5.7 SENSITIVITY ANALYSIS

Sensitivity analyses were conducted to demonstrate the effects of variability in key modeling parameters. This type of analysis provides an indication of the impacts of various assumptions and calibration parameters.

The following parameters were selected for the sensitivity analysis:

ACQOP - the bacterial areal loading rate to land surfaces, in units of 10^6 org/acre/day. This is a key calibration parameter for washoff of bacteria from land surfaces during runoff conditions. It represents the cumulative daily loading of bacteria from a variety of potential sources, including wildlife and livestock, that is deposited on the land surface and subsequently available for washoff by runoff. Calibration values for ACQOP were developed for each land use category empirically during the calibration exercises. Values range from approximately 400 – 9000 10^6 org/acre/day in the model (see Table 5-4 for loading rates). Larger ACQOPs would represent larger numbers of bacteria deposited daily.

SQOLIM - the maximum accumulation of bacteria on the land surfaces, in units of 10^6 org/acre. This is a key calibration parameter that effects the washoff of bacteria from land surfaces during runoff conditions. It accounts for the decay of bacteria deposited on the land surface by establishing a maximum value that can be in place, available for washoff. Calibration values for SQOLIM were developed for each land use category empirically during the calibration exercises, and were set at three times the ACQOP. In effect, this limits the amount of bacteria available for washoff to three days of accumulation. A larger SQOLIM would mean that more bacteria are allowed to accumulate on the land surfaces.

FSTDEC - the first-order decay rate for bacteria, in units of 1/day. This is a key calibration parameter that effects bacteria numbers within the watercourse. It accounts for the decrease in bacteria numbers, or die-off, as they are transported downstream. The value used in calibration was 0.7 / day in the impaired reach. A larger decay rate would mean that bacteria die-off more rapidly.

WQSOP - the rate of surface runoff required to remove 90% of the bacteria accumulated on the land surfaces, in units of inches/hour. This is a key calibration parameter that effects the ability of deposited bacteria to be washed off the land surfaces during runoff conditions. It specifies the runoff rate and relates it to the ease with which bacteria are removed from the land surfaces. Two values for WQSOP were used in the calibration; a rate of 1.8 inches/hour was specified for PERLND (pervious) land surfaces, while a rate of 1.0 inches hour was specified for IMPLND (impervious) land surfaces. A larger WQSOP would mean that a larger runoff rate is needed to remove bacteria, in effect making it more difficult for the bacteria to wash off the surface.

Direct Nonpoint Sources - the contributions of bacteria directly to the receiving stream from wildlife, livestock, and leaking septic systems, in units of 10^6 org/day. This is a key source loading of bacteria in the modeling analysis under lower flow conditions, since this mechanism is not related to runoff. It was developed empirically during the calibration

exercises. A larger value for direct nonpoint source would mean a larger contribution from the various potential sources that contribute directly to the stream.

Proctor Lake Boundary Condition - the bacteria loading from the reservoir, in units of 10^6 org/day. This is a key source loading of bacteria in the modeling analysis, particularly under lower flow conditions. It was based upon data for releases from the reservoir provided by the USCE and historical monitoring data for bacteria at the station at Hwy 377-67, located approximately one mile downstream of the dam. A larger value would represent a higher concentration and therefore higher load from the reservoir.

