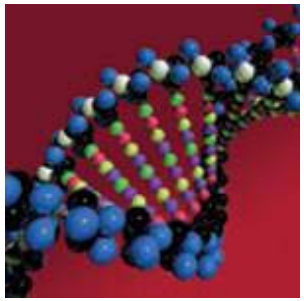
Baseline Ecological Risk Assessment



Undeveloped Stony Creek Floodplain

Noblesville, Indiana

May 21, 2009

ENVIRON

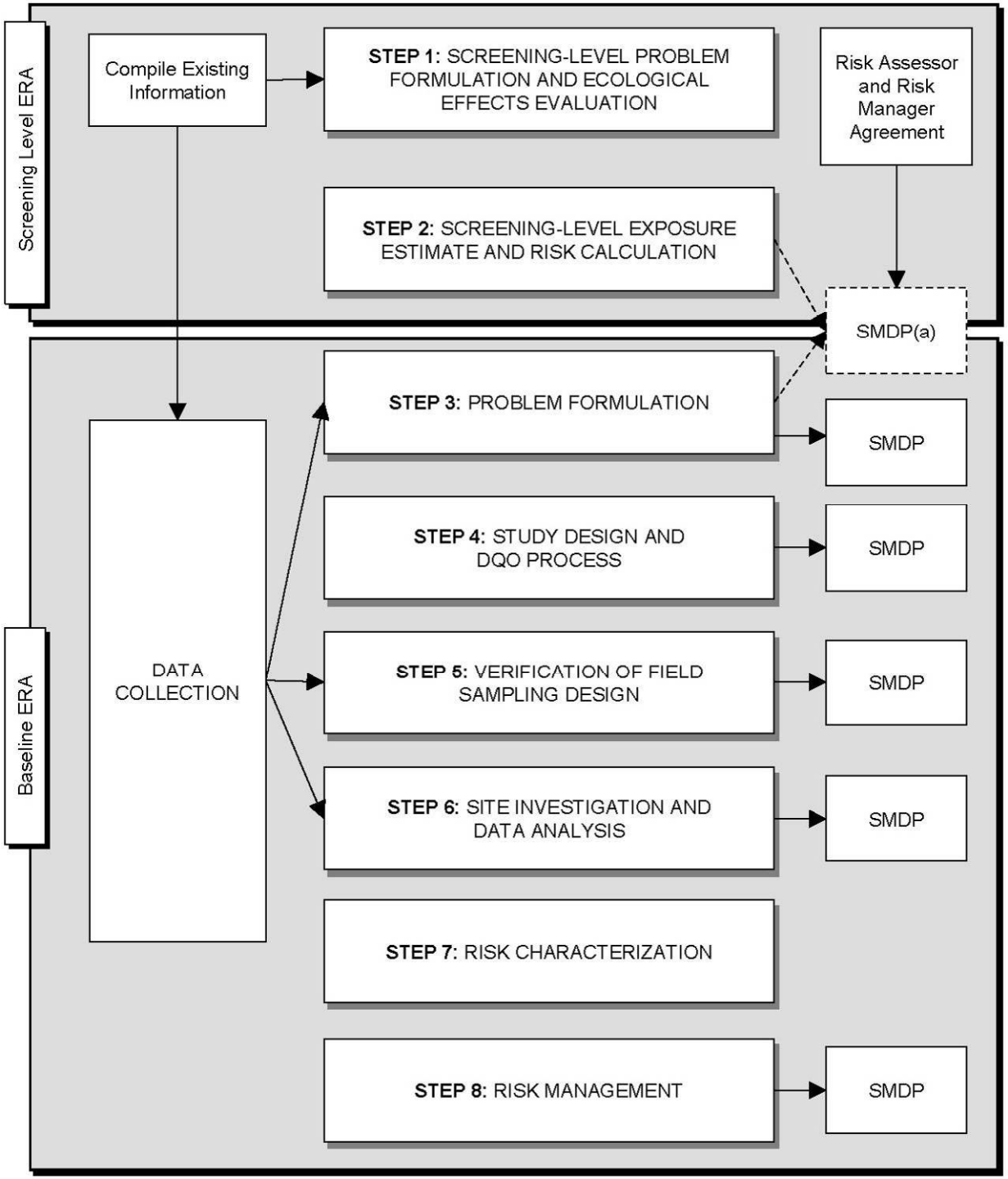
Presentation Overview

1. Background
2. Problem formulation
3. Exposure assessment
4. Effects assessment
5. Risk characterization
6. Conclusions and questions

Introduction

- Overall goal - characterize nature and extent of any risks posed to wildlife inhabiting the study area from PCBs in floodplain soil or prey
- Exclusive focus on PCBs consistent with 3/29/2001 Administrative Order on Consent (AOC)
- Methods consistent with
  - USEPA guidance (1992, 1997, 1998, 2001)
  - USEPA-approved risk assessment work plan (ENVIRON 2008)
  - SETAC session on ecological effects assessment (Allard et al. 2007a, b, Sample et al. 2007)

