Conceptual Site Model for the South River Aquatic System

Abiotic and Biotic Pathways Diagrams And More…

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Drivers for a Conceptual Site Model (CSM)

- Identify Hg sources and pathways that are primarily responsible for elevated Hg levels in smallmouth bass
- Identify specific pathways that are feasible to interrupt to effectively reduce Hg levels in smallmouth bass

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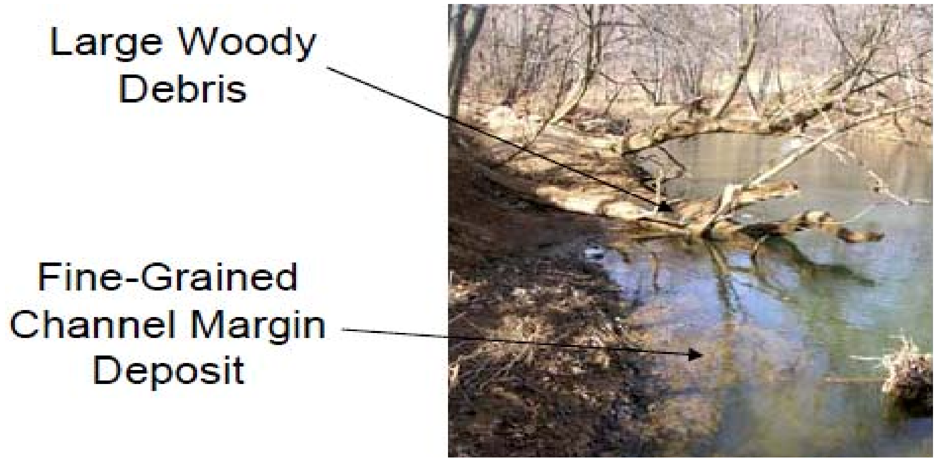
CSM Identifies and Quantifies…

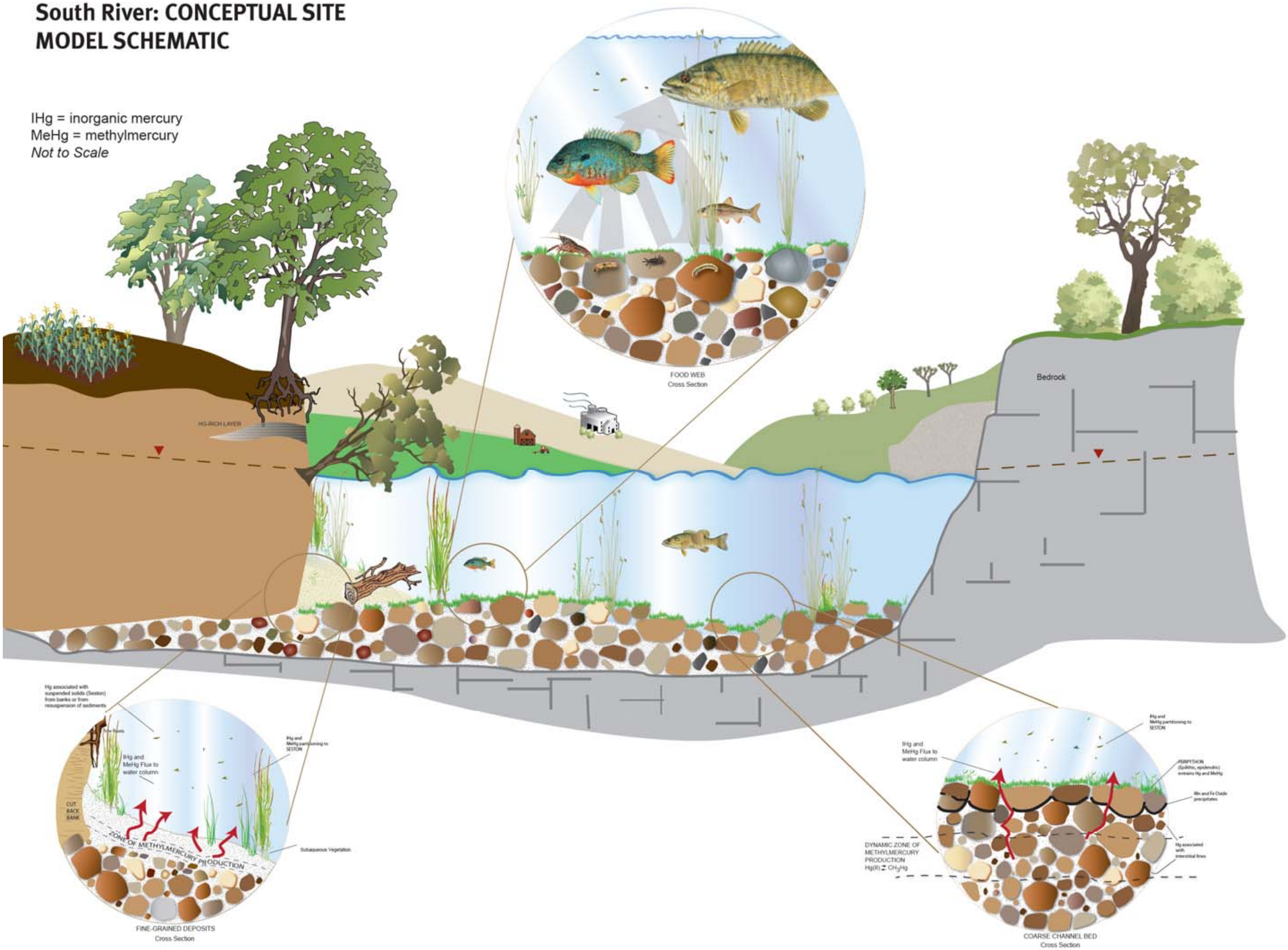
- Sources of and abiotic pathways by which IHg moves through aquatic system to sites of methylation
- MeHg production compartments that supply biota at base of aquatic food web
- Biotic pathways by which MeHg bioaccumulates up the aquatic food web to smallmouth bass

