Total Maximum Daily Load for Dioxin in the Houston Ship Channel

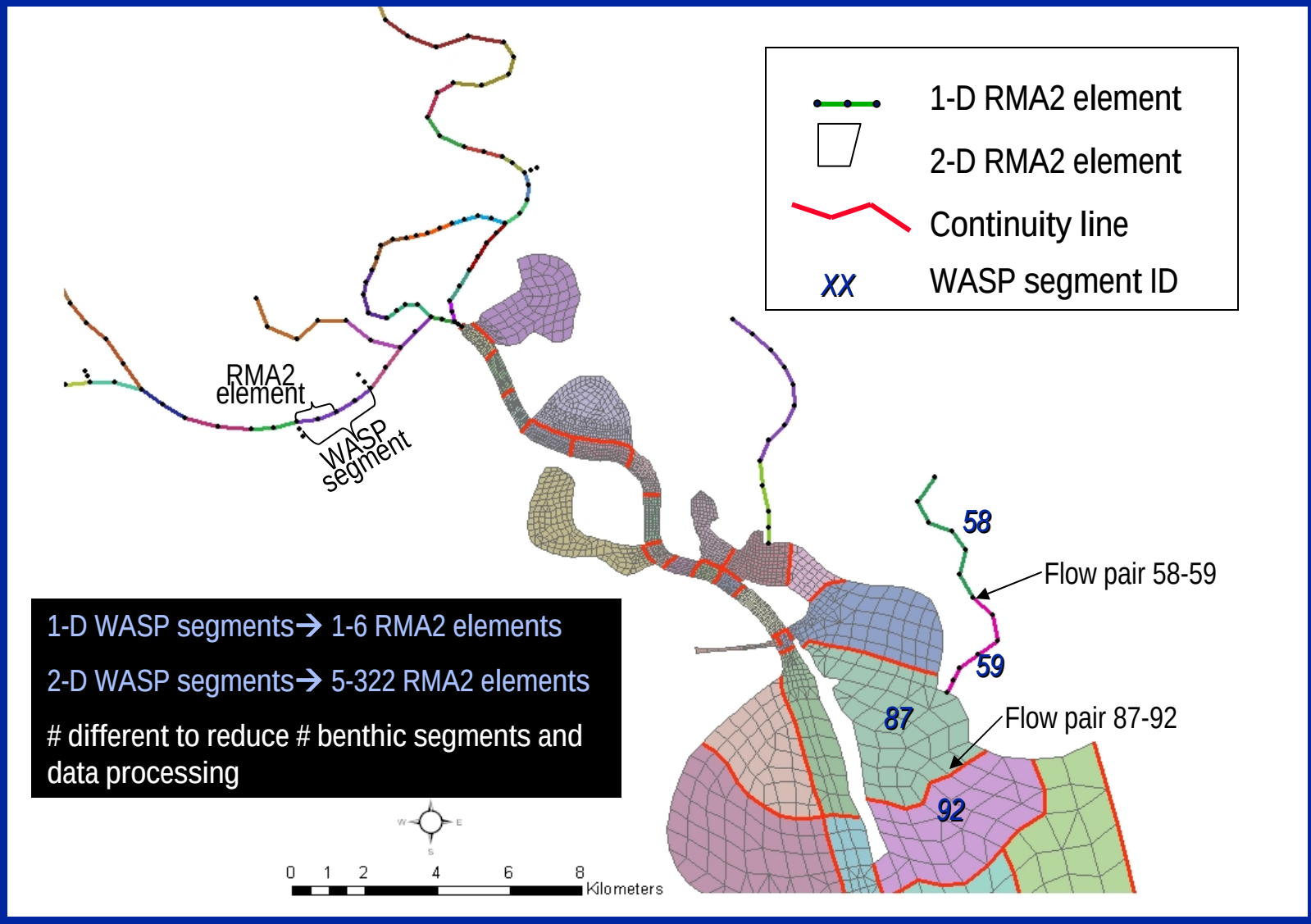
University of Houston
Parsons Water&Infrastructure

April 5, 2007

Focus

- RMA2-WASP modeling update
- Load allocation spreadsheet model

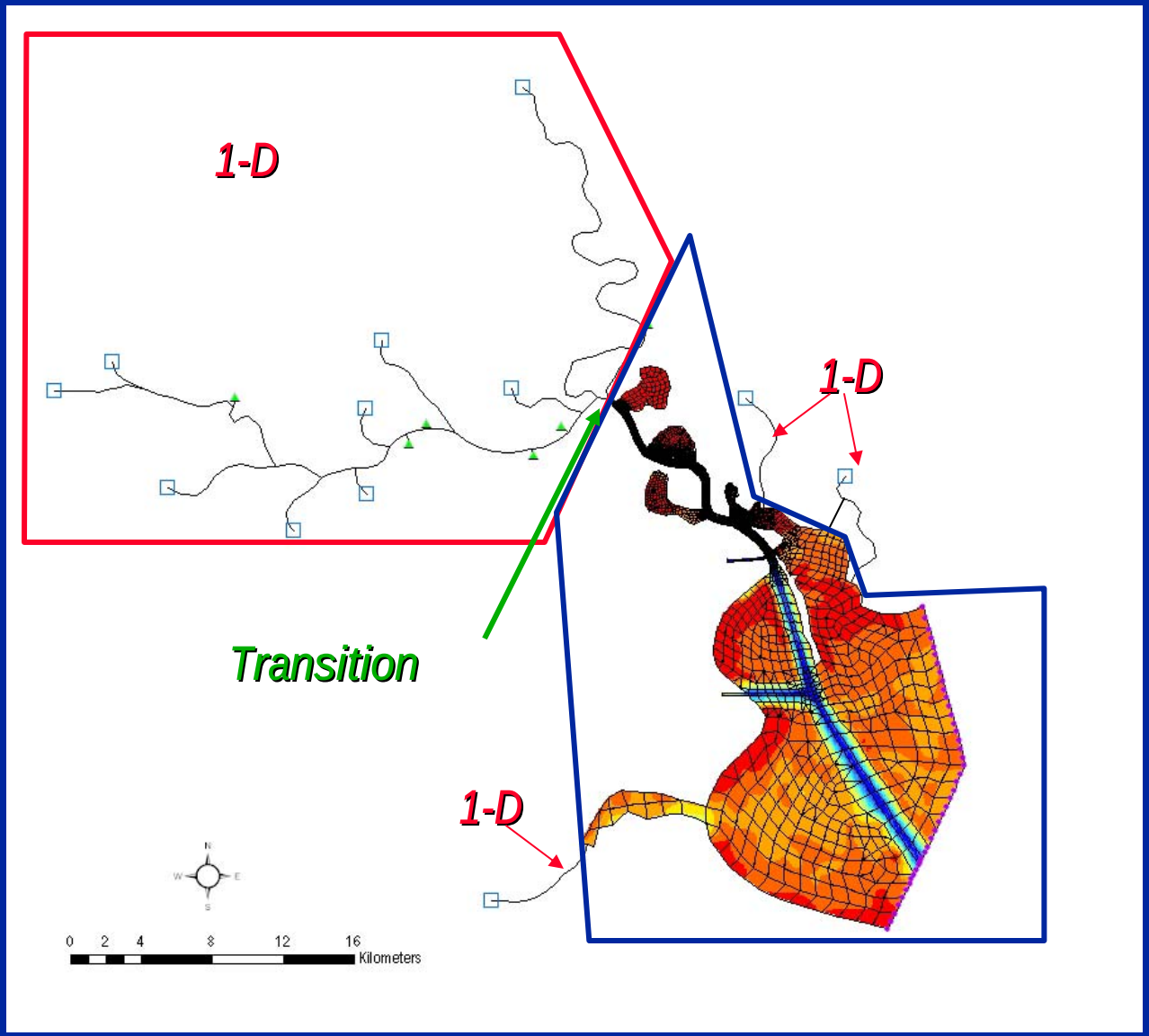
RMA2-WASP segmentation



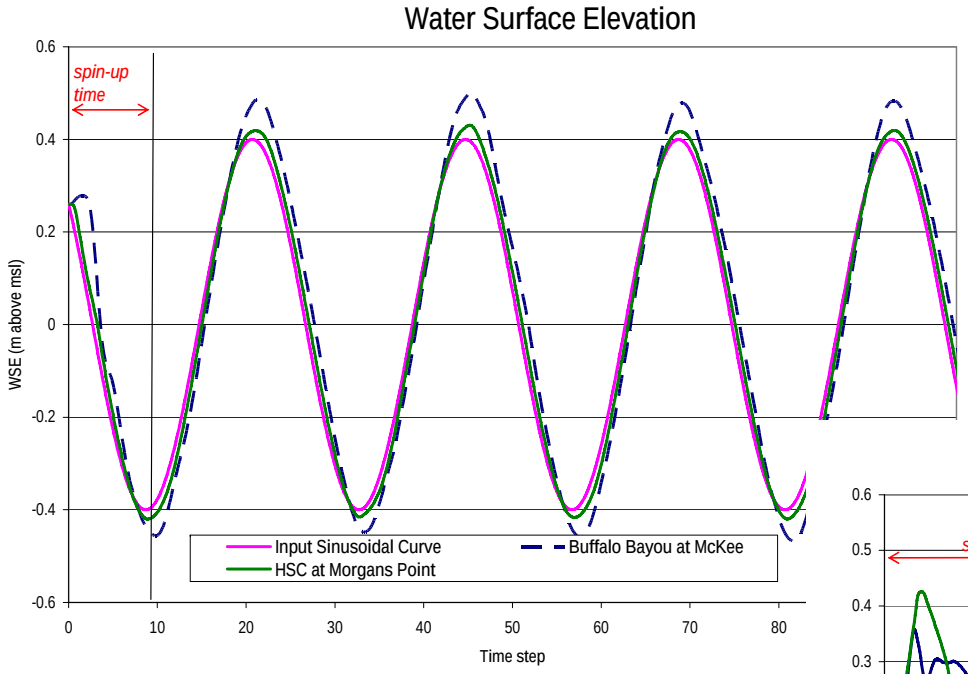
RMA2 Update

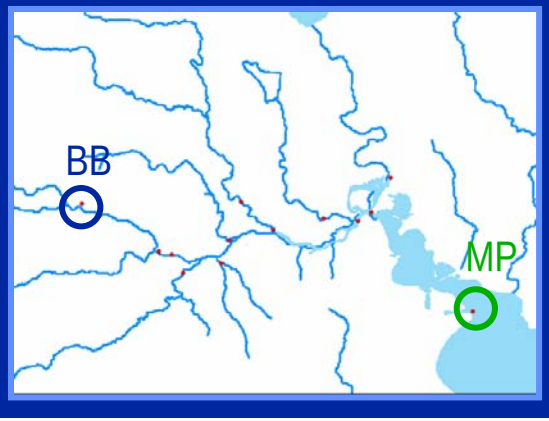
- Added segment to simulate flow out of the model domain at Cedar Bayou
- Verified spin-up time
- Completed 3-year runs with 30 minute time steps

