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Addressing Uncertainties in PFAS Risk Assessment

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Risk Assessment uncertainties result in risk management challenges

High pressure to take potentially very expensive action in the face of large uncertainties

Act Now versus Study More?

Today's topics

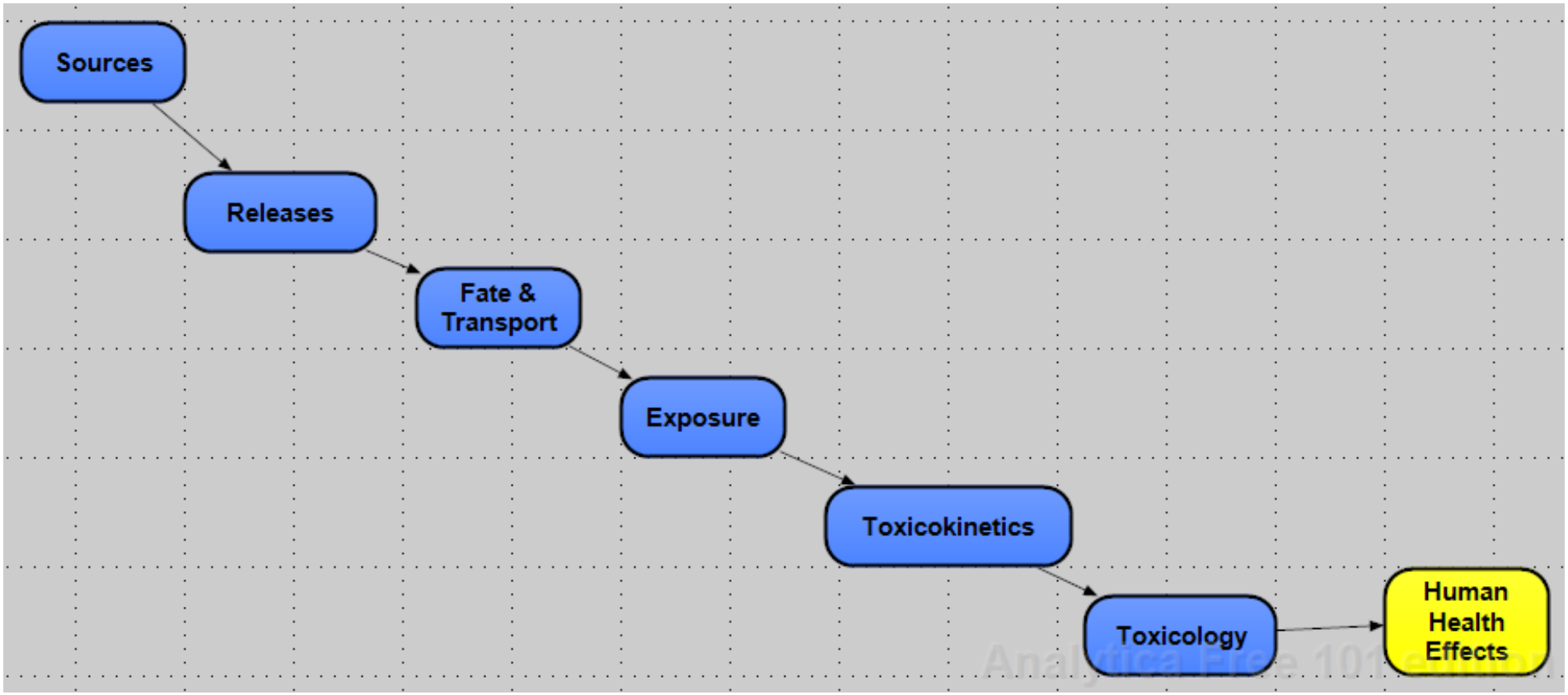
What are the key uncertainties?

How do these uncertainties affect our ability to assess risk?

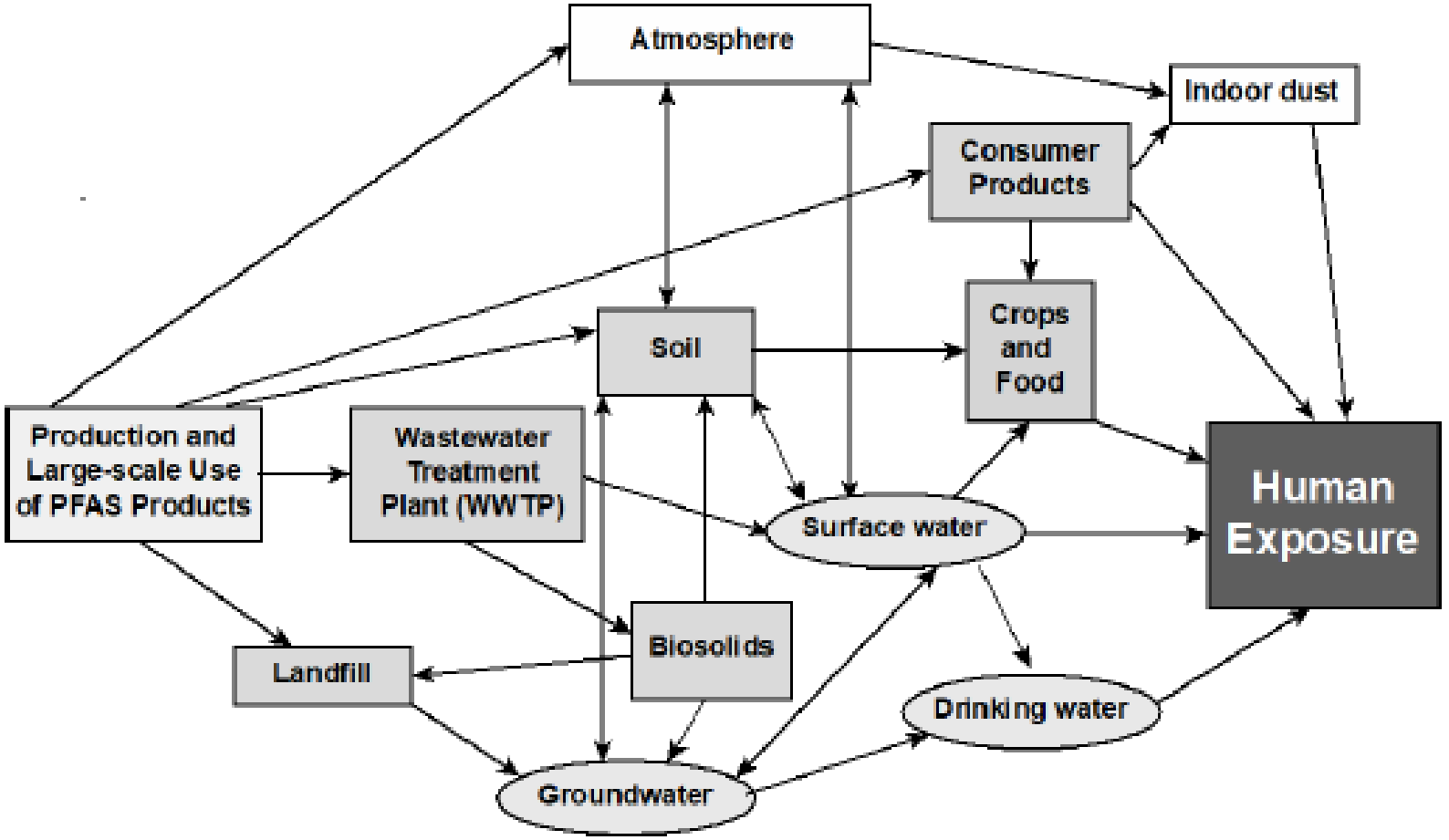
Which ones matter the most?