Emphasis placed on multiple lines of evidence supported by actual field data

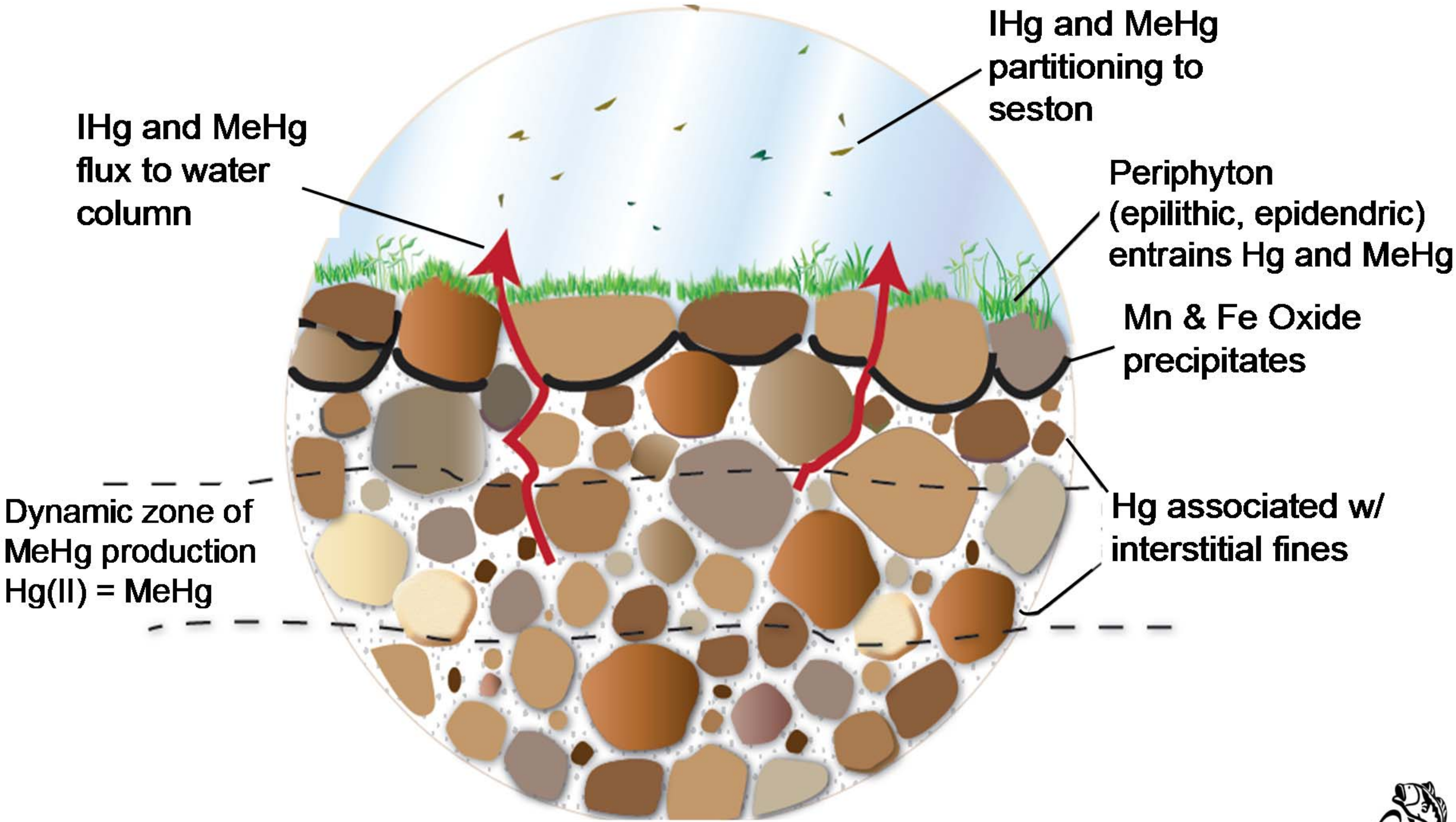


South River: CONCEPTUAL SITE MODEL SCHEMATIC

IHg = inorganic mercury
MeHg = methylmercury
Not to Scale



Coarse Channel Bed Cross Section



Coarse Channel Bed Cross Section

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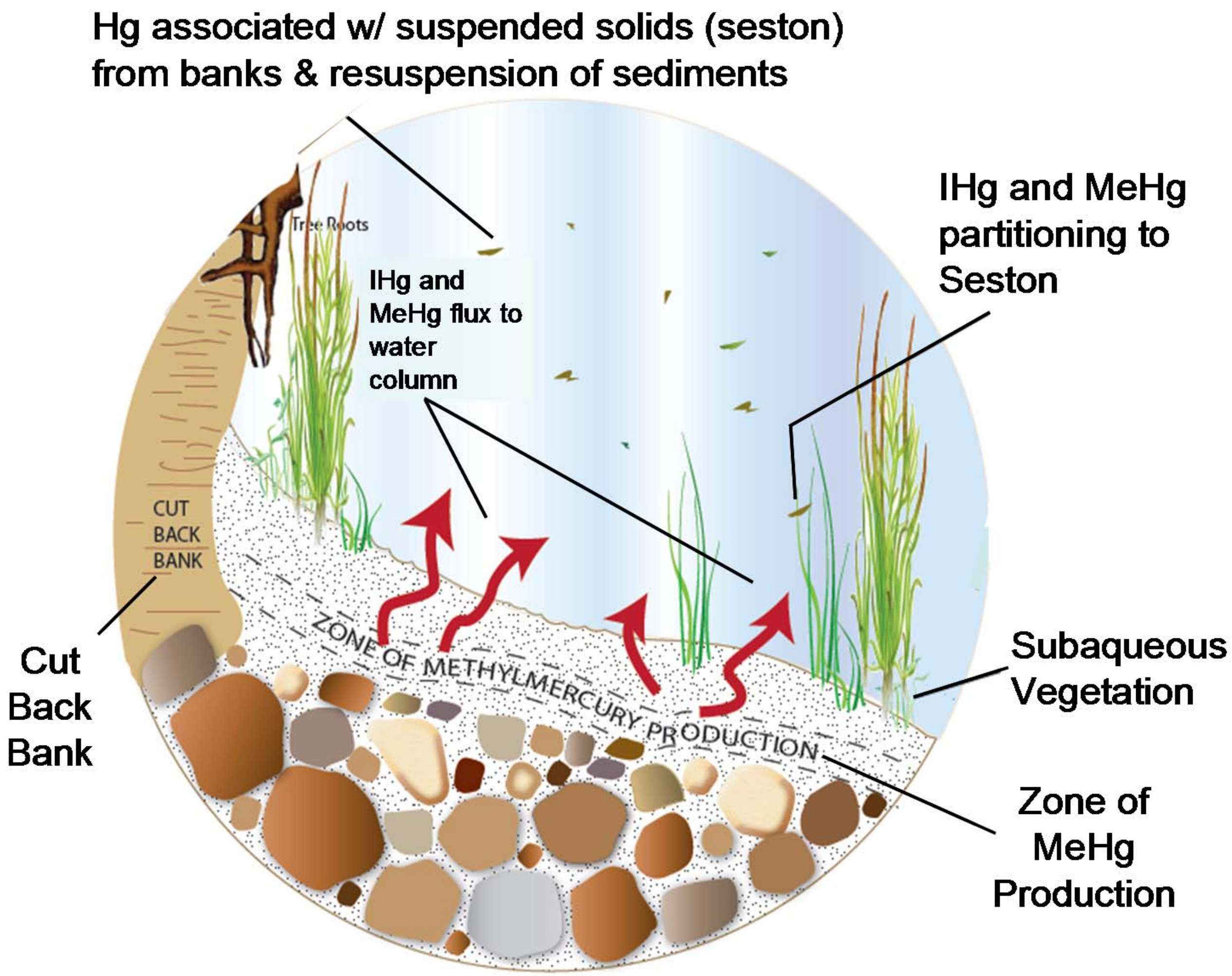
Fine-Grained Deposits Cross Section



Fine-Grained Deposits Cross Section

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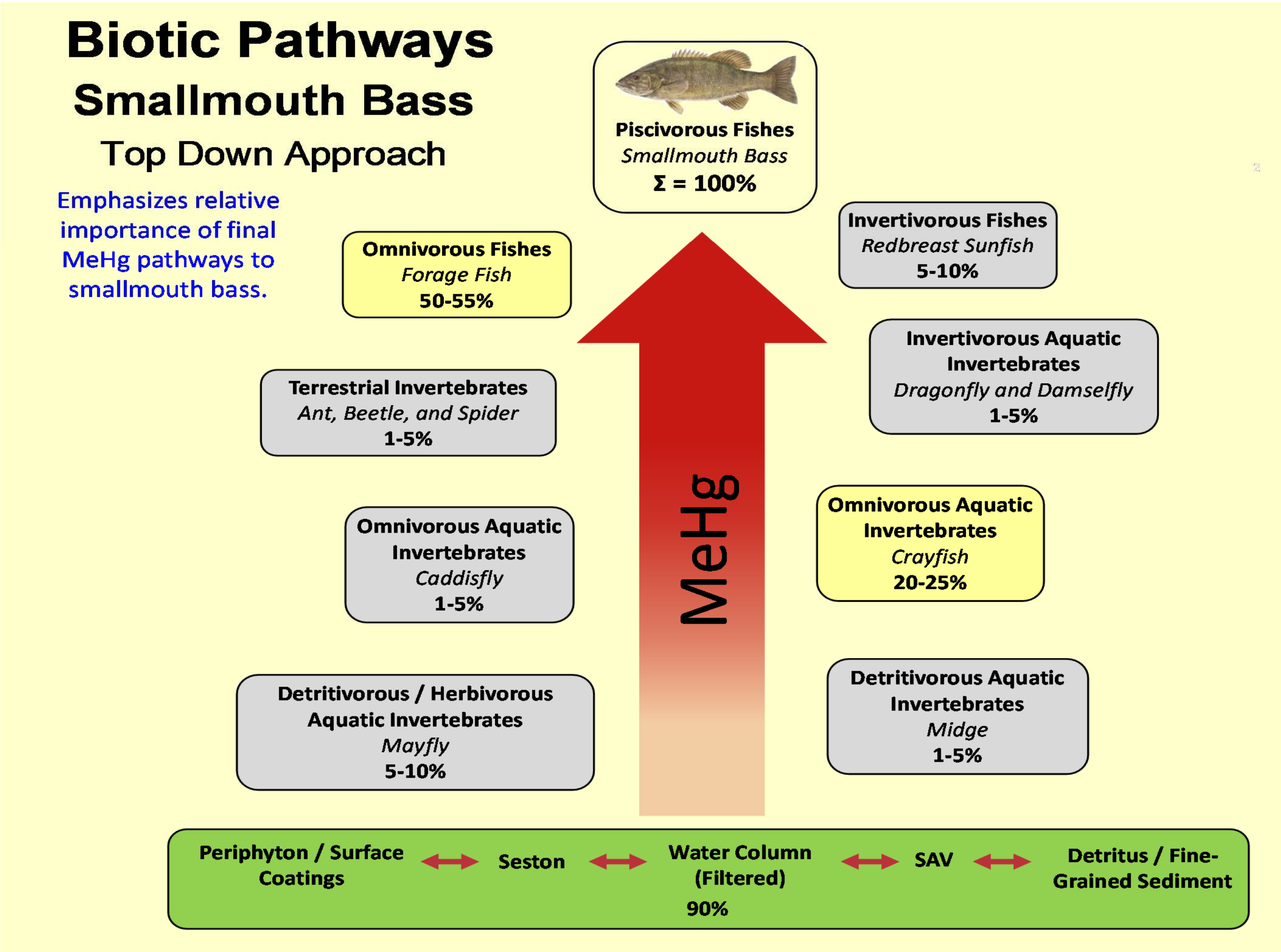
Biotic Pathways Diagram

FOOD WEB
Cross Section


Biotic Pathways
Smallmouth Bass
Top Down Approach
Emphasizes relative importance of final MeHg pathways to smallmouth bass.
Piscivorous Fishes
Smallmouth Bass
Σ = 100%
Omnivorous Fishes
Forage Fish
50-55%
Invertivorous Fishes
Redbreast Sunfish
5-10%
Invertivorous Aquatic Invertebrates
Dragonfly and Damselfly
1-5%
Terrestrial Invertebrates
Ant, Beetle, and Spider
1-5%
MeHg
Omnivorous Aquatic Invertebrates
Caddisfly
1-5%
Omnivorous Aquatic Invertebrates
Crayfish
20-25%
Detritivorous / Herbivorous Aquatic Invertebrates
Mayfly
5-10%
Detritivorous Aquatic Invertebrates
Midge
1-5%
Periphyton / Surface Coatings
Seston
Water Column (Filtered)
SAV
Detritus / Fine-Grained Sediment
90%

Approach / Key Assumptions for Biotic Pathways Diagram

- Approach:
  - Top down approach emphasizes relative importance of final MeHg pathways (direct) to smallmouth bass
  - Lower trophic levels are less important as direct MeHg pathways to smallmouth bass, but are important initial pathways into the food web and indirect pathways to smallmouth bass by way of secondary consumers
- Key Assumptions:
  - Diet accounts for 55% of MeHg uptake by mayfly, caddisfly, and midge
  - Diet accounts for 66% of MeHg uptake by crayfish and invertivorous invertebrates

  (Diet versus aqueous uptake pathways for invertebrates based on 2010 *in situ* uptake study for mayfly, nymph and crayfish)

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Data Sources for Biotic Pathways Diagram

Biotic Pathway Components	Data / References
MeHg in Physical / Biological Media	• South River Science Team databases containing MeHg information from various programs
MeHg Uptake Pathways	• Phase II Ecological Study - BASS model outputs for smallmouth bass, redbreast sunfish, and common shiner • Phase II Ecological Study - *In situ* Hg uptake study for mayfly nymph and crayfish
Dietary Composition	• Phase II Ecological Study - Fish stomach content analyses for smallmouth bass, redbreast sunfish, and common shiner • Snyder and Hendricks (1995) - Study on Hydropsychid caddisflies in South River • Merritt et al. (2008) - Invertebrate diet information
Assimilation Efficiency	• Wiley and Wike (1986) • Shuter and Post (1990) - Smallmouth bass • Headon et al. (1996) - Crayfish • Trebitz (1997) - Sunfish • Duffy (1998) - Cyprinids • Karimi et al. (2007) - Invertebrates

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Abiotic Pathways Diagram

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How Were the Sources and Pathways Quantified?

