Toxicity-Weighting: QA & Prioritization Tool

David Wright
Maine Dept of Environmental Protection

Session 6 - Air Toxics

Emission Inventories: Integration, Analysis, and Communications
Research Triangle Park, North Carolina

May 16, 2007

Or… Toxicity-Weighting For Fun and Profit!!!

Presentation Overview

- What is toxicity-weighting?
- Why toxicity-weight an inventory?
- What is the basis for toxicity-weighting?
- Where can you get toxicity-factors?

What is toxicity-weighting?

- A simplistic tool to prioritize emissions based on risk
  - Ton for Ton, not all HAPs are equal in terms of impacts to public health
  - Common Weighting Scale - Allows for an “apples to apples” comparison of pollutants in HAP inventories
  - Which is worse, a ton of toluene, or a pound of dioxin?
  - Are 10 tons of HAP emissions from a factory worse than 10 tons of HAP from lawn mowers?

Toxicity weighted Emissions =

Emissions * Toxicity-factor

Why Toxicity-Weight an Inventory?

- 188 HAPs – 1000's Air Toxics
  - Where to focus resources?
- Summarize complex data in a meaningful way
- Allow comparisons of HAP inventories between different years and regions
- Track Progress
- GIGO – Sound modeling depends on a high quality inventory inputs

Why Toxicity-Weight an inventory?

Summarizing complex data for a diverse stakeholder Group

Maine Air Toxics Initiative

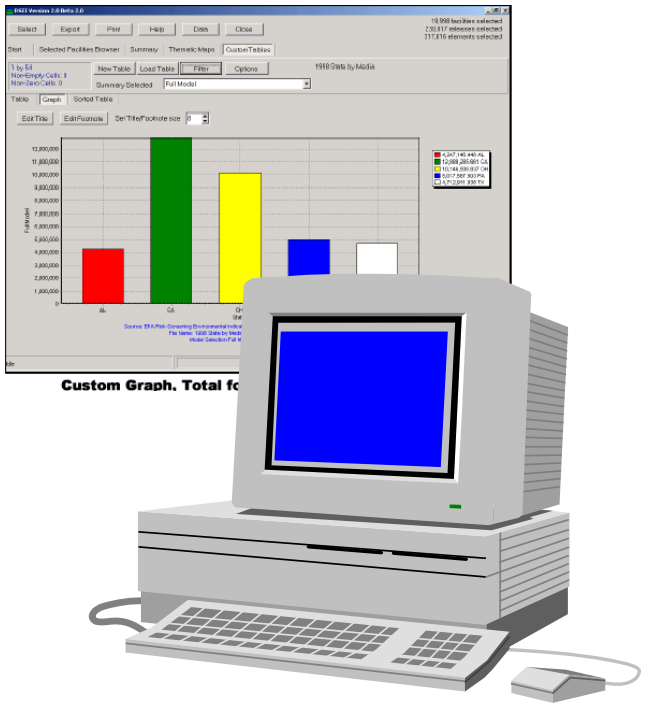
- Healthy Communities Grant
- Statewide Stakeholder Process
- Phase I: Holistic Review all available data – is there an AT risk in Maine, and if so, what ATs drive the risk?
- Phase II: Develop strategies to Mitigate unacceptable risk

Maine Air Toxics Priority Ranking

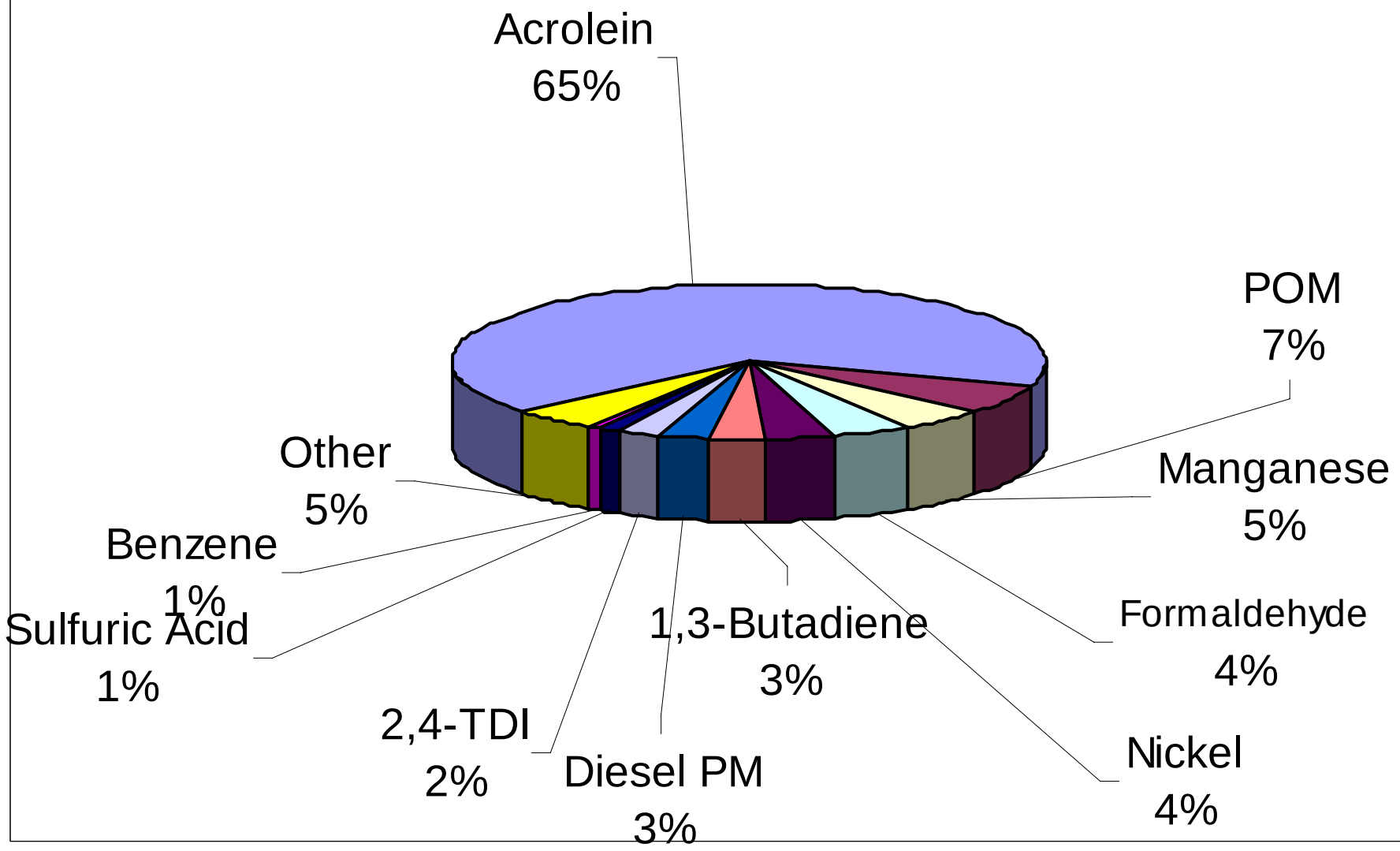
- Based on 2 factors:
  - Emission volume (State HAP inventory)
  - Toxicity (Toxicity Factors from RSEI)
- Also qualitatively consider
  - Transport (What pollutants come from "away")
  - Persistence (What is the pollutant's Residence time?)
  - Bioaccumulation (Do concentration increase up the food chain?)
- Real world check w/ AT monitoring data