How can they be accounted for in risk management decisions?

Uncertainties propagate through the risk assessment process

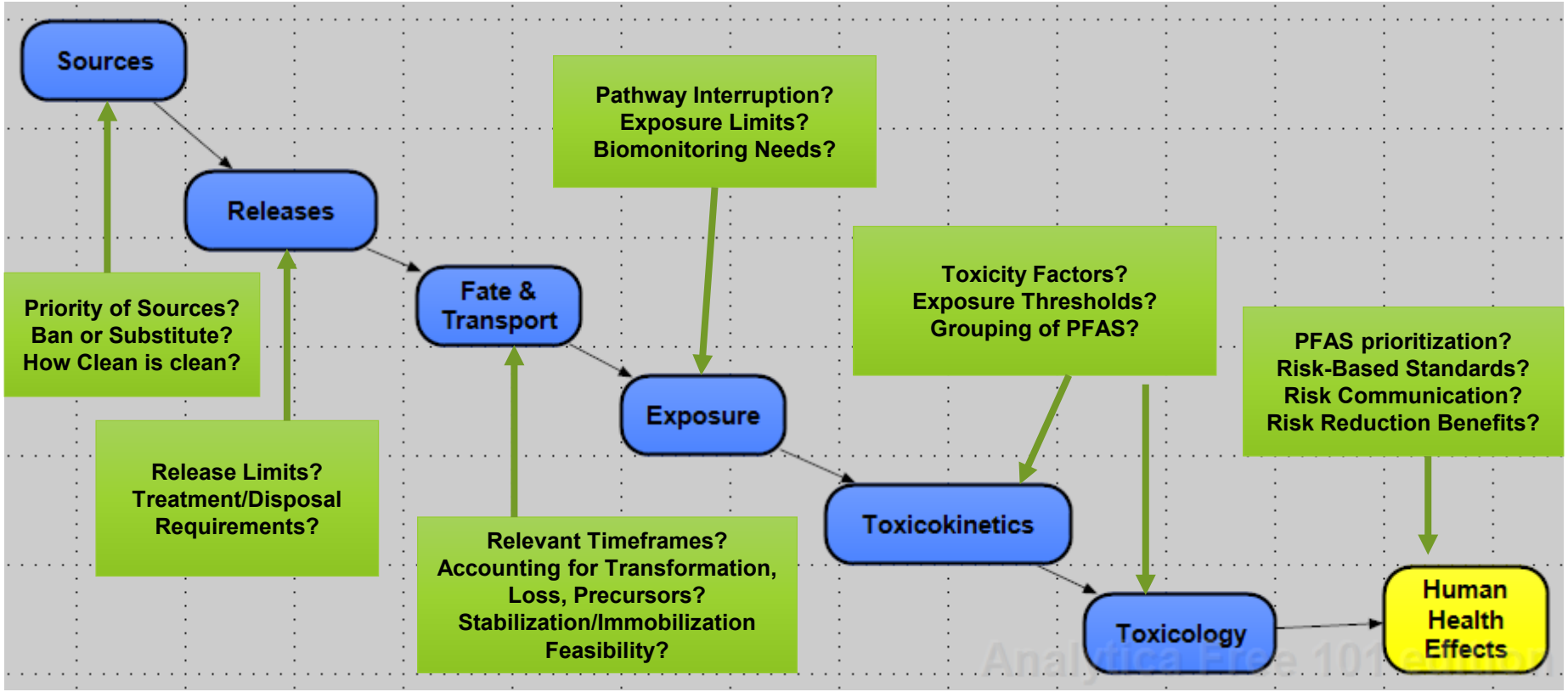


Interrelationships look more like spaghetti



Source: Scientific Evidence and Recommendations for Managing PFAS Contamination in Michigan. Michigan PFAS Science Advisory Panel. December 7, 2018.

Uncertainties affect risk management decisions



All major sources have significant uncertainties

- Legacy PFAS
- Class B Fire-Fighting Foam Use
- Chemical Production and Processing
- Landfills
- Industrial Use
- Wastewater Treatment Plants
- Consumer Commercial Product Use
- Biosolids Production and Application