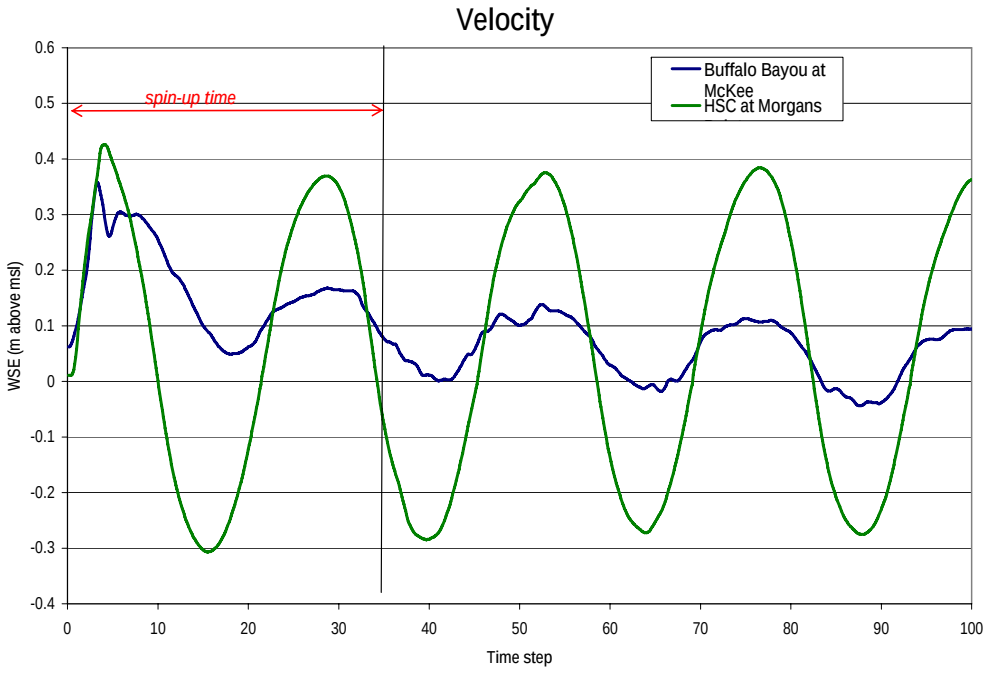
RMA2 final grid



RMA2 model – spin-up time verification

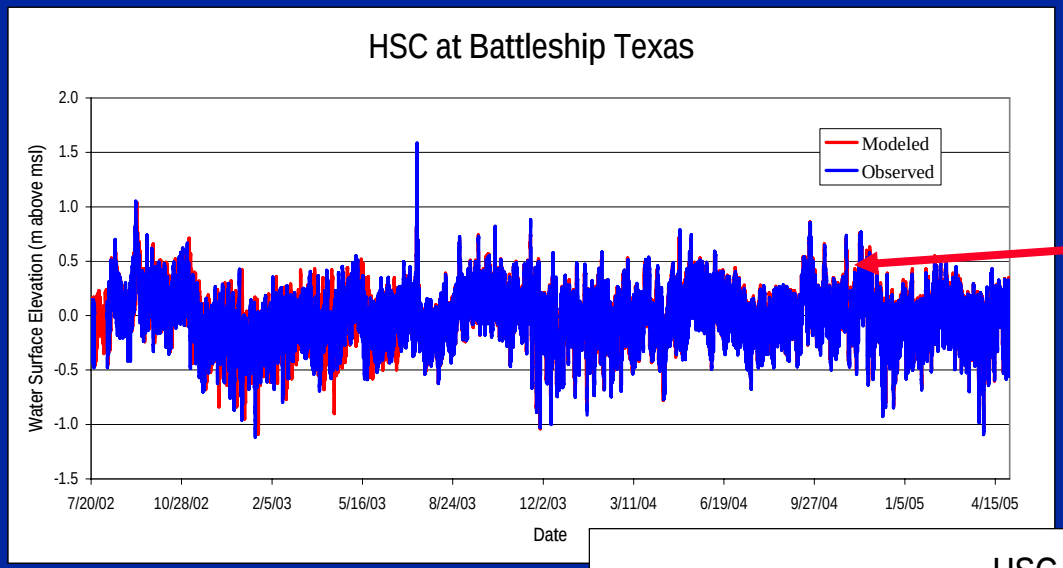


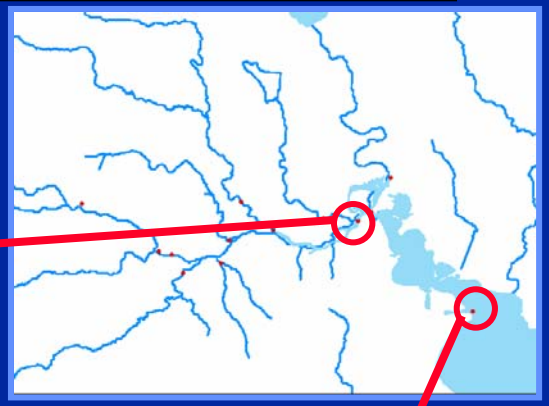


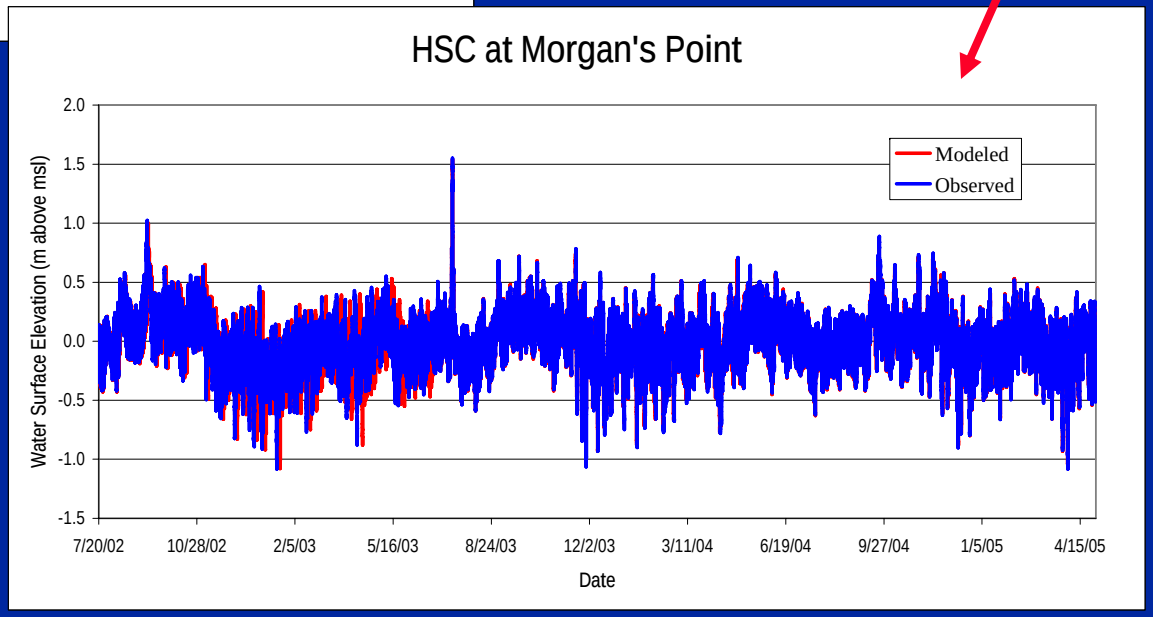


RMA2 spin-up time: 36 time steps → 3.6 hours

