Total Maximum Daily Loads for PCBs in the Trinity River

Segments 0829, 0806, 0841, & 0805

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Texas Commission on Environmental Quality

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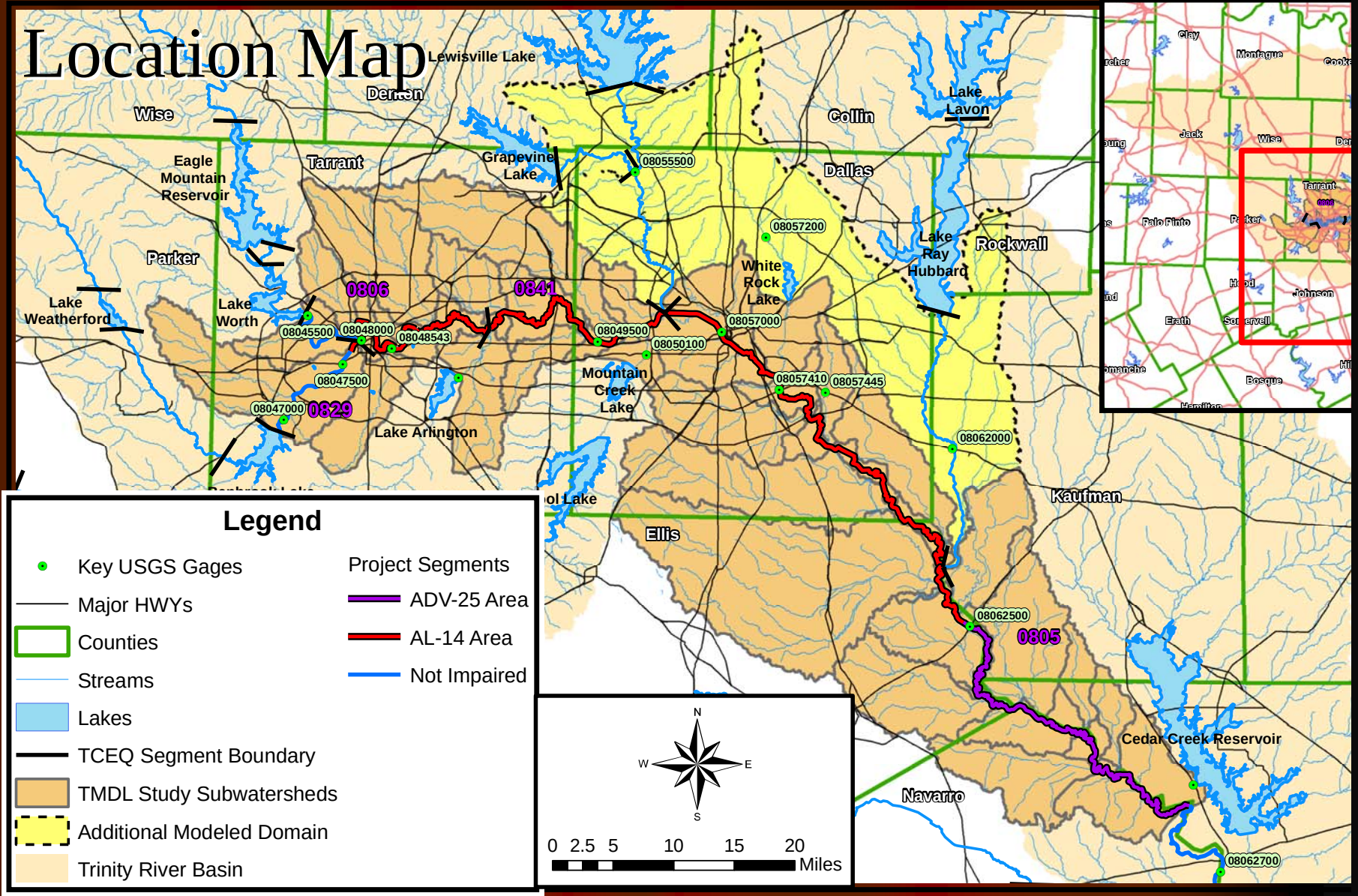
Problem Definition

- Texas Department of State Health Services (TDSHS) issued Aquatic Life Order 14 (AL-14) and Fish Consumption Advisory 25 (ADV-25) in 2002 due to "PCBs in fish tissue" for 150 miles of the Trinity River

- As a result the TCEQ placed four segments (nine Assessment Units (AUs)) of the Trinity River on the CWA 303 (d) list due to impairment of the "fish consumption" designated use

Location Map



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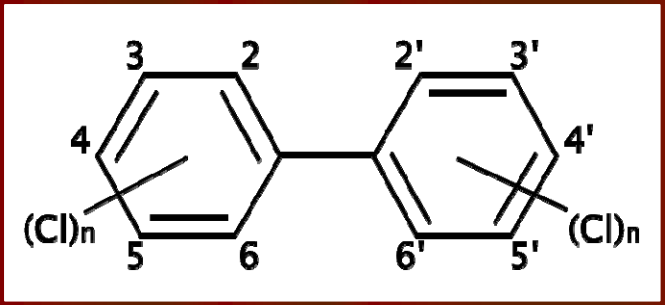
Polychlorinated Biphenyls (PCBs)

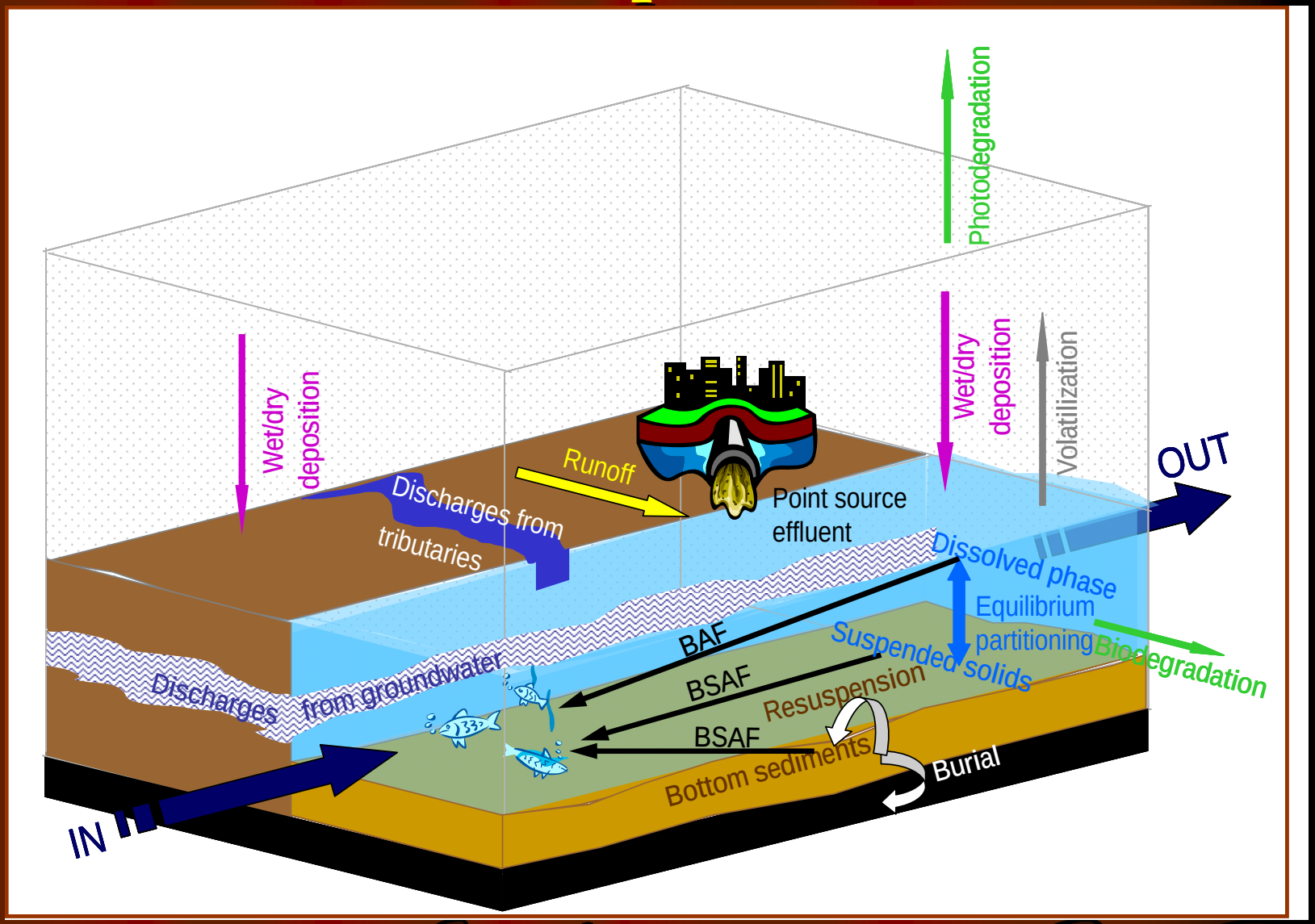


- A group of 209 compounds, known as PCB congeners
- From 1 to 10 chlorines on 2 connected benzene rings
- Properties and toxicity vary, but all poorly soluble in water
- Tend to be associated with sediments in aquatic systems
- Highly resistant to degradation
- Residence times in aquatic systems on the order of decades

Polychlorinated Biphenyls (PCBs)

- Sold in the USA under trade name Aroclor
- Used mainly as
  - Dielectric fluids in transformers
  - Heat transfer fluids
  - Heat-resistant hydraulic fluids
- Myriad other uses
- Production, distribution and new use banned in 1976 by Toxic Substances Control Act (TSCA)

PCB Conceptual Model



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PCB fate in water is largely controlled by their partitioning to sediments

- PCBs and water mix like oil and water
- Given the chance, PCBs dissolved in water will tend to “sorb” to suspended or bed sediment particles
- Organic particles can absorb a large amount of PCBs relative to most mineral particles.
- This is also why fish “bioaccumulate” PCBs to high levels
- Among minerals, clays can take up more PCB than silt or sand due to greater surface area.
- PCB uptake by sediments is controlled largely by their organic content.
- Given enough time, an equilibrium distribution of PCB concentrations between dissolved and sediment phases occurs

Data Collection

March – August 2008

In-stream PCB concentration measurements

- 18 measurements at 13 main stem sites

- Sediment PCB concentration measurements
  - 77 measurements at 32 main stem and 43 tributary sites
- PCB loads from wastewater discharges
  - 8 measurements at 4 facilities
- PCB loads from storm water
  - 9 measurements at 5 sites
- Individual PCB congeners measured by EPA Method 1668A

