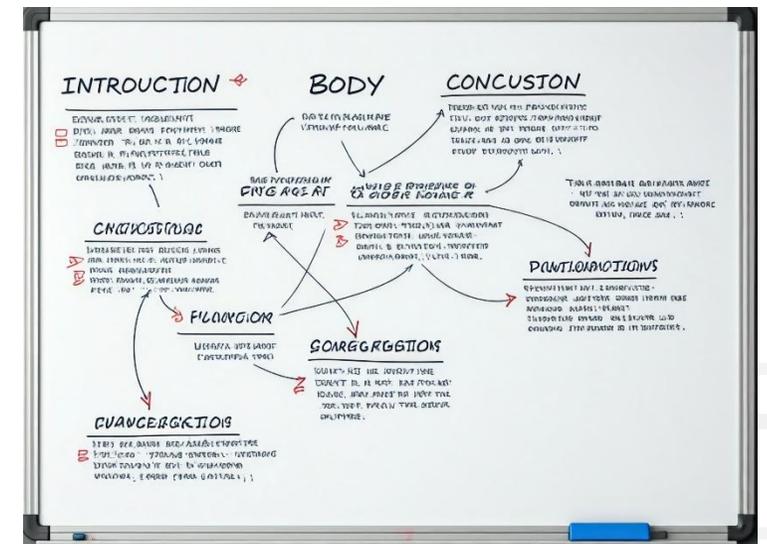
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Case Study



- MSW Facility
 - 120+ acres permitted, 85+ Constructed, 65+ acres closed, Multiple Landfills
- ~31,000 gpd total leachate generation
- Currently haul and discharge to a POTW (under IPP)
- Need for on-site treatment
 - Impending PFAS requirements
 - No existing pre-treatment
 - Dwindling disposal options

- Considered Technologies:
 - GAC with IX → POTW
 - GAC with FF → POTW
 - RO → Direct Discharge
- Advantages:
 - Re-use of existing infrastructure
 - Building with dual containment
 - Storage tanks
 - No off-site surface water discharge
- Disadvantages:
 - Separate leachate conveyance systems at each landfills
 - Remote location



Cost Considerations: Capital Costs



Site Improvements

Forcemain Systems,
Utilities, Basins,
Storage/EQ tank,
Buildings



Supporting Equipment

Pre- and Post-Treatment
Equipment, Tanks, Pumps,
Instrumentation, Controls



Engineering

Design, Permitting,
Construction
Management, Oversight
and Documentation



Treatment Equipment

GAC/IX
GAC/FF
RO



Construction & Operation

Delivery, installation,
testing, startup

Cost Considerations: Capital Costs

| Capital Cost | GAC and IX | GAC and FF | RO |
|--------------------------------------|-----------------------|-----------------------|-----------------------|
| Site Improvements | \$1,619,600.00 | \$1,641,600.00 | \$921,000.00 |
| Equipment | \$406,600.00 | \$1,425,000.00 | \$2,697,100.00 |
| Construction | \$644,200.00 | \$459,200.00 | \$794,200.00 |
| Contingency (25%) | \$667,600.00 | \$881,500.00 | \$1,103,100.00 |
| Total | \$3,338,000.00 | \$4,407,300.00 | \$5,515,400.00 |
| Total (Debt Service, Annual)* | \$279,400.00 | \$368,800.00 | \$461,600.00 |

* Assumes 20-year loan with 5.5% interest rate

* Rounded to the Nearest \$100 (USD)

