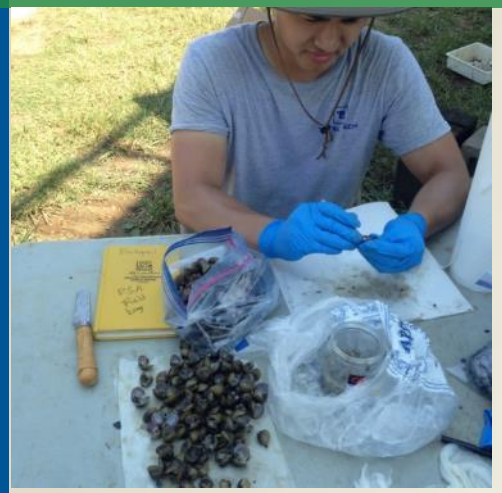



Anacostia River Sediment Project (ARSP) Ecological Risk Assessment Summary

June 8, 2017

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Overview

- Conceptual site model
- Food chain model
- Data Gaps- Supplemental Data 2016
  - Whole sediment larval fish bioassay
  - Benthic invertebrate tissue (in situ)
  - Invertebrate presence in river
  - Turtle tissue
  - Causal factors for invertebrate and larval fish bioassay toxicity
- Additional Updates to the BERA
  - Critical Body Residue
  - Additional Sediment Chemistry
  - Use of background HHRA fish results in the ERA
- Ecological Risk Assessment Summary Results
- Ecological RAOs/PRGs for sediment and surface water

Conceptual Site Model- Food Web

Food Chain Modeling

- Direct toxicity criteria for sediment and surface water do not apply to higher vertebrates
- Ingested doses are more typically evaluated in the ERA for birds and mammals.
- Calculated daily dose is compared with toxicity reference value (TRV) to estimate risk.

$$Dose_{total} = \frac{([IR_{prey} \times C_{prey}] + [IR_{sed} \times C_{sed}] + [IR_{sw} \times C_{sw}]) \times SUF}{BW}$$

$Dose_{total}$ = Estimated dose from ingestion (mg/kg-day)
IR_{prey} = Ingestion rate of prey (kg/day)
C_{prey} = Dry weight concentration of COC in prey (mg/kg)
IR_{sed} = Ingestion rate of sediment (kg/day)
C_{sed} = Dry weight concentration of COC in sediment (mg/kg)
IR_{sw} = Ingestion rate of surface water (L/day)
C_{sw} = Total concentration of COC in surface water (mg/L)
SUF = Site use factor (unitless)
BW = Adult body weight (kg)

Representative Daily Dose

- UCL_{95} concentration in surface sediment, surface water, and prey
- Highest of the four UCL_{95} concentrations in invertebrate tissues
- Mean reported body weight for each receptor
- SUF based on mean foraging range

Data Gaps Addressed in Phase 2 Supplemental Data

- Uncertainty Regarding Early Life Stage Fish Toxicity
  - Whole sediment larval fish bioassay- survival and growth
- Uncertainty Regarding Forage Fish Food Sources
  - Chemical characterization of invertebrates: snails and clams.
  - Identification of benthic, epibenthic and aquatic invertebrates in the study area: Hester Dendy samplers and stomach contents of lower trophic fish
- Turtle and Crayfish Tissue Data Unavailability
  - Collection of turtles and crayfish for chemical characterization
- Causal factors to observed benthic invertebrate bioassay toxicity
  - Additional chemical data in pore water and surface sediment (pyrethroid based pesticides and polybrominated diphenyl ethers- flame retardants)
  - Multi-variate statistical evaluation of Phase 1 benthic invertebrate bioassay data and Phase 2 larval fish bioassay data