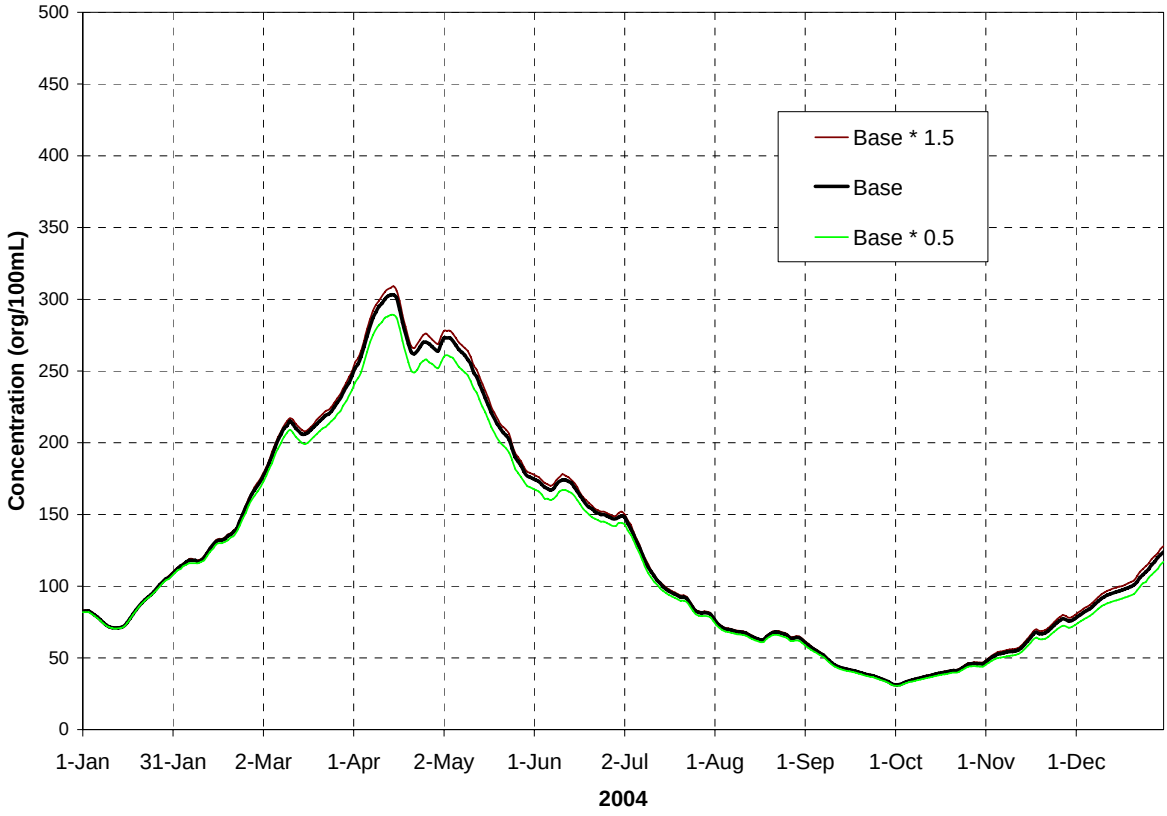
Each of the preceding parameters was analyzed individually at a level of plus or minus 50% of the base value. In this parlance, the base value is the calibrated set of model coefficients and parameter values. The ACQOP and SQOLIM were analyzed individually and, in addition, as a paired set of values where the inter-parameter ratio employed in the model was maintained. In other words, when ACQOP was varied by plus or minus 50%, the SQOLIM was varied accordingly, consistent with the fundamental assumption in the base case.

For each sensitivity condition, the model was rerun and results obtained as simulated daily bacteria concentrations for the period 2001 - 2004. To facilitate comparison of the results, the daily bacteria concentrations simulated at Hwy 281 were transformed to moving 91-day geometric mean values. Plots for each parameter are displayed in Figures 5-13 through 5-19. In these plots, only the geometric mean values for the year 2004 are presented in order to amplify the results.

In Figure 5-13 are shown the results for the sensitivity analysis on ACQOP. Variation of this parameter individually demonstrated relatively small differences in the results. The range of plus or minus 50% represents a reasonable range for ACQOP, but actual values could be much higher.