  - results reflect Sum PCBs as the sum of “detected” congeners

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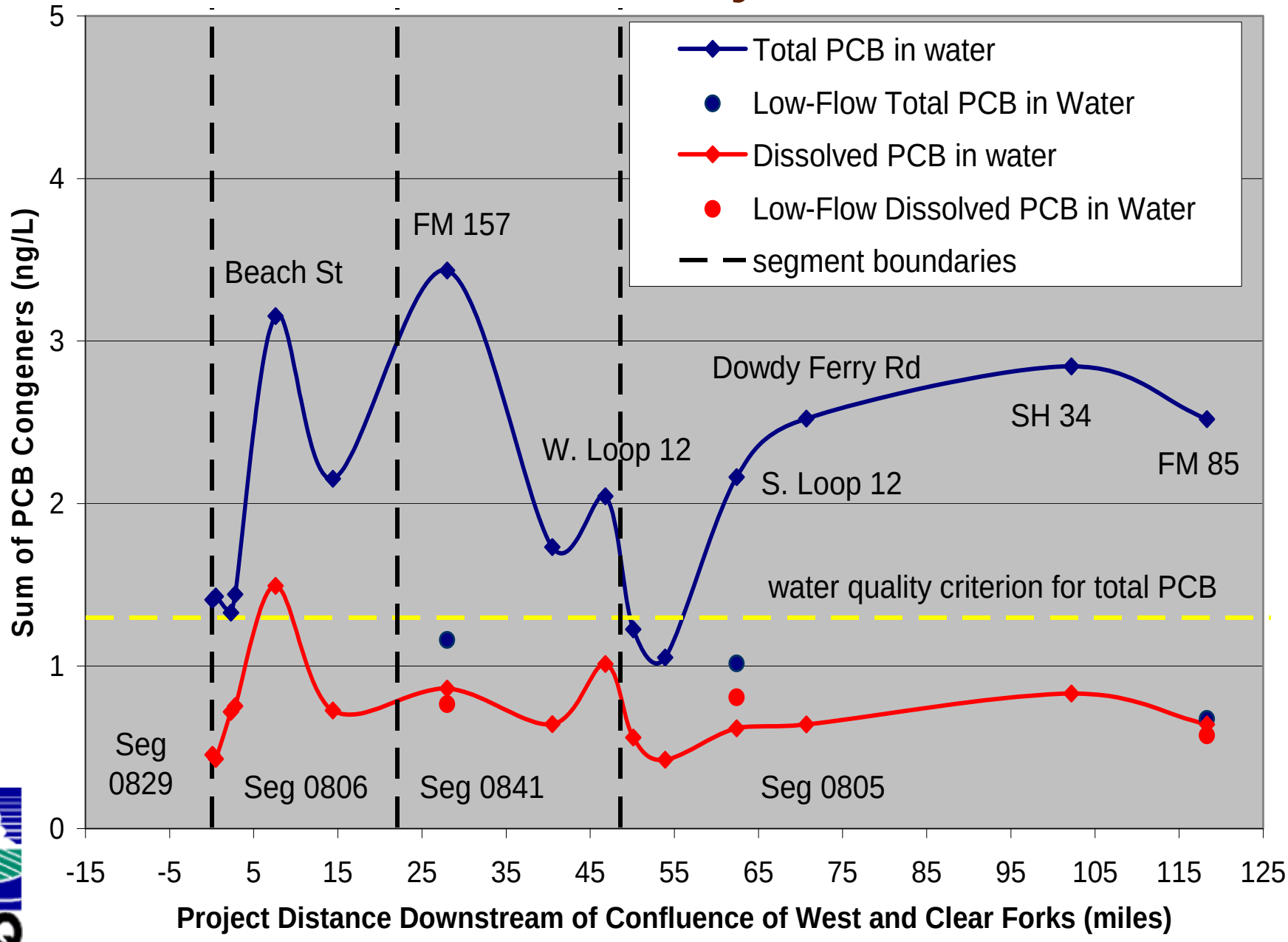
PCB Levels in Trinity River Water



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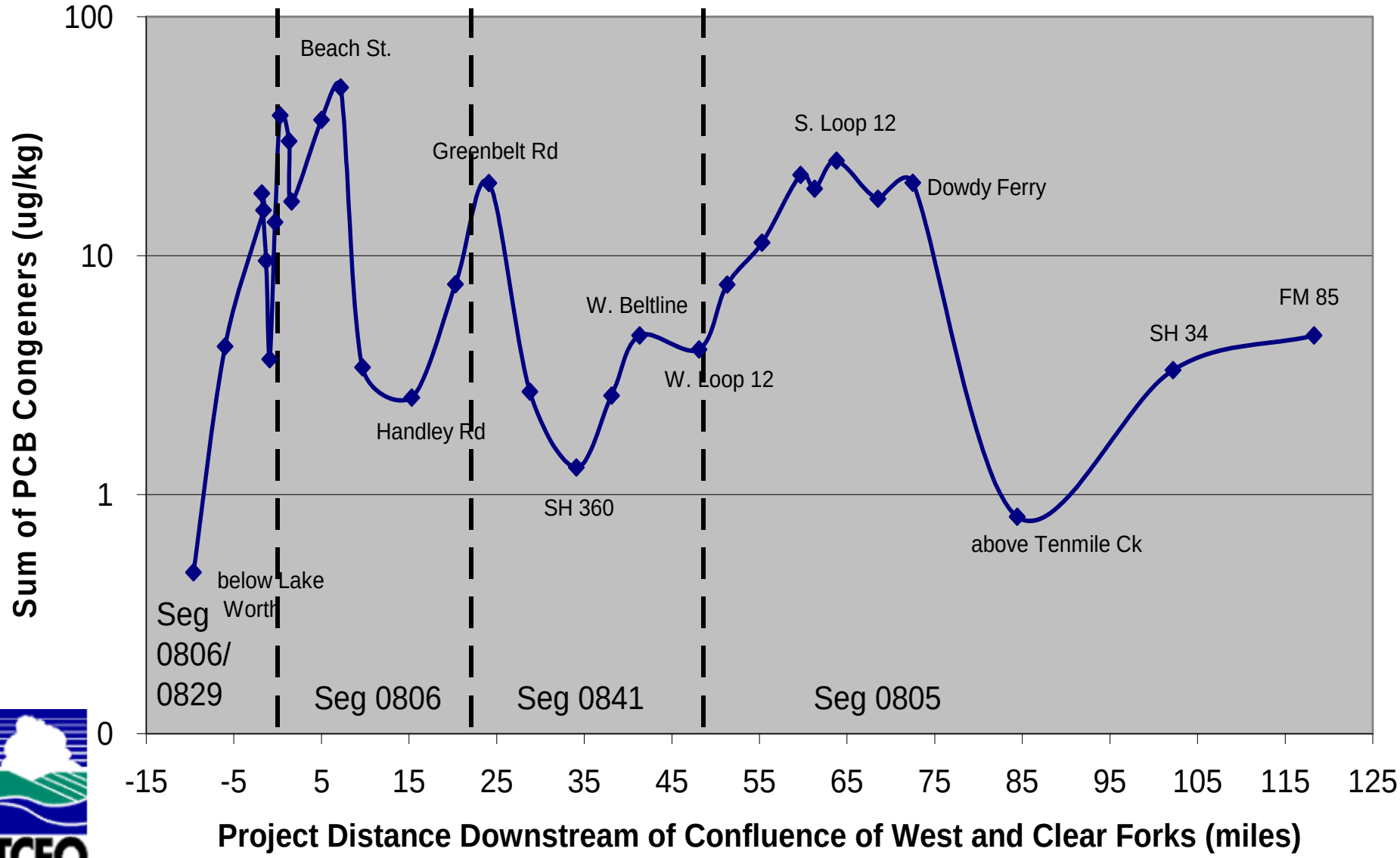
PCB Levels in Trinity River Bed Sediments



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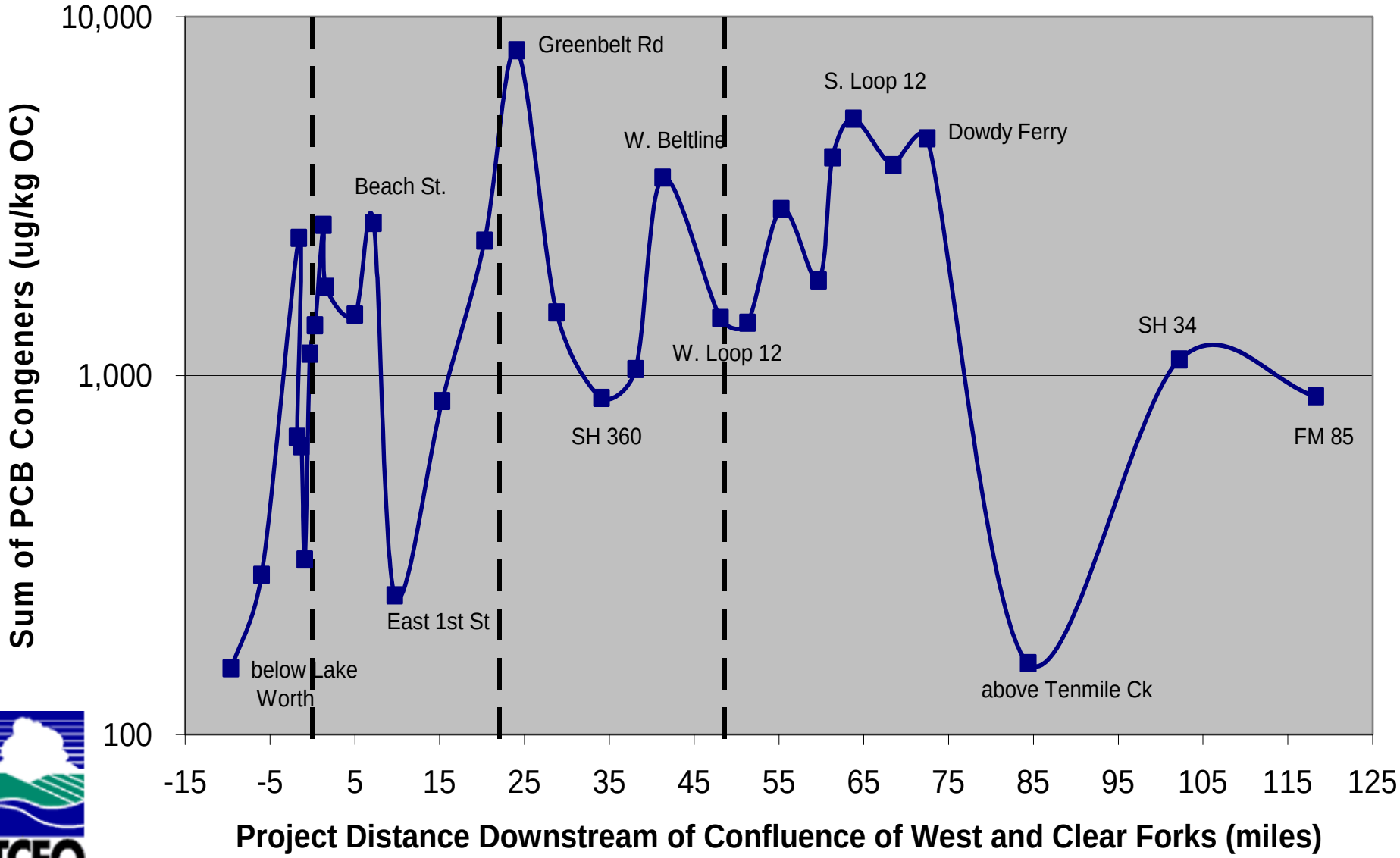
Organic Carbon Normalized PCB Levels in Trinity River Bed Sediments



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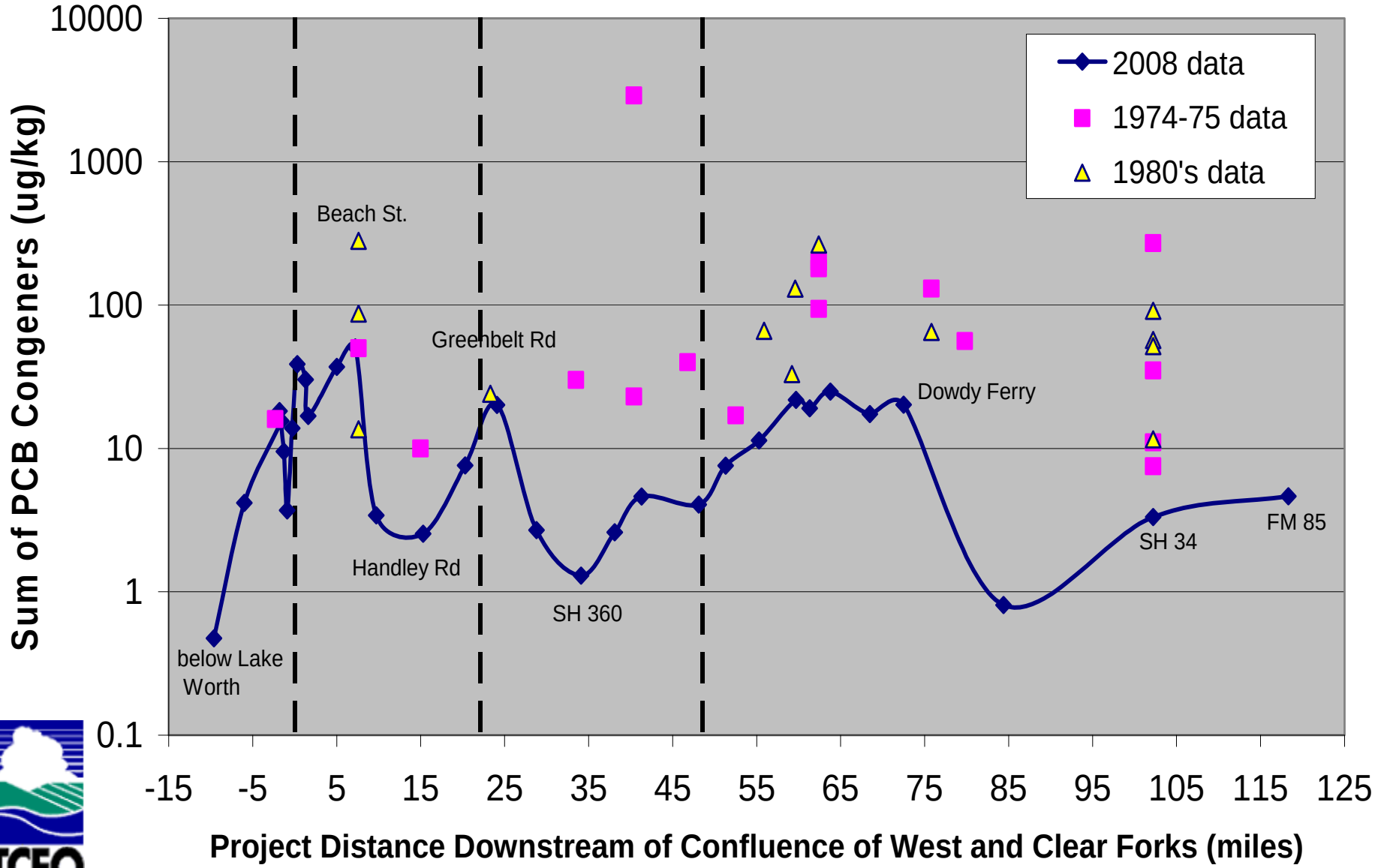
Historical Bed Sediment PCB Levels



