Peer Review of Michigan State University Field Studies in the Floodplain of the Kalamazoo River

Presented by
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U.S. EPA ERAF and TSERAWG
Joint Winter Meeting

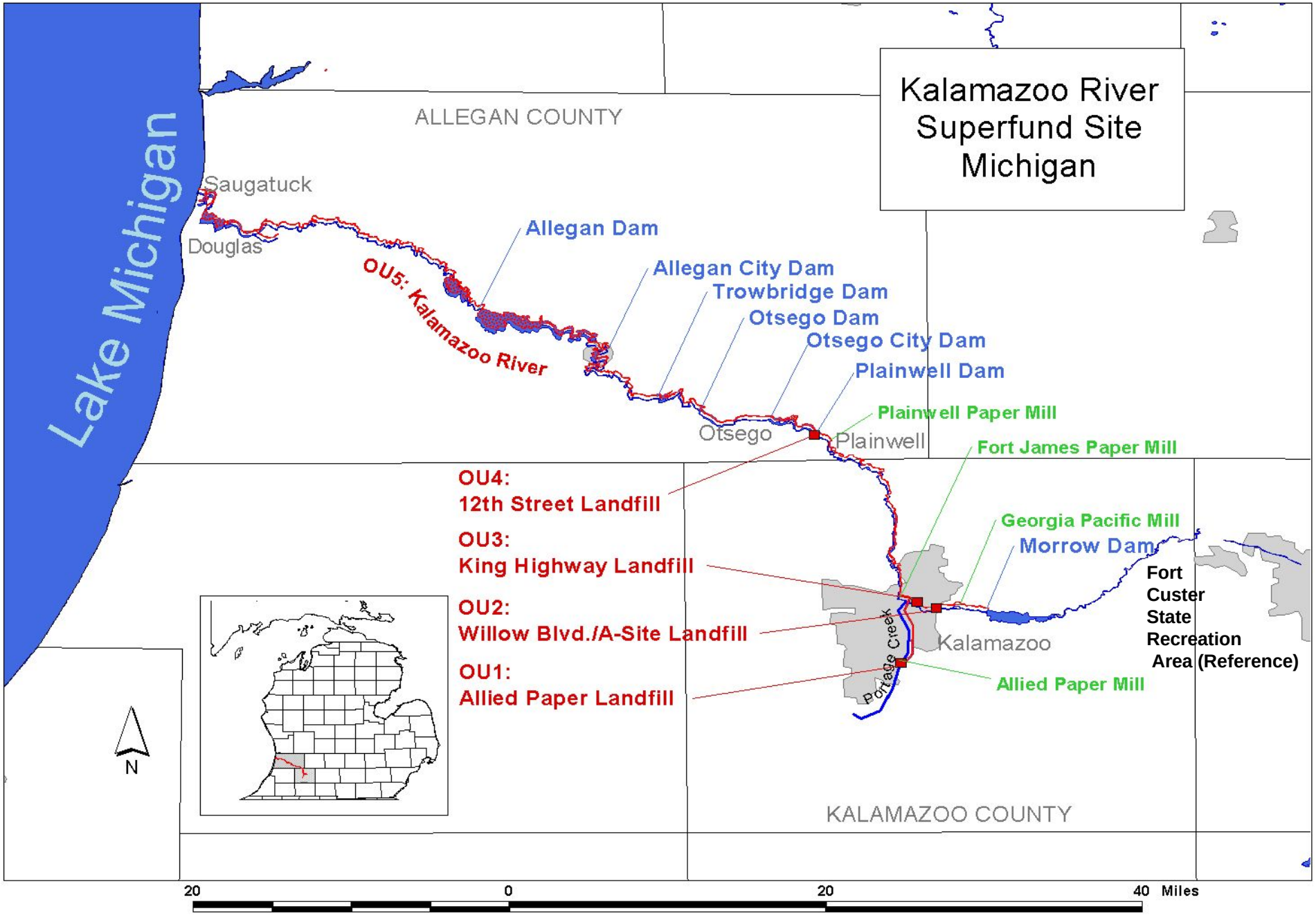
U.S. Army Engineer Research and Development Center
Vicksburg, MS
January 27-29, 2009

Main Points

- Example of charge
- High bar for field study of effects
- Endorsement of assessing likely future conditions
- Caveat published data

