Minutes from South River Science Team
April 17, 2007

Agenda

Call-In Number 866-249-5325 (code: 230874)

8:30 Welcome, Introductions Don Kain
Communications
8:40 Announcements All
8:45 Newsletter / Website Update / Communications Mike Liberati
8:55 Publications / Presentations Ralph Stahl
Science Discussions and Presentations
9:05 DEQ Trust Fund Monitoring 2007 Calvin Jordan
9:15 Ecological Study Update – Phase I Todd Morrison
9:25 Hydrologic and Hydraulic Models Mary Roman
9:45 Stormwater Sampling Results 2006 - 2007 JR Flanders
10:00 Break
10:10 Geomorphology Update Jim Pizzuto
10:30 South River Source Tracing Dick Jensen / Ralph Turner
10:50 Ground Water Results Mike Jacobi
11:10 Mercury Loading from Former DuPont Plant
Outfalls Robert Brent
11:30 South River TMDL Update Jack Eggleston
11:45 Amphibian / Reptile Proposal Bill Hopkins (via phone)
12:00 Lunch
1:00 Update on Bird Study Anne Condon / Scott Friedman
1:30 Bat Studies John Schmerfeld / David Yates
1:45 Food Web Study Mike Newman
2:00 Earthworms / Soils Bill Berti / Dean Cocking
2:15 CSM Update Aaron Redman
2:45 Discussion - comments from Expert Panel Members Ralph Stahl
3:00–3:15 Recap, Action Items, Next Meeting, Adjourn Don / Ralph

Announcements: Mike Liberatie

Newsletter- Fish tissue sampling, Lidar, Fish tissue and Hg trends, Hg in the diet
Outreach- earth science local school
Grand Caverns grand opening May 11th fish exhibit and bug exhibit
Fly fishing festival April 21st
Riverfest week of 25th

Ralph Stahl- another outreach effort elementary school kids
- call for papers, send them to Kathy Adams

DEQ Trust Fund Monitoring: Calvin Jordan/DEQ

-fish collection almost complete
-organs and tissue collected from some fish for histopathology work for the Shenandoah fish kill investigation
-water sampling continuing bimonthly
-sediment sampling will be taking place in the summer to take advantage of low flow
-flood plain sampling late fall, winter to take advantage of low foliage
-help was asked to design a sampling plan for the floodplain sampling. Calvin took names and will contact interested parties when the time comes.

Ecological Study: Todd Morrison/URS

Phase I System Characterization: Year 1 Summary
Year I Physical and Biological Data Sets

Quarterly Storm Sampling
- Four storm events with 8 sample stations at bridges

Monthly Baseline Characterization
- 13 baseline stations in study area; 3 reference stations

South River Spatial Data Sets
Base Maps and Data:
- Aerial photo coverage (1937-2005)
- LiDAR based digital elevation model

River Geomorphology:
- Observed eroding banks
- Fine-grained sediment deposits
- Historic river channel migration (1937 - 2005)

Hydrologic and Hydraulic Modeling
- Floodplain inundation boundaries for various storm return periods

Habitat Characterization:
- Land use and cover types (including wetlands)
- Submerged aquatic vegetation coverage

South River Habitat Characterization

<u>Spatial Habitat Evaluations in GIS</u>
- Land use data from National Land Cover Data set (NLCD 2001)
  Aerial photo interpretation and river survey for cover types
- Wetland types attached to river and in floodplain
- Submerged aquatic vegetation coverage along the South River

South River Habitat Characterization
Habitat Characterization
South River 2-year Floodplain
South River 100-year Floodplain
Preliminary Evaluations for Phase II Study Areas

<u>Principle Components Analysis using geospatial data by RRM</u>

- Overlap between historic deposits and currently observed eroding banks
- 0.3-yr flood plain used to evaluate areas frequently in connected with river including wetlands
- Volume of fine-grained deposits
- Observed eroding banks (% of channel bank)
- Submerged aquatic vegetation coverage
- Gradient

Evaluations for Phase II – RRM results

PCA indicates 2 "predominant" groups of geospatial data

Potential Year 2 Studies for Phase I

- Collection of surface water at South River baseline stations in April and May to determine seasonal pattern in MeHg
- Characterize river features which may act as sources for THg within targeted RRMs
- Mercury bioavailability and microbial study (bioindicator work with Rutgers University)
- Adding an additional reference area along the Middle River for lower gradient river conditions

Scheduled Activities

- Meet with NRDC on May 7th and 8th
- Ongoing data evaluations for Year 1 data
- Planning for Year 2 studies