* Values inflated from 2024 USD to 2025 USD assuming an inflation rate of 3.5%

Cost Considerations: Operations and Maintenance Costs



Staffing

- Part time
- Full time



Compliance and Process Sampling and Analytics



Electrical Demand



Cleaning, Maintenance, Repairs, & Disposal

- Equipment
- Media



Processing Chemicals and Materials



Residuals Management

- Waste materials
- Sewer Service Fees

Case Study – Annual Operations and Maintenance Costs

| Annual Operating Cost | GAC and IX | GAC and FF | RO |
|-----------------------|-----------------------|-----------------------|---------------------|
| Staffing & Analytics | \$242,200.00 | \$190,200.00 | \$146,500.00 |
| Processing Chemicals | \$192,700.00 | \$140,500.00 | \$277,200.00 |
| Electricity | \$33,100.00 | \$35,800.00 | \$42,000.00 |
| Effluent Hauling | \$1,482,800.00 | \$1,482,800.00 | \$0.00 |
| Residuals Management | \$44,900.00 | \$74,300.00 | \$211,100.00 |
| Contingency (25%) | \$498,925.00 | \$480,900.00 | \$169,200.00 |
| Total | \$2,494,625.00 | \$2,404,500.00 | \$846,000.00 |

* Assumes 20-year loan with 5.5% interest rate

* Costs rounded to the nearest \$100 (USD) except for cost per gallon

* Values inflated from 2024 USD to 2025 USD assuming an inflation rate of 3.5%

Case Study – Cost Comparison

| Cost | GAC/IX (POTW) | GAC/FF (POTW) | RO (Direct Discharge & Recirculation) |
|---------------------------------------|--------------------|--------------------|---|
| Capital Cost (Annual Debt Service) | \$279,400.00 | \$368,800.00 | \$461,600.00 |
| Operating Cost (Annual) | \$2,494,625 | \$2,404,500 | \$846,000 |
| Total | \$2,774,025 | \$2,773,300 | \$1,307,600 |
| Cost per Gallon | \$0.245 | \$0.245 | \$0.115 |



Cost of Delay: Why Now?

Why now?

- All landfills face leachate treatment expenses.
- On-site system costs will increase
- **Limited Alternatives :**
 - Send leachate to WWTP.
 - More final covers or additional storage tanks equal or exceed new treatment system costs and don't fix the problem



Cost of Delay: Why Now?

Why now?

Increased Treatment Costs: Inevitable regulatory changes will increase expenses; ignoring them isn't a solution. Future prices are uncertain

Future Readiness

- Prepare for regulatory impacts and assess long-term implications of decisions.
- Evaluate local resources.
- Loans and Grants Available But Uncertain (e.g. EPA Drinking Water Grants, State Revolving Fund Programs, Innovation Grants)
 - Times are changing – Staying up to date is key



Summary

Regulations

- Federal: uncertain
- States: likely to proceed
- Funding: uncertain, make informed decisions

Leachate Treatment

- No one solution fits all
- Evaluate options based on comprehensive Cap & Op expense assessment