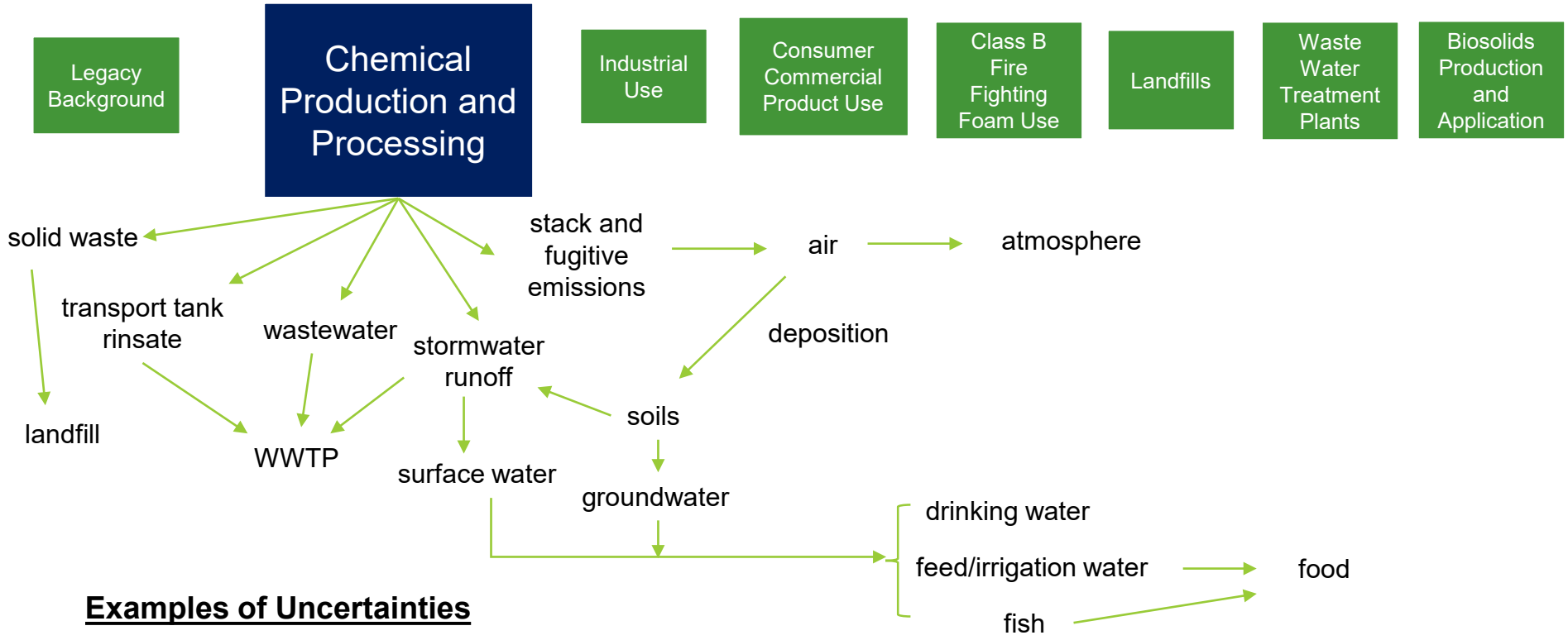
Uncertainties — Major sources and releases

Examples of Uncertainties

- **Thousands of PFAS but currently:**
  - **Validated standard EPA methods for only 25 PFAS in drinking water**
  - **None for surface water, non-potable groundwater, wastewater, or solids**
  - **What is out there?**

- **What is PFAS "background," and how do we differentiate it from a source or site of interest?**

Uncertainties — Major sources and releases



Examples of Uncertainties

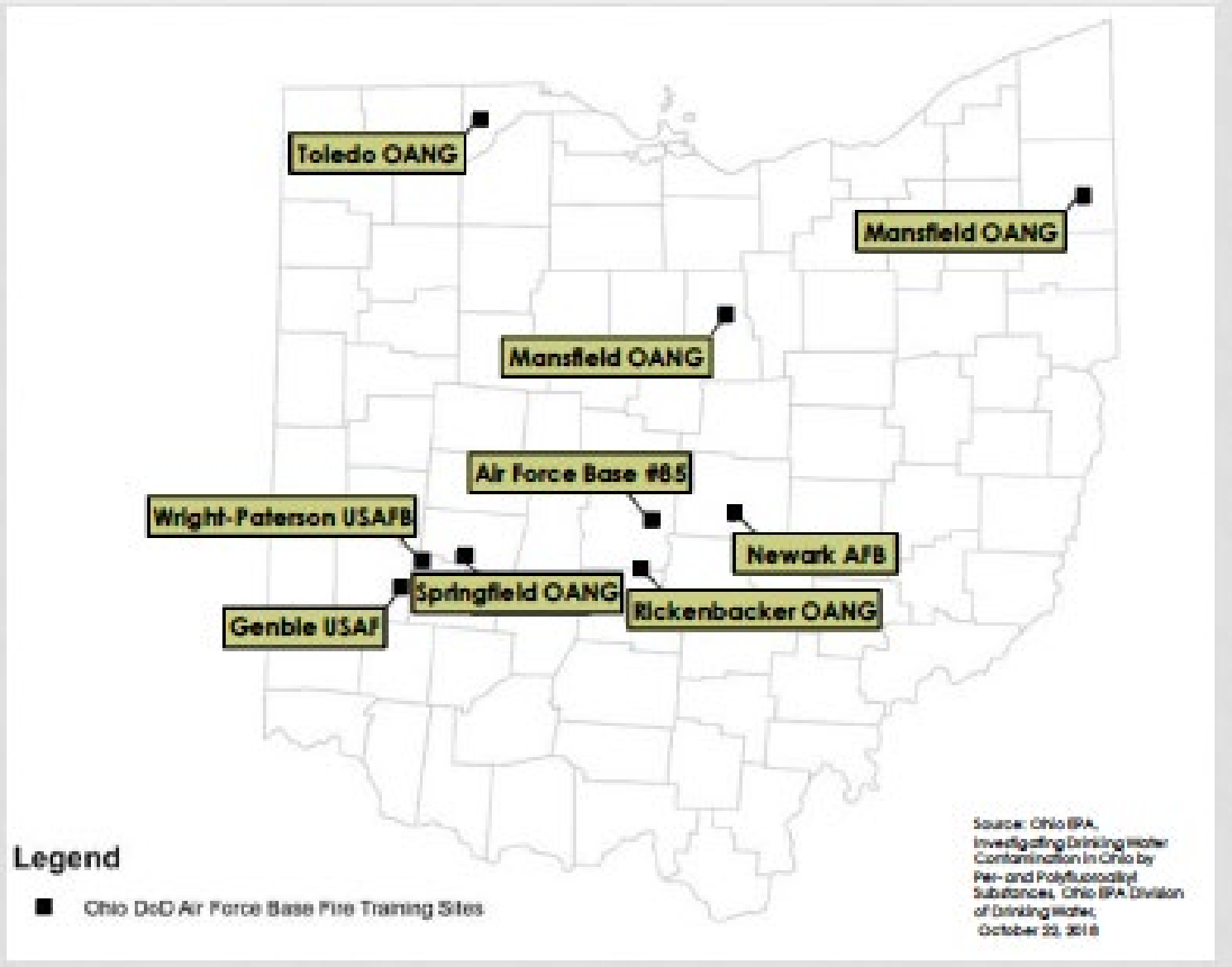
- **What PFAS are being made, how much, and at what locations (US and abroad)?**
  - ***No comprehensive data on quantity of PFAS produced over the years***
- **What PFAS are being emitted in solid waste, wastewater, stormwater, rinsate, and air? How much?**
  - ***Not currently measured under permits – CBI restricts data access***
  - ***What happens to old stocks of PFAS no longer planned for use?***

Potential risk management strategy directed at sources?