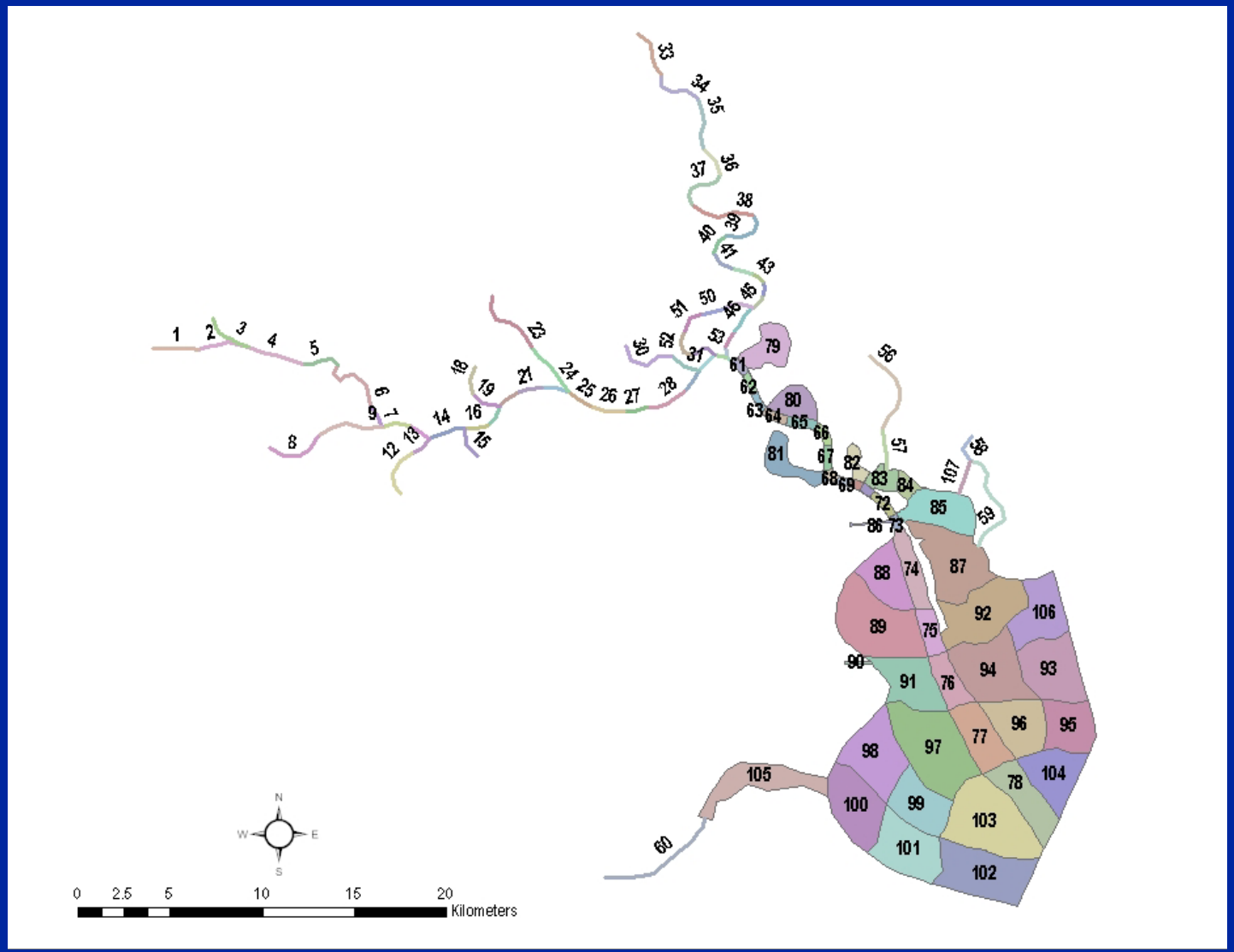
RMA2 model – water surface elevations



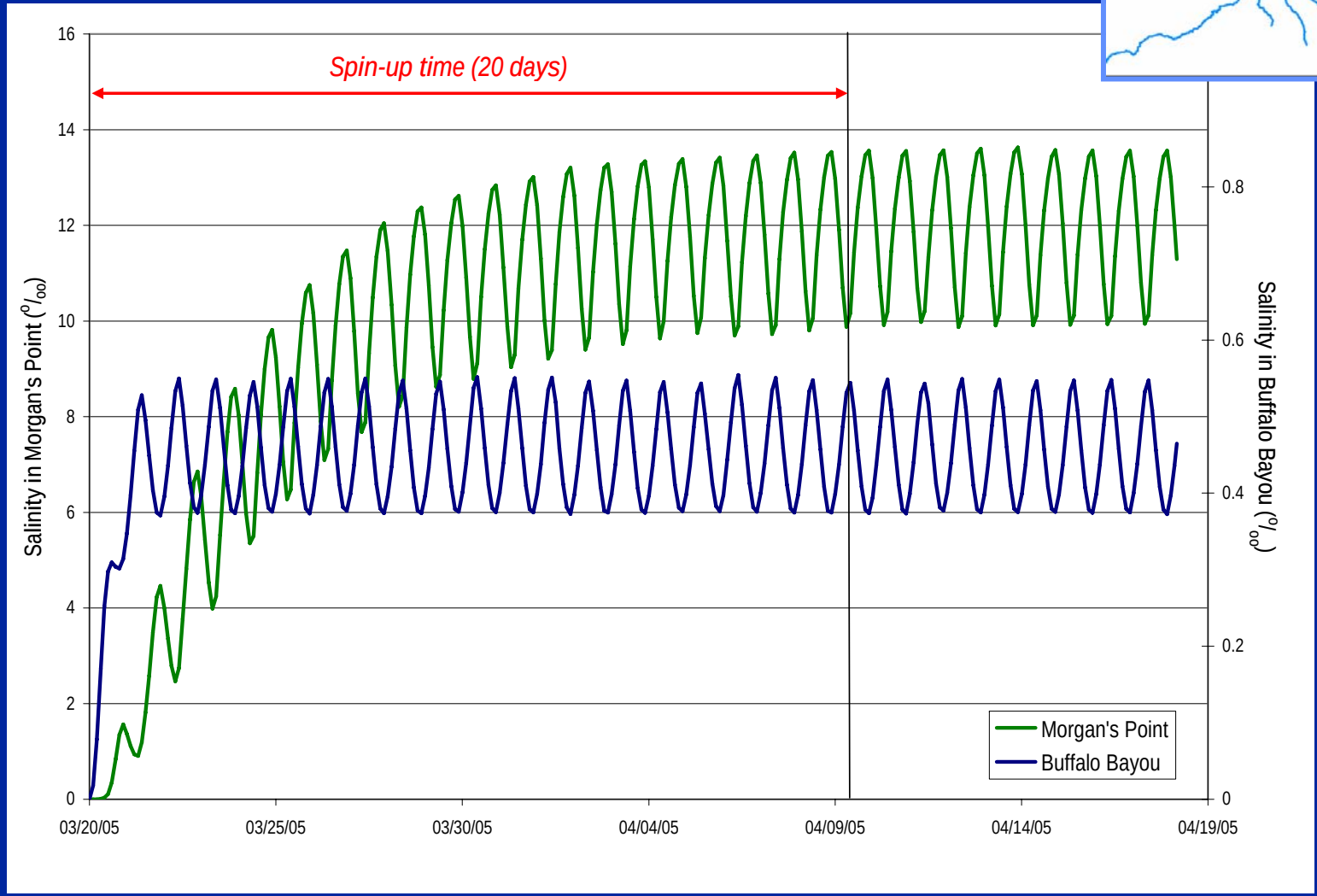




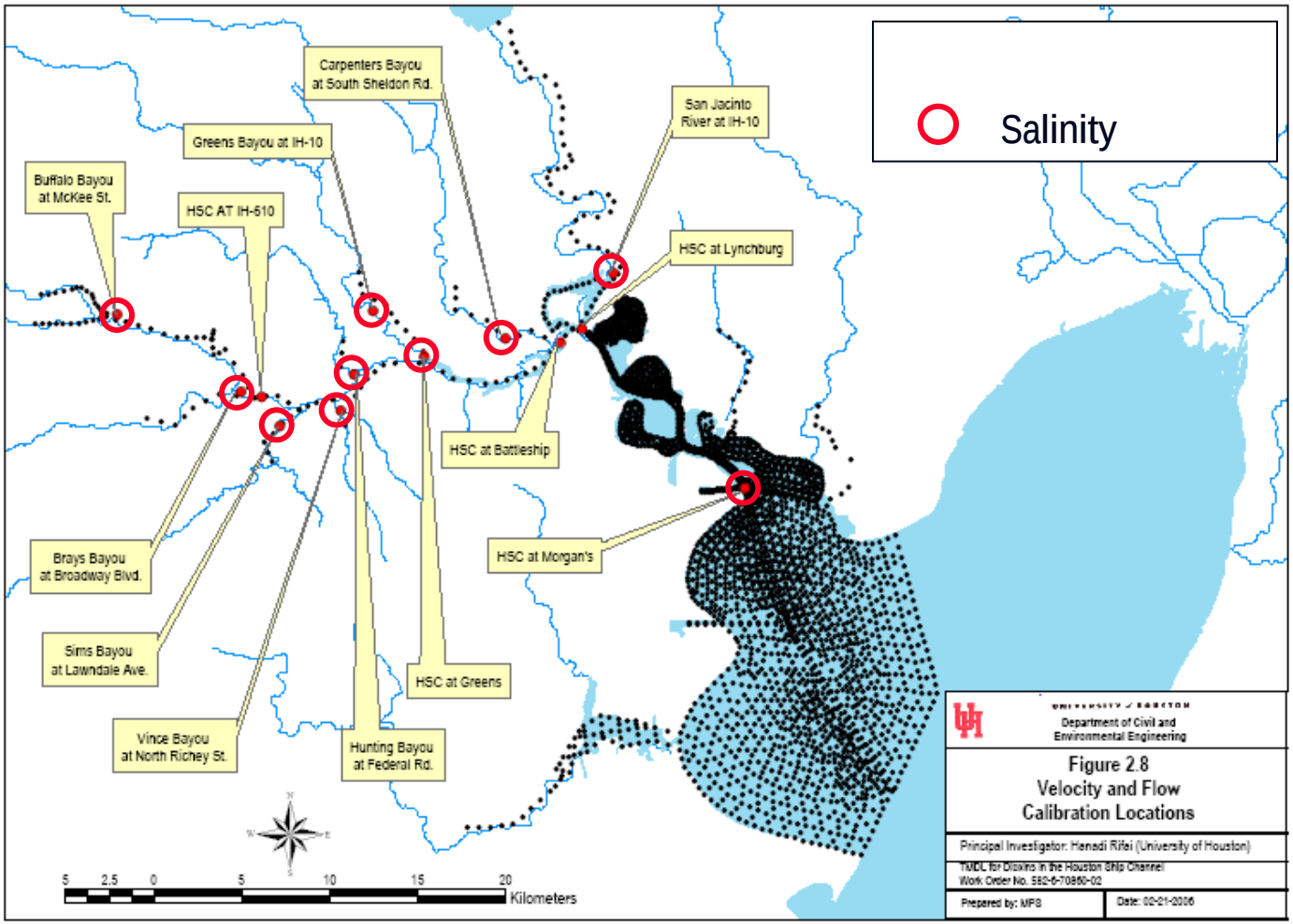
WASP final model segmentation



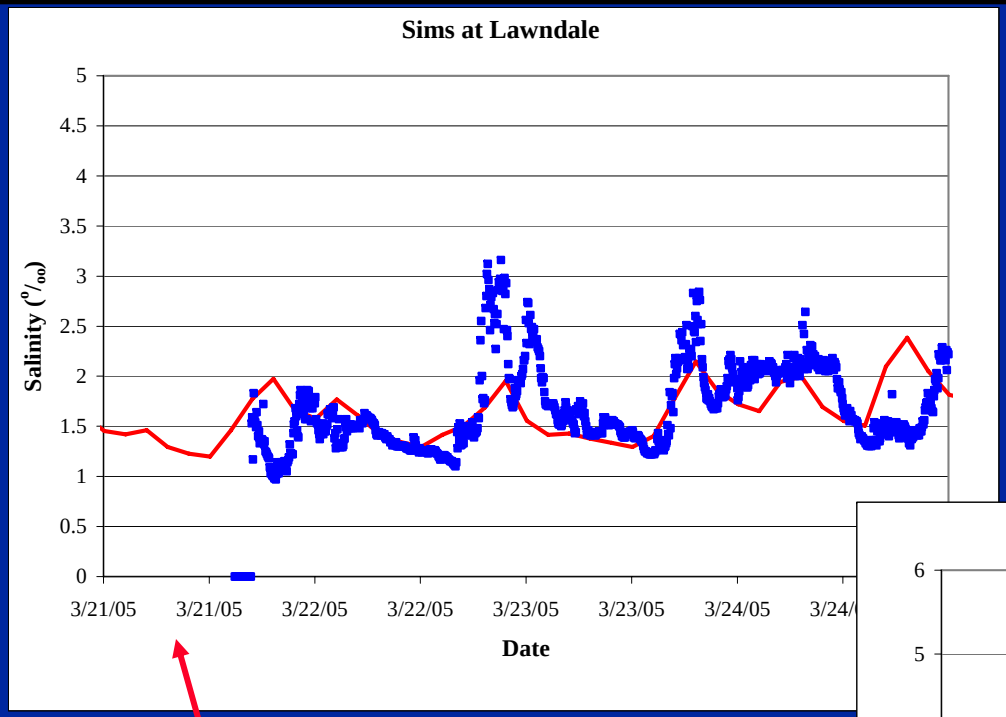
WASP spin-up time



Salinity model – calibration locations