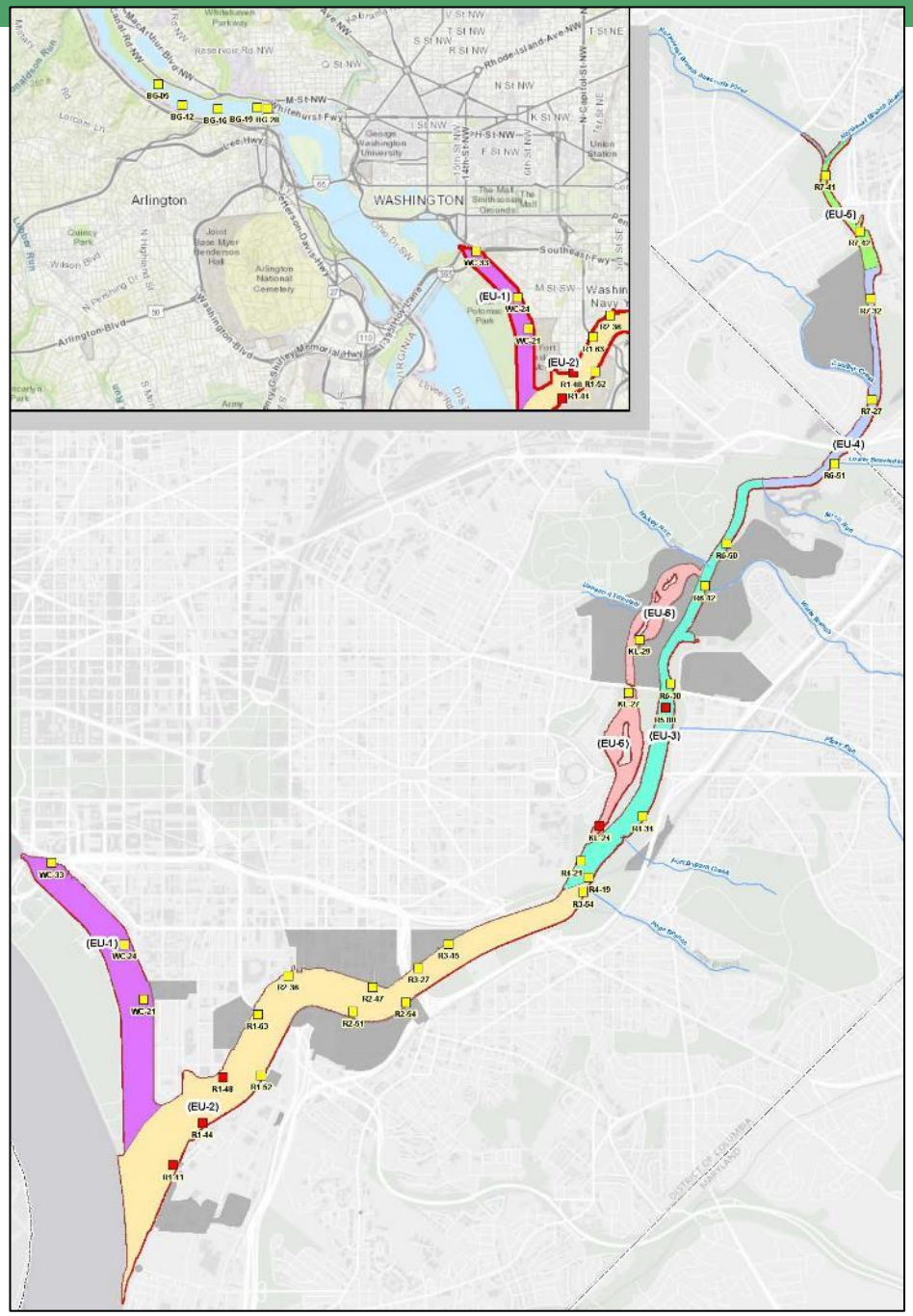
Supplemental Data – Phase 2

Whole sediment larval fish bioassay

Larval Fish Bioassay

Methods

- Surface sediment from 31 Anacostia and 5 Potomac locations
- Newly hatched fathead minnow (*Pimephales promelas*) larvae
- Standard EPA invertebrate exposure scenario modified to accommodate the fish
- Surface water from the tidal Anacostia used as overlying water in the test chambers and replaced daily



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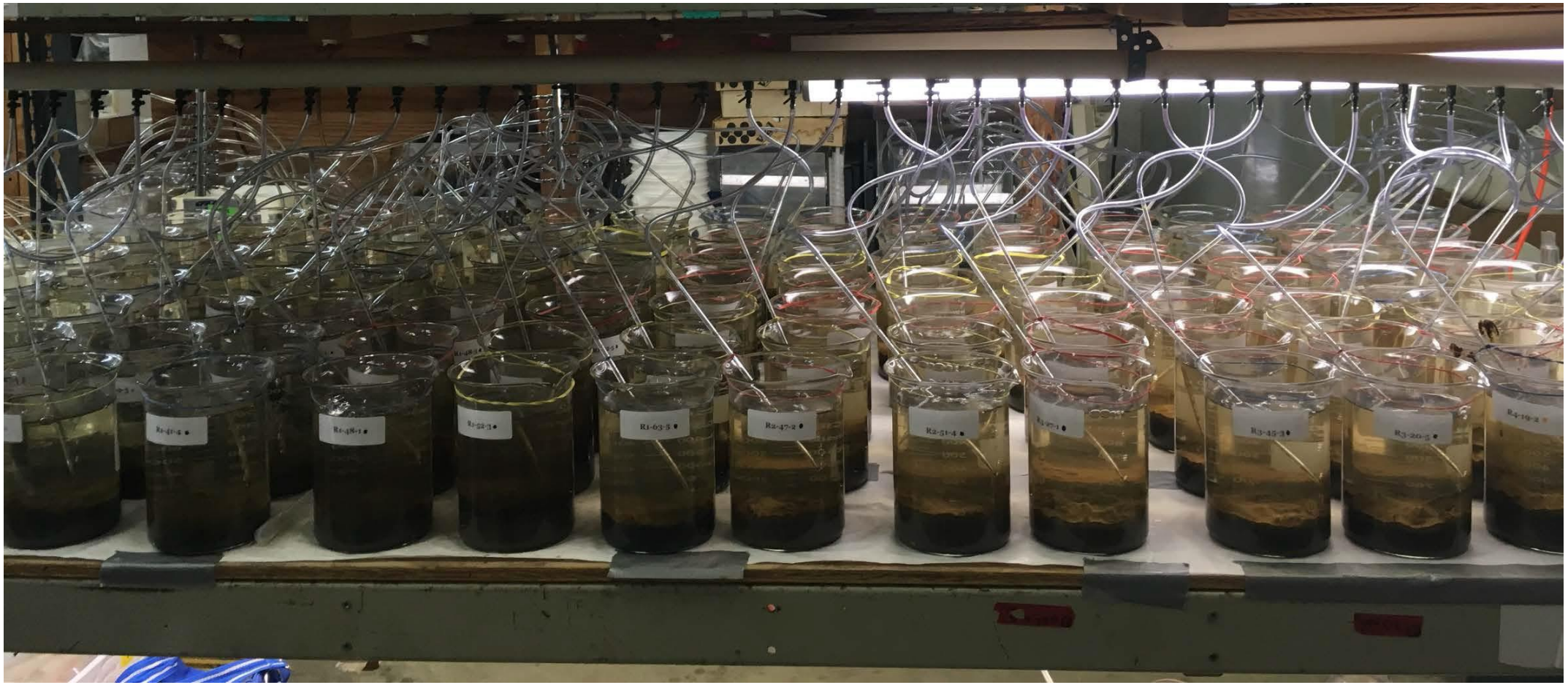
Larval Fish Bioassay Setup