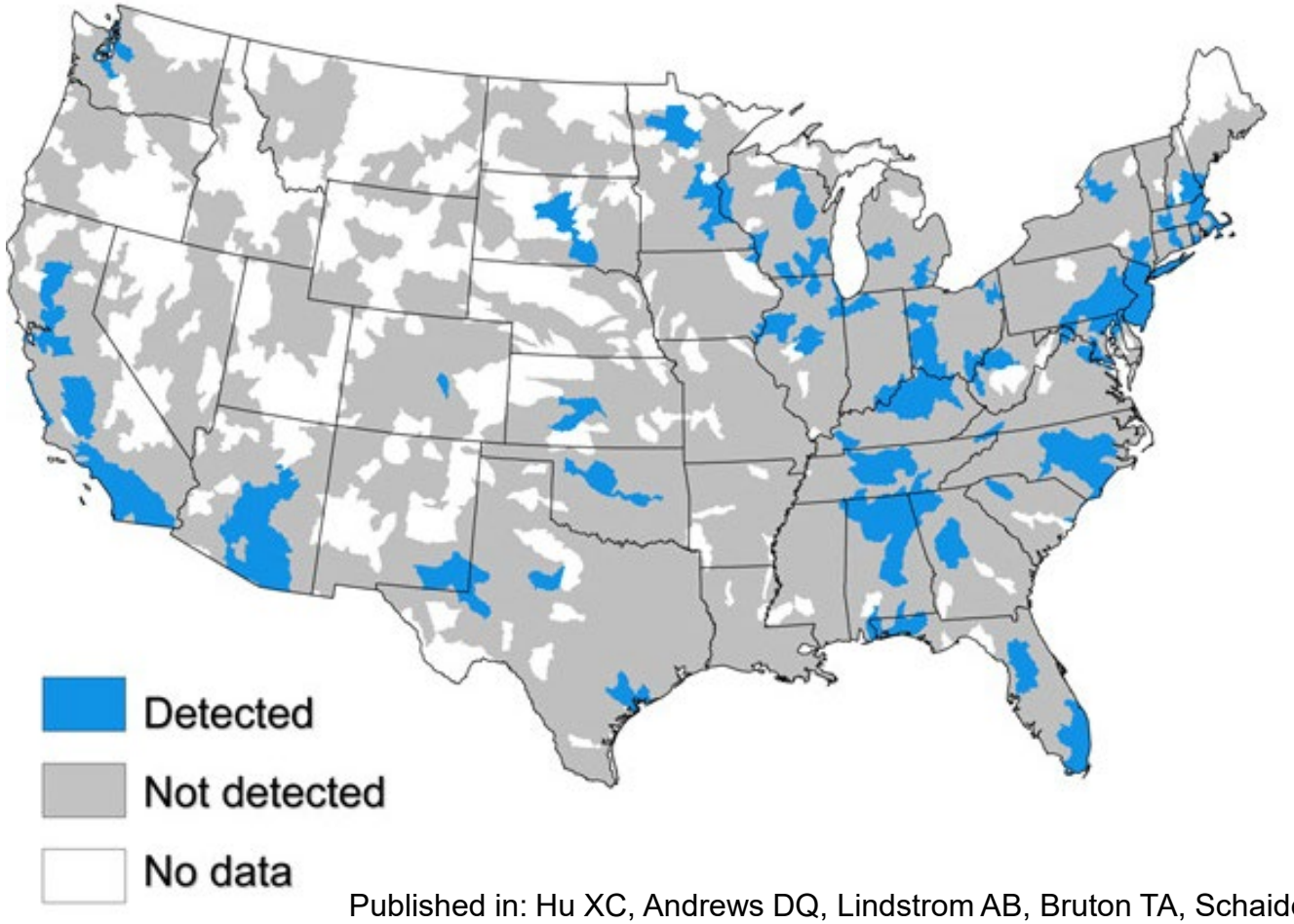
- **Could focus on reducing or eliminating releases from the major sources**
- **Biomonitoring effectiveness of strategy**

Major Source	Potential Management Strategies
Chemical production and process plants	Water and air discharge limits Bans and substitutions
AFFF use sites	Remediate military and major airport sites Example – Ohio Buy back AFFF from fire departments
Consumer Products	Offer substitutes for PFAS water/stain repellants
Landfills	Ban landfill disposal of carpeting Investigate and remediate unlined landfills Monitor leachate and pre-treat if needed
Wastewater Treatment Plants	Discharge limits Analyze biosolids and treat/incinerate if needed Will eliminating PFAS discharges to WWTPs eliminate biosolids as significant source?

However – Developing release limits and remediation standards to support this strategy still requires addressing uncertainties about fate & transport, exposure, toxicology.


