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# Sensitivity Analysis of the NorthMet Water Quality Models – Version 2

## *NorthMet Project*

Prepared for
Poly Met Mining Inc.

January 2015

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# Acronyms, Abbreviations, and Units

| Acronym | Description |
|---|---|
| | |
| FEIS | Final Environmental Impact Statement |
| FTB | Flotation Tailings Basin |
| LTVSMC | LTV Steel Mining Company |
| OSP | Ore Surge Pile |
| P10 | lower 10th percentile model result |
| P50 | median or 50th percentile model result |
| P90 | upper 90th percentile model result |
| RMSE | root mean square error |
| SDEIS | Supplemental Draft Environmental Impact Statement |
| WWTF | Waste Water Treatment Facility |
| WWTP | Waste Water Treatment Plant |
| USEPA | U.S. Environmental Protection Agency |

| unit | Description |
|---|---|
| cfs | cubic feet per second |
| gpm | gallons per minute |
| in/yr | inches per year |
| mg/L | milligram per liter |
| mm | millimeters |
| mm/day | millimeters per day |
| µg/L | micrograms per liter |

# 1.0 Introduction

This report has been prepared to consolidate various sensitivity analyses that have been performed for the NorthMet water quality models, both at the Mine Site and the Plant Site. The analyses included here are intended to address questions raised about the effect of various modeling assumptions on the outcomes presented in the Water Modeling Data Package, Volume 1 – Mine Site (Reference (1)) and Volume 2 – Plant Site (Reference (2)). Sections 2.0 through 6.0 were prepared based on analysis of Version 5.0 of the water quality models (Mine Site and Plant Site) prior to publication of the SDEIS. **All references to PolyMet data packages in Sections 2.0 through 6.0 are relative to the data package versions prepared for publication of the SDEIS.** Section 7.0 is based on analysis of Version 6.0 of the Mine Site water quality model and has been prepared to support publication of the FEIS.

Section 2.0 of this report includes the results of the detailed sensitivity analysis performed on nearly all uncertain inputs to the Mine Site model. The results of the screening-level analysis are presented in Section 2.2, and the results of the more detailed sensitivity analysis are presented in Section 2.3.

Sections 3.0 and 4.0 of this report document additional probabilistic model runs that have been performed at the request of the model review team. Section 3.0 examines the assumed distribution of background groundwater quality at the Mine Site, and Section 4.0 addresses the modeling of recharge to groundwater at the Plant Site.

Sections 5.0 and 6.0 of this report include the results of sensitivity analyses performed on the Mine Site and Plant Site water quality models to assess the effects of climate change on the model outcomes. These analyses were previously published in Reference (1) and Reference (2) and have been moved to this document without changes.

Section 7.0 of this report presents a sensitivity analysis of the Mine Site water quality model for the effects of higher-than-expected groundwater baseflow in the Partridge River.

# 2.0 Mine Site Detailed Sensitivity Analysis

The water quality model discussed here is a probabilistic model for the entire NorthMet Mine Site (Version 5.0 as documented in Reference (1)). The model performs a Monte Carlo simulation (uncertainty analysis) in which the uncertainty in many model inputs is explicitly included in calculating the model results. Because of the probabilistic model construct, most of the possible combinations of worst-case input values will be randomly included in each complete model simulation used for impacts analysis in the EIS.

The NorthMet Project Description has undergone significant revisions since the initial request for a sensitivity analysis was received from the U.S. Environmental Protection Agency (USEPA) in early 2012. Most significantly, the primary discharge of water from the Mine Site to the environment is now modeled as being via a mechanical Wastewater Treatment Facility (WWTF) in long-term closure. The treated water discharge accounts for more than 90% of the total flow of water leaving the Mine Site. The only other pathways for impacted water to leave the Mine Site are via groundwater flow paths, which eventually deliver water to the Partridge River. Due to the hydraulic properties of the geologic materials in the vicinity of the Mine Site, the travel time through the surficial aquifer flow paths to the river is estimated to be between 50 and 200 years, while travel time through bedrock to the river is estimated to be much greater than 200 years.

