TECHNICAL MEMORANDUM

TO:	Russ Cepko - CBS Dottie Alke - CBS	**DATE:**	May 18, 2007
FROM:	David Glaser, Wen Ku, Kevin Russell, Jim Rhea, Deirdre Reidy	**RE:**	Model Uncertainty Analysis
CC:		**JOB#:**	VIAnea:110

Introduction

This memorandum describes an uncertainty analysis that was performed for the PCB fate, transport, and bioaccumulation model of polychlorinated biphenyls (PCBs) in Conard's Branch and Richland Creek at the Neal's Landfill Site. Alternative parameter sets were developed resulting in similar model/data relationships for the calibration period but different responses to remediation during the projection period. This approach permitted evaluation of the effects of key sources of uncertainty on future projections of the selected remedy (i.e., source control with the existing Spring Treatment Facility [STF]). This approach accounted for the two main sources of uncertainty: 1) model calibration; and 2) assumptions regarding future conditions made during simulation of management scenarios.

Approach

The approach presented here consists of developing two "bounding calibrations", in which model parameters were modified within the range of realistic values such that they produced a larger or smaller system response to management actions, but still honored the calibration data collected from the site. This approach is recommended in the United States Environmental Protection Agency's (EPA's) December 2005 contaminated sediment guidance document.

Two sources of uncertainty were considered here: (1) model calibration uncertainty and (2) future condition uncertainty. Model calibration uncertainty refers to the uncertainty associated with values used for parameters of the model. The uncertainty analysis involved assessing the extent to which alternative sets of parameters result in different model projections while remaining consistent with the calibration data. Two bounding calibrations were developed for the Neal's Landfill model: one (referred to hereinafter as BC1) in which the system responds to source control actions to a lesser degree than the base calibration (referred to as the Base Case);

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and one in which the system responds to a greater degree (referred to as BC2). Model simulations based on these two bounding calibrations were conducted for the selected management scenario. The simulation period was extended to 20 years to evaluate fish PCB concentrations closer to steady state conditions, as discussed in our response to EPA's supplemental comments emailed on June 16, 2006.

The choice of parameters that were adjusted in developing BC1 and BC2 was based on the results of sensitivity analyses that have been conducted to date. These parameters are:

- Rate of decline in Spring PCB concentrations;
- North Spring Bypass (NSB) PCB loads;
- Sediment/water mass transfer coefficient (i.e., diffusion);
- Volatilization rate coefficient;
- Flow-PCB relationship in springs during storms; and
- Relative amount of water column vs. benthic invertebrates in fish diet.

Future condition uncertainty refers to the lack of knowledge associated with conditions such as hydrology over the next 10-20 years. The uncertainty analysis for the Neal's Landfill model involved developing alternative realistic representations of the system's hydrology over the projection period. One bounding simulation incorporated relatively high flows, and one simulation incorporated relatively low flows for the entire projection period, as discussed in our response to EPA's supplemental comments emailed on June 16, 2006. Uncertainty in future hydrology was evaluated using the Base Case calibration only.

Development of Alternative Parameter Sets

Calibration Uncertainty: Fate and Transport Model

Ranges of values for the bounding calibration parameters were determined based on published literature studies and previous data analyses. Detailed descriptions of those calibration parameters were documented in the final model report (QEA 2007). A brief summary of the range of values used in the uncertainty analysis follows:

- Spring decay rate: The spring decay rates were estimated to be in the range of 4% to 9% per year, representing the 95% confidence interval of the mean rate of natural recovery (6% per year) derived from the trend analysis (see Appendix A of QEA 2007).
- North Spring Bypass PCB loads: There are two components associated with the uncertainty of PCB loads from NSB (see Equation 3-6 of QEA 2007): (1) the dilution factor α, which is associated with groundwater seepage, was estimated to be in the range of 0.5 to 0.8 based on the analysis of site data; and (2) W_{bank}, which represents PCB loads from the bank soils associated with the period inundation during STF effluent cycling.

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The value of W_{bank} was determined during the calibration of the alternative parameter sets.

- Sediment/water mass transfer coefficient: A range of 1 to 5 cm/day was used in the bounding calibrations, which is within the range of values found in other aquatic systems (e.g., Thibodeaux and Bierman 2003).
- Volatilization rate coefficient: The rate of volatilization of PCBs depends on the value of the Henry's Law Constant (HLC), which was calculated for the Neal's Landfill model based on published values for PCB congeners presented by Brunner et al (1990; see Section 3.2.1.3.7 of QEA, 2007). HLC was estimated to be in the range of 5 to 25 for the bounding calibrations, based on the known PCB source as a mixture of Aroclors 1242 and 1248.
- Flow-PCB relationship at Conard's Branch at the Weir (CBW) during storms: PCB concentrations in the water during a given storm event were estimated using an event-mean PCB concentration and a peaking factor, both of which were related to the flow rate during the storm event (see Section 3.2.1.1.2 of QEA, 2007). A scaling factor between 0.7 and 1.3 was applied to the regression-based relationships used in the original model calibration. This range of factors results in model values of the event mean PCB concentrations and the peaking factors that fall within the range of storm data collected at CBW between 1998 and 2005 (see Figures 3-15 and 3-16 of QEA 2007).

The selected management scenario for the Site (i.e., source control and continued operation of the existing STF) primarily addresses PCB concentrations in the water column under low flow conditions, through the reduction of PCB loads from NSB, and to a lesser degree, through removal of sediments in the upper section of Conard's Branch. For bounding calibration BC1 (lesser response to this remediation) parameters were adjusted as follows:

- system recovery was slowed by using the lower end spring decay rate;
- PCB loads from NSB were decreased by using the lower range of the dilution factor α and by reducing W_{bank}, but only to the extent that ensured that model results remained within the bounds of the data;
- water column PCB loads during storms were increased by using the upper end of the scaling factors in the flow-PCB relationship at CBW;
- to maintain calibration, PCB loads from sediment to the water column were increased by using the upper range of the sediment/water transfer coefficient; and
- to maintain calibration, the volatilization rate was adjusted.

For bounding calculation BC2 (greater response to remediation) the parameters were adjusted in the opposite direction. The calibrated values for parameters used in BC1 and BC2, as well as those in the Base Case, are summarized in Table 1.

Table 1. Parameter sets used in BC1, BC2, and Base Case calibration for the PCB fate and transport model.

Parameters	Range	BC1	Base Case	BC2
Spring decay rate (yr^{-1})	0.04 – 0.09	0.04	0.06	0.09
Dilution factor α (NSB; dimensionless)	0.5 – 0.8	0.5	0.8	0.8
W_{bank} (NSB; mg/day)	Site-Specific	1	27	75
Sediment/water mass transfer coefficient (cm/day)	1 – 5	5	2	1
Volatilization (HLC; pa-m^3/mol)	2 – 25	5	5	7
Flow-PCB relationship at CBW during storms (scaling factor)	0.7 – 1.3	1.3	1	0.7

Calibration Uncertainty: Bioaccumulation Model

The response of fish PCB concentrations to remediation depends strongly on the relative contributions of PCBs from local sediments and from the water under low-flow conditions. This is because the planned remedial actions will have their most dramatic impacts on low-flow water column concentrations. Thus, feeding preferences for creek chub and longear sunfish were adjusted within the range of realistic diets to create one bounding calibration that responded more strongly to the selected remedy and one scenario that responded more weakly to the selected remedy.

BC1 was developed to show a relatively smaller response to the remedial action. Because the selected remedy primarily affects low-flow water column PCB concentrations, tying the fish diets strongly to benthic invertebrates, which feed in sediments that are not subject to remediation, was expected to result in a smaller impact on PCB concentrations in the fish and therefore a smaller response to the remedy. Feeding preferences for both fish species were assigned within realistic limits (Table 2). To bring the model results back into calibration, the terrestrial component also was adjusted within a realistic range.

Table 2. Fish diet used in BC1: sediment exposure maximized.

Species	Location	Season	Base Case Diet (Terr/WC/Sed %)	BC1 Diet (Terr/WC/Sed %)
Creek chub	B	Winter	60 / 25 / 15	30 / 30 / 40
		Summer	70 / 20 / 10	40 / 20 / 40
Creek chub	D	Winter/ Summer	10 / 60 / 30	10 / 40 / 50
Longear sunfish	D	Winter / Summer	0 / 40 / 60	0 / 20 / 80

BC2 was developed to produce a larger response to the remedy. Towards this end, the fish were specified to feed more strongly in the water column. Feeding preferences for both fish species were again assigned within realistic limits (Table 3) and calibration was achieved by adjusting the terrestrial component.

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Table 3. Fish diet used in BC2: water column exposure maximized.