Toledo OANG
Mansfield OANG
Mansfield OANG
Air Force Base #85
Wright-Paterson USAFB
Newark AFB
Springfield OANG
Rickenbacker OANG
Genble USAF
Legend
Ohio DoD Air Force Base Fire Training Sites
Source: Ohio EPA, Investigating Drinking Water Contamination in Ohio by Per- and Polyfluoroalkyl Substances, Ohio EPA Division of Drinking Water, October 23, 2018

Hydrologic units with detectable PFAS



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Key uncertainties — Fate and transport

Too many uncertainties to cover in time allotted

- **Lack of reliable physical and chemical property data on PFAS**
- **Uncertain partitioning mechanisms and lack of coefficients**
- **Leaching flux from soil very difficult to estimate**
- **Precursor transformation is important but uncertain**
- **Broad ranges of Koc values (orders of magnitude) and wide variability in sorption and mobility: Makes predicting groundwater transport difficult**
- **Lack of air emission rates and complexity of wet and dry deposition modeling**
- **For many of these processes, standard fate-and-transport models are probably not applicable**

Key uncertainties — Uptake

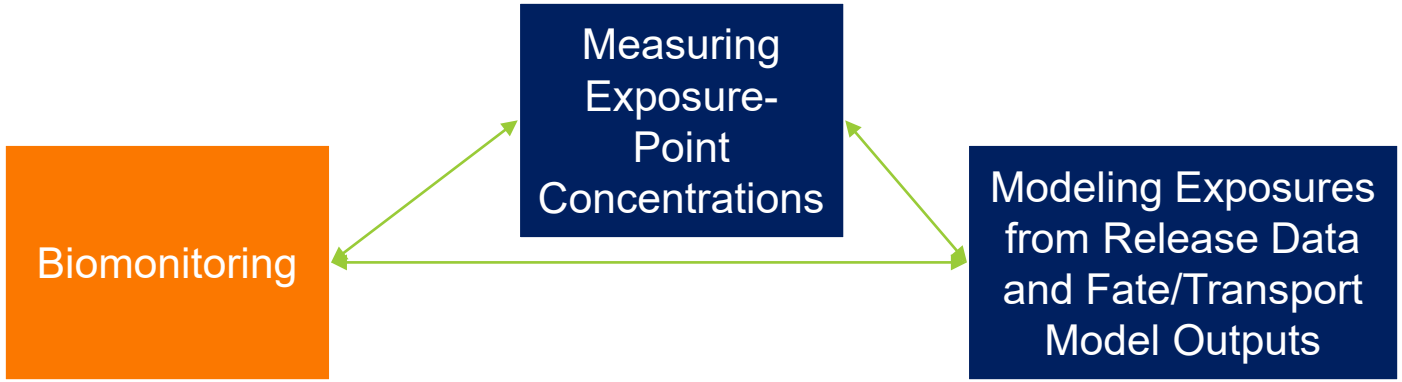
- **Aquatic Uptake**
  - Bind to blood proteins rather than fatty tissue
  - So typical models are not applicable (based on Kow)
- **Plant Uptake**
  - Particularly relevant to biosolids, irrigation, and animal uptake
  - BAFs measured in wheat vary from 0.06 to 70 and decrease with chain length
- **Terrestrial Uptake**
  - BAFs measured in worms vary from 0.1 to 23 and vary by chain length

Risk management challenges posed by fate & transport uncertainty

- **How do we know how to manage releases if we are uncertain which PFAS and at what concentrations will end up at exposure points?**
- **How to account for transformation, loss, and precursors in cleanup decisions and discharge limits?**
- **Should we just use worst-case assumptions about fate and transport and uptake until understanding is better?**
- **What are the relevant timeframes that risk management decisions must take into account?**
  - Timeframes over which F & T and uptake processes can result in significant changes in PFAS exposure-point concentrations

Source | Release | **Fate & Transport** | Exposure | Toxicology | Human Health Risk

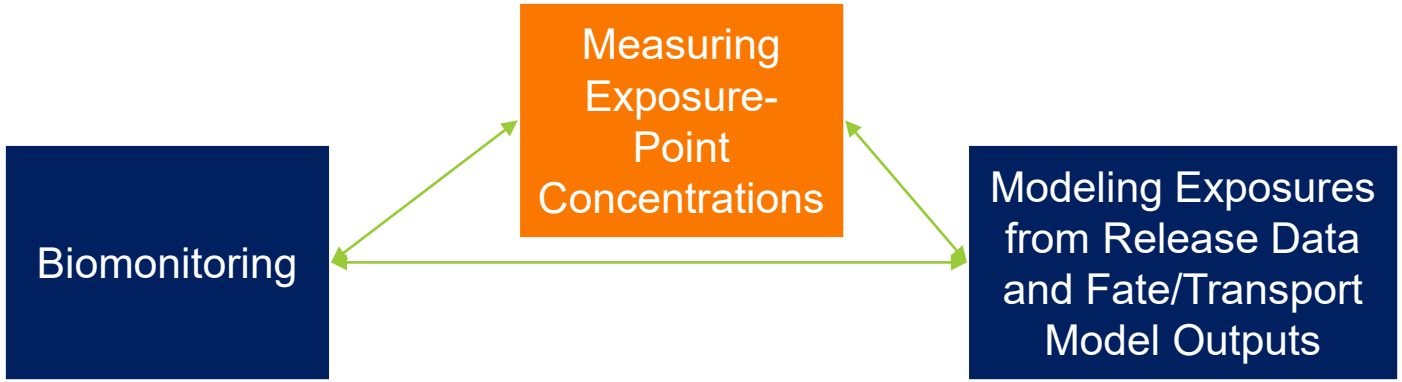
Key uncertainties — Exposure Assessment



Key Uncertainties – Biomonitoring

- **Lack of biomonitoring data for many PFAS**
- **Where data are available – difficult to attribute to one source out of many potential sources**
- **Lack of surveys that establish strong correlations between specific sources of exposure and PFAS levels in blood**
- **Is the decreasing trend in blood serum levels attributable to the phase out of long-chain PFAS?**