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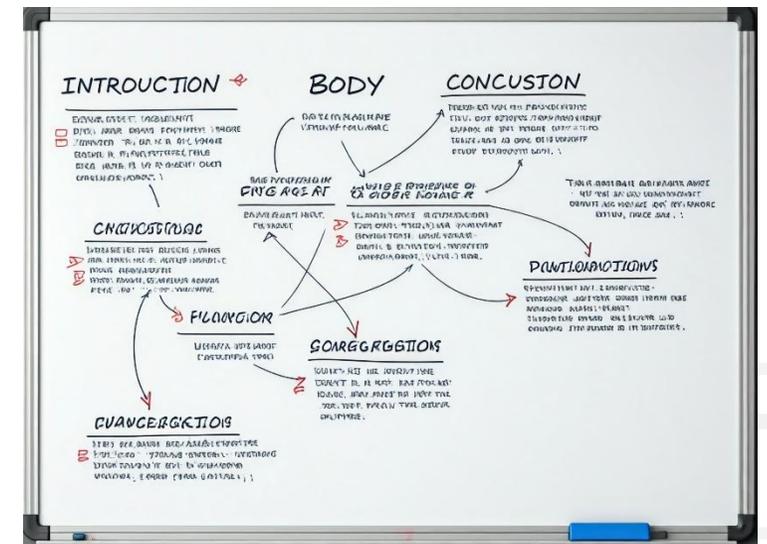
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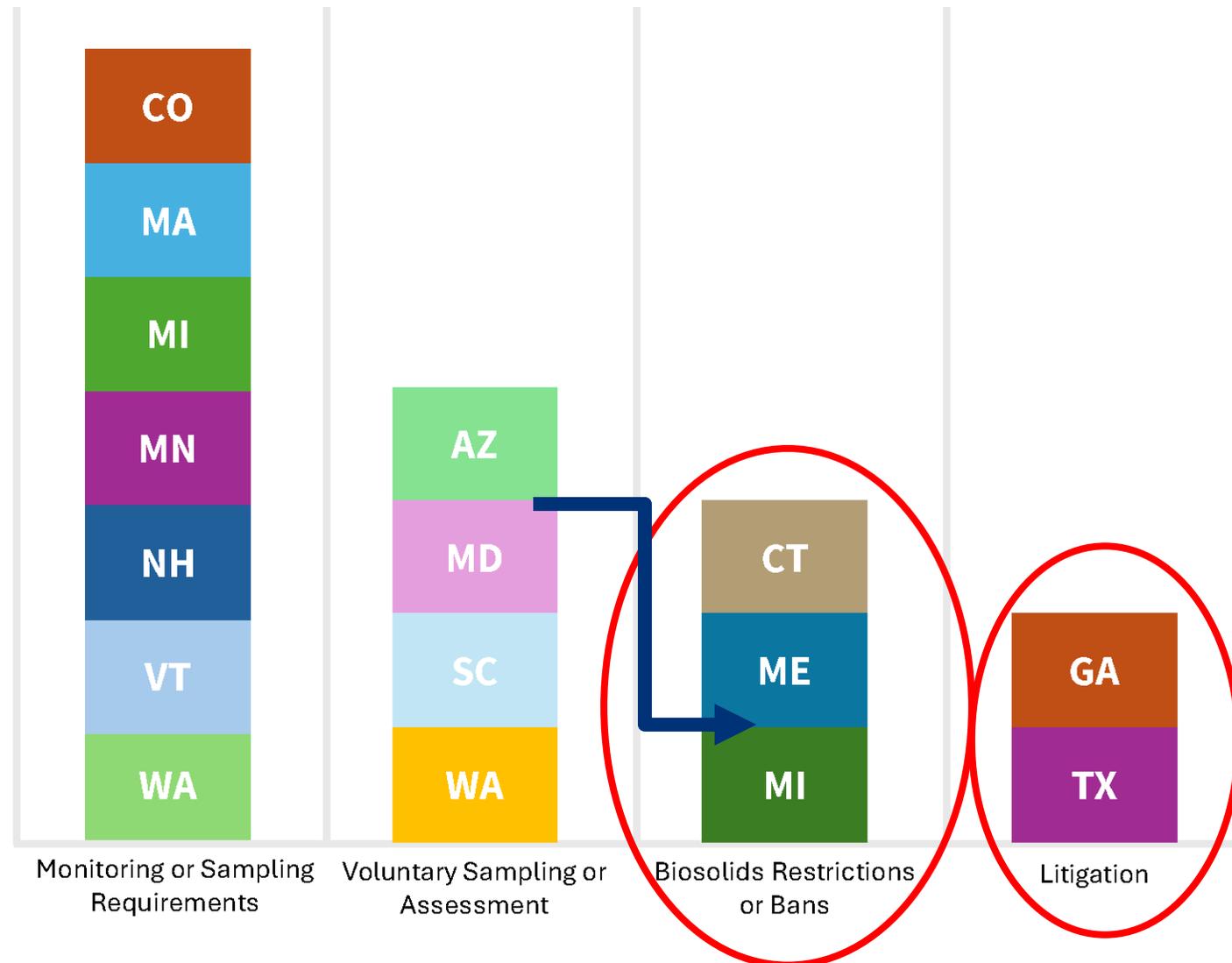
- Biosolids
- Compost
- Spent PFAS Treatment Media
- Contaminated Soils