Risk Screening Environmental Indicators Model (RSEI)

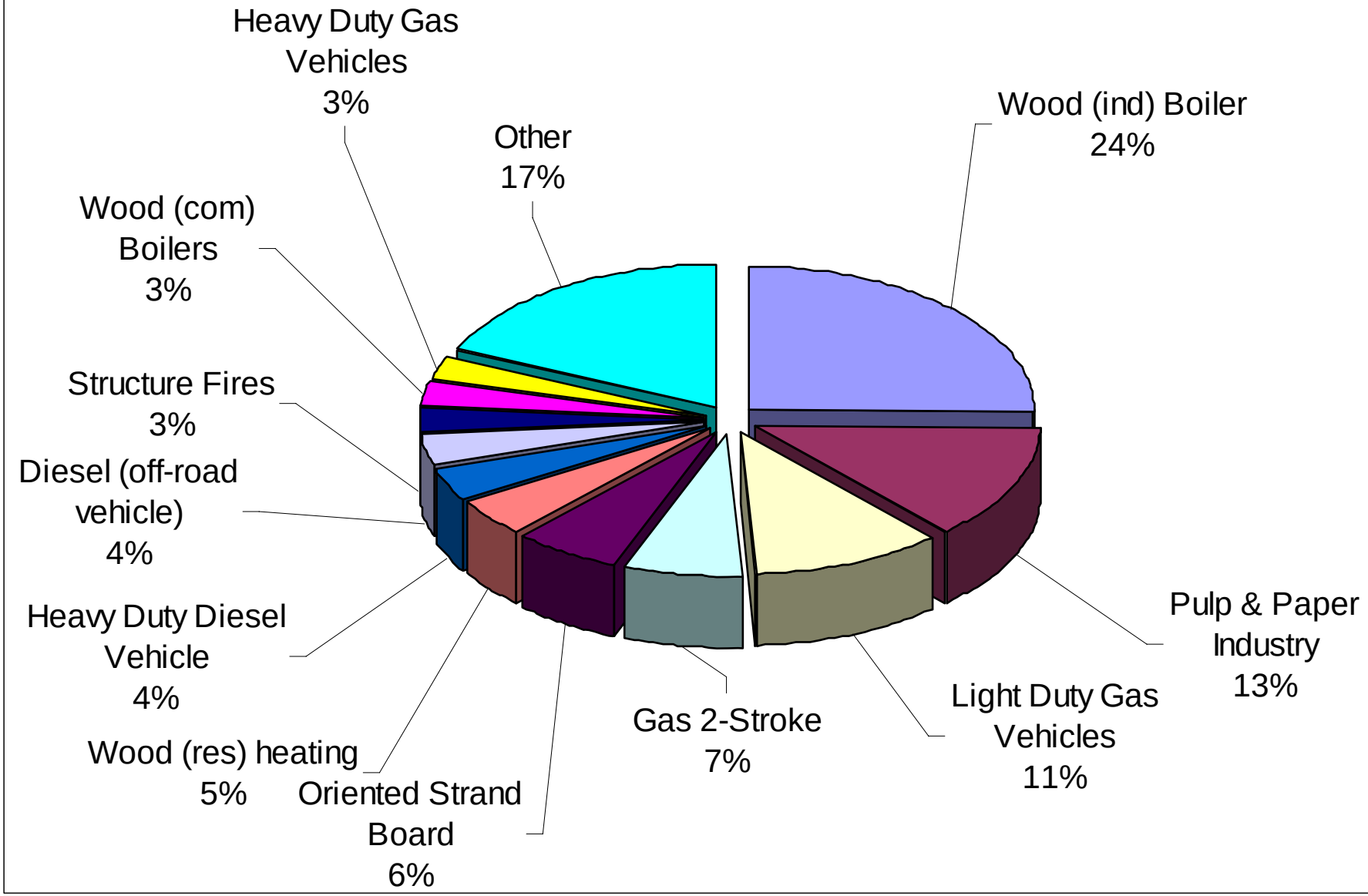
- EPA Risk model - Estimates impacts of TRI chemical releases, considering:
  - toxicity
  - exposure
  - population
- To develop Maine AT Priority List, Using only **RSEI Toxicity Factor** from the model