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Endpoint Identification

- Current Water Quality Criterion for Protection of Human Health (Fish Consumption): 1.3 ng/L PCB in water †
- Ultimate TMDL Water Quality Target: 47 ng/g PCB in fish tissue
- TMDL WQ Target in Water= Tissue Conc. / BAF‡
- BAF calculated based on TDSHS-collected fish PCB measurements, from site-paired fish and dissolved PCB concentration measurements from summer 2008

† Proposed 2010 revisions to Texas Surface Water Quality Standards include a criterion of 19.96 ng/g PCB in fish tissue, which can be translated to a criterion of 0.64 ng/L PCB in water

‡ bioaccumulation factor

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Endpoint Identification

- Baseline BAFs calculated according to USEPA guidance

$$\text{Baseline BAF} = \frac{C_{tissue} / F_{lipid}}{C_{water,diss}} - \frac{1}{F_{lipid}}$$

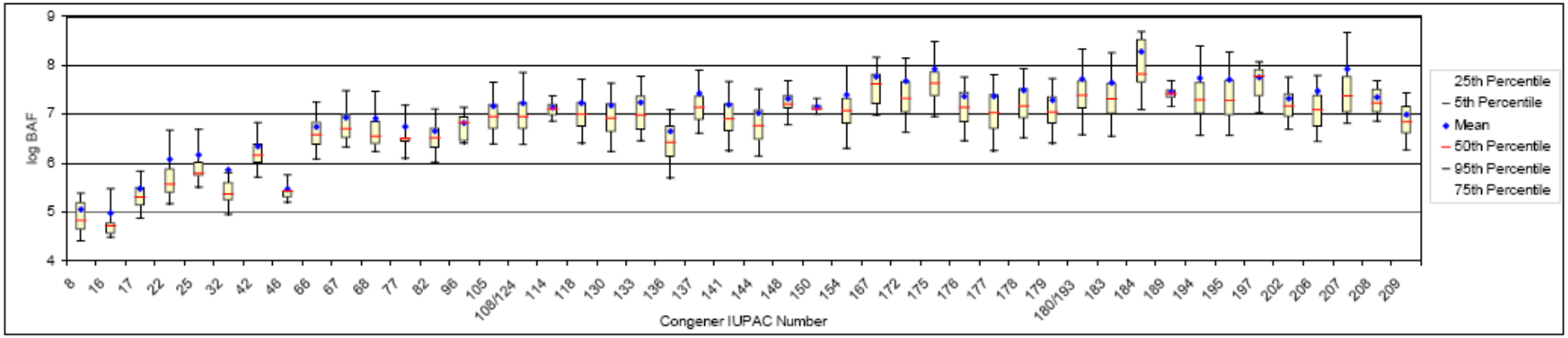

Figure 2.14 Baseline Bioaccumulation Factors for Individual PCB Congeners to Trinity River Fish

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Endpoint Identification

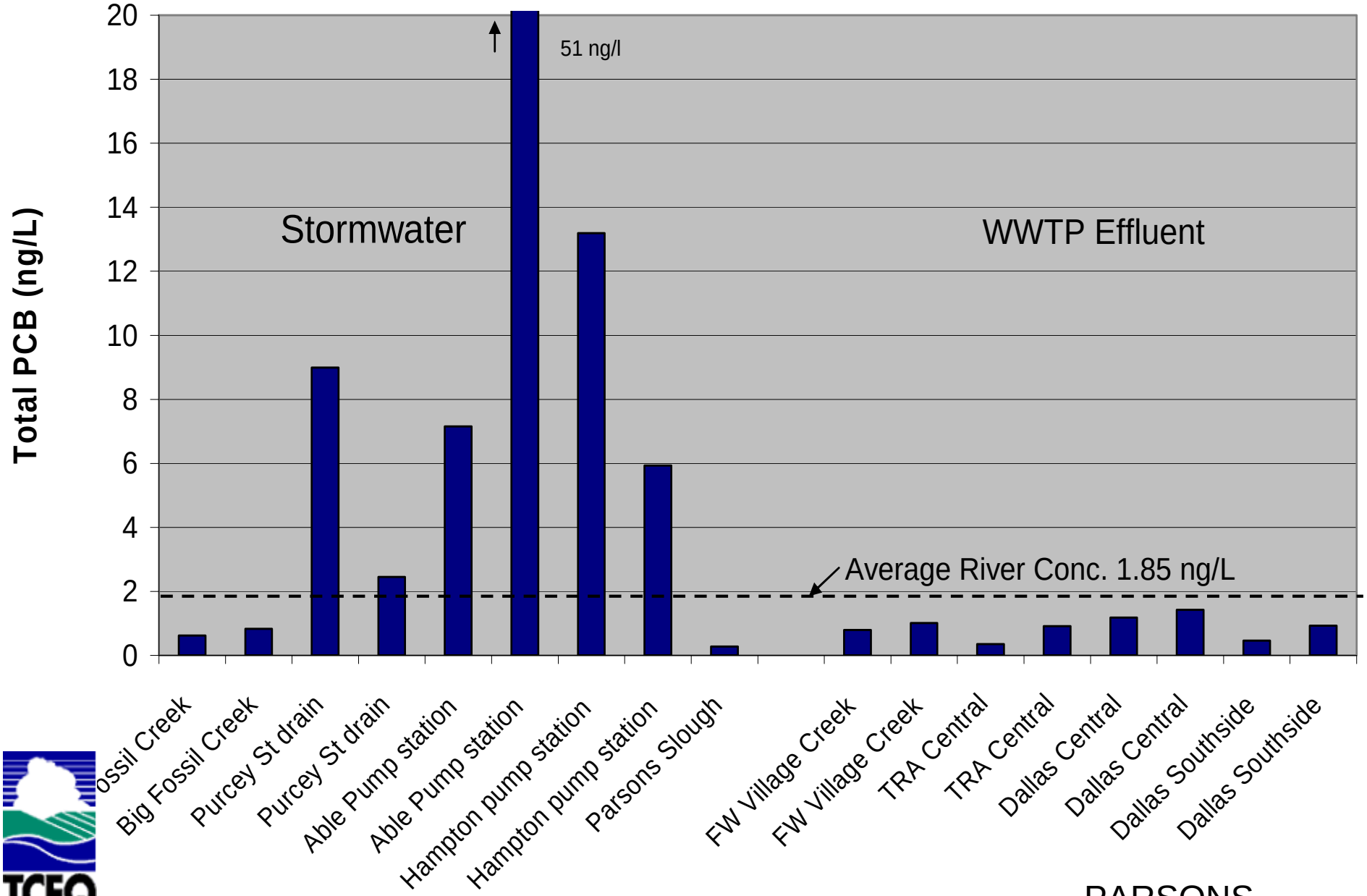
- Average Baseline BAF for PCBs: 6.28×10^6 L/kg
- To be consistent with Texas Surface Water Quality Standards, the baseline BAF was converted to a BAF for total PCB using the average dissolved fraction of PCB in water (44%) and a fish lipid content of 3%
- Total PCB BAF = 8.3×10^4 L/kg
- TMDL Water Quality Target in Water =

$$\frac{47\,\text{ng PCB/g fish}}{8.3 \times 10^4\,\text{L/kg fish}} \times \frac{1000\,\text{g}}{1\,\text{kg}} = 0.57\,\text{ng/L PCB}$$

Pollutant Source Assessment

- Inflows from Upstream Segments
- TPDES Permitted Point Sources
  - Individually Permitted Sources (e.g., municipal WWTFs, industrial storm water, treated groundwater)
  - TPDES Regulated Storm Water
    - Municipal Separate Storm Sewerage Systems (MS4s)
    - TPDES general permits (e.g., construction, multi-sector)
- Non-Regulated Sources
  - Nonpoint Source Runoff
  - Dry and Wet Air Deposition
  - Fluxes from Contaminated Sediments

PCB Sources: Stormwater and WWTP Effluent



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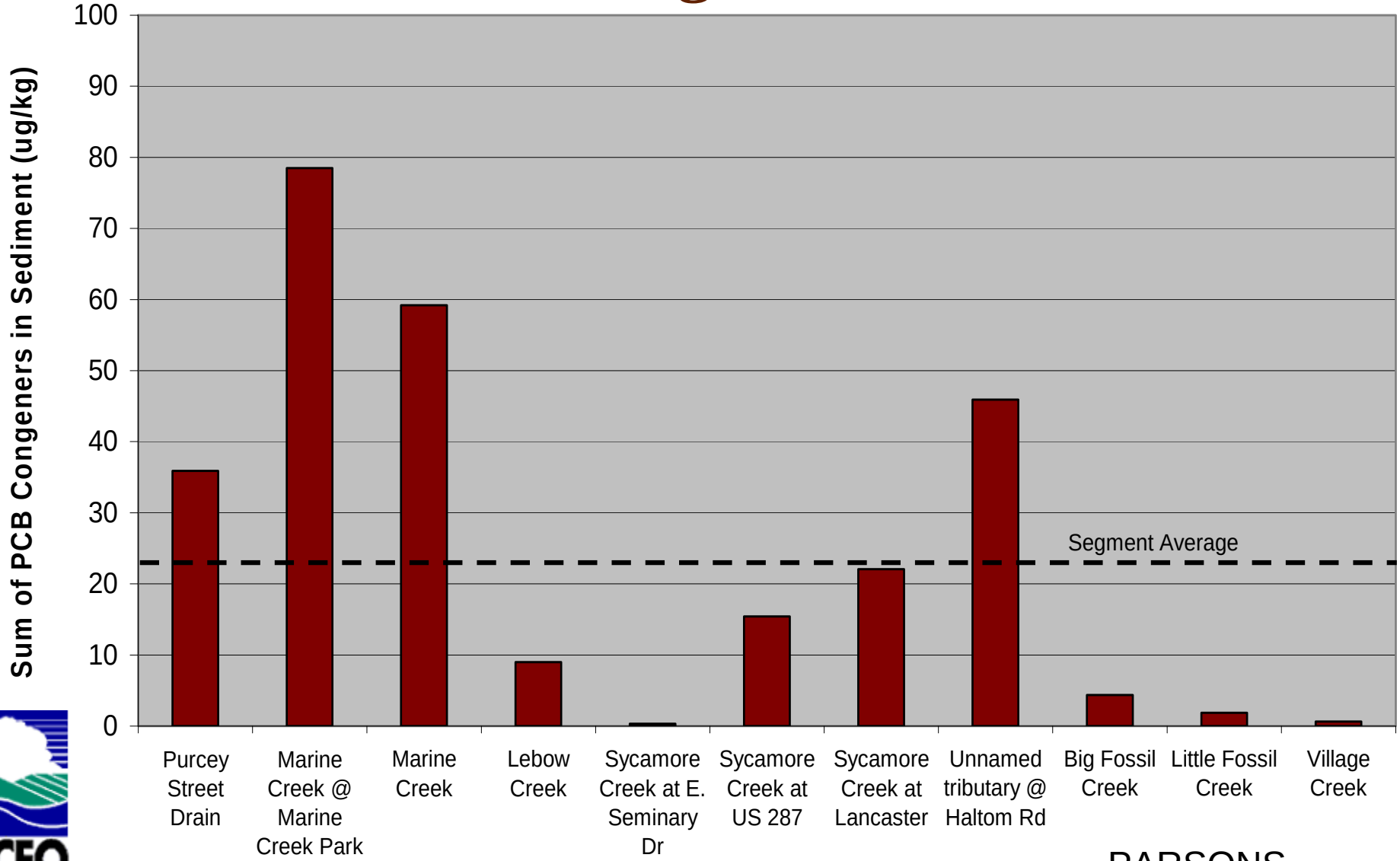
PCB Levels in Bed Sediments of Tributaries to Segment 0806/0829