Allied Paper, Inc. / Portage Creek / Kalamazoo River Superfund Site, MI

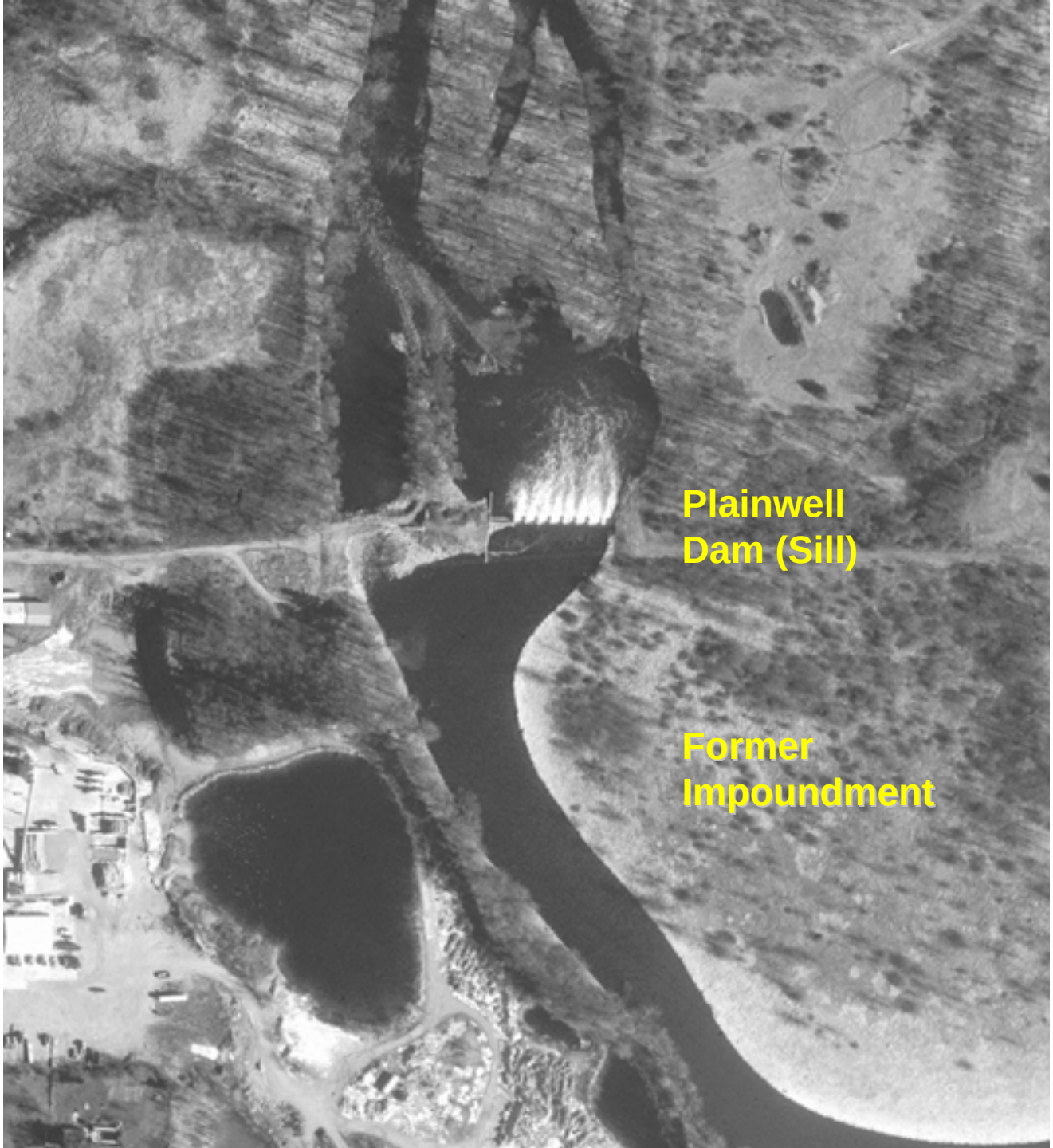
- PCBs
- Main source – paper mill discharges from recycling of carbonless copy paper
- Thick deposits of paper waste accumulated behind series of dams


Kalamazoo River Superfund Site Michigan
Lake Michigan
ALLEGAN COUNTY
Saugatuck
Douglas
OU5: Kalamazoo River
Allegan Dam
Allegan City Dam
Trowbridge Dam
Otsego Dam
Otsego City Dam
Plainwell Dam
Otsego
Plainwell
Plainwell Paper Mill
Fort James Paper Mill
OU4:
12th Street Landfill
OU3:
King Highway Landfill
OU2:
Willow Blvd./A-Site Landfill
OU1:
Allied Paper Landfill
Georgia Pacific Mill
Morrow Dam
Fort Custer State Recreation Area (Reference)
Portage Creek
Kalamazoo
Allied Paper Mill
N
KALAMAZOO COUNTY
20
0
20
40 Miles

Several dams dismantled to sills

- Converted sediment/waste deposits of formerly impounded areas into “floodplain” soils
- Erosion of exposed banks in former impoundments is an important current source of PCBs to river
- Direct exposure to terrestrial receptors from formerly impounded-area soils


Plainwell Dam (Sill)
(MDEQ)



(MDEQ)


Plainwell Former
Impoundment
(MDEQ)