PARAMETER	UNITS	DEFINITION	VALUE IN CALIBRATION	RESULTS OF +/- 50% SENSITIVITY	INTERPRETATION
ACQOP	10^6 org/ac/d	Bacterial areal loading rate	400-9000, depending on land use category	Relatively small differences in results; simulated instream bacteria concentration change less than 10% on geometric mean	Relates to bacteria washoff during runoff; cumulative loading of bacteria from wildlife, livestock to the land surface; +/- 50% could relate to total number of animals in the watershed

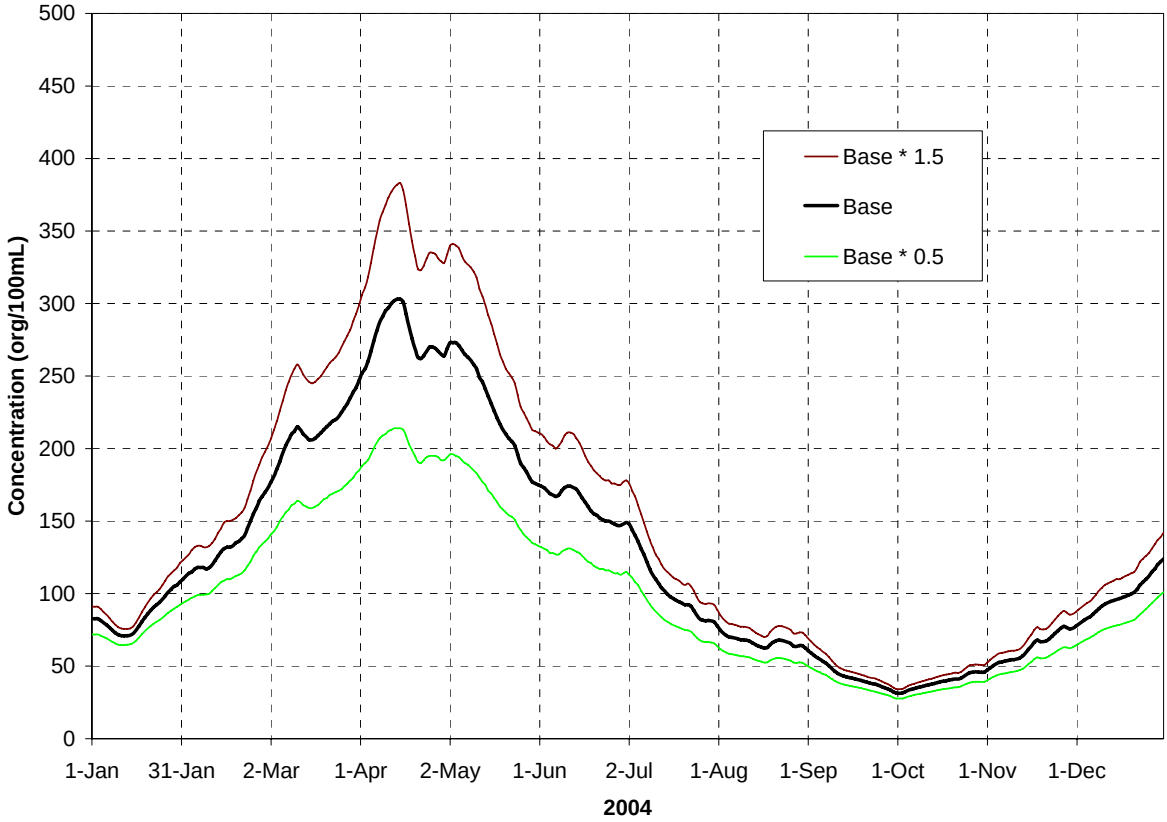
Figure 5-13: ACQOP Sensitivity Analysis, 91-Day Geometric Mean



The sensitivity analysis on SQOLIM is shown in Figure 5-14. Variation of this parameter individually showed a moderate amount of differences in the results, compared to the base case. The range of plus or minus 50% represents a reasonable range for SQOLIM, but actual values could be much higher.