- Tapped collective knowledge and expertise of SRST members and outside experts
- Utilized appropriate mix of databases and statistical, analytical, & numerical models to quantify mass loading and flux
- Where practical, Monte Carlo simulations or other error analysis techniques were used to estimate uncertainty

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The SR CSM Integrates South River Data and Other Model Results

Numerical Predictive Models
- BASS Model
- **HSPF Model (TMDL)**
- **HEC RAS Model**

Analytical Modeling
- **Statistical Models**
- Trophic Transfer
- **Geomorphic Models**
- **Mass Flux Models**
- **HQI Loading Analysis**
- **Phase 1 Eco Report**

Biotic Pathways

Conceptual Site Model

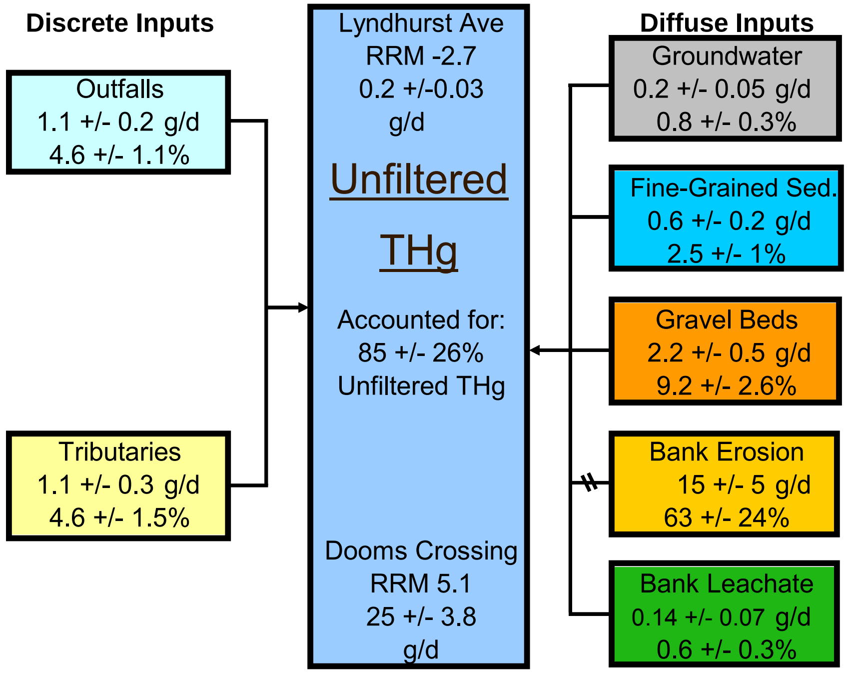
Abiotic Pathways

Field Data
- **Eco Study Data (Phases 1&2)**
- **SRST Investigations**
- **Site Outfall Monitoring**
- **Bank Pilot**

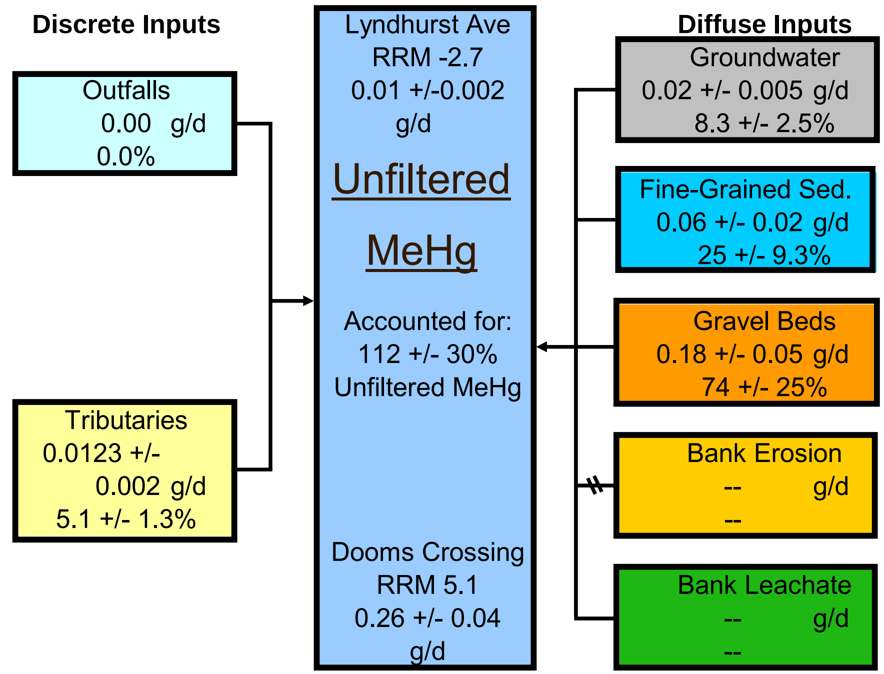
Lab Studies
- **U. Waterloo Soil & Sed Charac.**
- **U. Texas DGT**
- **SERC/UMBC**
- **Battelle**

Notes:
BASS - Bioaccumulation and Aquatic System Simulator

Daily Water and Hg Mass Budgets - Lyndhurst to Dooms (RRM -2.7 to 5.1)

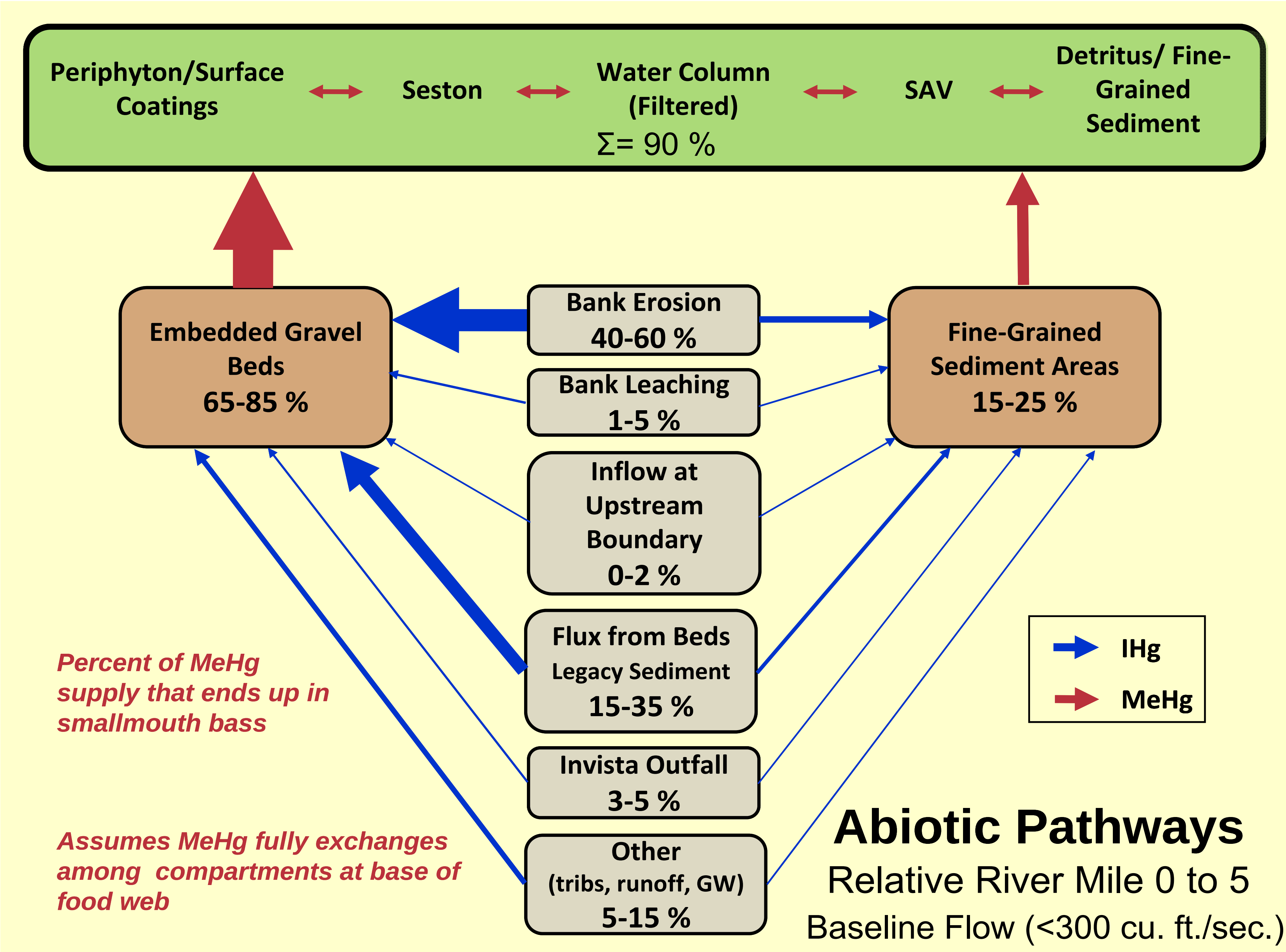


- Tributaries, millraces, wetlands & bedrock GW are minor sources
- Bank-to-bank sources important, particularly bank erosion and flux from embedded gravel beds



Note: All mass flux values were calculated independently, not by difference.

