

Biosolids Risk Assessment: Do We Have What We Need?

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Talk Overview

- Risk assessment overview
- How it's formulated for biosolids
- Biosolids Risk Calculator
- USEPA PFAS biosolids draft risk assessment
- Michigan's Interim approach



What is a risk assessment?

Risk Assessment Overview

- USEPA uses risk assessments to characterize the nature and magnitude of health risks to humans and ecological receptors from a contaminant in the environment
- Risk is considered to be the chance of a harmful effect to human health or ecological systems resulting from exposure to an environmental stressor (e.g., chemical contaminant)
- Risk assessments enable informed decision-making by identifying potential hazards, evaluating the likelihood of harm, and determining the severity of their impact
- A well-crafted risk assessment can support sound decision-making

Biosolids Risk Assessment

- Scientific evaluation of the potential human health or ecological risks associated with the presence of a contaminant in biosolids
- A typical risk assessment involves:
 - ✓ Identifying hazards that could cause harm
 - ✓ Determining who or what is at risk
 - ✓ Evaluating risks based on its likelihood and severity
 - ✓ Implementing control measures to reduce the risk
 - ✓ Monitoring and reviewing the effectiveness of those control measures over time

How is it formulated?

Approach – Human Health Risk

- **Exposure** - develop model formulations and input data for the fate and transport of a chemical contaminant
 - ✓ Plant uptake (fruits and vegetables, forage and silage crops, grain crops)
 - ✓ Bioaccumulation by beef and dairy milk, and chicken and eggs
 - ✓ Leaching to and transport in groundwater
 - ✓ Runoff to surface waters and bioaccumulation in fish
- **Effects** – develop non-cancer health guidelines and cancer risk values for the chemical contaminant
 - ✓ Obtain average daily dose (ADD) for ingestion of soil, water, and food items by age groups (USEPA Exposure Factors Handbook)
 - ✓ Obtain the reference dose (RfD) and cancer slope (CSF) for the chemical contaminant (USEPA CompTox Chemicals Dashboard)

Non-Cancer Risk

Reference Dose (RfD) - estimates of daily oral exposure of a contaminant that is likely to be without a discernible risk of non-cancer effects (chronic toxicity) to the general human population, including sensitive subgroups, during a lifetime of exposure

Hazard Quotient

$$\mathbf{HQ = ADD / RfD}$$

✓ **HQ** = Hazard Quotient, **ADD** = Ave Daily Exposure Dose (mg/kg_{bw}/day), **RfD** = Reference Dose (mg/kg_{bw}/day)

HQ < 1, indicates a non-cancer hazard is not expected

HQ > 1, indicates an exceedance of the non-cancer health guideline, thus a potential for non-cancer adverse effects

Cancer Risk

Cancer Slope Factor (CSF) - estimates of daily oral exposure to a contaminant that is likely to be without a discernible risk of cancer to the general human population, including sensitive subgroups, during a lifetime of exposure.

Cancer risk formula

$$\mathbf{CR = (D \times CSF) \times (ED / LY)}$$

- ✓ **CR** = Cancer Risk, **D** = Age-Specific Dose (mg/kg_{bw}/day), **CSF** = Cancer Slope Factor ((mg/kg_{bw}/day)⁻¹), **ED** = Age-Specific Exposure Duration (years), **LY** = Lifetime in Years (78 years)

CR < 1.0E-06, indicates a cancer risk should be negligible

CR > 1.0E-06, indicates that the lifetime cancer risk exceeds the typical regulatory target risk level

Biosolids Risk Calculator

Biosolids Risk Assessment Tool

- **Exposure:** Selected model formulations are incorporated into a user-friendly (Excel with VBA) risk tool for assessing human health
 - ✓ Concentrations in the till layer after biosolids amendment using the approach from Chari et al. (2012)
 - ✓ Model formulations for plant uptake, animal uptake, surface runoff, and fish bioaccumulation were obtained from the USEPA Biosolids Tool (BST)
 - ✓ Vadose zone and groundwater transport model formulations were from Lee et al. (1998)
- **Effects:** Non-cancer health guidelines and cancer risk values obtained for the chemical contaminant
 - ✓ Obtain average daily dose (ADD) for ingestion of soil, water, and food items by age groups from the USEPA Exposure Factors Handbook, along with the reference dose (RfD) and cancer slope (CSF) from the USEPA CompTox Chemicals Dashboard