Trowbridge Former
Impoundment
(Peer Review Final Report)
05/14/2008 10:0

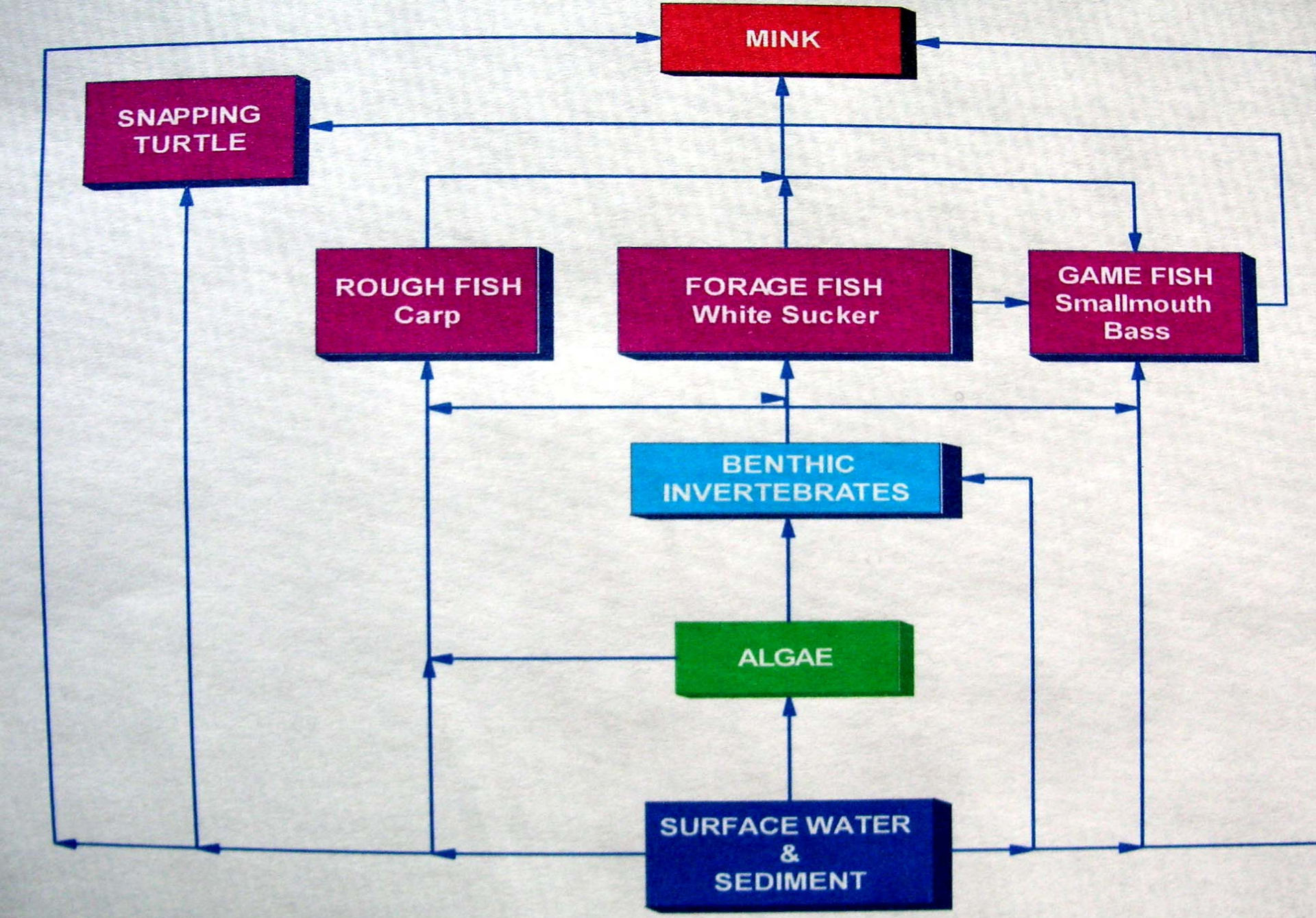
Paper waste in bank of former impoundment
(MDEQ)

Michigan Department of Environmental Quality
Remediation and Redevelopment Division

Final (Revised) Baseline Ecological Risk Assessment
Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

April 2003

www.michigan.gov/deq/0,1607,7-135-3311_4109_4217_28657-85234--,00.html



AQUATIC ECOSYSTEMS

BERA Aquatic PRGs

- **Range of protective total PCB concentrations in INSTREAM SEDIMENT AND FLOODPLAIN SEDIMENT associated with aquatic or semi-aquatic ecosystems is 0.5 to 0.6 mg/kg (based on mink).**
- **But management decisions are driven by human health risk**

  0.33 mg/kg

Enjoy Your Sport Fishing

Watch Which Fish You Eat

Eat With Caution means no more than one meal per week for a healthy adult male. Women of childbearing age and children under age 15 should not eat these fish.

Read the advisory listed below for the area you are fishing.

ADVISORY AREA A

From Morrow Pond Dam downstream to Allegan Dam and on Portage Creek downstream of Monarch Mill Pond

Should Not Eat: Carp, Suckers, Catfish, Largemouth Bass or Smallmouth Bass.

Eat With Caution: All fish except those listed above. (Read definition listed above.)

ADVISORY AREA B

Downstream from Battle Creek to the Morrow Pond Dam.

Should Not Eat: Carp.

No other fish restrictions.