Species	Location	Season	Base Case Diet (Terr/WC/Sed %)	BC2 Diet (Terr/WC/Sed %)
Creek chub	B	Winter	60 / 25 / 15	80 / 15 / 5
		Summer	70 / 20 / 10	85 / 10 / 5
Creek chub	D	Winter/ Summer	10 / 60 / 30	20 / 70 / 10
Longear sunfish	D	Winter / Summer	0 / 40 / 60	10 / 60 / 30

Future Condition Uncertainty: Hydrology

Because most of the spring flow is collected and treated by the STF during low flow periods, the uncertainty analysis for future hydrology focused on the number of times that total system flows are projected to exceed the a high flow criteria that results in water bypassing the STF. That high flow was defined as 800 gpm for total system flow, which represents the sum of 300 gpm (used to define storm conditions at CBW in the model; see Section 3.2.1.1.2 of QEA 2007) and the existing 500 gpm STF capacity for the selected management scenario. Cumulative probability plots of the total system flow data are presented in Figure 1 for years 2001 through 2004. In 2001 and 2002, 800 gpm was exceeded 13% and 12% of the time, respectively. The flow records for these two years were selected to represent the higher flow years. In the bounding calculations, the flows from those two years were repeated for the entire 20-year period. In 2003 and 2004, 800 gpm was exceeded 10% and 6% of the time, respectively. These two years were selected to represent lower flow years. These flows were repeated for the entire 20-year projection period[1].

Results

Calibration Uncertainty

Figure 2 shows PCB concentrations in the water column at CBVP (fish sampling Location B) and RCVP (fish sampling Location D) computed by the model over the 2001 to 2005 calibration period for the Base Case, BC1, and BC2 parameter sets. Compared to the Base Case, the water column PCB concentrations are generally higher for BC1 during storms and lower under low-flow conditions, except after June 24, 2005, when PCB loads from the bank were eliminated due to temporary relocation of the STF effluent (QEA 2007). This period posed a constraint for the calibrated volatilization rate and sediment/mass transfer coefficients. Water column concentrations generally exhibit less variability for BC2 at CBVP mostly due to the smaller scaling factor (0.7) that was applied for the flow-PCB relationship at CBW during storms and a

[1] Flow data in 2005 were not used in the future condition uncertainty analysis due to incomplete flow records.

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faster spring decay rate (0.09 yr^{-1}). At RCVP, PCB concentrations for BC1 are higher during storms but generally lower than the Base Case due to a lower PCB load from NSB, whereas PCB concentrations for BC2 are lower during storms but higher during low flow at RCVP.

Figure 3 shows a comparison of projected annual average water column PCB concentrations for BC1, BC2, and the Base Case. As expected, higher water column PCB concentrations were computed for BC1 and lower concentrations were computed for BC2 at both CBVP and RCVP. The decrease in annual average water column PCBs, from the end of the calibration (2005) to the end of the projection period (Year 20), were approximately 36%, 26%, and 19% for BC1, Base Case, and BC2, respectively at CBVP; and 44%, 30%, and 19% for BC1, Base Case, and BC2, respectively at RCVP.

Bioaccumulation model results for creek chub and longear sunfish at Conard's Branch Location B and Richland Creek Location D for the two bounding calibrations straddle the Base Case calibration (Figure 4).

Projected fish PCB concentrations for BC1, Base Case, and BC2 are presented in Figures 5a through 5c for the three location/species combinations simulated by the model. As anticipated, fish PCB concentrations for projection BC1, with a weaker response to remediation and a stronger sediment tie, remain higher than the Base Case, while concentrations for the BC2 projection, with a stronger response to remediation and feeding more strongly tied to the water column, were lower.

The model projections were compared with ecological LOAEL (horizontal dashed lines in Figure 5; 2.3 ppm for Conard's Branch and 0.9 ppm for Richland Creek). Average PCB concentrations over the period from year 6 through year 10 were:

- 3.74 mg/kg for BC1 and 1.05 mg/kg for BC2 for creek chub at Conard's Branch,
- 0.62 mg/kg for BC1 and 0.31 mg/kg for BC2 for creek chub at Richland Creek, and
- 0.50 mg/kg for BC1 and 0.29 mg/kg for BC2 for longear sunfish at Richland Creek.

Rates of decline of PCB concentrations in each fish species for the 20-year projection period are presented in Table 4. As expected, the rates of decline were higher for BC2 and less for BC1.

Table 4. Rates of decline in fish concentrations for the 20 year projection period: model parameter uncertainty

Species	Location	Base Case (yr^{-1})	BC1 (yr^{-1})	BC2 (yr^{-1})
Creek chub	B	0.037	0.025	0.045
Creek chub	D	0.033	0.027	0.051
Longear Sunfish	D	0.022	0.022	0.032

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Future Condition Uncertainty

Figure 6 shows a comparison of model-simulated annual average water column PCB concentrations under three different flow conditions: the Base Case (repeating flows from 2001-2005); higher flow years (repeating flows from 2001-2002); and lower flow years (repeating flows from 2003-2004). Annual average water column PCB concentrations were generally higher in the higher flow simulation than in the lower flow simulation due the positive relationship between PCB concentrations and flow during storm conditions. The differences between the simulations were approximately 20% at CBVP and were slightly higher (30%) at RCVP, because PCB concentrations in the waters of Richland Creek are more sensitive to storm PCB loads than Conard's Branch (see Section 4.1.1 of QEA 2007).

Model projection results for fish tissue concentrations under the two alternate hydrological conditions are plotted in Figure 7, using the base case model parameter values. PCB concentrations tended to be lower for the lower flow case and higher than the higher flow case, although differences were fairly small. Calculated rates of decline over the 20 year projection period were similar for the three simulations (Table 5).

Table 5. Rates of decline in fish concentrations for the 20 year projection period: uncertainty in future hydrology

Species	Location	Base Case (yr^{-1})	Higher flow (yr^{-1})	Lower flow (yr^{-1})
Creek chub	B	0.037	0.037	0.035
Creek chub	D	0.033	0.034	0.029
Longear Sunfish	D	0.022	0.022	0.019

Conclusions

The model uncertainty analysis presented here provides bounds on the projected response of the Neal's Landfill system to the selected remediation. The alternative calibrations and their associated projections are considered less likely, but possible, outcomes for this site.

References

Brunner, S., E. Hornung, H. Santi, E. Wolff, O.G. Piringer, J. Altschuh, and R. Brüggemann, 1990. Henry's Law constants for polychlorinated biphenyls: experimental determination and structure-property relationships. *Environ. Sci. Technol.* 24:1751:1754.

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Quantitative Environmental Analysis, LLC, 2007. *Development, Calibration, and Application of a Mathematical Model of Surface Water PCB Fate, Transport, and Bioaccumulation at the Neal's Landfill Site, Bloomington, IN.* Prepared for CBS Corporation, March 2007.

Thibodeaux, L.J. and V.J. Bierman, 2003. The bioturbation-driven chemical release process. *Environ. Sci. Technol.* 37(13):252A-258A.

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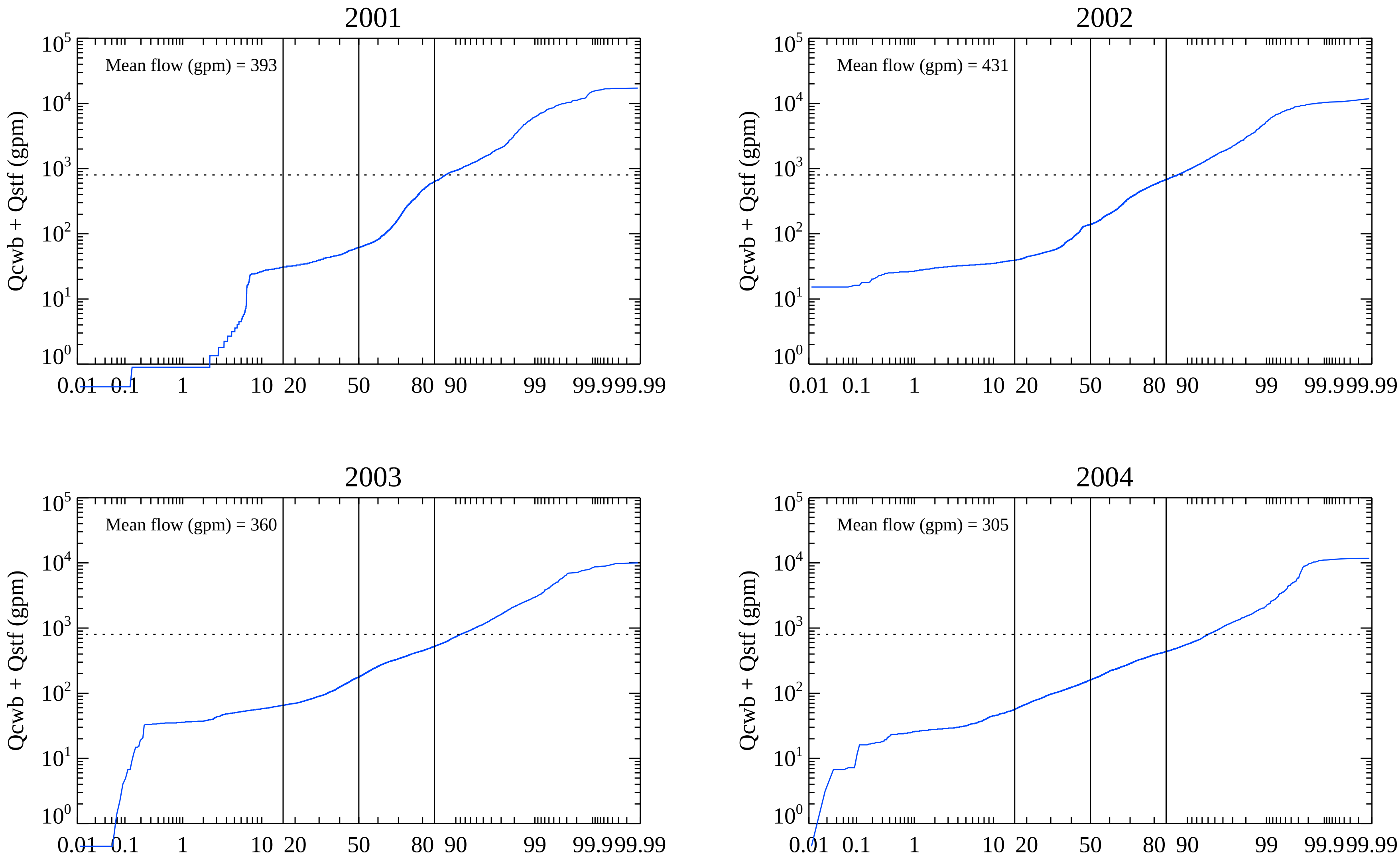