USEPA Ecological Risk Assessment Process

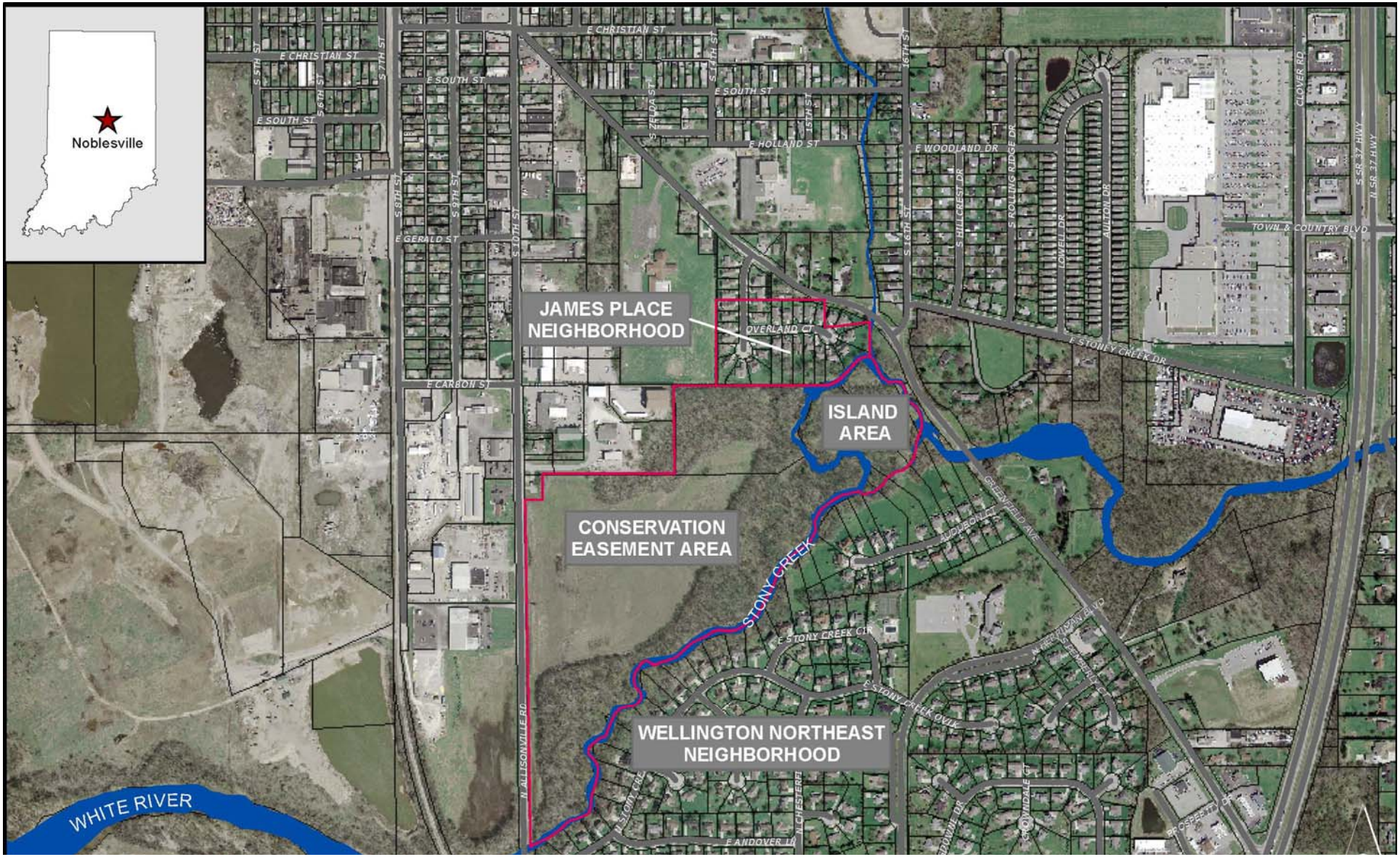


SMDP: Scientific Management Decision Point

BERA Framework

1. **Problem formulation** – establishes goals, breadth, focus; planning step that identifies factors to be considered…linked to the regulatory and policy context of the assessment
2. **Effects assessment** – analyzes relationship between stressor and assessment and measurement endpoints
3. **Exposure assessment** – evaluates interaction of the stressor with the receptor
4. **Risk characterization** - evaluates likelihood of adverse effects as a result of exposure to stressor