MeHg: Methylmercury; THg: Total Mercury

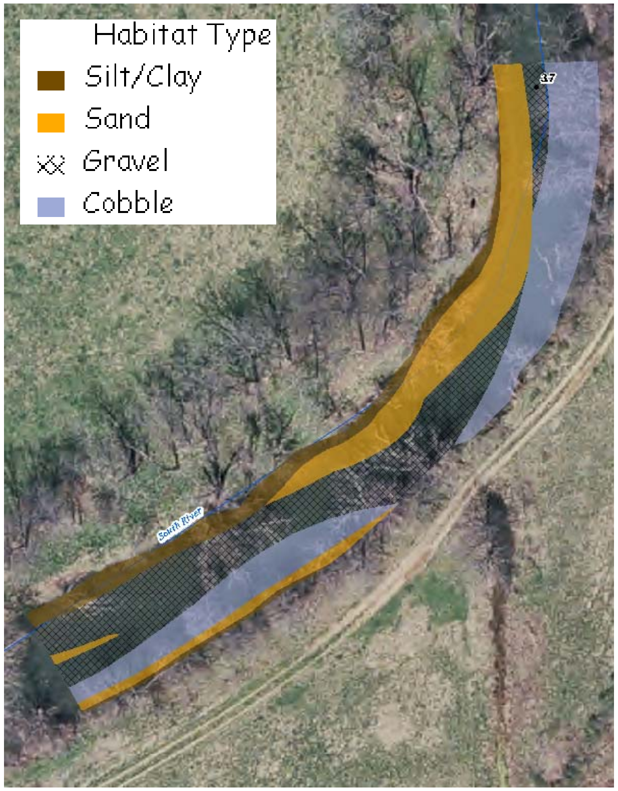

Periphyton/Surface Coatings
Seston
Water Column (Filtered)
Σ= 90 %
SAV
Detritus/ Fine-Grained Sediment
Embedded Gravel Beds
65-85 %
Bank Erosion
40-60 %
Fine-Grained Sediment Areas
15-25 %
Bank Leaching
1-5 %
Inflow at Upstream Boundary
0-2 %
Flux from Beds
Legacy Sediment
15-35 %
Invista Outfall
3-5 %
Other
(tribs, runoff, GW)
5-15 %
IHg
MeHg
Percent of MeHg supply that ends up in smallmouth bass
Assumes MeHg fully exchanges among compartments at base of food web
Abiotic Pathways
Relative River Mile 0 to 5
Baseline Flow (<300 cu. ft./sec.)

Assumptions & Data Sources for Abiotic Pathways Diagram: Sources of Inorganic Hg

Hg Sources	Data / References
Tributaries	Eco Study Data (April/May/June 2008); Calculated Daily Mercury Budget for South River (Dyer and Flanders, revised 4/2011)
Groundwater	Genicom Facility / Schifflett Farm Final Soil, Groundwater, and Surface Water assessment report, Waynesboro, VA (USEPA, 2007); Bank stabilization pilot data and monitoring report (URS, 2011); Comprehensive RFI Report Former DuPont Waynesboro Site (URS, 2009); Report on Groundwater at Basic Park (Turner & Jensen, 2006)
Floodplain Runoff	Mercury floodplain study and analysis (VA DEQ, 2008); Phase 1 Eco Study Report (URS, 2006)
Invista Plant Outfalls	Stormwater outfall monitoring data collected 2003-2006 as part of RCRA Corrective Action permit; Mercury Loading to South River from Plant Outfalls-Analysis of Base Flow and Storm Flow Data (Dyer, Nov. 2007); TMDL Development for Mercury in the South River, South Fork Shenandoah River, and Shenandoah River, Virginia (USGS, 2009)
Inflow at Upstream Boundary	Phase I & II Eco Study surface water monitoring data (URS, 2005-2010); Conceptual Site Model for Mercury in the South River, VA, (HydroQual, Inc., 2009)
Bank Erosion	Bank Erosion Estimates based on Aerial Photography Analysis, Erosion Pins and Land-based LiDAR Surveys (Pizzuto et al.,2006-2011)
Bank Leaching	Sediment-column leaching data and flux estimates for bank soils (University of Waterloo, 2010-2011)
Flux from Beds (Legacy Sediment)	Benthic flux chamber data (Landis, 2006-2008), Mass Transfer analytical models to predict flux based on pore water data (Dyer and Landis, 2009-2011)

Assumptions & Data Sources for Abiotic Pathways Diagram: MeHg Production Compartments

- Direct loading of MeHg from floodplain soil << MeHg production within wetted perimeter of river
- Embedded Gravel Beds[1]: Comprise ~85% of river bed area
- Fine-Grained Sediment Areas[2]: Comprise remaining 15% of river bed area
- Median Filtered IHg (FIHg) Pore Water Concs. for silt/clay substrates are 1X-4X median pore water concs. for cobble/gravel/sand substrates based on data for four 2009 study areas
- Resulting 75%/25% Split in MeHg Production between gravel beds & fine-grained sediment areas based on weighting factor of (bed area x pore water conc.)



[1] Areas mapped as cobble/gravel/ sand during 2009 substrate mapping exercise

[2] Areas mapped as silt/clay during 2009 substrate mapping exercise

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Lines of Evidence for Abiotic Pathways Diagram

Excel® document containing

- Name of source/compartment
- Description of source/compartment
- % contribution to mass loading
- Uncertainty range
- Calculation basis
- Lines of evidence
- Data and document references

Lines of Evidence Document Sample Screen Capture

Source	Description	Percent Contribution	Uncertainty Range	Calculation Basis
Advective/Diffusive Flux from Beds at Depth (Legacy Sediments)	Upward flux of inorganic mercury that originates deeper within the embedded gravel beds and FGCM deposits below the optimum redox zone where methylation occurs. Includes diffusion of IHg driven by elevated pore water concentrations and advection driven by upwelling alluvial groundwater.	25	15-35	Basic Data for Mass Transfer Calculations - 2008 FIHg daily mass budget, RRM -2.7 to 9.9 (Lyndhurst Ave. to Crimora Rd.) - 2009 pore water data, Phase II EcoStudy - 2010 DGT probe data, Univ. of Texas at Austin - Eroding bank/floodplain soils & embedded gravel beds within the river channel are two sources of FIHg flux to water column. - FIHg flux measured by benthic flux chambers (BFCs) should fall within uncertainty bounds of mass flux predicted by a suitable MT model. - Flux measured by BFC best represented by a steady-state model (snapshot in time). - An overall lumped mass transfer coefficient will capture all mass transport mechanisms in a single parameter (diffusion, advection, hyporheic exchange, colloidal transport), thereby simplifying the model calculations. - IHg (log Kd = 6) partitions more strongly to sediment solids than MeHg (log Kd = 5). - For constituents with a very large Kd (such as IHg), mass transfer will often be water-film controlled. Calculate 50% & 75% probability values for FIHg mass load based on 2009 pore water data. Use a correlation based on turbulent flow mass transfer theory to estimate an overall kA and sum load contributions from 2 substrate types: gravel/cobble/sand & silt/clay. Compare to measured reach-wide FIHg mass load (based on 2008 MeHg daily mass budget) from Lyndhurst Ave. to Crimora Rd. (RRM -2.7 to 9.9).

Lines of Evidence Document Sample Screen Capture

Source	Lines of Evidence
Advective/Diffusive Flux from Beds at Depth (Legacy Sediments)	Benthic flux chamber studies from May to August 2008 measured -82 to 222 ng FIHg/m2.hr with a median of 37 ng/m2.hr from embedded gravel beds and -45 to 214 FIHg/m2.hr with a median of 17 ng/m2.hr from FGCM deposits. Ex-situ desorption studies by Turner/Jensen at Basic Park using cartridge filters preloaded with contaminated sediment generate FIHg flux rates ranging from 50 to 200 ng/m2.hr Monte Carlo simulations using a steady-state mass transfer model (k estimated from published correlation for water-film-controlled mass transfer) predict that 20-40% of the reach-wide FIHg river load can be accounted for by diffusive/advective flux from the river bed at rates that agree well with the 2008 BFC studies. For a worst-case scenario using calculated k values for FMeHg, Monte Carlo model simulations predict that 40-80% of the reach-wide FIHg river load can be accounted for by the river bed, but at areal flux rates much greater than those measured in any of the 2008 BFC studies. 2009 porewater measurements by URS using Henry probes in 4 study areas provide evidence for significant concentration gradients for mass transfer at > 5 cm depth. DGT probe studies in 2010 by Danny Reible at UT-Austin provide evidence for an even larger concentration gradient for mass transfer at > 5 cm depth. Fine particle residence times in the hyporheic zone calculated by Jim Pizzuto: residence time of fine-grained sediment in the stream bed is ~ 2 years; 20 years will be required to rework 90% of the streambed.

Example: Lines of Evidence for Advective/ Diffusive Flux from Beds

Filtered Inorganic Mercury (FIHg)

- Using published equations for diffusive/advective mass transfer, Monte Carlo simulations predict that 20-40% of reach-wide FIHg river load can be accounted for by flux from river bed at rates that agree well with benthic flux chamber (BFC) and other laboratory studies.
- By difference, results suggest that eroding bank soils contribute 60-80% of reach-wide FIHg river load.
- Hence, both BFC measurements and mass transfer calculations support hypothesis that FIHg primarily enters the water column from eroding banks.