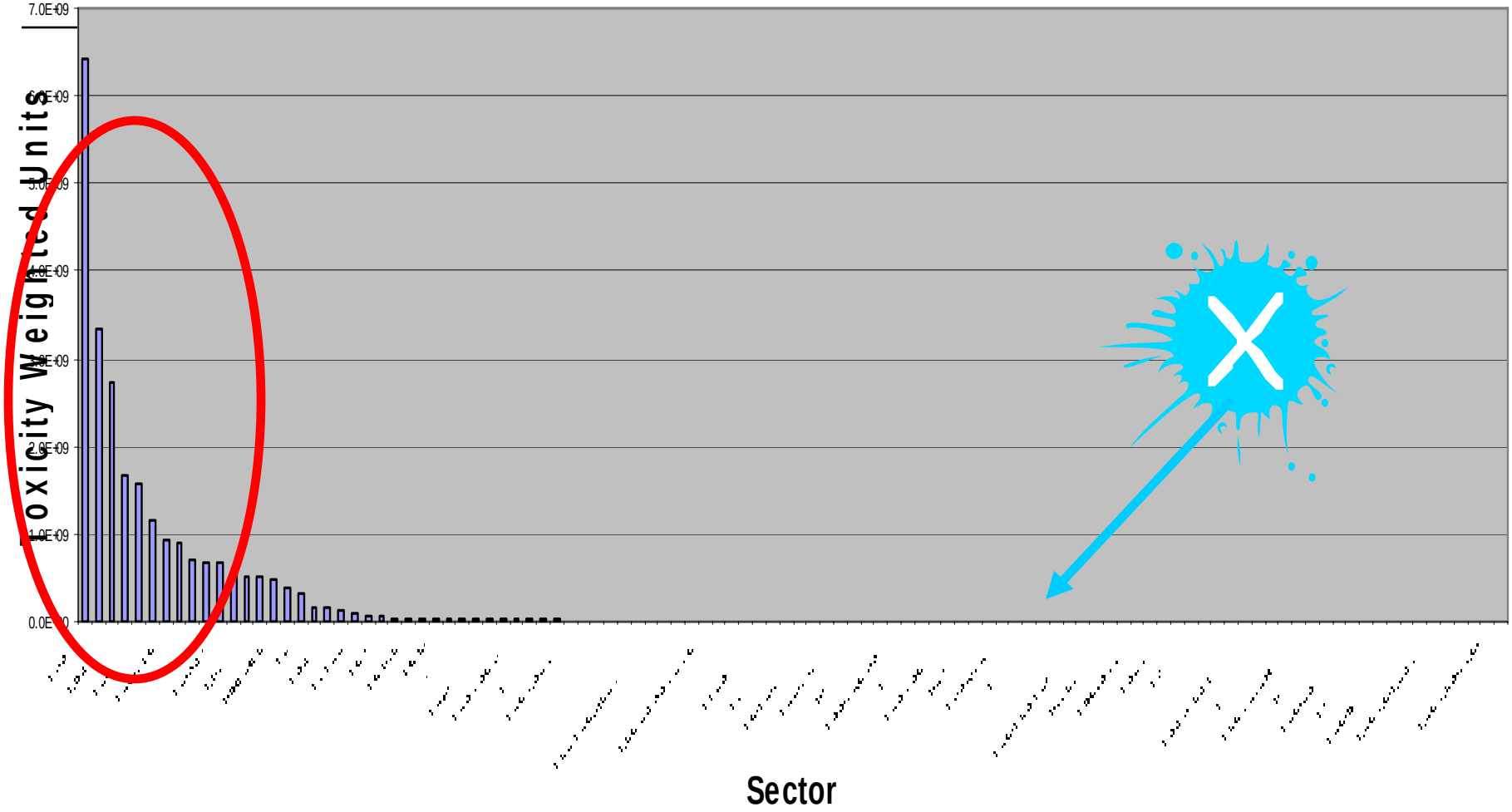
2005 Maine Tox-Weighted Emissions



Sources of Maine Emissions
(Based on 2005 Estimated Toxicity-Weighted Emissions)



Maine 2005 Statewide Toxicity-Weighted Emissions by Sector



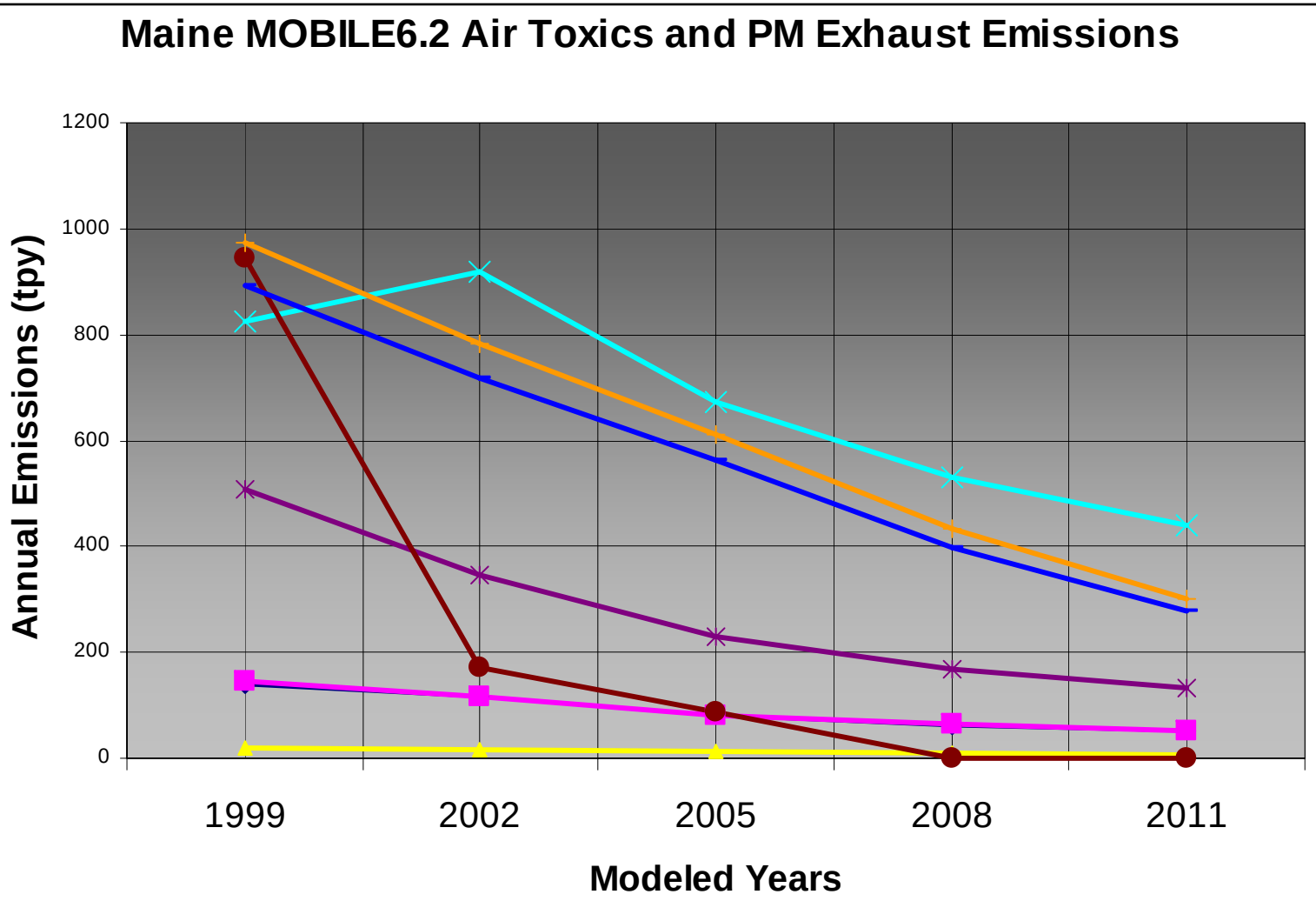
Toxicity-Weighting as an Inventory QA tool - Where to Focus QA/QC efforts?

HAP	TPY
Sulfuric Acid	9,007
Glycol Ethers	83
Styrene	67
Acrolein	61
Naphthalene	17
Chromium & Compounds	1

