

Program Office Collaboration: Biosolids Evaluation

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*The views expressed in this presentation are those of the author(s)
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Introduction

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EPA Office of Water, Biosolids Program

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Chemicals Selected for OW Biosolids Proof-of-Concept

- The Clean Water Act requires OW to evaluate chemicals and microbes that occur in biosolids for harm to human health and the environment
- OW's national sewage sludge surveys and literature surveys have found over 500 chemicals that have been detected in biosolids
- OW has developed a screening tool and probabilistic framework to evaluate risk for these chemicals
- OW needed a prioritization process to help determine which chemicals should be evaluated for first
- ORD applied the PICS process that was developed for TSCA to prioritize the biosolids chemicals for assessment

Future work for biosolids

- The PICS process could be updated to based the exposure values on the output of the biosolids tool as opposed to the exposure pathways from TSCA
- Finding future chemicals of concern in biosolids
 - SEEM could be updated to predict biosolids concentrations for chemicals outside of the chemicals currently detected in biosolids
 - These predicted biosolids concentrations would then be run through an updated PICS process to determine what chemicals outside of those currently found in biosolids may be of concern
 - OW would then consider those potential chemicals of concern for risk assessment or a future sewage sludge survey

Main presentation

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Overview

- What are biosolids?
- How EPA evaluates biosolids contaminants under the Clean Water Act
- Risk screening & assessment for biosolids contaminants has been slowed by lack of available data regarding hazard & exposure
- EPA Office of Water (OW) proposes a new process to increase efficiency
- Researchers from EPA Office of Research & Development (ORD) Center for Computational Toxicology & Exposure (CCTE) are working closely with OW to develop and adapt data & tools to support OW's decision-making process
 - CCTE collaboration: Curation of list of chemicals found in biosolids
 - CCTE collaboration: Chemical prioritization workflow
 - CCTE collaboration (work in progress): High-throughput model of biosolids chemical occurrence

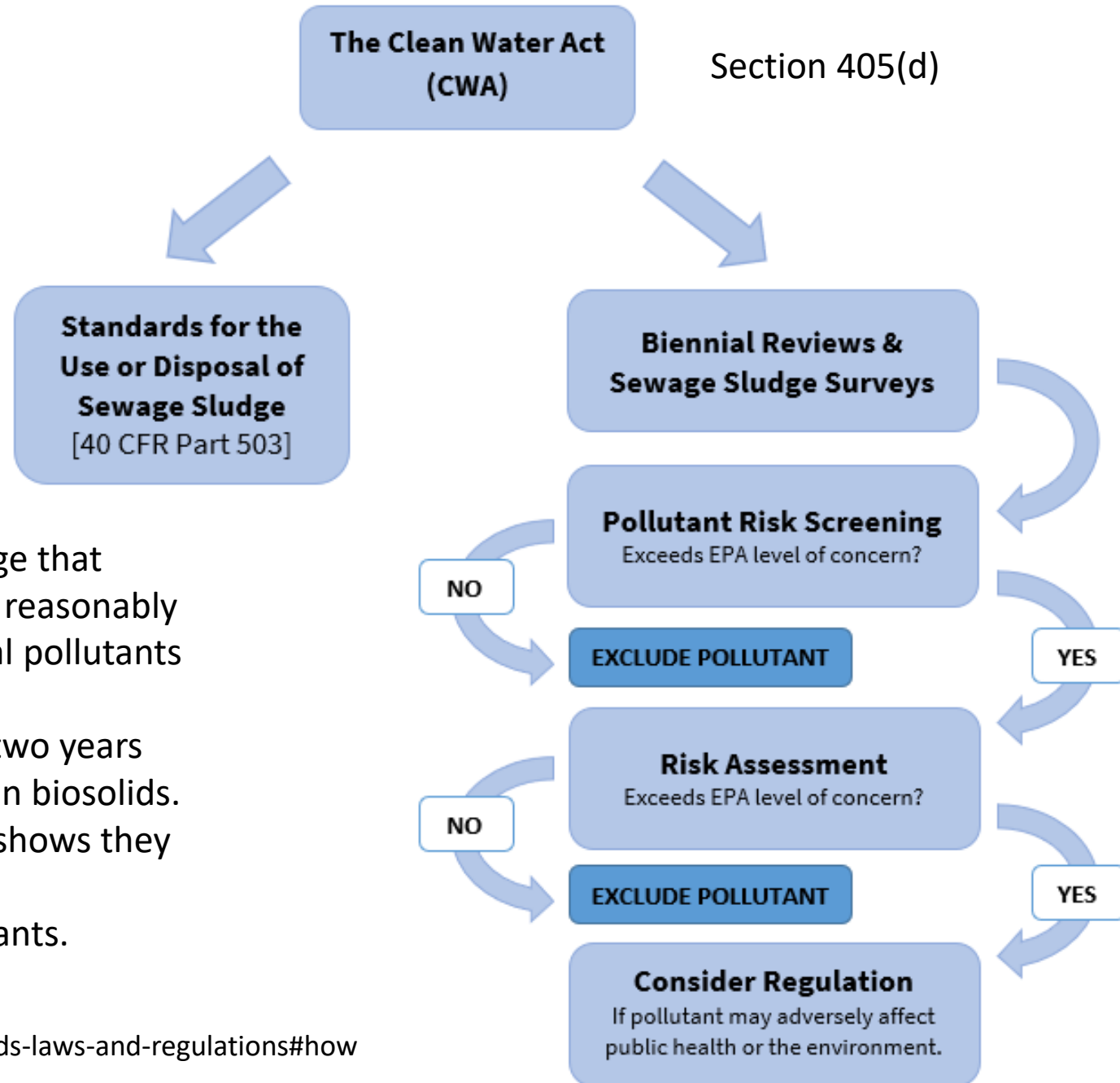
What are biosolids?

- Biosolids are treated sewage sludge.
- During wastewater treatment process, solids and liquids are separated
- Solids are treated physically and chemically to produce a semisolid, nutrient-rich product known as *biosolids*
- Biosolids are used or disposed in one of several ways:
 - Land application: Biosolids may be used as fertilizer on agricultural land, soil amendment on non-agricultural land, etc
 - Landfill
 - Incineration
 - Other