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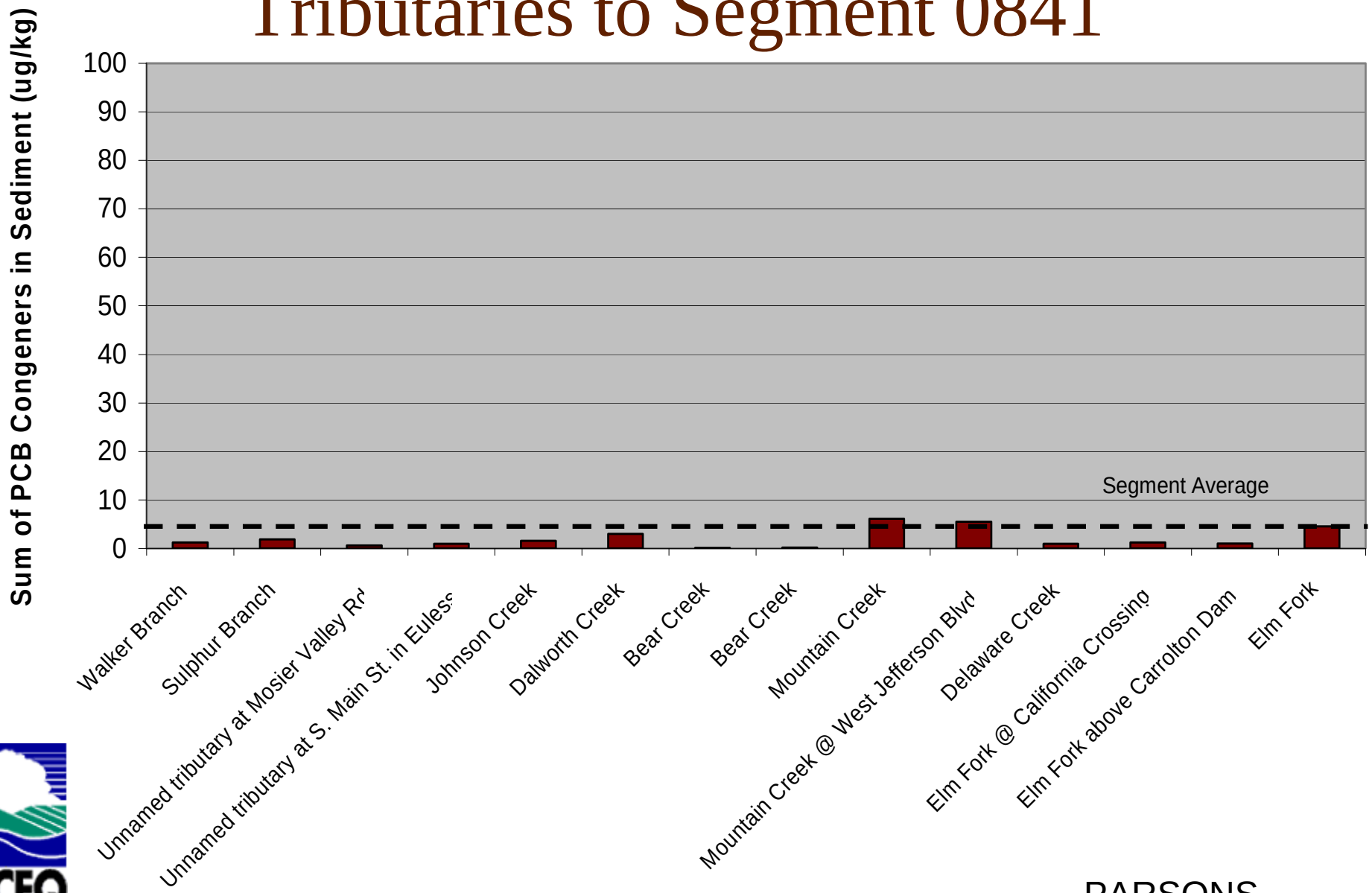
PCB Levels in Bed Sediments of Tributaries to Segment 0841



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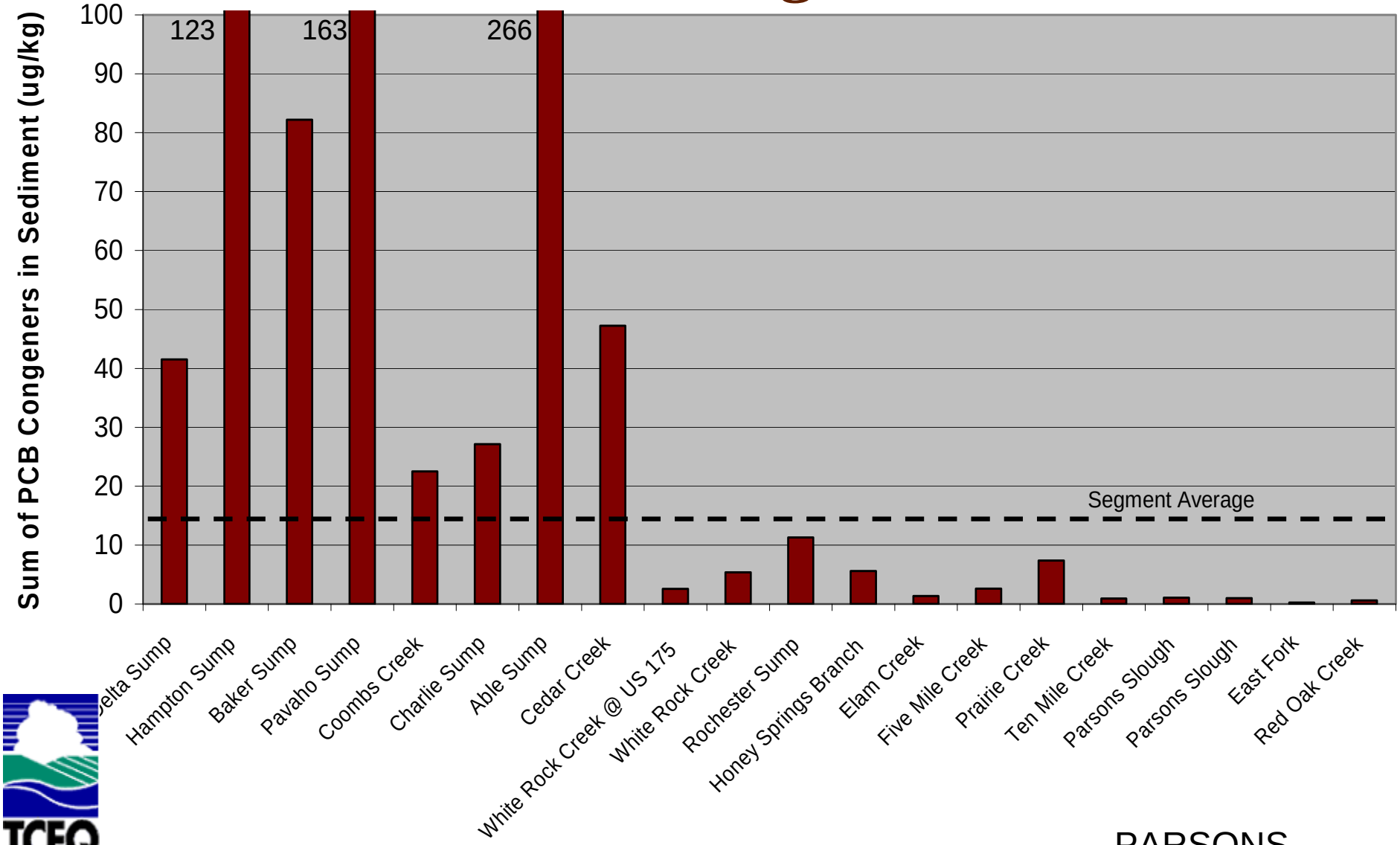
PCB Levels in Bed Sediments of Tributaries to Segment 0805



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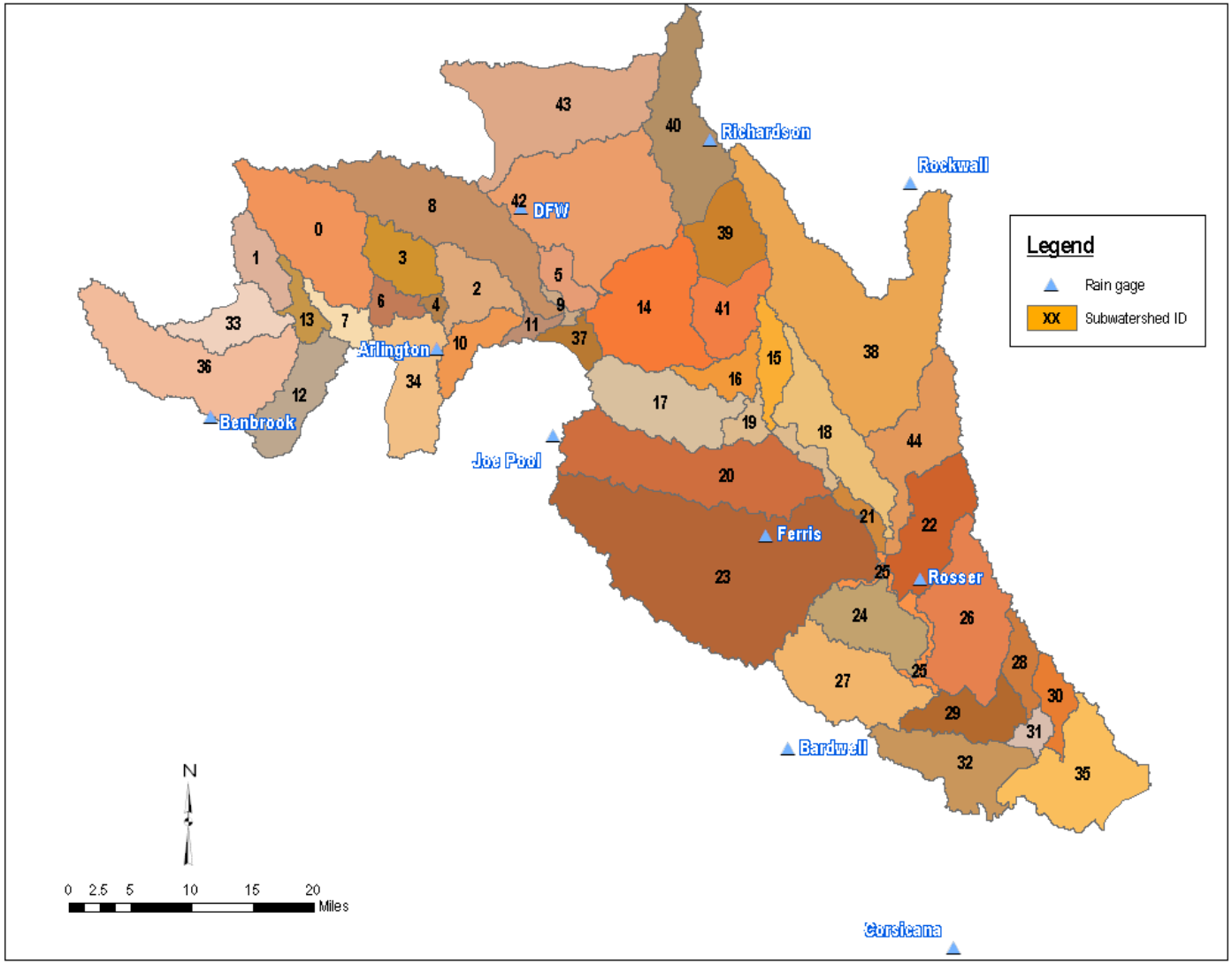
Watershed Runoff