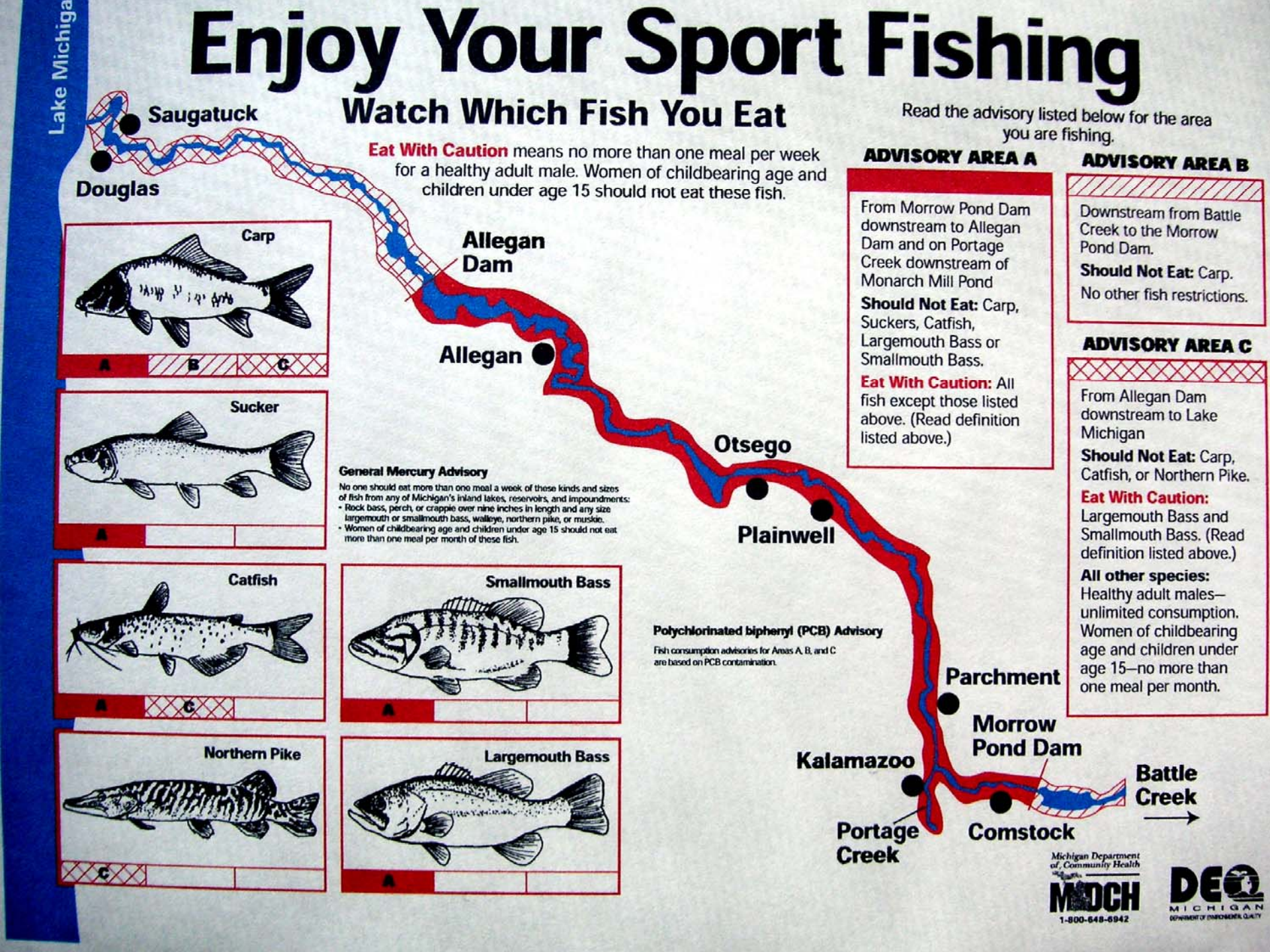
ADVISORY AREA C

From Allegan Dam downstream to Lake Michigan

Should Not Eat: Carp, Catfish, or Northern Pike.

Eat With Caution: Largemouth Bass and Smallmouth Bass. (Read definition listed above.)

All other species: Healthy adult males—unlimited consumption. Women of childbearing age and children under age 15—no more than one meal per month.



General Mercury Advisory

No one should eat more than one meal a week of these kinds and sizes of fish from any of Michigan's inland lakes, reservoirs, and impoundments:

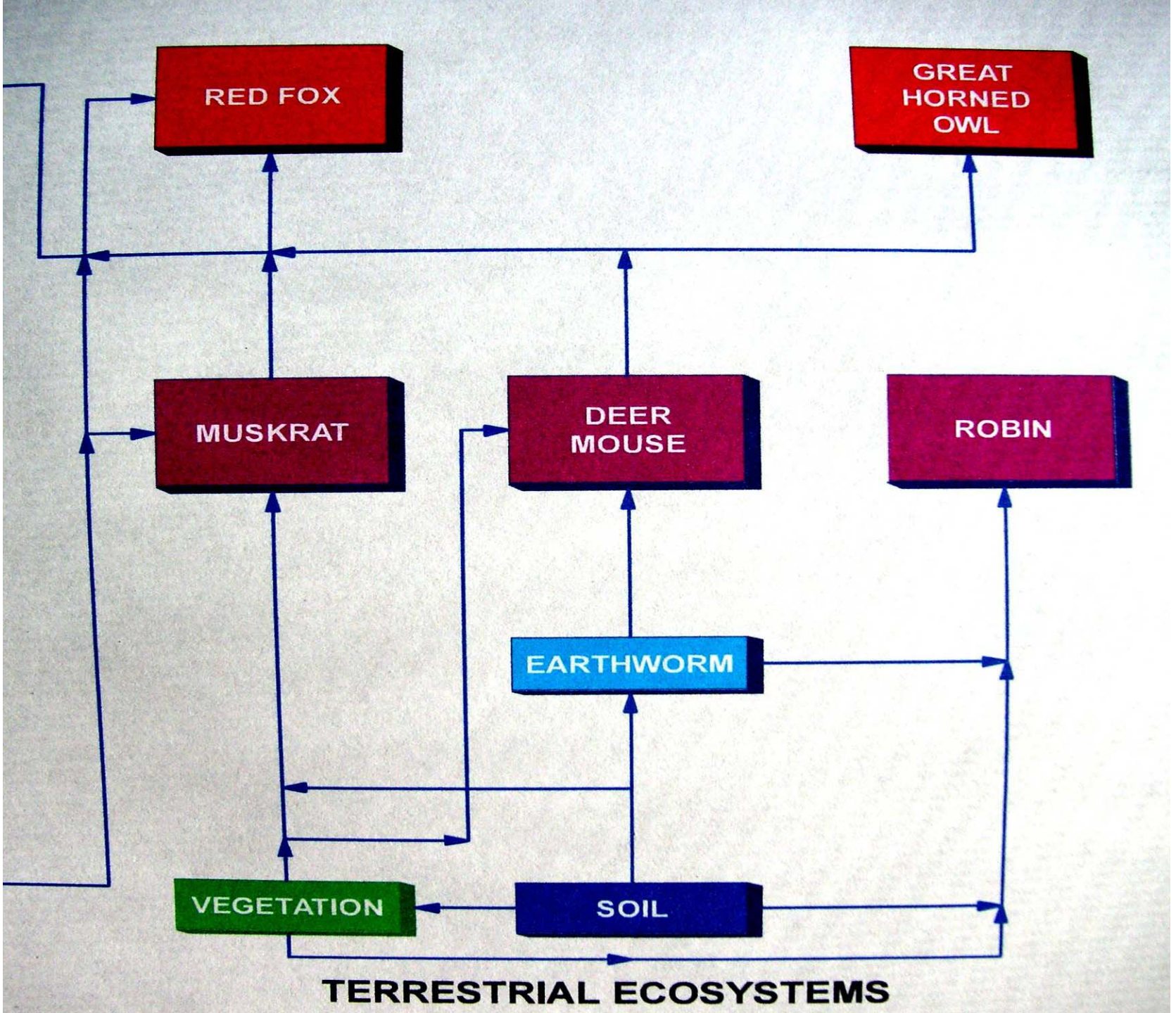
- Rock bass, perch, or crappie over nine inches in length and any size largemouth or smallmouth bass, walleye, northern pike, or muskie.
- Women of childbearing age and children under age 15 should not eat more than one meal per month of these fish.

Polychlorinated biphenyl (PCB) Advisory

Fish consumption advisories for Areas A, B, and C are based on PCB contamination.

Michigan Department of Community Health
MDCH
1-800-648-6942

DEQ MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY



TERRESTRIAL ECOSYSTEMS

BERA Risk Characterization

- Omnivorous mammals (white-footed and deer mouse)
  - Unlikely to be at significant risk
- Carnivorous mammals (red fox)
  - Unlikely to be at significant risk
- Carnivorous birds (great-horned owl)
  - May be at significant risk depending on diet
- Omnivorous/vermivorous birds (robin)
  - Moderate but significant risk

BERA Terrestrial PRGs

- **Range of protective total PCB concentrations in SURFACE SOILS AND FLOODPLAIN SEDIMENTS associated with terrestrial ecosystems is 6.5 to 8.1 mg/kg (based on omnivorous songbirds such as robin). To protect carnivorous mammals such as red fox, the range is 5.9 to 29.5 mg/kg.**
- **Risk management decisions are driven by ecological risk**
  - **Human recreational PRG 23 mg/kg**

KRSG

- Kalamazoo River Study Group formed by Georgia-Pacific Corporation and Millennium Holdings, LLC
- Grants to Michigan State University to perform ecological studies
  - Professor John P. Giesy, principal investigator
  - Dr. Matthew Zwiernik, project leader
  - Research conducted through the auspices of National Food Safety and Toxicology Center (NFSTC) and the Center for Integrative Toxicology (CIT) at MSU

MSU Aquatic-based Studies

- Aquatic food web PCB bioaccumulation
  - Congener-specific
- Mink
- Tree Swallows

Not included in peer review because aquatic / sediment management decisions driven by human health risk