Figure 1. Probability plot of total system flow by year during 2001 and 2004.

Notes: Dashed line represents the storm flow criteria (800 gpm) used in the current analysis; flow records in 2004 are incomplete.

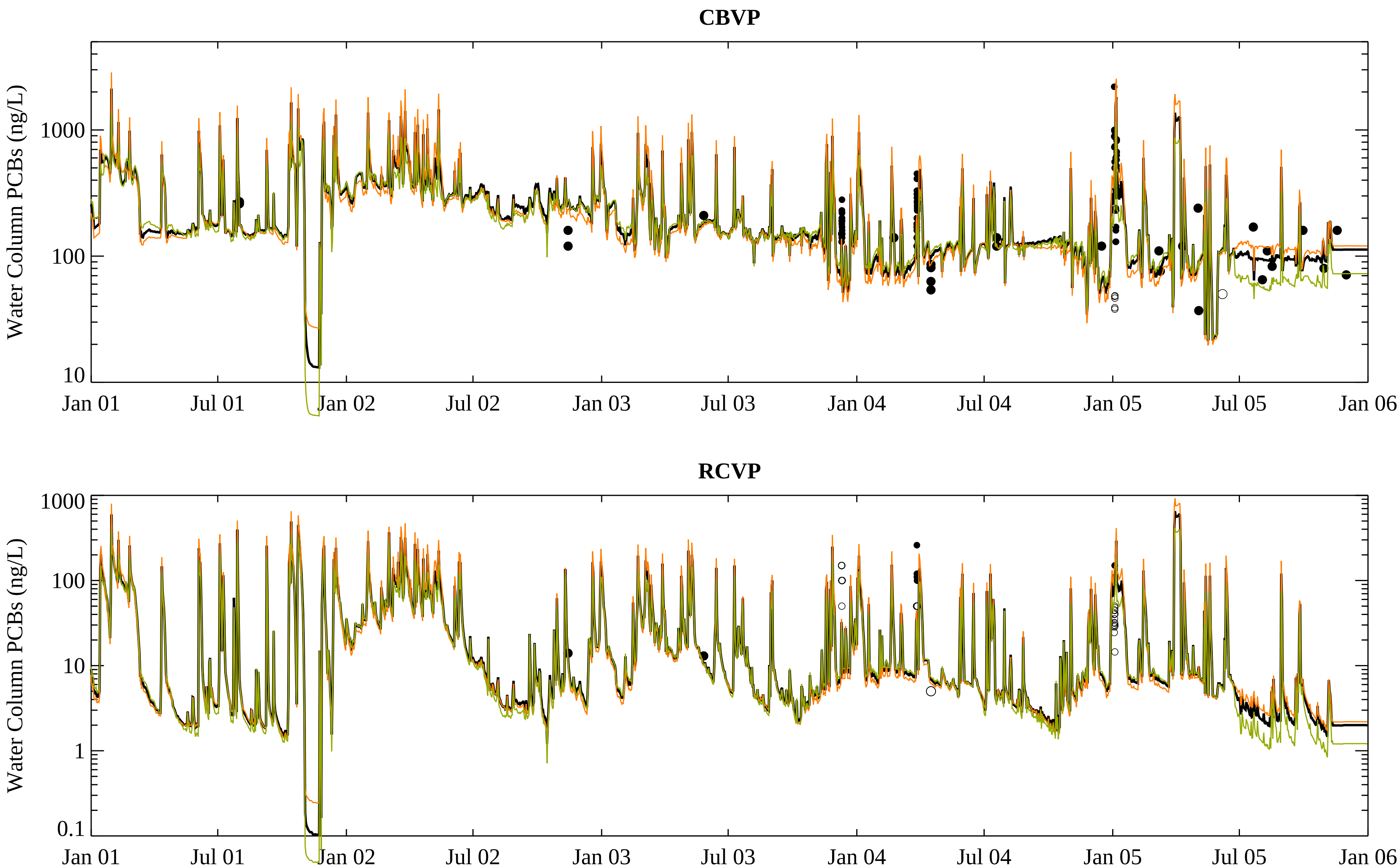

Figure 2. Alternative calibration: Observed and computed PCB concentrations in the water column at CBVP and RCVP.

Base Case
BC1
BC2

Note: Non-detect PCBs plotted as open symbols at 1/2MDL.
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BC2: \\legolas\d_drive\VIAnea\model\outputs\calibrate\runs\run65\run65h

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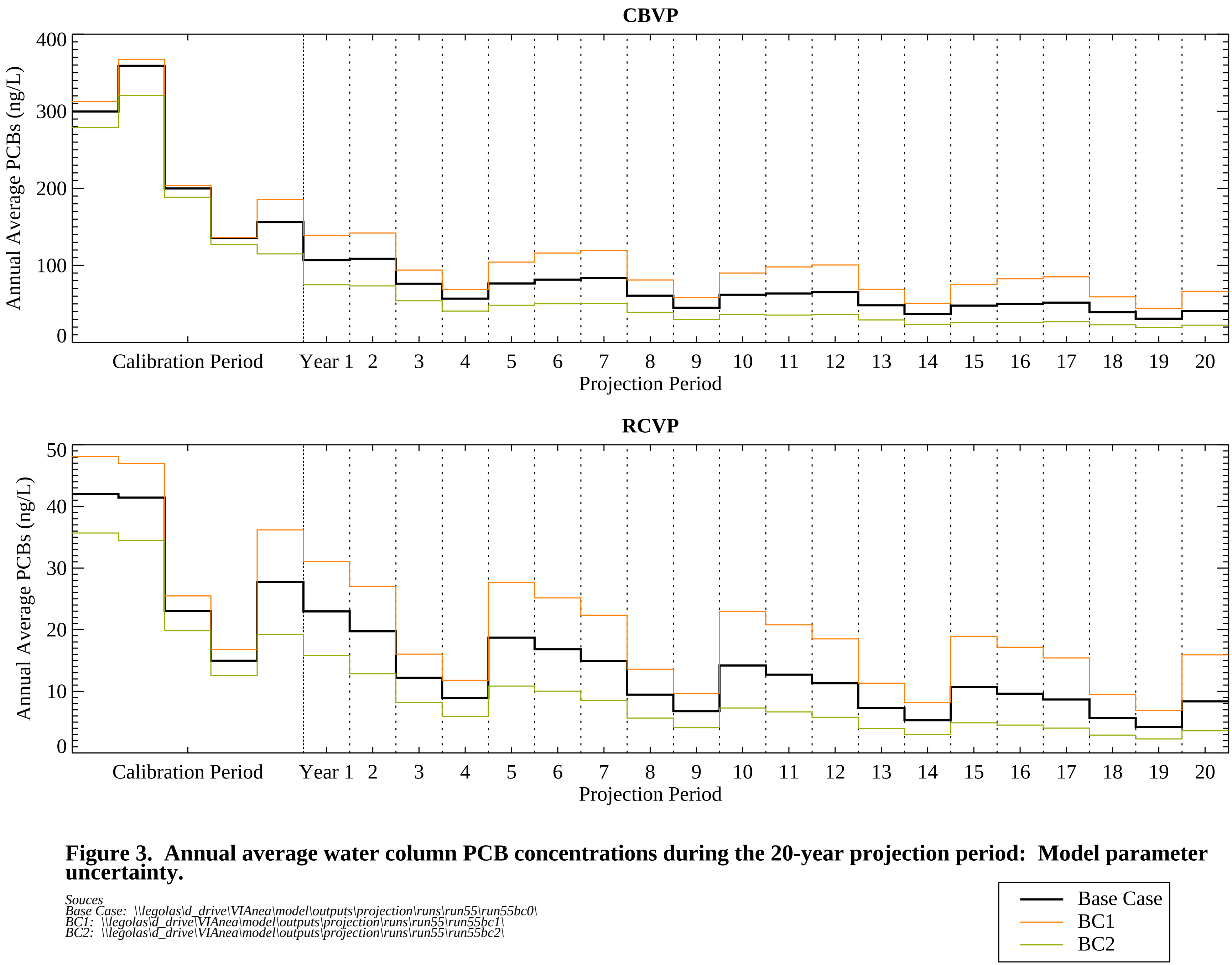

Figure 3. Annual average water column PCB concentrations during the 20-year projection period: Model parameter uncertainty.