South River Hydrologic/Hydraulic Analyses Project Update: Mary Roman/URS

-Gage data analysis
-Hydraulic analysis

Overview of Hydrologic Analyses

-Discharges were determined for the following recurrence intervals: 1, 2, 5, 10, 25, 50, 100, and 500

-National Flood Flow Frequency Methodology – weighted averages of:

-Gage data
-Rural regression equations

–Used results in hydraulic modeling and for gage analyses

Discharge Regression Equation Based on Hydrologic Analyses

USGS Gage Analysis – Source Data

–Harriston Data:

–Annual Peak Flows For Entire Period of Record
–01/17/1926 – present
–30-minute Incremental Flow
–01/01/1991 – 09/30/2003
–15-minute Incremental Flow
–10/01/2003 – 11/14/2006
–Daily Mean Discharges (does not include peak discharges)
–01/17/1926 - present

–Similar data sets are available for gages at Waynesboro (54 yrs of record) and Dooms (17 years of record)

Evaluating Historic Flood Events – (Frequency and Maximum Discharge)

- –Historic data available for each gage (prior to 1991)
  - –Daily mean discharges
  - –Annual peak discharge (one event per year)
- –Without instantaneous data, peak discharges can not be accurately determined
- –On average, the daily mean discharge was 30 percent less than the peak flow

Evaluating Historic Flood Events – (Frequency and Maximum Discharge)

- –Example (9/6/96)
  - –Annual peak flow: 28,900 cfs
  - –Daily mean discharge: 10,800 cfs
  - –Daily mean discharge is 63 percent lower
- –Example (3/19/83)
  - –Annual peak flow: 10,300 cfs
  - –Daily mean discharge: 6,680 cfs
  - –Daily mean discharge is 35 percent lower

Cumulative Frequency of Peak Flows – 1991-2006 – Harriston Gage

Cumulative Frequency of Mean Daily Discharges – Harriston Gage

Peak Flows for Entire Period of Record – Harriston Gage

Hydraulic Analyses

- –Utilized U.S. Army Corps of Engineers HEC-RAS Program as developed with GIS-based Watershed Information SystEm (WISE) platform

HEC-RAS Model – Key Input Data

- –Cross section data (Lidar, field survey, USGS)
- –Manning's N values (roughness coefficients)
- –Bridge data (field survey)
- –Discharges

HEC-RAS Model – Calibration Efforts

- –Calibrated model to USGS gage data at three gaging stations. Highwater mark surveys have not been conducted to date.
- –Primary calibration efforts consisted of changing Manning's n values (roughness coefficients)
- –Difference between the HEC-RAS model and the USGS gage data varies from -1.8 to 1.8 feet
- –Further calibration is not recommended prior to conducting additional cross section field surveys in the vicinity of the gages

Hydraulic Model Results – Data Uses

- –Utilize output parameters, such as velocity and shear stress, to aid in erosion rate estimates
- –Estimate discharge that causes out of bank inundation for specific areas
- –Develop rating curve data for use in loading analyses for storm sampling events
- –Analyze inundation areas for a variety of storms

Inundation Areas

- –Floodplain boundaries were plotted for the following storm events
  - –September 2006 event (0.3-year recurrence interval)

–2-year
–5-year
–Highest storm on record (62-year recurrence interval)
–100-year storm event

Inundation Areas – Selection of Storm Events to Plot

–Frequency of exceedence for instantaneous data (1991-2006)
–10-year: 3 events
–5-year: 7 events
–2-year: 24 events
–Frequency of exceedence for daily mean discharges:
–10-year: 1 event
–5-year: 7 events
–2-year: 29 events

Inundation Areas -RM 11.8-13.1

Inundation Areas – RM 11.8 to 13.1

Example – 2-Year Storm Event

Example – October 7, 2006 Storm Event

–Flow at Harriston – 6,840 cfs; close to the 2-year event
–Cross section data for 2-year storm
–Depth of water – 9.76 ft
–Channel banks not overtopped
–Velocity – 6.58 ft/sec
–Shear stress – 0.51 lbs/ sq ft

South River Hydrologic/Hydraulic Analyses

Project Update – April 2007

Stormwater Sampling   JR Flanders/URS

Storm Event Sampling

Sampling Update:

- Target one storm event each season; sample at 8 bridge locations during
  - baseline conditions
  - 3-hr intervals during rising discharge
  - 1, 3, 5, and 7-days during falling discharge
- Three storms:

Date	Peak Flow Harriston (CFS)	Storm Return Interval (yrs)
June 28, 2006	2640	0.2
Aug 31, 2006	3010	0.31
Nov 16, 2006	3690	0.44

- Fourth storm sampled in late February 2007; data not yet available

Particulate THg Loading at Peak Flows

Results:

- Highest loading rates occurred in June and generally decreased over the course of 2006
- Load increases above 1000 CFS

- Shear stress
- Water surface elevation

Sum of Unfiltered Loads
Results:

- Sum of unfiltered loads was positive over length of SR during June 2006 storm event
- After June, sum of load were negative below Crimora, suggesting that primary sources are upstream
- Magnitude of loads decreases over course of 2006
- Results of 4th quarter storm will test idea that freeze thaw cycles provide added material for loads

Median THg and MeHg Loadings
Results:

- Evidence that sources are primarily upstream of Crimora (RRM-9.9)
- Larger differences between filtered and unfiltered THg loading as compared to MeHg
- Pattern between filtered and unfiltered MeHg loading due to partitioning behavior of MeHg in South River

Mercury Behavior During Storm Events
Results:

- Log K for inorganic mercury (THg – MeHg) is ~6 for all South River locations under storm flows; similar to baseline
- Inorganic mercury up to Main St. is associated with filter-passing fraction of surface water; lower than under baseline conditions
- As expected for MeHg, log K is lower than for inorganic mercury; similar to baseline overall

Conclusions:

- Storm peak flows show highest loading rates
- Data collected during rising discharge reveals areas contributing THg and MeHg to the system
    - Hopeman Parkway to Crimora for particulate and filtered loads
- Storms lower concentrations of THg and MeHg on particles by mixing downstream solids with clean, upstream solids
- Concentrations on particles return to baseline levels over the course of the falling discharge

Geomorphology update   Jim Pizzuto/U. DE

Outline of Topics

•Bank erosion profile modeling results

–Ranking of controlling variables

–Potential reductions in Hg loading by bank stabilization

•Update – calibrating reach scale bank erosion model using 1937-2005 aerial photo results

•New analyses of 1937-2005 erosion rates

- Statistical summary of linear erosion rates for entire study area
- Controls on bank erosion rates
- Erosion by category
- Significance of tributaries as a control of erosion rates

•Changes in bank erosion rates through time

- 1937-1957, 1957-1974, 1974-2005
- Relative control of erosion rates by storm frequency, changes in riparian vegetation, loss of mill dams

•Floodplain deposits formed by lateral migration – 1937-2005

•Lidar bank surveys – examples and updates

Some Examples of Floodplain Deposition, 1937-2005

- Aerial photo analysis facilitates new understanding of floodplain deposition
- Deposits assessed during lidar surveys
  - Coring
  - Sampling

Two Types of Deposits Described Here

- “Point-bar” like deposits related to lateral migration at bends
- “Bench-like” deposits

Interpretation of Bench Deposits

- Only in low slope areas
  - Long pools
  - Upstream of former mill dams
- Imply a complex history of:
  - Vertical incision (?) into and lateral migration away from terrace deposits
  - Deposition of the fine-grain bench deposits during a previous, low energy period
- Mill dams?
  - Current erosion

Summary – 1937-2005 Deposition

- Point bar and bench deposits contain:
  - High silt and clay content
  - Deposits that may date from period of high Hg release into the river
- Bench deposits are currently eroding
- All of these deposits have a high probability of erosion in coming decades

New Analyses of 1937-2005 Floodplain Erosion Rates

- Statistical summary of linear erosion rates for study reach
- Erosion by category
- Hydraulic and geologic controls on erosion rates
- Significance of tributaries
  - Still in progress
  - Not to be discussed today

Frequency Distribution
Many Low Erosion Rates, Few High Rates
Hydraulic, Biologic, and Geologic Controls on Erosion Rate

- Hydraulic
  - Near bank velocity related to channel curvature
- Biologic
  - Density of riparian vegetation
- Geologic
  - Eroding bank materials
- Bedrock
- Terrace
- Recent alluvium

Without Geologic Control, Bank Migration is Related to Near-Bank Velocity
Trees Reduce Migration Rates By A Factor of 4!!
Geology Trumps All Other Controls!

