South River - South Fork Shenandoah Conceptual Model and Hydrology Update

South River Science Team Meeting

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Conceptual System Model (CSM)

- Representation of the South River environmental system
- Presents hypotheses about the physical, biological and chemical processes that determine the transport of contaminants from sources through receptors
- Tests and refines hypotheses through characterization to define complete pathways
- Complexity of the CSM is determined by the complexity of the system
- CSM is “evergreen”

Uses of CSM

- Integrate all data and identify data needs
- Identify critical complete pathways
  - Identify remedial strategy options
  - Evaluate effectiveness of potential options to reduce exposure of receptors to contaminants
  - Evaluate implemented action's effectiveness
- Communication tool
  - among scientists and decision-makers
  - stakeholders

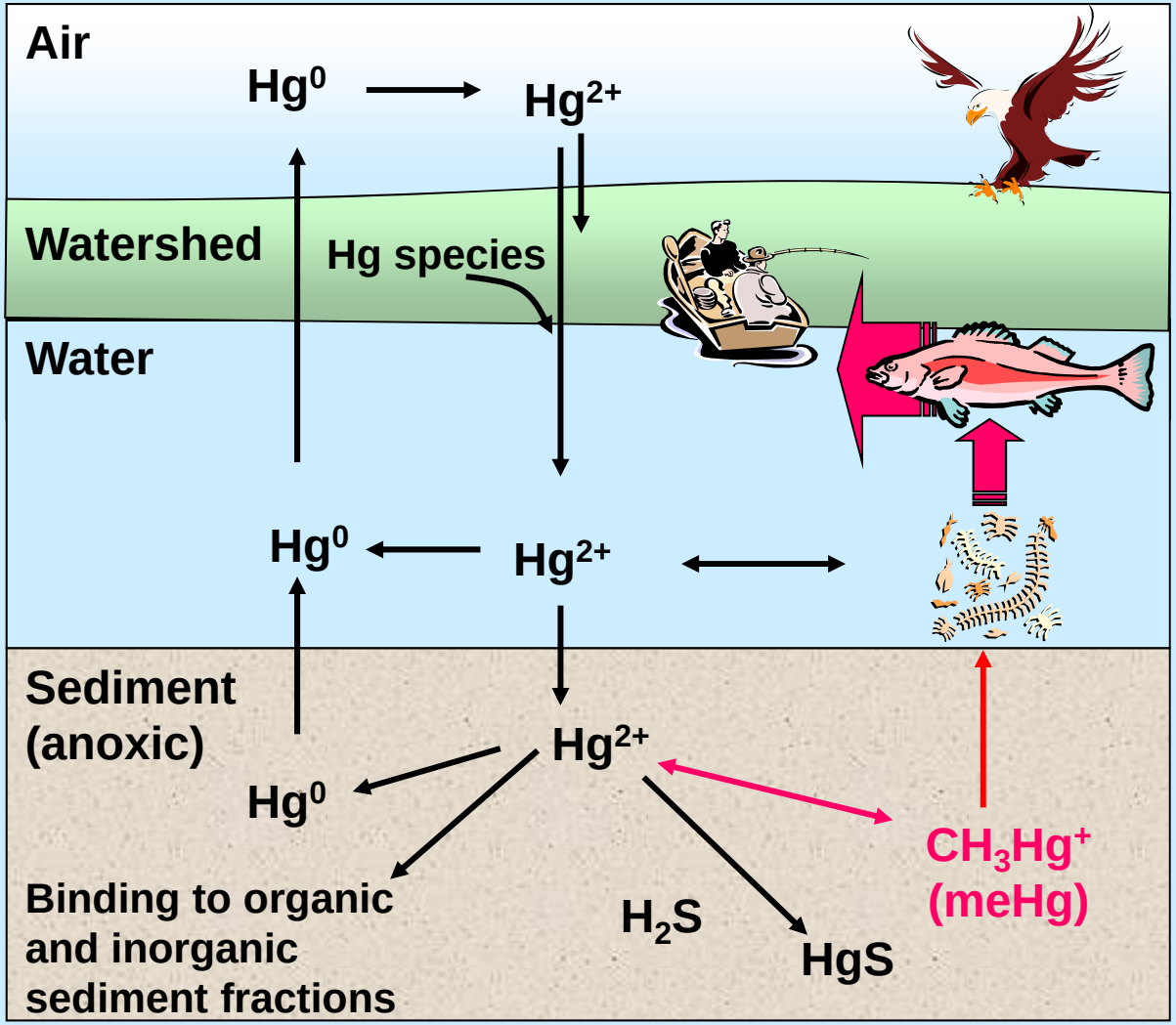
CSM - South River Summary

Potential Primary Secondary Sources	Release/transport Mechanisms	Potential Sources Exposure media	Exposure Routes	Potential Receptors
Waynesboro Plant Hg Recovery Unit (1929-1950) **Soil, Storm Sewers, River Bank Soils, Groundwater, Permitted Outfalls** **Municipal** **Histor. Landfill, WWTP, POTW** **Other Industry** **Atmospheric (ambient)**	**Spills, Combustion/Air** **Leaching, Stormwater Runoff, Surface water flow, Sediment movement, Storm events, Biogeo-Chemical changes**	**Soils** **Surface Water, Sediments, Wetland areas, Mill Ponds, Isolated Pools, Floodplain Soils, Upland Soils**	**Direct:** **Ingestion, Inhalation, Dermal** **Indirect:** **Food (fish) Bioaccumlation** **Direct:** **Ingestion, Inhalation, Dermal**	**Human Ecological**

