GREEN-DUWAMISH POLLUTANT LOADING ASSESSMENT

TECHNICAL ADVISORY COMMITTEE

July 16, 2015

Meeting 6

DEPARTMENT OF ECOLOGY State of Washington

EPA

TAC Meeting 5 Agenda

Time	Topic
9:00 am	Welcome & introductions
9:10 am	Data gaps and pollutant groupings memo recommendations
10:00 am	Modeling QAPP development
10:45 am	Model development: Flow and suspended sediments
11:10 am	Model development: Contaminants
11:40 am	Comments from the audience
11:50 am	Next steps
12:00 pm	Adjourn

Revisit data gaps and pollutant groupings memo input

Green/Duwamish River Watershed



Pollutant Loading Assessment

Technical Advisory Committee Meeting
July 16, 2015

DEPARTMENT OF ECOLOGY
State of Washington

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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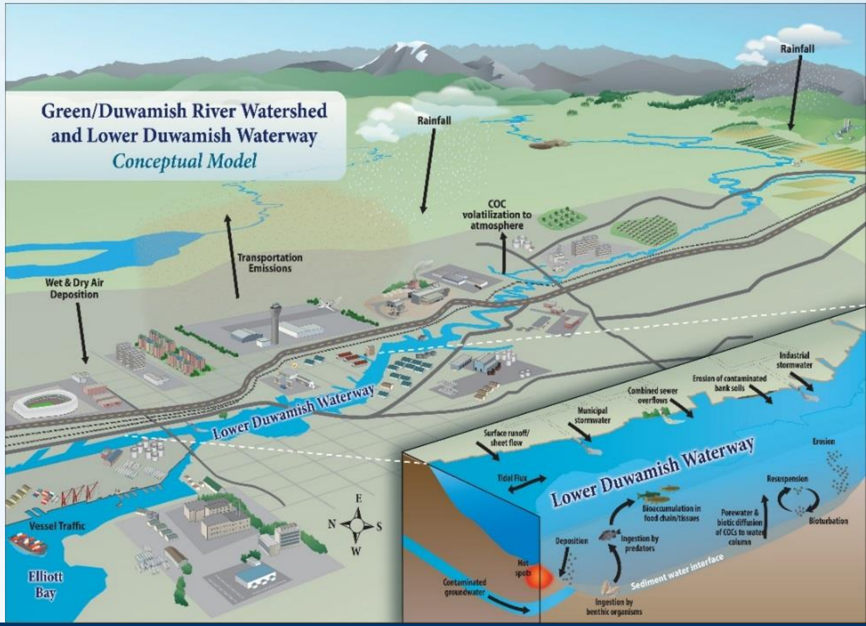
Overview

- ► QAPP overview and project sequencing
- ► QAPP elements
- ► LSPC model specification and HRUs
- ► Model development – flow and sediment
- ► Model development – contaminants



MODELING QAPP DEVELOPMENT

1D, 2D, or 3D?

Size of Model Domain?

Parameters of Interest?

Time Frame Simulated?

Available Data?

Project Team and Peer Review?

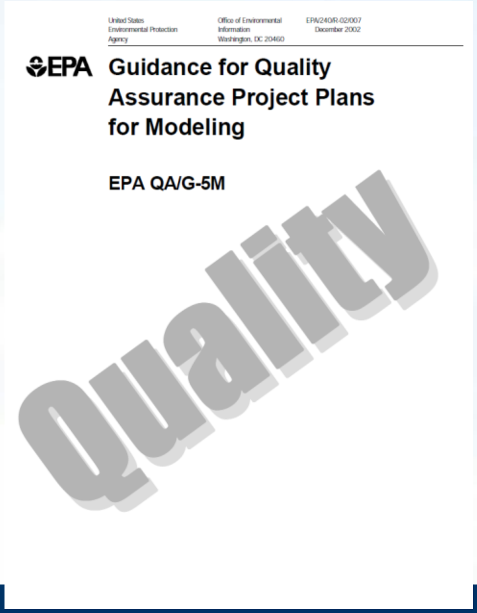
QAPP

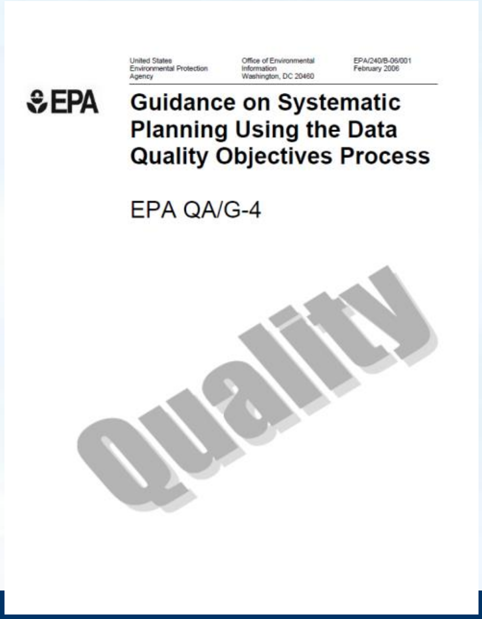
AKA “Who, what, how, and when we’re going to build a model”

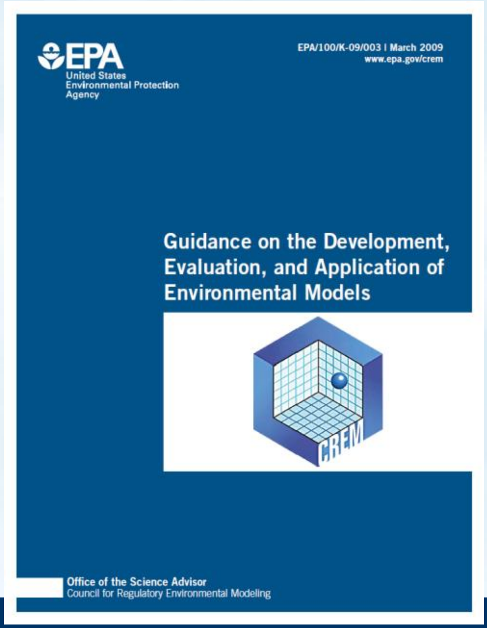
Modeling QAPP

- ► Modeling Quality Assurance Project Plan (QAPP)
  - Roadmap for modeling
  - Systematic planning process