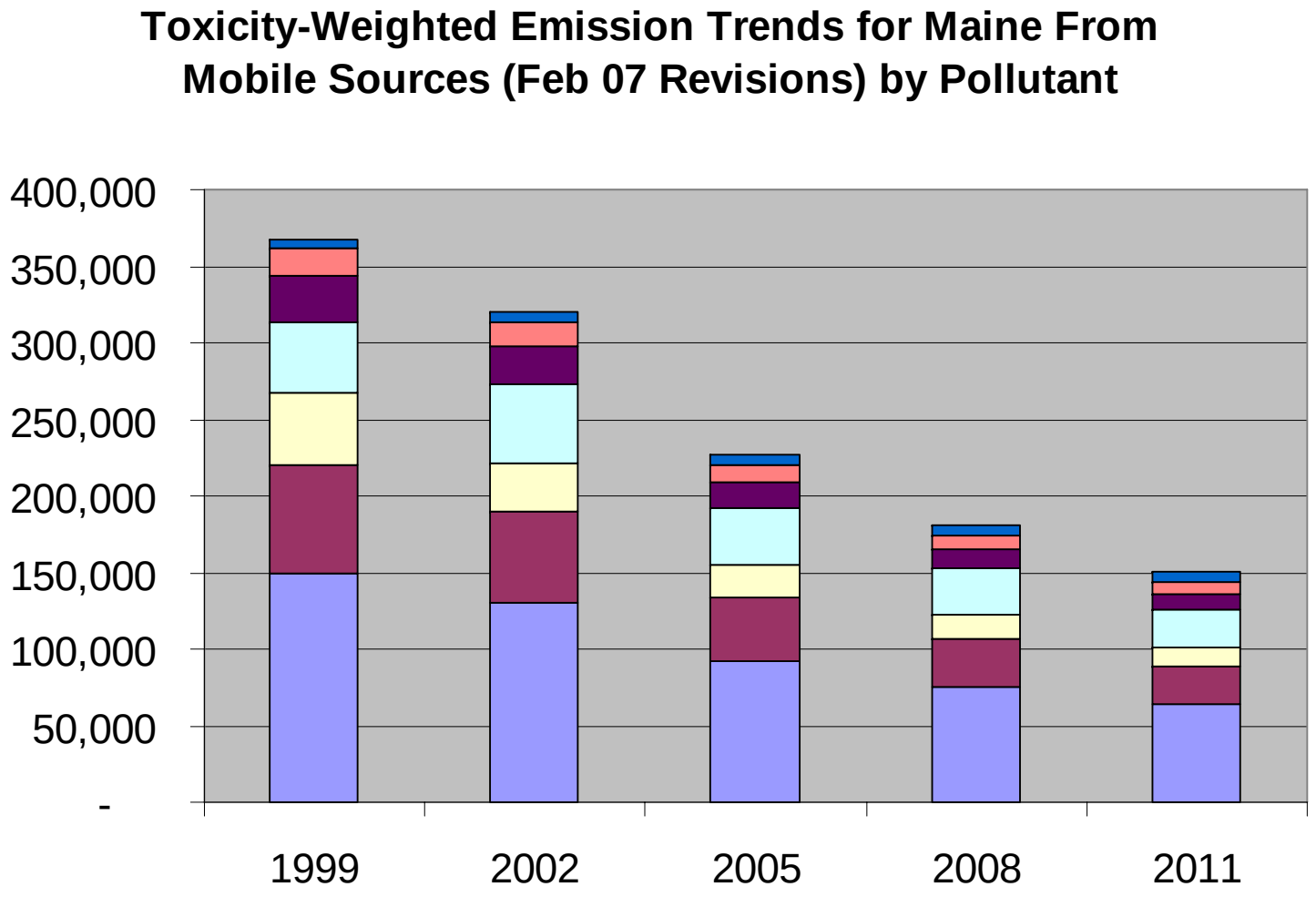
Where to Focus QA/QC efforts?

HAP	TF	* TPY =	TW-TPY
Sulfuric Acid	72	9,007	648,512
Acrolein	3600	61	218,357
Naphthalene	6400	17	106,747
Chromium & Cmpds	86000	1	99,556
Glycol Ethers	3.6	83	298
Styrene	0.072	67	5

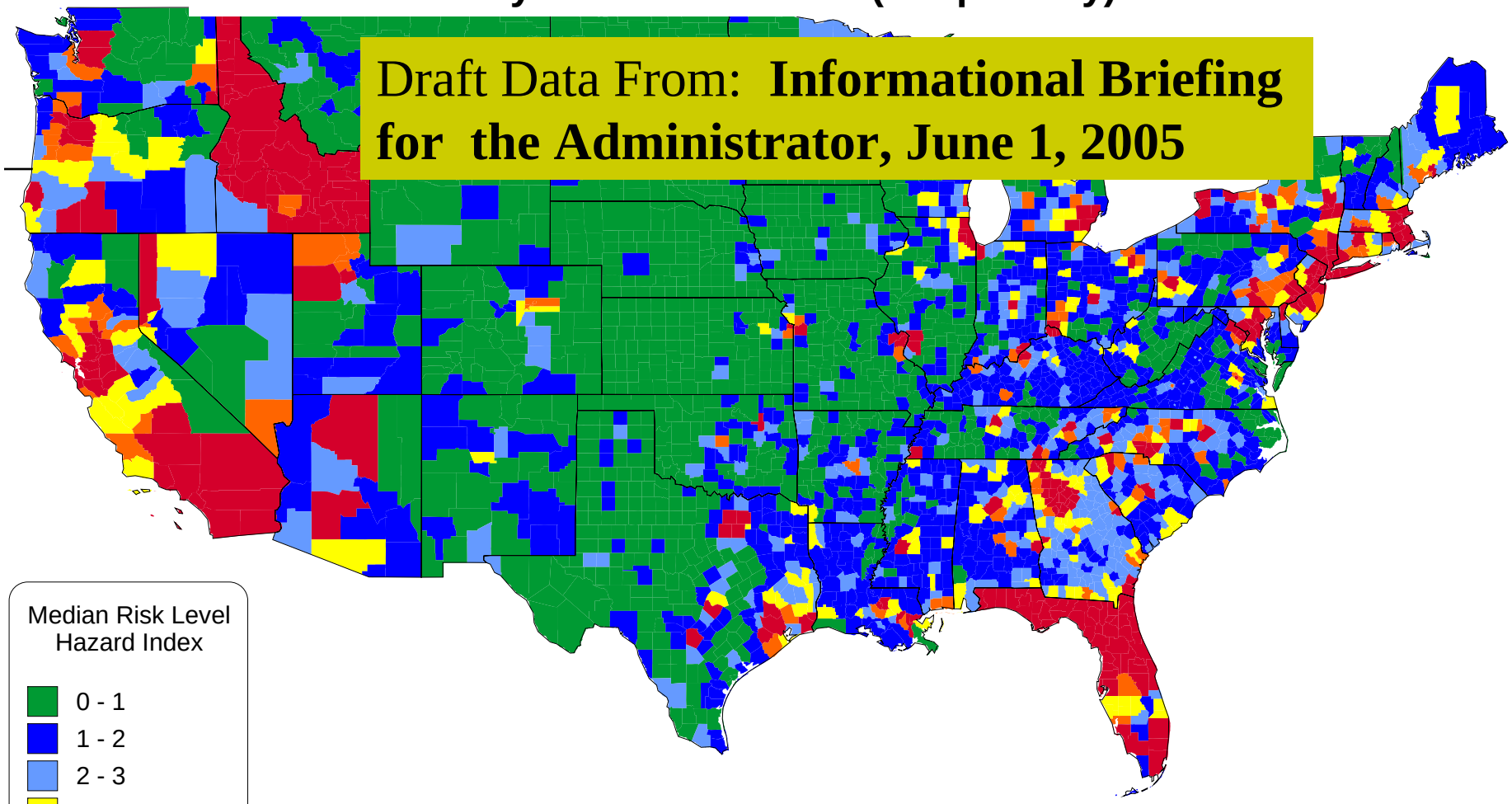
Mobile Source HAPs are declining
Is Risk Declining?