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BC1: \\legolas\d_drive\VIAnea\model\outputs\projection\runs\run55\run55bc1
BC2: \\legolas\d_drive\VIAnea\model\outputs\projection\runs\run55\run55bc2

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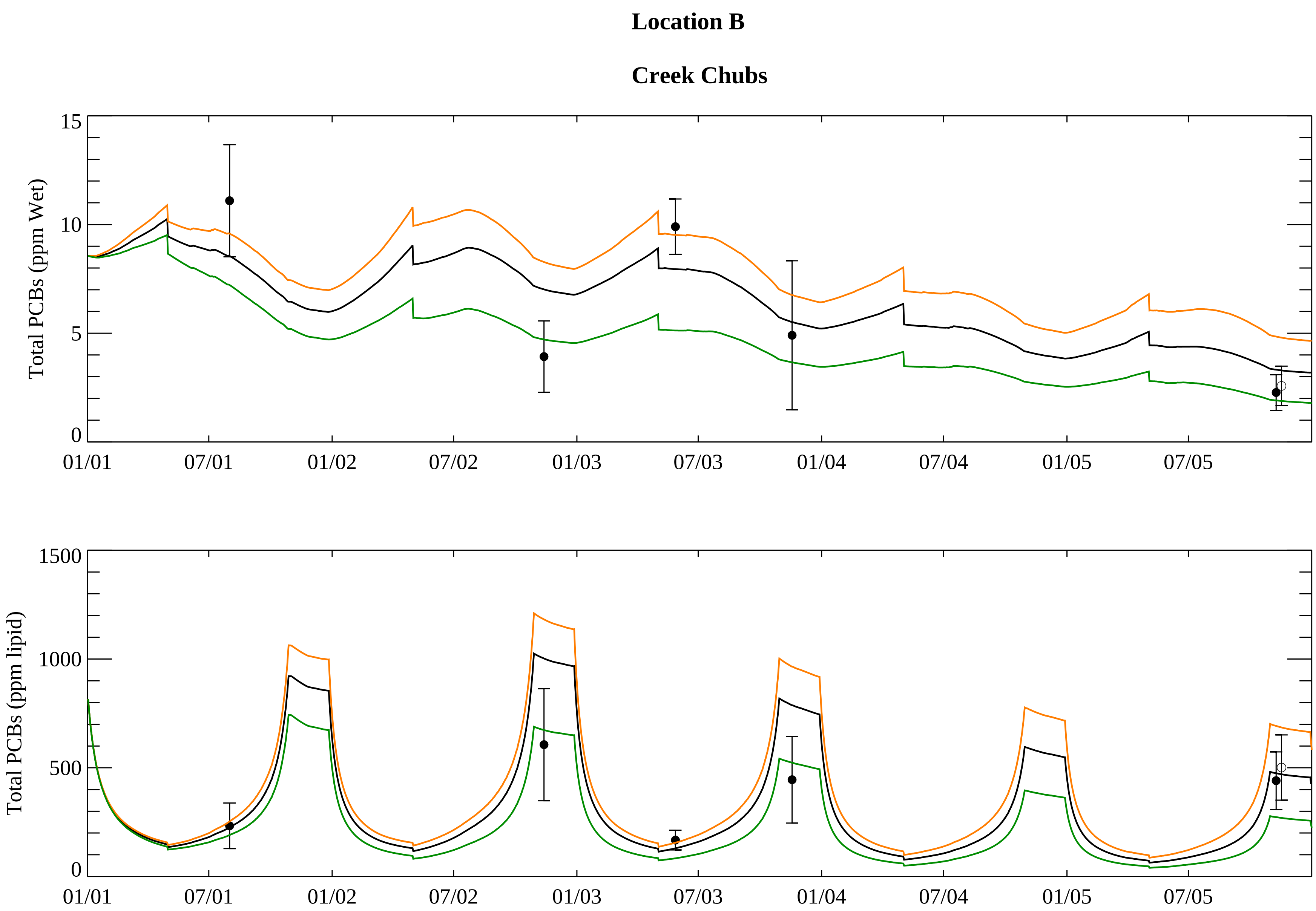

Figure 4a. Alternative calibration: Observed and computed PCB concentrations in creek chubs at Location B.

Note: 2005 data plotted on 11/9/2005.
Congener PCB data shown; open symbols represent ES Recovery adjusted values (offset to view).
Data plotted as mean +/- 2SE.
Model output is average of ageclass 2,3, and 4.
Model runs shown: runD90,PR53,and PR57

Calibration
BC1, sediment tie
BC2, water column tie

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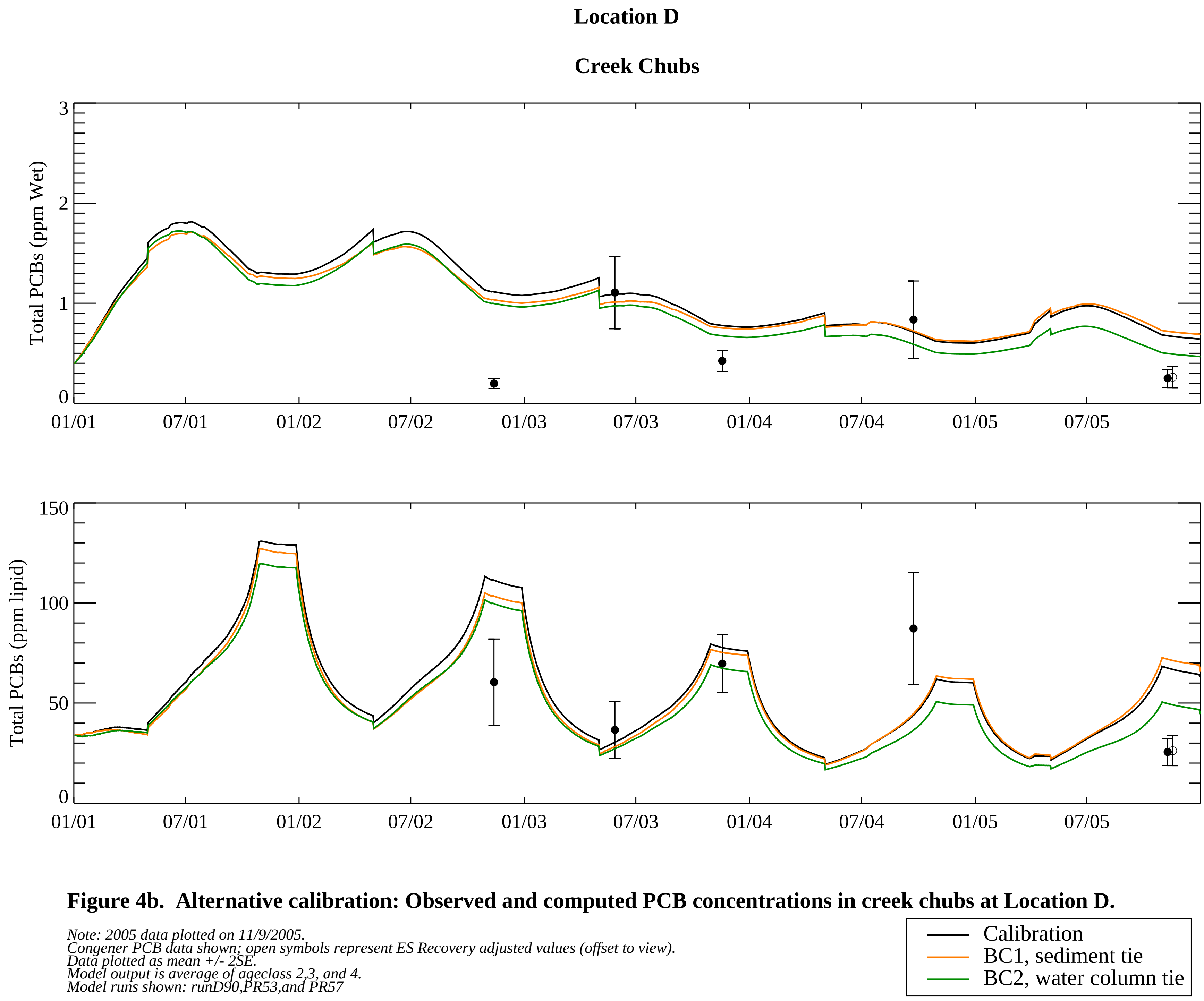

Figure 4b. Alternative calibration: Observed and computed PCB concentrations in creek chubs at Location D.