Settlement CRBI/SELC vs. Calhoun, GA

- Temporary cessation of land application
ALL biosolids to landfill
- Prohibition on land application of **ALL** biosolids regardless of PFAS content on land <1 mile from Coosawattee River and drinking water supplies
- Emergency upgrades to drinking water plants to comply with MCLs
- WWTP modifications – Effluent to meet EPA PFAS NPDES Guidance
- Other requirements



State Policies on Biosolids (in motion)



Source: Martin Law (2024)

What are Biosolids?

Sources

Biological wastewater treatment

Anaerobic digestion



Application & Benefits

Soil Amendments

Structural

Nutrients

Stormwater Management

Erosion Control

Carbon Sequestration

Resource Conservation

Circular Economy

Reduced Mobility of Toxic Substances

Biosolids Production

| Disposal Method | tons/year* | Percent |
|------------------|---------------------|-------------|
| Land Application | 4.74 million | 55% |
| Landfilling | 1.46 million | 17% |
| Incineration | 2.41 million | 28% |
| Total | 8.61 million | 100% |

* 18%-20% Moisture Content

Source:

Northeast Biosolids and Residuals Association (2007)

Biosolids PFAS Content

| Disposal Method | ΣPFAS (kg/year) | Percent |
|-----------------|----------------------|-----------|
| Land Applied | 1,375 – 2,070 | 50% - 60% |
| Landfilled | 470 – 590 | 14% - 21% |
| Incinerated | 550 – 690 | 16% - 25% |
| Total | 2,395 – 3,350 | |

Source:

Venkatesan & Halden (2013)