Key uncertainties — Exposure Assessment

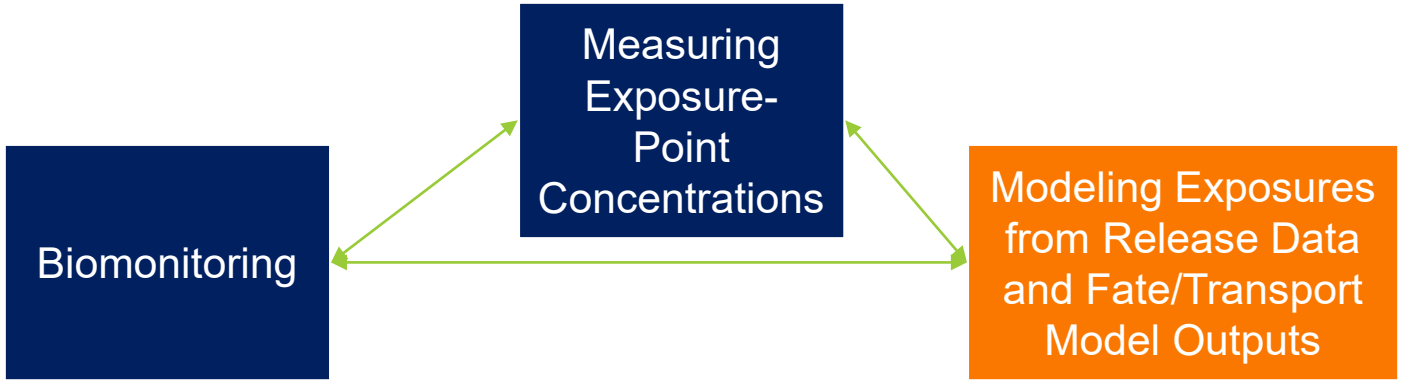


Key Uncertainties – Measuring Exposure-Point Concentrations

- **Since there are thousands of PFAS and only one valid method approved for 25 analyte (drinking water), what exposures are we missing?**
- **How can we distinguish contributions when there are multiple sources?**
- **What is potential for precursors to transform into PFOS or PFOA in the future?**

Source | Release | **Fate & Transport** | Exposure | Toxicology | Human Health Risk

Key uncertainties — Exposure Assessment

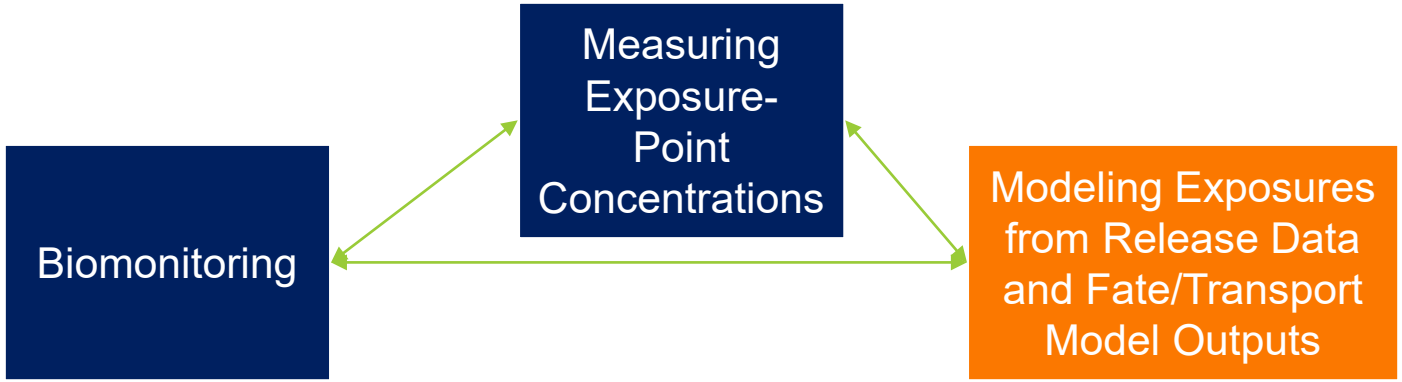


Key Uncertainties – Exposure Modeling

- **Significant lack of release data**
- **Fate/transport model uncertainties**
- **What are valid exposure models and assumptions for more susceptible receptors?**
- **How to model exposures at different life stages?**

Source | Release | **Fate & Transport** | Exposure | Toxicology | Human Health Risk

Key uncertainties — Exposure Assessment



Key Uncertainties – Exposure Modeling

- **Which locally sourced foods should be included in exposure models?**
- **What plant and animal uptake factors should be assumed?**
  - Soil and irrigation water to crops
  - Cooking water to food
  - Crops and feed water to animals and milk

Source | Release | **Fate & Transport** | Exposure | Toxicology | Human Health Risk

Risk management challenges posed by exposure uncertainties

- **Are uncertainties too large to set exposure limits at this time?**
- **Which exposure sources and routes are the most important to manage/reduce?**
  - Drinking water – especially close to major sources
  - Food – especially fish due to bioconcentration
  - House dust and fibers – infants and children?
  - Dermal uptake not significant contributor?
  - The dominant routes of human exposure are not uniform for all types of PFAS
- **What are the most important PFAS compounds with respect to exposure?**

Use SEEM3 model for exposure potential?

- **SEEM3 can produce ranges of exposure to different PFAS and from different sources**
- **Using databases such as:**
  - PFAS biomonitoring levels (e.g., NHANES)
  - Product compositions (e.g., EPA Chemical Products Database)
- **Using models such as SHEDS-HT to predict usage (prevalence, frequency, and magnitude) and exposure scenarios for a wide range of consumer products and foods**
- **Using surrogates of exposure such as proximity to landfills, AFFF sites, chemical plants, WWTPs with downstream surface-water potable source**
- **Combine to estimate relative exposure by population to various PFAS**