MSU Terrestrial-based Studies

- Terrestrial food web PCB bioaccumulation
  - Congener-specific
- Passerines
  - Eastern bluebird (BB) – nesting box
  - House wren (HW) – nesting box
  - American robin – adult collection
- Great-horned owl (GHO) – nesting platform
- Short-tailed shrew / other small mammals
  - trap

MSU Terrestrial Study Design

- Passerine nest box – 2 locations
  - On-site – Trowbridge former impoundment
  - Reference – Fort Custer (upstream of site along Kalamazoo River)
- GHO nesting platform & natural nests
  - Added 1 more reference and several on-site locations
  - Most data comparisons between Trowbridge and Fort Custer
- Multi-year studies, 3-5 years

MSU Site-specific Measures of Exposure (Terrestrial)

- Food web PCB/TEQ, soil BSAF
  - Soil, plants,earthworms, other invertebrates, small mammals
- Receptor dietary composition
  - Nestling ligature (BB, HW)
  - Regurgitated pellets/uneaten prey remains (GHO)
- Receptor PCB/TEQ residues, BMF
  - Eggs (BB, HW, GHO)
  - Nestlings (BB, HW) plasma (GHO)
  - Adult (HW, robin)

MSU Site-specific Measures of Effects (Terrestrial)

- Reproductive measures (GHO, BB, HW)
  - Nest success
  - Hatchability
  - Fledgling rate
  - Nestling growth
- Abundance (GHO)
  - Vocalization surveys (active & passive)
  - Nest/roost site utilization surveys
- Dietary- and egg-based HQs
  - PCB and TEQ

MSU Conclusions

- Elevated on-site PCB exposure
- GHO – minimal risk
  - HQ approach or effects measures
- Passerines
  - Dose HQ indicates risk for conservative TRVs, but not “more realistic” field TRVs
  - Tissue HQ indicates little risk
  - Inconsistent differences in reproductive performance due to factors other than PCBs
  - No population-level adverse effects

MSU Publications
Terrestrial Bioaccumulation

- Blankenship, A., et al. 2005. Differential accumulation of polychlorinated biphenyl congeners in the terrestrial food web of the Kalamazoo River Superfund site, Michigan. Environ Sci Technol 39:5954-5963.

- Neigh, A., et al. 2006a. Accumulation of Polychlorinated Biphenyls (PCBs) from Floodplain Soils by Passerine Birds. Environ Toxicol Chem 25: 1503-1511.

MSU Publications
Passerines (BB, HW)

- Neigh, A., et al. 2006a. Exposure and multiple lines of evidence assessment of risk for PCBs found in the diets of passerine birds at the Kalamazoo River Superfund site, Michigan. Hum Ecol Risk Assessm 12:924-946.

- Neigh, A., et al. 2007. Reproductive success of passerines exposed to polychlorinated biphenyls through the terrestrial food web of the Kalamazoo River. Ecotoxicol Environ Safety 66:107-118.

MSU Publications
Great Horned Owl

- Strause, K., et al. 2007a. Risk assessment of great horned owls (*Bubo virginianus*) exposed to polychlorinated biphenyls and DDT along the Kalamazoo River, Michigan, USA. Environ Toxicol Chem 26:1386-1398.

- Strause, K., et al. 2007b. Plasma to egg conversion factor for evaluating polychlorinated biphenyl and DDT exposure in great horned owls and bald eagles. Environ Toxicol Chem 26:1399-1409.

- Strause, K., et al. 2008. Risk assessment methodologies for exposure of great horned owls (*Bubo virginianus*) to PCBs on the Kalamazoo River, Michigan. Integrated Environ Assessm Managem 4:24-40.

- Zwiernik , M., et al. 2007. Site-specific assessments of environmental risk and natural resource damage based on great horned owls. Hum Ecol Risk Assessm 13:966-985.

MSU Studies & BERA

- No MDEQ or U.S. EPA participation or oversight in any stage
  - design, implementation, analysis, or interpretation
- U.S. FWS limited oversight for compliance with wildlife permits, split samples, participation in one study (owl plasma-egg relationship)

- MSU findings not incorporated into BERA

Peer Review Scope / Purpose

- AOC (2/21/07) Appendix A, SOW
- External peer review of MSU studies pertaining to floodplain soils
- Focus on terrestrial receptors whose potential risk is derived from the exposed sediments in formerly impounded areas of the Site
- Assess the quality and utility of the MSU studies as additional lines of evidence for evaluating potential ecological risk at the Site and informing risk management decisions

Peer Review Process

- Funded by KRSG
- Coordinated by
  - Ken Jenkins, ARCADIS, for KRSG
  - James Chapman, U.S. EPA, and liaison with federal and state trustees (BTAG)
- Consistent with U.S. EPA guidance

U.S. EPA. 2006. U.S. Environmental Protection Agency Peer Review Handbook, 3rd Edition. Science Policy Council. EPA/100/B-06/002.

www.epa.gov/peerreview/

Peer Review Panel

- Peer Review Manager

  Ken Dickson, University of North Texas

- Panel

  Larry Barnthouse, LWB Environmental Services, Inc.