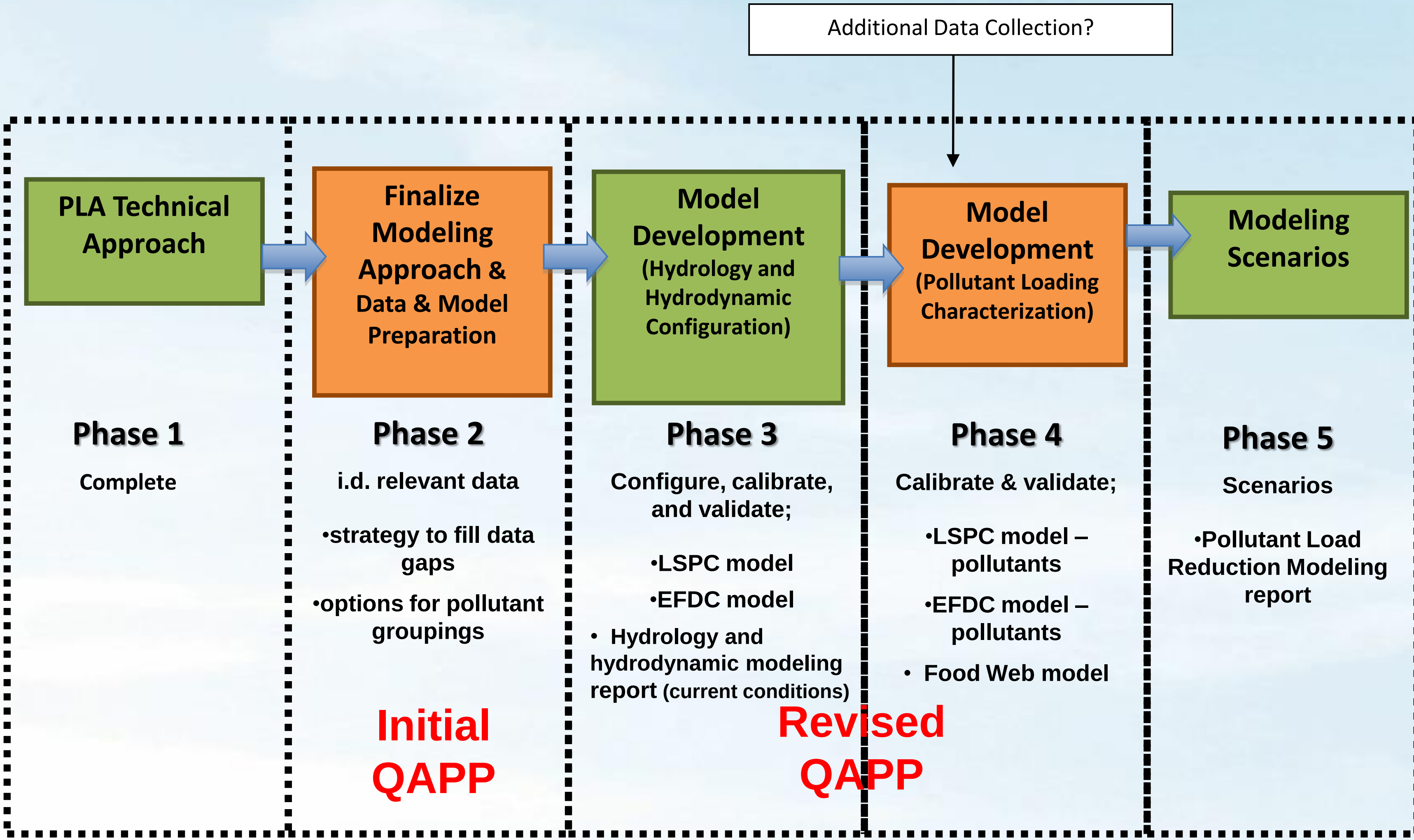
- ► EPA QAPP Guidance is available







Pollutant Loading Assessment – Phasing Ideas



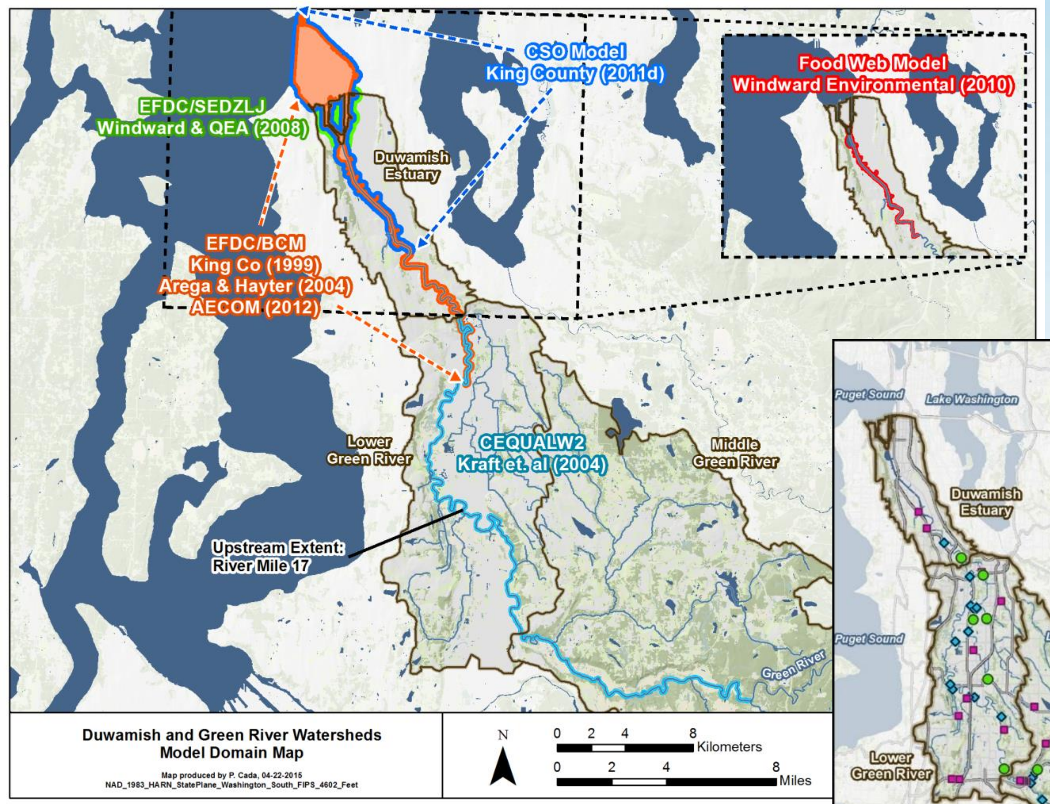
Some elements of a QAPP

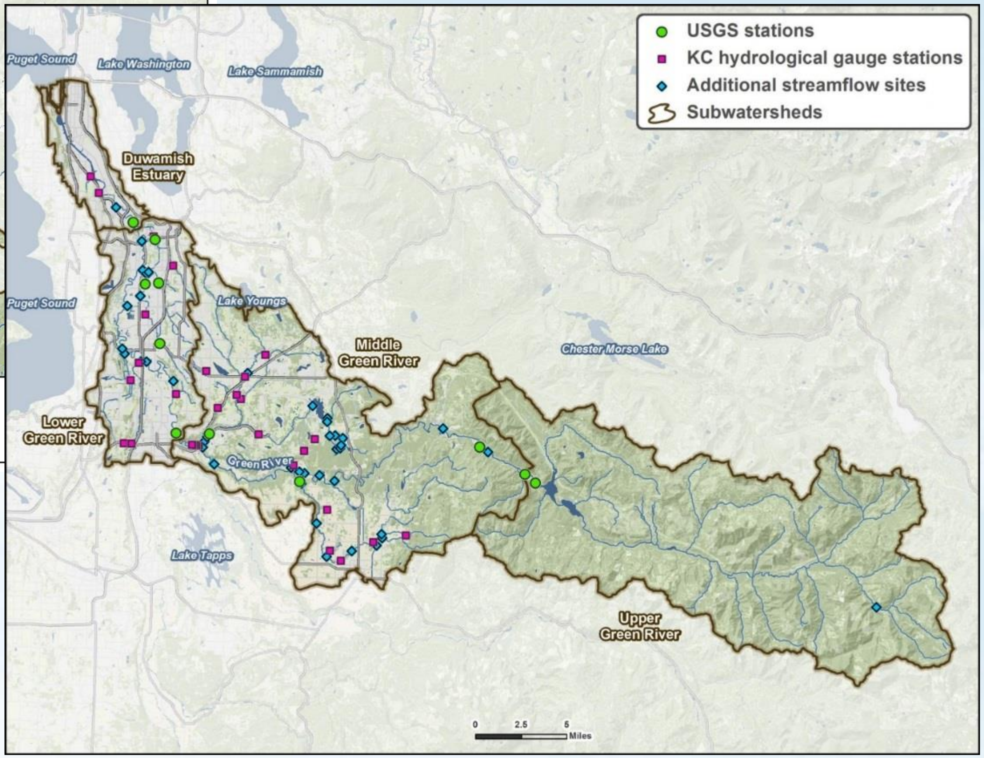
- Modeling objectives
- Study boundaries
- Parameters to be studied
- Model selection
- Secondary data
  - Including identified gaps
- Model development
  - Model representation of sources and processes
  - Including incorporation of previous work and refinements
  - Model configuration, simulation period, etc.
- Model calibration and validation
  - Including procedures and criteria

Modeling objectives

- CWA and CERCLA
  - Address 303(d) listings (relate water, sediment, and tissue concentrations)
  - Protect investment in LDW cleanup (recontamination potential)
- Develop tools to:
  - describe source, transport, and fate
  - compare model output to environmental quality targets
  - allow evaluation of management action

Study boundaries

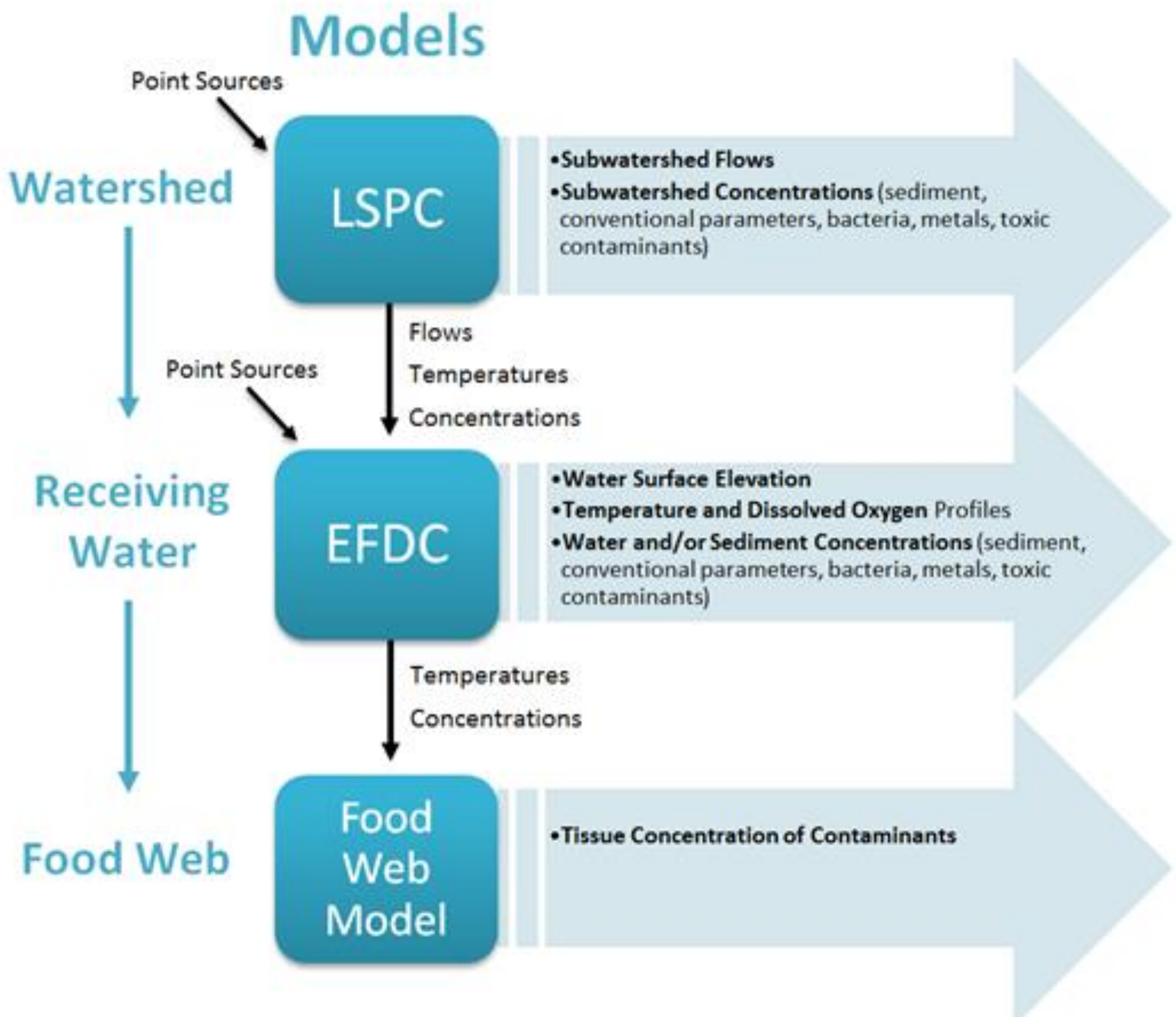




Parameter selection

Parameter	Fate and Transport	Food Web	Justification
PCBs	Y	Y	High concern to both WQ and CERCLA, accumulate in biota, fish consumption advisory, recontamination potential
cPAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h) anthracene, indeno(1,2,3-cd) pyrene)	Y	Y	High concern to both WQ (most 303d listings) and CERCLA, accumulate in biota, ecological concern, recontamination potential
Dioxins/Furans (2,3,7,8 TCDD)	Y	Y	High concern to both WQ (most 303d listings) and CERCLA, accumulate in biota, ecological concern, recontamination potential
Arsenic (inorganic)	Y	N	Concern for both WQ and CERCLA- natural background issue
Phthalates (Bis-2EH phthalate)	Y	Y	Primarily concern for CERCLA, recontamination potential, accumulates in biota- surrogate for other phthalates
Copper	Y	N	Aquatic toxicity concern for ESA species- indicator for built environment
Zinc	Y	N	Aquatic toxicity concern for ESA species- indicator for built environment
Mercury	Y	?	Limited 303d listings, concern for CERCLA, fish consumption advisory

Model selection



Data needs

- Four types of data
  - Background data – model configuration
  - Boundary conditions – model configuration
  - Kinetic processes (e.g., partitioning)
  - Data to support model calibration and validation

Watershed model (e.g., PCB data)

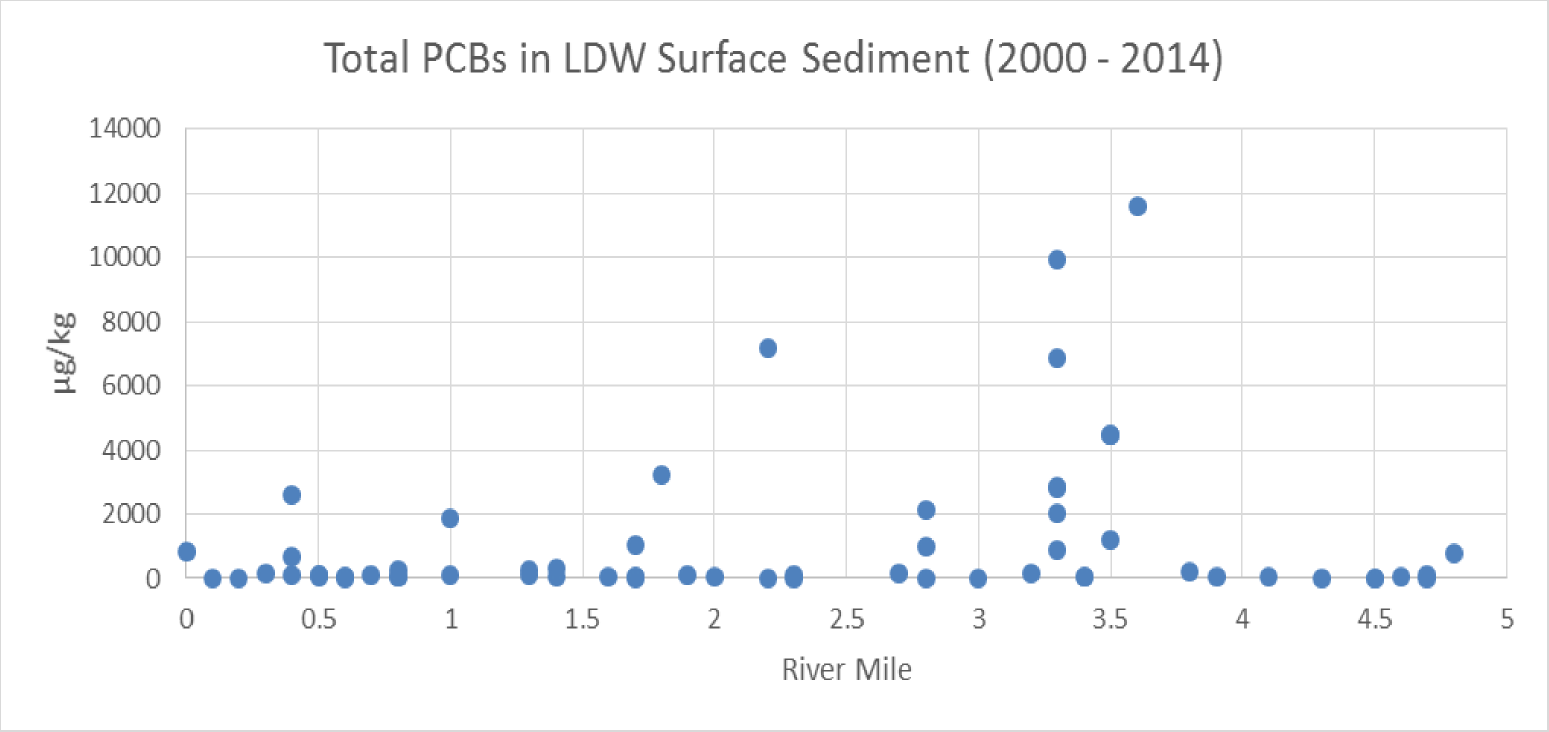
Table 1. Summary table of data/study by parameter - land use/land cover-based loading rates