PARAMETER	UNITS	DEFINITION	VALUE IN CALIBRATION	RESULTS OF +/- 50% SENSITIVITY	INTERPRETATION
SQOLIM	10^6 org/ac	Bacteria maximum accumulation	1200-27000, depending on land use category	Moderate differences in results; simulated instream bacteria concentration change 15-25% on geometric mean	Relates to bacteria washoff during runoff; maximum loading of bacteria from wildlife, livestock to the land surface that can accumulate; 3 days of accumulation base, so sensitivity looked at 1.5 – 4.5 days

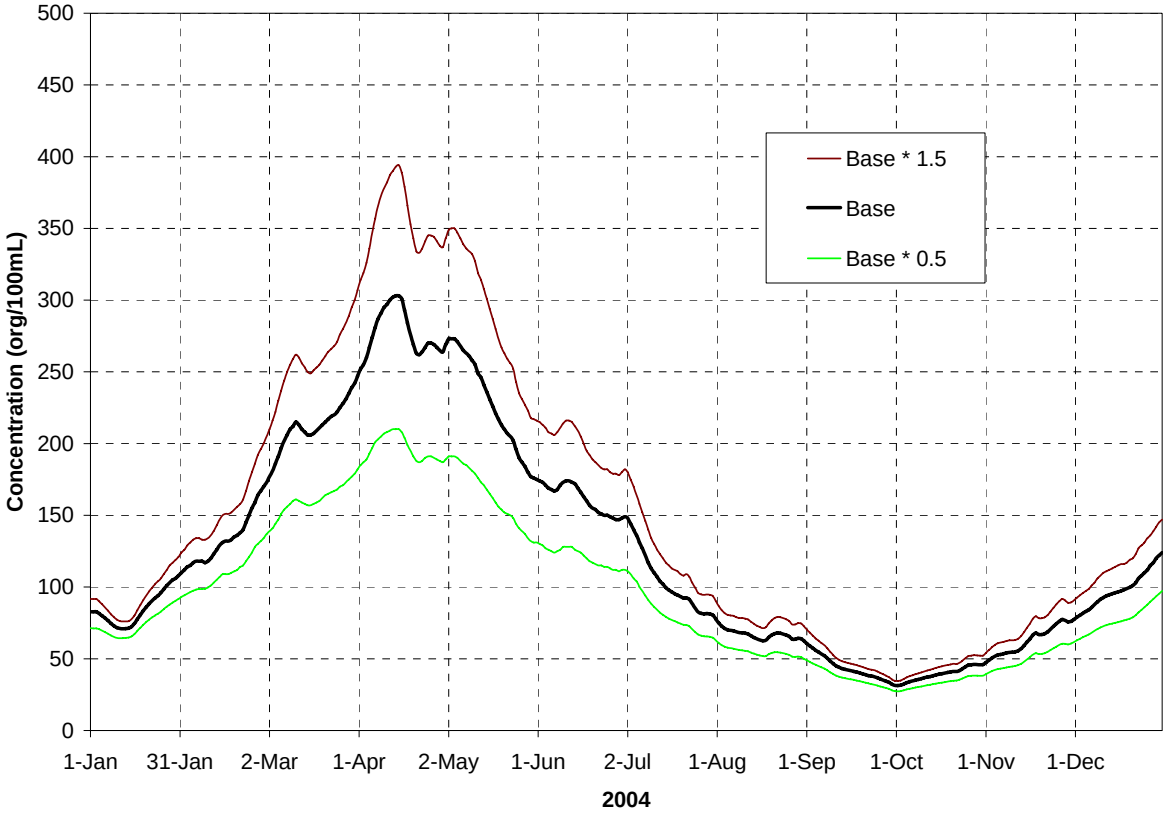
Figure 5-14: SQOLIM Sensitivity Analysis, 91-Day Geometric Mean



The sensitivity analysis on the paired combination of ACQOP and SQOLIM is shown in Figure 5-15. A moderate difference in results was demonstrated by variation of the paired parameters.

PARAMETER	UNITS	DEFINITION	VALUE IN CALIBRATION	RESULTS OF +/- 50% SENSITIVITY	INTERPRETATION
ACQOP & SQOLIM pair	10^6 org/ac/d and 10^6 org/ac	Bacterial areal loading rate and maximum accumulation	ACQOP at 400-9000; SQOLIM at 1200–27000 depending on land use category	Moderate differences in results; simulated instream bacteria concentration change 15-30% on geometric mean	Relates to bacteria washoff during runoff; cumulative loading of bacteria from wildlife, livestock to the land surface and maximum accumulation; +/- 50% change in the paired combination of the loading parameters

Figure 5-15: ACQOP & SQOLIM Sensitivity Analysis, 91-Day Geometric Mean



In Figure 5-16 are displayed the sensitivity results for FSTDEC. Variation of this parameter over a range of plus or minus 50% had a relatively large effect on the simulation results. The range of plus or minus 50% represents a reasonable range for the first-order decay coefficient in watercourses.