- Monthly average flows and suspended solids loads predicted based on Generalized Watershed Loading Function
- Computes runoff volume based on the NRCS Curve Number equation
- Computes sediment yield based on the Universal Soil Loss Equation and sediment delivery ratios
- Flow output calibrated at five gaged tributaries based on evapotranspiration cover coefficient
- Sediment yield also calibrated at another five tributaries based on ground cover factors

45 Sub-Watersheds Simulated



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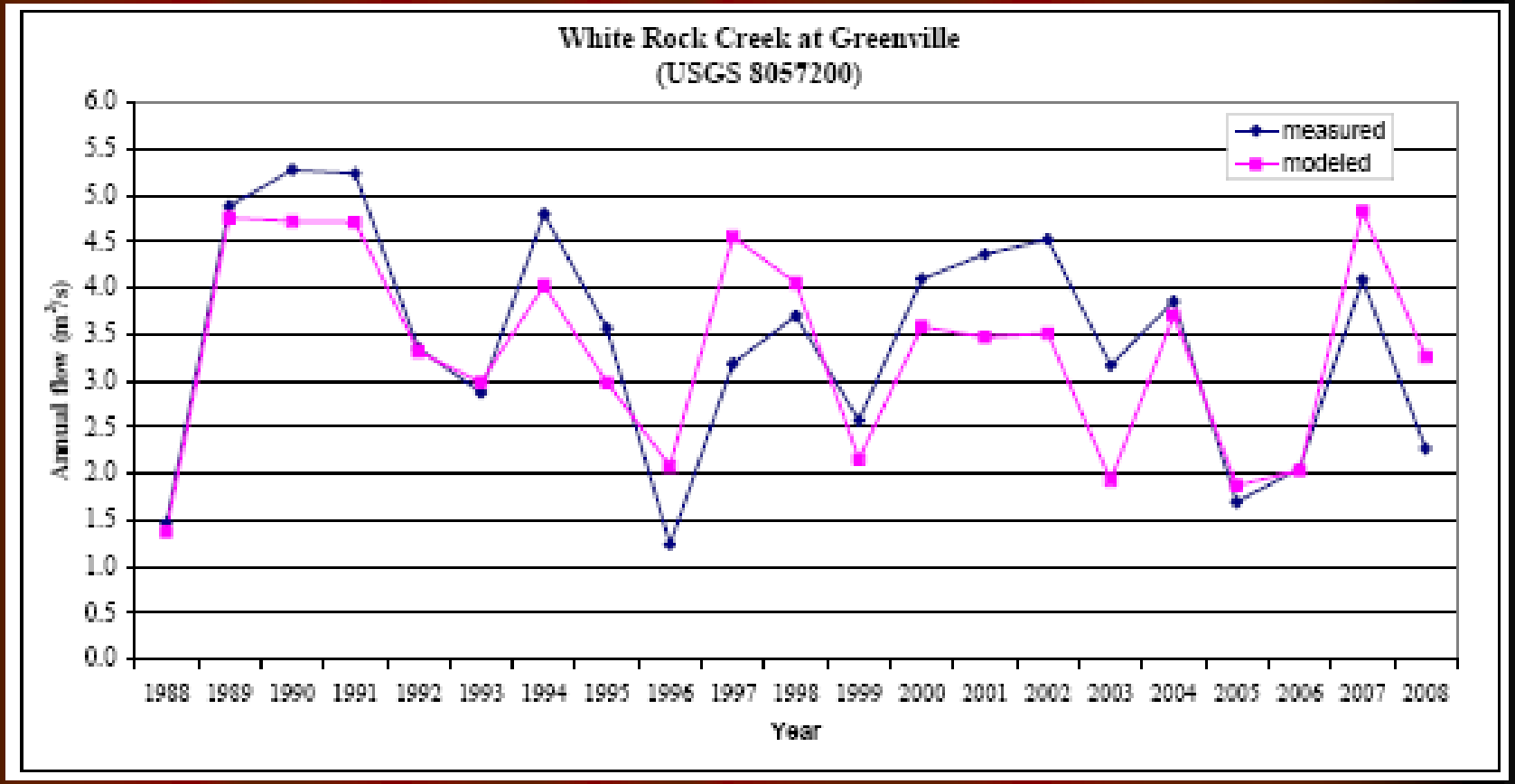
Example GWLF Flow Calibration



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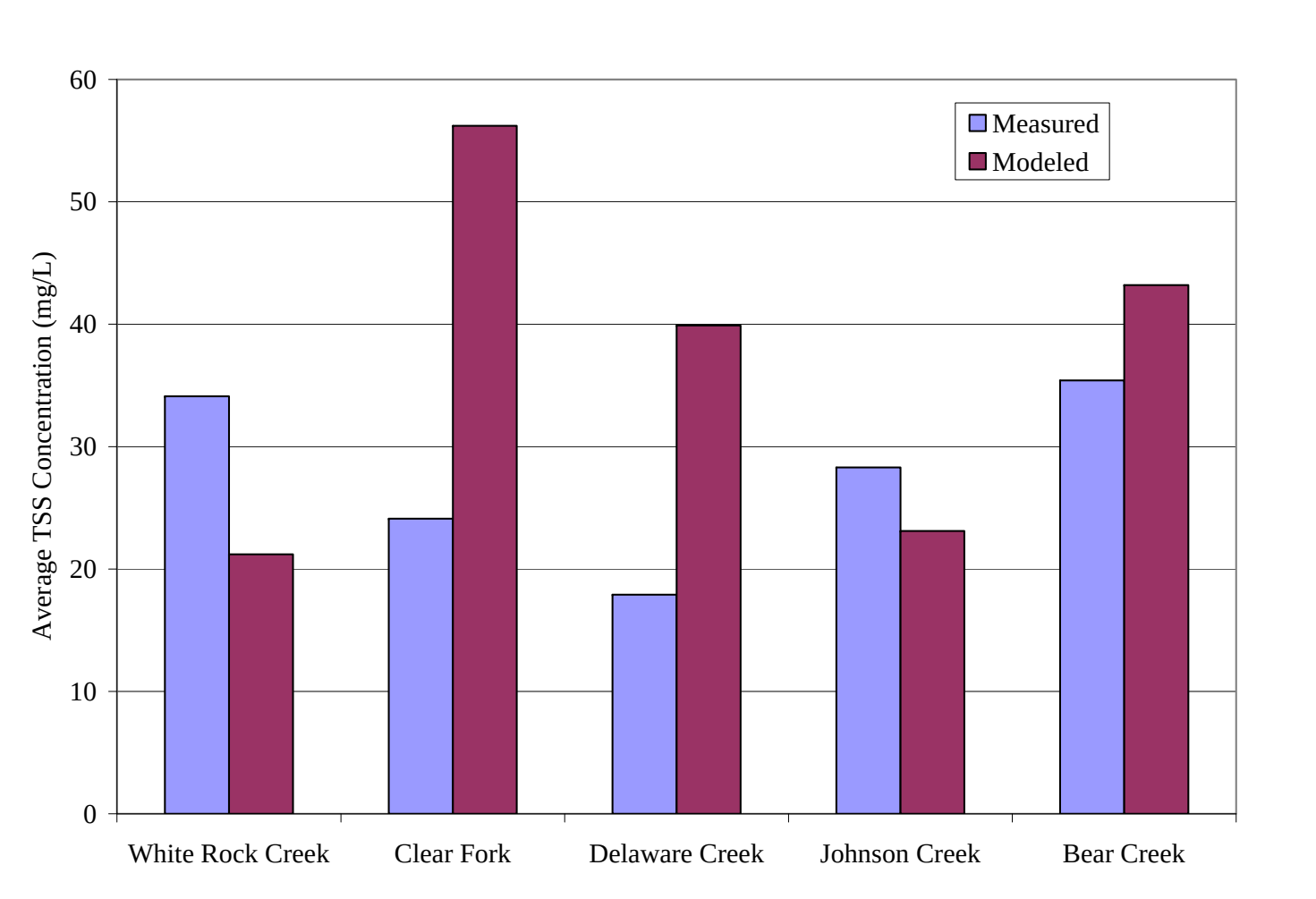
Runoff Solids Calibration



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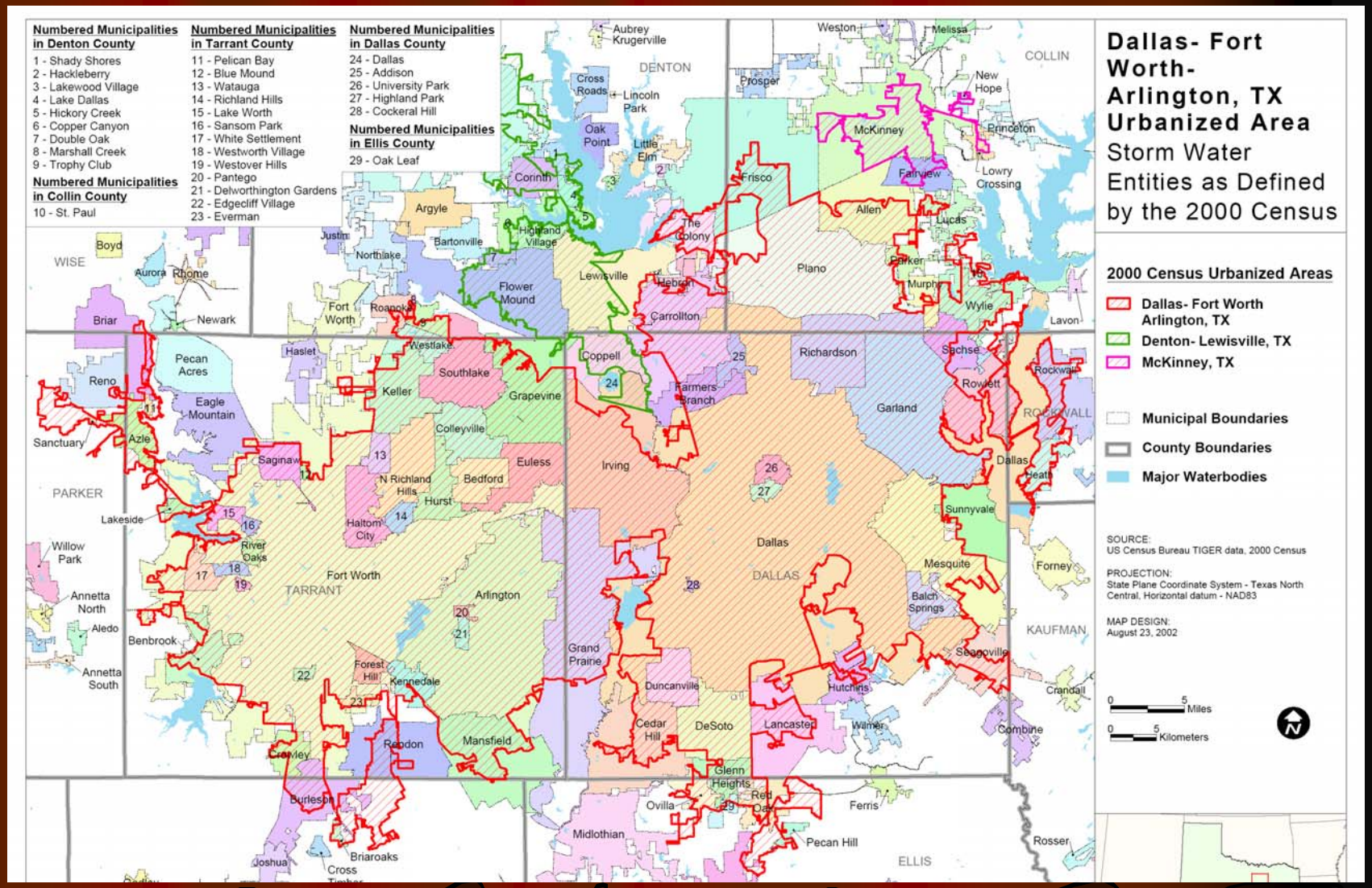
Existing Loads from Individually-Permitted TPDES Facilities