EPA and biosolids under the Clean Water Act

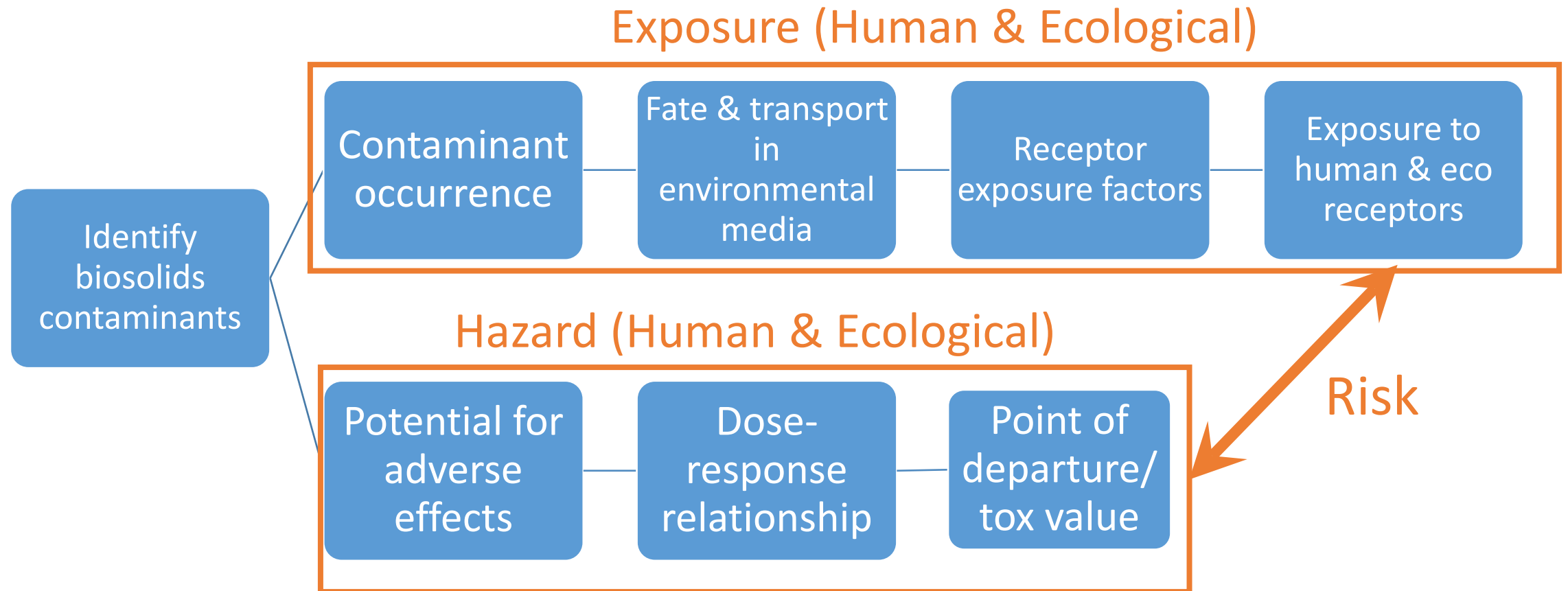
Section 405(d) of the CWA requires EPA to:

- Set standards for the use or disposal of sewage sludge that protect public health and the environment from the reasonably anticipated adverse effects of chemical and microbial pollutants (40 CFR Part 503)
- Review sewage sludge (biosolids) regulations every two years to identify any additional pollutants that may occur in biosolids.
 - Evaluate whether sufficient scientific evidence shows they may harm human health or the environment.
 - If so, then consider regulations for those pollutants.

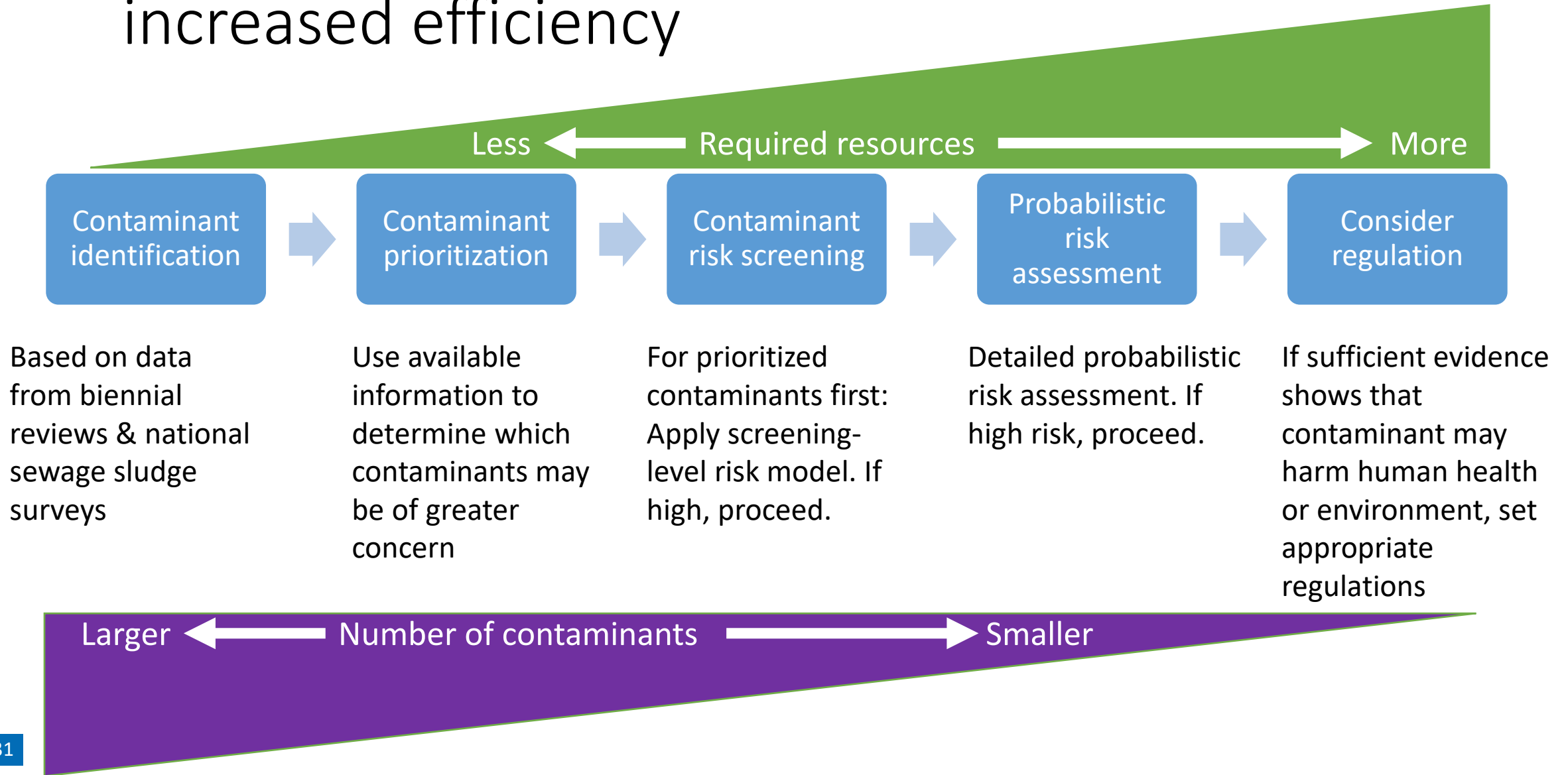


Risk screening & assessment for biosolids contaminants has been slowed by gaps in both exposure and hazard data.