  Anne Fairbrother, Parametrix Inc. [now with E^{x}ponent]

  Keith Grasman, Calvin College, MI

  Mark Harwell, Harwell Gentile & Associates, LC

  Lyman McDonald, West Inc.

  Charles Menzie, E^{x}ponent Inc.

  William Warren-Hicks, EcoStat, Inc

Charge to the Peer Review Panel

- General questions
  - Appropriateness of methods
  - Identification of uncertainties
  - Reasonableness as lines of evidence for risk management decisions
- Specific question topics
  - Exposure assessments
  - Effects assessments
  - Applicability of investigations
  - Risk Management

Exposure Assessments

- What are the relative strengths, limitations, and uncertainties for each receptor?
  - Site-specific dietary composition
  - Site-specific food web bioaccumulation
  - Modeled exposure
  - Receptor tissue residue
  - Extrapolation to other receptor exposures
  - Effect of future site conditions on exposure

Effects Assessment

- What are the relative strengths, limitations, and uncertainties associated with:
  - Field productivity assessments (BB, HW, GHO)
    - Extrapolation to other receptors
    - Causal attribution
  - HQ approach
    - TRV selection
    - Interspecific extrapolation
    - Lab-field extrapolation

Applicability of the Investigations

- What are the relative strengths, limitations, and associated uncertainties as potential lines of evidence for risk management?
  - Study design
  - Data interpretation (including statistical methods)
  - Population-level inferences
  - Spatial extrapolation (to other former impoundment areas)

Risk Management

- Please comment on the applicability of the information presented in the MSU studies for informing risk management decisions.

Final Report

Peer Review of
Michigan State University's
PCB Exposure and Effects Studies
in the Floodplain of the
Kalamazoo River

December 1, 2008

www.epa.gov/region5/sites/kalproject/

Primary Strengths

- Site-specific direct measurements of PCB concentrations in eggs, soil and prey items
- Congener-specific data / TEQ
- Studies of productivity of BB, HW, GHO
- Opportunity to explore the development of spatially explicit shrew:soil bioaccumulation functions
  - although not performed in MSU publications

Primary Limitations

- Absence of a comprehensive conceptual ecological model for
  - identifying pathways of exposures
  - relating effects to endpoints of concern
- The species studied (BB, HW, GHO) do not necessarily represent the most highly exposed or the most sensitive species present in the riparian corridor.
  - Not adequate surrogates for addressing the question of risk to all avian species that may potentially use the site.

Primary Limitations

- Utility of these studies in assessing risks associated with terrestrial exposure pathways is limited because of:
  - Reliance on species for which aquatic organisms are a significant portion of the diet
    - BB, GHO
  - Lack of direct measurements of PCB concentrations in diets of robins (bolus)
    - Most highly exposed avian species addressed in the BERA

Primary Limitations

- Failure to consider plausible changes in future conditions is a major limitation
  - Removal of the remnant dam structures, as planned by the State
  - Understanding of habitat succession
  - Potential effects of climate change
- If the former impoundments change to a more terrestrial environment over time, as anticipated, it will be important to consider the potential for changes from the current species assemblage
  - Such changes could directly alter the trophic structure that determines exposure pathways and therefore risks

Primary Limitations

- Nest productivity studies are limited by
  - Small sample size
  - Pseudo-replication
  - Confounding factors (on-site vs. reference)
    - Habitat differences
    - Number of years passerine nest boxes established
    - These two issues significantly undermine the defensibility of conclusions
  - Calculation and analysis of reproductive parameters

Confounding Habitat Factor

- The habitat characteristics of the Fort Custer site differs so much from the former impoundment sites that its utility as a reference site is quite limited.
  - Habitat differences include more open areas on-site and more riparian woods at the reference site
  - BB boxes have been on-site for [30] years at Fort Custer but were newly erected at Trowbridge
- Given these difficulties, it is not possible to make statistical inferences based on hypothesis testing about productivity

Primary Limitations

- Averaged exposures over selected sampling sites within the study areas
  - rather than developing spatially explicit models of uptake and exposure
- Inadequate documentation and justification of the selected TRVs
  - MSU's TRVs are quite high and significantly influence their conclusions of no or minimal risk
  - The specific justification used to select the particular study to represent the effects level is needed, *including the rationale for not selecting alternative studies*

Primary Limitations

- Overuse or inappropriate use of tests of null hypotheses to pool data sets and reach conclusions
- General lack of quantification of sources of uncertainty in exposure and effects metrics
- Failure to account for observational artifacts

Remaining Uncertainties

- Uncertainty concerning population-level effects
  - The nest productivity studies conducted by MSU address organism-level effects
  - Do not support inferences concerning population-level effects of PCB exposures.
    - Did not measure all the parameters necessary to develop a population model
      - e.g. survival