Changes in Bank Erosion Rates Through Time

- 1937-1957, 1957-1974, 1974-2005
- Relative control of erosion rates by:
  - storm frequency
  - riparian vegetation
  - loss of mill dams
- 22 sites selected with significant erosion
- Visual estimates of the extent of 37-05 erosion completed by 1957 and 1974
  - More quantitative estimates pending

Possible Explanations

- Differences in storm history
- Changes in riparian vegetation
- Loss of mill dams

Storm History

- Created a continuous record of daily flows for South River at Harrison gaging station
  - Missing data obtained from regression equations from other sites
- South R. near Waynesboro (URS regression eq.)
  - Used for 1953-1967
- Middle R. near Grottoes
  - Used for water year 1952 only

Computed A Sediment Transport Index For Flows > 1500 cfs

- Computed water surface elevation for each flow
  - Used roughness coefficients from URS
  - Typical channel and floodplain cross-sectional geometry and slope
- Computed total bedload transport for each flow
  - Totaled for each year

•Scaled values for each year by 1 day of transport by the 2 year peak discharge (used URS estimates of this discharge)

Storm Transport Index Is Low ’57-’74:

storm frequency does NOT explain observed increases in bank erosion

Storm Transport Index: Box Plots of 5 Year Running Mean Values

(’57-’73 mean value is significantly lower)

Riparian Vegetation

•Used aerial photographs to visually classify density of riparian forest at each site

Density of Riparian Trees Has INCREASED since 1937 – *Changes in Riparian Vegetation CANNOT explain increases in erosion!*

Working Hypothesis – Increase in bank erosion rates after 1957 is related to loss of mill dams

Updated Historic Mill Dam Database

Tripod Lidar Survey Update

Some Maps Showing Spatial Extent of Lidar Surveys

Bank Erosion – Results of Profile Modeling

•Ranking variables that control bank erosion rates
  –Effect of trees neglected in these computations

•Reduction in erosion rates associated with vegetation assessed elsewhere

•Potential benefits of bank stabilization on
  –Soil erosion
  –Hg loading

Ranking of Variables Controlling Bank Erosion

•4 cases considered:
  –Steep banks, unprotected from flow

•steep, hi flow
  –Steep banks, protected from flow

•steep, low flow
  –Gently sloping banks, unprotected

•gentle, hi flow
  –Gently sloping banks, protected

•gentle, low flow

•2 years of flow events at Brandywine Creek

•3 variables:
  –near-bank velocity
  –number of freeze-thaw events
  –water level

The Modeling Tool

•Empirical model of bank erosion based on profiles surveyed along an eroding bend of Brandywine Creek from 1986-1988

•The Site:
  –Forested riparian zone
  –Silty bank soils
  –Banks mostly bare soil (not covered with grass)

•Variables:

–Near-bank “wake” velocity
–#of freeze-thaw cycles between high flows
–Water surface elevation
–Duration of high flow events
–Bank profile morphology

Approach

- Run model simulations with each controlling variable set equal to 0
- Determine the volume of erosion that can be attributed to each variable

Ranking and % of Erosion Explained For All 3 Variables

Conclusion: Reducing the velocity will help reduce a large fraction of the worst bank erosion problems

Model Estimates of Potential Reductions in Hg Loading From Bank Stabilization, South River, Virginia

- Computations Track:
  - Volume of soil eroded
  - Mass of Hg eroded
- Based on Basic Park Hg profile

Summary

- Growing understanding of floodplain deposition related to lateral channel migration
  - New appreciation for:
    - Different types of deposits, some not previously described in the literature (i.e., the “bench” deposits)
    - Temporal variations in depositional and erosional processes related to mill dams (?)
- Different types of models provide capability to predict bank erosion on short timescales (individual storms, etc).
  - Is this capability worth developing?
  - Calibration an important requirement…

Source Tracking Dick Jenson/Ralph Turner

Intensive Data Dump Coming

- Only time to discuss a few details
- Maybe need forum for sub-group to get deeper into the details
- For instance
  - Intense plant reach SW/PW study in February
  - Extensive extraction and ultra-filtration studies
  - Near-bank mud pore water results
  - Groundwater monitoring at Basic Park and FS

Synopsis from October and January

- Getting closer to answering the question “How is Hg getting into the South River in bioavailable (“dissolved”) form?”
  - Very likely not from point source(s)

–Likely related to presence of Hg in floodplain/bank/bed solids in form(s) that can be released continuously into surface water

–Role of shallow alluvial groundwater still being quantified

•However...

Baseflow Inputs of Dissolved Total Mercury at Basic Park

•Preliminary material balance data suggest…

–Groundwater is contributing ~ 1-10%

–Muddy near-bank bottom is **under**-contributing

–Then, by difference, the cobble/gravel areas must be **over**-contributing, on an aerial basis

–Thus the **focus** on the gravel bars

Gravel Bar Observations

- Hyporheic water THg generally higher than surface water across gravel bar.
- If you can partly accept conductivity as surface vs groundwater…
  - Conductivities suggest SW-related, not GW
- Pressure differentials suggested downward movement of water into gravel in October transverse study location.

Tentative Gravel Bar Thoughts

- Are gravel bars important Hg storage compartments?
- Are gravel bars high-surface area, longer contact time sources, acting like “packed columns”?