Because of the proposed engineering controls and the adaptive water management strategy, it is not expected that the modeled concentrations in the Partridge River would exhibit much sensitivity to most input variables for the Mine Site water quality modeling, except those inputs that control water quantity and quality from unimpacted portions of the watersheds. If this expectation is borne out in the sensitivity analysis, the results will be positive with respect to the potential for environmental impacts: this will indicate that as long as the engineering controls perform as planned and the adaptive water management strategy is able to achieve its objectives, there is little likelihood that a mischaracterized input variable would result in unforeseen environmental outcomes.

## 2.1 Sensitivity Analysis Background

A classic sensitivity analysis involves a series of deterministic simulations for which the "baseline value" is a simulation with all input variables held at their expected or median values. Key model inputs are varied one-at-a-time while all other model inputs are held constant. The results allow for an assessment of how sensitive the model outputs are to changes in the key inputs.

In order to assess model sensitivity to changes in the input variable values in a sensitivity analysis, a target model output is defined for each constituent and evaluation location combination. Example model outputs that are appropriate for this analysis are the maximum or average value of a modeled result (ex. concentration, flow, loading) for a particular constituent and location throughout the simulation, or the total cumulative value throughout a specified time period (ex. cumulative load, number of exceedances of a standard).

The target output must be selected with care so that it provides the most information relative to the goal of understanding the underlying model construct. Outputs that are very frequently zero (such as the total number of exceedances of a standard) are less valuable because they may show very low sensitivity for all input variables when the model is run in a deterministic simulation with most input variables held at their central (median) values.

The target outputs selected for this analysis are the maximum modeled concentrations of key constituents at specified evaluation locations over the entire 200-year model period. This provides information on the general effect of changes to the model inputs in the conditions at the evaluation locations. These outputs are the most relevant outputs for evaluation of water-quality standard compliance. The constituents analyzed are As, Cl, Co, Cu, Ni, Pb, Sb, Se, and $SO_4$. The evaluation locations for this analysis are SW004, SW004a, SW004b, SW005, and Colby Lake. The target output, constituents analyzed, and evaluation locations were discussed and agreed to by the Co-lead Agencies and the USEPA. The analysis was performed on the Version 5.0 model (Reference (1)) as proposed by Barr (Reference (3)) with additions to the list of input variables as discussed for the screening-level results (Reference (4)).

## 2.2 Screening-level Sensitivity Analysis

### 2.2.1 Screening-level Sensitivity Analysis Methodology

Prior to adjusting any input variables, a model run was performed to establish a baseline output concentration for each key output (i.e., each location and constituent combination). The target output was defined as the highest concentration estimated for each constituent at each output location during the 200-year simulation, e.g., the maximum concentration of chloride at SW004. This baseline run allows for a relative percentage change to be calculated for comparison with the runs associated with changing different model inputs. The baseline run was conducted by setting all of the uncertain inputs to their median (50th percentile) value and running a 200-year simulation.

The Mine Site model was then run with each of the model input variables included in the analysis at the 1st percentile (low run) and the 99th percentile (high run) of the input distribution; this established the range of output values that could be expected given the uncertainty in the input. A complete list of the model input variables that were varied is included in Large Table 1. In general, the model inputs include: surface water and groundwater quality variables, stream flow and hydrogeologic variables, waste rock release rate variables and concentration cap variables. Virtually all of the model inputs included as uncertain variables in the Mine Site model that affect the referenced constituent concentrations in the water leaving the Mine Site were included in this analysis.

In addition to the uncertain inputs that were tested, two other model input variables were included in the sensitivity analysis: the flow from the Peter Mitchell Pit associated with dewatering to the headwaters of the Partridge River at SW001 (variable name *Flow_PMP*) and the base flow added to the Partridge River from groundwater (*GW_Inc_Baseflow*). Although these inputs were not originally proposed for analysis, they were added to the list of inputs for analysis because of their potential to impact critical conditions with respect to water quality (low flow periods) in the Partridge River. The flow from the Peter Mitchell Pit has a deterministic value of 1 cfs in the Mine Site model (defined for the Version 5.0 model in

Section 5.2.4.5 of Reference (1)); for the screening-level sensitivity analysis, the model was run with this input set to 0.5 cfs (low run) and 10 cfs (high run) with the water quality of the discharge assumed to be unchanged. The groundwater base flow to the Partridge River is a deterministic input that varies spatially along the river based on the hydrologic analysis of the watershed (defined for the Version 5.0 model in Section 5.2.4.3.5 of Reference (1)). For the screening-level sensitivity analysis, the model was run with the base flow to each river segment set to 300 % (high run) of the deterministic values. A low run of the groundwater base flow was not performed for the screening-level analysis because reduced loading from the groundwater would not increase concentrations in the Partridge River and Colby Lake. Note that although both the flow from the Peter Mitchell Pit and the base flow have an effect on the calibration of the surface runoff water quality in the Partridge River watershed, the calibrated runoff water quality distributions were not varied in this analysis.