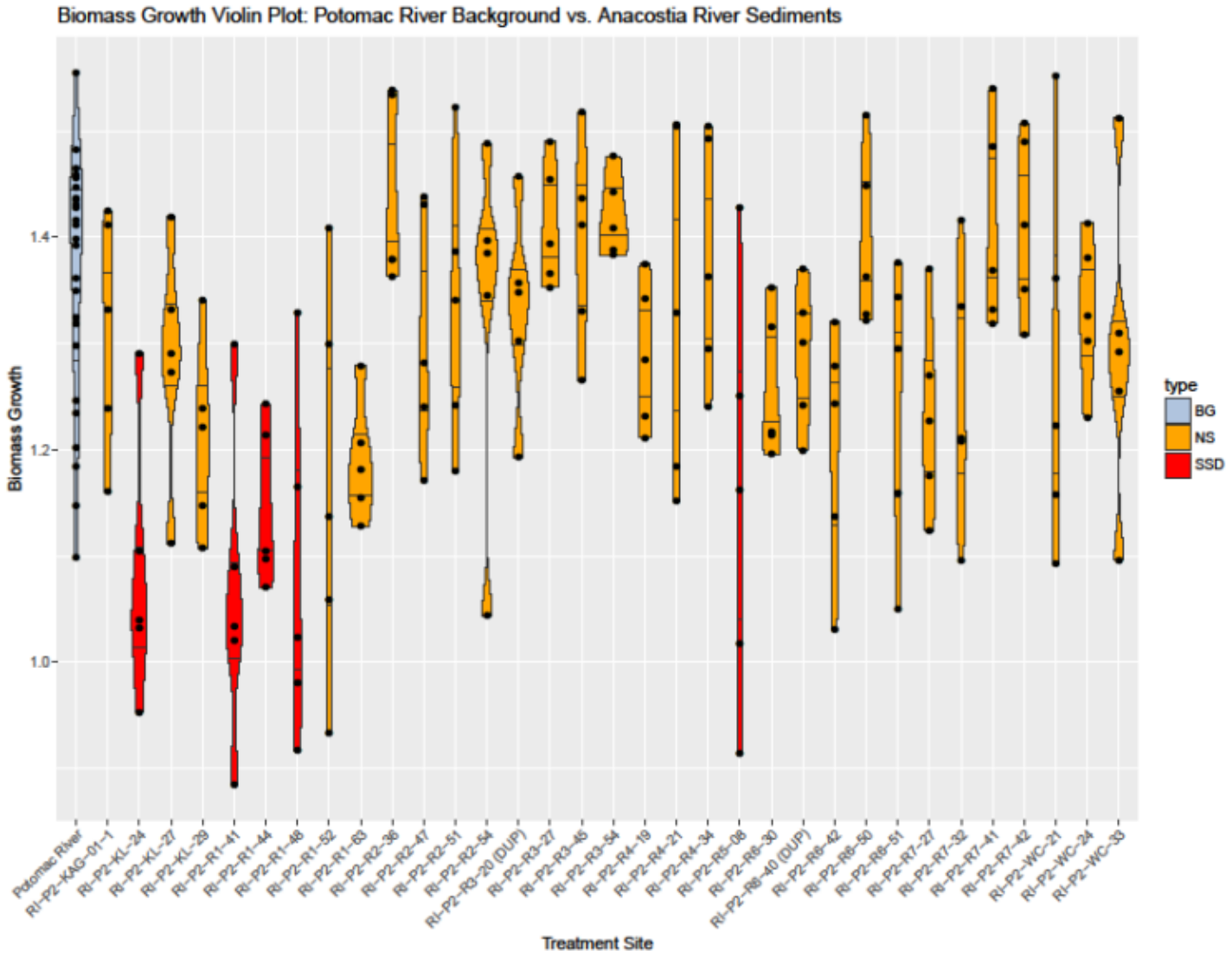


Wye Research Lab, University of Maryland

Larval Fish Bioassay Results

- Endpoints: survival and growth
- Survival was high and comparable in Anacostia and Potomac samples.
- Growth was reduced in several Anacostia samples.
- No relationship between bioassay results and sediment chemistry was observed.