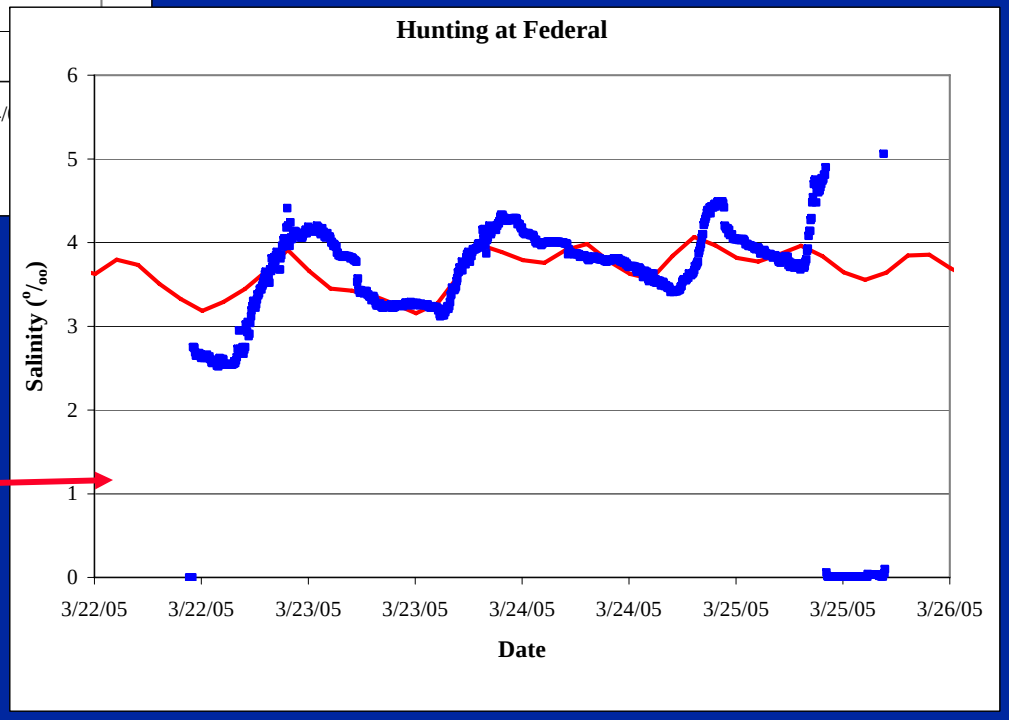


WASP model – salinity calibration

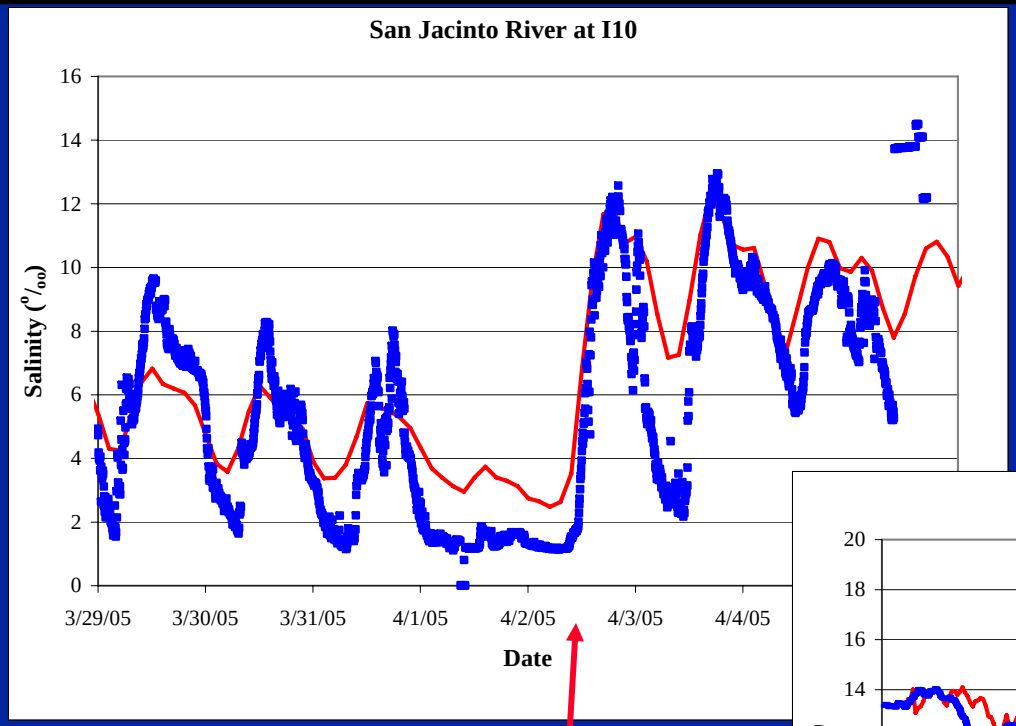


Red → Modeled

Blue → Observed

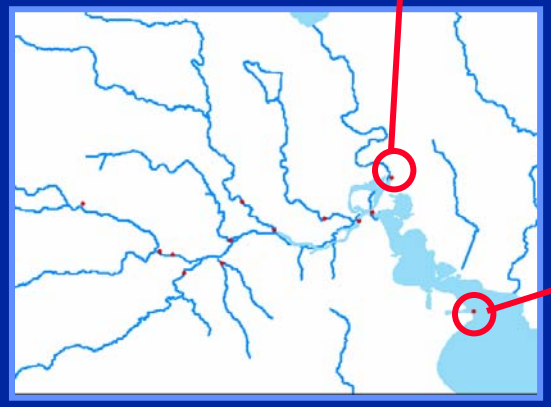


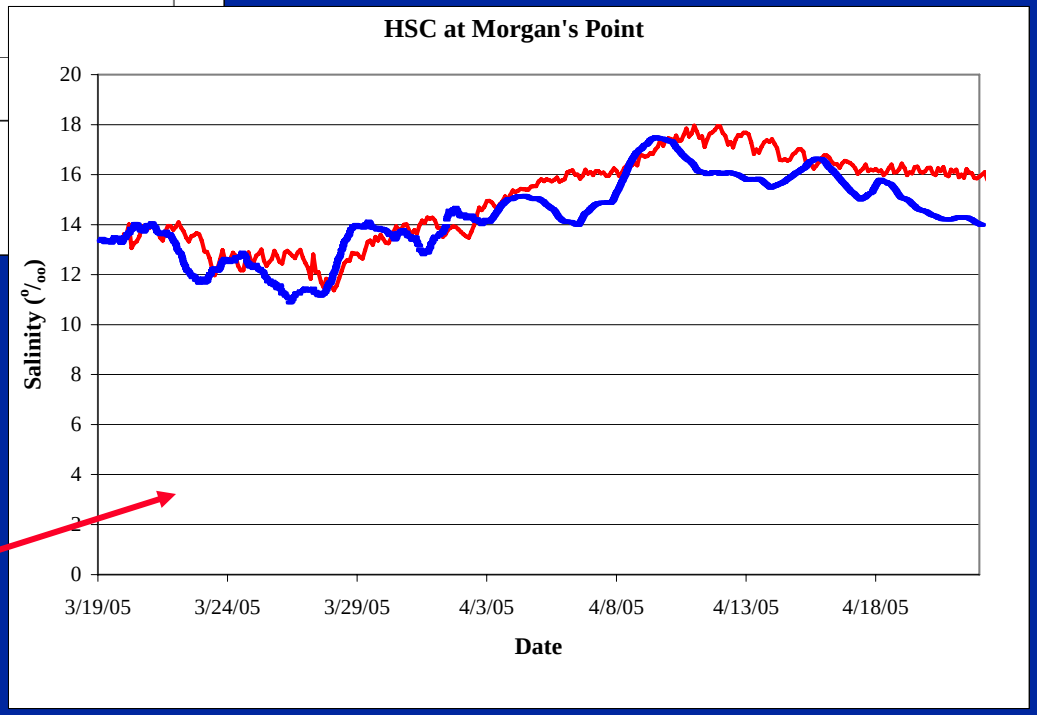
WASP model – salinity calibration (cont'd)