Hypothesis: After the Hg falls into the river and disperses, Hg resides in fine sediments (in bar) and desorbs and emerges at upwelling side of bar.

Longitudinal Series

- Pore waters at 6-8 or 12 inches depth
- Near bottom surface waters
  - Probe tip placed on gravel bottom surface
- Thalweg surface water (2 reps)
- All filtered
- Field readings with YSI meter
- Bottom and SW elevations

April Field Activity

- Repeat of longitudinal sampling
  - Repeat long series - extended up and down
  - Two additional short longitudinal series with sharp elevation drop
  - Other

Groundwater Results: Mike Jacobi/EPA

Results

•Soil

–Total Hg: < 0.034 mg/kg to 136 mg/kg

•Groundwater

–Unfiltered Hg: <1.5 ng/l to 778 ng/l

–Filtered Hg: < 1.5 ng/l to 25.8 ng/l (detected in 5 wells)

–Filtered Methyl Hg: < 0.04 ng/l to 0.23 ng/l (detected in 5 wells)

–TOC: < 2.0 mg/l to 3.4 mg/l
–TSS: 2.0 mg/l to 274 mg/l

•Surface Water

–Unfiltered Hg: 37.1 ng/l to 281 ng/l
–Filtered Hg: < 1.5 ng/l to 56 ng/l
–Filtered Methyl Hg: 1.5 ng/l to 3.52 ng/l
–TOC: 2.9 mg/l to 10.8 mg/l
–TSS: 2.0 mg/l to 11 mg/l

Mercury Loading From the Plant Outfalls: A Look at the First Year of Phase III Outfall Sampling : Robert Brent/DEQ

Background

•In 2005, DEQ requested additional baseflow and stormflow data from the plant outfalls to better characterize Hg contributions for the TMDL Study

•Dupont agreed to do this sampling as part of Phase III RCRA Investigation

Phase III Monitoring Results: Total Hg Conc.

- With the exception of 006, Hg concs. in external outfalls are higher than in South River along the plant reach (18 ng/L avg at Const. Park)
- High concentrations in 011 and 008
- WW treatment fairly good at removing mercury (101 lowest avg. conc.)

Phase III Monitoring Results: Diss. Hg Conc.

- Diss Hg concentrations in external outfalls are higher than in South River along the plant reach (1.9 ng/L avg at Constitution Park)
- Highest dissolved conc. in 001
- Fraction of dissolved to total Hg in 001 is 53% (typically 10% in South River)

Phase III Monitoring Results: Total Hg Loads

- Total Hg loads range from 0.26 to 2.4 g/d under baseflow and from 0.81 to 12 g/d under stormflow
- Outfall 001 by far contributes the largest portion of the load, but 008 also contributes a significant portion
- Loading from 011 could be very large if discharged to the river

Phase III Monitoring Results: Diss. Hg Loads

- Dissolved Hg loads range from 0.22 to 0.81 g/d under baseflow and from 0.08 to 0.80 g/d under stormflow
- Outfall 001 by far contributes the largest portion of the load

How Do These Loads Compare to Hg Loads in the South River?

•Loading analysis was performed along the plant reach to determine the percentage of mercury in the South River that could be accounted for by current plant outfalls

•Mercury loads at Constitution Park were estimated across the flow frequency distribution

•Flows estimated from Waynesboro gauge +10% + 20 cfs (for springs, outfall, and Rockfish Run)

- •Mercury estimated at average value (18 ng/L total Hg; 1.9 ng/L diss Hg)
- •Mercury loads at Constitution Park were compared to outfall loadings under stormflow for upper end of flow frequency curve and baseflow for lower end of flow frequency curve

Outfall Contributions to Total Hg Loads at Constitution Park

Summary of Loading Analysis Along Plant Reach

- •Along the plant reach, plant outfalls can account for the majority of the mercury in the South River under most flow regimes
- •Particularly under baseflow conditions, dissolved mercury from the plant outfalls more than accounts for dissolved mercury in the river along the plant reach

How About Further Downstream Where Mercury Levels Peak?