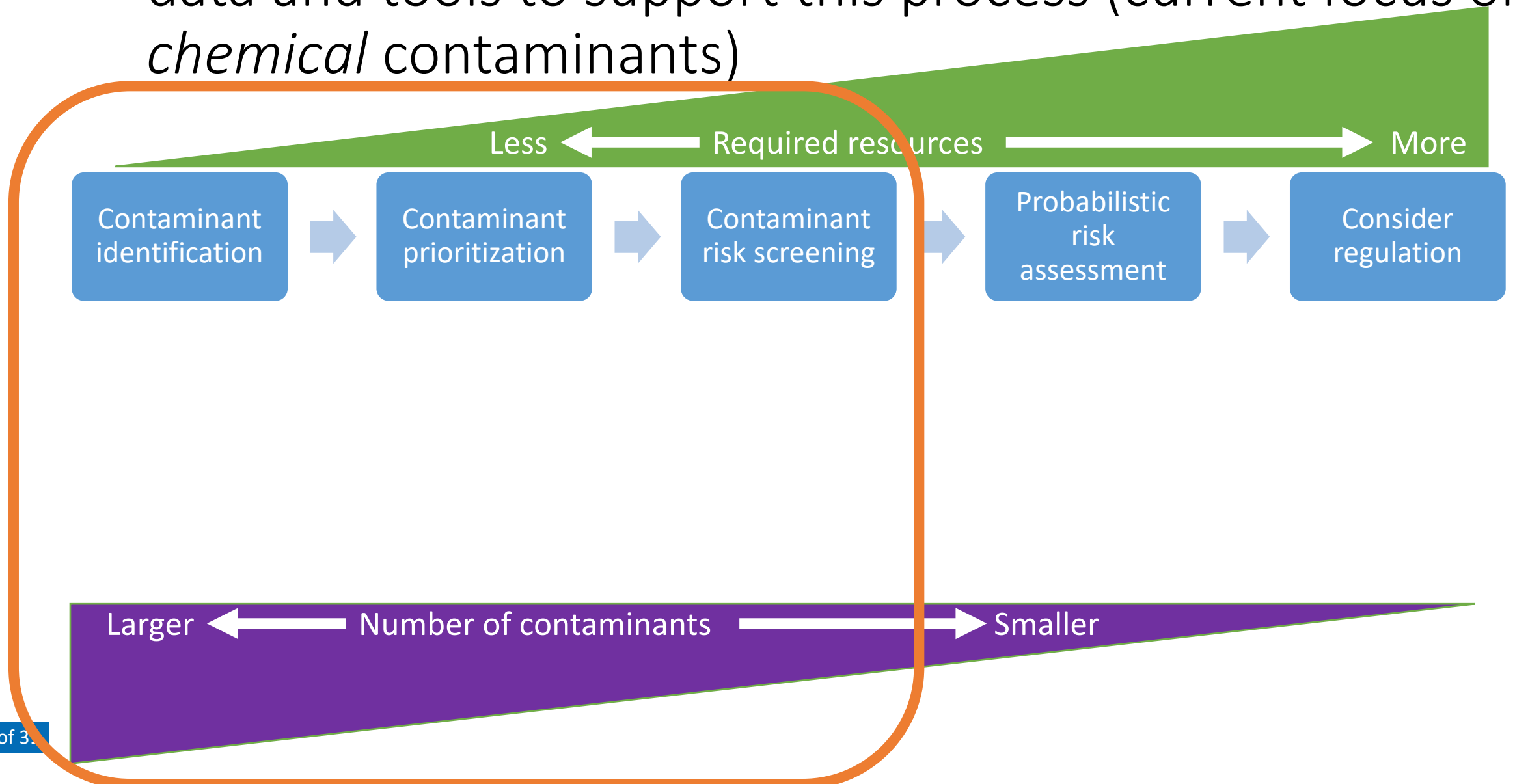
[NRC 2002; USEPA 2018]



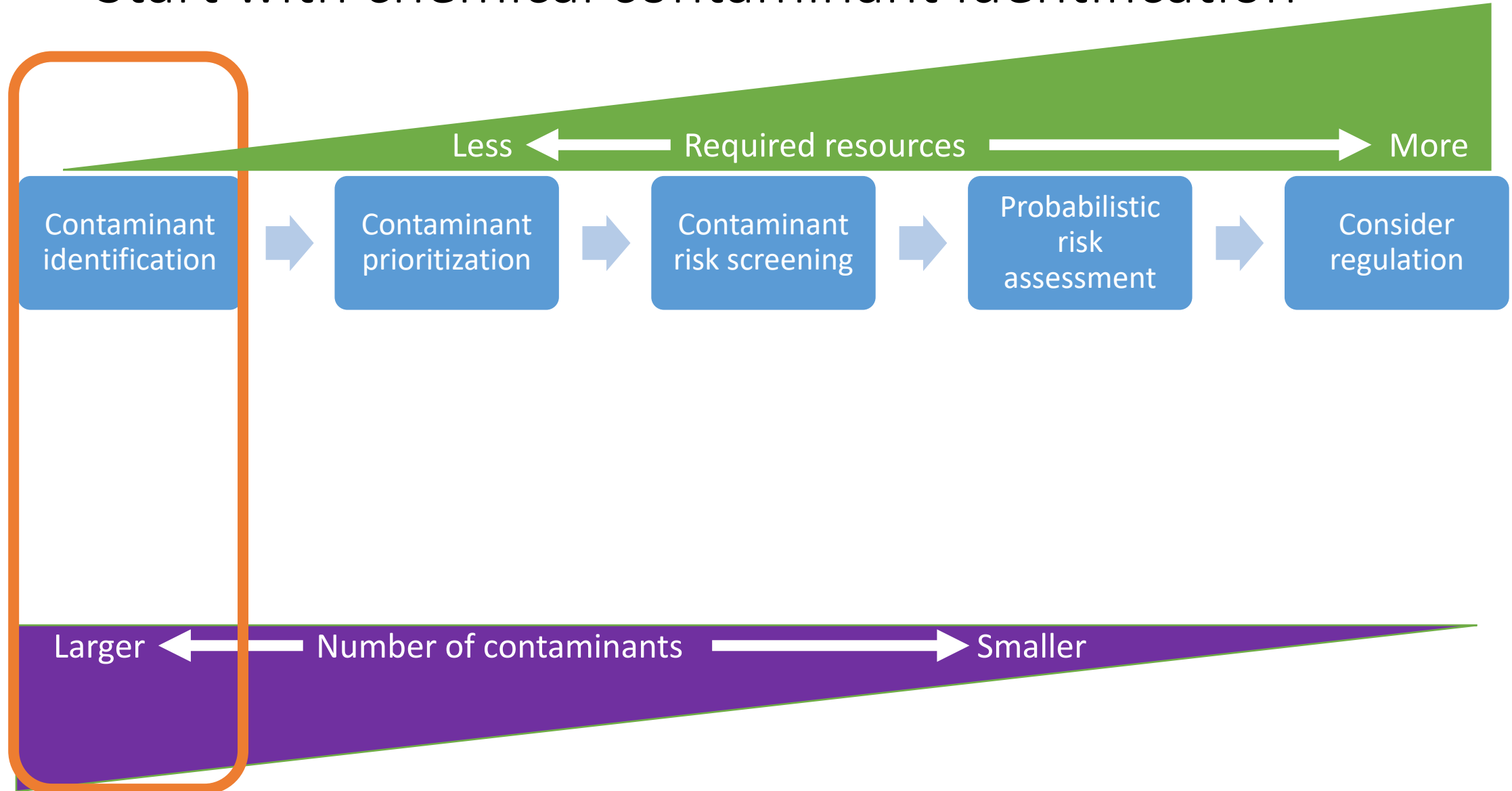
EPA's Office of Water proposes a new approach for increased efficiency



ORD-CCTE researchers are working with OW to develop data and tools to support this process (current focus on *chemical* contaminants)