Components of Conceptual System Models

- Historic and current sources (magnitude and duration)
- Regional and local groundwater
- Watershed hydrology and water balance
- Sediment transport and deposition
- Distribution of Hg in the environmental compartments
- Exposure assessment
- Contaminant transport mechanisms and transformation
  - transport in dissolved phase or as particulates
  - Hg fate and cycling
- Hg uptake and food web modeling
- Conceptualization of remedial strategy

Biogeochemical Cycling of Hg in the Environment



Hydrology Question Currently Facing the Science Team

- Are some of the spatial patterns we see in fish tissue influenced by dilution effects in the river (e.g. from outfalls, tribs, etc.)
- Is there an on-going source to the river and if so, can the hydrology help to identify its origin?

Approach

- Review available data
  - Compute a rough water balance using two different methods and compare
    - Estimate proportional contributions to the river flow from overland runoff, tributaries and springs, groundwater, and permitted outfalls.
    - Estimate using annual precipitation in the watershed

      $P = R + ET + I + GW$

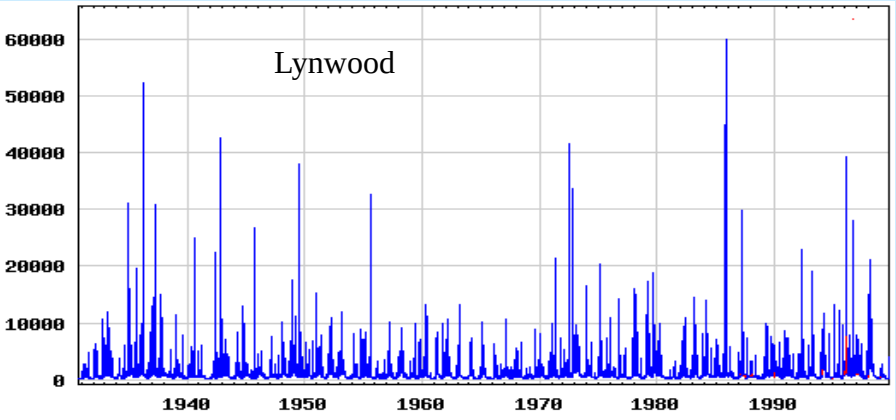
South River Hydrology
Watershed Attributes

- Valley and Ridge Physiographic Province
  - **Ridges - Clastics and metamorphics**
  - **Valleys - Carbonates**
  - Quaternary Sediments
    - Terrace deposits (sand and silt), High-level terrace and alluvial fan deposits (gravel and sand in a red clay matrix)
- River and flood plain generally constrained by valley walls and urbanization
- “Riffle and Pool” river
- Land use: 65% forested, 30% agriculture, 5% urban
- Annual Precipitation 43.16”
- Annual Runoff 12” to 19”

South River Water Flow Statistics

through 1996

- Surface Water Flow at Waynesboro Sta.
  - Mean daily flow ranges from 22 cfs to 2,100 cfs
  - Mean annual flow 149 cfs (70% time flow is greater)
  - Lowest annual mean was 47.5 cfs
  - Highest annual mean was 265 cfs
  - Base flow is approximately 28 cfs



Flow Analysis South River

pprox. River Mile	Landmark / Gauging Station	Annual Mean Flow (cfs)	Cumulative Drainage Area (D.A., sq. mi.)	Approx. Base flow	Tributaries (D.A, sq. mi.)	Ratio mean flow to D.A.	% Base Flow
29.0	Lynnwood	1,033	1084	250		0.95	15.5
24.9	Confluence w/North R.		235				
					Miller Run (4.9)		
21.3	Grand Caverns		222.7				
19.5					Stull Run (2.5)		
17.0	Harriston	262	212	43		1.2	16.4
16.4					Paine Run (6.8)		
14.5					Meadow Run (5.7)		
10.2					Mine Branch (4) Tunnel Branch (1.7)		
7.5					Porterfield (5.8)		
5.2					Saw Mill Run (10.3)		
2.6	Hopeman Pkwy	214	149	52		1.4	24.3
1.0					Steel Run (5.1)		
					Lothe Spring		
-2.9	WaynesboroGauge	149	127	28		1.2	18.8

Initial Water Analysis

- Observations
  - Estimated flows near the confluence

    North River: 735 cfs

    South River: 280 cfs

    South Fork Shenandoah: 1,015 cfs
  - Between Waynesboro and Hopeman Pkwy gauging stations, base flow is about 16 cfs higher than expected at 52 cfs
  - Contributions to base flow in that reach from dischargers and possibly groundwater

Evaluation Needs

- Detailed evaluation at urban sites
  - Input from tributaries and springs
  - Input from Permitted Discharges
    - Waynesboro
      - » DuPont, Genicom, Crompton, Virginia Metal Crafters
      - » POTW, WWTP
    - Harriston
    - Grottoes
- For the watershed obtain:
  - Infiltration rates
  - Evapotranspiration rates
- Refine conceptual understanding
- Test hypothesis(es) with field data