Amphibians and Reptiles: Bill Hopkins/VA Tech

*no slides…via telephone

-sampling going as planned

-4 species of amphibians collected

-collecting eggs

-2 species with good spatial coverage

Terrestrial frog

Aquatic salamander

Salamanders: doing tail and body concentrations

Frogs: Blood, whole body and eggs

TMDL Update: Jack Eggleston/USGS

Goals of the TMDL Project

- **Collect data characterizing mercury (Hg) and methyl-mercury (MeHg) fluxes and production rates in the South River watershed.**
- **Develop numerical models for simulating surface water flows and Hg cyling and transport.**
- **Using the surface water and contaminant transport models, calculate maximum allowable mercury loads (TMDL) from all point and non-point sources.**

Hydrologic Modeling Framework - HSPF

HSPF Data Flow

Basic Input : (by sub-basin)

- Land Use
- Basin geometry and Channel morphology
- Sediment erosion and Mercury source parameters

Time Series Input : (hourly)

- Precipitation
- Meteorology: air temp, dewpoint, windspeed, potential evapotranspiration, solar radiation, cloud cover

Time Series Output : (hourly)

- Discharge

- Suspended Sediment
- Dissolved Total Mercury
- Suspended sediment sorbed Mercury

South River precipitation/runoff model uses hydrologic data and parameters directly from the Chesapeake Bay HSPF model

- **Land use**
- **Slope**
- **Precipitation**

Sub-Basin Delineation

Land Use, Precipitation, Meteorology

Hourly Streamflow (cfs) – Waynesboro

Hourly Streamflow (cfs) – Harriston

How good is the streamflow modeling?

Modeling of the South River

Next Up: **Suspended Sediment**
Mercury
Accounting of Total Mercury in the South River Water Column

Update on Bird Study:

Elevated Hg Levels in Terrestrial Birds: Scott Friedman/W&M

-Hg levels in birds from highest to lowest: Carolina Wren (~4.5ppm), Kingfisher (~3.5ppm), House Wren (~2.5ppm), Bluebird (~1.5ppm), Bricknell's Thrush
-Both species of wren consumer similar amount of spiders
-Spiders had highest Hg levels of prey species
-Emerging aquatic insects were not consumed in great numbers
-According to Monte Carlo Simulation, Carolina Wrens are ingesting more ng Hg per day per gram of bird then House Wrens
-Simulation- metabolism, assimilation, fractionation
-Based on SI – analysis, both wrens were feeding at similar levels on the food chain
-Hg blood levels for Carolina wren range from <2 to about 13 ppm and appear to increase down river.
-Hg Blood levels in house wren range from <1 to about 5.5 ppm and also seem to increase down river.
-Spider Hg levels vary with river mile and range from 0-~4ppm
-Spiders have greater Hg levels than all other prey species combined.

Hg Levels in Newly Independent Songbirds: Anne Condon/W&M

Adults have about twice as much blood Hg than nestlings
Feathers remove 50-95% hg from body
Once feather growth is complete, does Hg rise in blood?
Blood Hg: Rises
Trophic level: No change

Methods

Radio-telemetry, trapped 46 individuals, collected blood and feathers, mixed effect linear model

4 feather growth stages

Blood Hg rises with age and decrease feather growth

Delta N rises with age

Future work:

Examine relationship of delta N with growth-controlled study

Collect more samples of molting fledglings

Implications:

Post-fledgling period=high stress

Hg may impact juvenile survival

Bats and Ducks David Yates/BRI

Average Hg levels in Bats:

200 ppm in fur

1.6 ppm in blood

Also going to be working with mallard ducks

Trapping hen mallards and outfitting with transmitters so they can find nest

Trophic Transfer Models for South River Mercury: Mike Newman/W&M/VIMS

General Objectives

- Define Hg at base of scraper food web
- Define general relationship for Hg in scraper trophic web members
- Quantify trophic transfer of Hg in scraper trophic web (leading to edible fish species)
- Apply careful experimental designs (power, PPV)
    - Optimize information/unit cost
    - Enhance soundness of conclusions
    - Enhance quality of predictions/projections
    - Enhance legal defensibility

Base of Scraper Food Web

2006 Conceptual Model General Trophic Web Structure

- Relationship emerging – three locations in high [Hg] region of river.
- Using diverse sample types from different sources and years.
- Clear trends perhaps getting clearer with distance downriver.
- General models successfully built from preliminary data for various sources.
- Clear proof of concept established (consistent with substantial literature).

2007 Trophic Transfer Modeling

<u>Objectives</u>

Generate and formally cross-validate fine-grained aquatic trophic transfer models by conducting a careful 2007 sampling (May & June) of five locations:

Constitution Park
Pool location - "Shifflett" Farm or between miles 7 and 9
Dooms Crossing (Rt 611)
Crimora (Augusta Forestry Center)
Grottoes (Town Park)

Test H (using model slopes): Downriver movement of mercury is slowed by its conversion to mHg and efficient trophic incorporation.