Most input variables were varied one at a time. However, in cases where the model treats the variables as independent, all the constituents being analyzed were modified simultaneously. Examples of inputs where this occurred are the overburden concentrations in peat and the bedrock groundwater concentrations. Changes in the modeled bedrock groundwater concentration for one constituent have no influence on the Partridge River water quality for other constituents, so for modeling efficiency the “high” and “low” runs were performed simultaneously for all constituents.

### 2.2.2 Screening-level Sensitivity Analysis Results

Once all screening-level model runs were complete, the model results were normalized as a percent change from their baseline value (maximum concentration in 200 years). The outputs were then sorted and compiled into tornado charts to highlight the input variables to which each modeled target output is the most sensitive. Each tornado plot typically shows only the inputs which have a non-zero effect on the specified output (several inputs have a very small effect that is rounded to 0.0% in the plots). Inputs that had zero effect on a given output are not included unless there were fewer than 10 inputs that had an effect on the output. See Appendix A for the full complement of screening-level tornado plots.

The results from the sensitivity analysis have been analyzed in terms of results that generated a concentration increase of a constituent at an evaluation location. The reason for this is simply that inputs that only reduce a concentration relative to the baseline value are not of concern with respect to the potential environmental impacts of the NorthMet Project (Project). In the context of water quality regulations, model inputs that increase the modeled concentrations of a constituent are more important than those that decrease the concentration when the baseline concentration is already below the applicable water quality standard which is the case for most of the constituents and locations being analyzed.

Large Table 2 shows the input variable that caused the largest increase in the output concentration for each constituent-location combination. The table also shows the baseline output concentration and the output concentration represented by the largest positive change. While there are several cases where the largest positive change in concentration is over 100%, the only cases where the change resulted in a concentration that exceeds the applicable standard are the concentration of sulfate at SW005 (the baseline output also exceeds the standard) and the concentration of arsenic at Colby Lake (caused by increase in flow from the Peter Mitchell Pit).

For most of the constituent-location combinations included in the sensitivity analysis, the model inputs to which the outputs are the most sensitive relate to the modeling of background conditions in the Partridge River rather than the generation or transport of constituent load from the Project features. This result was expected based on the proposed engineering controls and the adaptive water management strategy discussed in the introduction to Section 2.0.

The model inputs that are not associated with background conditions in the Partridge River that appear in Large Table 2 are as follows:

- *K_EP23surf*: Hydraulic conductivity of the East Pit – Category 2/3 surficial flow path. This model input affects cobalt concentration at SW004 due to enhanced transport in the surficial aquifer.
- *Annual_Precip_Cuberoot*: Annual precipitation on the Mine Site. This model input affects cobalt, copper, nickel, and lead concentrations at SW004a, SW004b and SW005 due to increased discharge of treated West Pit water from the long-term WWTF.
- *Acid_Factor_DC*: Increase in sulfate release rate when Duluth Complex rock goes acidic. This model input affects antimony concentration at SW004a and downstream due to increased concentration of antimony in the West Pit water (concentrations are generally below the long-term WWTF treatment target, which means that there is no modeled reduction in concentration as a result of treatment).

## 2.3 Detailed Sensitivity Analysis

### 2.3.1 Detailed Sensitivity Analysis Methodology

Based on the results of the screening-level analysis described above, all inputs that resulted in a 5% or larger increase in the maximum concentration in the Partridge River or Colby Lake are summarized in Large Table 3. The inputs in Large Table 3 were carried forward for a detailed analysis in the next phase of the sensitivity analysis. The screening-level results show that many of the target outputs are sensitive to the same list of input variables, so the list of proposed inputs for the detailed analysis is relatively small (31 inputs). The detailed sensitivity analysis involved re-running the model with each of these inputs at their 5th, 10th, 90th, and 95th percentile values. These runs combined with the runs from the screening-level analysis (1st, 50th, and 99th percentiles) provide sufficient information about the sensitivity of the model within this range and provide particular emphasis on the tails of the distribution.