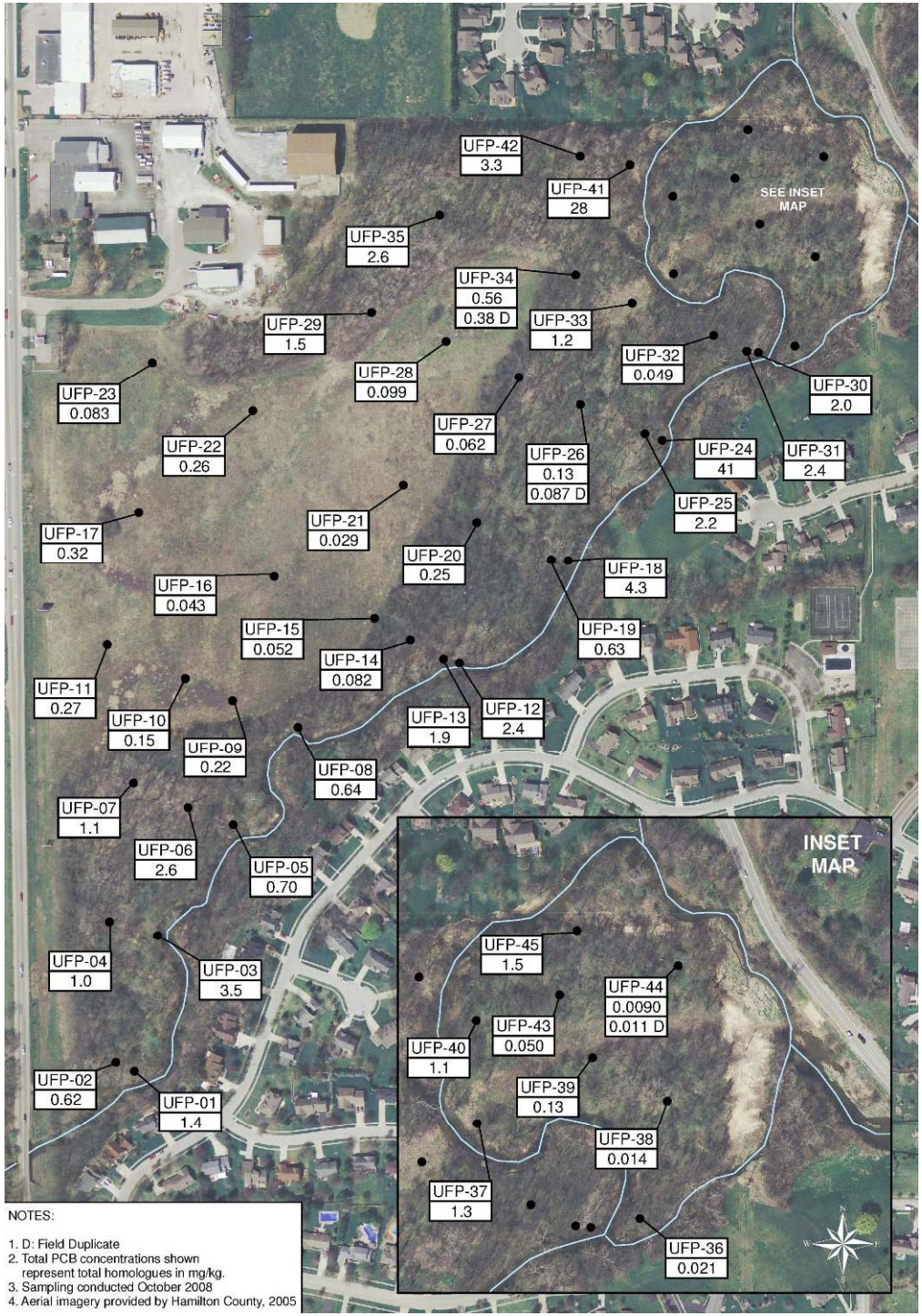
Study Area Location



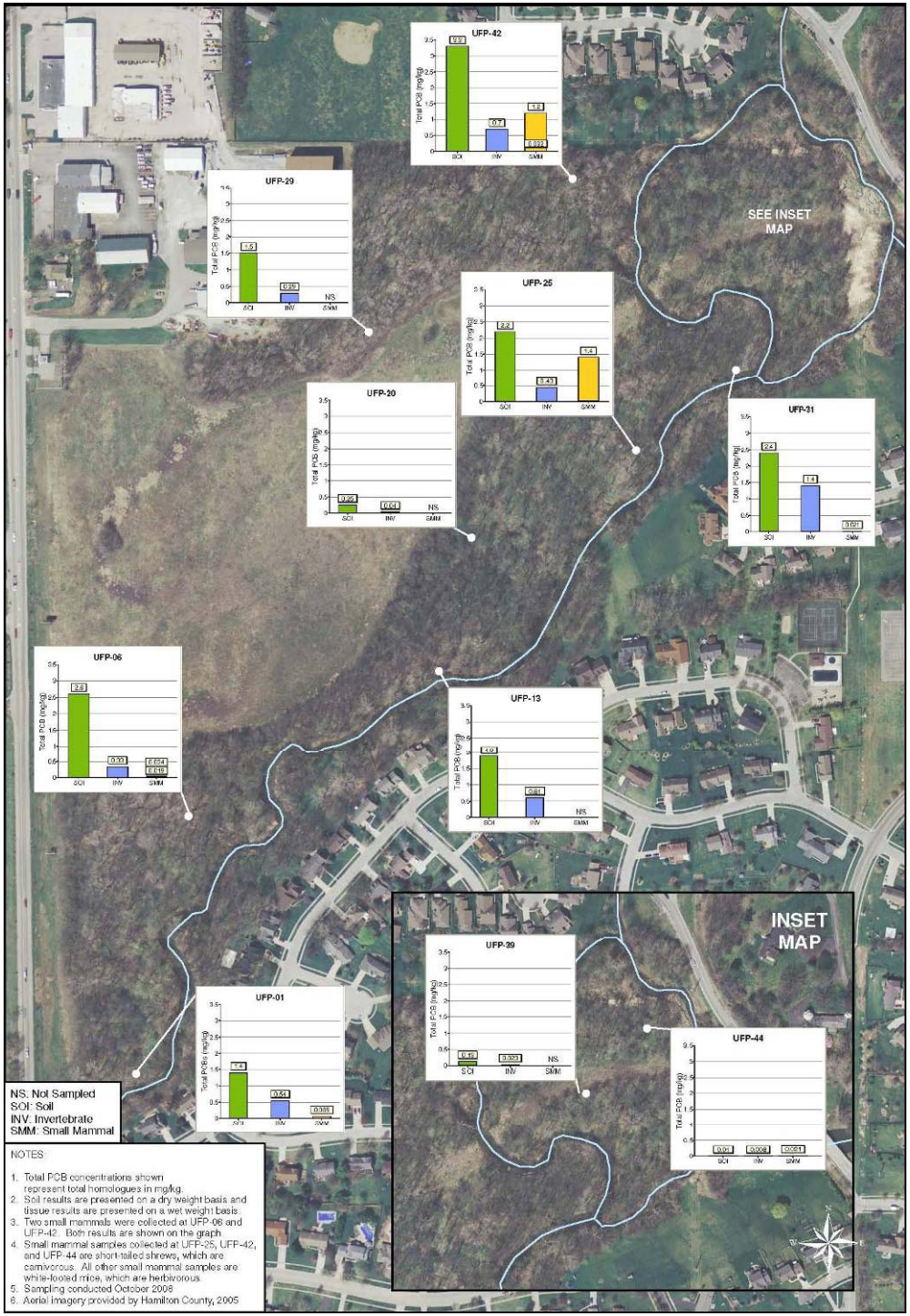
Setting

- Generally wooded and flat
  - 37 acres forested
  - 22 acres oldfield habitat
- National Wetland Inventory defines much of study area as Palustrine Forested, Broad-Leaved Deciduous, Seasonally Flooded (PFO1C)
- Study area zoning = flood hazard
  - Surrounding land zoned for single family residential, general business, and heavy industrial
- Divided into Conservation Easement Area (CEA) and Island Area