Note: 2005 data plotted on 11/9/2005.
Congener PCB data shown; open symbols represent ES Recovery adjusted values (offset to view).
Data plotted as mean +/- 2SE.
Model output is average of ageclass 2,3, and 4.
Model runs shown: runD90,PR53,and PR57

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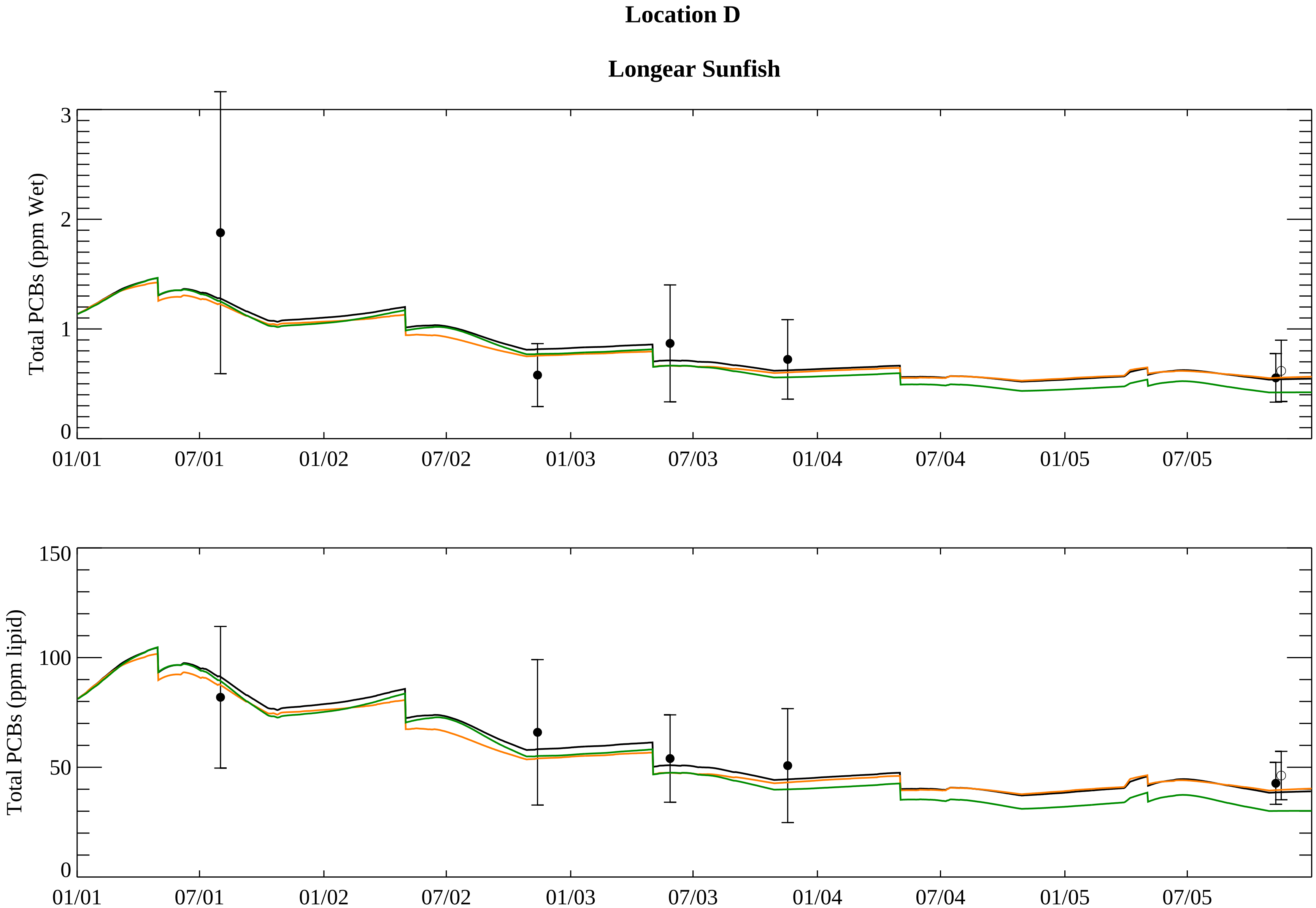

Figure 4c. Alternative calibration: Observed and computed PCB concentrations in longear sunfish at Location D.

Note: 2005 data plotted on 11/9/2005.
Congener PCB data shown; open symbols represent ES Recovery adjusted values (offset to view).
Data plotted as mean +/- 2SE.
Model output is average of ageclass 2,3, and 4.
Model runs shown: runD90,PR53,and PR57

Calibration
BC1, sediment tie
BC2, water column tie

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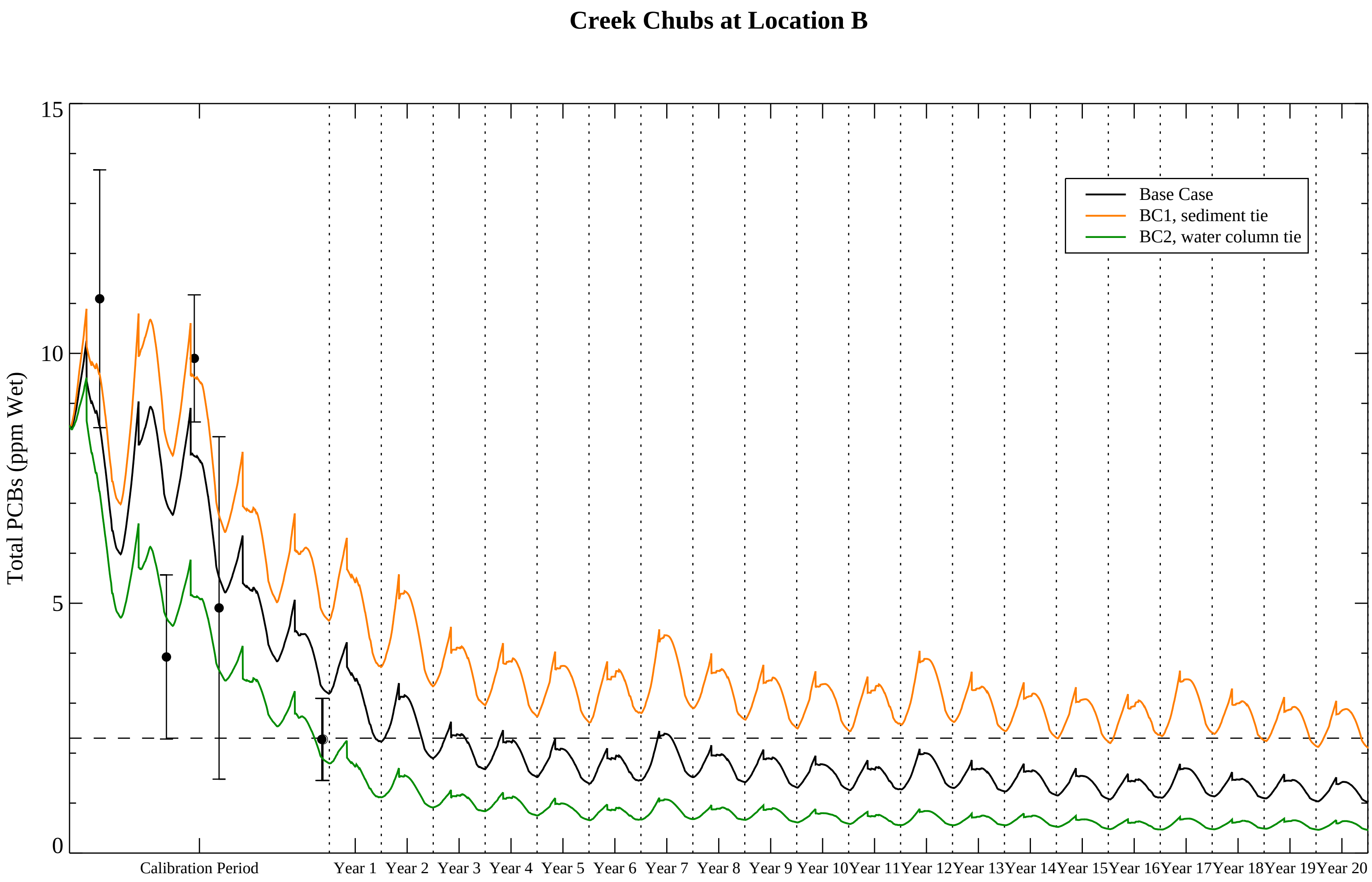

Figure 5a. PCB concentrations in creek chubs during the 20-year projection period: model parameter uncertainty.