- See handout
- PCB loads calculated as average self-reported flow (2004 – 2008) multiplied by average measured total PCB concentration in effluent
- For facilities where we did not measure PCB concentrations, used average concentrations from four facilities with sampled discharge
- For facilities without self-reported flow, assumed half of the permitted flow

Municipal Separate Storm Sewer Systems



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Runoff Loads to TMDL Assessment Units

- Calculated from GWLF output (flows and solids) together with measured PCB levels in tributary sediment

Assessment Unit	Average Flow [a] (cms)	Total PCB Load (mg/day)	% of Watershed Addressed Under MS4 Permits	PCB Load in TPDES-Permitted Runoff (mg/day)[b]	PCB Load in NPS Runoff (mg/day)[c]
0829_01	2.7	296	52%	154	142
0806_01	7.7	853	81%	691	162
0841_02	4.5	113	100%	113	0
0841_01	5.8	217	95%	206	11
0805_04	4.0	1673	100%	1673	0
0805_03	2.4	162	100%	162	0
0805_06	4.2	116	72%	84	32
0805_02	11.7	110	18%	20	90
0805_01	4.8	78	0%	0	78
Overall	47.8	3,618		3,103	515

[a] *Runoff flows from the GWLF*

[b] *Total PCB load times the percent of watershed covered by MS4 permits*

[c] *Total PCB load minus MS4-permitted PCB load*

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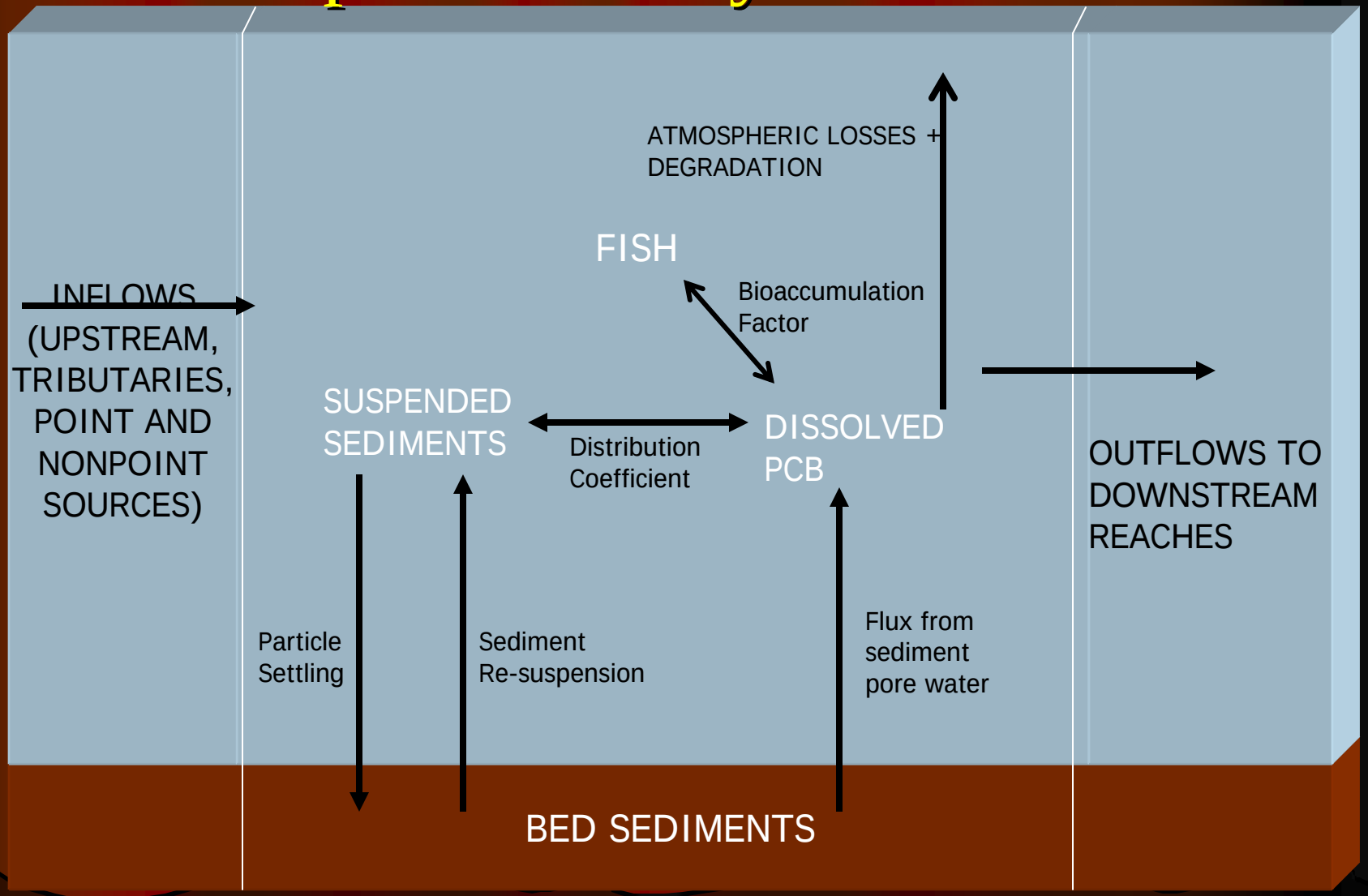
Instream Mass Balance Model Written to Capture the Key Processes



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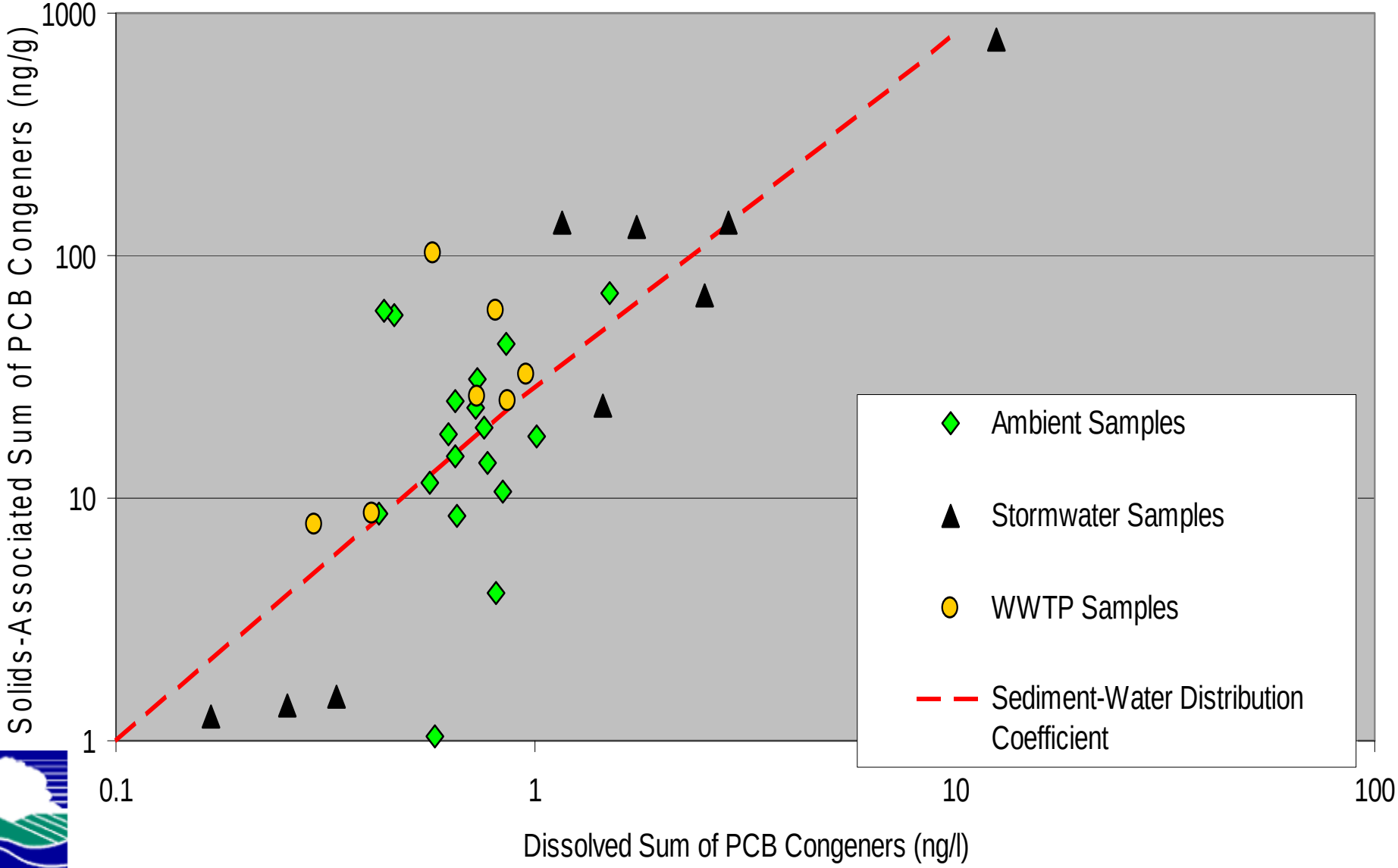
Suspended Sediment : Dissolved Phase Partitioning of PCBs in Trinity River Water



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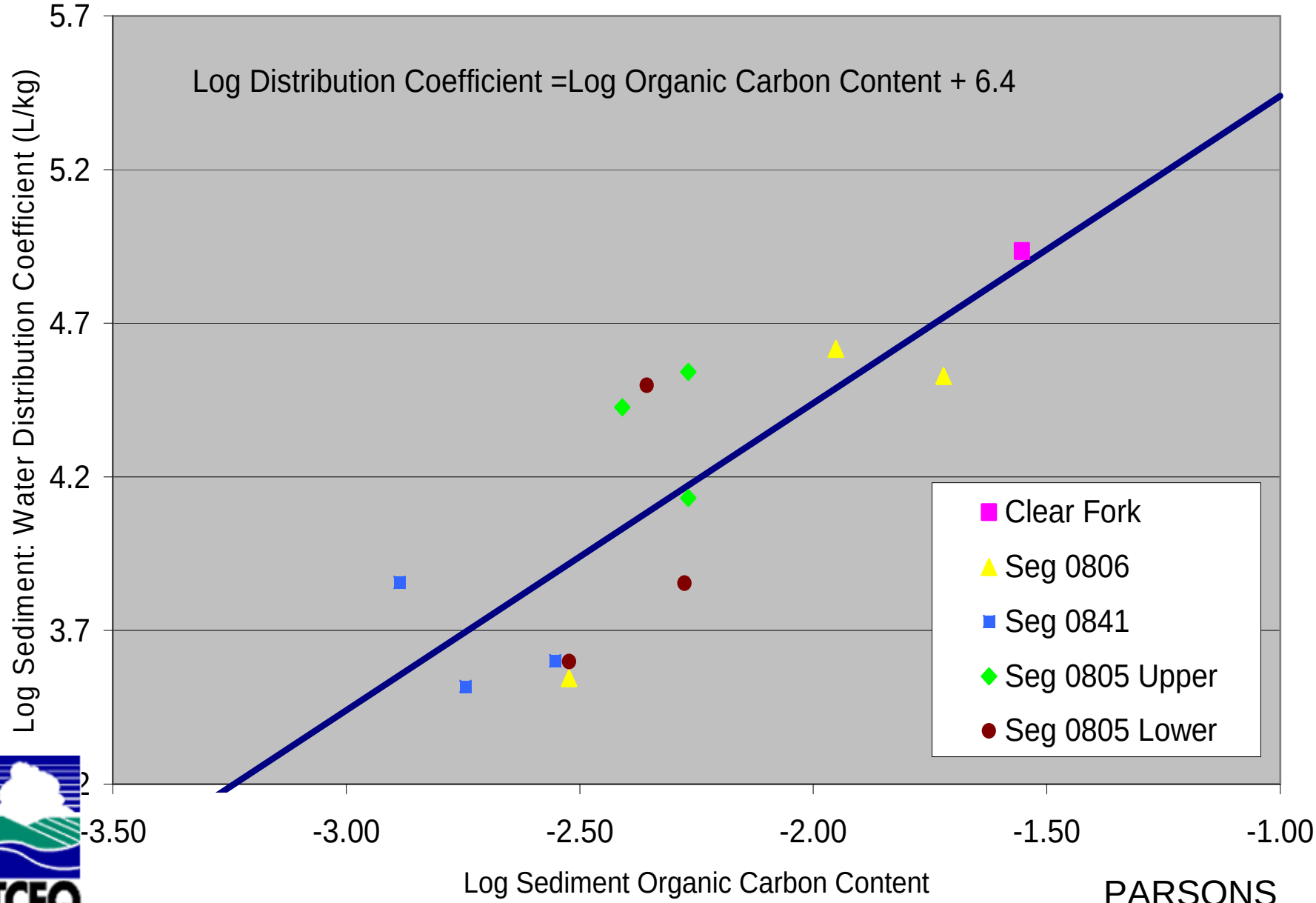
Bed Sediment-Dissolved Phase Partitioning