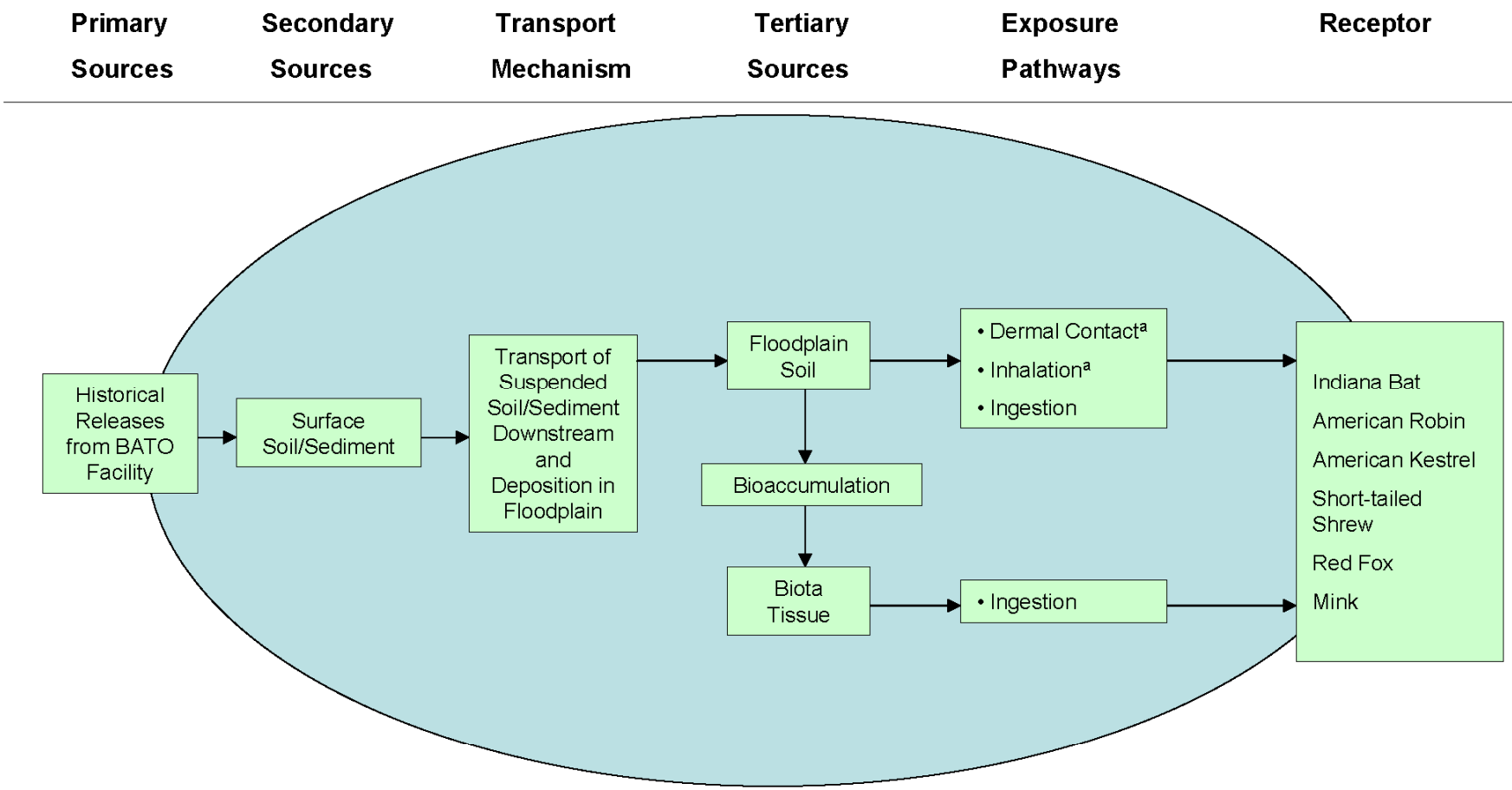
Chemical Characterization: PCBs in Soil (mg/kg)



Chemical Characterization: PCBs in Biota (mg/kg)



Problem Formulation



BATO: Bridgestone Americas Tire Operations, LLC

a. Dermal contact with and inhalation of chemicals in floodplain soil are minimal, and limitations with toxicological and exposure information preclude assessment of these exposure pathways.

Receptors of Interest

- American robin
- American kestrel
- Short-tailed shrew
- Red fox
- Mink
- Indiana bat

ENVIRON

Assessment Endpoints

1. Survival, reproduction, and growth of invertivorous and carnivorous bird populations foraging in the floodplain of Stony Creek

2. Survival, reproduction, and growth of insectivorous and carnivorous mammal populations foraging in the floodplain of Stony Creek

Why Populations?

- Populations are groups of interbreeding individuals of a single species, occurring within a geographic area

- "Regulations, policies, directives, and guidance documents frequently discuss the need for ecological risk assessments to consider risks to populations, not simply to individual organisms or organism-level attributes. The reason for this is that, from a management perspective, the population-level attributes, such as abundance, persistence, age composition, and genetic diversity are usually more relevant than are the health or persistence of individual organisms."

Barnthouse et al. (2008)

Measurement Endpoints: Birds

- Survival, reproduction, and growth of birds, as estimated by
  - Comparing most likely and high end **doses** of PCBs by **American robins** to toxicity data (expressed as dose) derived from the scientific literature
  - Comparing most likely and high end **doses** of PCBs by **American kestrels** to toxicity data (expressed as dose) derived from the scientific literature

Measurement Endpoints: Mammals

- Survival, reproduction, and growth of mammals, as estimated by
  - Comparing most likely and high end **doses** of PCBs by **short-tailed shrews** to toxicity data (expressed as dose) derived from the scientific literature
  - Comparing most likely and high end **doses** of PCBs by **red fox** to toxicity data (expressed as dose) derived from the scientific literature
  - Comparing most likely and high end **doses** of PCBs by **mink** to toxicity data (expressed as dose) derived from the scientific literature
  - Comparing most likely and high end **body burdens** of PCBs by **mink** to toxicity data (expressed as tissue concentration) derived from the scientific literature
  - Comparing high end **dose** of PCBs by **Indiana bats** to no-effect toxicity data (expressed as dose) derived from the scientific literature

ENVIRON

Exposure Assessment Methods

- Dose calculation based on USEPA (1993):

$$DI = [\Sigma(C_{diet} \times FIR) + (C_s \times SIR)] \times AF \times AUF \times (1/BW)$$

- Body burden (mink only) based on Fuchsman et al. (2008):

$$C_{wb} = \Sigma C_{diet} \times (A_i \times D) / K_i \times (1 - e^{-K_i t})$$

- Estimated <u>Most Likely</u> and <u>High End</u> exposures
  - Most Likely: average exposure within population
  - High End: highly exposed individuals within population

Exposure Point Concentrations

- Based on 2008 sampling program data for soil, invertebrates, and rodents
- Contact assumed periodic and random
  - Mean concentrations used for Most Likely exposures
  - 95% UCL concentrations used for High End exposures

Medium	n	Most Likely EPC (mg/kg)	High End EPC (mg/kg)
Soil	45	2.5	5.5
Plants	N/A	0.026	0.057
Inverts	10	0.44	0.70
Rodents	8	0.35	0.81

Example Exposure Calculations: Robin

Parameter		Values	Units	Source
Body Weight	BW	0.077	kg	USEPA 1993
Total Normalized Ingestion Rate	NIR	0.80	g/g-day	USEPA 1993
Food Ingestion Rate	FIR	0.062	kg ww/day	BW x NIR
Fraction of Diet as Plants	Ftp	28%	unitless	USEPA 1993
Fraction of Diet as Invertebrates	Fti	72%	unitless	USEPA 1993
Soil Ingestion Rate	SIR fraction	0.104	proportion plant diet	Beyer et al. 1994[a]
	SIR	0.0004	kg dw/day	
Foraging Range	FR	0.37	acres	USEPA 1993
Area Use Factor	AUF	1.0	unitless	FR < Site Area

ENVIRON

Example Exposure Calculation: Robins (cont'd)

	Surface Soil		Terrestrial Plants		Terrestrial Inverts		All Pathways	
	Most Likely	**High End**	**Most Likely**	**High End**	**Most Likely**	**High End**	**Most Likely**	**High End**
EPCs (mg/kg)	2.5	5.5	0.026	0.057	0.4	0.7		
Dose (mg/kg-day)	0.012	0.026	0.0059	0.0130	0.25	0.40	0.27	0.44
% of Dose	4%	6%	2%	3%	93%	91%	100%	100%