Start with chemical contaminant identification



ORD-CCTE & OW collaborated to curate a list of chemical substances found in biosolids [Richman & Williams, in prep]

Multiple reports listing chemicals found in biosolids:

- National Sewage Sludge Surveys (1988, 2001, 2009)
 - nationwide monitoring surveys of biosolids from wastewater treatment facilities
- Biennial Reports (2004-2019)
 - biosolids monitoring data found in the published literature

Problem:

- Each of these reports was a totally separate effort
- Data formats and reporting standards changed between reports
- Chemical identifiers (names, CASRNs) were not standardized among reports

Difficult to combine data from different reports, let alone connect to other chemical data necessary for risk screening and assessment

ORD-CCTE & OW collaborated to curate a list of chemical substances found in biosolids [Richman & Williams, in prep]

Solution: Data curation

- Extract data from reports & harmonize formatting
- Standardize chemical names
 - Fix misspellings & typos
 - Identify synonyms
 - Identify neutral forms of salts & charged anionic perfluorinated compounds
- Identify individual components of chemical combinations
 - e.g., chemicals that can't be separated by standard analytical chemistry methods, such as co-eluting PCBs
- Identify correct CASRNs (ensure Active CASRNs)
- Map to DSSTox Substance IDs [Gulke et al. 2019]

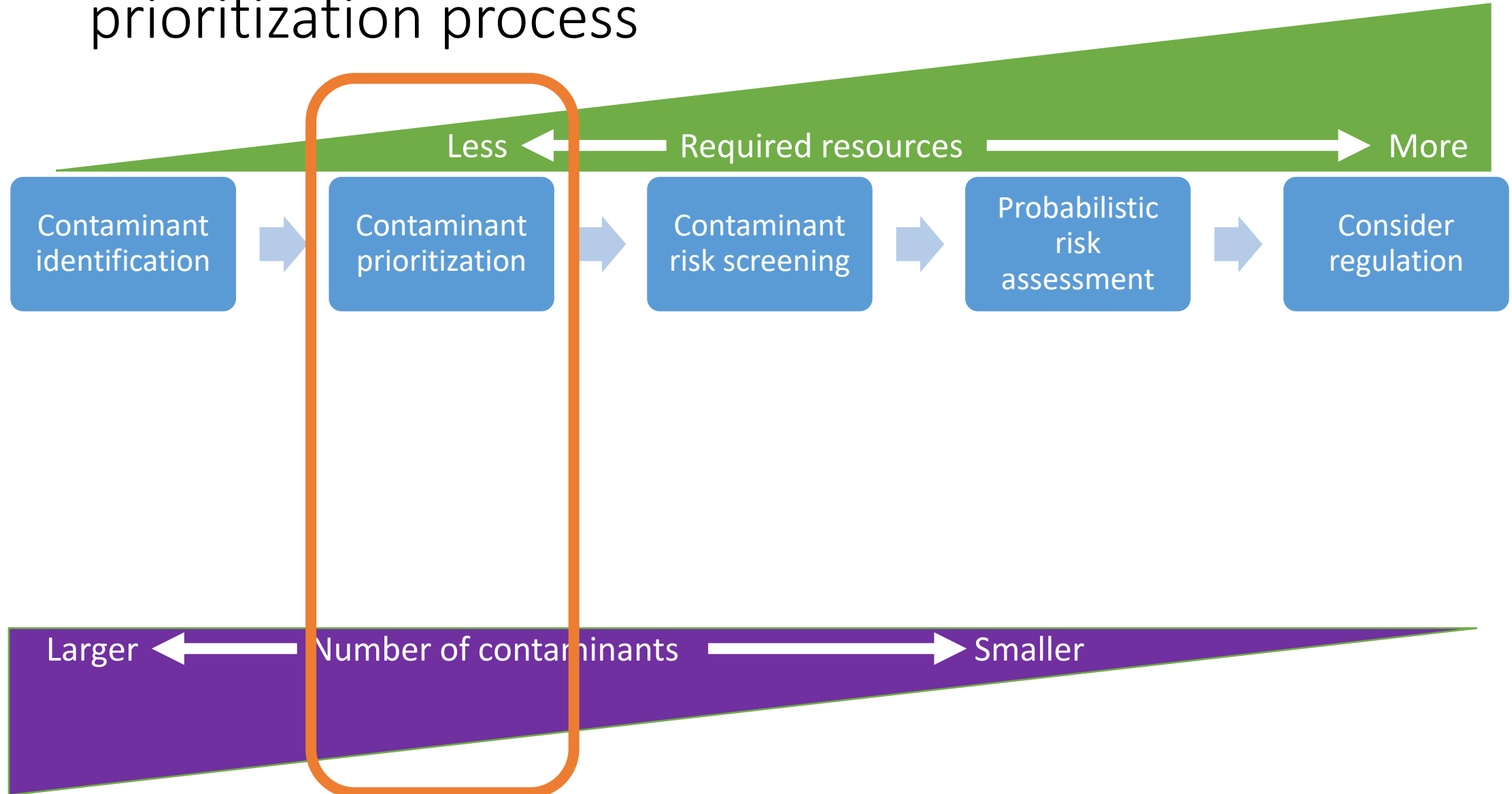


Chemical curation allows OW and ORD researchers to...

[Richman & Williams, in prep]

- Correctly determine when each chemical was identified
 - For example, the 2018-2019 Biennial Report reported 116 “newly identified” chemical pollutants in biosolids.
 - After curation, it turns out 41 of 116 had actually been identified previously!
- Query hazard-, exposure-, and risk-relevant data sources for biosolids chemicals, e.g., data available through the CompTox Chemicals Dashboard [Williams et al. 2017]
 - Structure
 - Physicochemical properties
 - Chemical categories
 - Chemical functional use
 - High-throughput exposure predictions
 - ToxCast/Tox21 high-throughput *in vitro* screening data
 - Existing *in vivo* toxicology data

Curated chemical list can be used to apply a chemical prioritization process



ORD-CCTE worked with OW to adapt a prioritization workflow originally developed in the context of TSCA prioritization as an ORD-CCTE/OCSP collaboration:

PICS (Public Information Curation and Synthesis) [USEPA 2021c]

[previously presented to CSS BOSC by Dr. Richard Judson in February 2021]

To prioritize chemical substances, PICS integrates publicly available information from multiple domains:

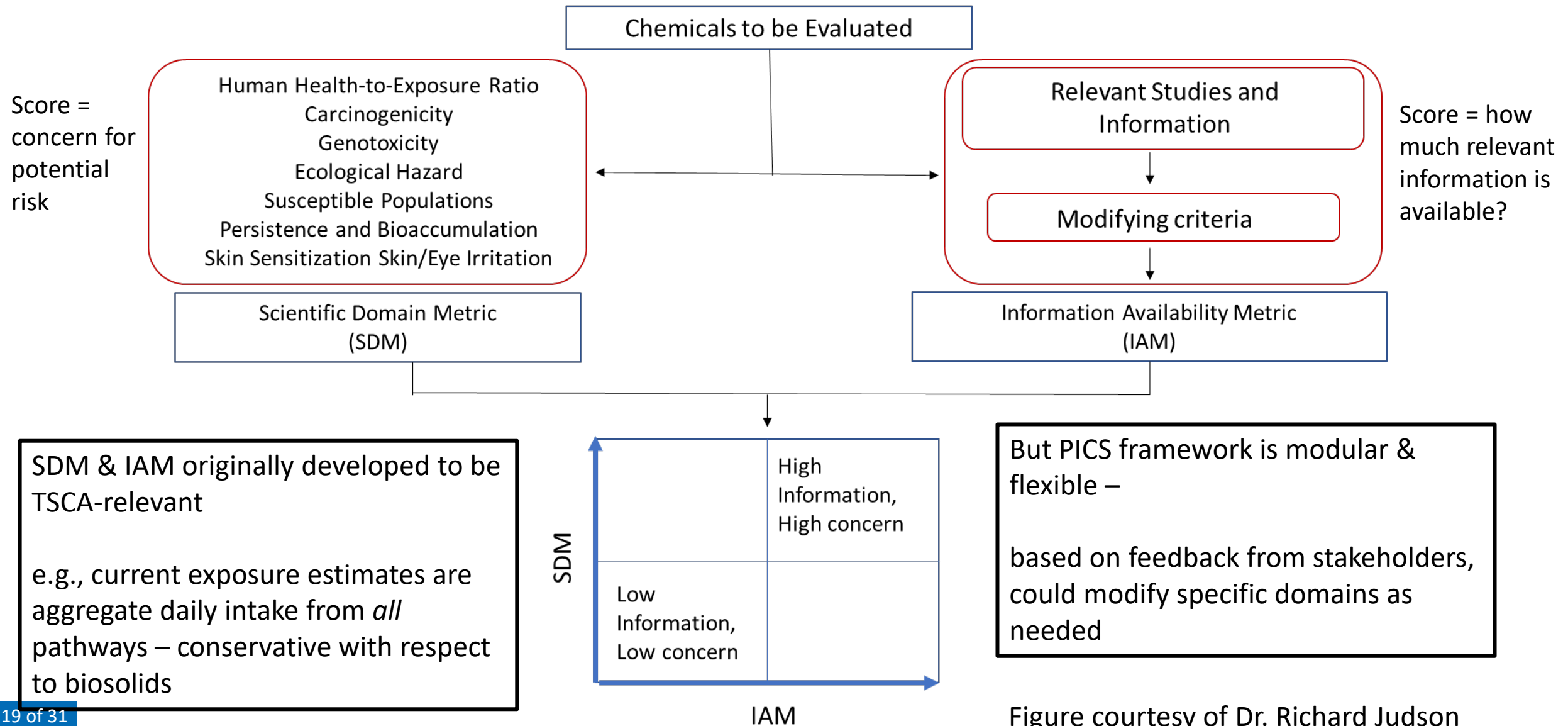
- hazard
- exposure
- persistence & bioaccumulation

PICS synthesizes information from traditional methods and New Approach Methodologies

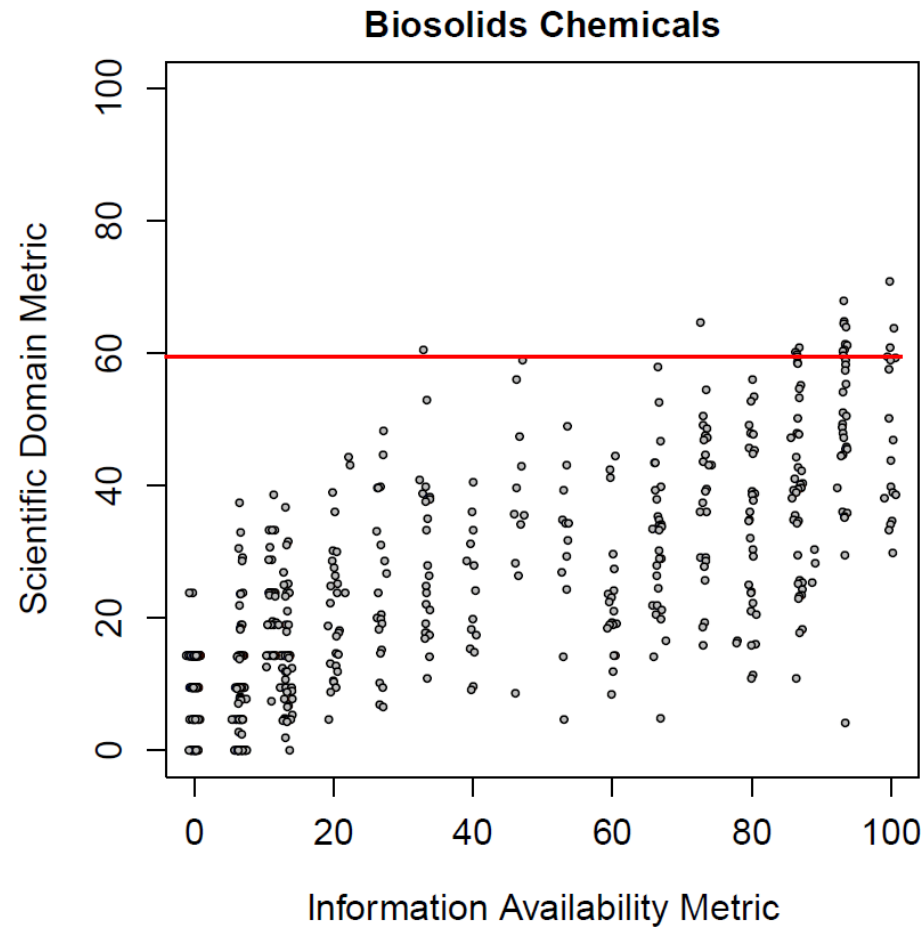
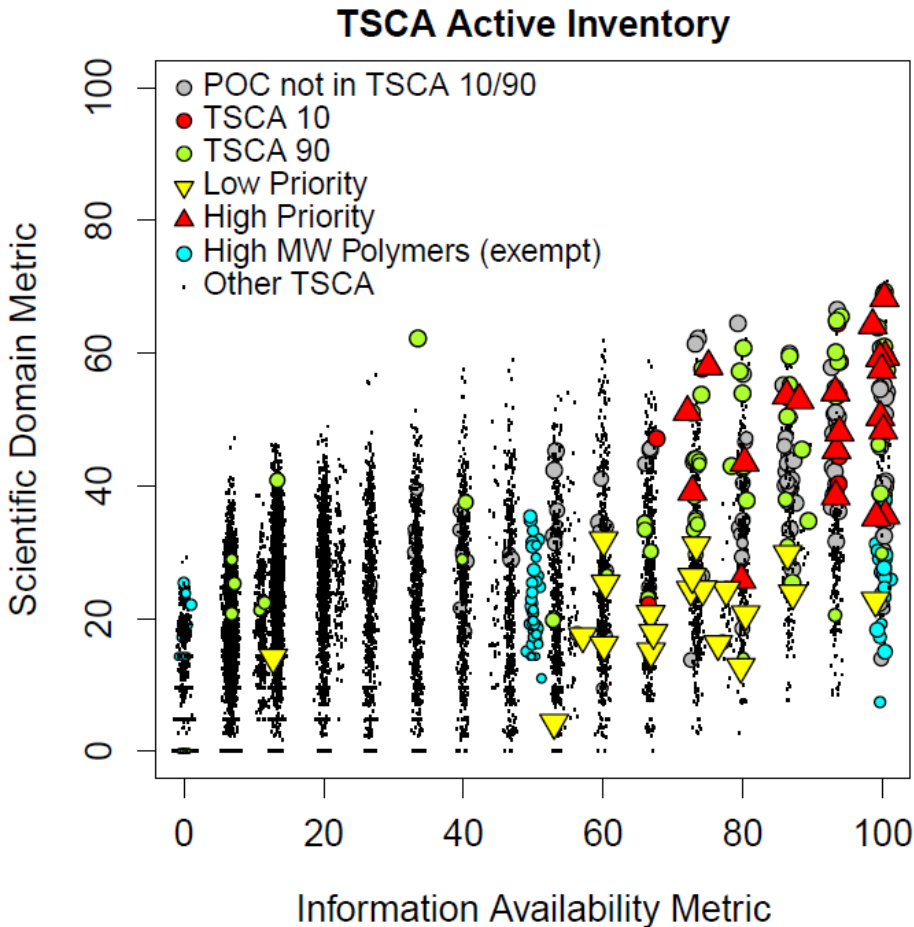
PICS was designed to:

- understand the overall **degree of potential concern** related to human health and the environment, based on available information
- understand the **relative coverage of potentially relevant information** about human health and ecological toxicity and exposure
- inform **level of effort and resources** that may be needed to evaluate a specific substance
- be **readily adaptable to address prioritization needs** under other mandates (not just TSCA!)

PICS workflow: chemicals are scored on two metrics, Scientific Domain Metric & Information Availability Metric



PICS TSCA case study results vs. Biosolids preliminary results



Left: For TSCA prioritization, PICS generally agreed with previously-identified high- and low-priority chemicals

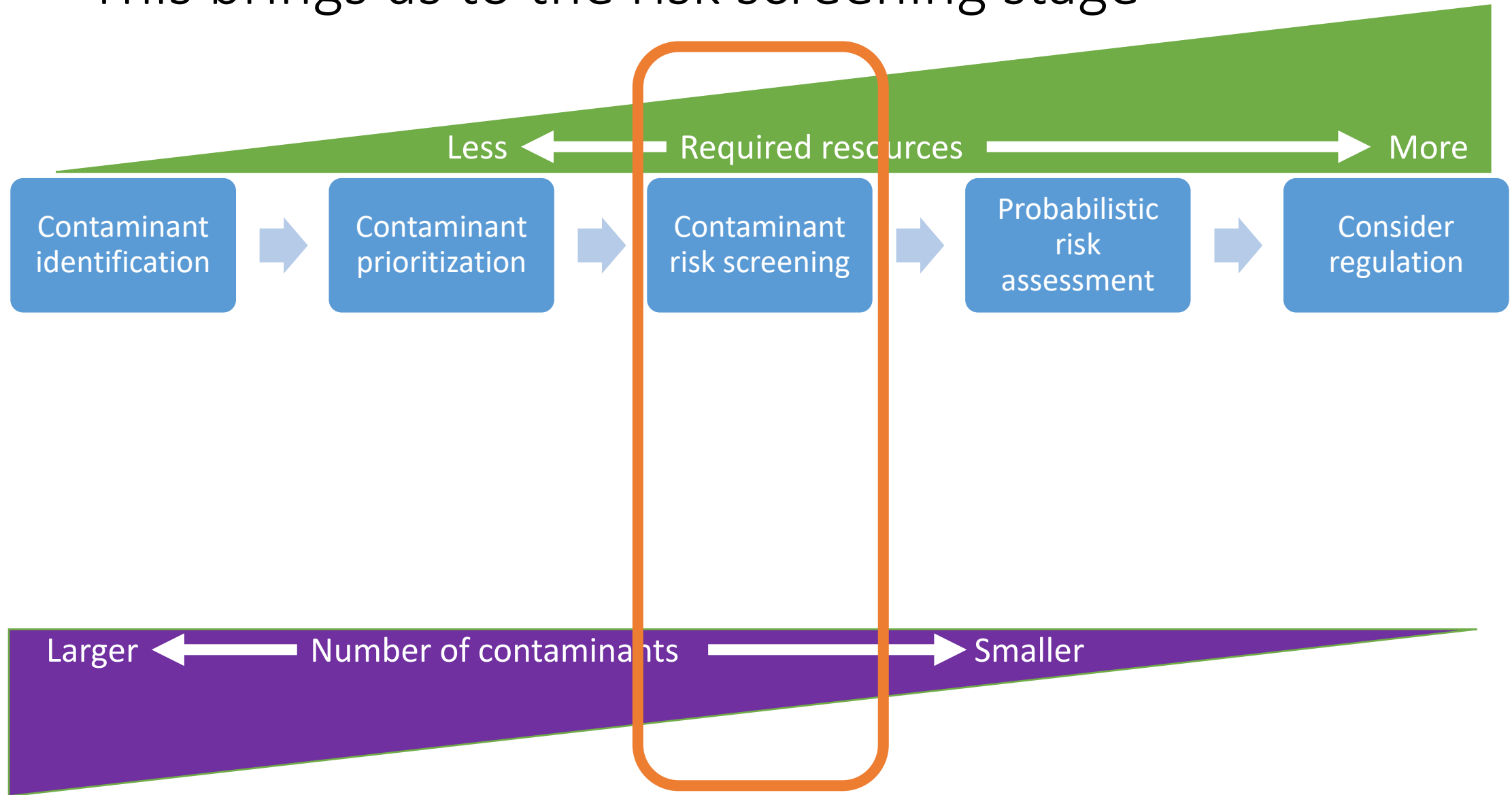
Right: Distribution of SDM/IAM is similar in biosolids chemicals and in TSCA Active Inventory

Scientific Domain Metric criteria (red line) can be used to prioritize chemicals for risk screening

[POC = PICS Proof of Concept chemical subset]