Parameter	Surface Runoff/Shallow Groundwater *	Atmospheric Deposition *
PCBs	Herrera (multiple citations) Ecology (2015)	King County (2013d) Leidos and Newfields (2013)

Table 1. Summary table of data/study by parameter and watershed area – instream calibration

Parameter	Upper Green River Watershed	Middle Green River Watershed	Lower Green River Watershed
PCBs	King County (2015)	King County (2014) King County (suspended solids study)	King County (2014) King County (suspended solids study) USGS (Tukwila monitoring) Ecology (2009)

PCB data - LDW



Total PCBs in LDW Surface Sediment (2000 - 2014)
µg/kg
14000
12000
10000
8000
6000
4000
2000
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
River Mile

Gaps to Address (PCBs)

- Lack of paired filtered/unfiltered data for site-specific determination of partition coefficients in both the water column and the sediments.
  - Use literature values for initial runs
  - Collect paired data to evaluate coefficients and improve accuracy over use of literature values alone?
- No data are currently available to directly constrain rates of exchange from the sediment into the water column, which may be enhanced above diffusion rates by biological action.
  - Treat rates as calibration parameter until/unless Ongoing work by MIT for USACE provides field data to enhance

Model development/set up

- Previous modeling
  - EFDC
  - HSPF
  - FWM
- Refinements and additions
  - Examples
    - Add water column water quality to EFDC
    - Refine watershed model sediment calibration
    - Add pollutants of interest to watershed model
    - Expand watershed models to cover entire direct drainage area to LDW

Simulation period

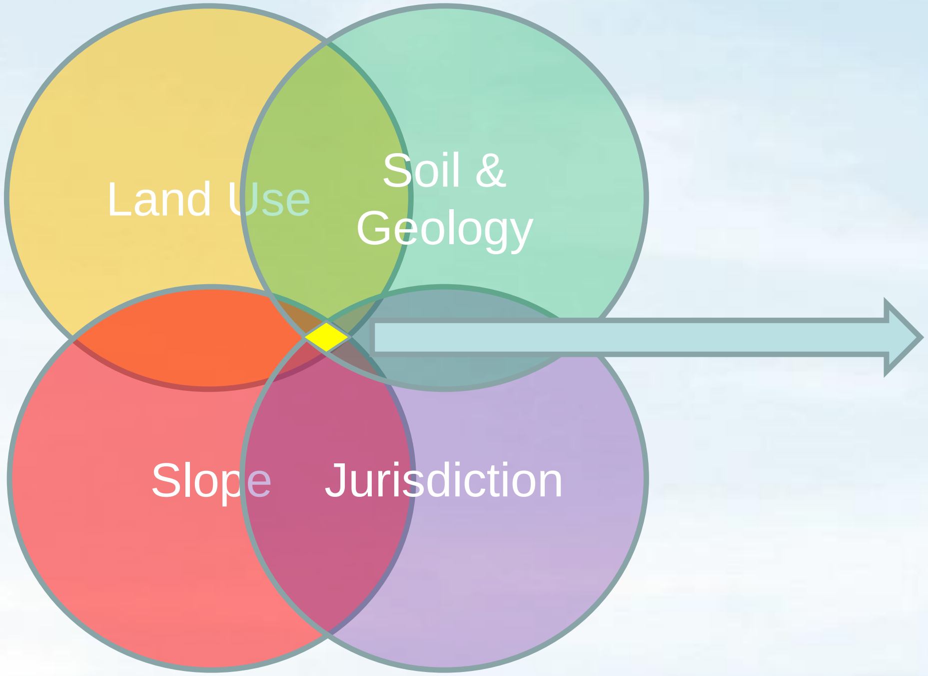
- Initial thoughts…
  - Watershed model
    - Current HSPF model period through WY 2009 – needs to be extended, convert to LSPC platform
    - Revised model calibration to be focused on 2008-2015
    - Initial validation:1996-2007
    - Additional validation: 2016-2017
    - Full simulation = 1996-2017 (20+ years)
  - EFDC
    - New calibration period
    - Validation
    - Full simulation (multiple years)

MODEL DEVELOPMENT SEQUENCE

- Model Specification
  - LSPC
  - EFDC (update existing model)
- Hydrology and Hydrodynamics
  - LSPC
  - EFDC
- Sediment/TSS
  - LSPC
  - EFDC
- Contaminants
  - LSPC
  - EFDC
  - Food Web

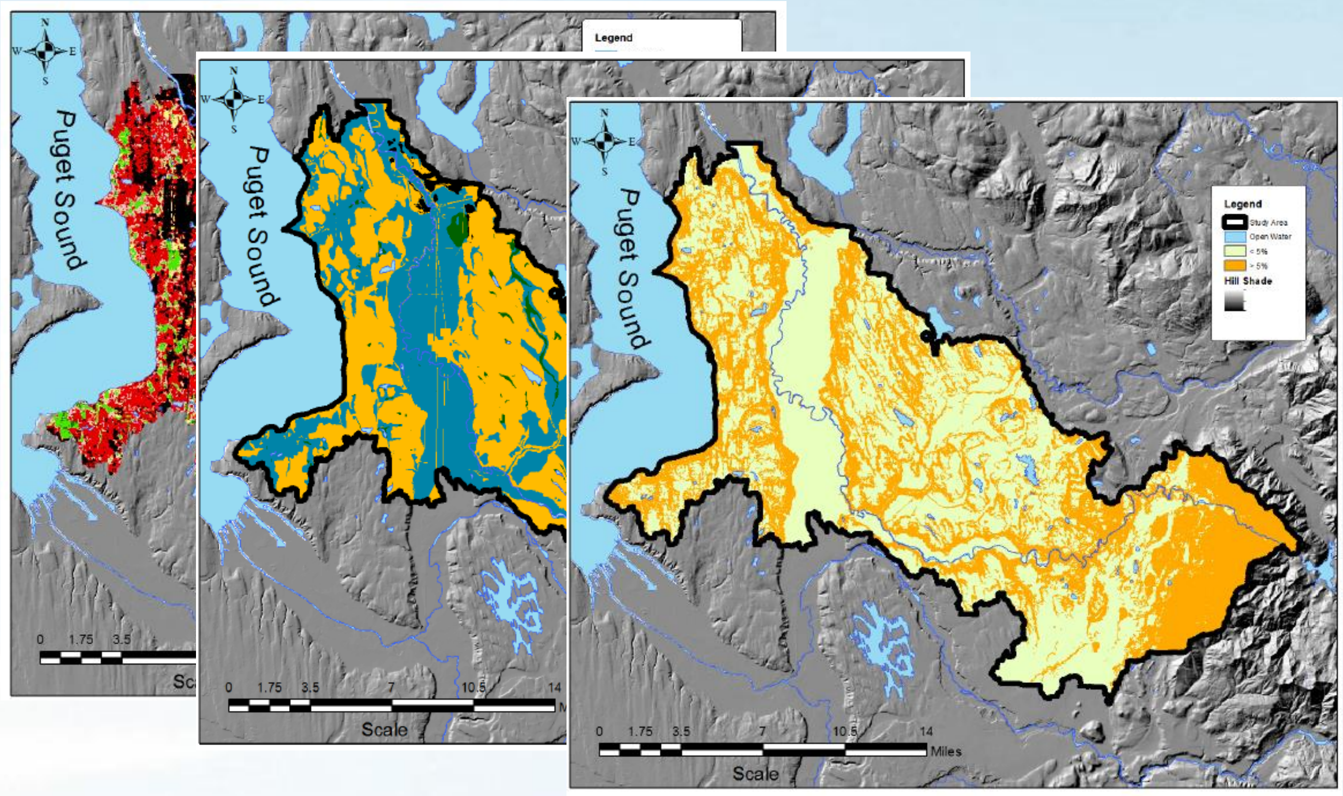
LSPC MODEL SPECIFICATION

Hydrologic Response Units (HRUs)



Unit area load at source, classified by land use, soil & geology, slope, and jurisdiction

Overlay of Land Use, Geology, Slope



King County HSPF - HRUs

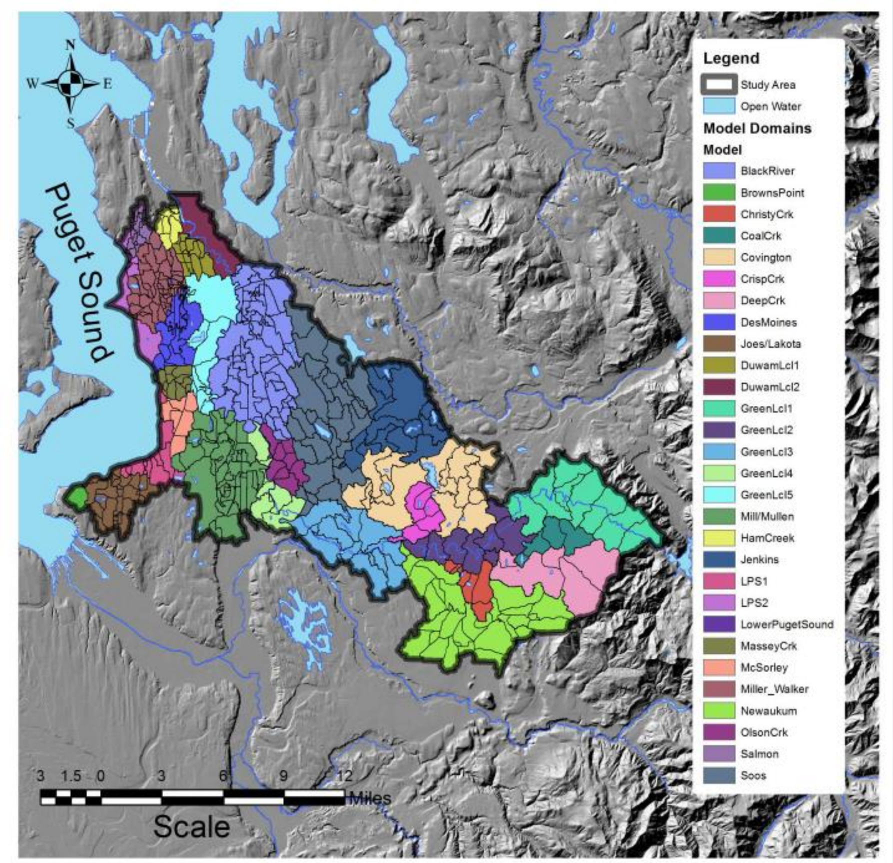
- The upland portions of the watersheds are simulated using HRUs that consist of an overlay of land use, geology, and slope.
- Land use and land cover is based on 30-m resolution 2007 satellite-derived dataset with 14 land use categories from the University of Washington.
- **Connected impervious** land areas were separated from the overall land cover distribution based on generalized percentages of effective (i.e., directly connected) impervious area. After the initial analysis, the impervious area in major roads was segregated as a separate category of impervious land.