Larval Fish Biomass Growth Results



Notes:
BG - Potomac River reference sediment
NS - No significant difference from Potomac River reference sediment
SSD - Significant difference from Potomac River reference sediment

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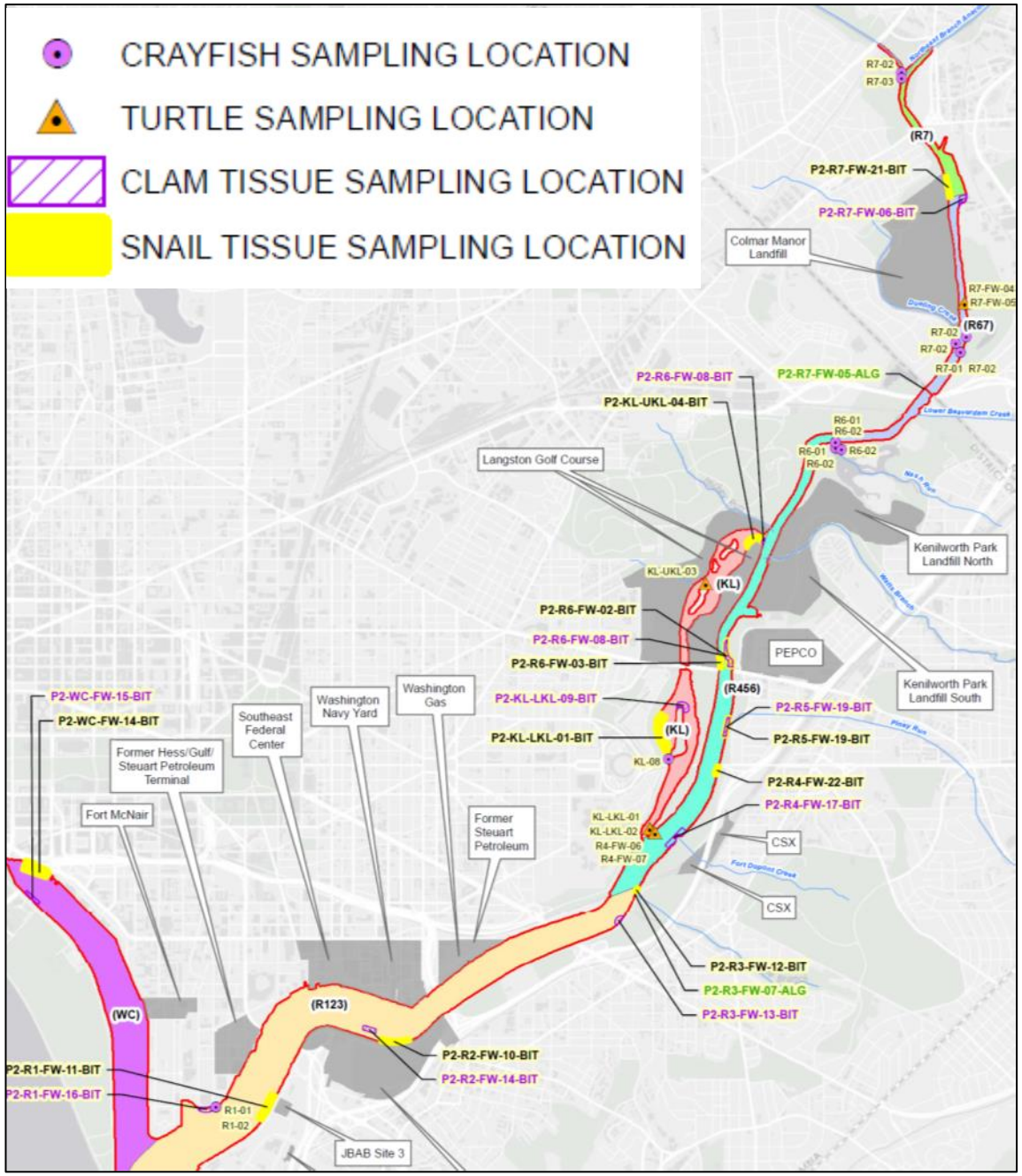
Supplemental Data – Phase 2

Invertebrate tissue (*in situ*) for chemical analysis

Supplemental Data – Phase 2- Tissue Sampling Locations

- Invertebrate tissue (in situ) for chemical analysis
  - Snails (10)
  - Clams (9)
  - Crayfish (8)
- Turtles (7)
- Algae (2)