As noted above for the screening-level analysis, two deterministic inputs (*Flow_PMP* and *GW_Inc_Baseflow*) were also varied to assess their impacts on the modeled concentrations in the Partridge River. A range of deterministic values were selected for the detailed analysis as shown in Table 2-1 below. Note that the minimum and maximum cases are changed from those that were used in the screening-level analysis. The USEPA specifically requested that a flow rate of 0 cfs be selected for the minimum flow rate from the Peter Mitchell Pit in order to assess potential changes in the surface water results if Peter

Mitchell Pit discharge were to cease in the future (letter from USEPA to the Co-lead Agency project managers, April 5, 2013, Reference (5)). New maximum cases were selected for both of these inputs for the detailed sensitivity analysis, representing the peak reported dewatering from the Peter Mitchell Pits from 2010-2012 (15 cfs) and the difference between the Version 5.0 estimated base flow at evaluation location SW003 (0.51 cfs, see Section 5.2.4.3.5 of Reference (1)) the minimum 7-day low flow measured at that location in 2012 (2.37 cfs, 465% of the estimated base flow). Although these input variables are deterministic in the model and the selected values do not have an associated percentile similar to the probabilistic input variables, the percentiles shown in Table 2-1 are used for plotting the results relative to those for other input variables.

**Table 2-1 Input Values for Deterministic Model Inputs to Detailed Sensitivity Analysis**

| | Plotting Percentile[1] | | | | | | |
|---|---|---|---|---|---|---|---|
| **Input Parameter** | **1 (Min)** | **5** | **10** | **50 (Base case)** | **90** | **95** | **99 (Max)** |
| Flow_PMP | 0 cfs | **0.5 cfs**[2] | 0.75 cfs | **1 cfs** | 5 cfs | **10 cfs** | 15 cfs |
| GW_Inc_Baseflow[3] | 75% | 80% | 85% | **100%** | 200% | **300%** | 465% |

(1) Plotting percentiles shown here are used in the results plots in Appendix B
(2) Cases marked in bold were run for the screening-level analysis
(3) Base flow percentages are relative to the estimated base flow in the Partridge River (see Section 5.2.4.3.5 of Reference (1))

One of the limitations of the screening-level sensitivity analysis is that the analysis did not differentiate between initial values and subsequent time steps to identify the maximum concentration for each model run. As a result, there are several constituent-location pairings that apparently exhibit zero or very little sensitivity when a maximum value approach is used. For these model outputs, the baseline maximum concentration was equal to the concentration at the initial time step (see concentrations in Table 2-2). The initial conditions were high enough that the model concentrations in subsequent time steps rarely or never exceeded the initial conditions in the sensitivity analysis runs. To correct for this situation and retrieve more-meaningful information regarding the model sensitivity, the maximum values for these constituent-location pairings were calculated for the detailed sensitivity analysis by excluding the concentrations in the first year of the simulation. The baseline concentrations used in the detailed sensitivity analysis are shown in Table 2-2 and are used as the basis for comparison in the results discussion and figures.

**Table 2-2 Revised Baseline Values to Exclude Initial Condition Effects**

| Constituent | Location | Screening-level Baseline Value (mg/L)[1] | Detailed Analysis Baseline Value (mg/L)[2] |
|---|---|---|---|
| Cl | SW004a | 1.50E+01 | 9.98E+00 |
| $SO_4$ | SW004a | 1.59E+01 | 1.46E+01 |
| Pb | SW005 | 1.27E-03 | 8.13E-04 |
| Se | SW005 | 1.13E-03 | 6.80E-04 |
| Cu | Colby Lake | 2.70E-03 | 1.20E-03 |
| $SO_4$ | Colby Lake | 3.41E+01 | 5.78E+00 |

(1) Maximum value from the 200-year baseline simulation, equal to the defined initial concentration at this location, see updated values Table 1-14 of Attachment C of Reference (1).
Equal to the values in Large Table 2.

(2) Maximum value from the 200-year baseline simulation, excluding the first year.