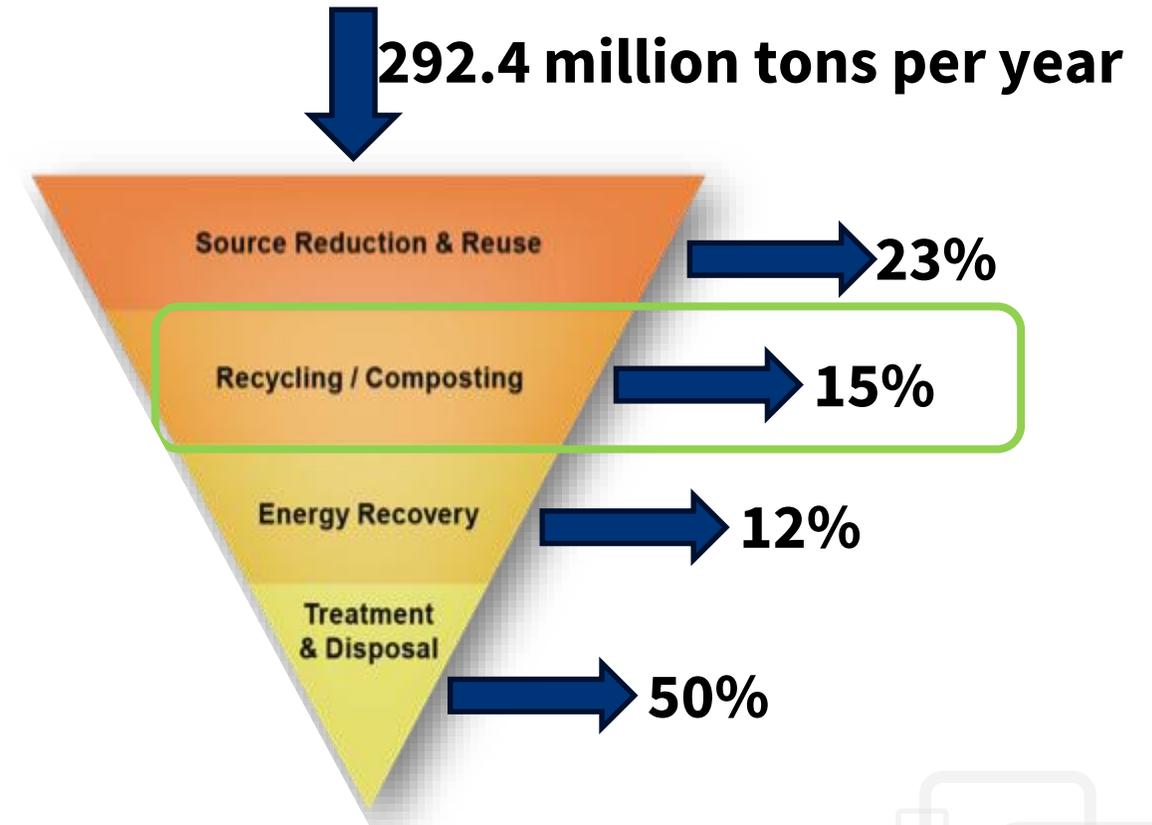
PFAS in Compost

PFAS Sources in Compost

- Biosolids
- Food packaging
- Compostable food containers
- Food waste

| Waste Stream | Σ PFAS (kg/year) |
|-----------------------|-------------------------|
| Recycling/Composting* | 334 – 3,140 |
| Landfilled MSW | 6,130 – 6,920 |

* Σ PFAS = 1.26-11.84 μ g/kg



Sources:
USEPA (2023)
Goossen et al. (2023)
Tetra Tech (2022)

PFAS from Potable Water Treatment

Sources

- Potable Water Usage
 - 39 billion gallons per day
- 2,000 affected System (2024)
- Media
 - Regenerated GAC: 10% to 50%
 - Single-use IX Resin
- Current annual media usage 300,000 to 400,000 tons/year
- Projected growth 7% to 8% from 2024 to 2028

Example

- Plant serving 100,000 population
- Treatment capacity – 10 MGD
- 150-200 tons per system per year
- 50% landfilled
- Sorbed Σ PFAS: 1,000 $\mu\text{g}/\text{kg}$ Media