Risk Calculator Inputs

- **Example:** Triclosan
 - ✓ User inputs the Chemical Abstracts Service Registry Number (CAS #)
 - ✓ Code imports default values for the scenario (USEPA farm family) and chemical input parameters (that can be changed)
 - ✓ User inputs biosolids concentration, and selects rainfall, evaporation, crop type, and soil type from drop down menus
 - ✓ Click on Calculate

UOC Risk Calculator V1.3 July 2025		Inputs	
Risk Assessor	McAvoy		
Date	6/1/2026		
CASRN	3380-34-5		
Chemical Name	Triclosan		
Farm and Chemical Information		Value	Units
Concentration of chemical in biosolids	0.001	mg/kg	
Soil Density	1.5	g/cm ³	
Rainfall (Precipitation)	1000	mm	
Evaporation loss	940	mm	
Concentration in Till layer	0.000003	mg/kg	
Input crop type	Fallow		
Input soil type	B		
Farm and Application Rate Inputs (Default)		Value	Units
Application rate	10	MT/ha	
Area of farm	32.4	ha	
Depth of the till layer	0.2	m	
Physiochemical Factors Input (Optional)		Value	Units
Absorption coefficient (Koc)	36,570	mL/kg	
Henry's Constant (H)	6.45654E-10	atm·m ³ /mol	
Distribution coefficient (Kd)	14628.04	L/kg	
Bio-Degradation Half-life	4.50619	days	
BCF Fish	52.8927	L/kg	
Human Health Factors		Value	Units
Cancer Slope Factor (CSF)		(mg/kg-day)	
Reference Dose (RfD)	3.00E-01	mg/kg-day	
Poultry and Egg		Value	Units
Fi (fraction of plant type grown)	1	fraction	
Qpi (quantity of plant type eaten)	0.2	kg/day	
Qs (quantity of soil eaten)	0.022	kg/day	
Bs (soil bioavailability factor)	1	fraction	
PF (phloem transfer factor)	0.1	fraction	

Output Concentrations

- Soil Concentrations
- Plant and animal uptake concentrations
- Groundwater concentrations
- Surface water concentrations

Concentration in aboveground tissues	
Forage (mg/kg dw)	1.68698E-08
Silage (mg/kg dw)	2.95222E-08
Exposed fruit (mg/kg dw)	1.18E-08
Exposed vegetable (mg/kg dw)	8.43E-09
Protected fruit (mg/kg dw)	1.01E-08
Protected vegetable (mg/kg dw)	1.10E-08
Concentration in belowground tissues	
Roots (mg/kg dw)	3.46862E-09
Root vegetable (mg/kg dw)	3.47E-11
Concentration in Beef products	
Beef (mg/kg ww)	7.67E-08
Milk (mg/kg ww)	1.62E-08
Concentration in soil invertebrates	
Earthworm (mg/kg fw)	3.09095E-08
Fish (mg/kg)	3.173E-10
Concentration in Fowl Products	
Eggs (mg/kg fw)	1.684E-10
Poultry (mg/kg)	1.190E-09
Runoff and Vadose zone concentration	
Dilution Factor	300
Concentration in groundwater (mg/L)	0.000E+00
Flowrate (Q) (L/day)	918.8849963
Dissolved water (mg/L)	5.99871E-12
Runoff (mg/L-day)	2.75606E-16
Pond (mg/L)	2.75606E-16
Index Reservoir (mg/L)	3.82E-17
Porewater concentration (mg/L)	2.27873E-10

Cancer and Non-Cancer Risks

- Cancer risk and hazard quotient calculated based on user inputs

UOC Risk Calculator V1.2 May 2025		Outputs		
Risk Assessor	McAvoy			
Date	6/1/2026			
CASRN	3380-34-5			
Chemical Name	Triclosan			
Average daily dose (mg/day)				
	Child (1-5)	Child (6-11)	Child (12-19)	Adult
Soil	8.889E-09	3.448E-09	5.464E-10	4.219E-10
Drinking Water	1.683E-18	1.185E-18	9.560E-19	1.300E-18
Fish	1.745E-10	1.745E-10	9.836E-11	1.491E-10
Beef	1.61E-07	1.61E-07	1.15E-07	1.23E-07
Milk	4.85E-07	1.94E-07	6.95E-08	1.95E-07
Exposed Fruit	2.15E-08	1.31E-08	7.20E-09	1.54E-08
Exposed Vegetable	5.40E-09	5.40E-09	5.57E-09	1.18E-08
Protected Fruit	2.33E-08	2.33E-08	1.21E-08	2.13E-08
Protected Vegetable	1.54E-08	8.66E-09	6.36E-09	6.58E-09
Roots	2.39E-11	1.80E-11	1.98E-11	3.05E-11
Eggs	1.18E-10	1.18E-10	1.18E-10	1.18E-10
Poultry	2.86E-09	1.90E-09	1.31E-09	1.31E-09