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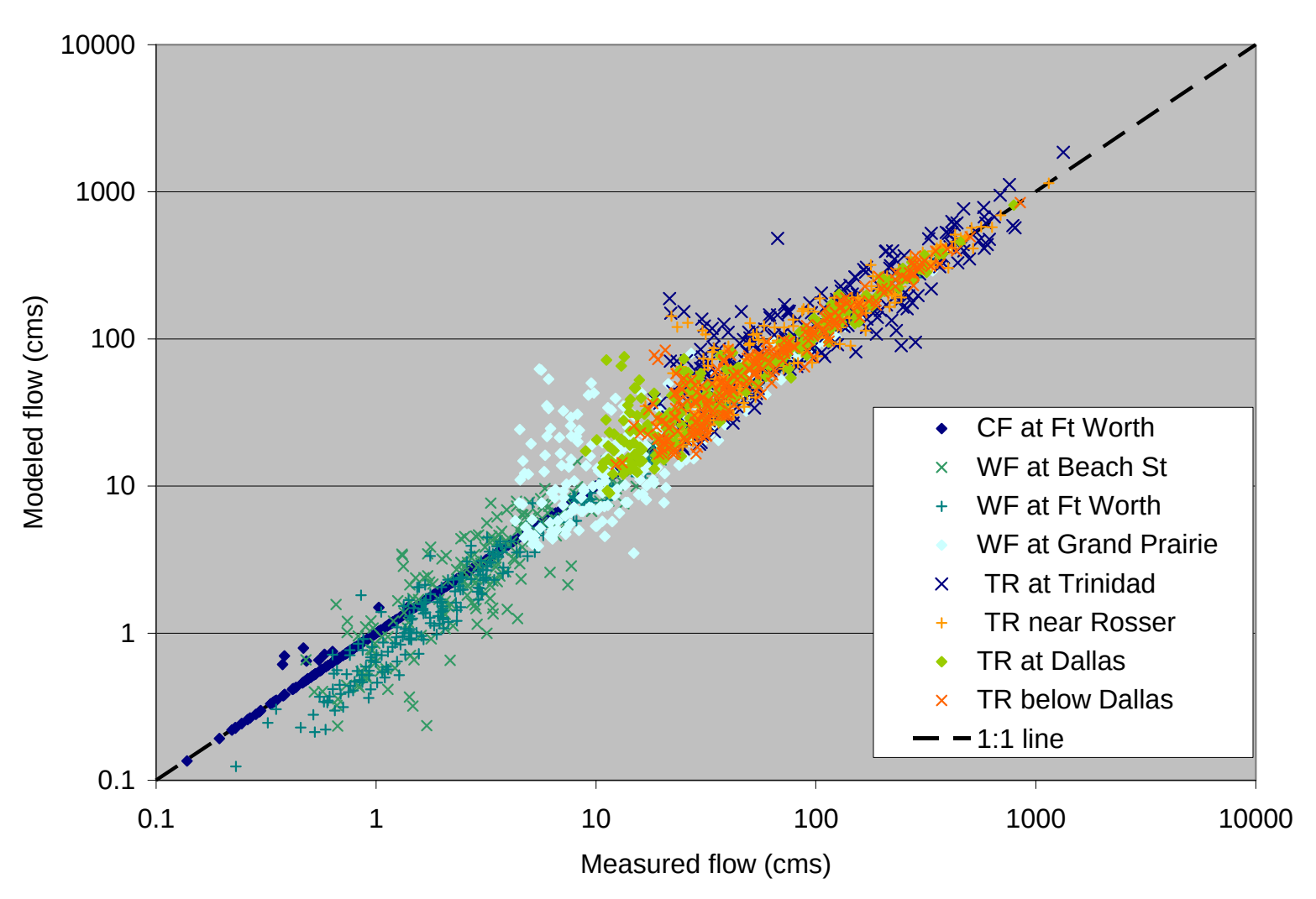
Flow Simulation 1988 - 2008



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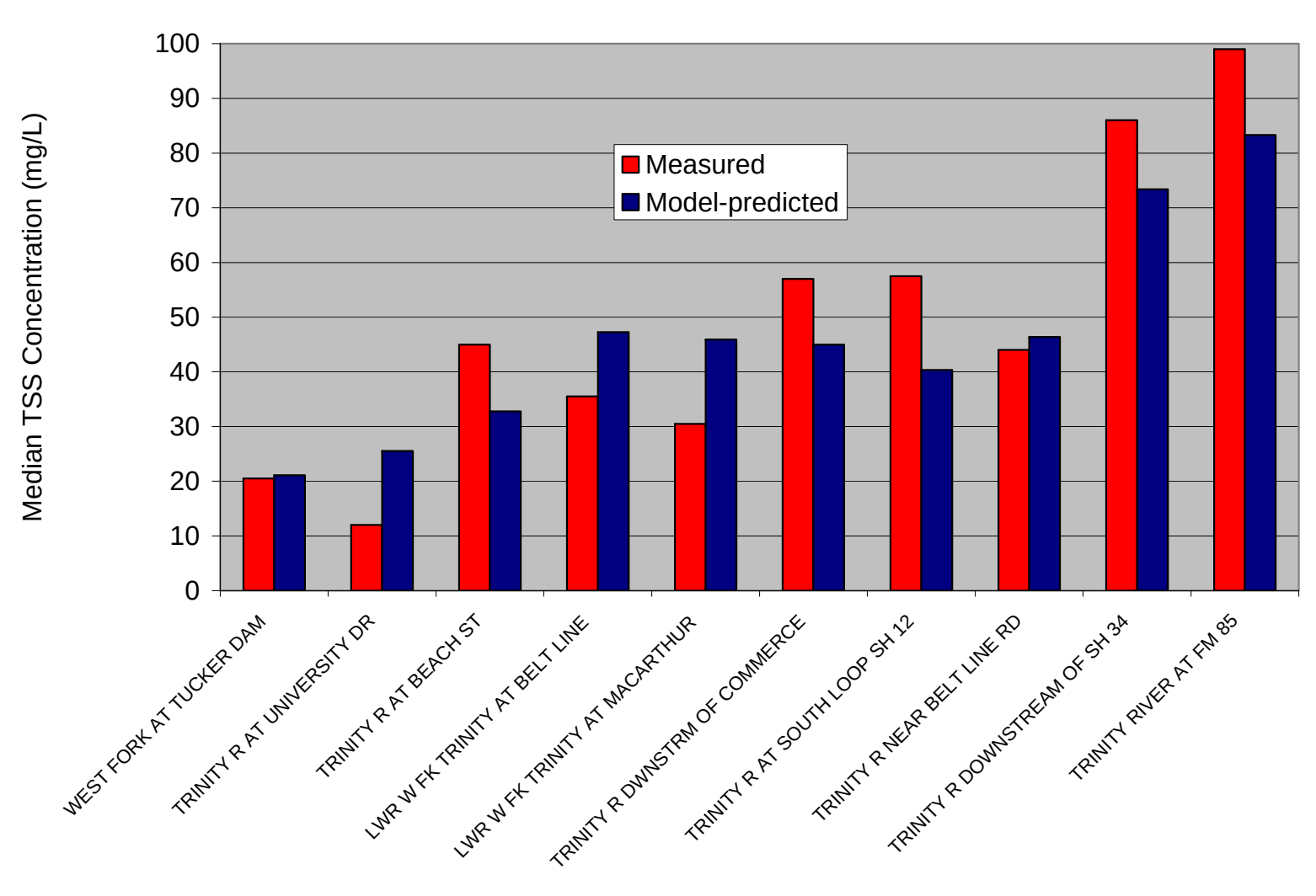
TSS Simulation



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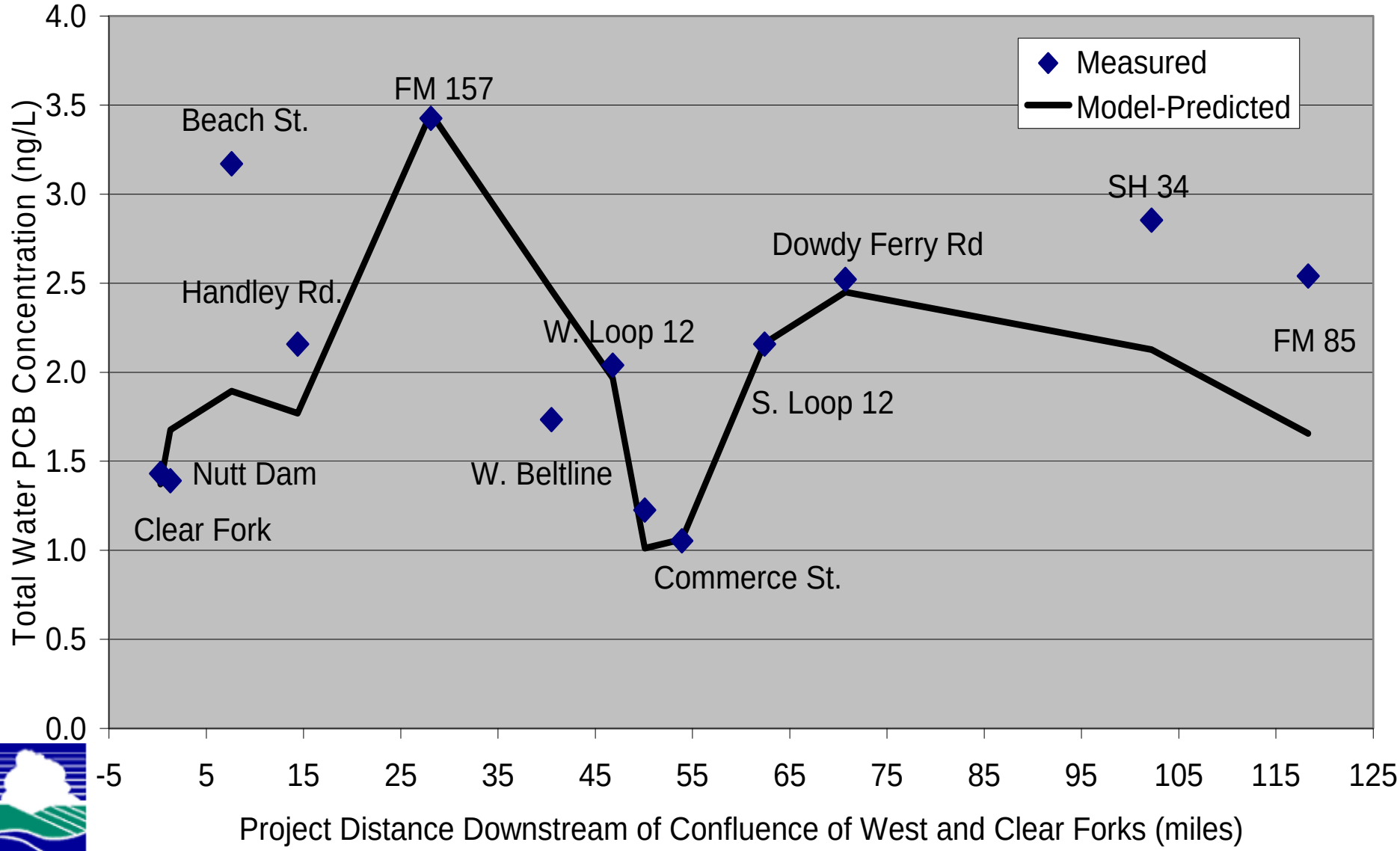
Total PCB Simulation – Spring 2008