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Chinese mystery snail

(*Bellamya chinensis, Cipangopaludina chinensis malleata*)

- 11 composite samples across the tidal river
- Analyzed for dioxins, SVOCs, PBDE, PCB Aroclors, pesticides (including pyrethroids), and metals

Reach	Number of Samples
Washington Channel	1
Reach 123	3
Reach 456	2
Reach 67	2
Reach 7	1
Kingman Lake	2

Asian Clam (*Corbicula fluminea*)

Reach	Number of Clam Samples
Washington Channel	1
Reach 123	4
Reach 456	3
Reach 67	1
Reach 7	0
Kingman Lake	1

- 10 composite samples across the river
- Tissue extracted from shells, ground at the lab and analyzed for: dioxins, metals, SVOCs, PBDE, pyrethroids, PCB Aroclors, and organochlorine pesticides

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Crayfish Samples

Reach	Number of Samples
Washington Channel	0
Reach 123	2
Reach 456	0
Reach 67	4
Reach 7	1
Kingman Lake	1

- 8 composite samples across the river by sex and species
- Red swamp crayfish (Procambarus clarkii): 3 females, 2 males
- Spinycheek crayfish (Oronectes limosus): 1 female, 2 males
- Analysis varied sample to sample but included: metals, SVOCs, PCB Aroclors, PBDE, pyrethroids, pesticides, and dioxins

Supplemental Data – Phase 2

Identification of benthic, epibenthic and aquatic invertebrates in the study area

- Hester Dendy samplers
- Stomach contents of lower trophic fish

Hester Dendy Samplers

- 9 locations, across each reach of the tidal Anacostia River
- Deployed July 1 – Aug 15, 2016
- Artificial substrate samplers collect invertebrates to allow for the identification of invertebrate prey for fish
- Collected worms, leeches, crayfish, amphipods, isopods, chironomids, damselflies, dragonflies, caddisflies, mayflies, beetles, snails, and bivalves

Fish Stomach Contents

- 87 fish
- 8 fish species from mid and lower trophic levels
- Stomach contents evaluated to document invertebrate fish prey in the tidal Anacostia River

Forage Fish Collected for Analysis of Stomach Contents

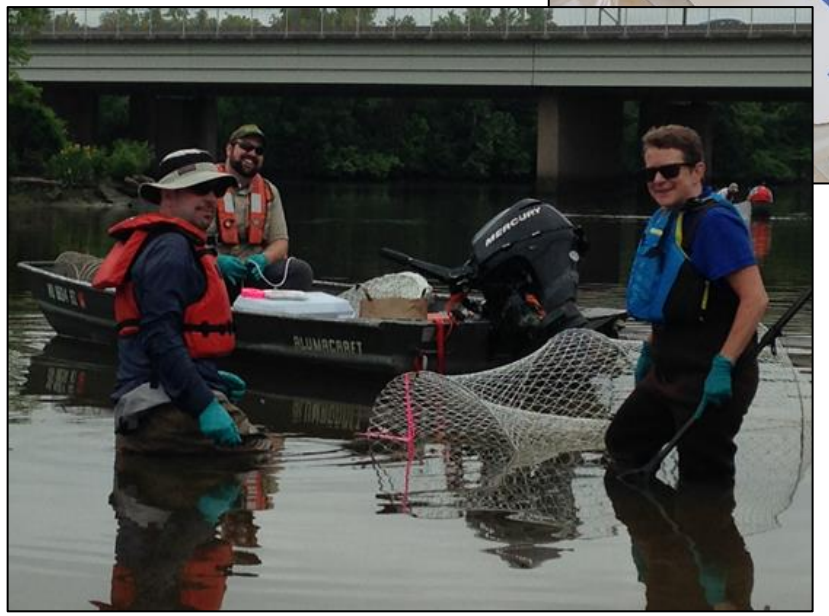
Common Name	Scientific name	Exposure Unit (EU)					
		1	2	3	4	5	6
Banded killifish	*Fundulus diaphanus*	2	5	5	0	1	0
Bluegill	*Lepomis macrochirus*	0	3	3	0	0	0
Eastern Silvery Minnow	*Hybognathus regius*	1	0	2	0	1	6
Mummichog	*Fundulus heteroclitus*	0	0	0	5	5	0
Pumpkinseed	*Lepomis gibbosus*	8	4	7	7	7	10
Redbreast sunfish	*Lepomis auritus*	2	0	0	0	0	0
Spotfin shiner	*Cyprinella spiloptera*	2	0	0	0	0	0
Lepomis hybrid	*Lepomis* sp.	0	0	0	0	1	0
	Total Fish per EU	**15**	**12**	**17**	**12**	**15**	**16**

Supplemental Data – Phase 2

Snapping Turtle Tissue

Common Snapping turtle (*Chelydra serpentina*)

- 6 adult males, 1 adult female (no eggs)
- Muscle, liver, and fat sample from each turtle submitted for chemical analysis of:
  - Dioxins, SVOCs, PCB Aroclors, organochlorine pesticides, pyrethroids, PBDE and metals