Red → Modeled

Blue → Observed

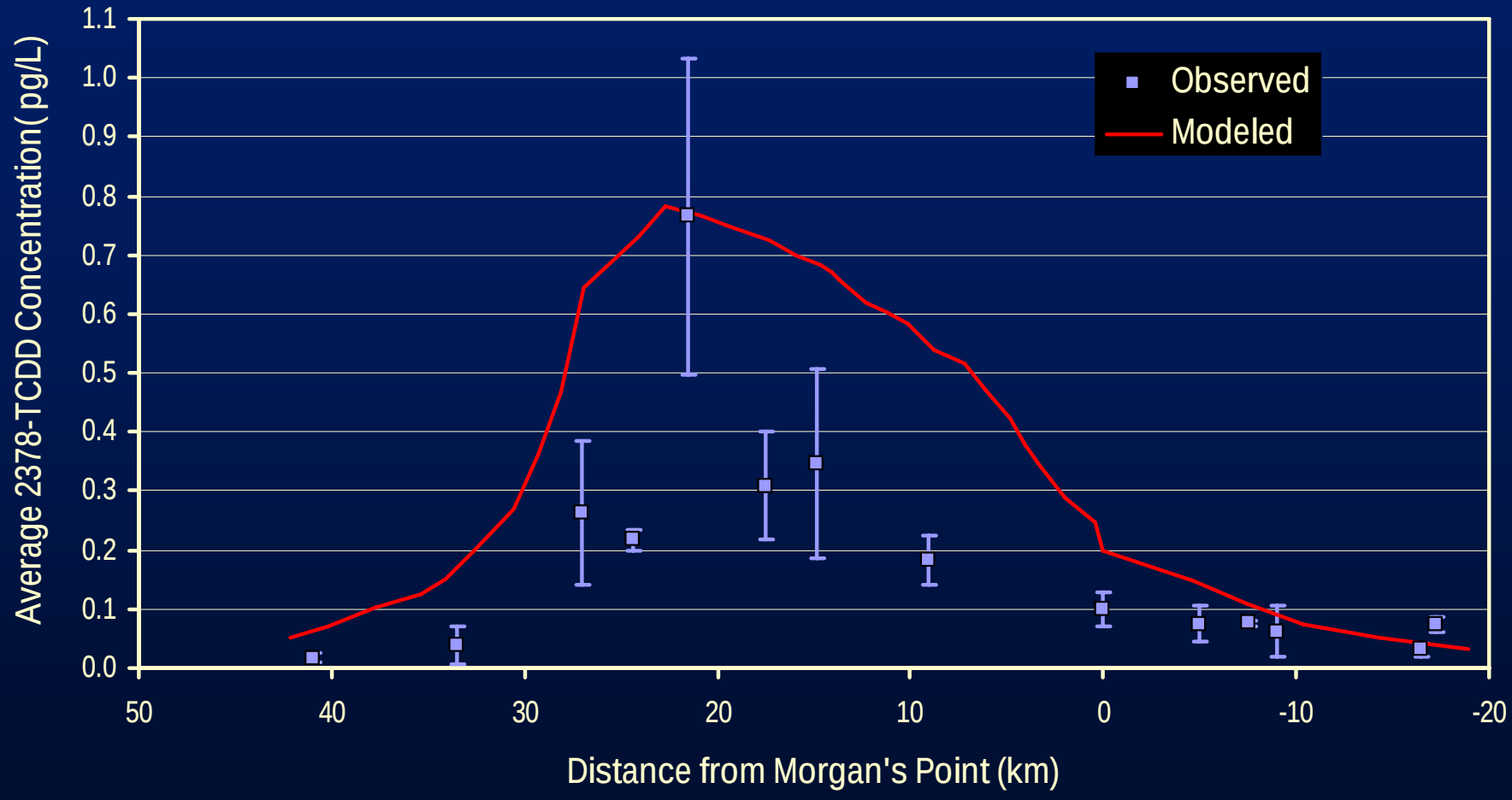




WASP 2378-TCDD model (2002-2005)

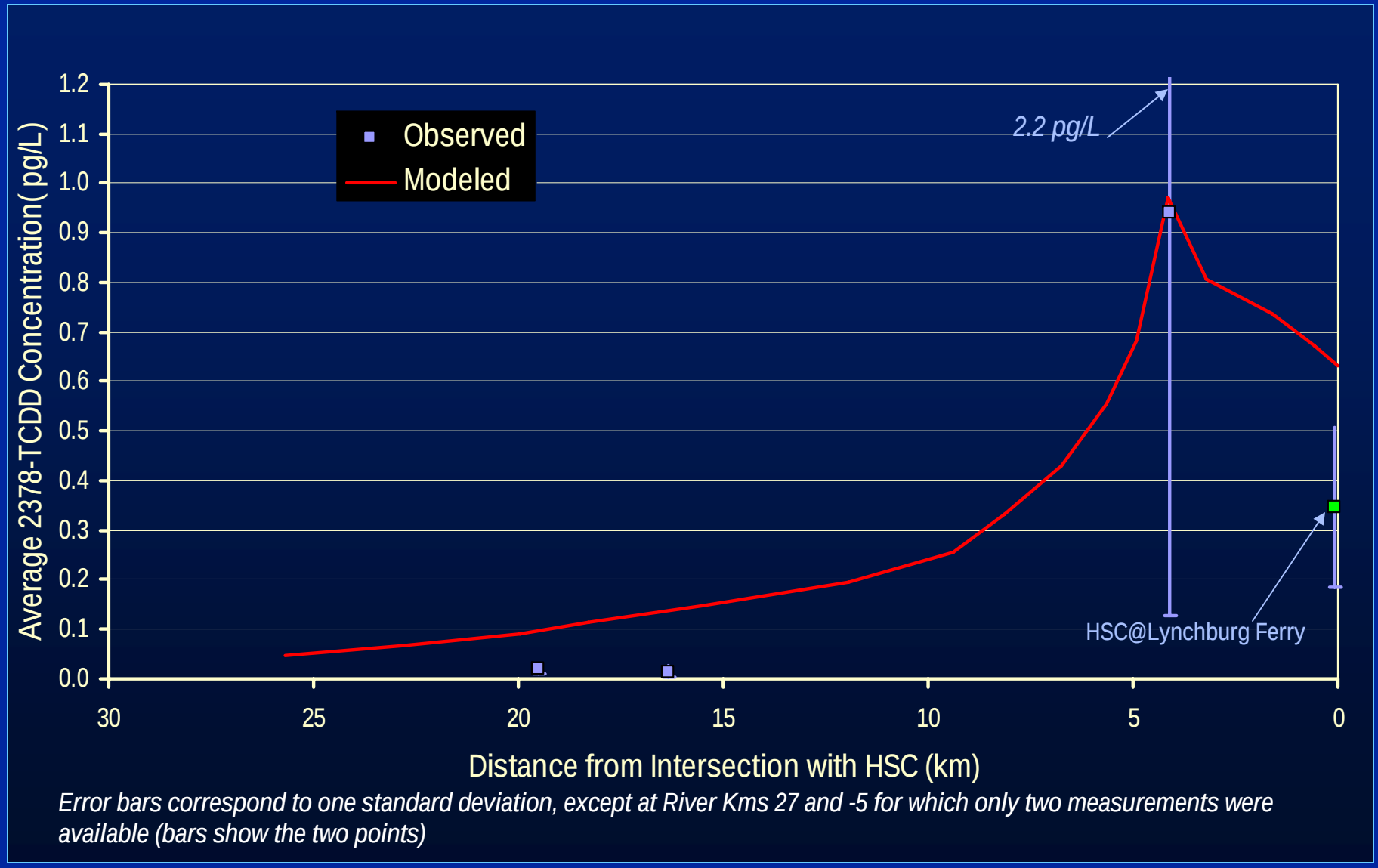
- Stormwater runoff and PS discharging u/s model segments: $Q_{USGS\ gage}$*Concentration. Concentration was determined as follows:
  - Dry days: (Load from PS)/Flow at USGS gage
  - Rainy days: (Runoff load + PS load)/Flow at USGS gage
- PS loads for direct discharges to WASP segments: $Q_{self\text{-}reported}$*Concentration
- Stormwater runoff discharging directly to WASP segments: Flow*Avg runoff concentration (0.017 pg/L). Flows determined using NCRS Method
- Direct deposition: deposition flux*area (rainy days → wet flux, dry days → dry flux)

WASP 2378-TCDD calibration – main channel



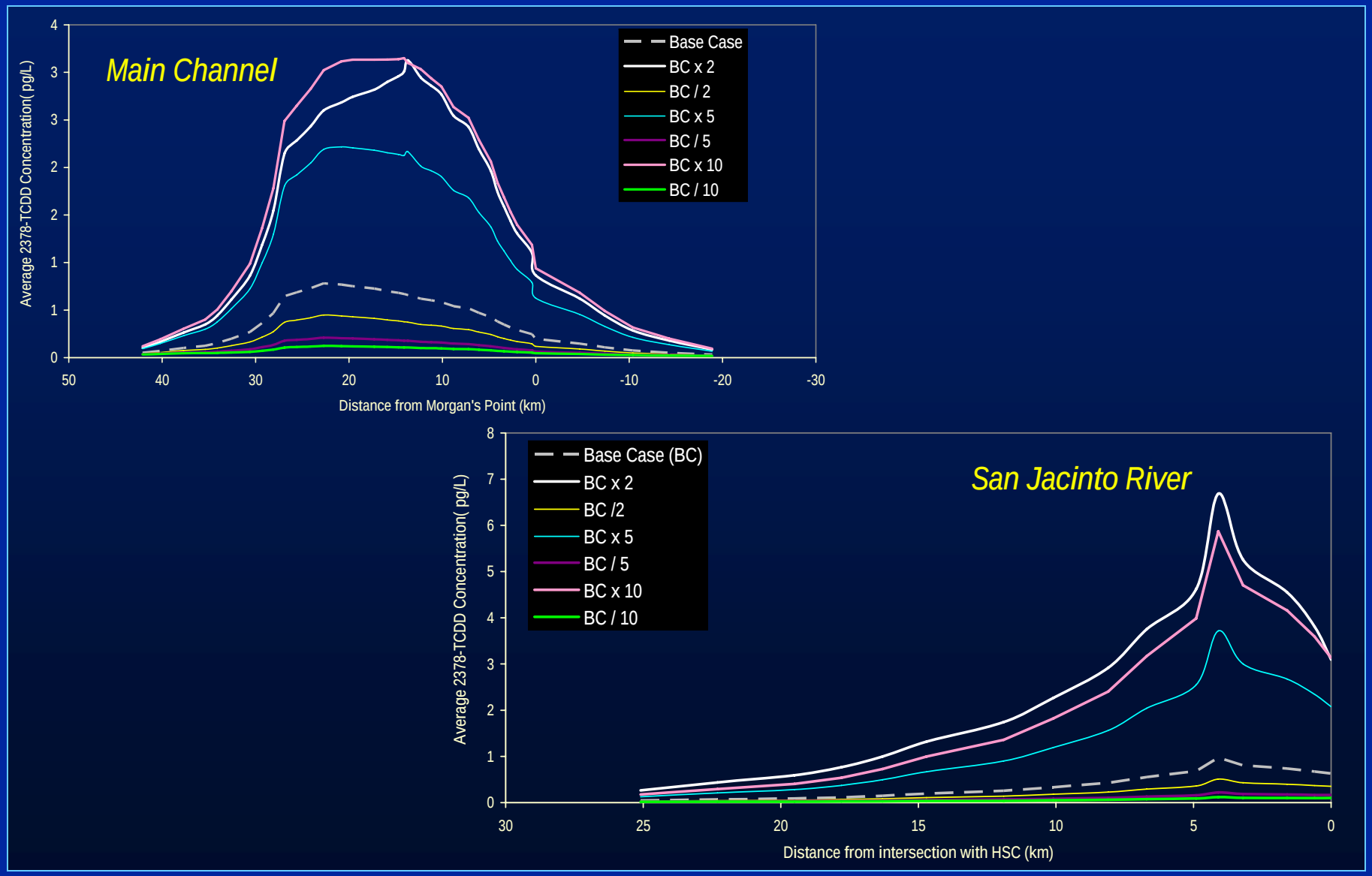
Error bars correspond to one standard deviation, except at River Kms 27 and -5 for which only two measurements were available (bars show the two points)