### 2.3.2 Detailed Sensitivity Analysis Results

Similar to the screening-level model runs, the model results for the detailed sensitivity analysis were normalized as a percent change from their baseline value (maximum concentration in 200 years). The outputs were then sorted and compiled into normalized x-y function charts to highlight the input variables to which each model output is the most sensitive (see example for arsenic in Figure 2-1, descriptions of each input variable are provided in Large Table 3). Each normalized x-y plot shows only the inputs which result in a 5% or greater increase in concentration for a given constituent-location pairing as described in Section 2.3.1. The inputs are shown in order of sensitivity, with the top input in the legend causing the greatest increase in concentration at this evaluation location. The x-axis shows the percentile for each input to the sensitivity analysis (the 50th percentile or median is the “baseline value”), while the y-axis shows the resulting relative change in the target concentration from the baseline value. The baseline concentrations for all outputs are the same as those shown in Large Table 2 and on the tornado plots in Appendix A, except as shown in Table 2-2.

See Appendix B for the full complement of normalized x-y plots.

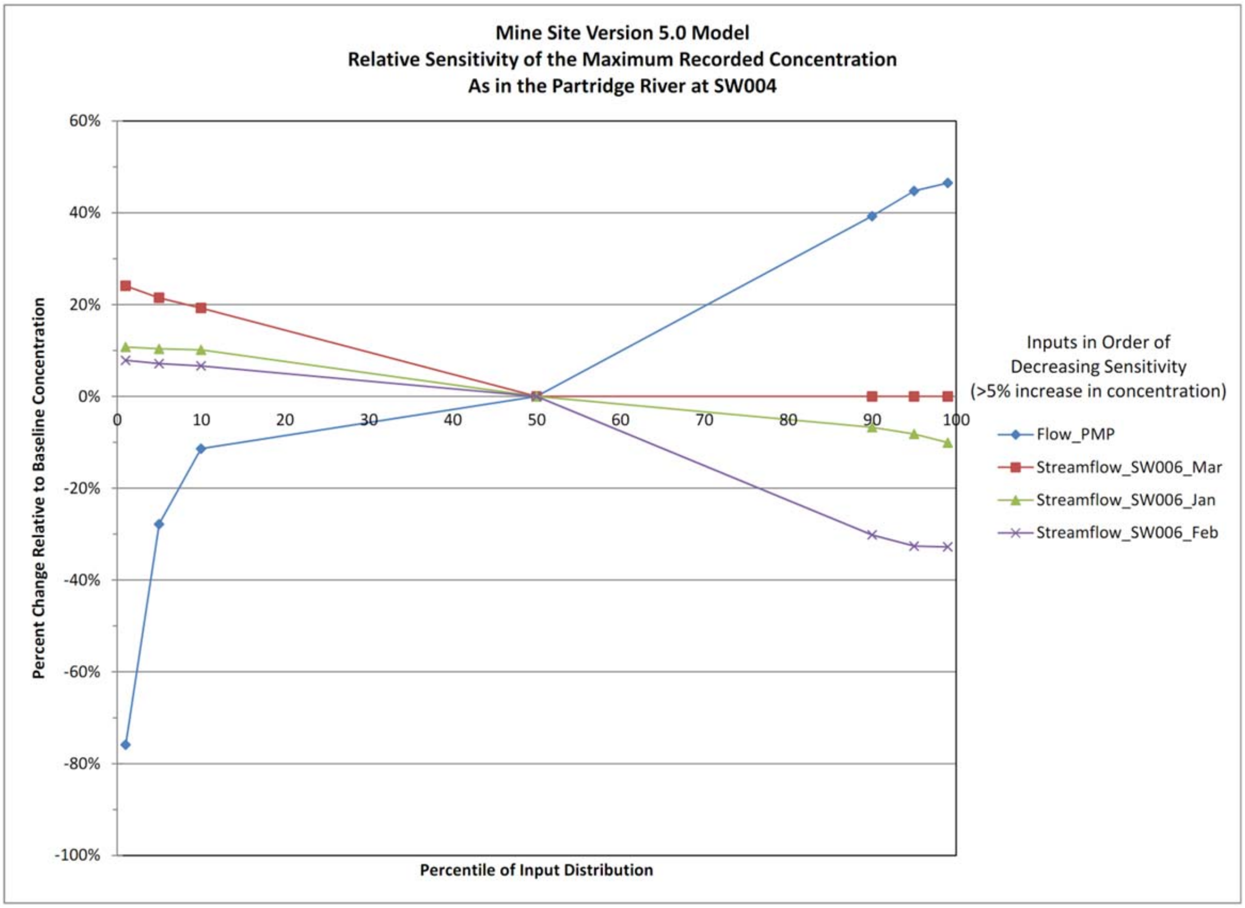



**Figure 2-1 Detailed Sensitivity Analysis Results for Arsenic at SW004**

### 2.3.3 Interpretation of Input Parameter Groupings

Large Table 4 shows the inputs that were carried forward to the detailed sensitivity analysis along with the constituent-location pairings for which the input generated a 5% or greater increase in concentration. In addition to the 31 proposed inputs variables in Large Table 3, the four additional stream flow inputs representing the months of May, June, September, and October were included due to the frequency that stream flow variables appeared in the screening-level analysis. The additional inputs bring the total number of inputs variables carried into the detailed analysis to 35. The detailed sensitivity analysis revealed that there are several primary categories of inputs with respect to how they affect the target model outputs. These groupings are shown on Large Table 4 and described below:

- Changes in the transport rate in the East Pit/Category 2/3 surficial groundwater flow path: inputs included in this group are annual precipitation, stockpile liner leakage, hydraulic gradient, and hydraulic conductivities; outputs are typically only sensitive to these input parameters at SW004 (exception is cobalt).
- Changes in the load generation in the temporary waste rock stockpiles and the East Pit: inputs included in this group are scaling factors (contact, size, acidity) and release factors for cobalt; cobalt is the only constituent that is sensitive to these inputs at SW004 and downstream.

- Changes in flow from the WWTF in long-term closure: inputs included in this group are parameters that affect the water balance of the flooded West Pit (precipitation, evaporation, runoff, and groundwater inflow) and the timing of East Pit treatment completion (acidity factor); many constituents are sensitive to these input parameters at SW004a and downstream.