- HRU numbering scheme from King County (2013) with associated surficial geology, land cover, slope (partial table)

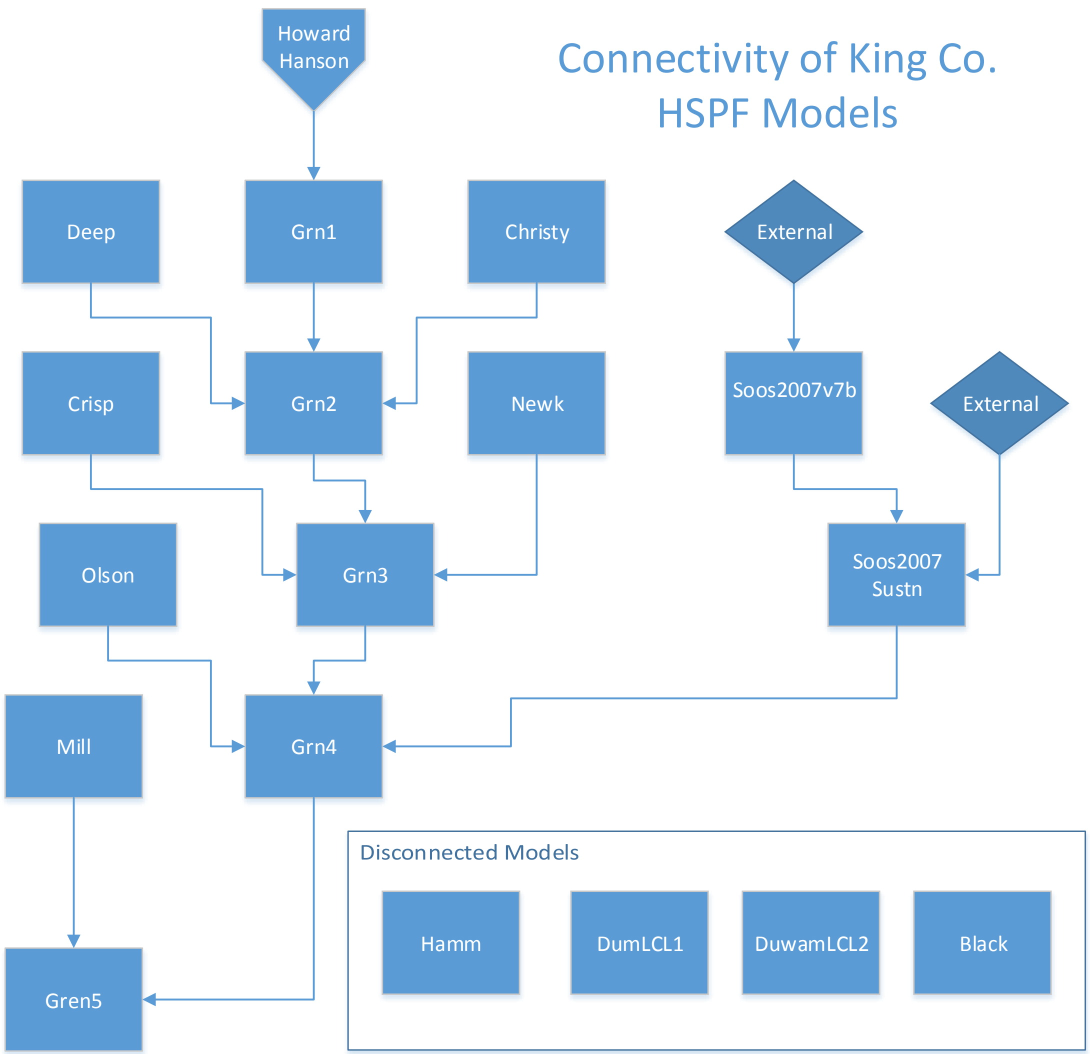
HRU Number	Surficial Geology	Land Cover	Slope	Description	Short Descr.
1	Till	Roads grass	Flat	Till Road Grass Flat	TR1
3			Moderate	Till Road Grass MED	TR3
11		Commercial grass	Flat	Till Road Grass Flat	TC1
13			Moderate	Till Road Grass MED	TC3
21		High Density Residential grass	Flat	Till Road Grass Flat	THR1
23			Moderate	Till Road Grass MED	THR3
31		Low Density Residential grass	Flat	Till Road Grass Flat	TLR1
33			Moderate	Till Road Grass MED	TLR3
41		Cleared Lands	Flat	Till Road Grass Flat	TCLR1
43			Moderate	Till Road Grass MED	TCLR3
51		Grasslands	Flat	Till Road Grass Flat	TGR1
53			Moderate	Till Road Grass MED	TGR3
61		Forest	Flat	Till Road Grass Flat	TF1
63			Moderate	Till Road Grass MED	TF3
71		Clear Cuts	Flat	Till Road Grass Flat	TCC1
73			Moderate	Till Road Grass MED	TCC3
81		Forest Regeneration	Flat	Till Road Grass Flat	TFRG1
83			Moderate	Till Road Grass MED	TFRG3
91		Agriculture	Flat	Till Road Grass Flat	TAG1
93			Moderate	Till Road Grass MED	TAG3
100	Outwash	Roads grass	N/A	OUTWASH, Road Grass	OR
101		Commercial grass		OUTWASH, COM Grass	OC
102		High Density Residential grass		OUTWASH, HD Grass	OHD
103		Low Density Residential grass		OUTWASH, LD Grass	OLD
104		Cleared Lands		OUTWASH, Cleared	OCLR
105		Grasslands		OUTWASH, Grassland	OGR
106		Forest		OUTWASH, Forest	OF
107		Clear Cuts		OUTWASH, Clear Cut	OCC
108		Forest Regeneration		OUTWASH, Forest Regen	OFRG
109		Agriculture		OUTWASH, Agriculture	OAGR

King Co. WRIA 9 Models

- ► Multiple linked models
- ► Include county drainage to LDW and direct to Puget Sound



Connectivity of King Co. HSPF Models



King Co. HSPF Models

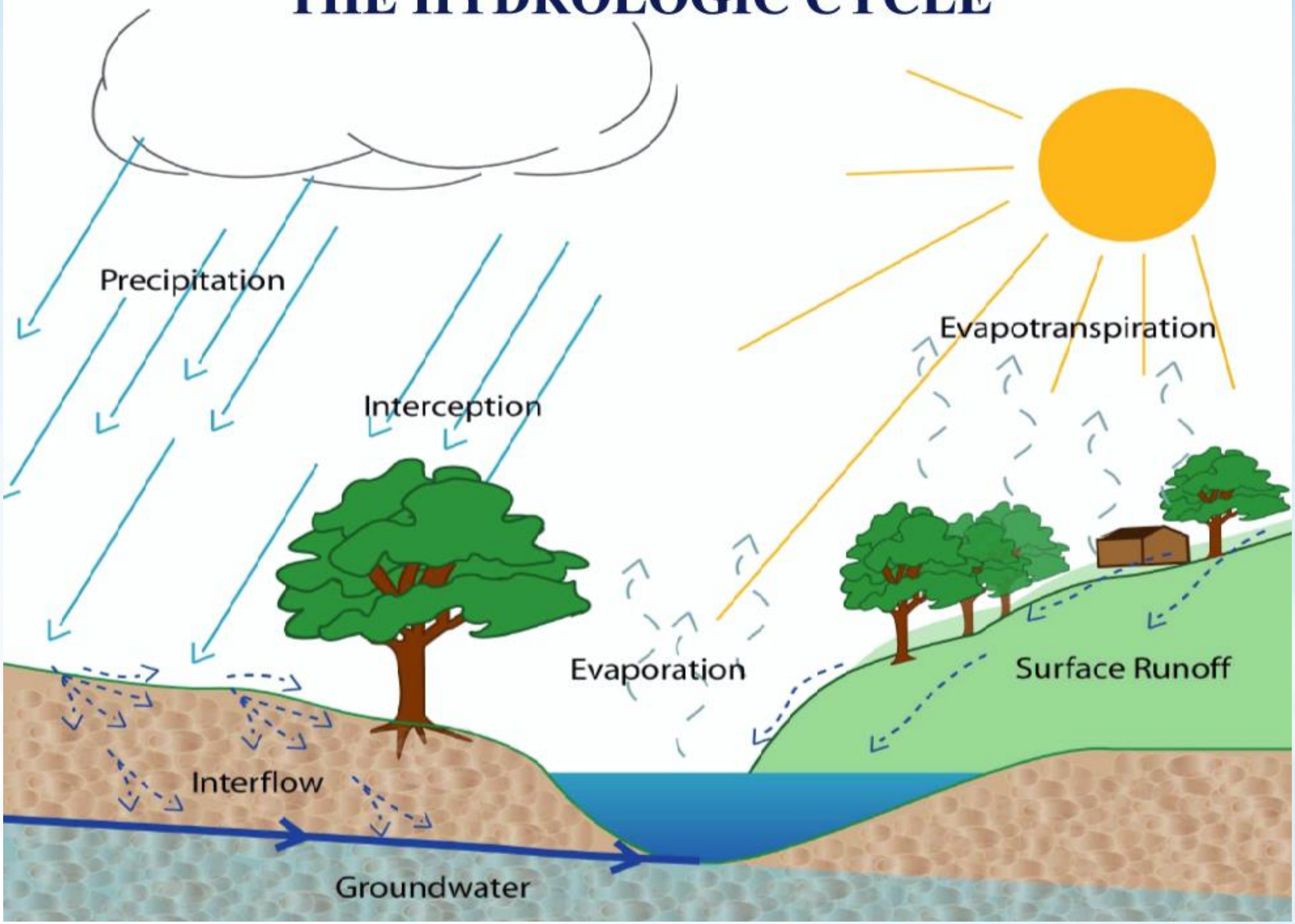
- ► Lack Seattle portion of LDW direct drainage
- ► Calibrated for flow and sediment – although quality of sediment calibration is sometimes noted as "poor"
- ► The multiple individual models can have differing parameters
- ► PLA project will evaluate models and improve calibration if feasible

MODEL DEVELOPMENT – FLOW AND SUSPENDED SEDIMENT

Dynamic Flow and Sediment Modeling

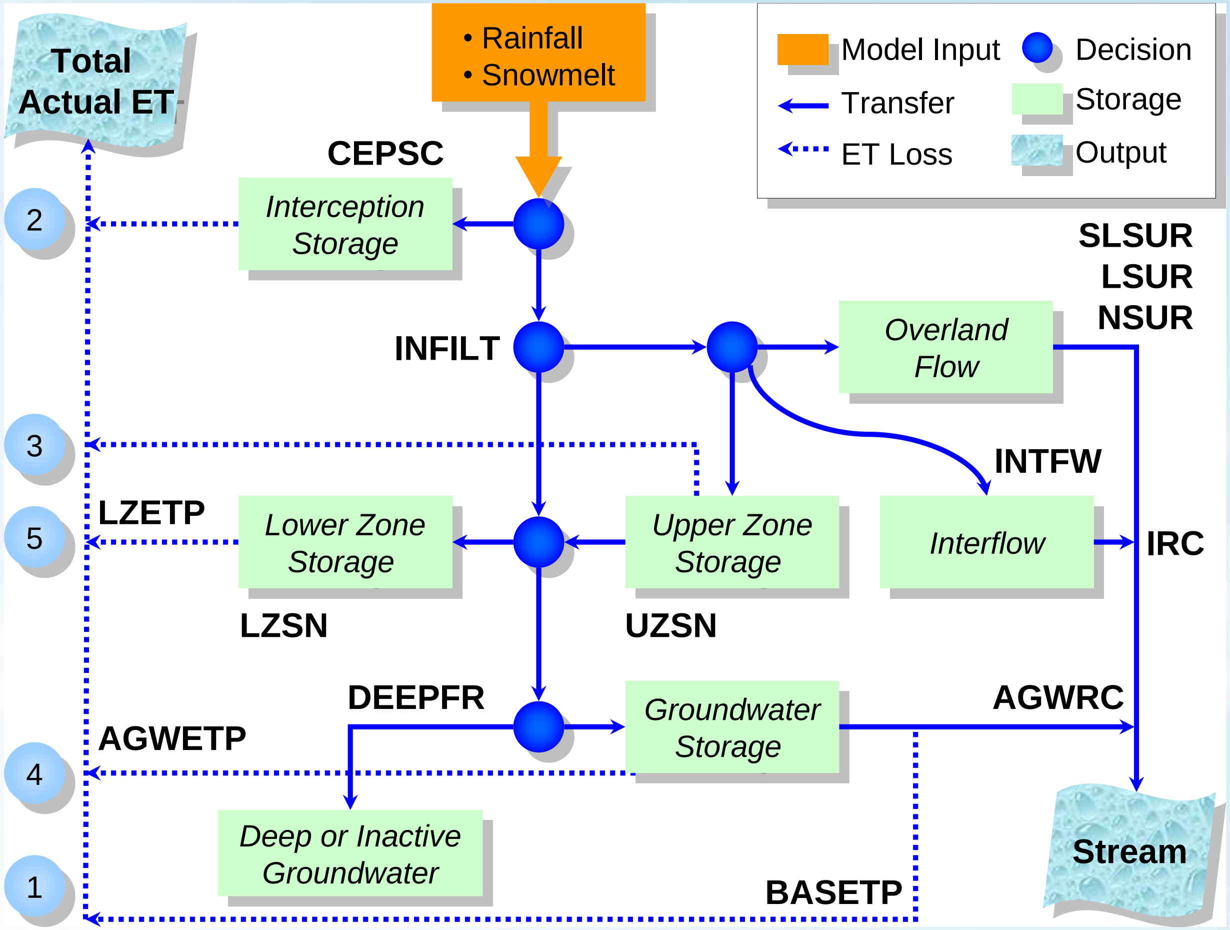
- Model is dynamic – continuous simulation over long periods of time at an hourly time step
- Therefore captures runoff and erosion events
- Need accurate simulation of flow and sediment transport to describe the generation and movement of dissolved and sediment-sorbed contaminants