PARAMETER	UNITS	DEFINITION	VALUE IN CALIBRATION	RESULTS OF +/- 50% SENSITIVITY	INTERPRETATION
FSTDEC	1/day	Bacterial decay rate	0.7/day	Large differences in results; simulated instream bacteria concentration change 30-50%on geometric mean	Rate at which bacteria die off in the stream, after they are introduced by point or nonpoint sources; at rate of 0.7/d approx half die in one day

Figure 5-16: FSTDEC Sensitivity Analysis, 91-Day Geometric Mean

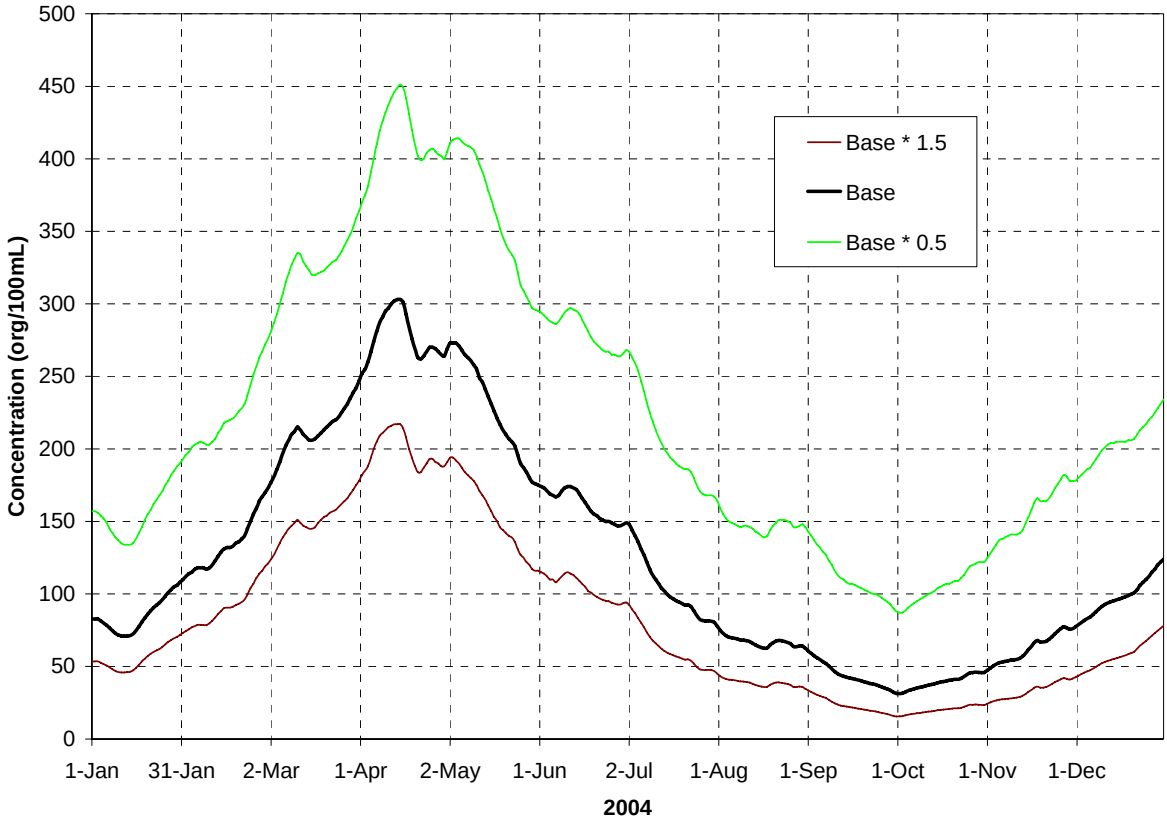
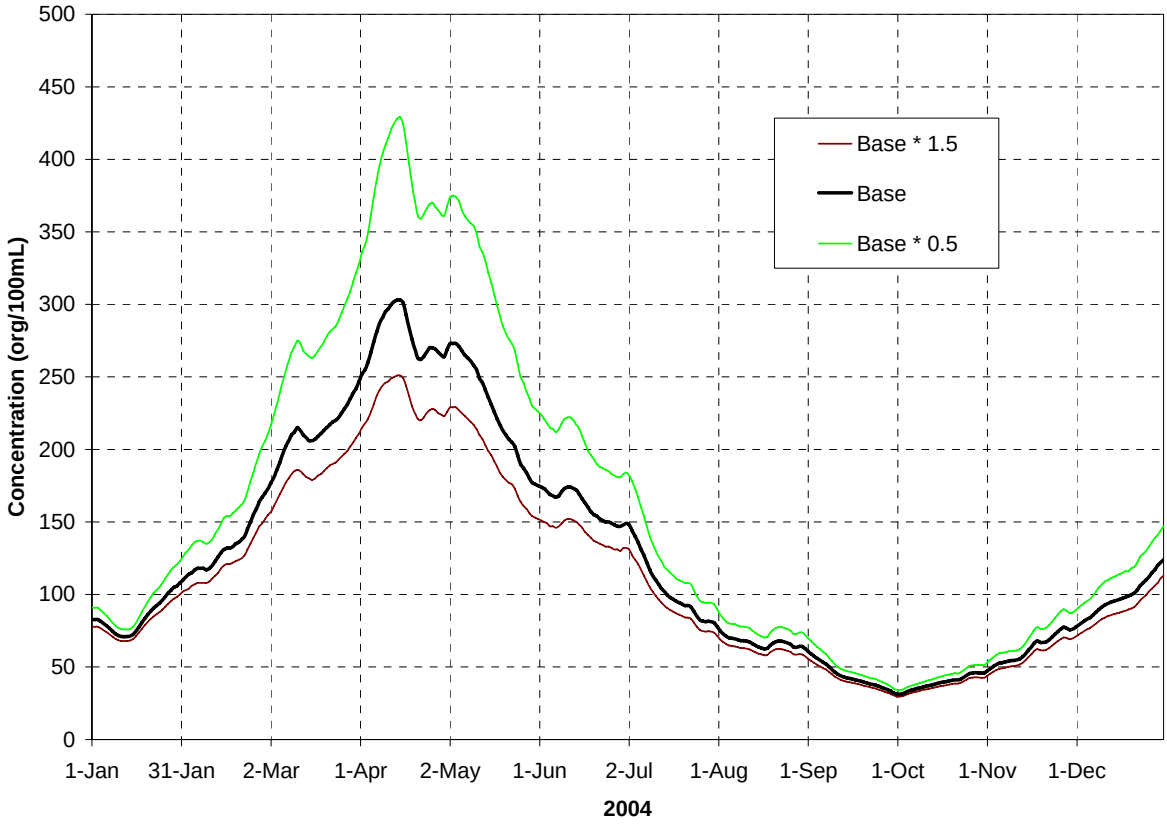


Figure 5-17 shows the results of the sensitivity analysis for WQSOP. Differences from variation of this parameter are relatively small to large in magnitude. The range of plus or minus 50% represents a reasonable range for the runoff rate.