**300 – 400 kg PFAS per year based on
2,000 Potable Water Treatment Systems**

Potential Impact on Landfilling

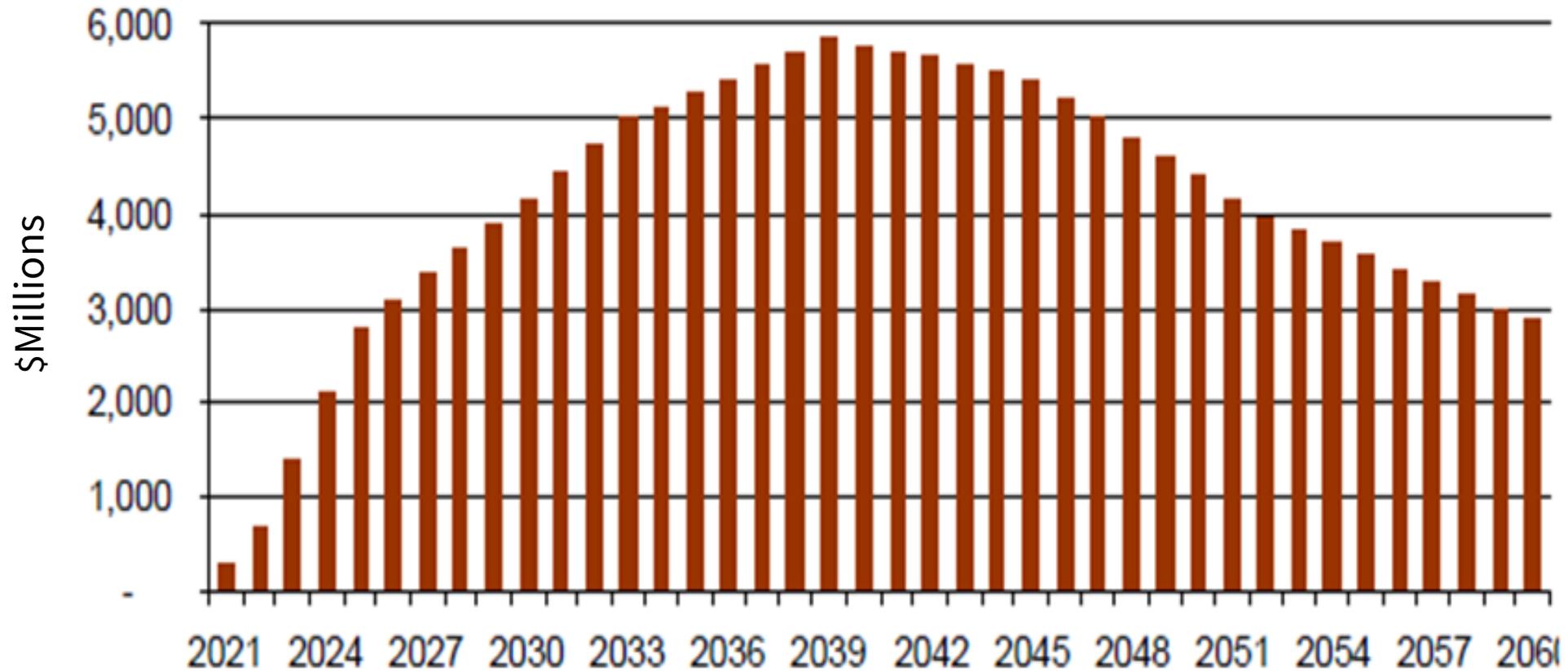
Annually Landfilled Tonnage

| Material | Annual Weight |
|-----------------------------|--------------------------------|
| Landfilled MSW | 126.0 million tons |
| Recycling/Composting | 43.9 million tons |
| Biosolids | 4.74 million tons |
| Spent Media | 0.36 million tons |
| Total | 175.0 million tons +39% |

Annually Landfilled ΣPFAS

| PFAS Source | ΣPFAS (kg/year) |
|----------------------|-----------------------------------|
| Landfilled MSW | 6,130 – 6,920 |
| Biosolids | 1,375 – 2,069 |
| Recycling/Composting | 334 – 3,140 |
| Spent Media | 270 – 360 |
| Total | 8,109 – 12,489 +(33 – 80)% |

40-year Projection for Remediation Market



Source:

Environmental Business Journal, Volume 37 Numbers 5/6: Q3 2024 Remediation & PFAS Market Report

- Regulatory uncertainty
- High costs of incineration and Alternative Disposal Methods
 - Limited geographic distribution of incinerators & capacity
- Limited availability of Regeneration Technology
- Growing waste streams
- Landfill capacity and practices concerns
- **Limitation on land-application of biosolids**