THE HYDROLOGIC CYCLE



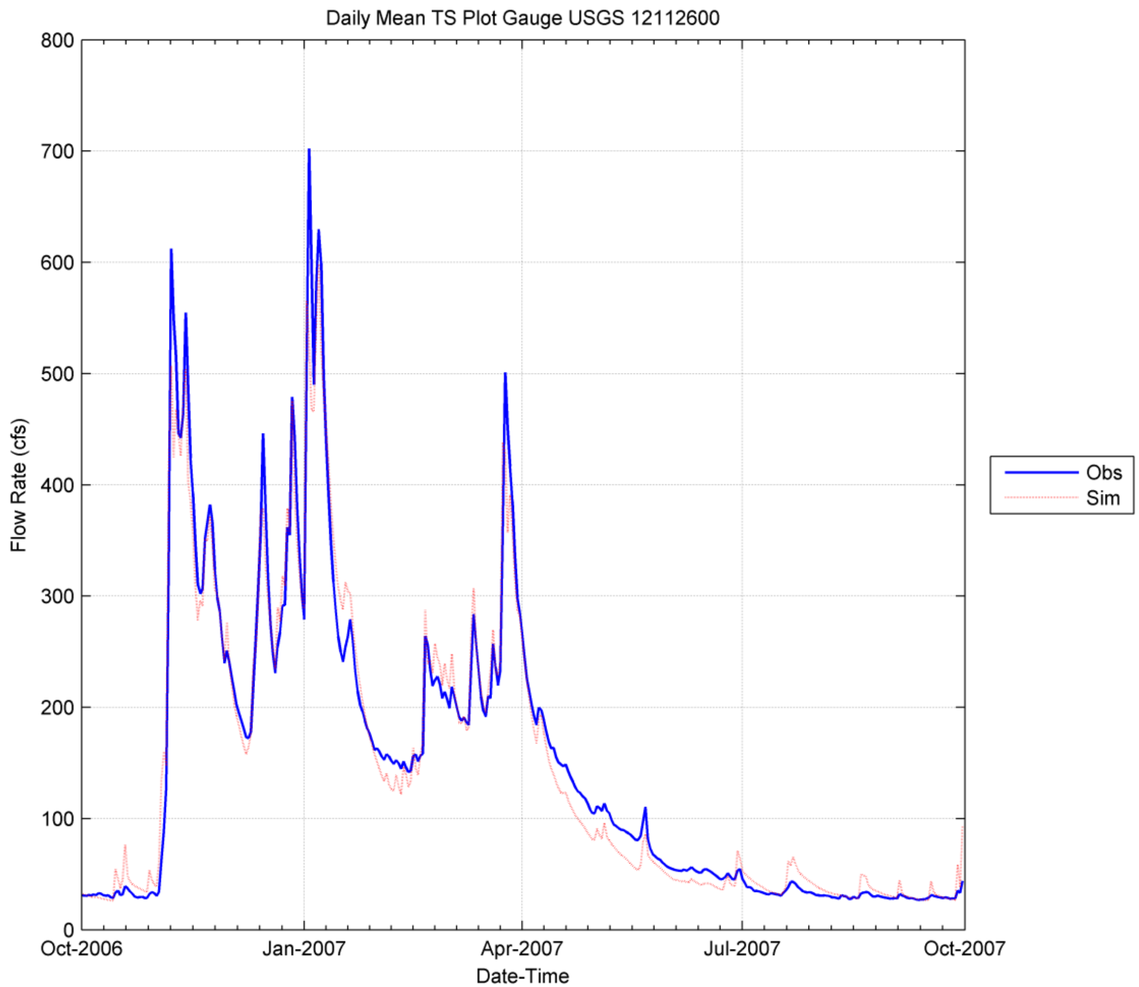
LSPC Hydrology Model

- Hydrologic Components:
  - Precipitation
  - Interception
  - Evapotranspiration
  - Overland flow
  - Infiltration
  - Interflow
  - Subsurface storage
  - Groundwater flow
  - Groundwater loss