WASP 2378-TCDD calibration – San Jac

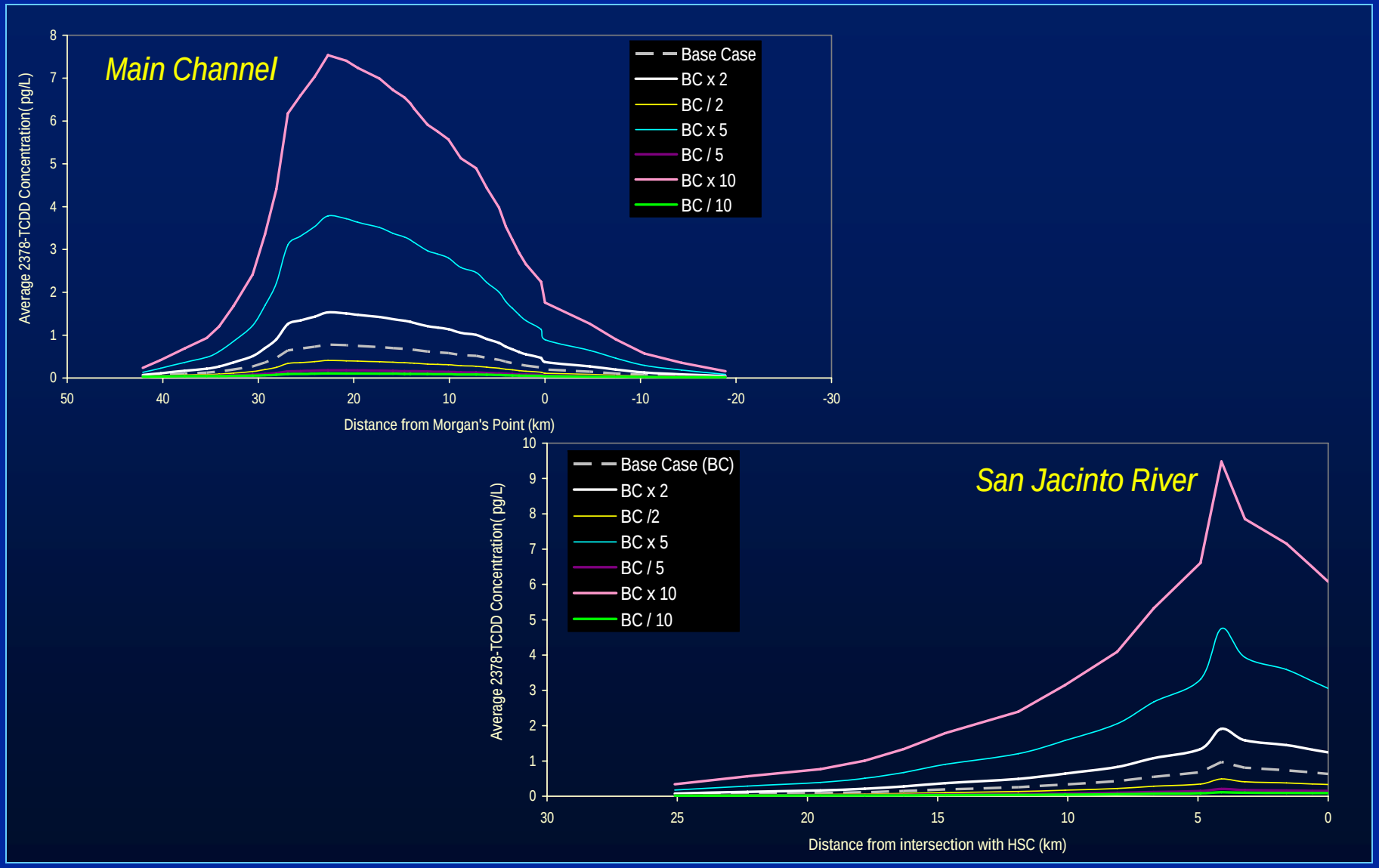


Error bars correspond to one standard deviation, except at River Kms 27 and -5 for which only two measurements were available (bars show the two points)

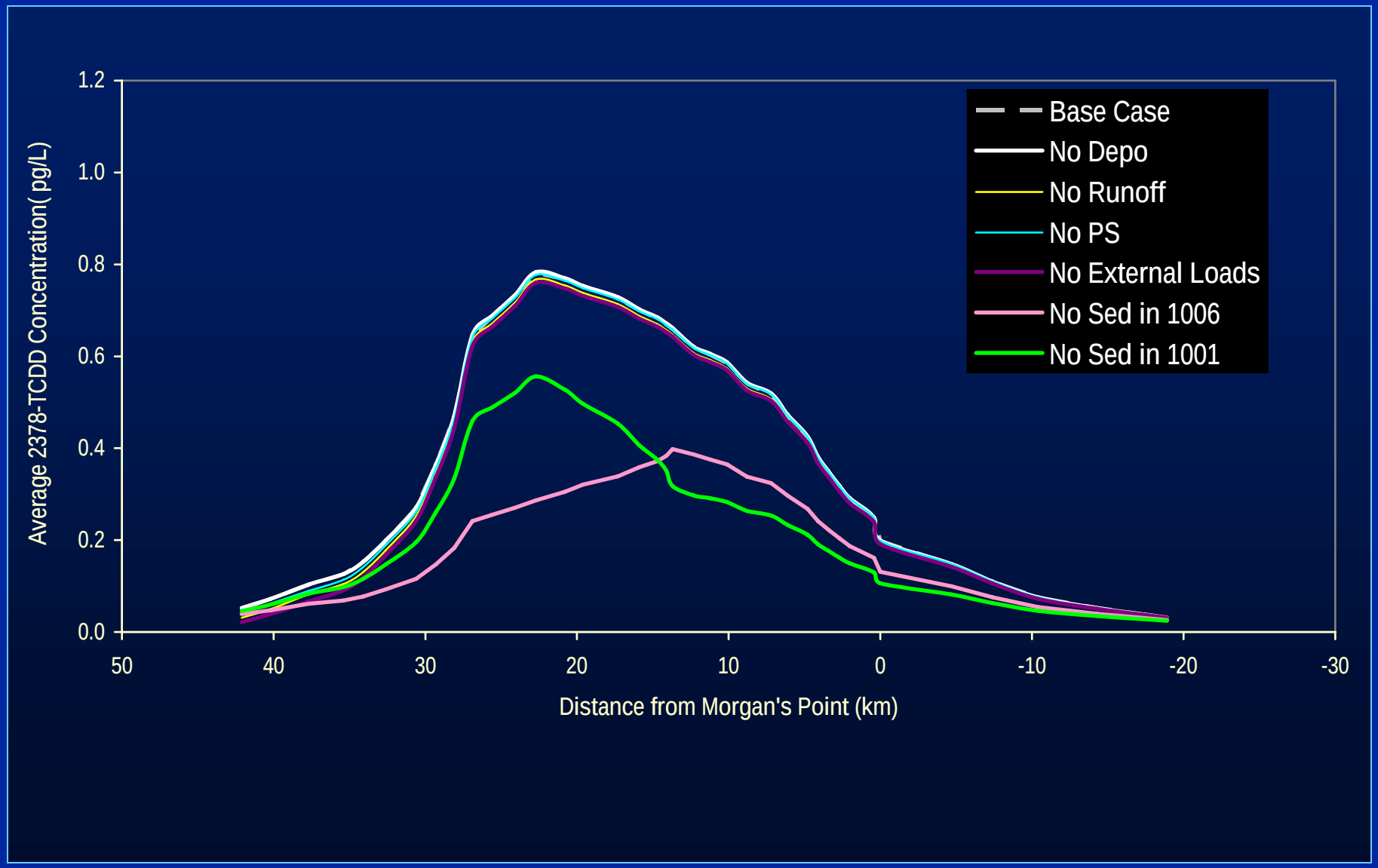
WASP sensitivity analysis - scour



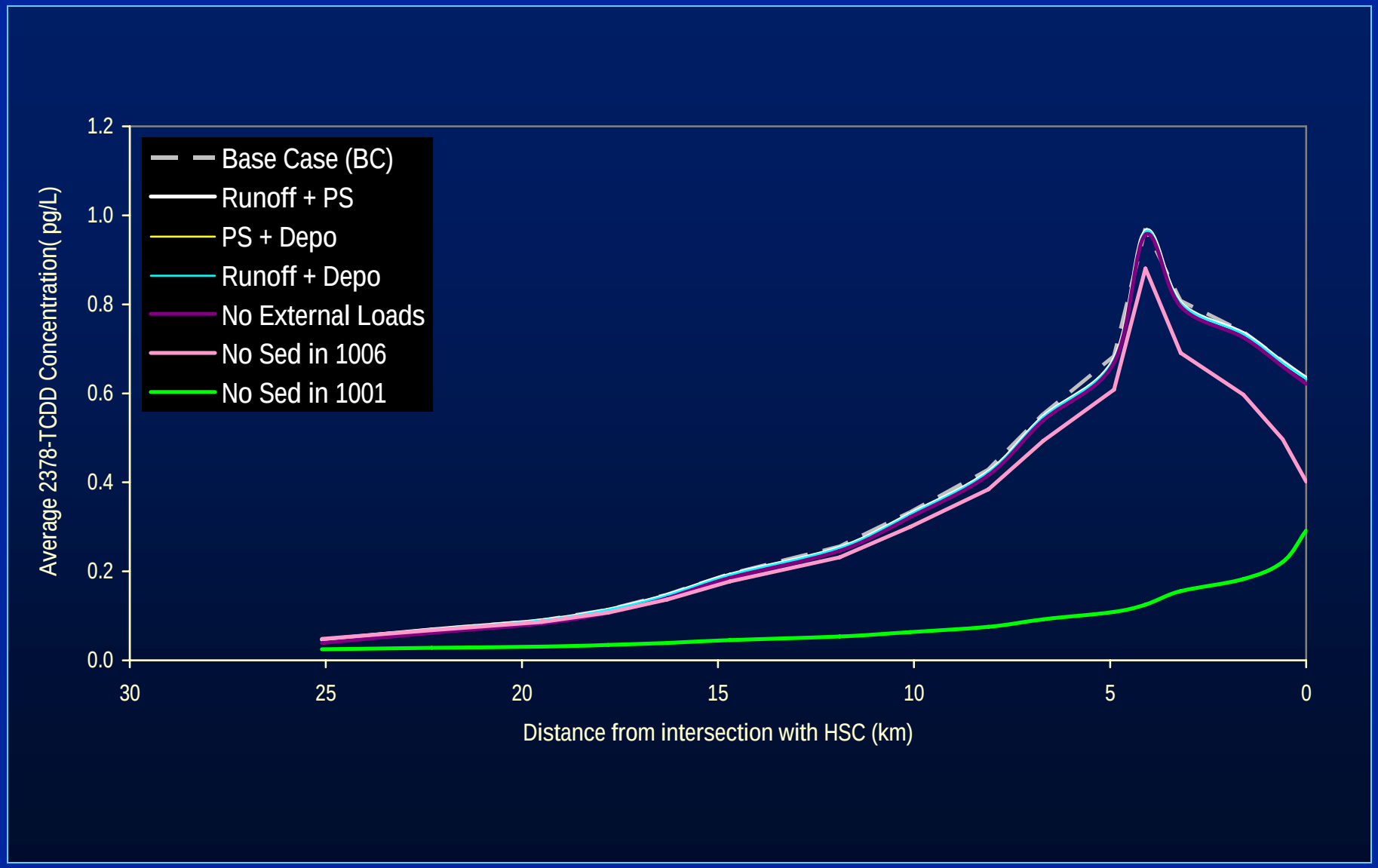
WASP sensitivity analysis – benthic conc.