Supplemental Data – Phase 2

Causal Factors Bioassay Results

Evaluation of Causal Factors for Bioassay Results

Benthic Invertebrate

Phase 1 : Compared invertebrate toxicity results with laboratory controls

- No clear causal agents

Phase 2 : Compared invertebrate toxicity results with Potomac River reference area samples

- Simple and multiple regression analyses
- Chemical concentrations in surface sediment (metals, SVOCs, dioxins, PCBs, and OC pesticides)
- Chemical concentrations in pore water (metals, SVOCs, dioxins, PCBs, and OC pesticides)
- Other factors (TOC, percent clay, PAH potency ratios, $\sum$SEM-AVS/f_{oc}, ammonia)
- Probable effect concentration quotients
- PBDEs and pyrethroids in sediment and pore water

Phase 2 Larval Fish: Compared larval fish toxicity results from the Anacostia River to the Potomac reference area samples

- Sediment and pore water samples were also analyzed for PBDEs, pyrethroids, and dioxins and furans

Additional Updates to the BERA – Phase 2

Critical Body Residue

Additional Sediment Chemistry

Use of background HHRA fish results in the ERA

Critical body residue

- The CBR is a tissue concentration that is empirically associated with an effect (LOAEL) or lack of effect (NOAEL) in the organism.
- CBRs compiled from peer-reviewed literature on representative invertebrates and fish – not site specific
- Tissue concentrations of field-collected crayfish, clams, snails, and fish compared with taxonomically-appropriate CBRs
- Tissue concentrations of oligochaete exposed to sediments in laboratory bioaccumulation test

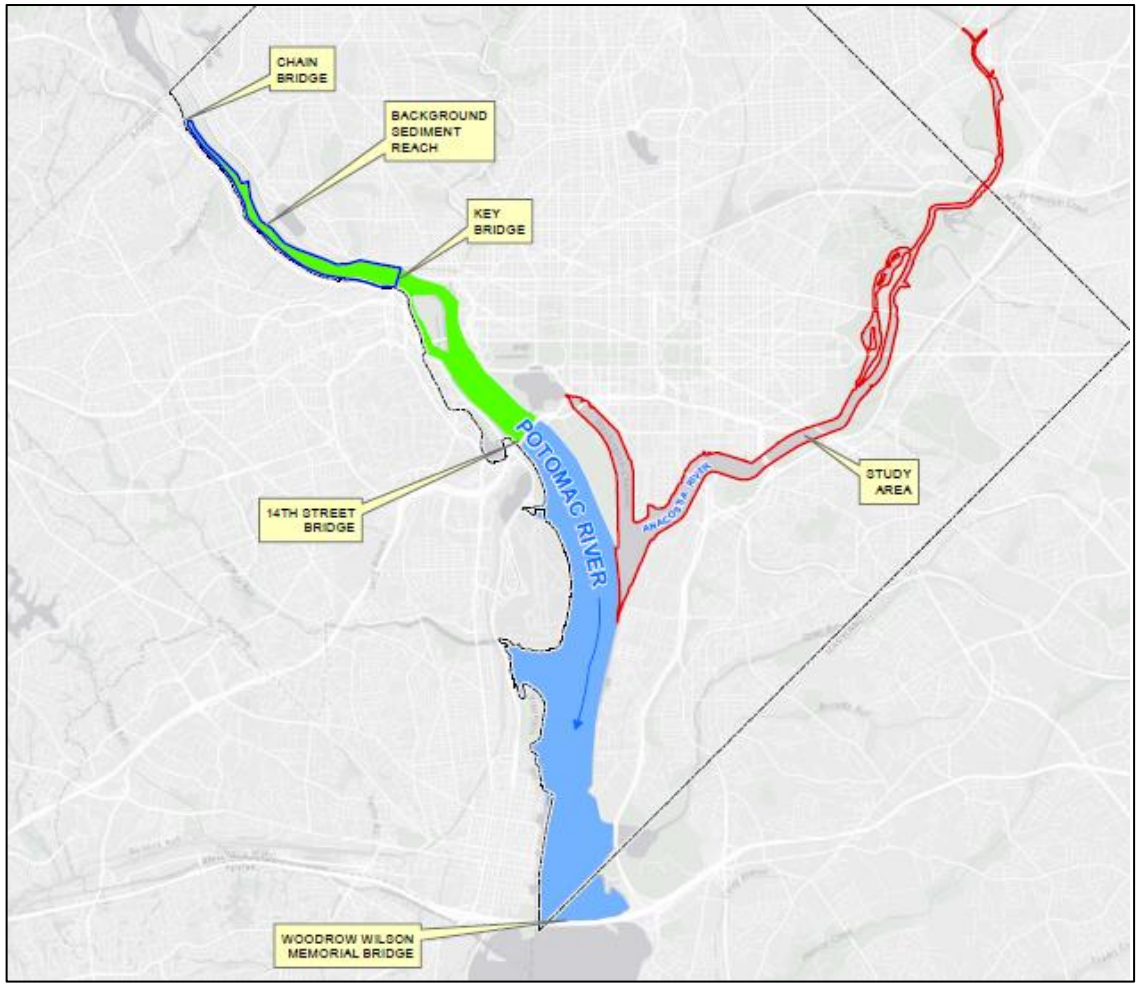
Phase 1 and Phase 2 Surface Sediment Chemical Sample Comparison