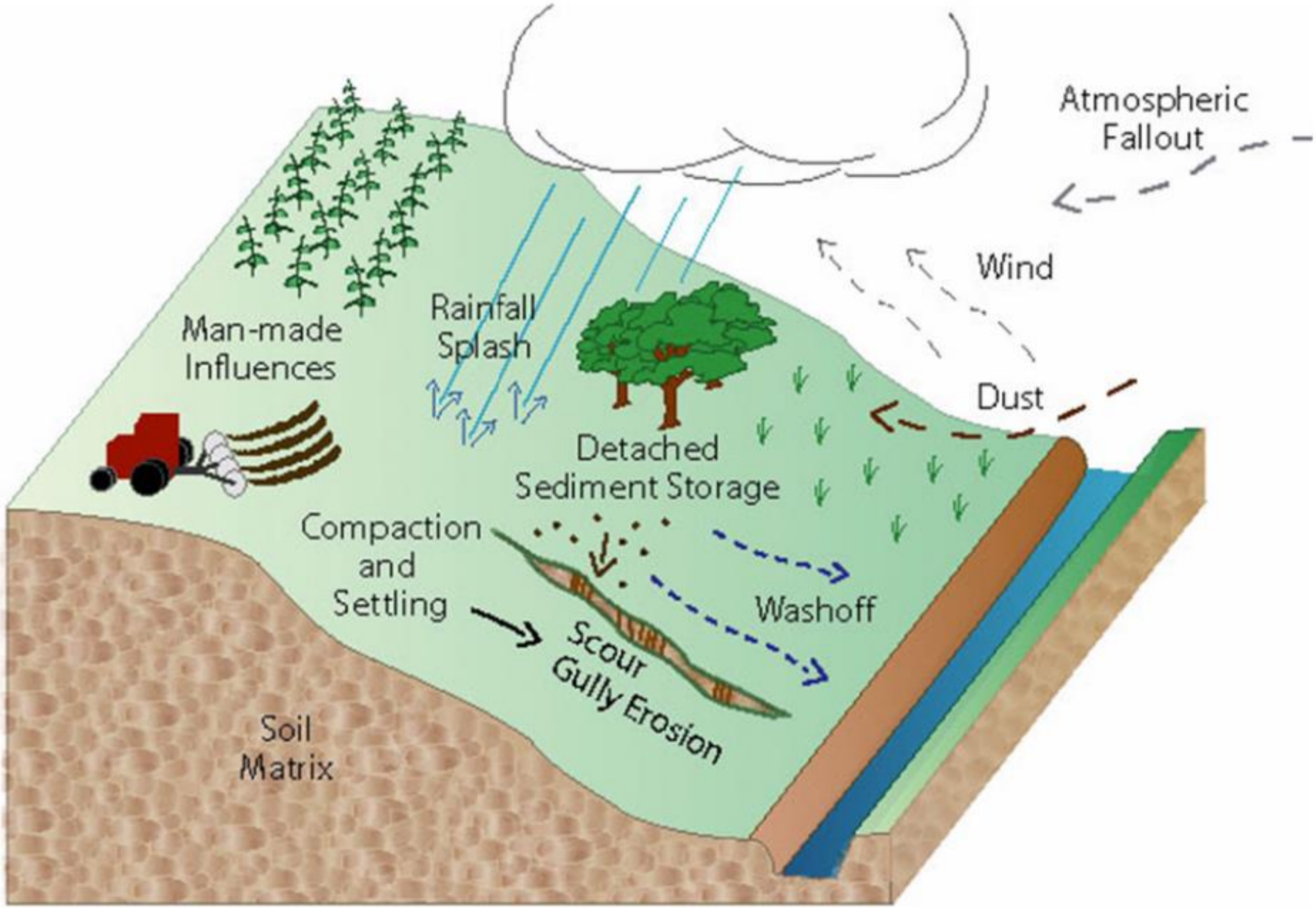
Source: Stanford Watershed Model

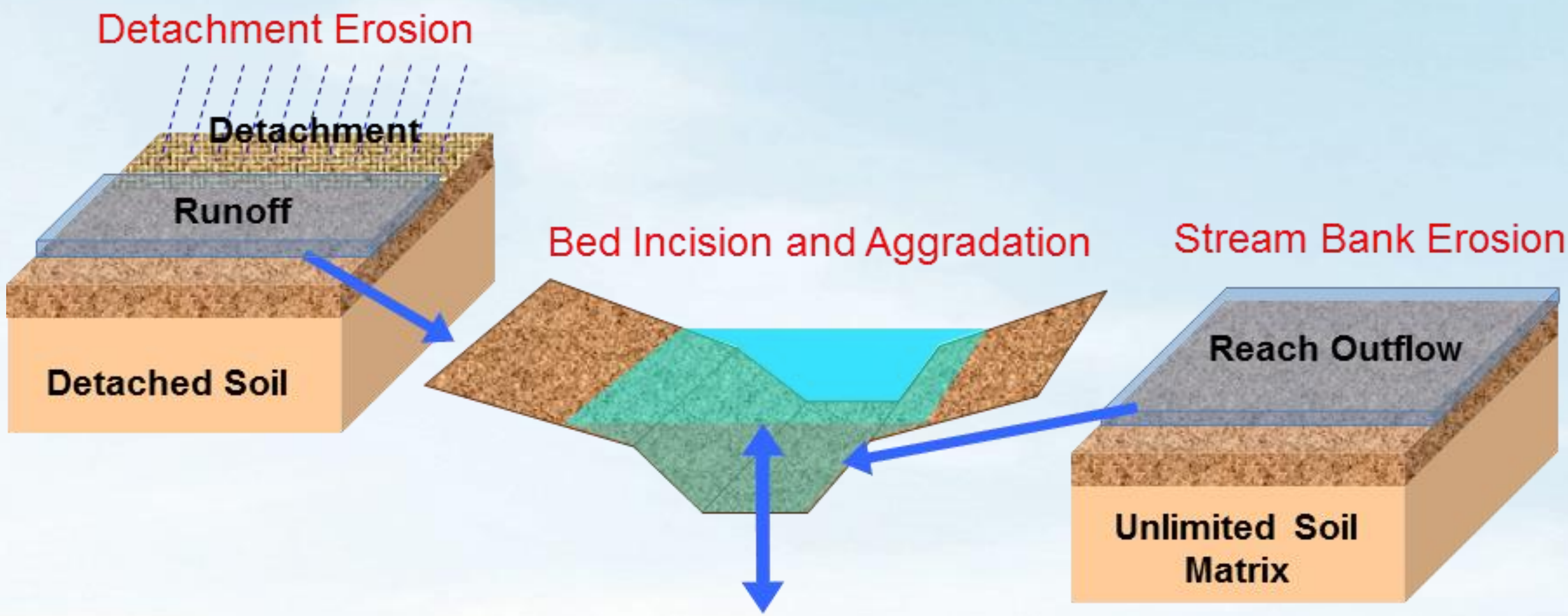
Example Flow Calibration – Big Soos



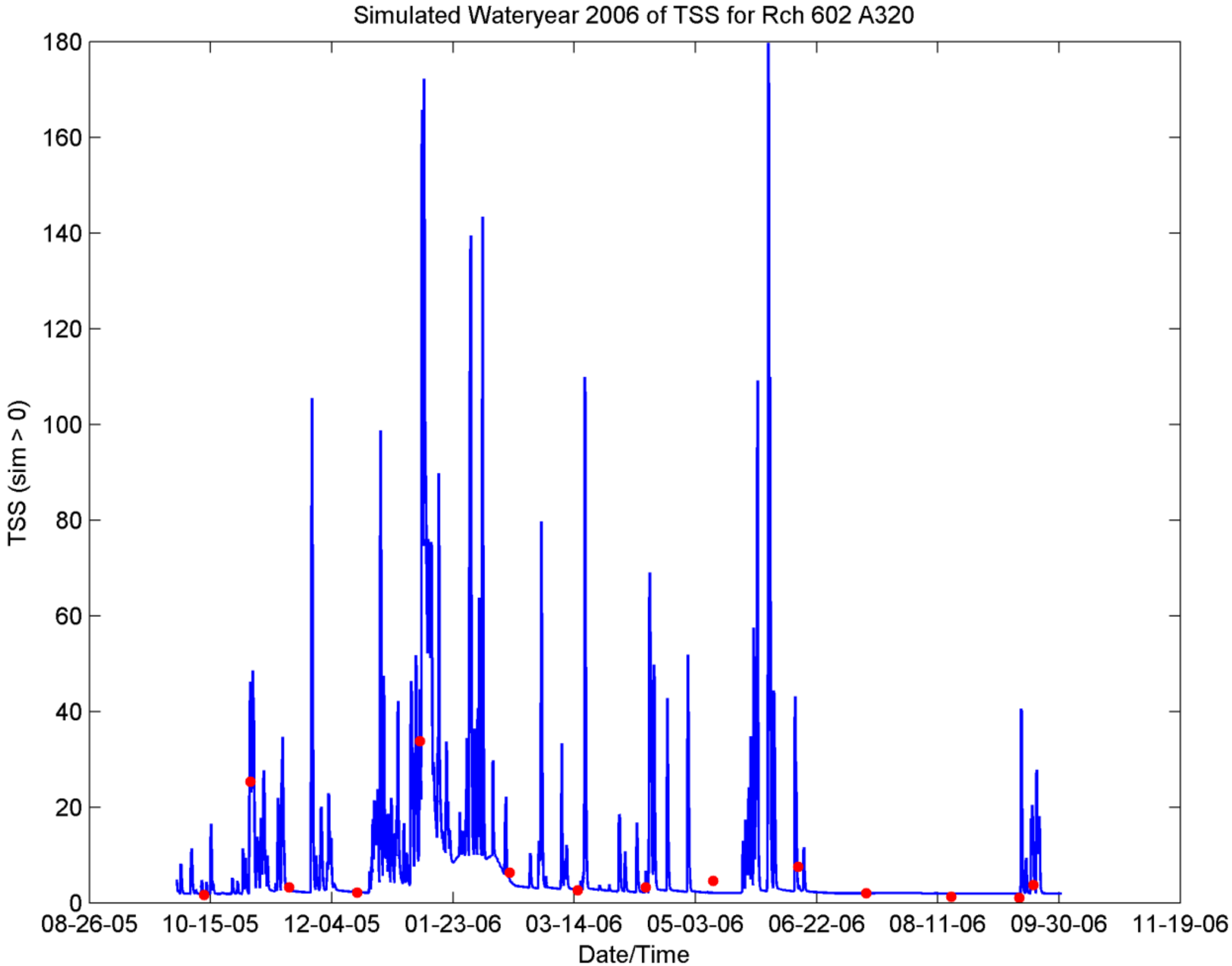
Source: WRIA9 Report

SOIL EROSION PROCESSES




Detachment Erosion
Detachment
Runoff
Detached Soil
Bed Incision and Aggradation
Stream Bank Erosion
Reach Outflow
Unlimited Soil
Matrix

Suspended Sediment Calibration, Big Soos



Source: WRIA9 Report

MODEL DEVELOPMENT - CONTAMINANTS

Constituents

Parameter	Fate and Transport	Food Web	Justification
PCBs	Y	Y	High concern to both WQ and CERCLA, accumulate in biota, fish consumption advisory, recontamination potential
cPAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h) anthracene, indeno(1,2,3-cd) pyrene)	Y	Y	High concern to both WQ (most 303d listings) and CERCLA, accumulate in biota, ecological concern, recontamination potential
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Zinc	Y	N	Aquatic toxicity concern for ESA species- indicator for built environment
Mercury	Y	?	Limited 303d listings, concern for CERCLA, fish consumption advisory

Which PCBs?

- Group of 209 congeners with a wide range of chemical properties. Simulating total PCBs as a single state variable will lead to inaccuracies, but it is not feasible to simulate 209 congeners individually.
- 10 Homolog groups: mono- through decachlorobiphenyls
- Recommend simulating reduced set of homologs, but majority of data are for Aroclors, requiring translation
- Delaware River used four-homolog model of tetra-PCB, penta-PCB, hexa-PCB, and hepta-PCBs to support a TMDL for PCBs in the estuary (Suk and Fikslin, 2011)
- Final decision to be made to reflect model objectives: Do we need to predict toxicity associated with individual congeners or criteria associated with total PCBs?

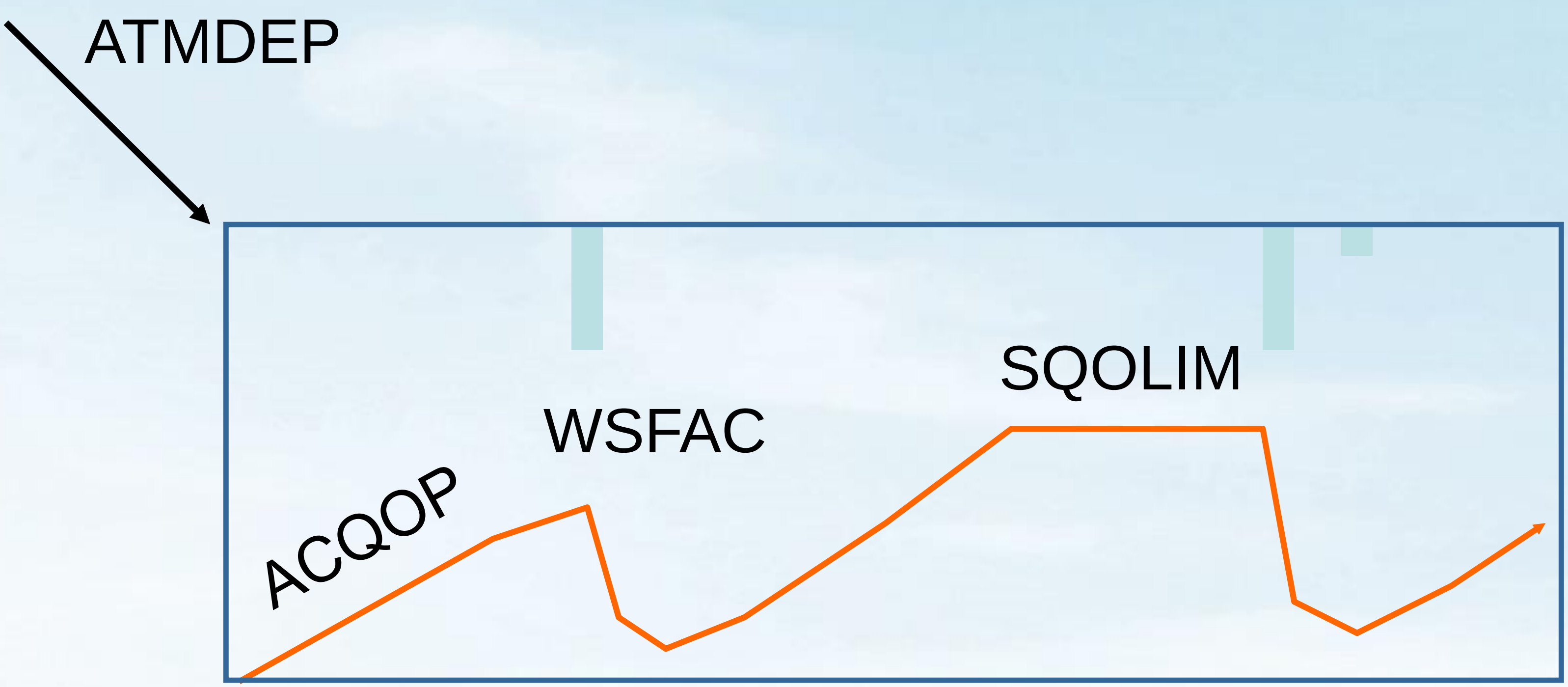
What to do about Aroclors?

- Data for PCBs reported as Aroclors is problematic for comparison to congeners and homologs due to changes in composition from differential weathering.
  - Use samples analyzed for both Aroclors and congeners to evaluate site-specific relationships between environmentally altered Aroclors and congeners

Overland Water Quality Processes

- Urban Land Units
  - Impervious areas
    - Dust and dirt build-up functions
  - Pervious areas
    - Dissolved pollutants with runoff
    - Erosion and adsorbed pollutants with sediment
- Rural Land Units
  - Erosion and adsorbed pollutants with sediment
  - Dissolved pollutants with runoff

Build-up and Wash-off Model



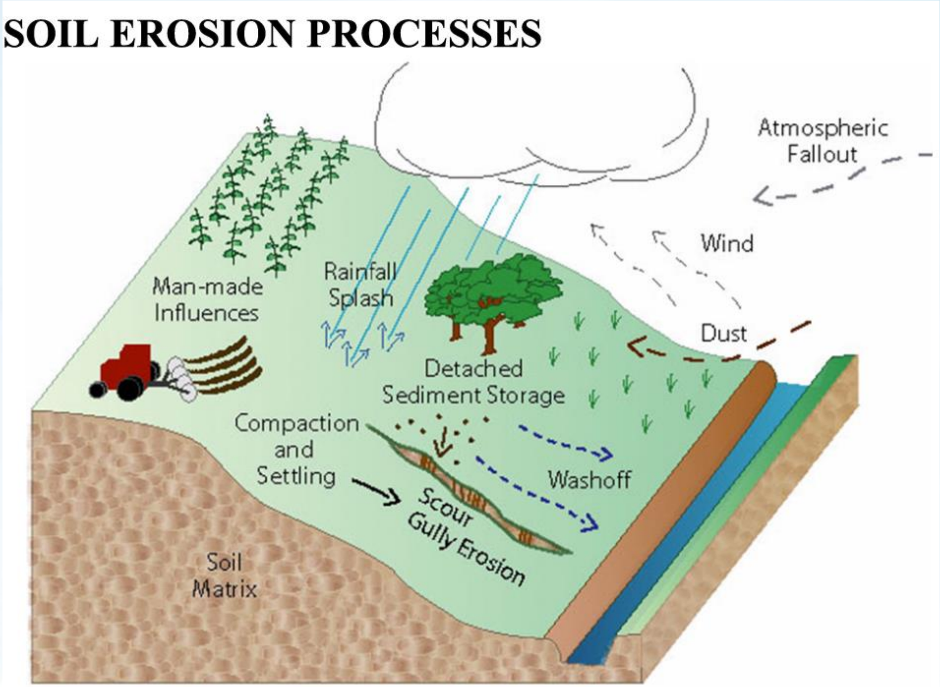
Key model parameters

ATMDEP = atmospheric deposition
ACQOP = accumulation rate of the constituent (quantity/ac per day)
SQOLIM = maximum storage capacity of constituent on land (quantity/ac)
WSFAC = susceptibility of the quality constituent to washoff (/in)

About buildup-washoff

- Pollutants, including indirect atmospheric deposition, are modeled as accumulating and then washing off based on rainfall and overland flow.
- Accumulation rates are assigned to HRUs to simulate buildup of pollutants on the land surface, along with an asymptotic maximum storage.
- Accumulation rates can be estimated on the basis of typical pollutant production rates for sources associated with different HRU types. Use both local data and literature.