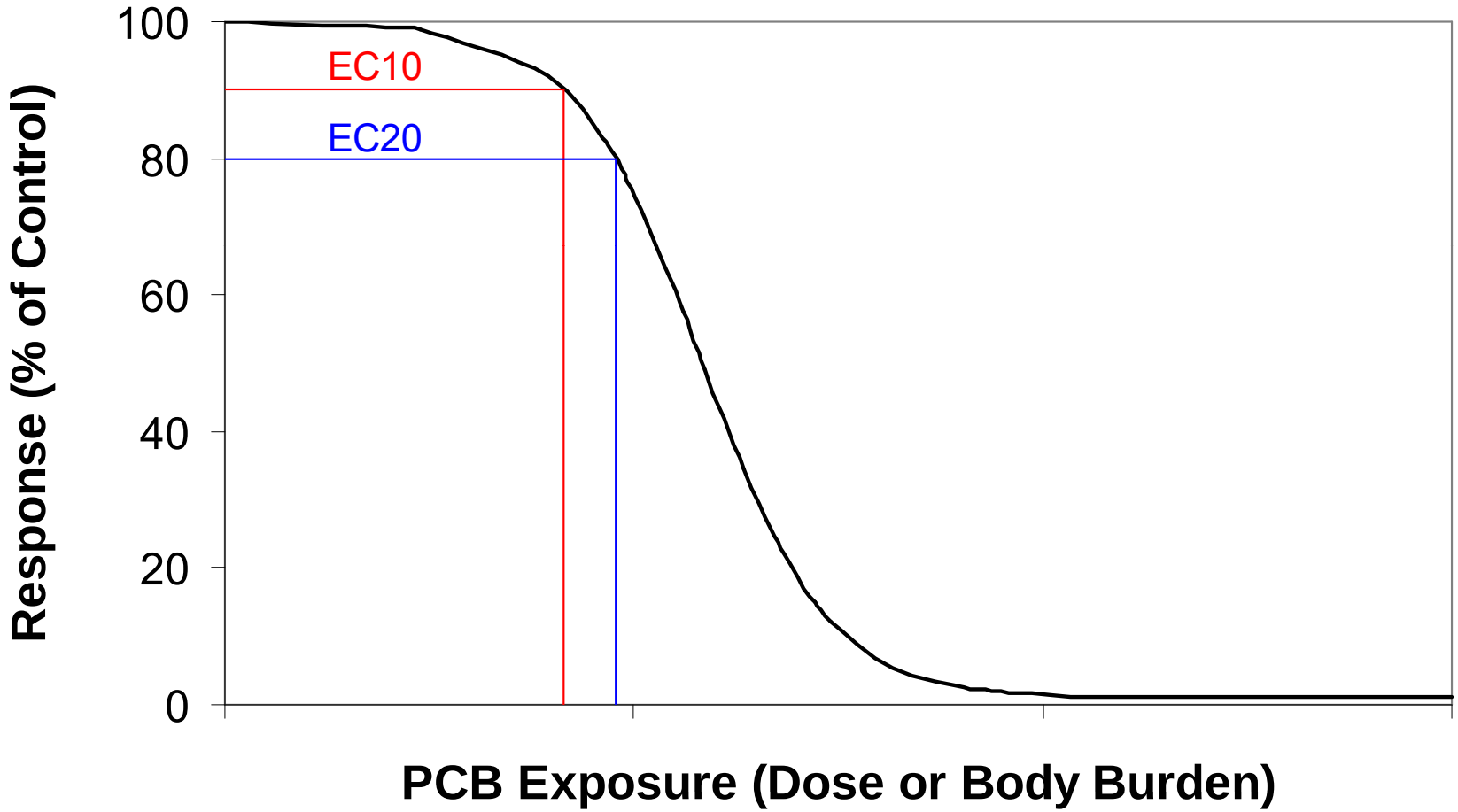
Mink Exposure: Modeled Body Burden

PCB Homologue	Homologue Concentration in Diet (mg/kg ww)	Homologue Daily Intake (mg/kg-day)	Whole-body Total PCBs in Mink (mg/kg)
Monochlorobiphenyls	0.000092	0.0000016	0.0000028
Dichlorobiphenyls	0.000092	0.0000016	0.0000005
Trichlorobiphenyls	0.0026	0.00004	0.000020
Tetrachlorobiphenyls	0.064	0.0011	0.0020
Pentachlorobiphenyls	0.21	0.0036	0.012
Hexachlorobiphenyls	0.064	0.0011	0.031
Heptachlorobiphenyls	0.0087	0.00015	0.0040
Octachlorobiphenyls	0.0018	0.000031	0.00085
Nonachlorobiphenyls	0.00072	0.000012	0.00037
Decachlorobiphenyl	0.000092	0.0000016	0.000047
Total PCBs			**0.050**

Effects Assessment

- Followed recent guidance of Sample et al. (2007) and Allard et al. (2007a,b)
- Use <u>dose response curves</u> where possible
  - EC10: concentration resulting in 10% decrease in response from control
  - EC20: concentration resulting in 20% decrease in response from control
- Use species-specific study NOAEL and LOAEL, if insufficient data for dose response curve