Mobile Source HAPs are declining
Is Risk Declining? Yes (Probably).



1999 NATA - National Scale Assessment
Predicted County Level Noncancer (Respiratory) Risk



Note: Idaho Risk Levels are suspect due to inventory issues related to fires

Over 40% of counties hazard index greater than 1
Several counties hazard index greater than greater than 10
High values in Florida and Idaho from forest fires

Why toxicity-weight? QA Model Inputs NATA Model to Monitoring Comparisons

Pollutant	Within Factor of 2	Within 30%	Under Estimated
Benzene	89%	59%	59%
Formaldehyde	53%	28%	88%
Acetaldehyde	59%	22%	91%
Lead	18%	10%	91%
Cadmium	15%	5%	85%
Chromium	28%	19%	83%

From: NATA Website, Model to Monitor Comparisons, Table 8: http://www.epa.gov/ttn/atw/nata/draft6.html#secV

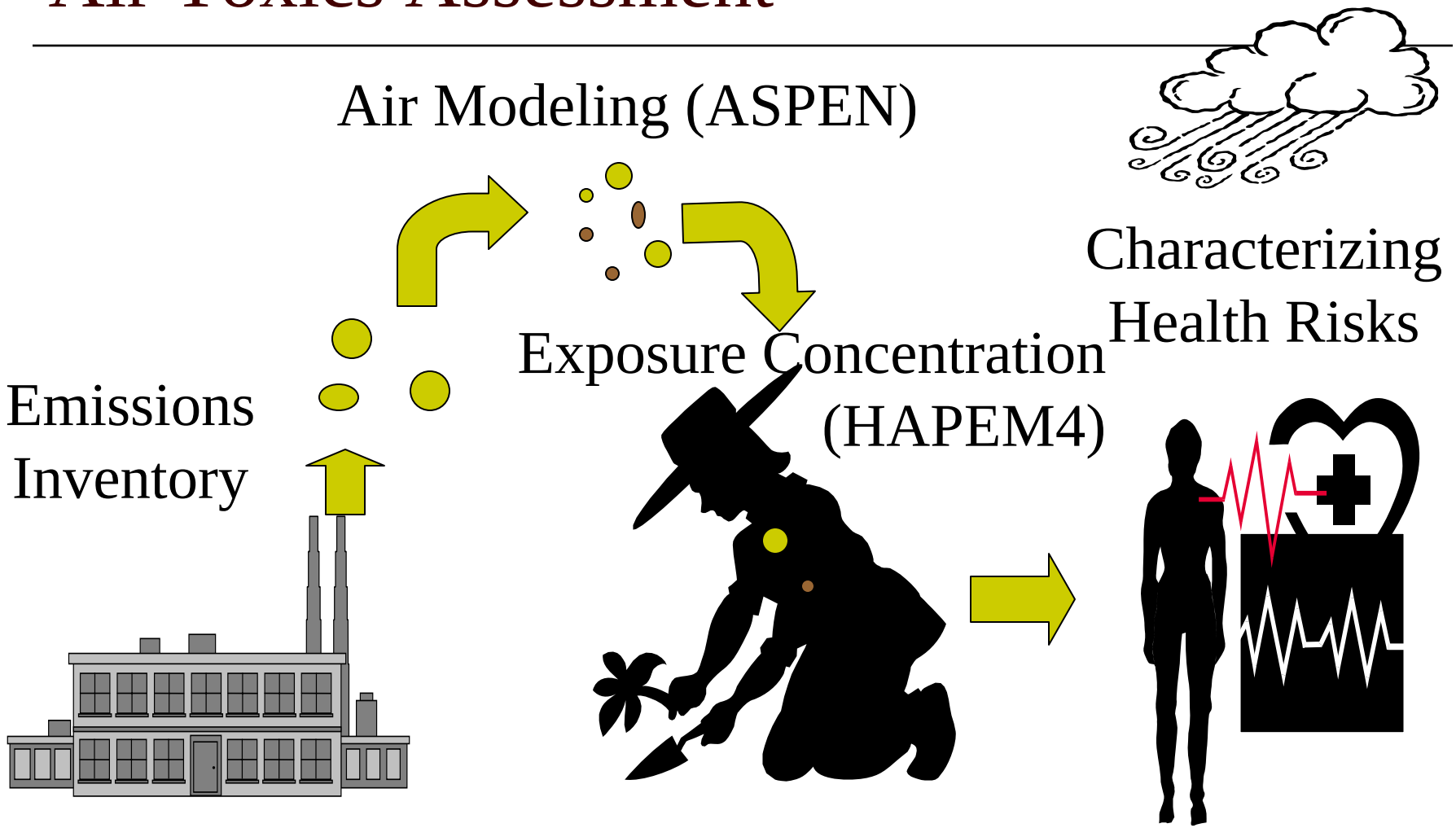
What is the basis for toxicity-weighting?