Note: 2005 data plotted on 11/9/2005.Open symbols represent ES Recovery adjusted values (offset to view).
Data plotted as mean +/- 2SE.
Model output is average of ageclass 2,3, and 4.Dashed line at 2.30 represents the LOAEL for mink at location B.

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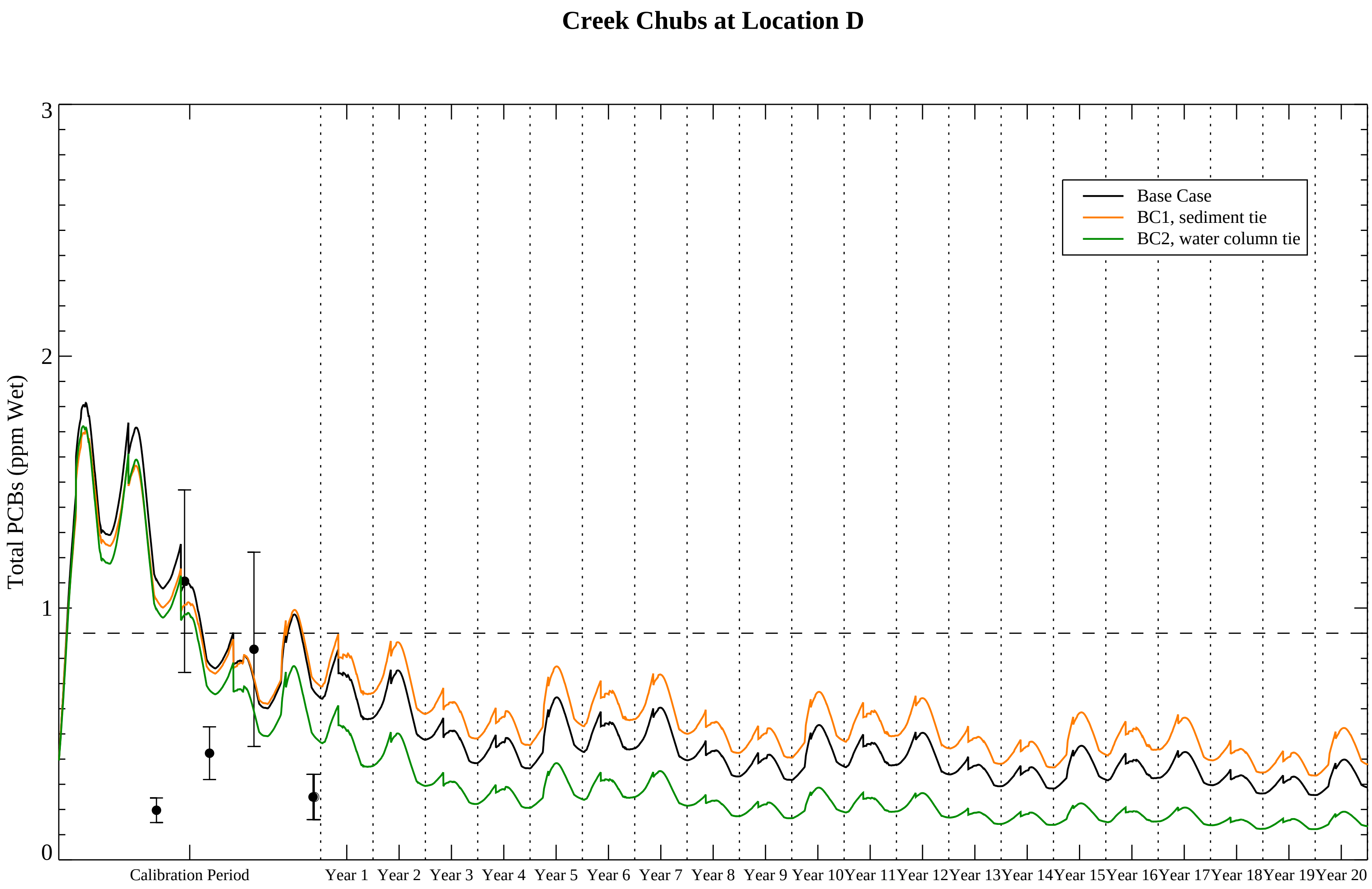

Figure 5b. PCB concentrations in creek chubs during the 20-year projection period: model parameter uncertainty.

Note: 2005 data plotted on 11/9/2005.Open symbols represent ES Recovery adjusted values (offset to view).
Data plotted as mean +/- 2SE.
Model output is average of ageclass 2,3, and 4.Dashed line at 0.90 represents the LOAEL for mink at location D.

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Longear Sunfish at Location D

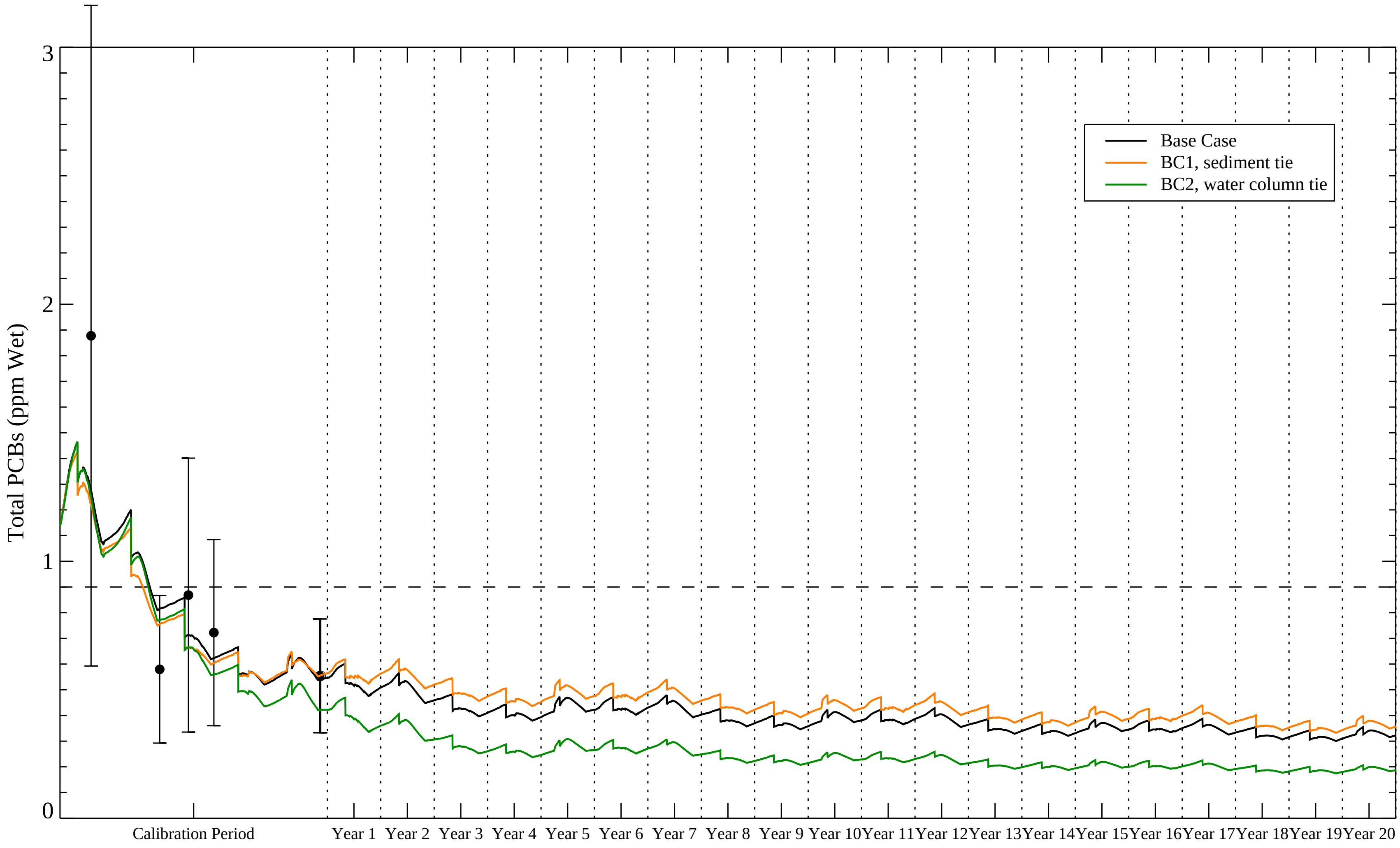

Figure 5c. PCB concentrations in longear sunfish during the 20-year projection period: model parameter uncertainty.