Example Dose Response Curve



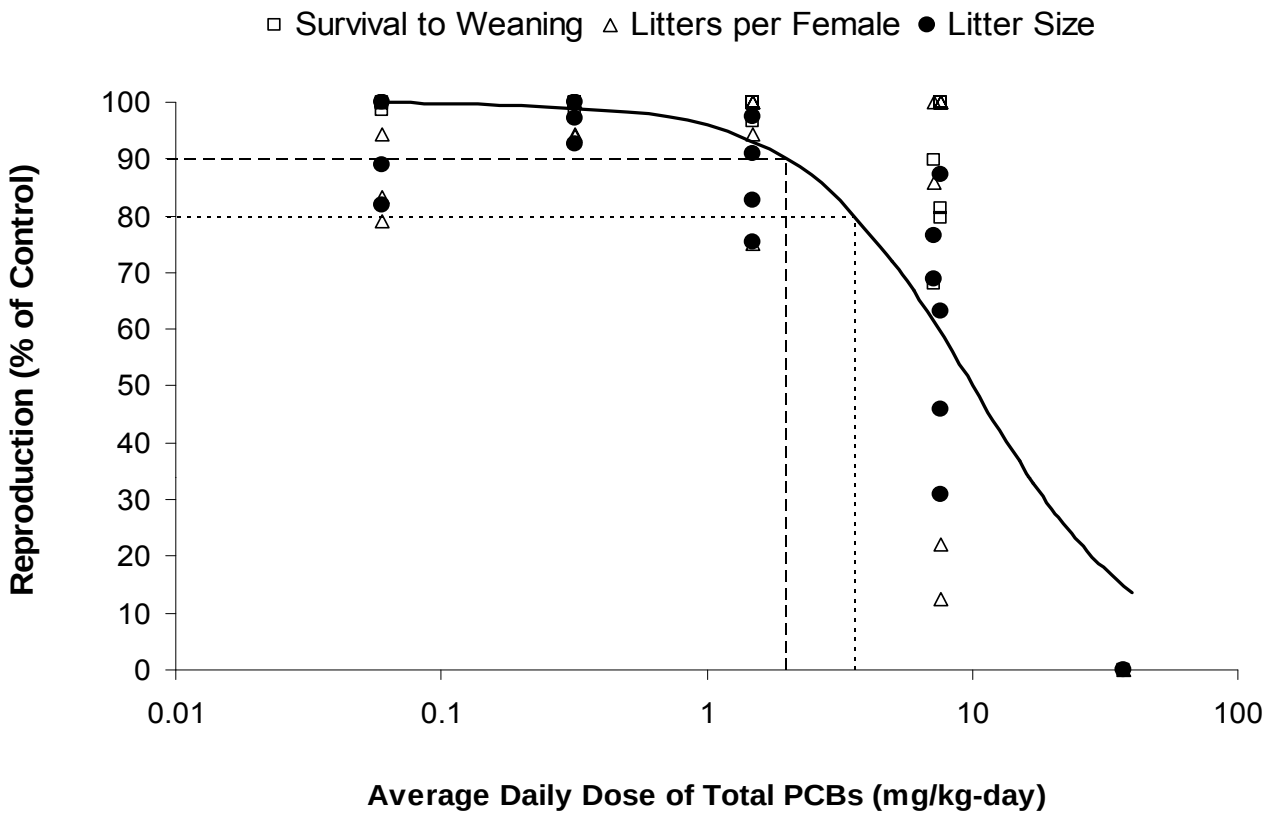
ENVIRON

Reproductive Toxicity Studies for Birds

Aroclor	Test Species	Days	NOAEL (mg/kg-day)	LOAEL (mg/kg-day)	Reference
1254	Mallard	30	8.1	NR	Custer and Heinz 1980
1254	Pheasants	112	1.8	7.1	Dahlgren et al. 1972
1248, 1254, 1260	American kestrel	100	NR	7	Fernie et al. 2001, 2003
1242	Mallard		42	NR	Haseltine and Prouty 1980
Total PCBs	Robins	Breeding season	7.8	NR	Henning et al. 2003
1254	Chicken	63	NR	0.12	Lillie et al. 1974
1248	Screech owl	360	0.41	NR	McLane and Hughes 1980
1254	Mourning dove	42	NR	2.6	Tori and Peterle 1983

Reproductive Toxicity Studies for Mammals (Except Mink)

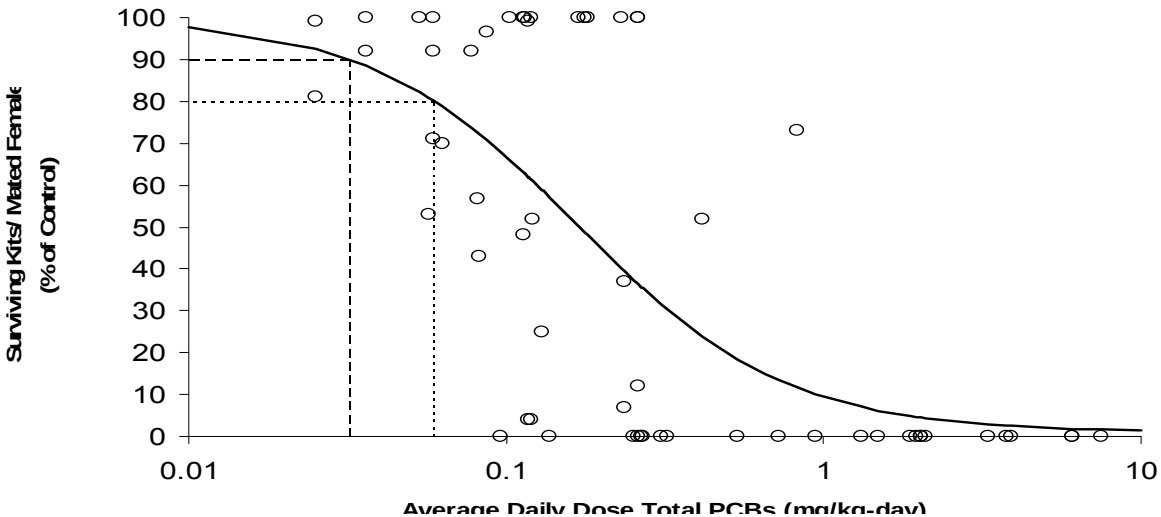
Aroclor	Test Species	Days	NOAEL	LOAEL	Reference	Units
1248	Monkey	420	NR	0.1	Barsotti et al. 1976	mg/kg-day
1254	Rat	multi-generation	0.32	1.5	Linder et al. 1974	mg/kg-day
1254	Mouse		NR	1.4	Linzey 1988	mg/kg-day
1254	Mouse	365	NR	0.68	McCoy et al. 1995	mg/kg-day
1254	Mouse		1.4	3.4	Voltura and French 2007	mg/kg-day