Approach

For 16 different sample/species types at each location …

- Take 3 samples (individuals or pooled for smaller species)
- Analyze all for total Hg and one set from the triplicate for mHg also.
- Use two samples/type to generate a model for each site.
- Use remaining samples to do formal cross-validation.
- Also generate prediction residuals and compare to regression residual for models built with all replicates. For mHg samples (16 per site or 80 samples from biota ranging entire trophic web):
- Estimate change in % Hg that is mHg in biota of different trophic positions
- ANCOVA design

Product

Five (or one general) model(s) predicting [Hg] of any relevant aquatic species for predicting, planning, and decision making.

Test of hypothesis about Hg retention in the South River below the historic source.

Utility

- Move beyond description for better prediction of Hg changes with time, location, or management.
  - How long until the bass are lower than …
  - How far down river until the bass are …
  - What would happen if we altered the trophic structure of …
  - If sediment and periphyton Hg was reduced to …
- Capable of interpolation to other species as they become of interest.
- Explicitly define the uncertainty while doing all of the above.

Earthworms: Bill Bertie/DuPont

Objectives

▪Evaluate potential food web interactions using earthworms, which are an example of a lower tropic level organism in terrestrial ecosystems.
▪Evaluate the extent to which mercury bioaccumulates in earthworms.
▪Evaluate the relationship between total Hg and MeHg concentrations in earthworm and paired soil samples.

▪Survey the molecular species of Hg in the soil utilizing synchrotron radiation to determine the in-situ speciation of Hg in selected soils.

·Goal is to examine the relationship of Hg speciation in soil to its bioavailability.

Current status

■Field work completed in Dec. 2006

■Earthworm and soil samples undergoing total and methyl mercury analysis at *Studio Geochemica*.

■Selected earthworm and soil samples retained for Hg speciation and isotope study.

Path ahead

▪Draft report – September 2007

▪Evaluate earthworm Hg content along river gradient

▪Compare patterns of Hg concentration in earthworms with other biological data (aquatic and terrestrial)

▪Integrate earthworm data with soil speciation information

▪Explore food web implications and risk analysis for Hg contaminated earthworms

▪Evaluate need and potential for expanded earthworm and/or other soil invertebrate study

Conceptual Model: Aaron Redman?HydroQual

- Data analysis and loading calculations of monthly monitoring data and storm events
  - Time-variable estimates of flow necessary to understand storm events
- Temporal plots
  - Evaluation of seasonal patterns
- Fish-Hg
  - Statistics and bioaccumulation calculations

Data Analysis

•**Observations**

–Data reflect passage of storm's wave

–Positive relationship between Flow and TSS

•**Conclusions**

–Initial dilution of particulate Hg

–Increasing TSS scrubs out dissolved material

Incremental loading analysis

•**Observations:**

–Location of peak Hg, meHg load migrates downstream as flows increase

•**Conclusions**

–Suitable tool for steady state situations, at high or low flow

•Need fate and transport calculation to assess movement of large masses of solids and Hg during passage of storm waves

–Relationship between location of peak Hg, meHg loads and flow (at Harriston)

- A potential tool for estimating the location (and magnitude) of Hg, meHg loads during steady state situations
- TSS is introduced all along the River

– Possibly related to stream stage and location of inundated side-channels or islands

Temporal Plots

- **Observations**
  - – Peak meHg.Part in April – June
  - – Peak Temperature June-August
  - – Enrichment of WC meHg.Sorb (but not Hg.Sorb)
- **Conclusions**
  - – Temperature/season affects meHg production
  - – Possible bioavailability affects on methylation
  - – Possibly due to greater association of meHg with certain particle types that are more readily resuspended

Fish Bioaccumulation Model

- **Thomann-Farley model**
  - – Bioenergetics are generic for white perch
  - – Assumed that bioenergetics have not changed over the last 30 years..
  - – Fish-age based on length relationships in Murphy 2004
- **Dietary structure and concentrations**
  - – Extended from Murphy 2004
  - – Assimilation of dissolved and dietary Hg, meHg parameterized from Literature and CARP datasets

Fish Hg

- **Observations:**
  - – Some more recent fish-Hg (>1990) measurements are much higher than historic fish-Hg (<1990)
  - – Initial bioaccumulation calculations are in good agreement with well-characterized sites
- **Conclusions**
  - – Much of the variability in fish-Hg can be explained by size and location of fish sample
  - – Largemouth Bass and Redbreast seem to have more Hg in more recent years
    - Change in diet or habitat characteristics?
  - – Calculated fish-Hg highly sensitive to prey-meHg content, very little from water column
    - Evaluation of recent prey and fish data can further constrain calculations

Other ongoing or future work

- **Data analysis of additional biological data (fish and prey items)**
  - – Including extension of initial bioaccumulation calculations to assess long-term bioavailability patterns
- **Assessment of Hg(II) speciation with standard models (WHAM6)**

–Impact on Hg bioavailability for methylation?