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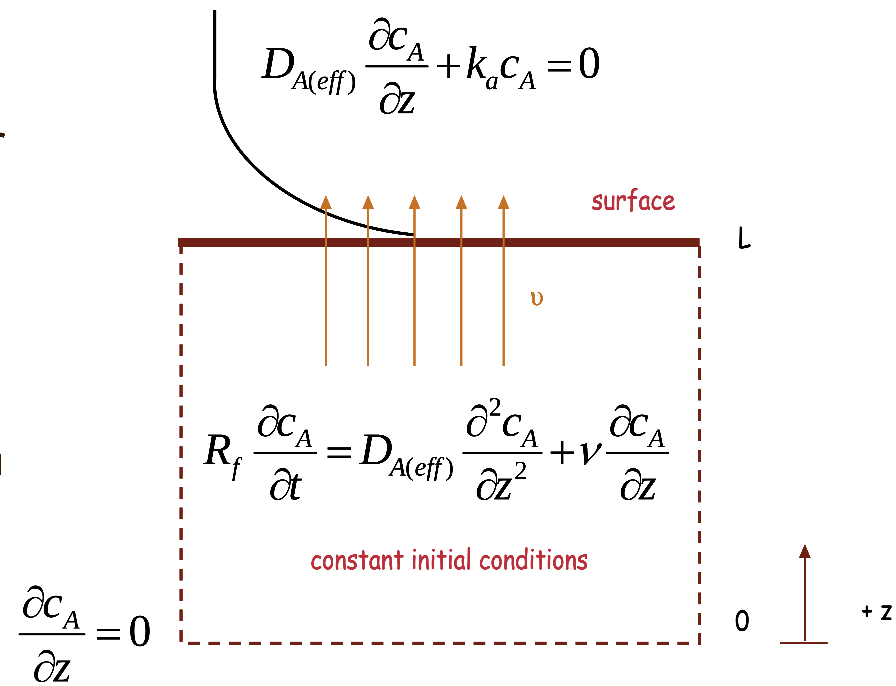
Example: Lines of Evidence for Advective/ Diffusive Flux from Beds

Filtered Methylmercury (FMeHg)

- Similarly, mass transfer equations predict that > 95% of reach-wide FMeHg river load can be accounted for by flux from river bed at rates that agree well with BFC studies.
- For example, model-predicted FMeHg flux values (18 to 90 $ng/m^2 \cdot hr$) fall well within range of flux values measured in field by BFCs (-12 to +160 $ng/m^2 \cdot hr$).
- Hence, both BFC measurements and mass transfer calculations support hypothesis that FMeHg primarily enters the water column from the river bed.



Working Hypotheses for Absence of a Decline in Fish-Tissue Mercury

- Hg-contaminated soil particles from eroding banks and floodplain soil are an ongoing, long-term, primary source of bioavailable IHg to the aquatic ecosystem
- Over time, this has led to an accumulation of Hg-rich, fine-grained sediment particles in near-bank areas and sand/gravel/cobble beds within the river channel, continuing to supply pore water with dissolved and colloidal IHg that diffuses to sites of methylation

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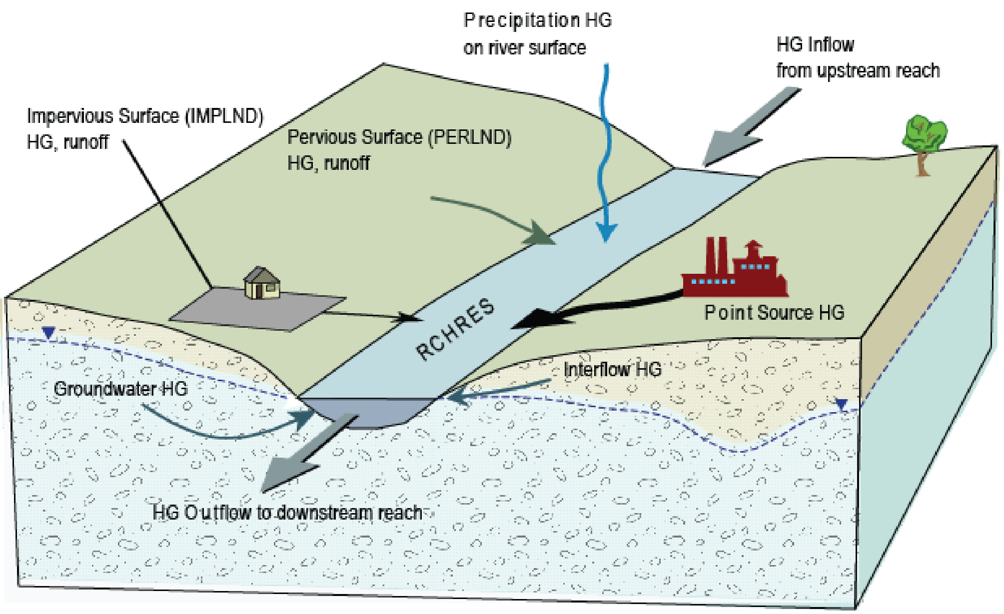
What About Downstream of RRM 5?

- What does the TMDL (i.e., HSPF) model tell us about unfiltered total Hg?



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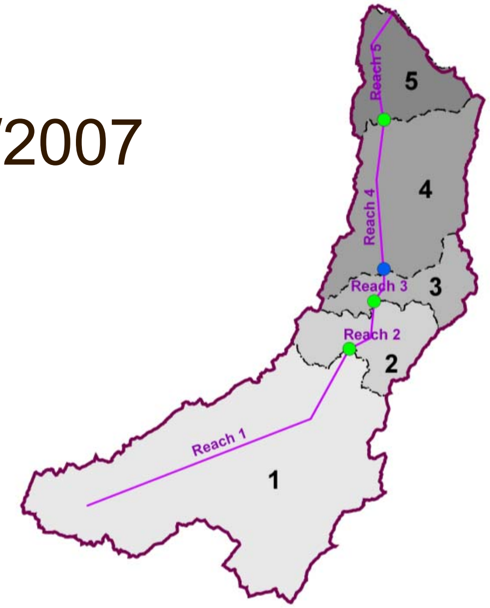
Bases For Analysis of TMDL Model Output

- Unfiltered Total Hg (UTHg)
- Model output for 04/01/2005 thru 03/31/2007
- 5 river reaches defined in HSPF model
  - #1: Upstream to RRM -2.8 (Waynesboro)
  - #2: RRM -2.8 to 2.3 (Hopeman Parkway)
  - #3: RRM 2.3 to 5.3 (Dooms)
  - #4: RRM 5.3 to 16.5 (Harriston)
  - #5: RRM 16.5 to 24 (Port Republic)



- Definition of stormflow based on flow duration curves
  - defined as "discharge rate that is exceeded 10% of time"
  - > 325-350 cfs @ Waynesboro & > 500-600 cfs @ Harriston per Figures 32-33 from TMDL modeling report**

** Mercury Loads in the South River and Simulation of Mercury Total Maximum Daily Loads (TMDLs) for the South River, South Fork Shenandoah River, and Shenandoah River: Shenandoah Valley, Virginia by USGS

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General Characterization of Reaches from UTHg-Loading Perspective

- Waynesboro to Dooms (RRM -2.8 to 5.3)
  - Bank erosion & bed flux dominate
- Dooms to Port Republic (RRM 5.3 to 24)
  - Floodplain runoff & bank erosion dominate

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1. Annual Basis by Segment

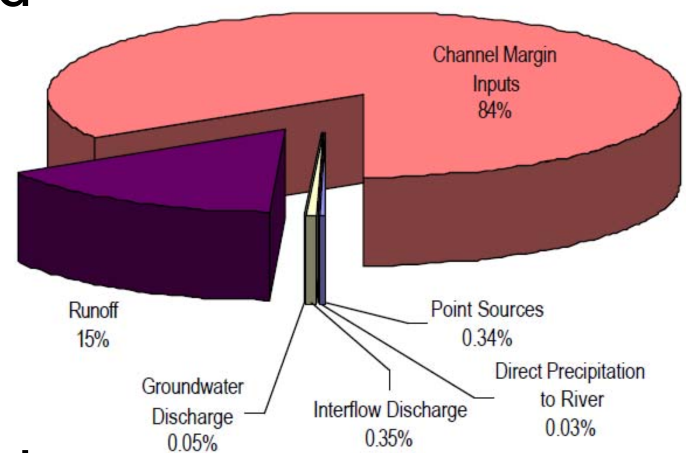
- RRM -2.8 to 5.3
  - 80% of total annual UTHg load of which 97% is channel margin inputs (bank erosion, flux from beds, bank leaching, etc.)
- RRM 5.3 to 16.5
  - 20% of total annual UTHg load of which 60% is floodplain runoff

Annual Basis (%)

	% of Total Annual UTHg River Load					
Reach	1	2	3	4	5	Total all Reaches
Point Sources	0.0%	0.3%	0.0%	0.0%	0.0%	0.3%
Direct Precipitation to River	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Interflow Discharge	0.2%	0.0%	0.0%	0.1%	0.0%	0.4%
Groundwater Discharge	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Runoff	0.3%	0.1%	2.1%	11.2%	1.8%	15.4%
Channel Margin Inputs	0.0%	31.2%	43.7%	7.7%	1.2%	83.8%
Totals	0.55%	31.67%	45.82%	18.97%	2.98%	100.00%

2. Annual Basis, Entire River

- Baseline Conditions
  - 25% of total annual UTHg load
  - 98% channel margin inputs



- Stormflow Conditions
  - 75% of total annual UTHg load
  - 80% channel margin inputs + 20% floodplain runoff