Cancer Risk				
	Child (1-5)	Child (6-11)	Child (12-19)	Adult
Soil	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Drinking Water	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Fish	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Beef	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Milk	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Exposed Fruit	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Exposed Vegetable	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Protected Fruit	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Protected Vegetable	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Roots	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Eggs	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Poultry	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Hazard Quotient				
	Child (1-5)	Child (6-11)	Child (12-19)	Adult
Soil	2.963E-08	1.149E-08	1.821E-09	1.406E-09
Drinking Water	5.608E-18	3.951E-18	3.187E-18	4.334E-18
Fish	5.817E-10	5.817E-10	3.279E-10	4.971E-10
Beef	5.372E-07	5.372E-07	3.837E-07	4.093E-07
Milk	1.616E-06	6.462E-07	2.316E-07	6.516E-07
Exposed Fruit	7.164E-08	4.369E-08	2.401E-08	5.117E-08
Exposed Vegetable	1.799E-08	1.799E-08	1.856E-08	3.936E-08
Protected Fruit	7.760E-08	7.760E-08	4.049E-08	7.085E-08
Protected Vegetable	5.117E-08	2.888E-08	2.120E-08	2.193E-08
Roots	7.978E-11	6.012E-11	6.590E-11	1.017E-10
Eggs	3.930E-10	3.930E-10	3.930E-10	3.930E-10
Poultry	9.517E-09	6.345E-09	4.362E-09	4.362E-09

USEPA PFAS Biosolids Risk Assessment

USEPA Biosolids Risk Assessment – PFOA and PFOS

- ▶ Risk assessment looks at a farm family that consumes most of their food and water from their biosolids amended fields (not typical of farm practices)
- ▶ Loading rate 10 dry MT/ha/yr at 1 ppb for 40 years
- ▶ Exposure via fruits and vegetables, beef and dairy cattle, chickens and eggs, drinking water, and fish consumption
- ▶ Risk assessment does not indicate or evaluate risks to the general public, but more on the highly exposed farm family
- ▶ Results should be thought of as preliminary and can change based on further scientific evaluations

USEPA Draft Biosolids Risk Assessment for PFOA and PFOS

- USEPA identified three areas of high concern
 - ✓ groundwater concentrations
 - drinking water: CR = 1E-4; HQ = 2.6
 - ✓ fish tissue concentrations
 - fish: CR = 1E-4; HQ = 2.5
 - ✓ fruit and vegetable concentrations
 - fruit and vegetables: CR = 1E-5; HQ = 1.1

Data Needs – PFOA and PFOS

- Groundwater
 - ✓ Field studies are lacking to assess the leaching potential of amended municipal biosolids under a variety of field conditions
 - ✓ Laboratory sorption studies are needed for a variety of soil types with amendment in a biosolids matrix

- Fish
 - ✓ Field studies are needed for assessing stormwater runoff and farm pond concentrations, which will depend highly on the size of the pond (volume), area of the field, and distance of the pond from the amended field

- Fruit and Vegetables
 - ✓ High-quality field studies are lacking on plant uptake concentrations and determining uptake factors (currently from greenhouse studies)

Michigan Interim Approach

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Michigan Interim Strategy Requirements

Below 20 ppb ($\mu\text{g}/\text{kg}$)

- *No restrictions*

Equal to or Above 20 ppb – Less than 100 ppb ($\mu\text{g}/\text{kg}$)

- **Required** to sample effluent and identify sources
- **Required** to mitigate during land application
 - Reduce land application rate to 1.5 dry tons/acre or submit alternative mitigation strategy

Equal to or Above 100 ppb ($\mu\text{g}/\text{kg}$)

- Deemed industrially impacted and **land application prohibited**
- **Required** to sample effluent and identify sources