•**Estimate mass of soil transported during low flow or storm events compared to geomorphology work**

<u>**Scope of work**</u>

•**Identify potential sources of mercury and methylmercury to the South River**

–Location and magnitude of loads migrates as function of flow

–*In-situ m*ethylation likely occurring throughout River

•Influenced by temperature, bioavailability, microbial respiration

•**Identify important processes for migration and exposure pathways**

–Bioaccumulation calculation and fish data analysis

–Storm waves resuspend (and transport?) large masses of solids

–Enrichment in meHg.Part, different particle type?

•**Identify data needs for further refinement of the CSM**

–Supporting evidence that soil erosion can be responsible for WC Hg in SR

–Controls on methylation and bioaccumulation of Hg

•**Recommend new or improved methodologies for collecting data to meet needs**

–Hg speciation and microbial respiration

–Entry of Hg, meHg into base of foodchain

Stream stage and/or velocity measurements coincident with samples

SOUTH RIVER SCIENCE TEAM MEETING – April 17, 2007

Name	Organization	Phone No.	E-Mail Address
Calvin Jordan	DEQ	540-574-7803	wcjordan@deq.virginia.gov
Jim Pizzuto	U of DEL	302-831-2710	pizzuto@udel.edu
Dean Cocking	JMU	540-568-6566	cockinwd@jmu.edu
Robert Brent	DEQ	540-574-7900	[illegible]@deq.virginia.gov
Amy Owens	DEQ	540-574-7868	amy.owens@deq.virginia.gov
Ralph Stahl	DuPont	302 892 1369	ralph.g.stahl-jr@usa.dupont.com
MOHINDER SAINI	VDH	540.722.3480	mohinder.saini@vdh.virginia.gov
[illegible]	URS	[illegible]	[illegible]@urscorp.com
Mary Roman	URS	410 487 8954	Mary_Roman@urscorp.com
Todd Morrison	URS	215-367-2472	todd_morrison@urscorp.com
Aaron Redman	HydroQual	215 484 5720	[illegible]@hydroqual.com
Vijay S	DEQ	804-698-4077	vhsatyal@deq.virginia.gov
Dave Frazer	DEQ	540-574-7837	[illegible]@deq.virginia.gov
Dawn Jeffries	DEQ	540-574-7848	dmjeffries@deq.virginia.gov
Scott Gregory	URS	540-949-5361	scott_gregory@urscorp.com
[illegible]	ENTRIX	302 395 1919	[illegible]@entrix.com
Joel Hennessy	EPA	215-814-3390	hennessy.joel@epa.gov
Dave Friedman	EPA	215-814-3395	friedman.david@epa.gov
Betty Ann Quinn	EPA	215-814-3388	Quinn.Elizabeth@epa.gov
Michael Jacobi	EPA	215-814-3435	Jacobi.Mike@EPA.gov
Brenda Kennett	IDAVISTA	540-946-1320	Brenda.Kennett@DAvista.com
Jack Eggleston	USGS	804-261-2652	jegglest@usgs.gov
Mike Newman	W&M VIMS	804 684-7775	newman@vims.edu
D. Gale Heffinger	USFWS	2[illegible]-1233	gale_heffinger@fws.gov
[illegible] Marzolf	FOSR	540 955 3019	rmarzolf@shentel.net
Bob Luce	FOSR	540-869-3764	lucerw@shentel.net
Garry Flory	DEQ	540-574-7840	gaflory@DEQ.virginia.gov
Anne Condon	William & Mary	757 [illegible]	[illegible]@wm.edu
Scott Friedman	"	717 907 [illegible]	[illegible]@wm.edu

SOUTH RIVER SCIENCE TEAM MEETING – April 17, 2007

Name	Organization	Phone No.	E-Mail Address
Ted Turner	DEQ	(540) 574-7858	rtturner@deq.virginia.gov
Bill Berti	DuPont	302) 366-6762	william.r.berti@usa.dupont.com
Dick Jensen	UES	302-541-6286	jensen@delaware.net
Jim Dyer	DuPont	302-774-8237	james.a.dyer@usa.dupont.com
Ed Garland	HydroQual	201 529-5151	egarland@hydroqual.com
Mike Liberati	DuPont	302892[illegible]	michael.r.liberati@usa.dupont.com
Paul Bugas	DGIF	540-248-9371	
David Yates	BRI	207-839-7600	dave.yates@briloon.org
George Beckey	INVISTA	540-949-2252	george.e.beckey@invista.com
Jorn Cianimer	[illegible]	[illegible]	[illegible]