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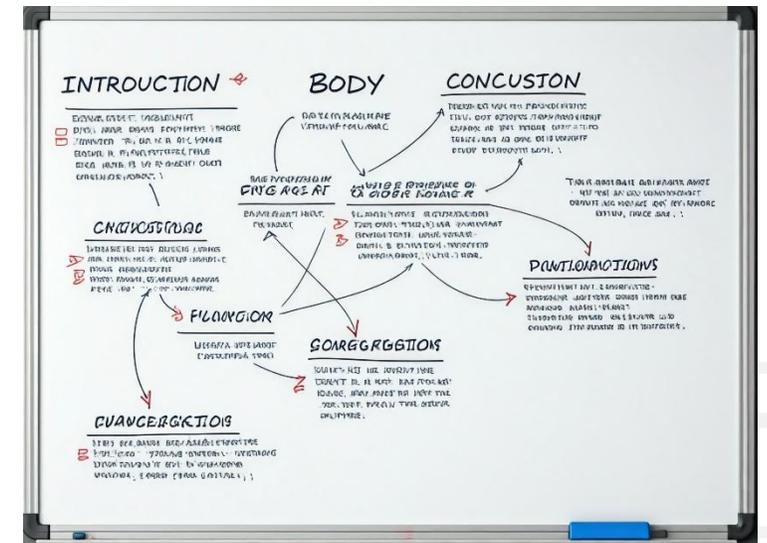
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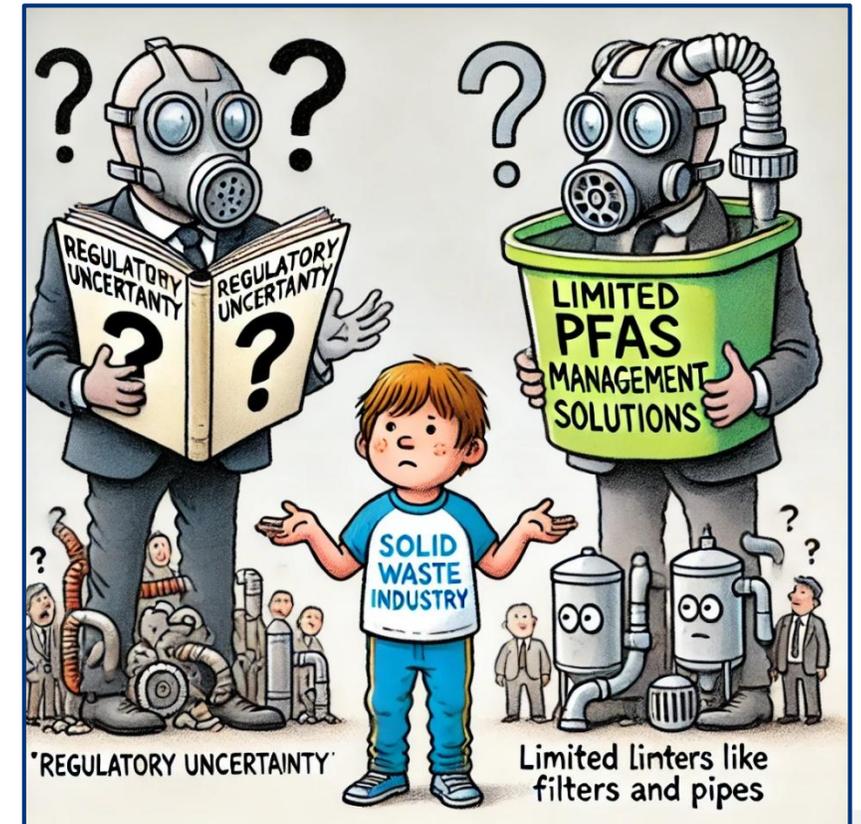
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Industry Position

- Regulatory uncertainty
 - Leachate management
 - Biosolids management
- Growing waste streams
- Limited to no-control over waste streams
 - Landfills do not issue IPPs
- Landfill capacity and practices
- High costs of alternative disposal methods
- Limited availability:
 - Regenerative technologies
 - availability and high cost of destructive technologies



Source: ChatGPT

Solid Waste Industry Outlook

- Landfills PFAS sequestration capability: 70% to 90%
- Regulatory requirements to meet PFAS discharges limits
 - from leachate
 - Industrial wastewaters
- New tipping fee structure for PFAS-containing waste
 - Biosolids
 - Spent media
 - Recyclables/Compost
- Limited disposal/incineration capacities



Industrialize and leaders in PFAS waste management

- Immediate availability
- Acceptance Standards for PFAS-containing Waste
- New revenue sources
 - Beneficiaries of settlements and litigations
 - Sludge and Biosolids dewatering
 - PFAS Capture/Destruction
 - Media re-activation
 - Food Waste Recycling



Comments? Questions?



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Leachate Management & Treatment