PARAMETER	UNITS	DEFINITION	VALUE IN CALIBRATION	RESULTS OF +/- 50% SENSITIVITY	INTERPRETATION
WQSOP	In/hr	Surface runoff rate required to wash off 90% of bacteria mass	1.8 for pervious, 1.0 for impervious surfaces	Small to large differences in results; simulated instream bacteria concentration change 0-40%on geometric mean	Effects washoff of bacteria during runoff; larger WQSOP means that larger runoff rate is needed to wash off bacteria; the runoff rate in the model is usually low

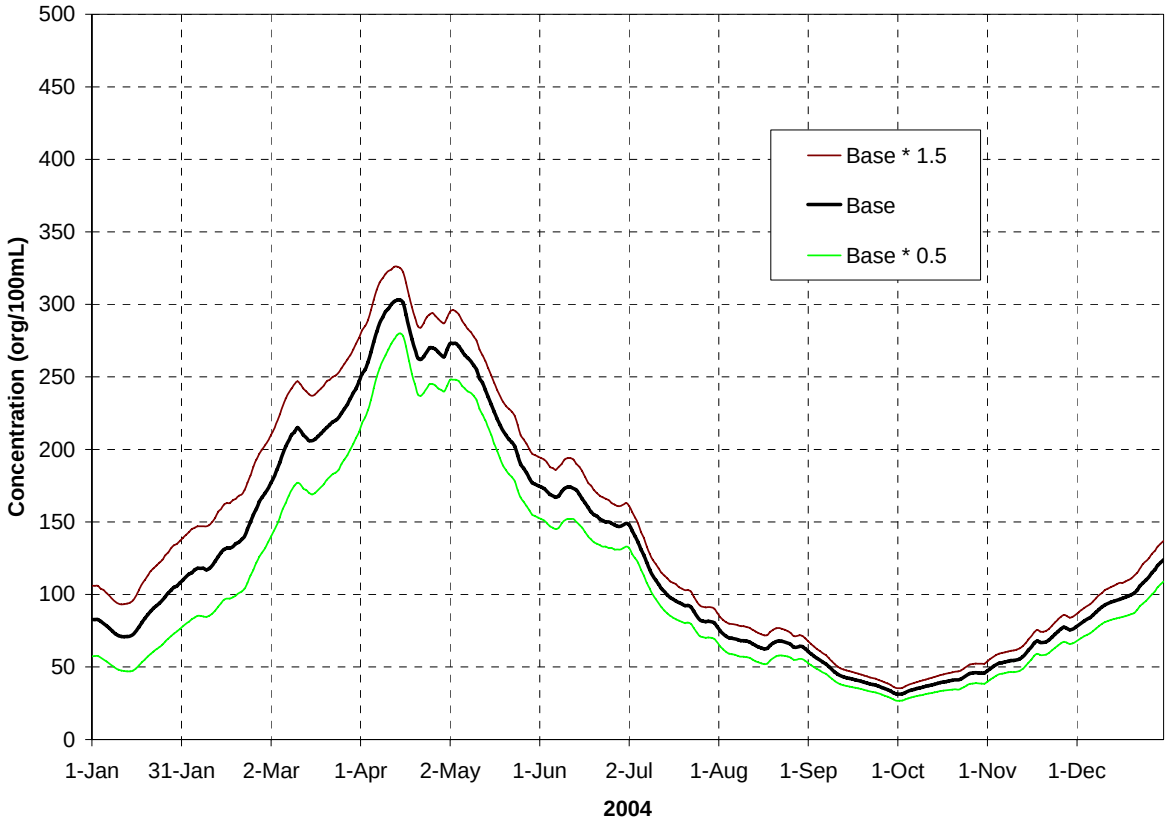
Figure 5-17: WQSOP Sensitivity Analysis, 91-Day Geometric Mean



Sensitivity to variation of direct nonpoint sources is illustrated in Figure 5-18. The observed effects of variation are relatively small. Actual values of direct nonpoint sources could vary by more than the tested range of plus or minus 50%, with potential values much higher.

PARAMETER	UNITS	DEFINITION	VALUE IN CALIBRATION	RESULTS OF +/- 50% SENSITIVITY	INTERPRETATION
Direct nonpoint sources	10^6 org/d	Direct bacteria concentrations to the stream	12000-144000 10^6 org/d, depending on reach	Relatively small differences in results; simulated instream bacteria concentration change 5-10% on geometric mean	Related to direct input of bacteria to stream from wildlife, livestock, septic systems, or sewage collection systems; not related to runoff

Figure 5-18: Direct NPS Sensitivity Analysis, 91-Day Geometric Mean



Effects of variation of the bacteria loading from Proctor Lake are shown in Figure 5-19. Variation of this parameter demonstrated a relatively small difference in results. The range of plus or minus 50% is probably a reasonable range for this source, though for short term releases values could be substantially higher.