slide adapted from Dr. Richard Judson

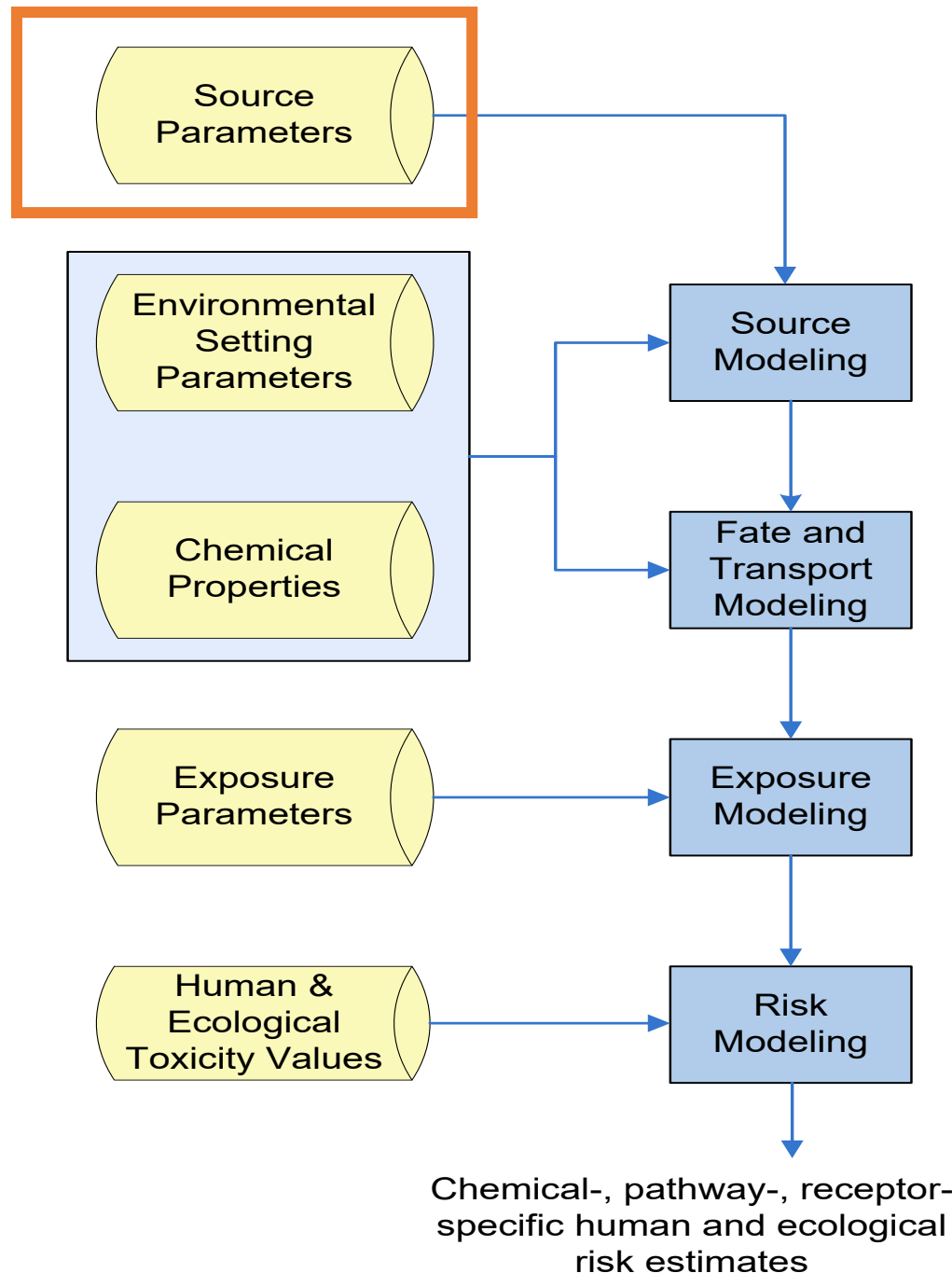
This brings us to the risk screening stage



For risk screening, OW has developed Biosolids Screening Tool (BST)

But BST requires biosolids
concentrations as input!

Measured biosolids
concentrations are only
available for about half of
chemicals on the curated
biosolids list.



Overview of Biosolids
Screening Tool modeling
framework

Simulates multiple
exposure pathways
relevant to land
application, incineration,
and surface disposal

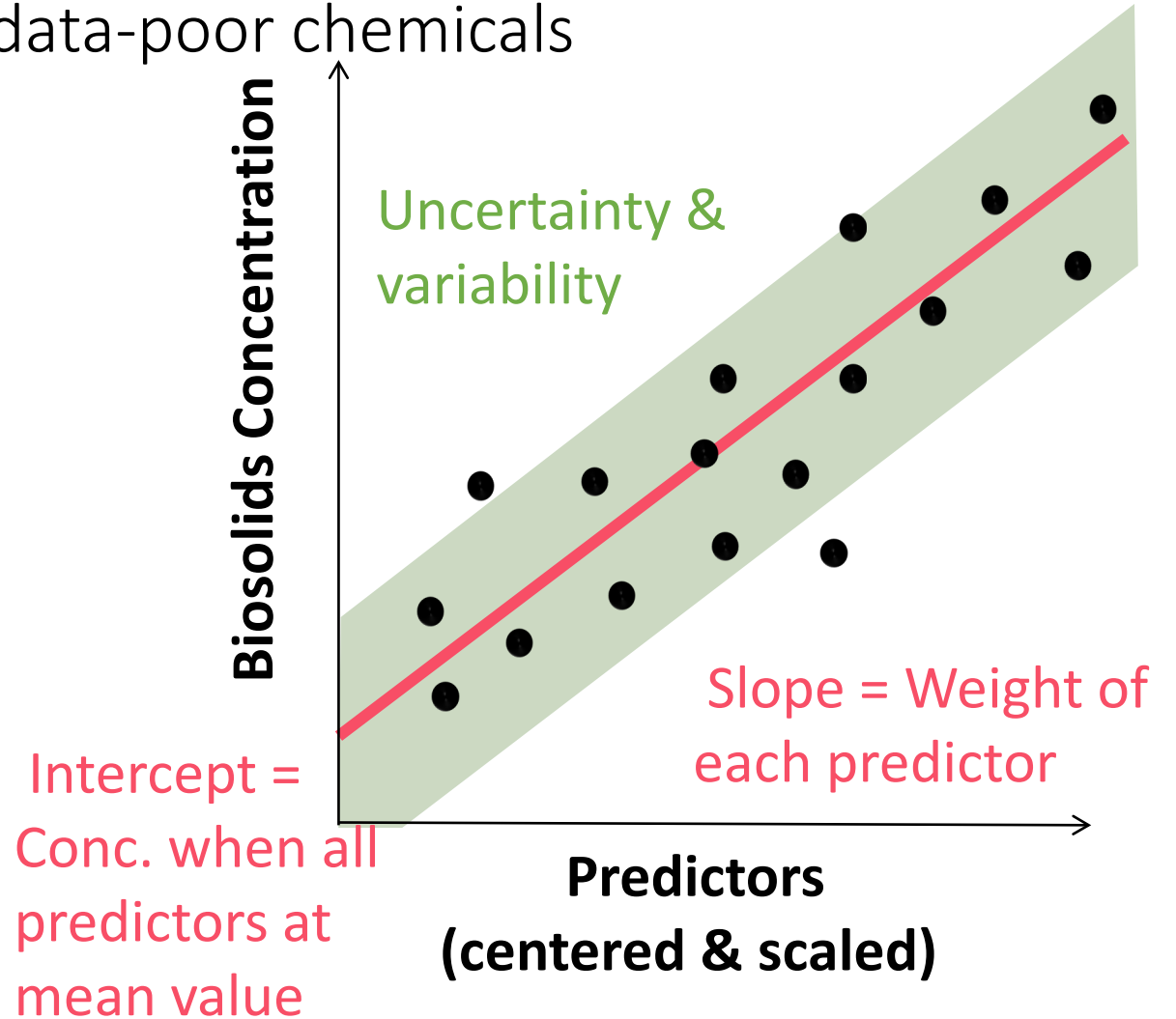
Figure from OW

How CCTE can help: Develop a model to rapidly *predict* biosolids concentrations for data-poor chemicals