Note: 2005 data plotted on 11/9/2005.Open symbols represent ES Recovery adjusted values (offset to view).
Data plotted as mean +/- 2SE.
Model output is average of ageclass 2,3, and 4.Dashed line at 0.90 represents the LOAEL for mink at location D.

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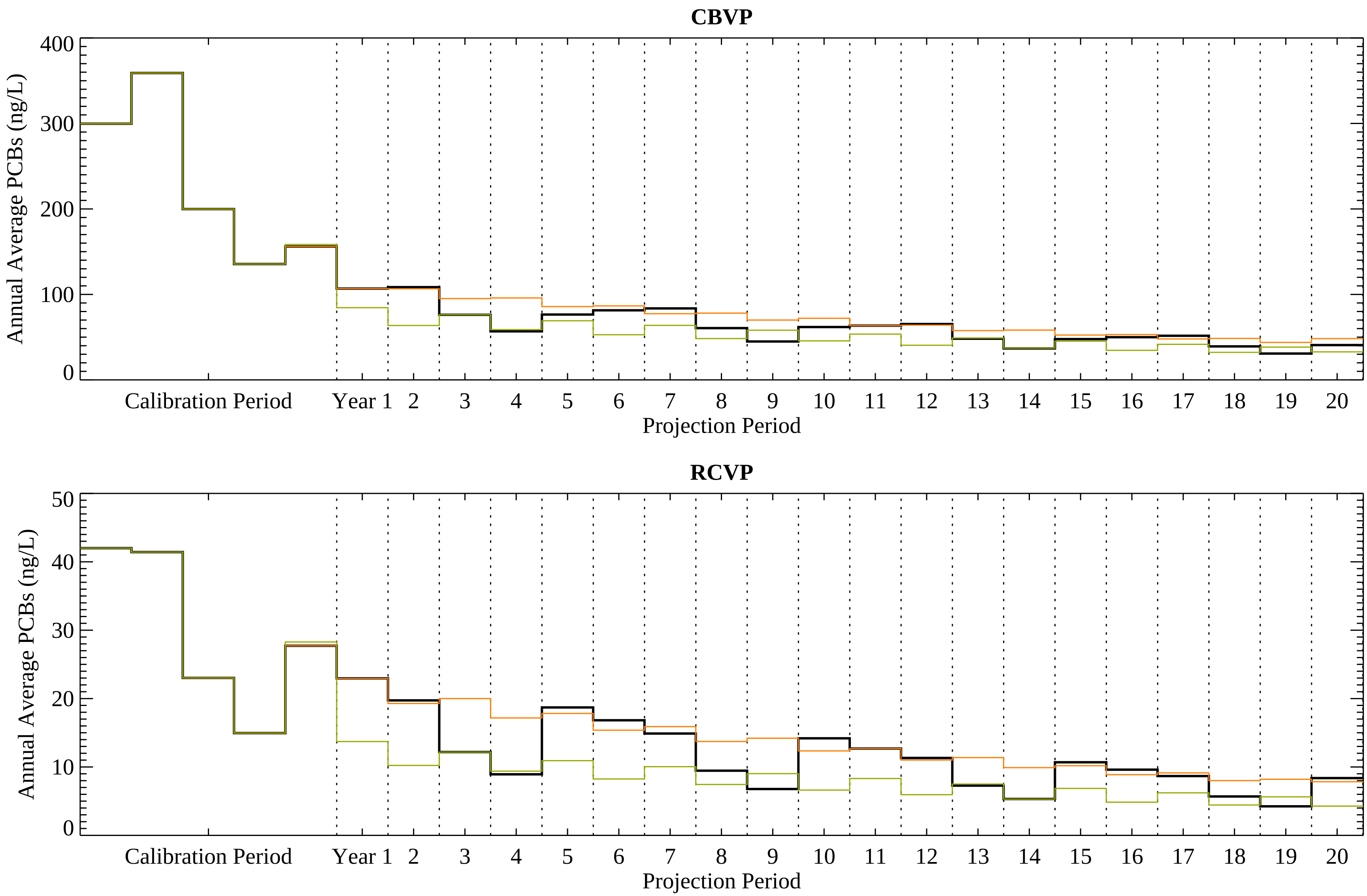

Figure 6. Annual average water column PCBs during 20-year projection period: Uncertainty in hydrology.

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Higher Flow Years: \\legolas\d_drive\VIAnea\model\outputs\projection\runs\run58\run58b

Base Case (2001-2005)
Higher Flow Years (2001-2002)
Lower Flow Years (2003-2004)

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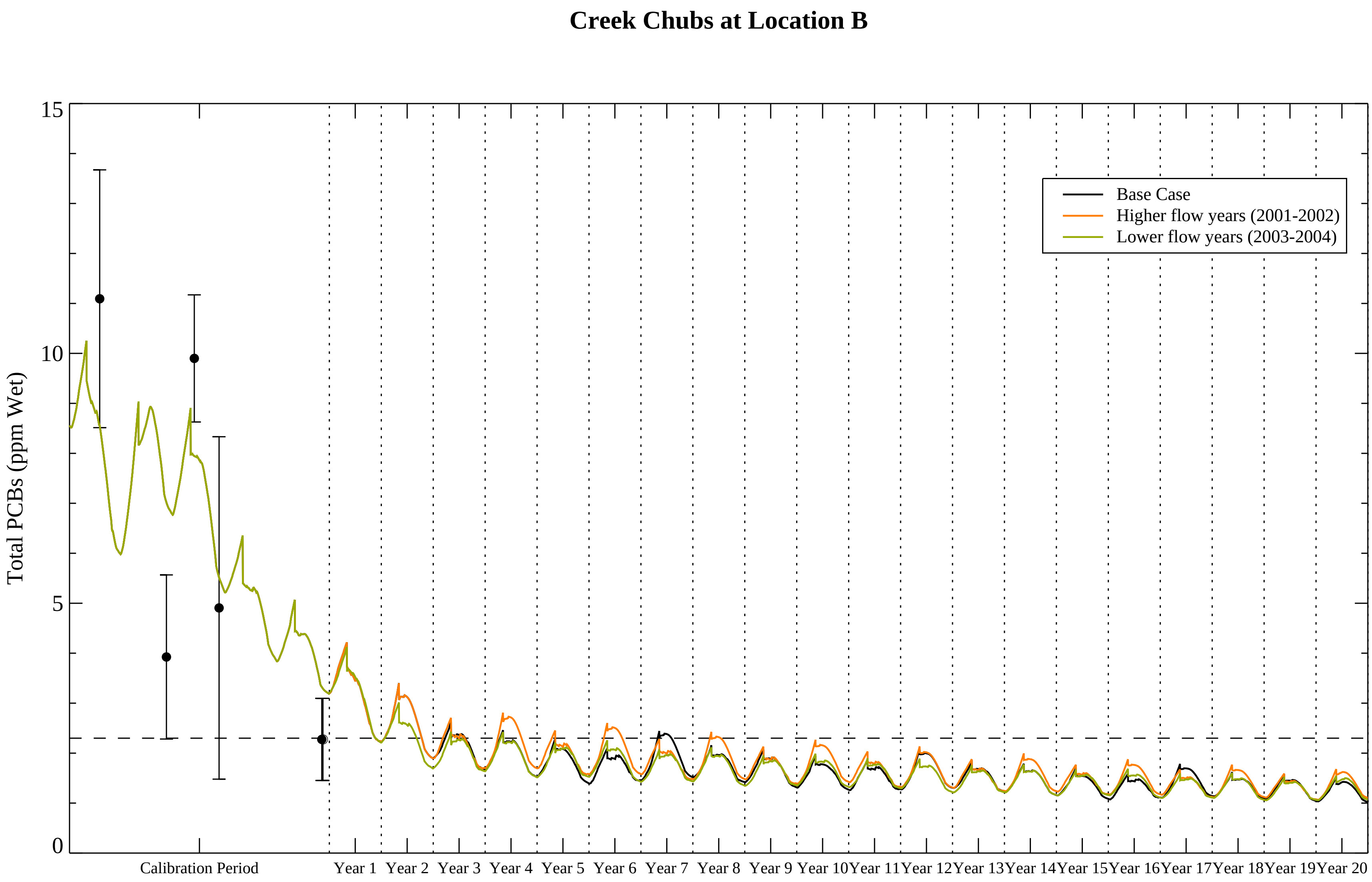

Figure 7a. PCB concentrations in creek chubs during the 20-year projection period: uncertainty in hydrology.

Note: 2005 data plotted on 11/9/2005.Open symbols represent ES Recovery adjusted values (offset to view).
Data plotted as mean +/- 2SE.
Model output is average of ageclass 2,3, and 4.Dashed line at 2.30 represents the LOAEL for mink at location B.