Sediment-Associated Loading



- ► PCB concentrations can be associated with each component of the soil erosion process to represent areas of known contamination

Proposed HRU Approach: PCBs

- Build upon King County HRUs to address loading
- Known source areas, such as specific urban industrial areas, can be split into distinct HRUs, with appropriate pollutant loading characteristics.

HRU Number	Surficial Geology	Land Cover	Slope	Description	Short Descr.
1	Till	Roads grass	Flat	Till Road Grass Flat	TR1
3			Moderate	Till Road Grass MED	TR3
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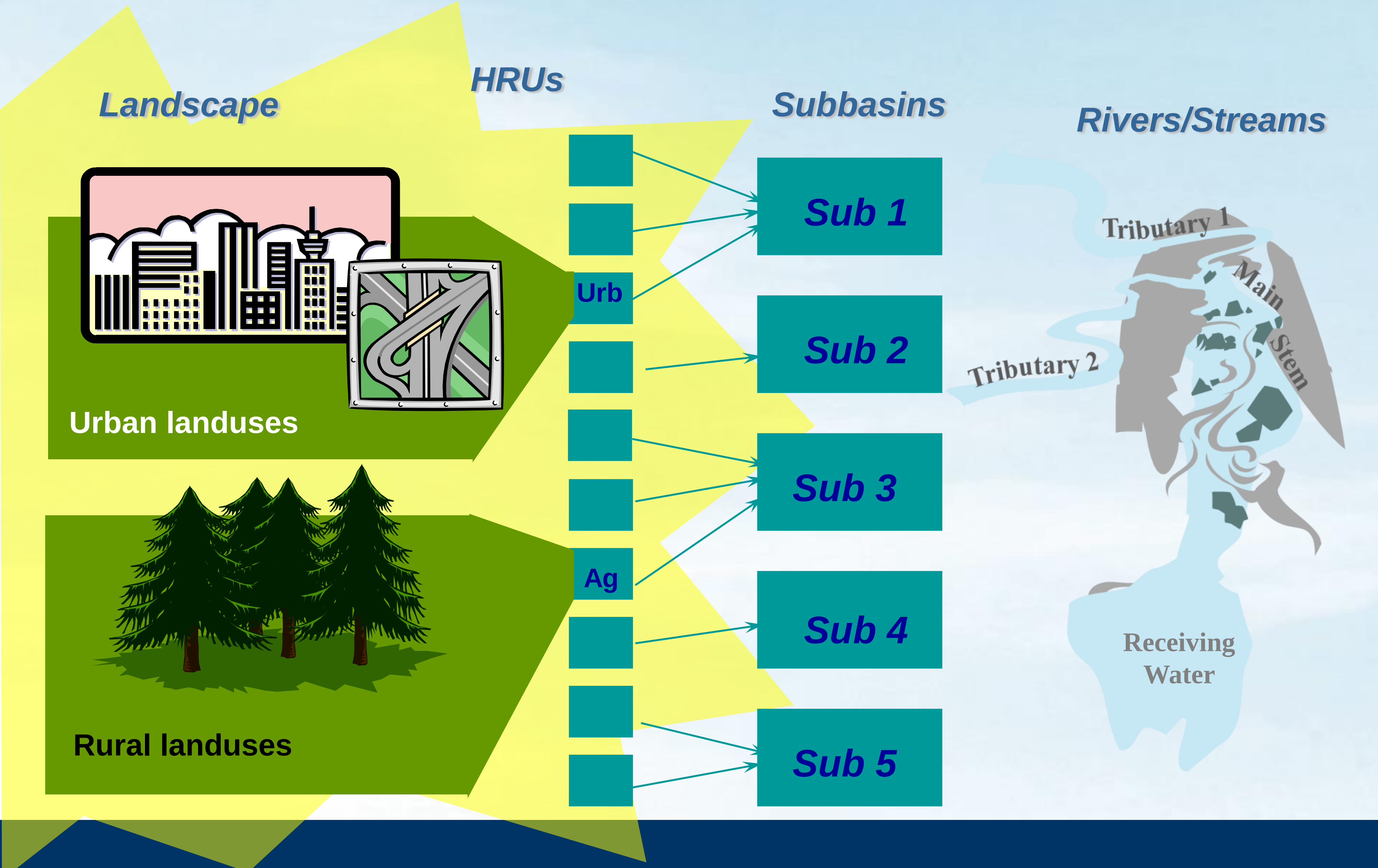
107		Clear Cuts		OUTWASH, Clear Cut	OCC
108		Forest Regeneration		OUTWASH, Forest Regen	OFRG
109		Agriculture		OUTWASH, Agriculture	OAGR

Watershed loading summary

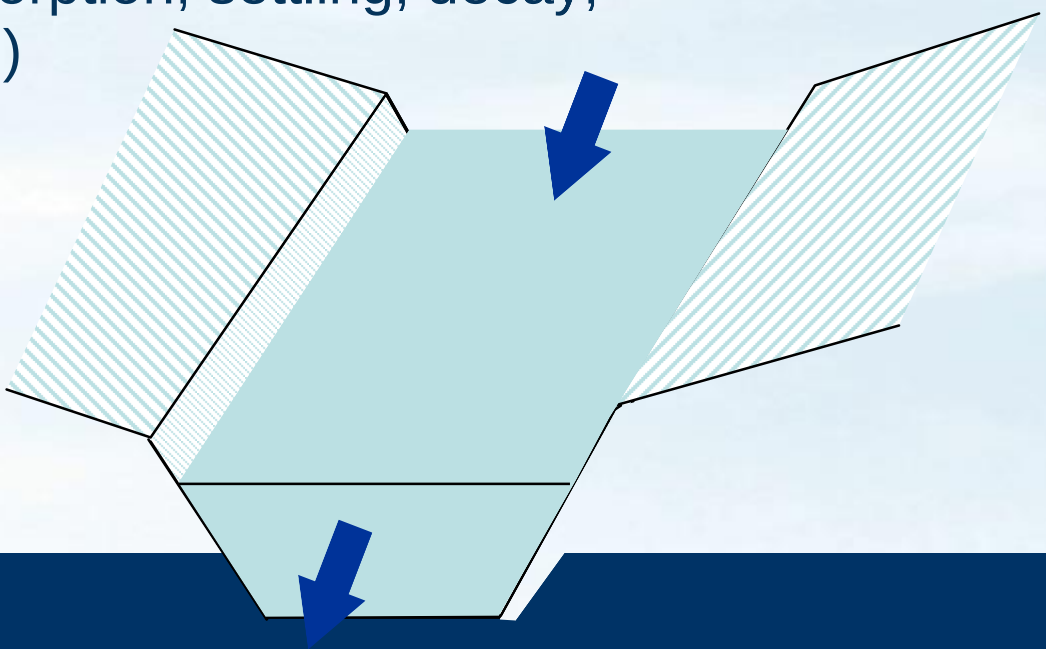
- Loading processes for pollutants in the watershed model
  - represented for each land unit (HRU) using pervious and impervious land segment modules
  - Use buildup/washoff (with atmospheric deposition) impervious land segment simulation of pollutant generation
  - For pervious land, potency (e.g., pounds of the COC per ton of sediment eroded), additional buildup/washoff, plus specification of concentrations in subsurface flow pathways
- Aggregate results from HRUs to subbasins and from subbasins to river systems

Watershed Loads



In-stream Simulation of Water Quality

- Simulates dissolved and sediment associated quality constituents
- Processes applicable to dissolved general quality constituents include:
  - Advection of dissolved material (dominant process in the watershed)
  - Kinetic processes (sorption, settling, decay, transformations, etc.)



Linking to EFDC

- Outputs from LSPC
  - Flow
  - Sediment
  - Containments load (dissolved and sediment-sorbed)
- Outputs from CSO models
- Facilitate with scripting (e.g., Python)

Linked HSPF-EFDC for Housatonic River PCBs

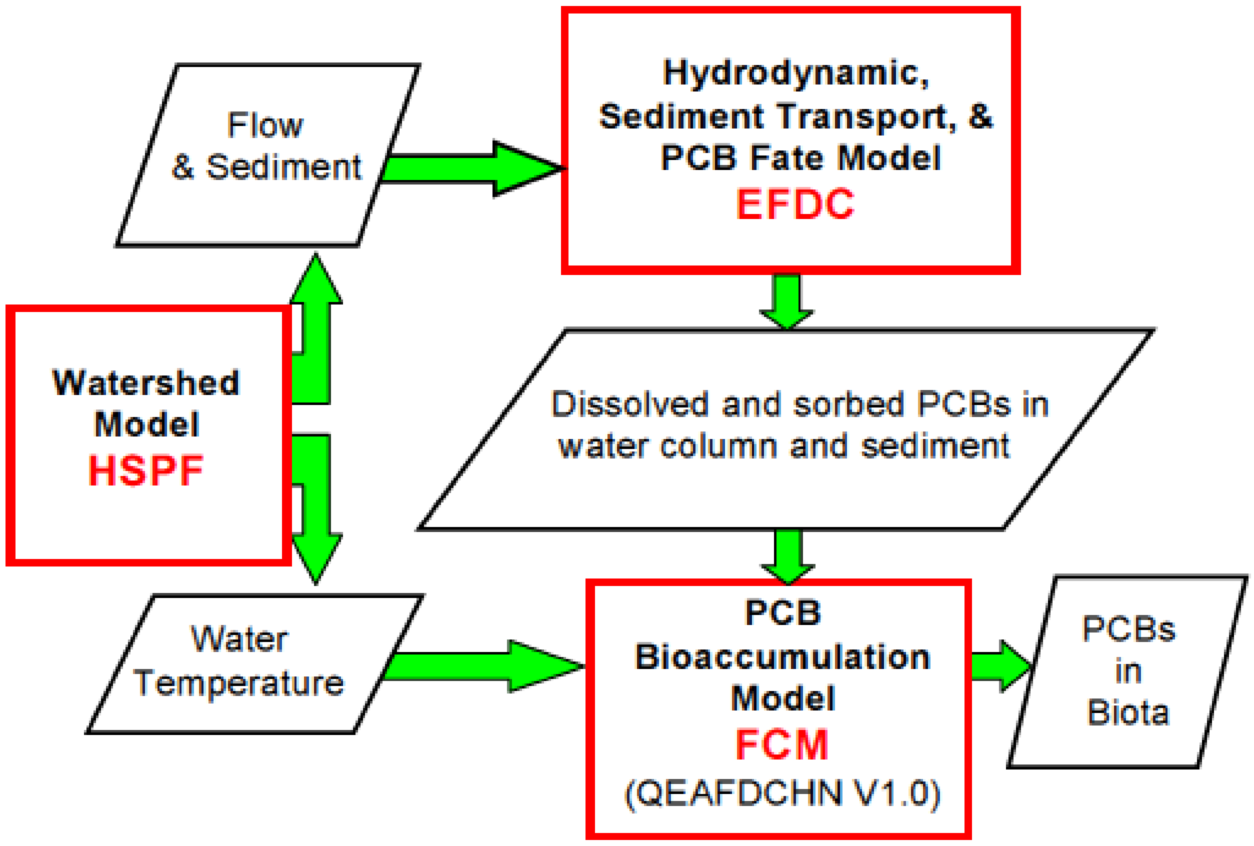


Figure 2. Modeling Framework for PCB Modeling of the Housatonic River Watershed.