- Detailed wastewater treatment plant (WWTP) models not feasible
 - Require chemical-specific data that are not available for many chemicals
 - liquid-solid partitioning coefficients
 - biodegradation in sludge
 - **WWTP influent concentration**
 - Require plant-specific operating parameter data that are typically not available
 - Typically can't be run quickly for hundreds or thousands of chemicals
- Need a model that requires minimal chemical-specific data, but can make use of any relevant data that *are* available
- Need to characterize *variability & uncertainty* in model-predicted biosolids concentrations

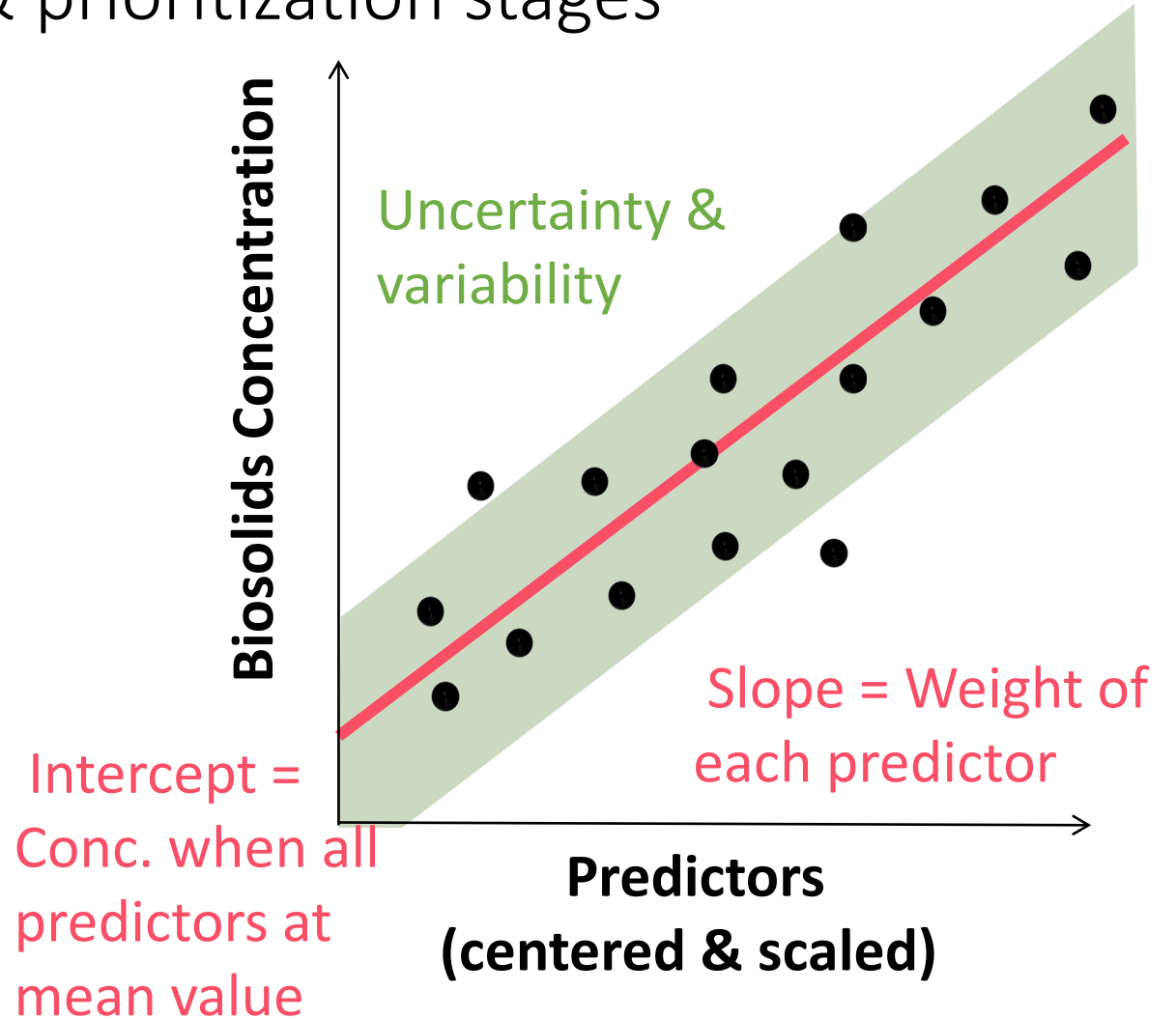
Solution (work in progress): A high-throughput consensus model that combines easily-available model predictions & data to predict biosolids concentrations for data-poor chemicals

- Essentially a multiple linear regression: a weighted sum of predictor variables
- Model will be trained on National Sewage Sludge Survey monitoring data
- Predictors for each chemical will be easily-available occurrence-relevant data and existing model predictions
 - e.g., down-the-drain models; chemical production volume; presence on lists of banned chemicals; use in consumer products, industry, pesticides, food, pharmaceuticals....
 - Any missing values simply imputed with average
- Will build on existing framework from consensus model of human aggregate daily intake rates: SEEM3 (Systematic Empirical Evaluation of Models, version 3) (Ring et al. 2019)



Consensus model predictions (work in progress) could also be used at identification & prioritization stages

- Consensus model could be applied to chemicals outside the curated biosolids list to identify additional chemicals with potential to occur in biosolids
- Identified chemicals could be prioritized using PICS process
- Could be used to propose candidates for new National Sewage Sludge Survey



Summary

- The Clean Water Act requires OW to evaluate chemicals and microbes that occur in biosolids for harm to human health and the environment
- OW has a need to fill data gaps to more efficiently evaluate biosolids contaminants
- CCTE researchers are working with OW Biosolids to provide data and tools to support biosolids chemical prioritization and screening
 - Curation of list of chemicals found in biosolids
 - PICS prioritization workflow
 - (Work in progress) High-throughput consensus model to predict biosolids chemical concentrations

Key People

OW Biosolids

- Liz Resek
- David Tobias
- Tess Richman (ORISE)

ORD CCTE

- Caroline Ring
- Paul Kruse (ORISE)
- Antony Williams
- Richard Judson
- PICS Proof of Concept Team (see next slide)
- Kristin Isaacs
- Marc Russell

PICS Proof of Concept Team

- Abhishek Komandur
- Allison Eames
- Amar Singh
- Andrew Greenhalgh
- Anita Pascocello
- Anita Simha
- Ashley Jackson
- Carlie LaLone
- Carolyn Gigot
- Catherine Gibbons
- Chris Grulke
- Chris Lau
- Colleen Elonen
- Dale Hoff
- Dan Vallero
- Dan Villeneuve
- David DeMarini
- Doug Young
- Elaina Kenyon
- Eric Weber
- Grace Patlewicz
- Janet Burke
- Jason Lambert
- Jeff Dean
- Jeremy Dunne
- Johanna Congleton
- John Cowden
- John Nichols
- John Wambaugh
- Katherine Phillips
- Kathie Dionisio
- Katie Paul-Friedman
- Kelly Garcia
- Kent Thomas
- Kristin Isaacs
- Lauren Koval
- Lawrence Burkhard
- Leora Vegosen
- Leslie Hughes
- Mary Gilbert
- Maureen Gwinn
- Michael Gonzalez
- Nagu Keshava
- Richard Judson
- Sarah Warren
- Todd Martin
- Antony Williams
- Urmila Kodavanti
- Yu-Sheng Lin

Thank you!

Questions?

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