- Phase 2 BERA uses all surface sediment analytical results
- Representative exposure point concentration is the 95 UCL

Sample Type	Phase 1 (Number of samples included in Phase 1 RI)		Phase 2 (Number of new samples in Phase 2)		Phase 2 (total number of samples used in Phase 2, including Phase 1 samples)	
	Anacostia	Potomac	Anacostia	Potomac	Anacostia	Potomac
SURFACE SEDIMENT						
Surface Sediment – all analytes (metals, SVOCs, Aroclors, OC pesticides)	321	20	138	5	459	25
Surface Sediment – AVS/SEM	203	20	0	0	203	20
Surface Sediment – PAHs	230	20	107	5	337	25
Surface Sediment – Dioxins and Furans	114	20	95	5	209	25
Surface Sediment – PCB Congeners	210	20	151	5	361	25
Surface Sediment – Polybrominated diphenyl ether (PBDE)	0	0	95	5	95	5
Surface Sediment – Pyrethroids	0	0	87	5	87	5

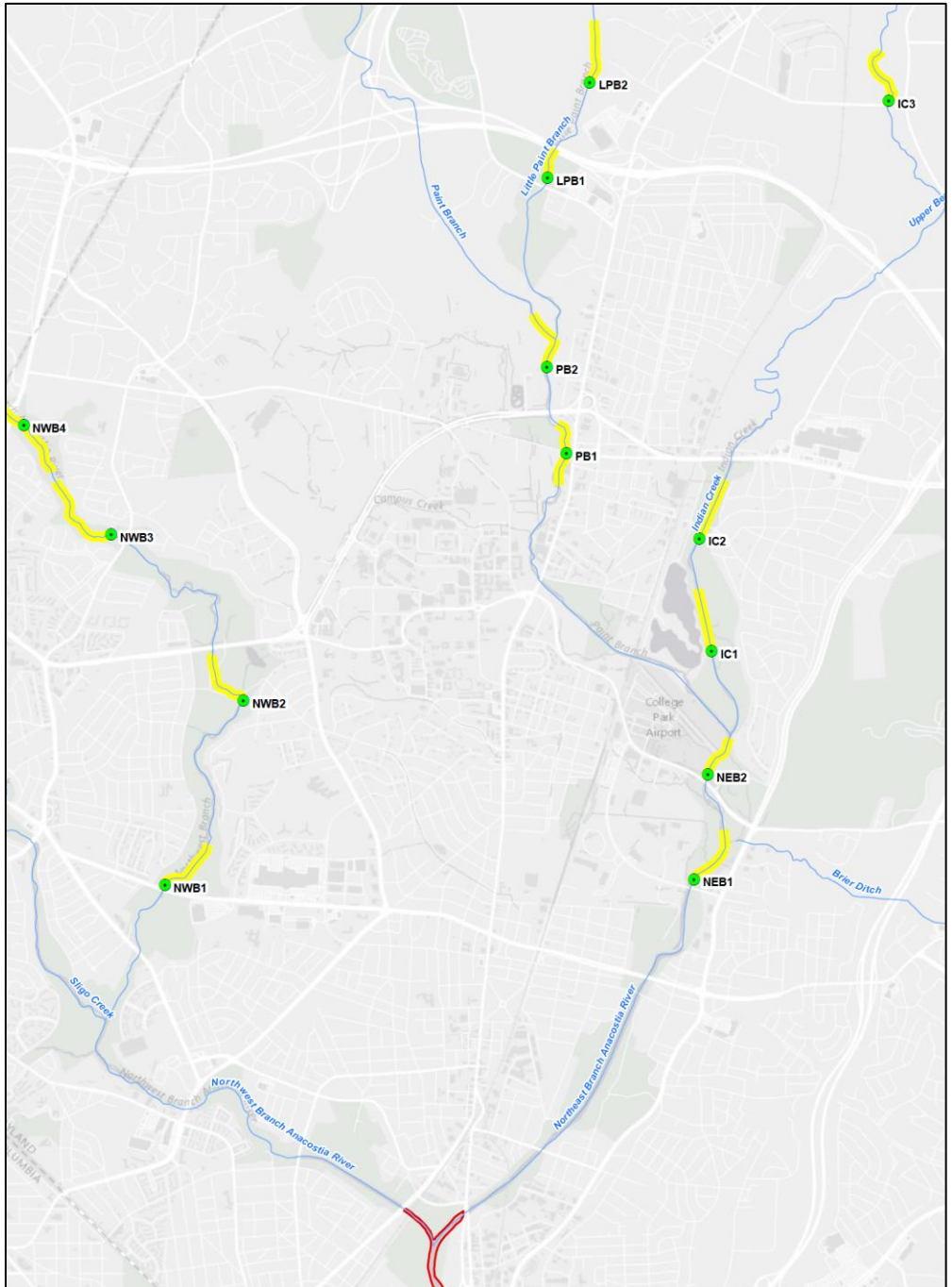
Use of background HHRA fish results in the ERA