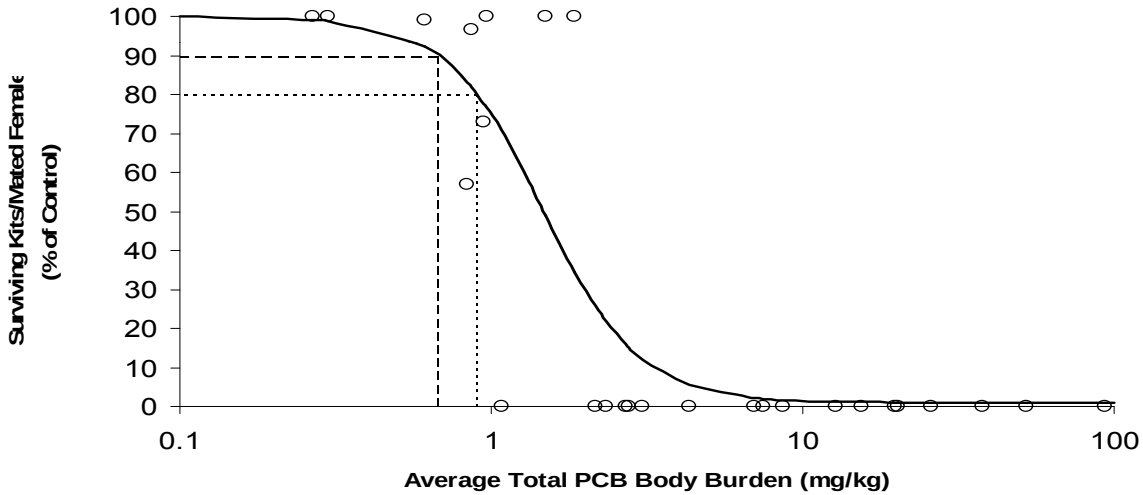


Dose Response Relationships for Rats Exposed to PCBs

Dashed Line indicates the EC10 (2.0 mg/kg-d) and dotted line indicates the EC20 (3.6 mg/kg-day)
Source: Linder et al. 1974
Dose response curve illustrated corresponds to the litter size endpoint

ENVIRON





Dose Response Relationships for Mink Exposed to PCBs

Dashed lines indicate the EC10 while the dotted lines indicate the EC20.
Source: Fuchsman et al. 2008
EC10 and EC20: effect concentration resulting in 10% and 20% decrease in reproduction endpoint from control.

ENVIRON

Risk Characterization Methodology

- Mathematical comparison of point estimates of exposure and effects often referred to as hazard quotient (HQ)
  - Reduces many complex sources of information to binary terms
  - Cannot characterize incidence, severity, or spatial distribution of effects
- This BERA compares Most Likely and High End exposures to NOAEL, LOAEL, EC10, EC20 and/or dose response curve
  - Where dose response curves are available (shrews, fox, mink), % response relative to controls estimated from

$$y = 100 + -99 / (1+\exp(-(a+b \times \ln(x)))$$

How Are Exceedances of Effects Metrics Interpreted?

	If Most Likely exposure estimate[a] exceeds…	If High End exposure estimate[b] exceeds...
LOAEL or EC20	Potential for detectable effects in local population	Potential for detectable effects in most highly exposed individual organisms
NOAEL or EC10	Potential for subtle effects[c] in local population	Potential for subtle effects[c] in most highly exposed individual organisms

a. Most likely exposure estimate is most relevant to species that are not threatened, endangered or special concern

b. High end exposure estimate is most relevant to threatened, endangered, or special concern species, where protection of individual organisms is important

c. Subtle effects not likely discernable in light of natural variability

Risk Characterization: Birds

- American robin
  - Most likely and high end doses compared to species-specific NOAEL and LOAEL values
  - All hazard quotients (HQs) < 1

- American kestrel
  - Most likely and high end doses compared to species-specific NOAEL and LOAEL values
  - All HQs < 1

Risk Characterization: Mammals

- Short-tailed shrew
  - Most likely and high end doses compared to dose response curve
  - All HQs < 1
  - Consistent with Housatonic River field study showing no population-level effects from higher PCB exposures

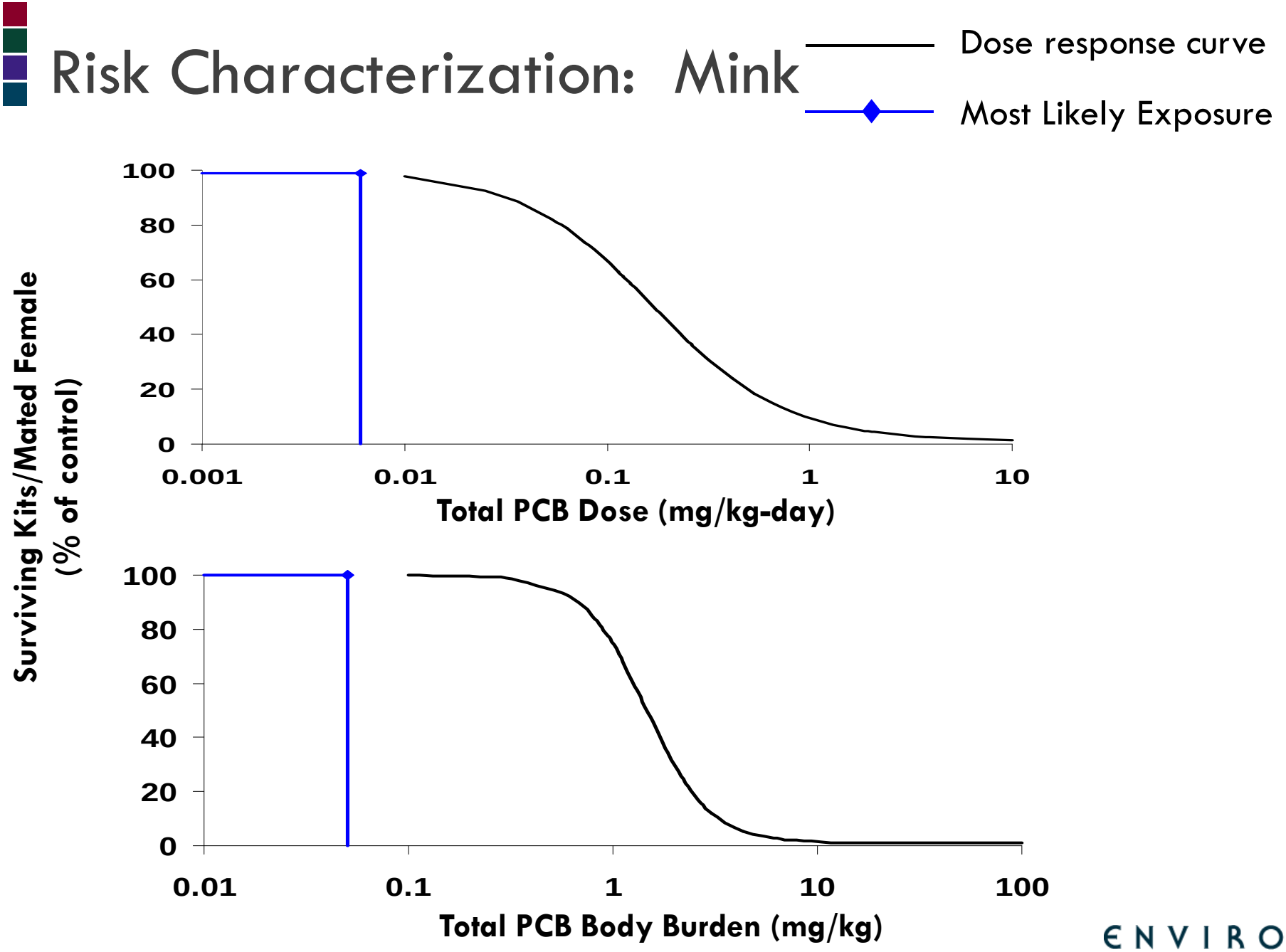
- Red fox
  - Most likely and high end doses compared to dose response curve
  - All HQs < 1