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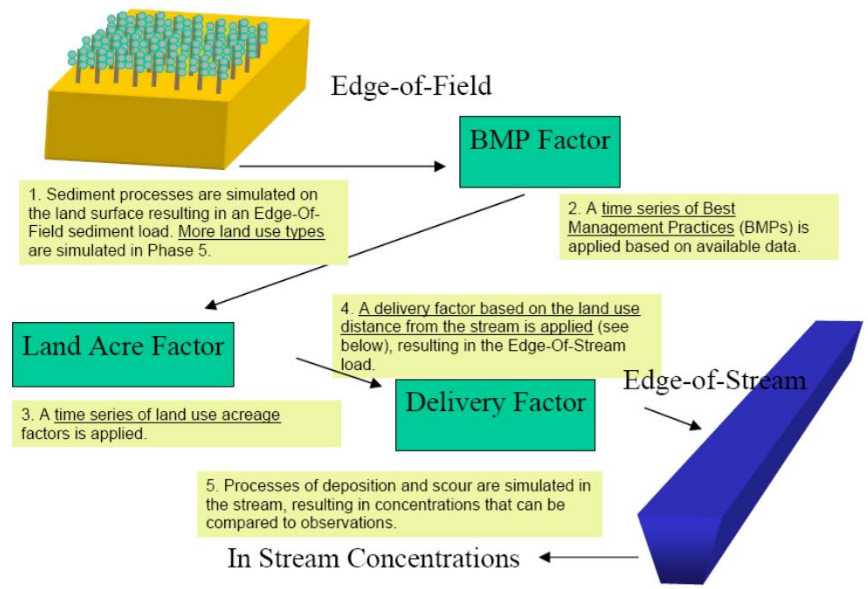
3. Floodplain Runoff - Daily Basis by Segment

- RRM -2.8 to 5.3
  - Up to 45-50% of daily UTHg load can be from floodplain runoff



- RRM 5.3 to 24
  - Up to 97% of daily UTHg load can be from floodplain runoff

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Conclusions from TMDL Model Output

- 80/20 Rule
  - UTHg loading primarily driven by channel margin inputs (banks inward) over RRM 0 to 5 under stormflow conditions (80)
  - Floodplain runoff during storms is a primary input downstream of RRM 5, but a secondary contributor overall (20)
- Does not necessarily apply to availability of inorganic Hg for methylationn & MeHg production itself

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What About Downstream of RRM 5?

- What does a preliminary water and Hg mass budget look like for RRM 5 to 10?

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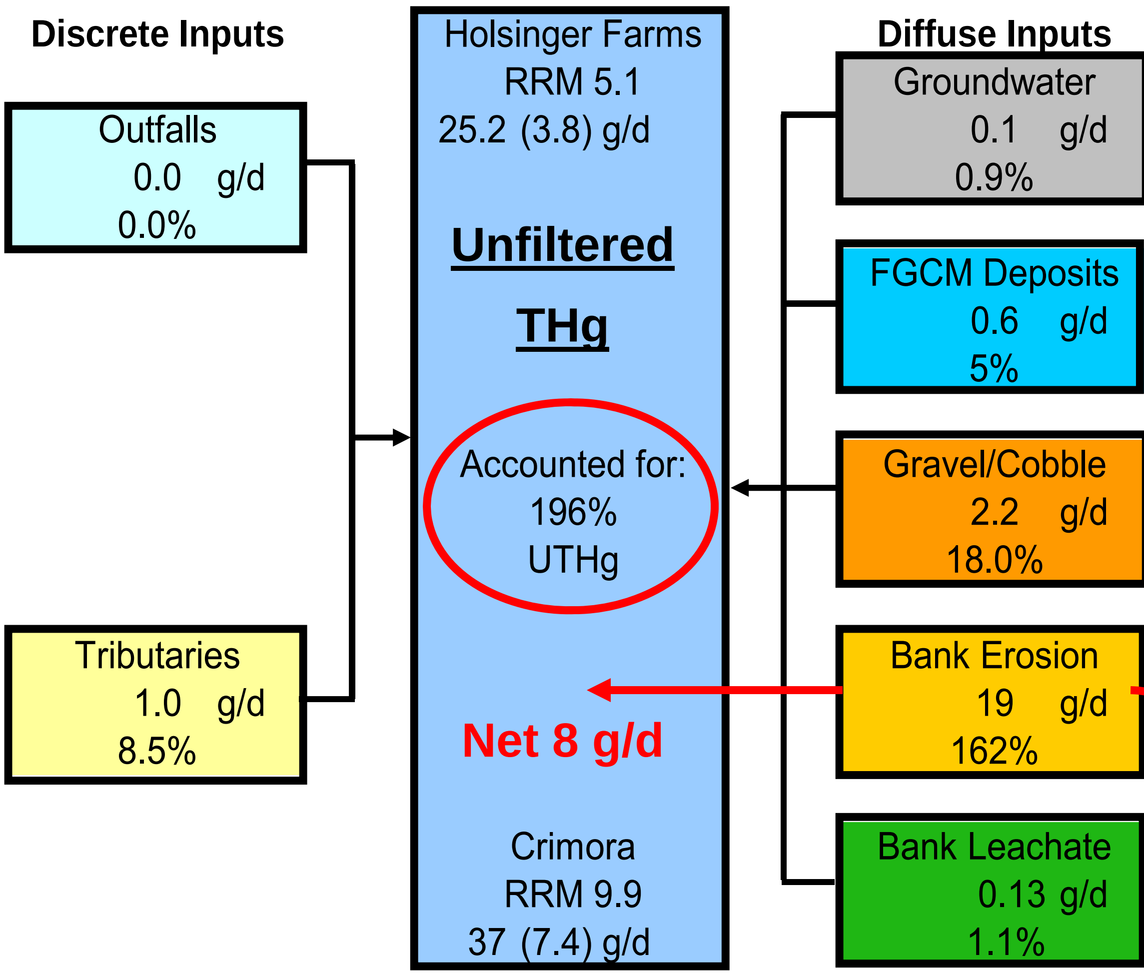
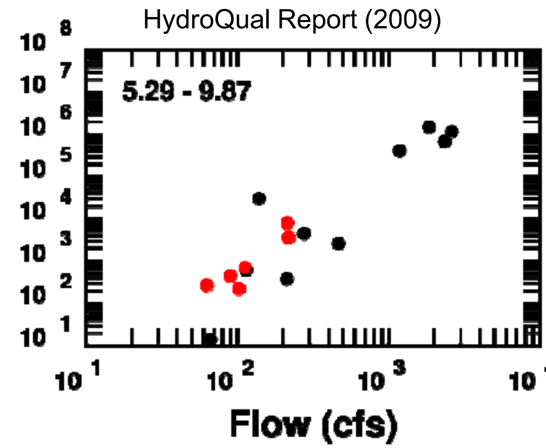
Daily Water & Hg Mass Budgets – Holsinger to Crimora (RRM 5.1 to 9.9) – Unfiltered Total Hg



Negative UTHg loads common in this reach @ baseflow conditions



Black = Positive Load

Red = Negative Load

Sediment Deposition

11 g/d ??

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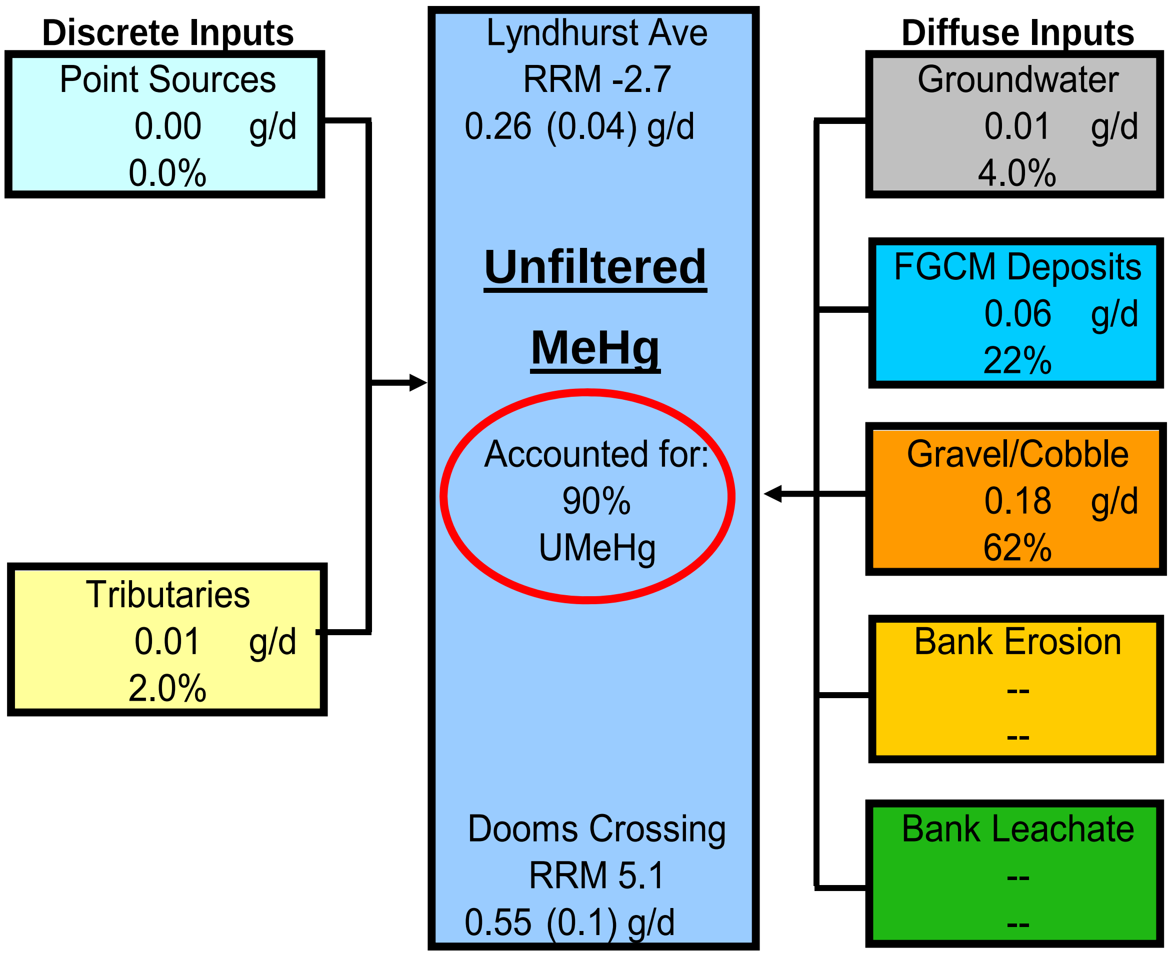
Daily Water & Hg Mass Budgets – Holsinger to Crimora (RRM 5.1 to 9.9) – Unfiltered MeHg