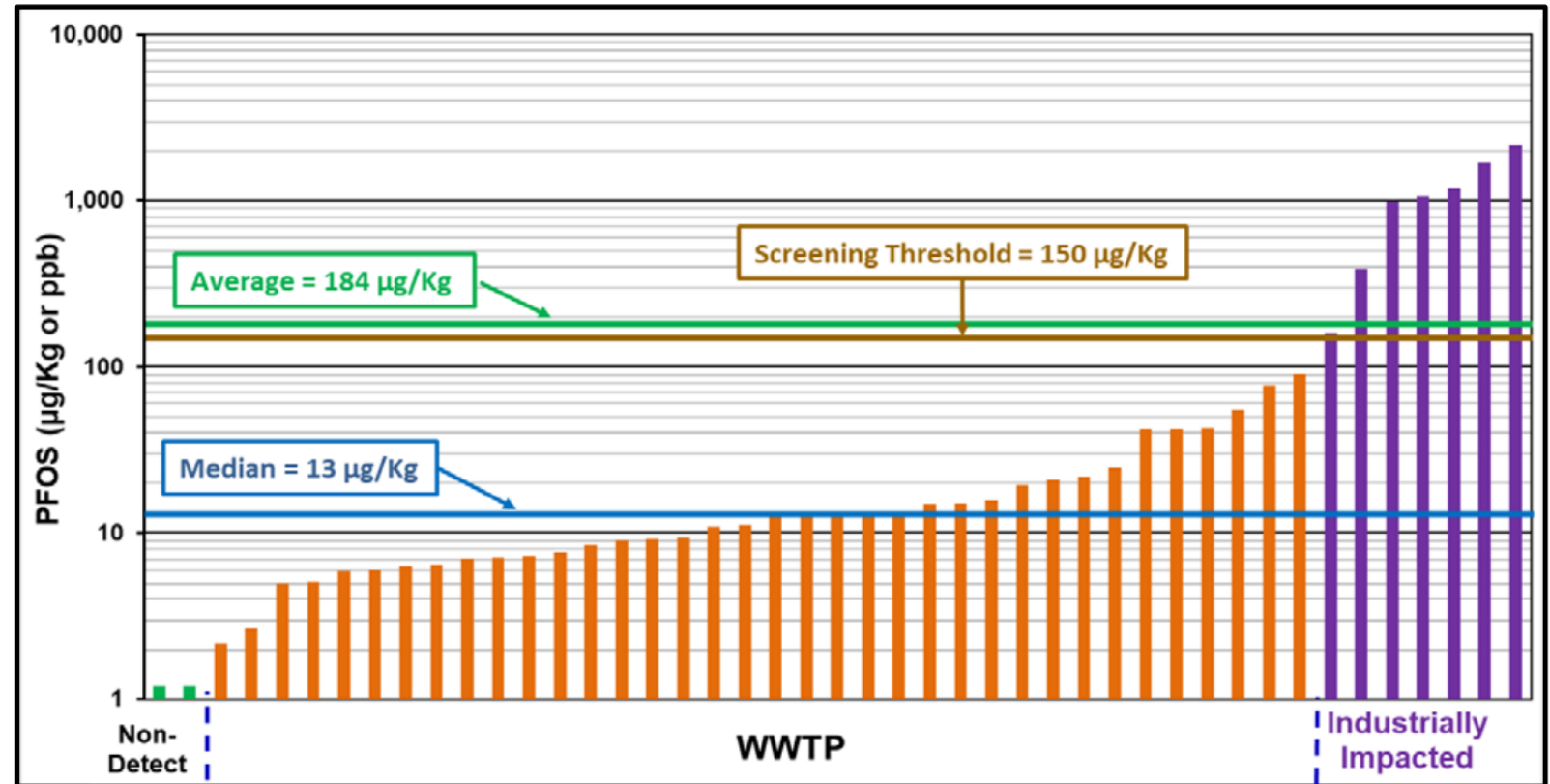
EQ Biosolids – PFOA + PFOS \leq 20 ppb

2018 Statewide Study Municipal WWTPs

Figure 33. Final Treated Solids (Sludge and Biosolids) PFOS Concentrations for 42 WWTPs

✓ 42 WWTPs

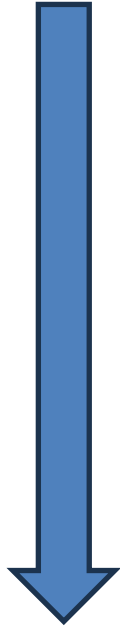
🧪 Influent, Effluent, Final Solids



Part 24, Land Application of Biosolids, Rule 4:

“On a case-by-case basis, the permitting authority may impose requirements for the use of biosolids in addition to, or more stringent than, the requirements in these rules if necessary to protect the public health and the environment from any adverse effect of a pollutant in the biosolids.”