- Compare with 2014 fish fillet concentrations
- Compare with Phase 1 tidal Anacostia whole fish concentrations
- Evaluate regional trends in fish (mercury and PCB)



Upstream Anacostia Background Fish Sampling Locations

- Top predators (e.g. largemouth bass) fillet and carcass results
- Mid-level predator (pumpkinseed) whole body results



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Ecological Risk Assessment Summary Results

Summary Ecological Risk Assessment – Phase 1

- **Constituents of Ecological Concern**
  - PCBs
  - Dioxins
  - PAHs
  - Pesticides (especially chlordane)
  - Lead, mercury, silver
- **Benthic and Aquatic Invertebrates –** 75% of samples demonstrated toxicity due to surface sediment exposure
  - Higher effects measured in the middle reaches of the river and lowest in the upper-most reach.
- **Fish**
  - Bioaccumulation of PCBs, dioxins, and mercury.
  - Higher forage level bioaccumulation in Washington Channel, and lower and middle reaches of the river.
- **Birds and Mammals**
  - Exposed to little or no risk related to Anacostia River sediments, surface water, fish, or invertebrate tissue.

Summary Ecological Risk Assessment – Phase 2 Update

Minor change in Constituents of Ecological Concern –

- PCBs (total Aroclors, total congeners, dioxin-like PCBs)
- Dioxins
- Total PAHs
- Pesticides (especially chlordane)
- Mercury

Benthic and Aquatic Invertebrates –

- **Bioassays** - Compared against reference site and similar distribution of toxicity as noted in Phase 1. Little correlation of chemicals to toxicity, indicating other parameters contributing to toxicity, such as TOC and percent silt and clay.
- **Tissue analysis** – Most of the highest concentrations in invertebrates were from samples collected in EU-2.
  - Relative concentrations varied across crayfish, snails, clams, and *Lumbriculus*
  - Bioaccumulation of PCBs, Dioxins, PAHs, pesticides, and metals observed.
- **Taxonomy- Hester Dendy-** 13 taxonomic orders including: worms, leeches, crayfish, amphipods, isopods, midges, damselflies, dragonflies, caddisflies, mayflies, beetles, snails, mussels, and clams. Diversity was generally greatest at the most upstream locations with the most organisms in EU-3, Reach 4.

Summary Ecological Risk Assessment – Phase 2 Update

Fish

- **Bioassay (larval fish)–** No evidence of increased mortality observed, limited effects of reduced growth observed
- **Tissue Analysis** –Upper Anacostia background location – similar concentrations to whole fish tissue from tidal Anacostia locations.
- **Bioaccumulation-** PCBs, dioxins, pesticides and mercury, but similar to Upper Anacostia background levels.
- **Biomagnification**- PAHs, pesticides, lead and mercury.
- **Fish Stomach Content**- Contents varied by genus but included- chironomids, mollusks, other invertebrates and algae. Many fish also were host to parasites.

Turtles

- **Tissue Analysis** – Concentrations of PCBs, pesticides, PBDEs, and metals similar to "clean sites."

Birds and Mammals

- Exposed to little or no risk related to Anacostia River sediments, surface water, fish, or invertebrate tissue as noted in Phase 1.

Ecological Remedial Action Objectives (RAO) and Preliminary Remediation Goals (PRG)

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Preliminary Ecological RAOs

- Reduce concentrations of COCs in surface sediment to levels *protective of benthic and aquatic invertebrates* based on direct chronic exposure.**
- Reduce concentrations of COCs in surface sediment to levels *protective of fish based on direct contact with sediment and ingestion of sediment and prey living in sediment*.**
- Reduce concentrations of COCs in surface sediment to levels *protective of aquatic birds and mammals based on direct contact with sediment and ingestion of sediment and prey living in sediment*. **

** Ensure that surface sediments are protected from additional releases of hazardous substances that would undermine the long term effectiveness of the remedy or threaten the successful reestablishment of *benthic and aquatic invertebrates, native fish, and aquatic birds and mammals.*

Development of Ecological PRGs

- Ecological PRGs vary by medium (surface water, sediment) and receptor.
- DOEE and federal effect concentrations were considered as initial ecological PRGs (e.g. District Water Quality Standards; EPA Region 4 sediment probable effect concentrations).
- Risk-based equations will be used when data are available to support them (e.g. back-calculating acceptable risk using food chain models) to develop PRGs for birds and mammals.
- Ecological PRGs for fish and benthic invertebrates based on results of direct toxicity tests will be considered to the extent the data support them.
- Potomac River reference areas will be considered during PRG development (e.g. Potomac River Reference Site Background Threshold Values)
- Ecological PRGs will be developed for the Anacostia River as a whole (not reach-specific).

Questions and Comments?

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