Good closure of mass balance again for UMeHg

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Path Forward

- Ongoing activity in support of remedial options team
- CSM will be updated/expanded when new information is available and our understanding of what is going on evolves
  - Updated bank erosion model
  - SAV study
  - Latest substrate mapping study
  - Invista site clean up
  - Other reaches and storm conditions
- Document findings in evergreen CSM report

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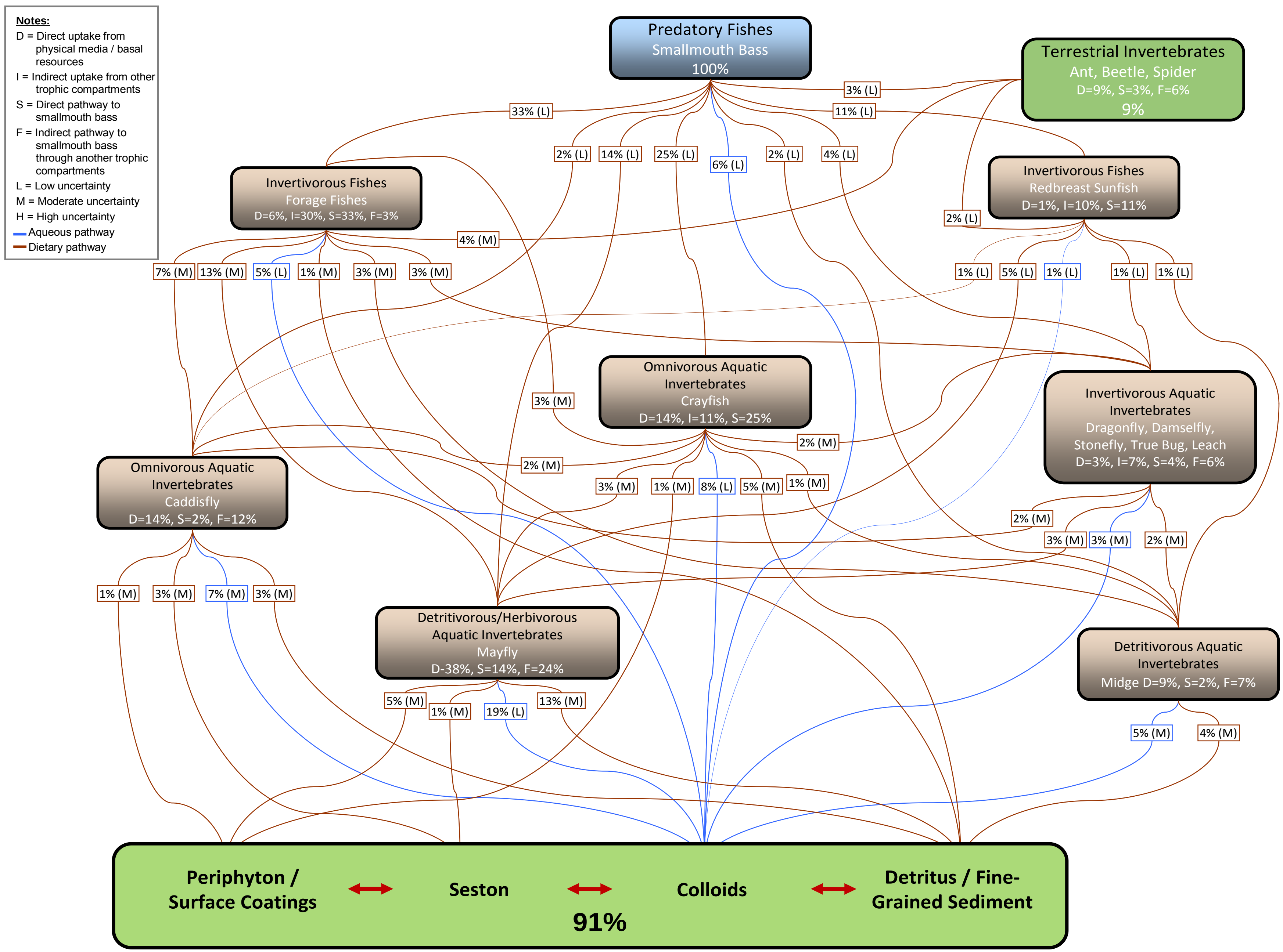
Back-up Slides

Biotic Pathways: From February 2011 NRDC Meeting



Implications of Storm Event on Biotic Portion of CSM

- **Wet-dry cycling and inundation-induced methylation impact on terrestrial biota**
- **Potential change in aquatic invertebrate biomass and community structure; though evidence that effects are short-term in duration (ref. Hendricks et al. 1995)**
  - shift in fish food habits; subsequent bioenergetics & mercury uptake
  - change in mercury flux to terrestrial food web
- **Change in mercury bioavailability for aquatic invertebrate uptake**
  - change in mercury uptake by fish
  - change in mercury flux to terrestrial food web
- **Effect on fish reproduction**
  - shift in fish food habits; subsequent bioenergetics & mercury uptake

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Implications of Storm Event on Abiotic Portion of CSM

- **Key issue is the potential for a major storm to mobilize Hg and induce a newly contaminated state**
  - A storm may mobilize previously unavailable Hg via
    - redistribution of river bed sediment
    - loading of floodplain Hg to river
    - increased riverbank erosion and collapse
  - Above may be partially offset by introduction of clean sediment from upstream and reduced erosion of contaminated soil from stabilized river banks
- **Floodplain runoff contribution likely to increase**
- **Need to consider impact of wet-dry cycling on methylation in banks and on floodplain**

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Example: Calculation Basis for Advective/Diffusive FlHg Flux from Beds - Model and Data Sources

- Reference for Mass Transfer Equations

  Environmental Chemodynamics: Movement of Chemicals in Air, Water, and Soil, 2nd Ed.

  Louis J. Thibodeaux

  Chapter 5

  Wiley-Interscience (1996)

- Nonlinear Equation Solver

  TK Solver with Monte Carlo simulation module

- Basic Data for Mass Transfer Calculations
  - 2008 FlHg daily mass budget, RRM -2.7 to 9.9 (Lyndhurst Ave. to Crimora Rd.)
  - 2009 pore water data, Phase II EcoStudy
  - 2010 DGT probe data, Univ. of Texas at Austin
- Benthic Flux Chamber Data from Landis/Flanders

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Example: Calculation Basis for Advective/Diffusive FIHg Flux from Beds - Premise for Modeling Approach

- Eroding bank/floodplain soils & embedded gravel beds within the river channel are two sources of FIHg flux to water column
- FIHg flux measured by benthic flux chambers (BFCs) should fall within uncertainty bounds of mass flux predicted by an appropriate mass transfer model
- Flux measured by BFC will be best represented by a steady-state model (snapshot in time)
- An overall lumped mass transfer coefficient will capture all mass transport mechanisms in a single parameter (diffusion, advection, hyporheic exchange, colloidal transport), thereby simplifying the model calculations
- IHg ($\log K_d = 6$) partitions more strongly to sediment solids than MeHg ($\log K_d = 5$)
- For constituents with a very large K_d (such as IHg), mass transfer will often be water-film controlled
- A published correlation based on turbulent flow mass transfer theory, therefore, can be used to estimate k_A for FIHg
  - should be less than k_A calculated for FMeHg = 1.2-2.8 cm/hr (p=50-75%)

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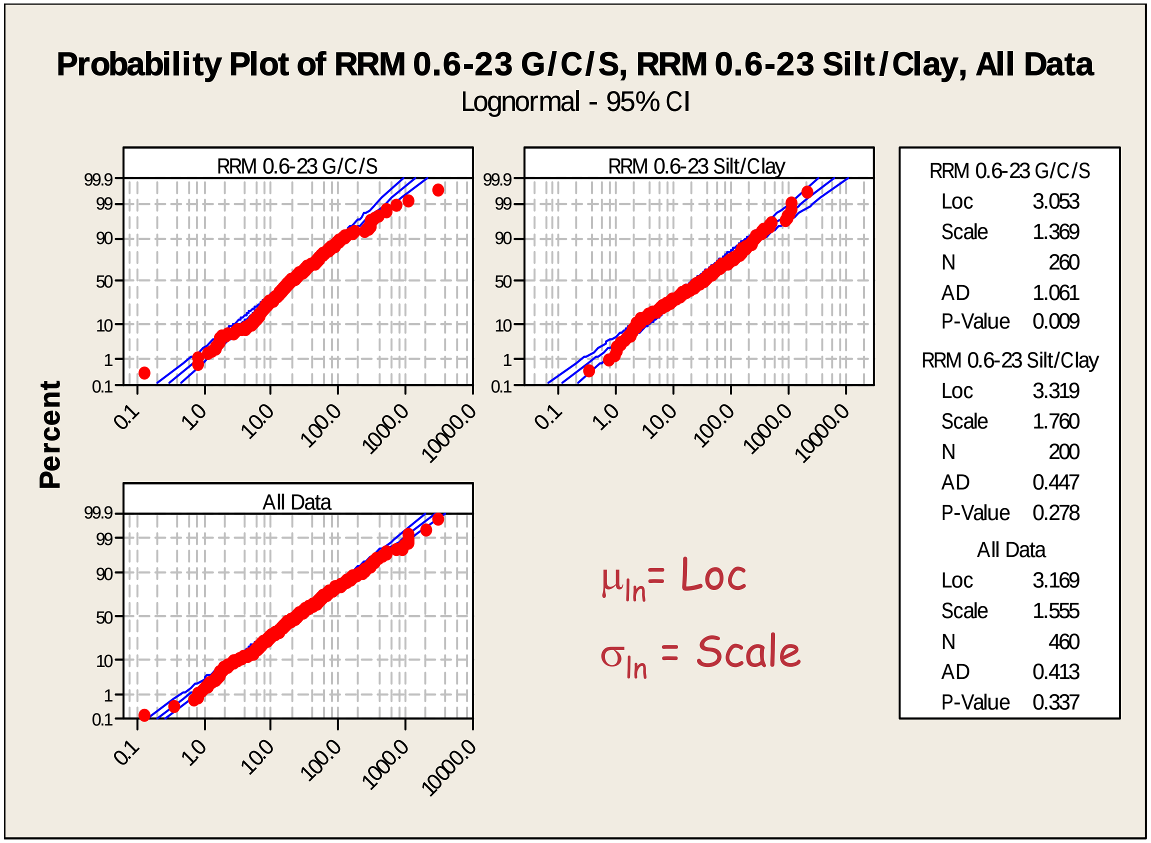
Example: Calculation Basis for Advective/Diffusive FIHg Flux from Beds - 2009 Pore Water Data