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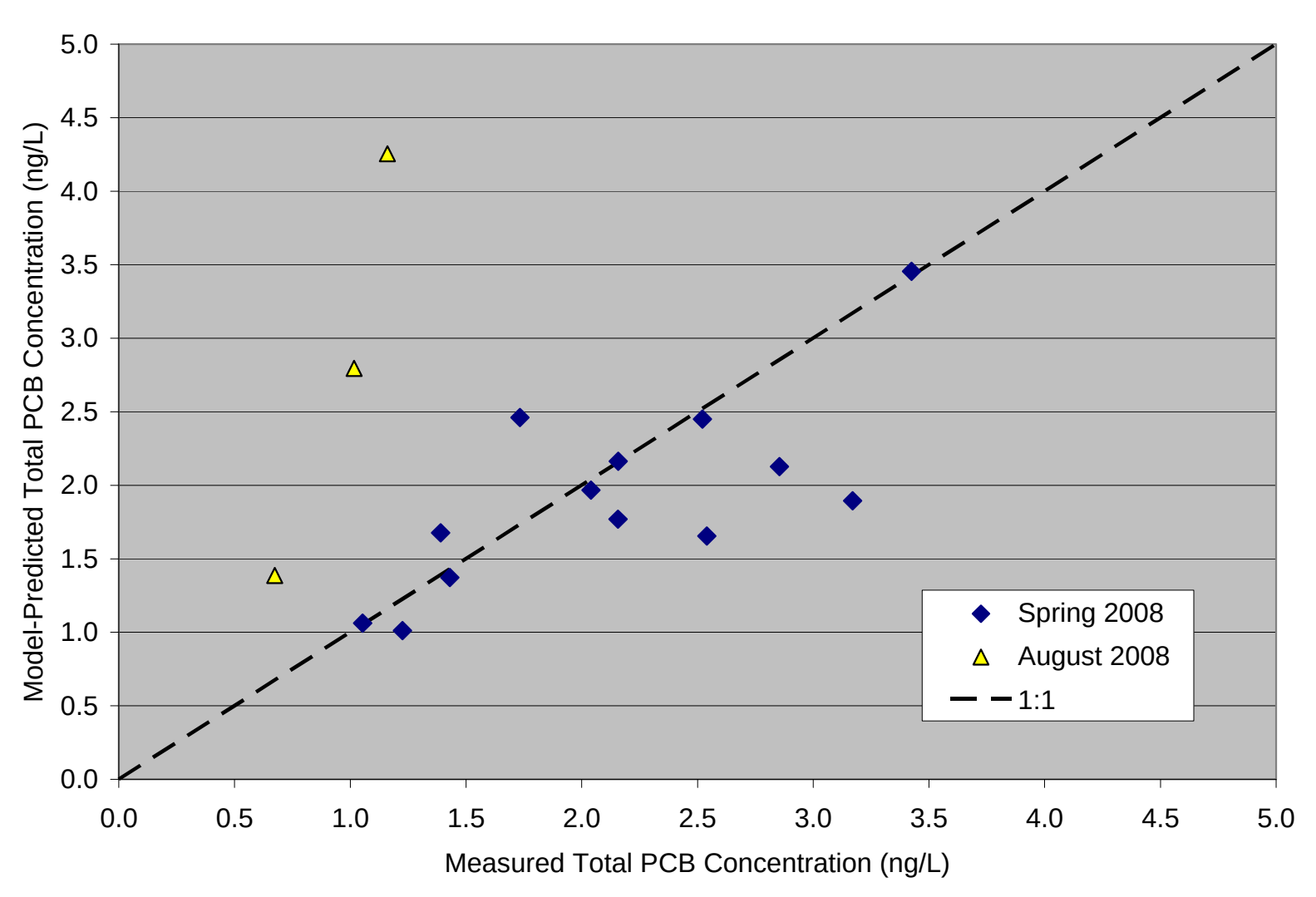
Model does not perform as well under very low flow conditions of August 2008



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Summary of Existing Average Conditions Predicted by Model

Assessment Unit	Predicted Average Total PCB Concentration (ng/L)
0829_01	1.8
0806_01	1.5 – 2.5 (3 sites)
0841_02	4.6
0841_01	2.1 – 3.4 (2 sites)
0805_04	1.6 – 1.8 (2 sites)
0805_03	2.4
0805_06	3.2
0805_02	2.2
0805_01	1.8

TMDL Water Quality Target = 0.57 ng/L Total PCB

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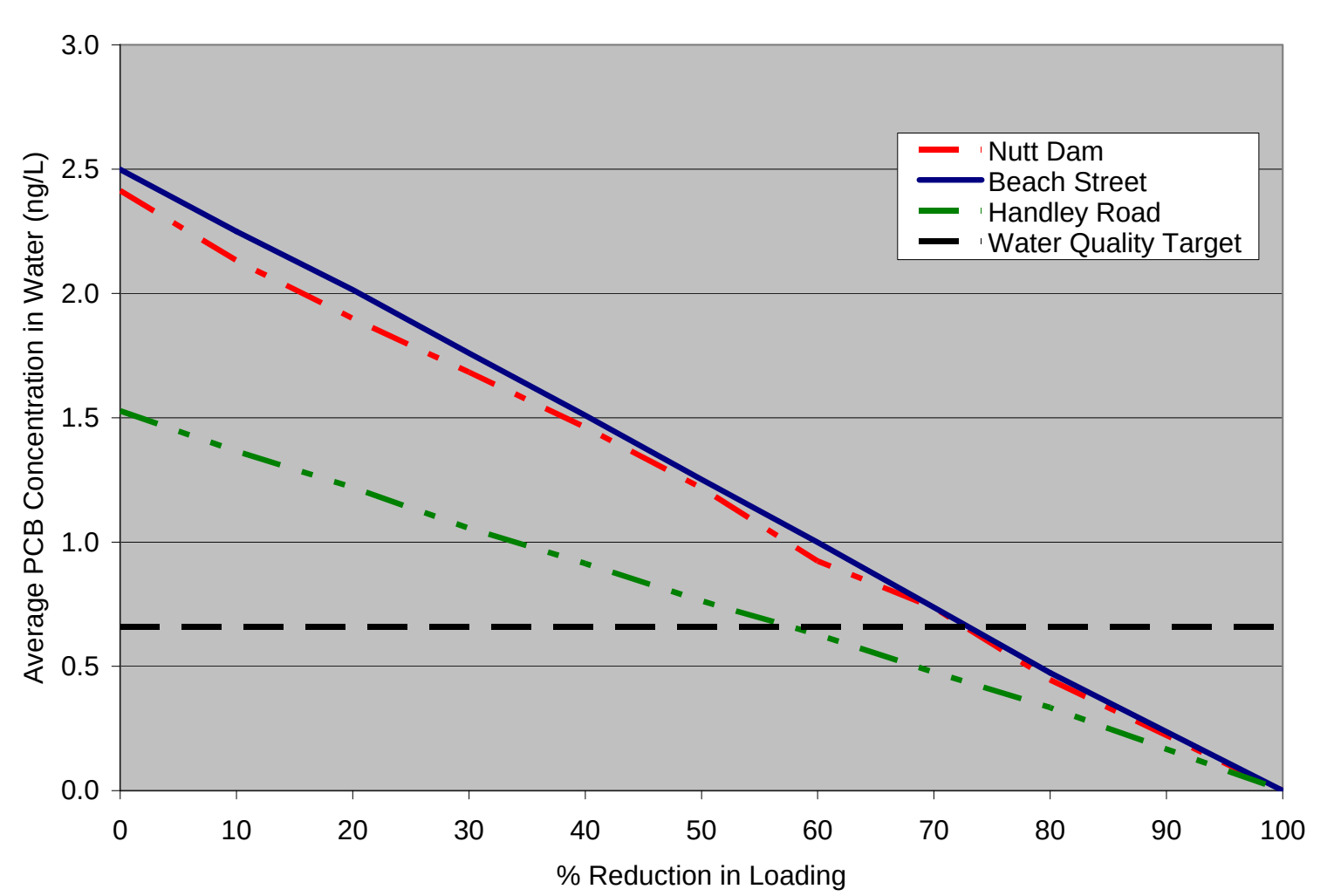
Percent Reductions Required to Meet Water Quality Target in Segment 0806



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Percent Reductions Required to Meet Water Quality Target

Assessment Unit	Required % Loading Reduction†
0829_01	60%
0806_01	76%
0841_02	86%
0841_01	81%
0805_04	64%
0805_03	74%
0805_06	80%
0805_02	71%
0805_01	65%

† reductions applied to both external point and nonpoint source loading and internal loading from sediments

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TMDLs for Total PCBs

Assessment Unit	Existing Load (mg/day)	Overall Required Reduction (%)	TMDL (mg/day)
0829_01	848	60%	339
0806_01	1,846	76%	443
0841_02	9,300	86%	1,302
0841_01	8,270	81%	1,571
0805_04	13,008	64%	4,683
0805_03	23,966	74%	6,231
0805_06	25,688	80%	5,138
0805_02	23,820	71%	6,908
0805_01	18,801	65%	6,580

Summary of Existing PCB Loads

Assessment Unit	Average Daily Loads (mg/day)							
	External Loads					Internal Load	Sum of External Loads to AU[c]	Load at Downstream Boundary of AU
	WWTFs	PS Runoff	NPS Runoff	Upstream Sources [a]		Sediment Exchange dS[b]		
				Non-Impaired	Impaired			
0829_01	0	154	142	34[d]	0	518	330	848
0806_01	0.008	691	162	151[e]	848	-6	1,852	1,846
0841_02	371	113	0	10[f]	1,846	6,960	2,340	9,300
0841_01	332	206	11	607[g]	9,300	-2,186	10,456	8,270
0805_04	0.49	1,673	0	694[h]	8,270	2,371	10,637	13,008
0805_03	602	162	0	130[i]	13,008	10,064	13,902	23,966
0805_06	169	84	32	0	23,966	1,437	24,251	25,688
0805_02	59	20	90	183[j]	25,688	-2,220	26,040	23,820
0805_01	0	0	78	0	23,820	-5,097	23,898	18,801
Overall	1,533	3,103	515	1,809		11,841		
	8%	17%	3%	10%		63%		

See handout table with footnotes

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Load Allocation Methodology

- Upstream non-impaired designated segments left at current loads
- Wasteload allocations for individually permitted facilities:
  - Permitted flow rate x the water quality target of 0.57 ng/L
- Other sources and internal loading from sediments:
  - reduced by required percentage

TMDL Load Allocations

AU	TMDL (mg/day)	Waste Load Allocation (mg/day)		Load Allocation (mg/day)			
		Individually Permitted Facilities	MS4	Upstream Sources		NPS	Internal (Sediment)
				Non-Impaired Segments	Impaired AUs		
0829_01	339	0	58	34	0	53	194
0806_01	443	0.008	119	151	339	28	-194
0841_02	1,302	359	15	10	443	0	475
0841_01	1,571	411	33	252[b]	1,302	2	-429
0805_04	4,683	2	535	694	1,571	0	1,881
0805_03	6,231	432	40	130	4,683	0	946
0805_06	5,138	237	17	0	6,231	6	-1,353
0805_02	6,908	66	6	183	5,138	25	1,490
0805_01	6,580	0.087	0	0	6,908	27	-355

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Implicit Margin of Safety

- Load reductions were calculated based on the most contaminated site in an assessment unit, while fish are mobile and also exposed to less contaminated sites.
- The model over-predicts PCB concentrations at some sites, thereby requiring greater reductions than necessarily required.
- The BAF-based current water quality target in water is less than 50% of the current water quality criterion.
- The TDSHS incorporates conservative assumptions in their risk assessments to ensure that public health will be protected.

Next Steps

- TCEQ will review final technical report
- TCEQ will prepare and issue a draft TMDL document for public comment
- TCEQ will request adoption of a final TMDL and submit the adopted TMDL to the USEPA for approval
- Work will begin on an Implementation Plan

Questions?

- For further questions:

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