- Changes in concentration in the West Pit and long-term WWTF influent: inputs included in this group are scaling factors (wall rock decay, acidity), release factors (antimony, selenium), and loading from other sources to the long-term WWTF (tailings basin water concentration and Category 1 Waste Rock Stockpile percolation rate); outputs are typically only sensitive to these inputs parameters for constituents that are below the treatment target for the long-term WWTF (antimony and selenium, exception is cobalt).

- Changes in background loading: inputs included in this group are the concentration of background surface runoff and surficial groundwater, flow from the Peter Mitchell Pit and the amount of base flow; most outputs are sensitive to these input parameters.

- Changes in flow in the Partridge River: inputs included in this group are monthly flows that experience low-flow conditions (November-April, July, August); most outputs are sensitive to these input parameters.

One of the model characteristics that the sensitivity analysis highlights is the importance of concentrations of constituents in the natural background groundwater and surface water relative to one another in driving peak concentrations under background conditions. For most constituents the background groundwater concentration is higher than the background surface runoff concentration, with the notable exception of chloride. As a result, model inputs that alter the ratio of groundwater loading to surface water loading in the Partridge River tend to have a significant impact on the modeled maximum concentration for most constituents.

As an example, stream flow values in the Partridge River in January, February, and March tend to be negatively correlated with increases in concentrations of several constituents at all evaluation locations on the Partridge River. When the stream flows are lower than normal (and especially when stream flow is below the estimated base flow), the concentration of the constituents tends to go up. In these cases the background flow in the river is almost entirely groundwater base flow, which has a higher natural background concentration than the surface water runoff.

A striking behavior demonstrated in the sensitivity analysis results presented in Appendix B is the non-linearity of the response to the background surface runoff concentration (*SW_RO_Random)* inputs. These inputs dictate the runoff concentrations of each constituent. The modeled maximum concentrations often show little to no sensitivity to surface runoff concentrations in the negative direction; low runoff concentrations do not "clean up" the river because, as discussed above, the peak concentrations typically occur under base flow-dominated conditions. However, the peak concentrations often grow exponentially when surface runoff concentrations are modeled in the 90th to 99th percentile. This behavior is responsible for the large number of cases where *SW_RO_Random* is the input to which there is the largest increase in concentration for a particular constituent-location pairing ($SO_4$ at SW004 for example, shown in Figure 2-2 and discussed further in Section 2.3.4.4). The reason for this behavior is that the input distributions for the surface runoff quality are defined as lognormal distributions and therefore have long positive “tails”, with 99th percentile values that may be an order of magnitude greater than the median concentration.