The underlying risk theory

Basic Risk Assessment Calculation

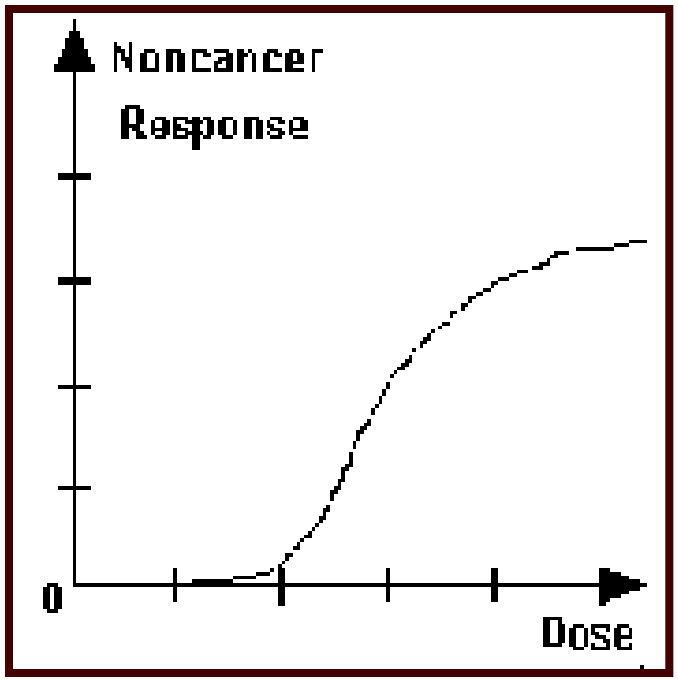
Risk = Intake * Toxicity

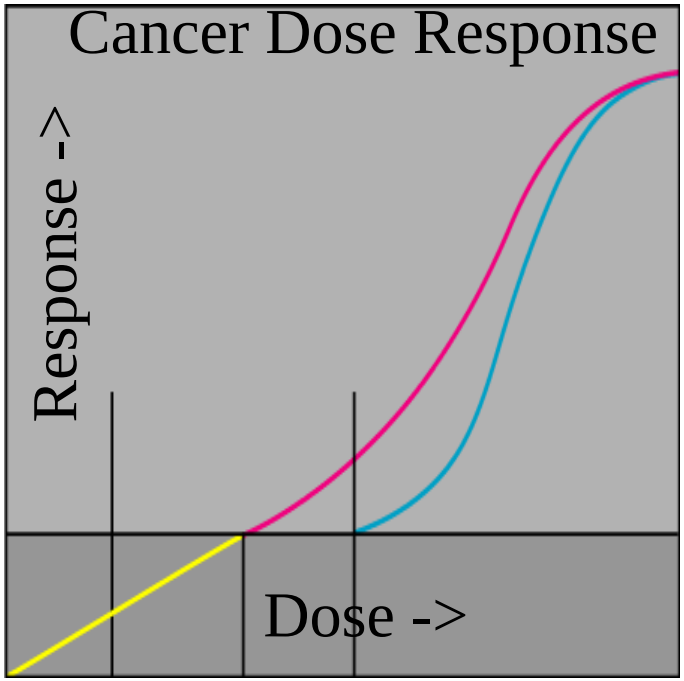
Risk Assessment Process – e.g. National Air Toxics Assessment



Development of Maine DEP Toxicity-Factors

- Risks from Carcinogens and Non-carcinogens are usually calculated separately





Simple Risk Assessment Formulas

- Noncancer Risk:

$$HQ = EC/RfC$$

- Cancer Risk:

$$ILCR = EC*IUR$$

EPA OAQPS lists IURs & RfCs: http://www.epa.gov/ttn/atw/toxsource/summary.html

- Where:

ILCR- Incremental Lifetime Cancer Risk

HQ- Hazard Quotient

IUR- Inhalation Unit Risk

RfC- Reference Concentration

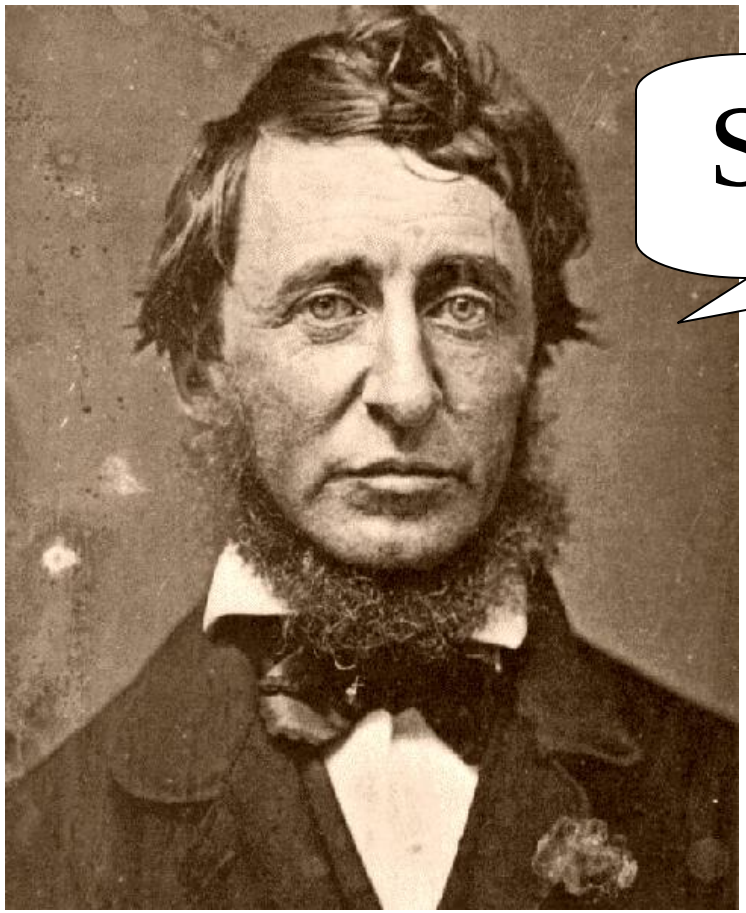
EC- Exposure Concentration

How do you assess Priority between Non-Cancer & Cancer Risks????

HAP-Cancer
B(a)P
Benzene
Cr (VI)
Diesel $PM_{2.5}$
Dioxin TEQ

HAP-noncancer
Acrolein
Benzene
Cr (III)
Diesel PM 2.5
Toluene

Melding the two lists: Carcinogens and Non-carcinogens



Simplify!!!

Calculating Risk

- Noncancer Risk:

  HQ = EC/RfC

- Cancer Risk:

  ILCR = EC*IUR

- Where:

  ILCR- Incremental Lifetime Cancer Risk

  HQ- Hazard Quotient

  IUR- Inhalation Unit Risk

  RfC- Reference Concentration

  EC- Exposure Concentration

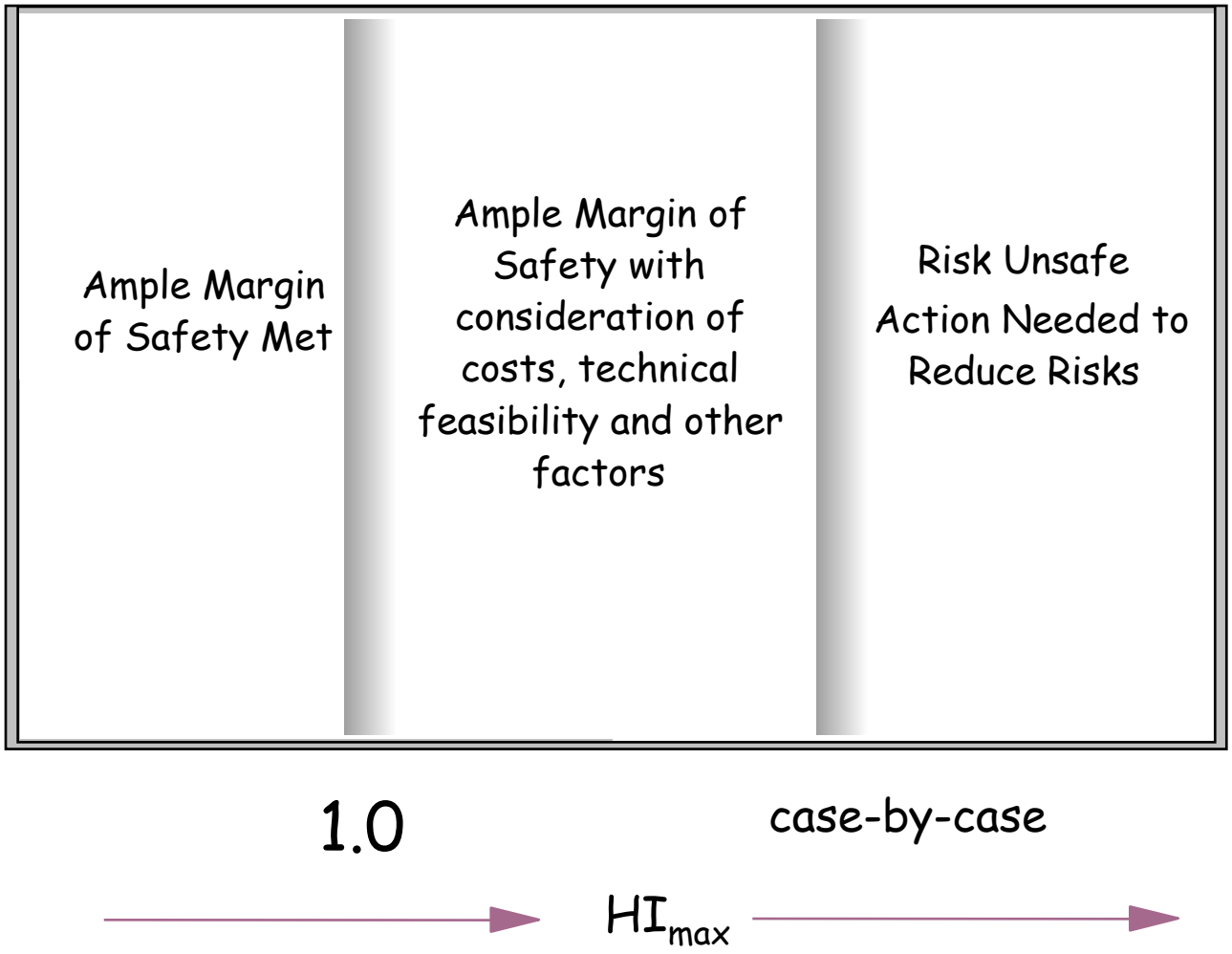
Melding the two lists: Carcinogens and Non-carcinogens

- Risk End Points determine relationship of Toxicity Factors for Carcinogens and Non-Carcinogens

What is Acceptable Risk?

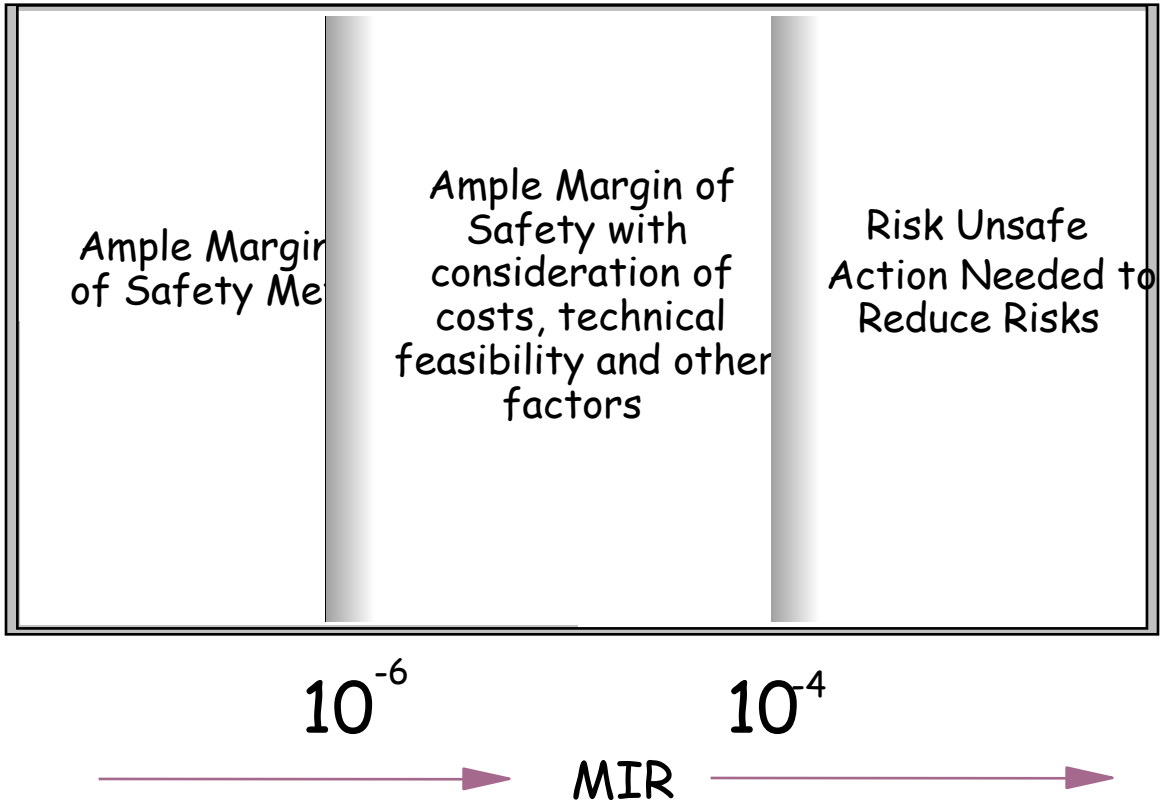
Relevant Non-Cancer Hazard Range

(Copied from: Kenneth Mitchell, EPA Region 4: Risk Assessment and the Air Toxics Program)



Relevant Cancer Risk Range

(Copied from: Kenneth Mitchell, EPA Region 4: Risk Assessment and the Air Toxics Program)



Calculating Risk

- Noncancer Risk:

$$HQ = EC/RfC$$

- Cancer Risk:

$$ILCR = EC*IUR$$

	RSEI	Maine
=	1	1
=	$2.5*10^{-5}$	10^{-5}

- Where:

ILCR- Incremental Lifetime Cancer Risk

HQ- Hazard Quotient

IUR- Inhalation Unit Risk

RfC- Reference Concentration

EC- Exposure Concentration

Calculating Risk – Solving for Exposure Concentration

- Noncancer Risk:

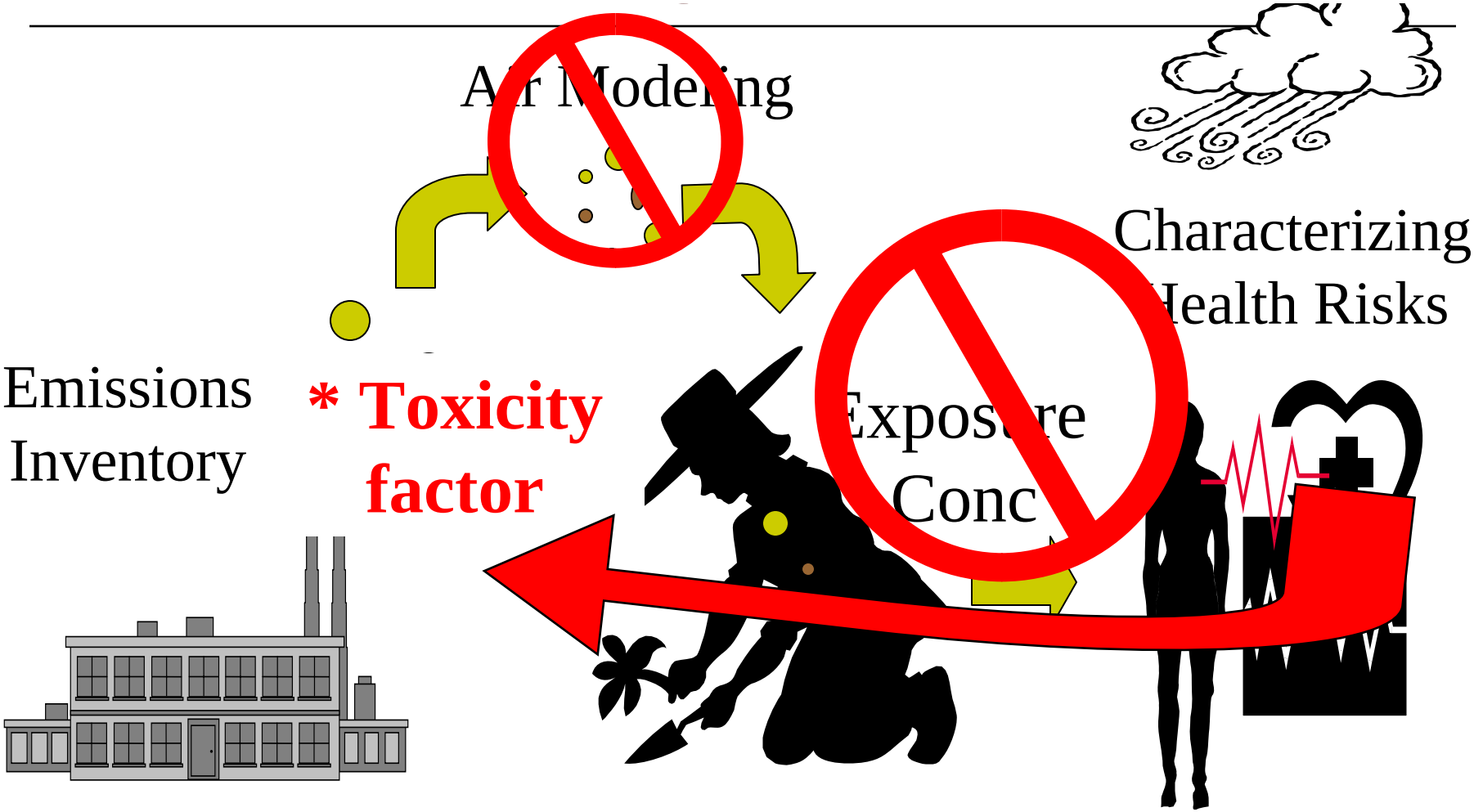
$$HQ = EC/RfC = 1$$

- Cancer Risk:

$$ILCR = EC * IUR = 10^{-5}$$

- Noncancer $EC = 1 * RfC$
- Cancer Risk $EC = IUR/10^{-5}$

Toxicity - Weighting



Deriving Toxicity Factor

- Simplify: Assume EC = TF
- Therefore:
  - Noncancer EC=1*RfC = TF noncarcinogen
  - Cancer Risk EC=IUR/10^{-5} = TF cancer
- Now NOT risk assessment, only *relative* risk of HAP emissions

Toxicity Factor = The Greater of:

- The toxicity Factor based on carcinogenic impacts

OR

- Toxicity Factor based on noncancer impacts

Unifying Non-Cancer & Cancer Risks

HAP	TF Cancer		
Dioxin TEQ	271,428,576		
B(a)P	6,400		
Acrolein			
Benzene	56		
Cr (VI)	86,000		
Cr (III)			
Diesel PM 2.5	2,100		
Toluene			

Unifying Non-Cancer & Cancer Risks

HAP	TF Cancer	TF Noncancer	
Dioxin TEQ	271,428,576		
B(a)P	6,400		
Acrolein		3,600	
Benzene	56	2	
Cr (VI)	86,000	720	
Cr (III)		0.01	
Diesel PM 2.5	2,100	14	
Toluene		0.18	

Unifying Non-Cancer & Cancer Risks

HAP	TF Cancer	TF Noncancer	**Maine TF**
Dioxin TEQ	271,428,576		**271,428,576**
B(a)P	6,400		**6,400**
Acrolein		3,600	**3,600**
Benzene	56	2	**56**
Cr (VI)	86,000	720	**86,000**
Cr (III)		0.01	**0.01**
Diesel PM 2.5	2,100	14	**2,100**
Toluene		0.18	**0.18**

Unified Toxicity-Factor table

HAP	Maine TF
Dioxin TEQ	271,428,576
Cr (VI)	86,000
B(a)P	6,400
Acrolein	3,600
Diesel PM 2.5	2,100
Benzene	56
Toluene	0.18
Cr (III)	0.01

Calculating Risk – Suburbanization of Maine

Sources of Toxicity Factors

- Risk Screening Environmental Indicators Model: http://www.epa.gov/oppt/rsei/pubs/tech_app_a_v212.pdf
- Maine DEP, Maine Air Toxics Initiative: http://www.maine.gov/dep/air/toxics/mati-docs.htm
- USEPA, 2002 NEI documentation: http://www.epa.gov/ttn/chief/net/2002inventory.html

Toxicity weighted Emissions =

Emissions * Toxicity-factor

Next Steps & Pending Issues

- Standardization of Toxicity Factors
- Maintenance: Updating Factors based on new toxicological information
- **Chromium Speciation**
- Derivation of values for missing toxicity-factors
  - Use of industrial hygiene information
- Polycyclic Organic Matter
- Persistence
- Bioaccumulation

Unified Toxicity-Factor table

HAP	Maine TF
Dioxin TEQ	271,428,576
Cr (VI)	86,000
B(a)P	6,400
Acrolein	3,600
Diesel PM 2.5	2,100
Benzene	56
Toluene	0.18
Cr (III)	0.01

Next Steps & Pending Issues

- Standardization of Toxicity Factors
- Maintenance: Updating Factors based on new toxicological information
- Chromium Speciation
- Derivation of values for missing toxicity-factors
  - Use of industrial hygiene information
- Polycyclic Organic Matter
- Persistence
- Bioaccumulation

Thanks

- The Air Toxics Advisory Committee
- EPA
- Inventory & AT staff
- Licensing Staff
- Meteorological Group
- Monitoring & Analysis Group
- Management
- NESCAUM, Casco Bay Project
- Etc.

For More Information

David Wright
Air Toxics & Emissions Inventory Section
Bureau of Air Quality, DEP
17 SHS, Augusta, ME 04333-0017

207-287-6104

David.W.Wright@Maine.Gov

http://www.maine.gov/dep/air/toxics/mati.htm