ENVIRON

Risk Characterization: Mink

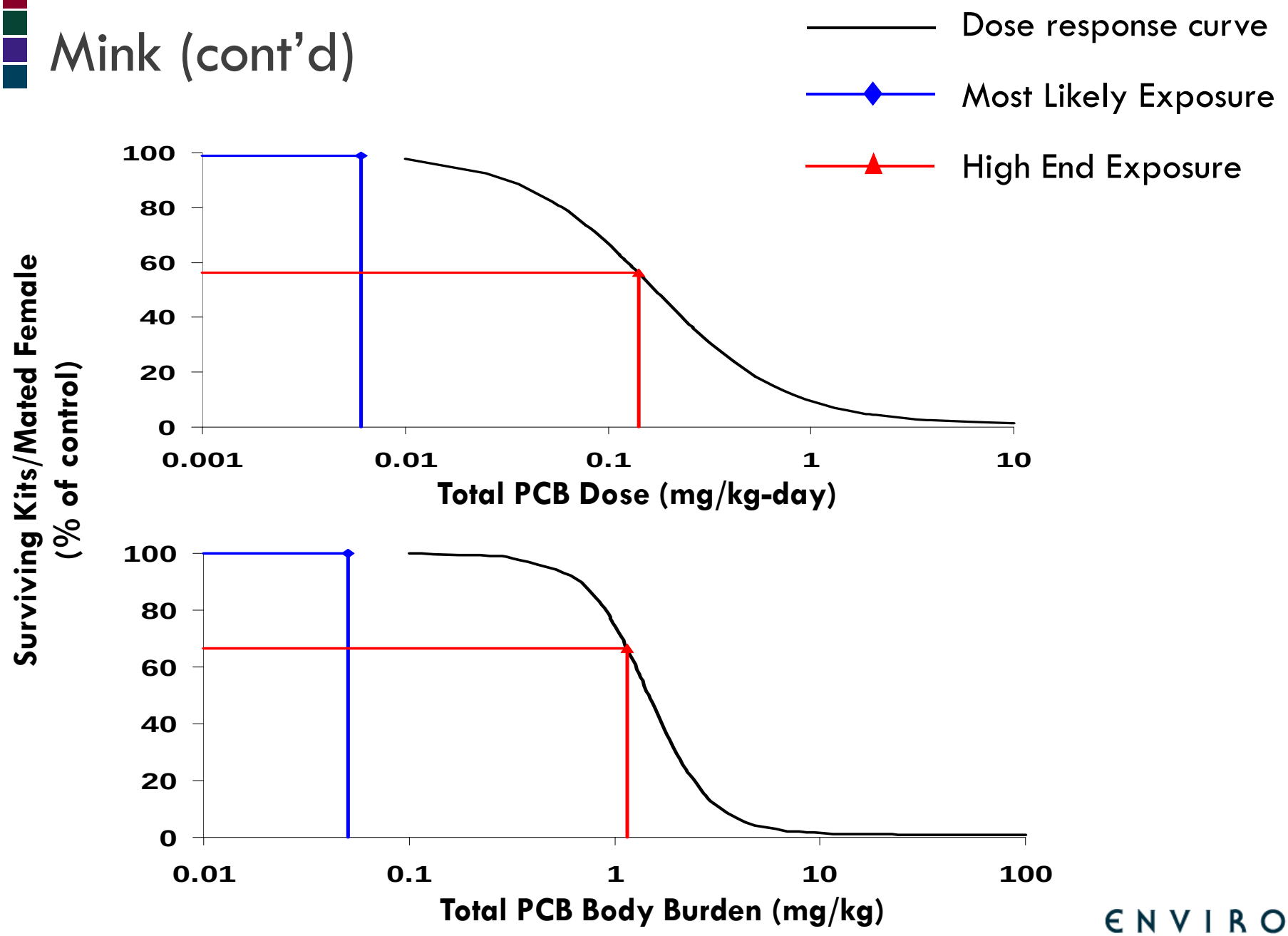
- Multiple lines of evidence, each with varying weight & certainty
  1. Comparison of estimated doses in the mink to the dose response curve to predict reductions in surviving kits per mated female, relative to controls
  2. Comparison of estimated doses in the mink to the EC10 and EC20 to yield HQs
  3. **Comparison of estimated body burdens in the mink to the dose response curve to predict reductions in surviving kits per mated female, relative to controls**
  4. Comparison of estimated body burdens in the mink to the EC10 and EC20 to yield HQs
- Dose response curves > HQs
- Body burden > dose

Risk Characterization: Mink



ENVIRON

Risk Characterization: Mink (cont'd)



ENVIRON

Mink Conclusions

- Study area habitat suitable for mink, but small area suggests that only one or two likely forage there
- Mink are not endangered, threatened or special concern, so most likely exposures (rather than high end exposure) most applicable
- Mammals expected to dominate diet of mink inhabiting study area, given the small size of Stony Creek
- Possible reproductive effects only in most highly exposed individual mink, but unlikely to translate to adverse effects in overall population
- Uncertainty analysis used alternative diet of 25% fish and 75% small mammals → most likely exposure below EC10 and EC20

Therefore…

Mink inhabiting the study area and consuming an average and realistic diet are not expected to be adversely affected

Risk Characterization: Indiana Bat

- Federally protected
- High end dose compared to NOAEL value
- HQ < 1

Photo credit: Adam Mann

ENVIRON

BERA Conclusions

- Wildlife populations that forage within the Stony Creek floodplain are not likely to be at risk from PCBs
- Individual Indiana bats that forage in the study area are not likely to be at risk from PCBs
- No further evaluation warranted; no remediation needed based on ecological risks

- Questions/discussion