Watershed and Receiving Water Model Linkage With HSPF: Issues and Example Applications

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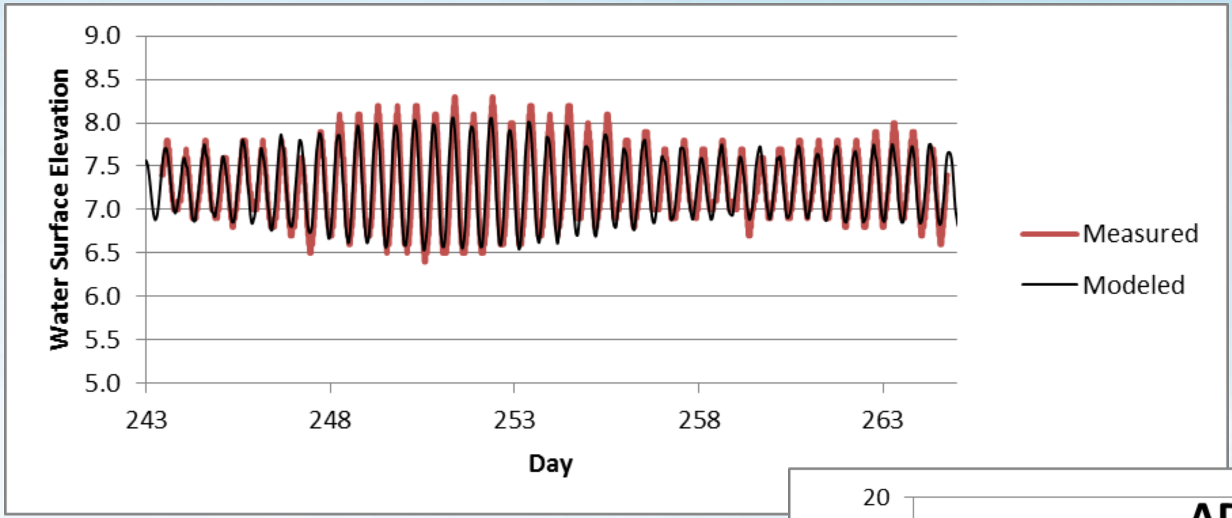
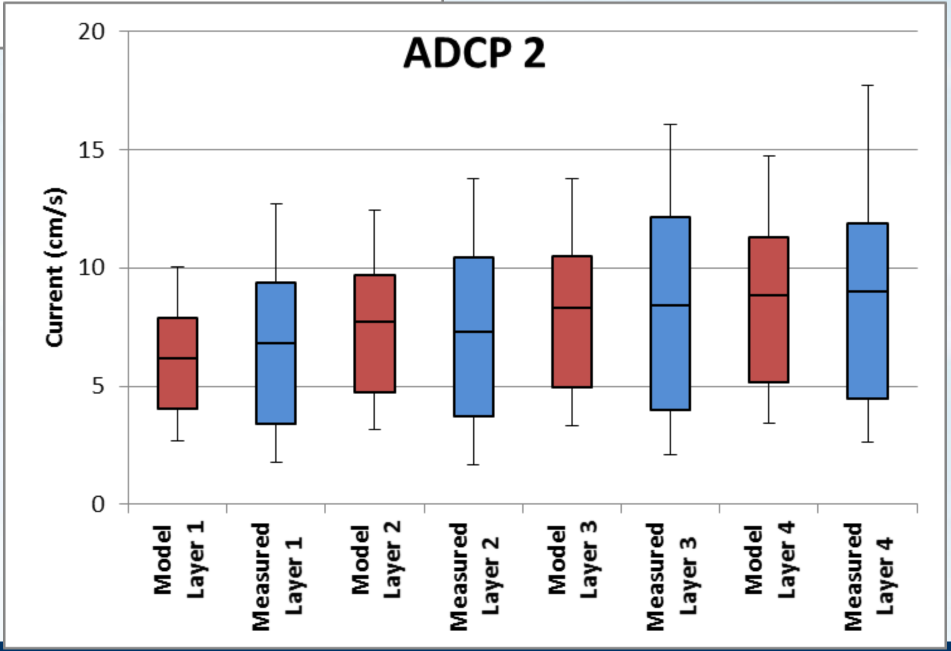
Brian R. Bicknell, AQUA TERRA Consultants, Mountain View, CA 94043
Jason T. Love, P.E., RESPEC, Rapid City, SD 57703

EFDC Hydrodynamic Calibration





Prior PCB Calibration Efforts

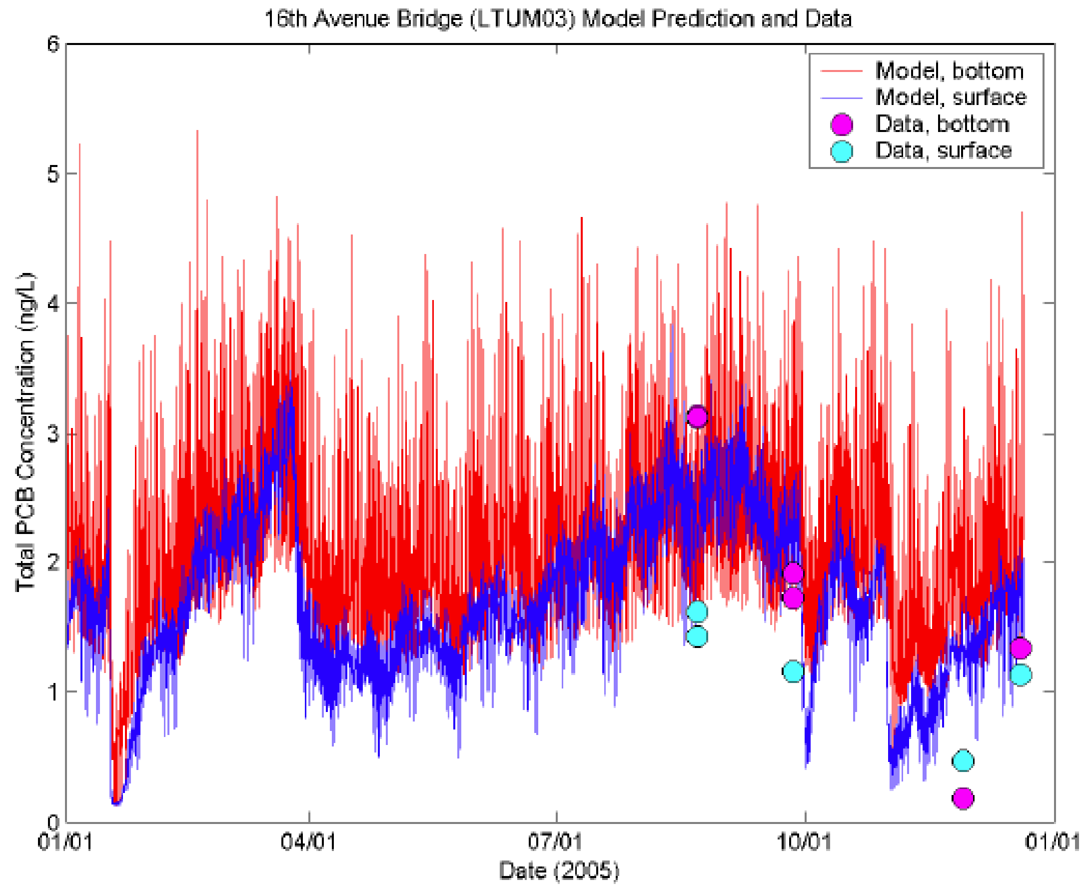
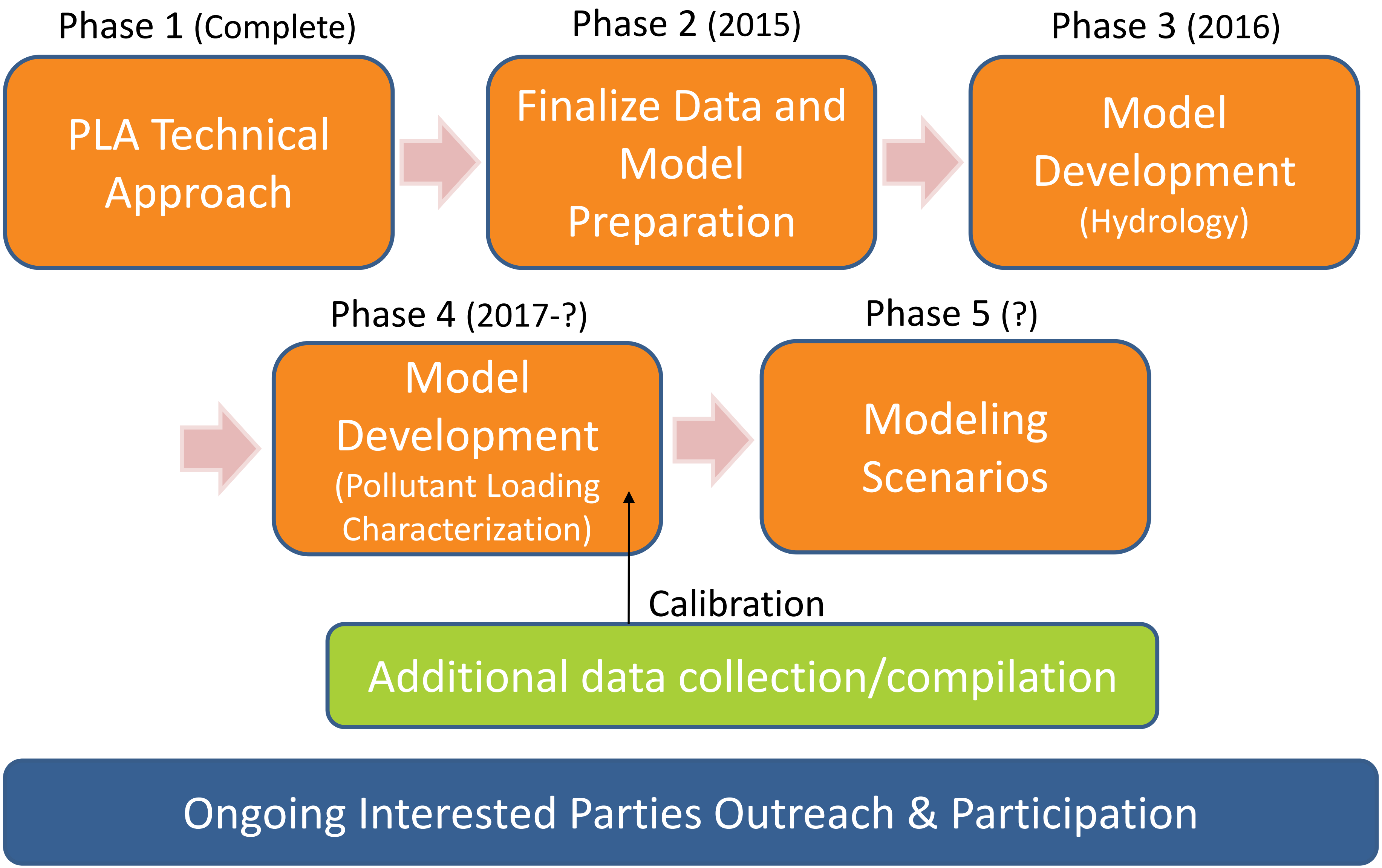


Figure 6. Model calibration for total PCBs at LTUM03 sampling location.

King Co., 2009

Questions and Discussion

PLA Development Timeline



Next steps

2015

- Recap TAC and Interested Parties input for steering committee; project scoping
- Complete draft of modeling QAPP
- TAC and Interested Parties review of draft modeling QAPP

2016+

- Develop hydrodynamic models
- Data assessment
- Develop and test initial water quality models

Next Meeting: end of 2015