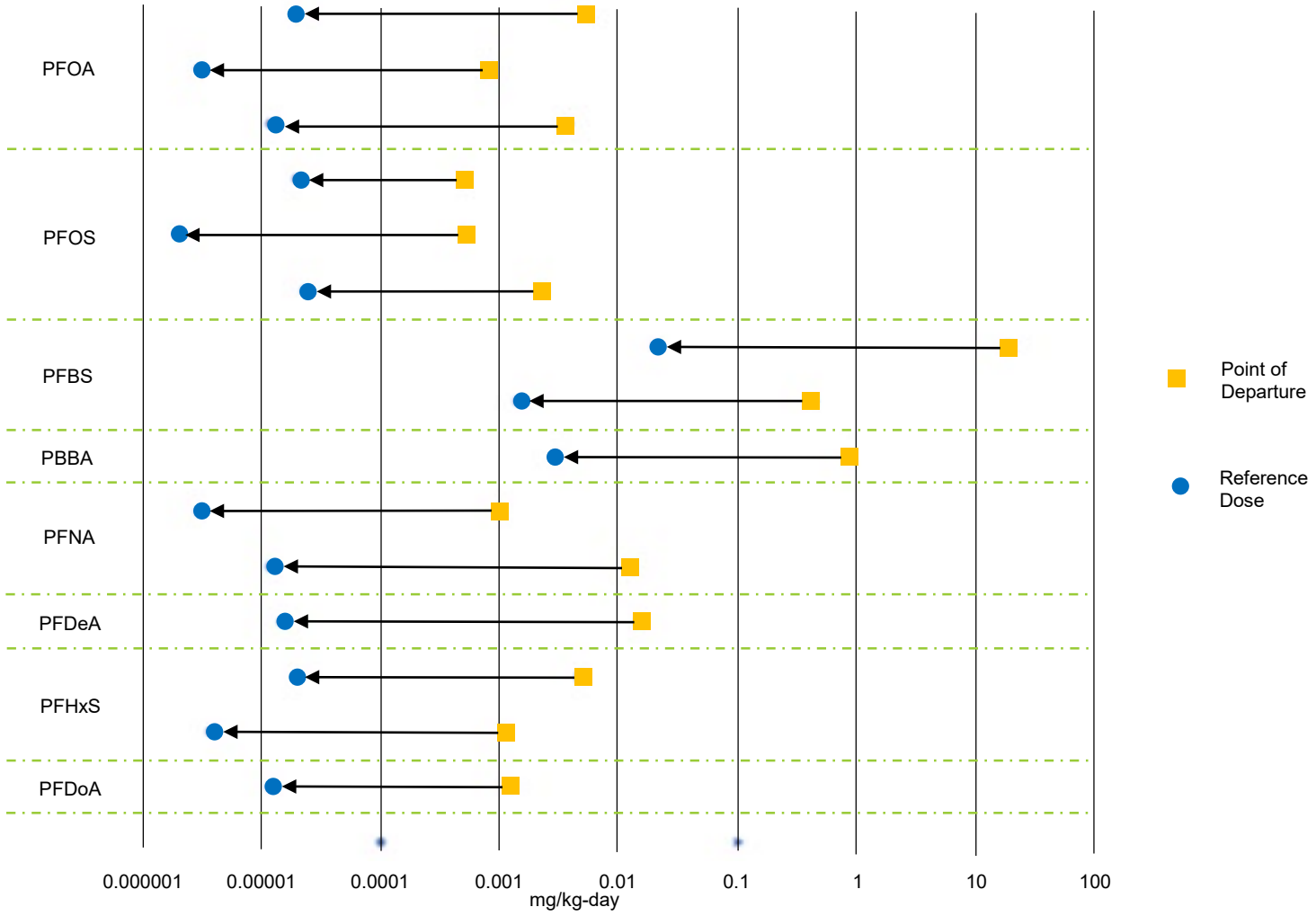
Example SEEM3 predictions for some PFAS

Chemical	SEEM3 Prediction (mg/kg/day)	SEEM3 Lower Bound (mg/kg/day)	SEEM3 Upper Bound (mg/kg/day)
PFBS	2.05E-05	5.08E-08	5.38E-03
PFHpA	3.22E-06	7.54E-08	2.27E-04
PFHxS	7.70E-06	1.90E-08	8.70E-04
PFOS	2.90E-06	4.41E-08	2.07E-04
PFOA	5.35E-08	3.94E-10	2.34E-05
PFNA	1.23E-07	9.80E-10	2.40E-05
PFDA	3.21E-10	4.78E-18	1.88E-05
PFUnDA	6.24E-09	3.12E-19	7.27E-06
PFDoDA	9.66E-09	2.59E-17	5.04E-06
FOSA	2.28E-07	1.66E-09	4.28E-05
EtFOSAA	1.27E-09	1.44E-18	1.50E-06
MeFOSAA	2.00E-09	1.73E-17	2.25E-06

Key uncertainties — Toxicology

- **Lack of toxicity values for many PFAS – Currently nine PFAS RfDs (out of thousands)**
- **Some differences of opinion on what health effect to use as basis for toxicity value**
- **Human half-life estimates are available for a handful of PFAS**
- **All of this has resulted in different toxicity values and drinking-water advisory levels**
  - EPA, ATSDR, States