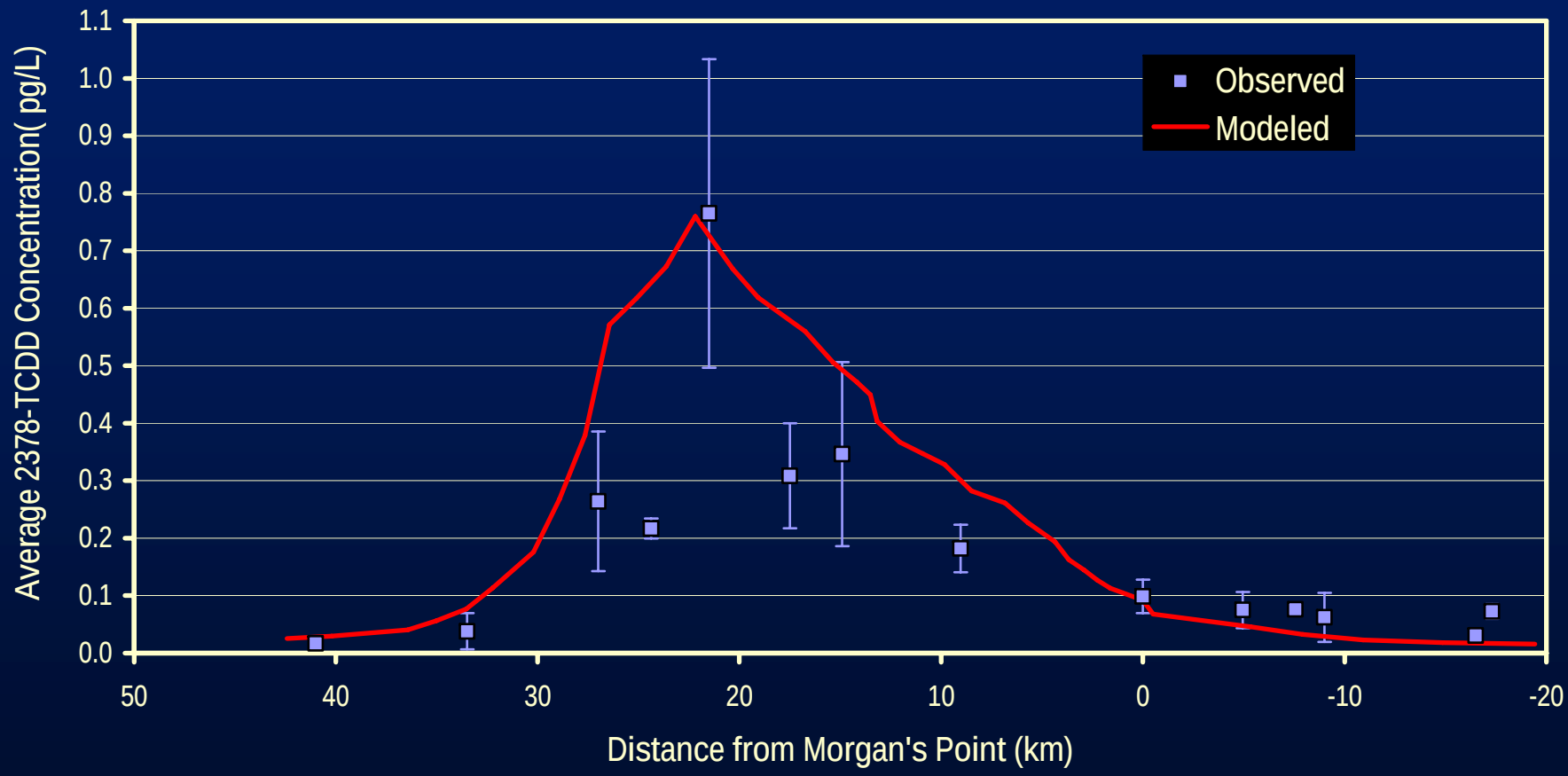
WASP load scenarios – main channel



WASP load scenarios – San Jacinto River



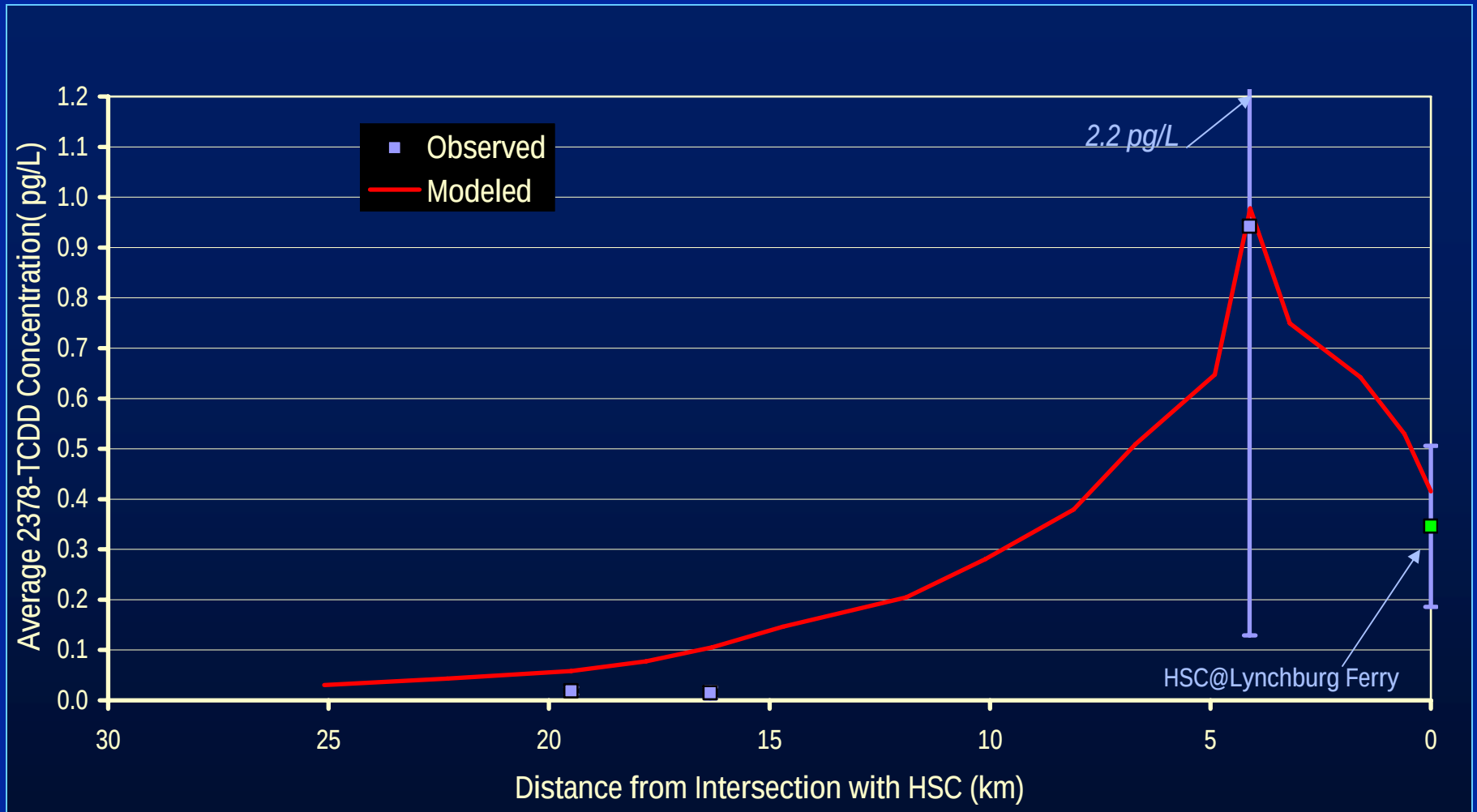
WASP 2378-TCDD high settling – main channel



Error bars correspond to one standard deviation, except at River Kms 27 and -5 for which only two measurements were available (bars show the two points)

Note: this model run results in an increase in TCDD concentrations in sediment in segments near hot spot