- June-August 2009 pore water data are best represented by a log-normal probability distribution where μ_{ln} and σ_{ln} are the mean and standard deviation of the variable's natural logarithm (data deviate slightly from log-normal dist. at extremes)



All Data: Mean = 83.8 ng/L (μ_{ln} = 3.17) , St Dev = 232 ng/L (σ_{ln} = 1.56)
G/C/S: Mean = 65.1 ng/L (μ_{ln} = 3.05) , St Dev = 226 ng/L (σ_{ln} = 1.37)
Silt/Clay: Mean = 108 ng/L (μ_{ln} = 3.32) , St Dev = 237 ng/L (σ_{ln} = 1.76)

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Example: Calculation Basis for Advective/Diffusive FIHg Flux from Beds - Steady State Mass Transfer Model to Estimate Flux

Calculate 50% & 75% probability values for FIHg mass load based on 2009 pore water data. Use a correlation based on turbulent flow mass transfer theory to estimate an overall k_A and sum load contributions from 2 substrate types: gravel/cobble/sand & silt/clay. Compare to measured reach-wide FIHg mass load (based on 2008 MeHg daily mass budget) from Lyndhurst Ave. to Crimora Rd. (RRM -2.7 to 9.9)

$$m_A = k_A A\left(C_{pw} - C_{wc}\right)$$

Mass Load (g/d)

Overall Mass Transfer Coeff. (m/d)

Interfacial Area (m²)

Conc. Driving Force (g/m³)

$$k_A = 0.036\,Re^{0.8}\,Sc^{1/3}\left(\frac{D_{mol}}{L_x}\right)$$

Reynolds Number

Schmidt Number

Characteristic Length (m)

- Probability distributions for variables in Monte Carlo simulations
  - u (avg. river flow velocity Gravel/Cobble/Sand): Triangular (0.3, 1, 1.5) ft/sec
  - u (avg. river flow velocity Silt/Clay): Triangular (0.1, 0.4, 1) ft/sec
  - (C_{pw}- C_{wc}) Gravel/Cobble/Sand: Log-normal (μ_{ln} = 3.05, σ_{ln} = 1.37) Ln(ng/L)
  - (C_{pw}- C_{wc}) Silt/Clay: Log-normal (μ_{ln} = 3.32, σ_{ln} = 1.76) Ln(ng/L)
  - A_{bed} = 0.3 0.4, 0.425 km² (gravel/cobble/sand)
  - A_{bed} = 0.05, 0.07, 0.075 km² (silt/clay)

Example: Calculation Basis for Advective/Diffusive FIHg Flux from Beds - FIHg Mass Load Predictions

Probability	Predicted FIHg Mass Load (g/d)			Predicted FIHg Mass Flux ($ng/m^2 \cdot hr$)		
	Gravel/ Cobble/ Sand	Silt/ Clay	Total River Bed	Gravel/ Cobble/ Sand	Silt/ Clay	Measured by BFC (2008)
50% Less Than	1.6	0.2	1.8 (21%)	175	120	-65 to +220
75% Less Than	3.1	0.35	3.5 (40%)	350	245	-65 to +220

(X%) is % of 2008 Total FIHg Mass Load (RRM -2.7 to 9.9) = 8.73 g/d

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Example: Calculation Basis for Advective/Diffusive FMeHg Flux from Beds - FMeHg Mass Load Predictions

Probability	Predicted FMeHg Mass Load (g/d)			Predicted FMeHg Mass Flux ($ng/m^2 \cdot hr$)		
	Gravel/ Cobble/ Sand	Silt/ Clay	Total River Bed	Gravel/ Cobble/ Sand	Silt/ Clay	Measured by BFC (2008)
50% Less Than	0.17	0.07	0.24	18	46	-12 to +160
75% Less Than	0.45	0.14	0.59	50	90	-12 to +160

2008 FMeHg Mass Load (RRM -2.7 to 9.9) = <u>0.272 g/d</u>

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TMDL Model Analysis
Insight #2 - Annual Basis, Entire River

% of Total Annual UTHg Load Attributable to Baseline Conditions

	% of Total Annual UTHg Load Attributable to Baseline Conditions					
Reach	1	2	3	4	5	Total
Point Sources	86%	87%	90%		91%	87%
Direct Precipitation to River	47%	46%	74%	76%	77%	58%
Interflow Discharge	38%	37%	38%	38%	36%	38%
Groundwater Discharge	83%	83%	83%	84%	84%	83%
Runoff	1%	6%	0%	0%	0%	0%
Channel Margin Inputs		24%	32%	22%	22%	28%
Total	20%	24%	30%	9%	10%	**24%**

% of Total Annual UTHg Load Attributable to Storm Conditions

	% of Total Annual UTHg Load Attributable to Storm Conditions					
Reach	1	2	3	4	5	Total
Point Sources	14%	13%	10%		9%	13%
Direct Precipitation to River	53%	54%	26%	24%	23%	42%
Interflow Discharge	62%	63%	62%	62%	64%	62%
Groundwater Discharge	17%	17%	17%	16%	16%	16%
Runoff	99%	94%	100%	100%	100%	100%
Channel Margin Inputs		76%	68%	78%	78%	72%
Total	80%	76%	70%	91%	90%	**76%**

TMDL Model Analysis
Insight #2 - Annual Basis, Entire River

Baseline Days Only, % of Total Baseline Loading

	% of Total Baseline Loading					
Reach	1	2	3	4	5	Total all Reaches
Point Sources	0.00%	1.17%	0.00%	0.00%	0.08%	1.25%
Direct Precipitation to River	0.03%	0.01%	0.00%	0.02%	0.01%	0.07%
Interflow Discharge	0.32%	0.04%	0.04%	0.13%	0.03%	0.56%
Groundwater Discharge	0.10%	0.01%	0.01%	0.04%	0.01%	0.18%
Runoff	0.01%	0.02%	0.00%	0.01%	0.02%	**0.06%**
Channel Margin Inputs	0.00%	31.37%	58.15%	7.23%	1.11%	**97.87%**
Totals	0.47%	32.62%	58.21%	7.43%	1.27%	100.00%

Storm Days Only, % of Total Storm Loading

	% of Total Storm Loading					
Reach	1	2	3	4	5	Total all Reaches
Point Sources	0.00%	0.06%	0.00%	0.00%	0.00%	0.06%
Direct Precipitation to River	0.01%	0.00%	0.00%	0.00%	0.00%	0.02%
Interflow Discharge	0.16%	0.02%	0.02%	0.06%	0.02%	0.29%
Groundwater Discharge	0.01%	0.00%	0.00%	0.00%	0.00%	0.01%
Runoff	0.39%	0.09%	2.77%	14.68%	2.29%	**20.23%**
Channel Margin Inputs	0.00%	31.20%	39.17%	7.82%	1.20%	**79.40%**
Totals	0.57%	31.37%	41.96%	22.57%	3.52%	100.00%

TMDL Model Analysis
Insight #3 – Floodplain Runoff
Daily Basis by Segment

Daily Loads from HSPF Model for South River TMDL

	Reach 2			Reach 3			Reach 4			Reach 5		
Date	Total Runoff (g)	Channel Margin Inputs (g)	% From Runoff	Total Runoff (g)	Channel Margin Inputs (g)	% From Runoff	Total Runoff (g)	Channel Margin Inputs (g)	% From Runoff	Total Runoff (g)	Channel Margin Inputs (g)	% From Runoff
Total	288.51	118358.97	0.24%	7996.62	165483.73	4.61%	42410.78	29101.67	59.31%	6632.60	4481.95	59.67%
Min	0.0001	0.650232	0.00%	0	1.168947	0.00%	0.0001	2.1810765	0.00%	0	0.3359076	0.00%
Max	50.28	7465.82	**45.95%**	1839.89	9381.99	**46.26%**	9766.53	1188.37	**97.22%**	1520.79	183.02	**97.24%**
Median	0.0001	9.058914	0.00%	0	8.17128	0.00%	0.0001	13.255863	0.00%	0	2.0415353	0.00%
Mean	0.395219998	162.1355759	0.31%	10.95427206	226.6900346	0.37%	58.09696	39.865304	1.94%	9.0857468	6.1396579	2.66%

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