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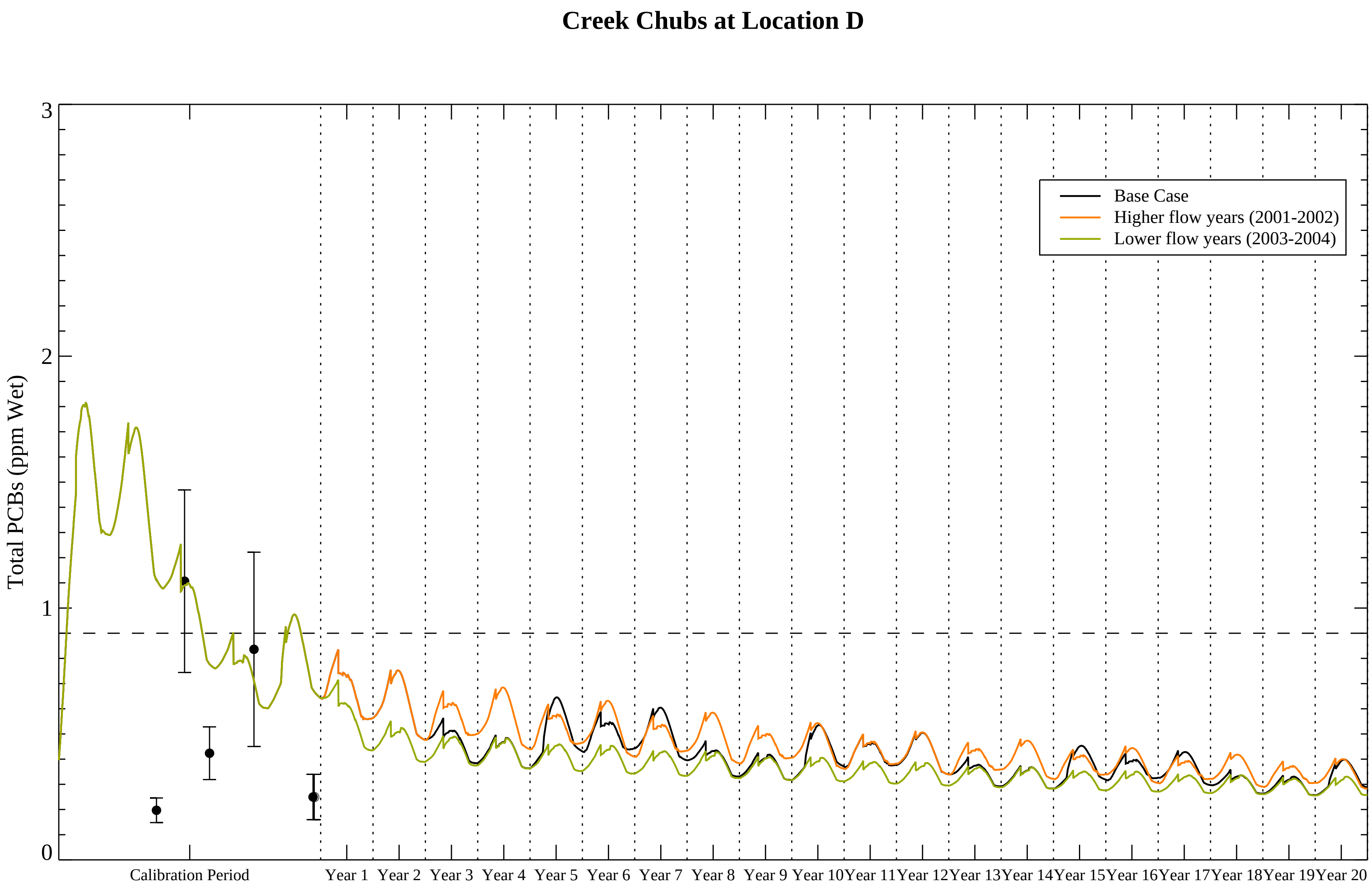

Figure 7b. PCB concentrations in creek chubs during the 20-year projection period: uncertainty in hydrology.

Note: 2005 data plotted on 11/9/2005.Open symbols represent ES Recovery adjusted values (offset to view).
Data plotted as mean +/- 2SE.
Model output is average of ageclass 2,3, and 4.Dashed line at 0.90 represents the LOAEL for mink at location D.

dr - V:\VIAnea\model\FDCHN\Analysis\Bounding_Calibration\Projections\projection_cc_plots_log.pro
Mon May 21 18:50:53 2007

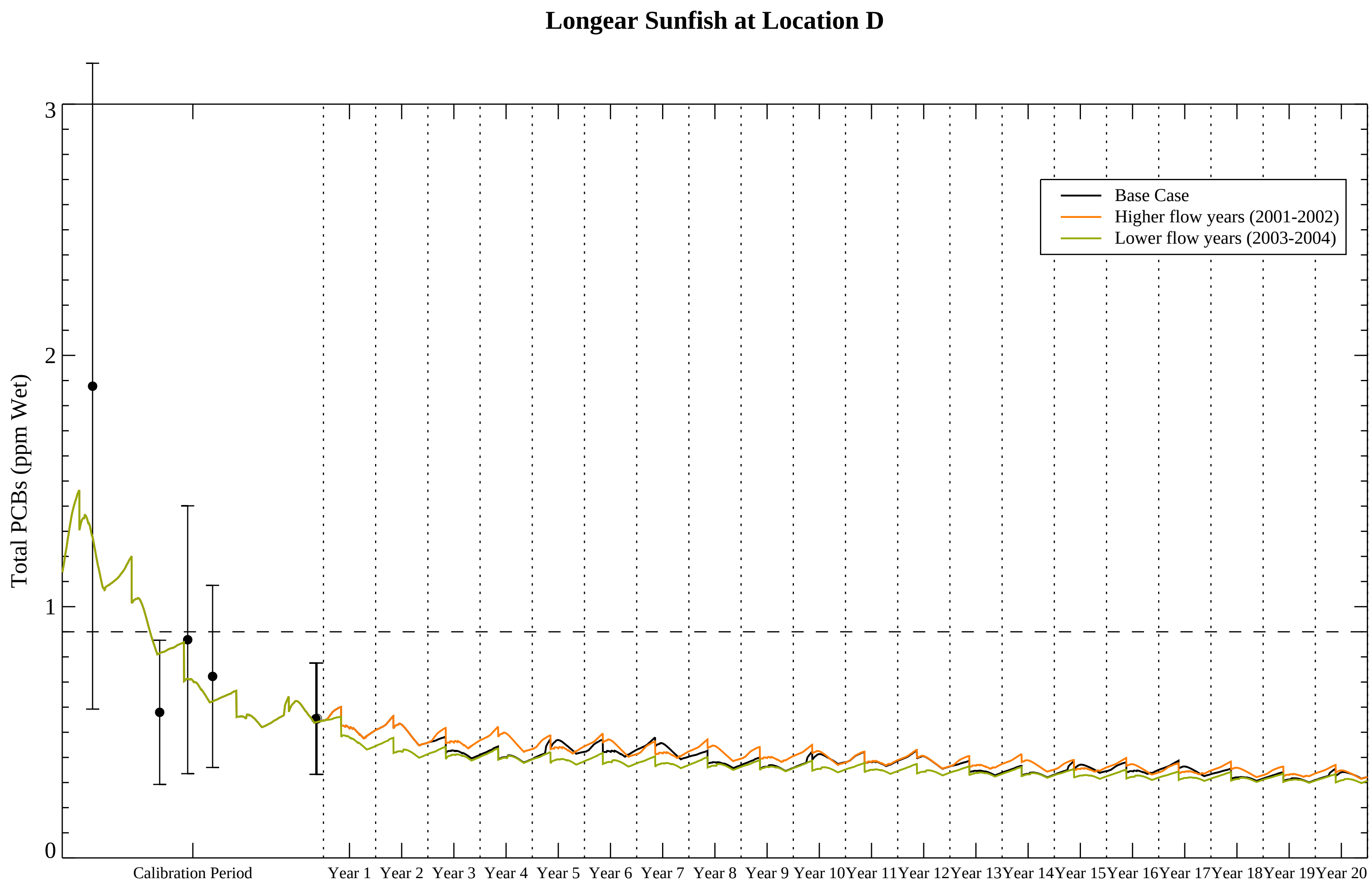

Figure 7c. PCB concentrations in longear sunfish during the 20-year projection period: uncertainty in hydrology.

Note: 2005 data plotted on 11/9/2005.Open symbols represent ES Recovery adjusted values (offset to view).
Data plotted as mean +/- 2SE.
Model output is average of ageclass 2,3, and 4.Dashed line at 0.90 represents the LOAEL for mink at location D.

dr - V:\VIAnea\model\FDCHN\Analysis\Bounding_Calibration\Projections\projection_cc_plots_log.pro
Mon May 21 18:54:15 2007