WASP 2378-TCDD high settling – San Jac

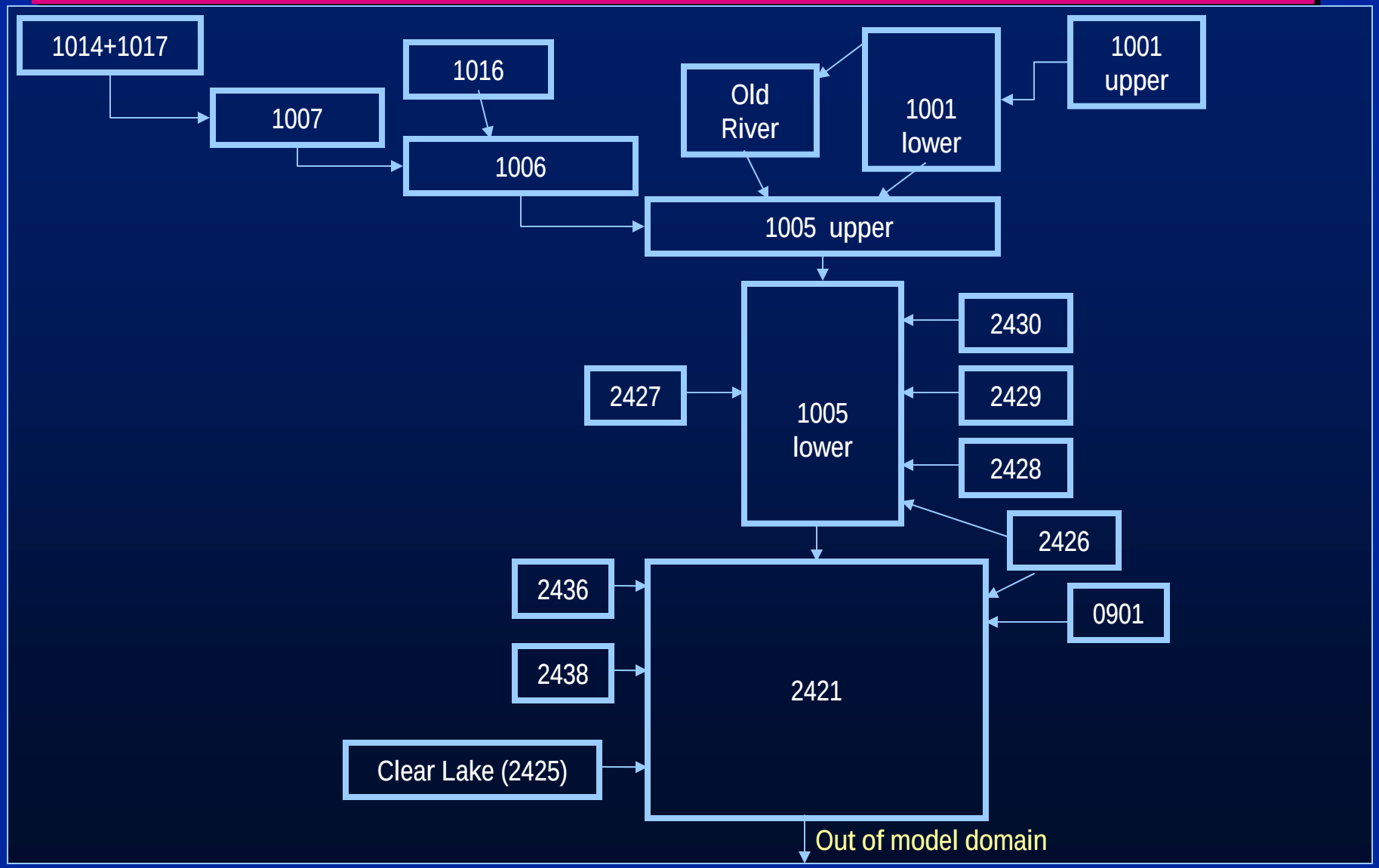


Error bars correspond to one standard deviation, except at River Kms 27 and -5 for which only two measurements were available (bars show the two points)

Note: this model run results in an increase in TCDD concentrations in sediment in segments near hot spot

Load allocation spreadsheet model

HSC spreadsheet segment structure



Point source load estimates

- 2378-TCDD and TEQ
- 5-year average of self-reported flows
- Dioxin concentrations
  - If effluent sampled in 2003, measured concentration
  - If only sludge measured in 2002, used sludge-effluent regression
  - If PS not sampled, average concentration for SIC code

Runoff load estimates

- 2378-TCDD and TEQ
- Flows determined using SCS curve method and daily precipitation data for years 2002-2005
- Dioxin concentrations in runoff measured in 2003 and 2005 assigned by proximity to watersheds

Direct deposition load estimates

- 2378-TCDD and TEQ
- Deposition fluxes measured in this project (100% non-detects for 2378-TCDD)
  - Wet: 0.6 pg/m^2/day for 2378-TCDD and 10 pg/m^2/day for TEQ
  - Dry: 0.4 pg/m^2/day for 2378-TCDD and 2.4 pg/m^2/day for TEQ
- Fluxes multiplied by surface area of the water quality segments
- Non-detects assumed as ½ MDL

In-stream load estimates

- 2378-TCDD and TEQ
- Net flow out of each segment (average of flows simulated for the period 07/2002 to 04/2005 at downstream end of segments)
- Average water concentrations at locations where flow was measured
- Load for a given segment is load out of the segment minus load from upstream segments

Load spreadsheet – preliminary mass balance (TCDD)

Segment	In-stream load[a]	Source Loads (ng/day)			
		Point Sources	Stormwater Runoff	Direct deposition	Unaccounted[b]
1014+1017	17,937	3,294	60,117	165	-45,639
1007	913,848	30,407	44,010	1,611	837,819
1016	46,762	1,440	16,757	92	28,473
1006	2,331,415	13,564	4,255	1,367	2,312,230
1001 upper	222,001	1,890	249,779	719	-30,387
1001 lower	11,005,048	525	244	305	11,003,973
1005 upper	-7,707,187	134	62	385	
Old River	1,149[c]	0	463	312	374
2430	676	0	176	1,848	-1,347
2429	653	46	539	1,410	-1,343
2428	38	-	111	501	-575
2427	2,329	610	878	1,463	-622
2426	39,154	521	2,734	1,280	34,620
2436	38	39	72	90	-164
1005 lower	-4,019,124	2,112	452	2,499	
2438	0	1,074	32	69	-1,175
2421	207,974	631	1,545	87,948	117,850
901	13,903	643	3,437	102	9,722
Clear Lake	1,578[c]	-	5,679	3,393	-7,494

[a] Average concentration measured in 2002-2004 times modeled net flow out of segment

[b] Difference between in-stream load and the sum of loads from PS, runoff, and direct deposition

[c] No dioxin data are available, thus, values are rough estimates

Non-detects assumed equal to 1/2MDL for load calculations

Load spreadsheet – preliminary mass balance (TEQ)

Segment	In-stream load[a]	Source Loads (ng/day)			
		Point Sources	Stormwater Runoff	Direct deposition	Unaccounted[b]
1014+1017	154,909	10,983	518,096	939	-375,109
1007	1,282,711	154,986	375,338	9,195	743,193
1016	202,633	4,798	186,102	526	11,208
1006	3,226,564	115,829	53,378	7,901	3,049,457
1001 upper	935,748	14,236	2,127,661	4,149	-1,210,298
1001 lower	15,096,421	5,263	3,092	1,742	15,086,324
1005 upper	-9,623,786	3,888	778	2,207	
Old River	4,742[c]	0	5,860	1,794	-2,912
2430	1,167	0	2,220	10,546	-11,599
2429	1,068	546	6,820	8,108	-14,405
2428	112	-	1,408	2,883	-4,178
2427	3,442	1,975	11,107	9,111	-18,751
2426	73,570	2,310	38,094	7,355	25,810
2436	60	382	911	509	-1,742
1005 lower	-5,725,072	7,467	5,717	14,302	
2438	1	3,571	408	386	-4,364
2421	1,061,624	2,097	19,545	501,383	538,598
901	30,819	4,601	43,448	587	-17,817
Clear Lake	13,624[c]	-	71,824	19,563	-77,763

[a] Average concentration measured in 2002-2004 times modeled net flow out of segment

[b] Difference between in-stream load and the sum of loads from PS, runoff, and direct deposition

[c] No dioxin data are available, thus, values are rough estimates

Non-detects assumed equal to 1/2MDL for load calculations

Load spreadsheet – preliminary overall reduction - TCDD

Segment	Net Flow[a] (m^3/s)	Allowable Load (ng/day)[b]	In-stream Load (ng/day)	% Overall Reduction
1014+1017	23.6	8,862	17,937	51%
1007	40.9	15,369	913,848	98%
1016	9.1	3,423	46,762	93%
1006	50.4	18,925	2,331,415	99%
1001 upper	138.1	51,893	222,001	77%
1001 lower	138.0	51,840	11,005,048	100%
Old River	0.7	263	1,149[c]	77%
1005 upper	188.2	70,696	-7,707,187	0%
2430	0.0	19	676	97%
2429	0.0	15	653	98%
2428	0.0	5	38	88%
2427	0.1	30	2,329	99%
2426	2.7	1,000	39,154	97%
2436	0.0	0	38	99%
1005 lower	191.7	72,026	-4,019,124	0%
2438	0.0	0	0	75%
2421	348.6	130,956	207,974	37%
901	2.6	970	13,903	93%
Clear Lake	2.1	779	1,578[c]	51%

[a] Average of simulated flows out of segment for period July 2002 to April 2005

[b] Net outflow times the Texas WQS (0.0933 pg/L) times the average contribution of TCDD to TEQ in water (46.6%)

[C] No dioxin data are available, thus, values are rough estimates

Load spreadsheet – preliminary overall reduction - TEQ

Segment	Net Flow[a] (m^3/s)	Allowable Load (ng/day)[b]	In-stream Load (ng/day)	% Overall Reduction
1014+1017	23.6	19,017	154,909	88%
1007	40.9	32,980	1,282,711	97%
1016	9.1	7,345	202,633	96%
1006	50.4	40,612	3,226,564	99%
1001 upper	138.1	111,359	935,748	88%
1001 lower	138.0	111,245	15,096,421	99%
Old River	0.7	564	4,742[c]	88%
1005 upper	188.2	151,708	-9,623,786	0%
2430	0.0	40	1,167	97%
2429	0.0	32	1,068	97%
2428	0.0	10	112	91%
2427	0.1	64	3,442	98%
2426	2.7	2,146	73,570	97%
2436	0.0	1	60	98%
1005 lower	191.7	154,562	-5,725,072	0%
2438	0.0	0	1	87%
2421	348.6	281,022	1,142,913	75%
901	2.6	2,082	30,819	93%
Clear Lake	2.1	1,673	13,624[c]	88%

[a] Average of simulated flows out of segment for period July 2002 to April 2005

[b] Net outflow times the Texas WQS (0.0933 pg/L)

[C] No dioxin data are available, thus, values are rough estimates

Summary

- Hydrodynamic and WASP models finished
- WASP predicts peaks wider than observed
- WASP model very sensitive to sediment-related parameters
- Preliminary load calculations and model results indicated major contribution from sediment

Next steps

- Define target
- Model additional congeners
- Run load reduction scenarios
- Update load spreadsheet model and define TMDL