GHO Studies

- Vocalization surveys confounded by
  - Use of artificial nest platforms
  - Habitat differences
- Reproductive productivity limited by
  - Small sample size (1 active reference nest)
  - Lack of replication of sites
- Little support for concluding on-site productivity is consistent with literature
  - Based on 1 study (very limited ecological analysis)
  - Panel cites other studies showing higher productivity

Remaining Uncertainties

- Uncertainty concerning assessment of passerine reproductive productivity
  - MSU partitioned reproductive success into various subcomponents and used only subsets of nests
    - Hatching success per egg laid
    - Fledgling success per egg hatched
    - Productivity = fledglings per egg laid
  - Potentially underestimates the cumulative effects of nest failure, embryonic mortality, and pre-fledgling mortality

Panel Recalculation of Overall Passerine Reproductive Success

- Recommend an integrated measure of fledging rate based on all nests initiated (e.g., Mayfield)
  - On-site vs reference fledgling/initiated nest
    - HW 18 % lower
    - BB 47 % lower (outlier has minor influence)
- MSU (Neigh, et al. 2007)
  - Combined clutches (early/late/all years)
    - HW productivity not affected or better
    - BB poorer productivity due to 1 outlier in 1 yr
      - Not signif. impaired without outlier

Remaining Uncertainties

- Uncertainty concerning extrapolation to other species
  - MSU selected species based on amenability to study
    - Not necessarily representative of typical species utilizing the site, most highly exposed, or most sensitive species
- Still substantial uncertainty concerning risks to ground-feeding birds
  - such as robins and woodcocks

Remaining Uncertainties

- Understanding the risks associated with the earthworm pathway is still unresolved especially for birds
  - Critical importance of the earthworm-to-robin pathway shown in the BERA
  - No worms were found in BB or HW diets

Remaining Uncertainties

- MSU's PCB exposure data for robins are uncertain
  - Observational data suggested that robins were foraging primarily outside of the floodplain
    - MSU presentation to Peer Review Panel, 5/13/08
    - [Not discussed in Blankenship, et al. 2005 who report site-specific Trowbridge Impoundment PCB soil-robin BSAF, diet-robin BMFs, and the associated relative potency ratios]

Robin Site Utilization During MSU Studies

- Based on Site-specific observations of *Turdidae* foraging, it was noted that bluebirds tended to forage on-site almost exclusively, while American robins appeared to spend significant time off-site, above the floodplain in managed short grass habitat (e.g., lawns and golf courses proximal to the Site study area). Thus, based on Site-specific habitat characteristics and Site-specific observations, it was deemed that the American robin Site use was likely less than that of its bluebird cohort, thereby reducing its exposure potential to floodplain contaminants.
  - Ecological Consequences of PCBs in the Exposed Sediments of Formerly Impounded Areas of the Kalamazoo River, Overview of Studies Conducted by Michigan State University. John Giesy and Matthew Zwiernik. Presented 5/13/08. Kalamazoo Peer Review Charge Delivery Meeting. Augusta, MI.

Remaining Uncertainties

- Uncertainty concerning extrapolation to future conditions
  - Key habitat characteristics in all of the former impoundments can be expected to change over time
  - Likely change the hydrological regime of the site and result in a significantly altered set of exposure pathways
    - e.g., In the future, as soils develop and inundation decreases, earthworm populations and feeding by robins are likely to increase within the floodplain..

Selected Panel Recommendations

- The Panel recommends that the MSU studies conclusions not be used to reach risk conclusions on their own.
  - Too much uncertainty underlying the data interpretation
  - Lack of robustness in the study design
  - Insufficient documentation (and lack of agreement) of TRV derivations.

Selected Panel Recommendations

- MSU data when combined with data from the BERA can be useful to inform the ecological risk assessment and risk management decisions
  - The risk assessment approach used in the BERA could be modified to accommodate MSU's site-specific exposure data, thereby significantly enhancing the quality of risk information available to risk managers.

Selected Panel Recommendations

- Multi-agency development of
  - CSM
  - Systematic approach for combining BERA and MSU datasets
  - TRVs

Selected Panel Recommendations

- Selection of the TRVs following a statistical approach that incorporates all available relevant toxicity data, rather than relying on a single study, is a preferred approach because it addresses:
  - issues of cross-species extrapolations
  - sensitivity differences between tested species and species of concern
  - future changes in species utilizing site

Selected Panel Recommendations

- Include a set of scenario-consequence analyses, in which a series of plausible future conditions are incorporated into the CSM and the assessments are done on the resulting risks
  - e.g., An alternate hydrological regime should be considered, such as following removal of remnant dam structures
  - It may be possible to use the data from the MSU diet studies, together with predictions of future habitat conditions, to predict future diets and exposure levels

Selected Panel Recommendations

- Although the former impoundment areas of concern do not seem to be good robin habitat at present, consideration of the soil—earthworm exposure pathway is essential for evaluating risks to other earthworm-eating wildlife such as woodcock, snipe, shrews, and robins.
- Wren and bluebird diets cannot be directly extrapolated to other species; however, PCB concentrations in invertebrates and earthworms can be used to estimate dietary doses to other species, using information on dietary preferences of those species.


Otsego City Dam
Plainwell Dam