Use of uncertainty factors in deriving currently available reference doses



Risk is a function of both hazard and exposure — Overlay the uncertainties

Tox studies: *in vitro, in vivo*, human, non-human, various endpoints/pathways…

Exposure measurements & modeling

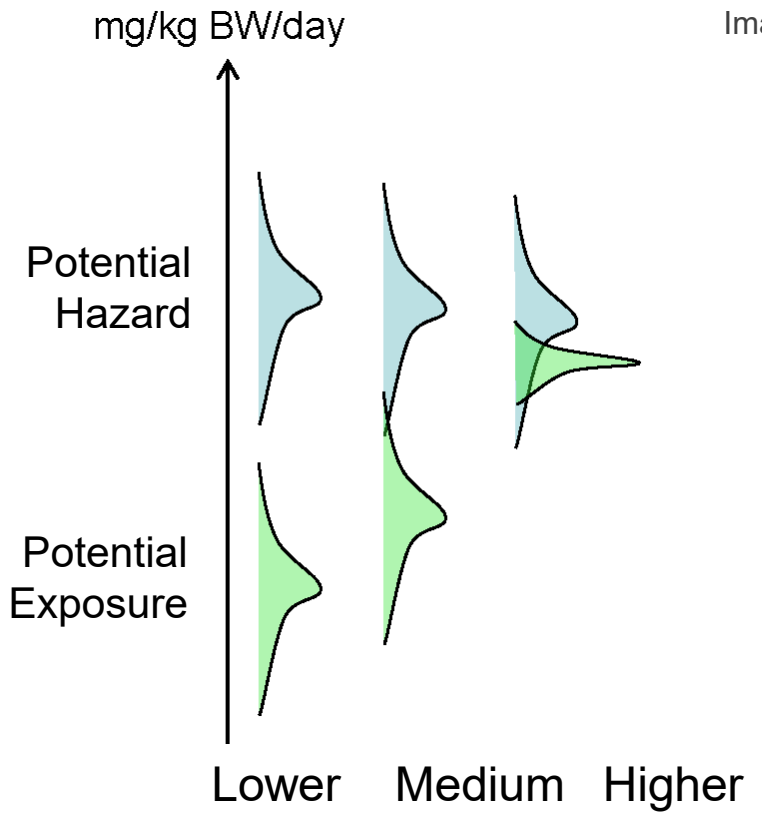
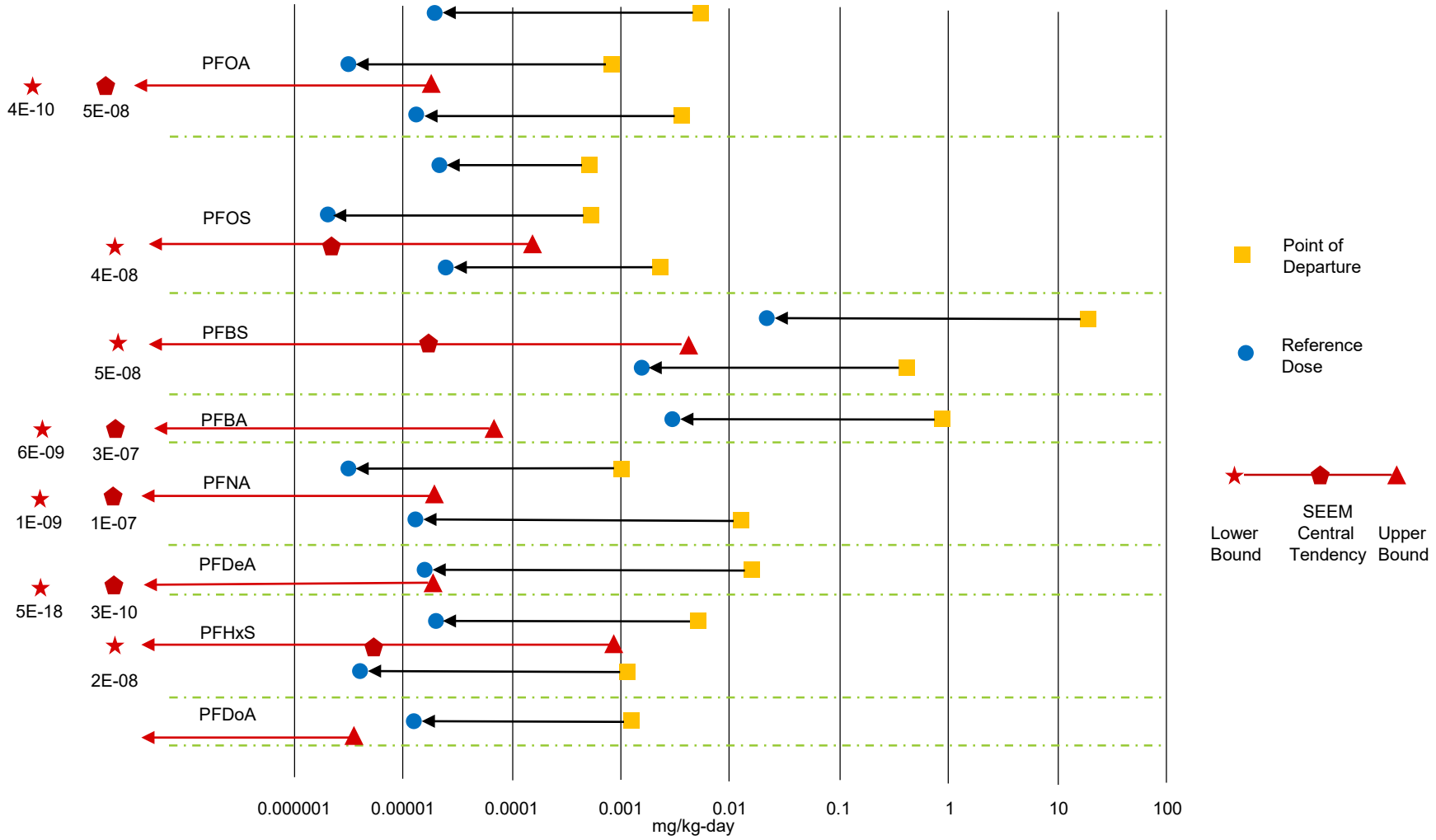


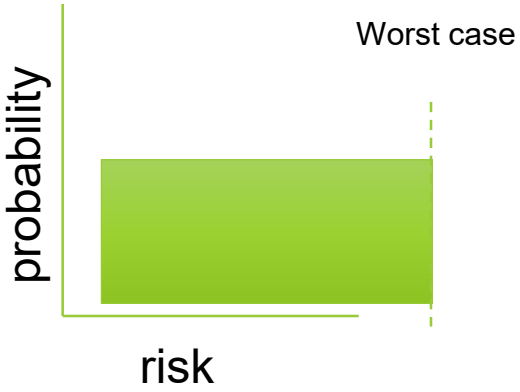
Image credit: John Wambaugh (EPA-NCCT)

Combine SEEM3 and reference-dose uncertainties



Risk management at different stages of uncertainty

Risks can only be bounded

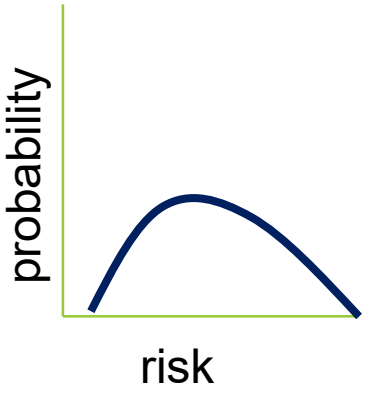


Base decisions and actions on worst-case assumptions

Screening levels of risk possible

Base decisions and actions on conservative assumptions and screening levels

Probability of risks can be quantified



Base decisions and actions on acceptable confidence level

Michigan PFAS Science Advisory Panel

Scientific Evidence and Recommendations for Managing PFAS Contamination in Michigan

(December 7, 2018)

"Given our incomplete understanding but quickly evolving scientific literature on the health effects of specific forms of PFAS, the Panel recommends that all judgments regarding acceptable levels … should be subject to periodic re-evaluation, with the potential for adopting more or less stringent criteria based on new insights."

- **This form of "adaptive risk management" is definitely warranted for risk-based decision making about PFAS**
- **Prioritize study and actions based on:**
  - **Focusing on where uncertainty ranges of possible exposure and possible hazard overlay the most**
    - General population (SEEM3 approach?)
    - Highly exposed persons near sources (Number exposed?)
  - **Managing releases from largest sources of these PFAS and exposures**
  - **Resolving uncertainties as to which predictions of exposure and risk are most sensitive for these sources, pathways, and receptors**

Thanks!

Questions?

(No pun intended)

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