PARAMETER	UNITS	DEFINITION	VALUE IN CALIBRATION	RESULTS OF +/- 50% SENSITIVITY	INTERPRETATION
Proctor Lake input	10^6 org/d	Bacteria contribution from lake releases	Average 260000 10^6 org/d	Relatively small differences in results; simulated instream bacteria concentration change 0-15% on geometric mean	Bacteria in releases from lake; +/- 50% has relatively small effect; input directly into stream

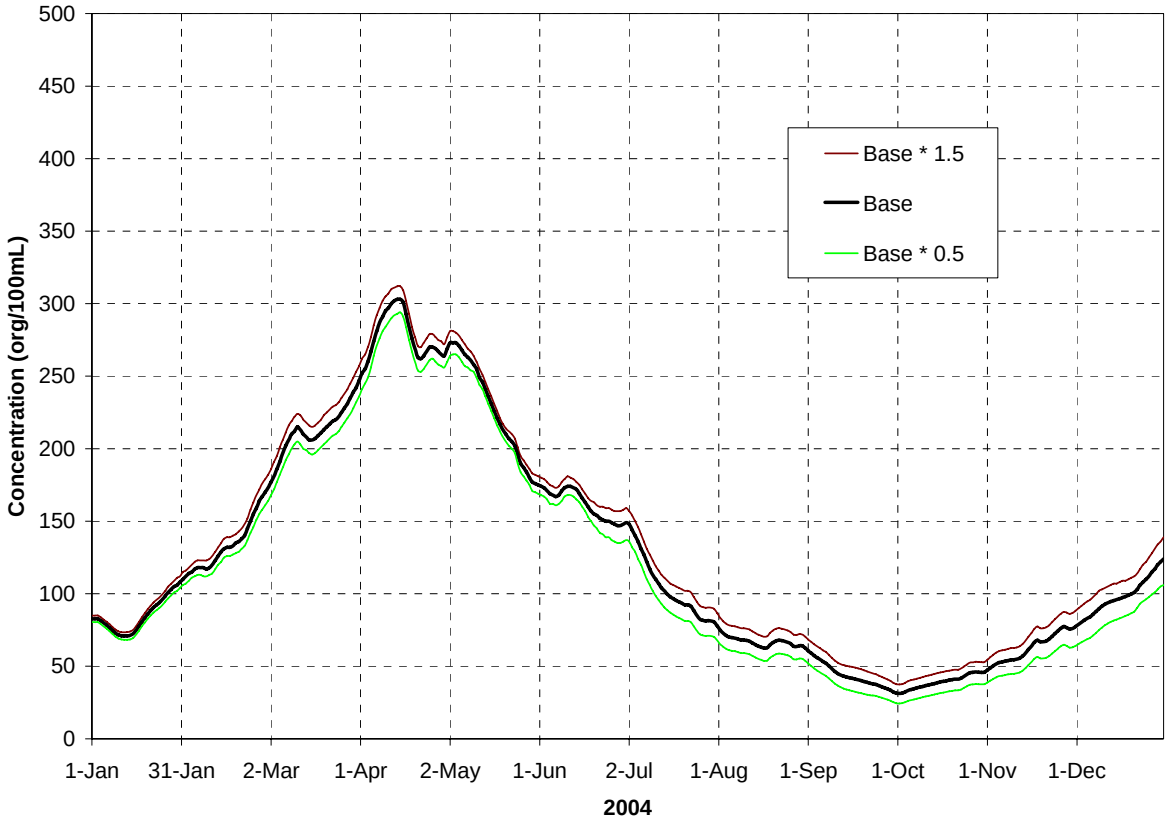



Figure 5-19: Proctor Lake Loading Sensitivity Analysis, 91-Day Geometric Mean