Mean and Median Values of Biosolids Concentrations Since 2018

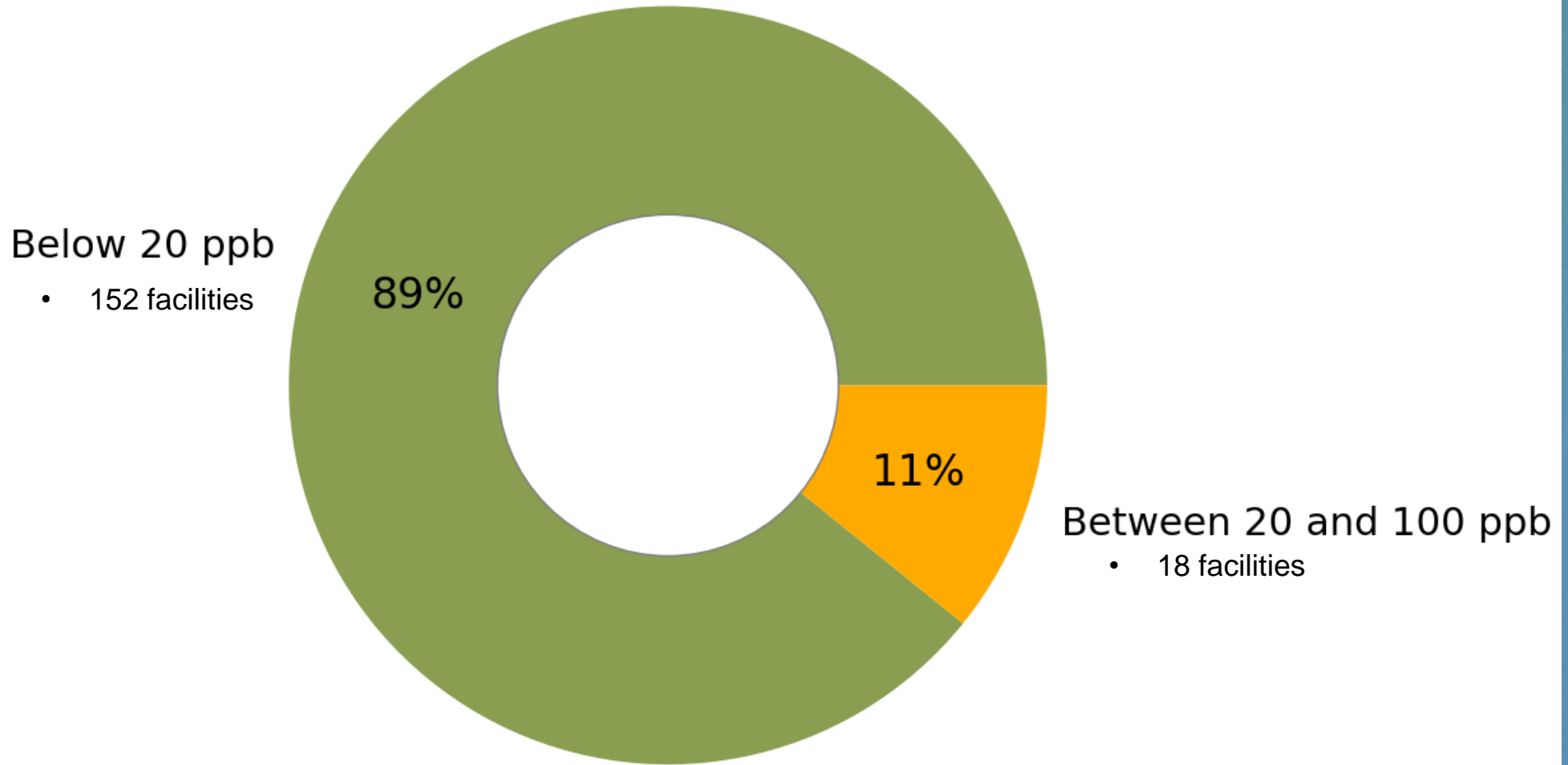


Year	PFOS (ppb)		PFOA (ppb)	
	Mean	Median	Mean	Median
2018*	184	13	25	7
2021	21	9	8	4
2022	16	10	7	3
2023	11	7	6	3
2024	8	5	5	2
2025**	7	6	2	2

*Includes data from industrially impacted facilities as part of a statewide study

**Calculations based on 24 results received as of 2/13/2025

2024 Interim Strategy Results



Concluding Remarks

Summary

- Biosolids risk assessments require scientifically sound fate and transport models for exposure estimate
- Model input parameters for final assessments should be derived from relevant and high quality experiments
- Reference Dose (RfD) and Cancer Slope Factors (CSF) should be derived from well designed toxicological effects studies
- Current USEPA Draft Biosolids Risk Assessment should address data concerns before publishing the final assessment
- Michigan's interim strategy, while not risk based, is observational based and is an acceptable approach for regulating PFOA and PFOS until we get better risk assessment data

**Thank You for
Your Attention!**