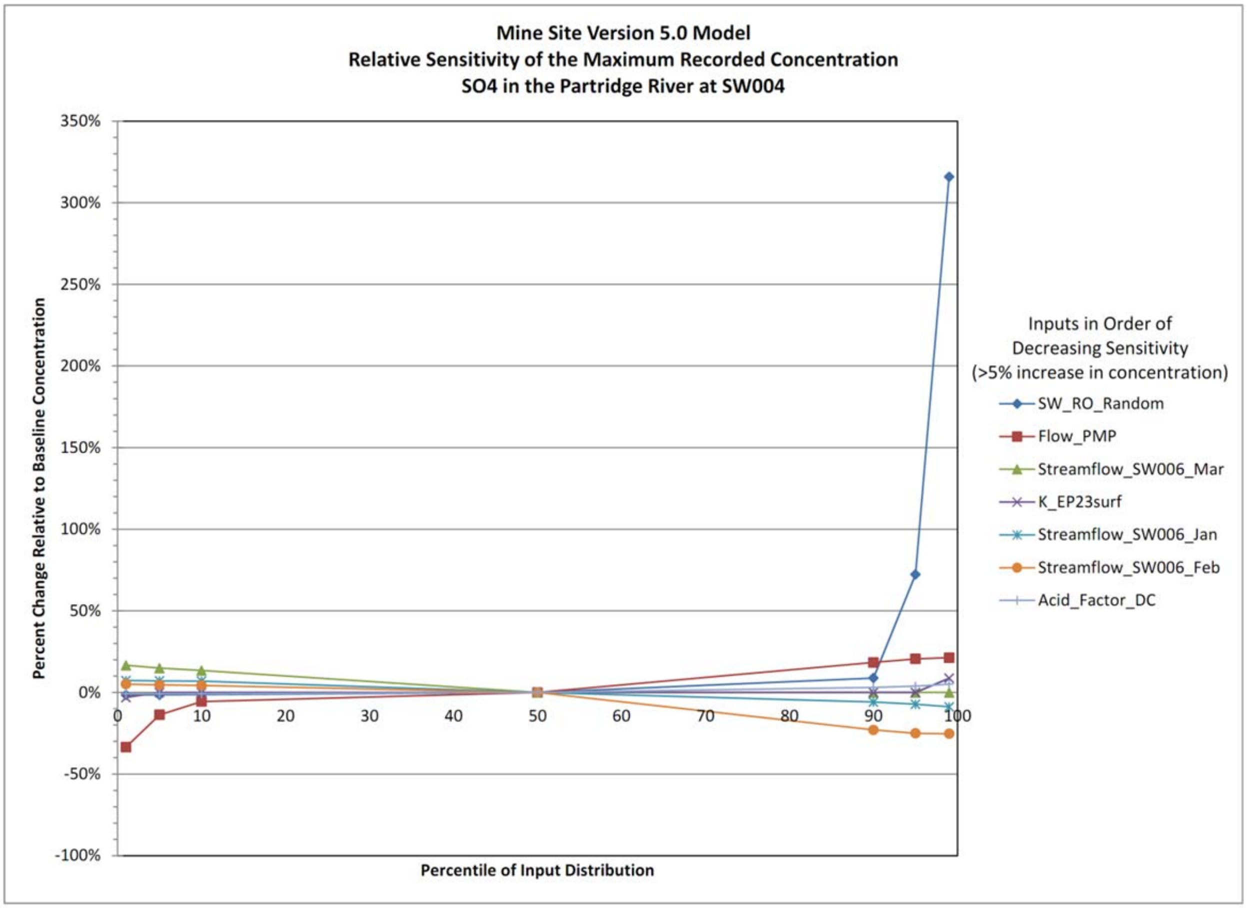



**Figure 2-2 Detailed Sensitivity Analysis Results for Sulfate at SW004**

Another model behavior that is highlighted by the sensitivity analysis is the effect that different pathways for the transport of Project loads have on the water quality in the Partridge River. At SW004 the only means for the transport of Project-impacted water to the river is through the groundwater flow paths. As such, factors that affect groundwater loading rates and background source loads are the inputs that tend to be the most sensitive at SW004 (see Large Table 4).

Downstream of the discharge of the long-term WWTF at SW004a, model inputs that have an impact on the amount of flow treated by the WWTF and the water quality of the West Pit begin to have a more significant impact on the water quality of the Partridge River. The annual precipitation on the Mine Site (*Annual_Precip_Cuberoot*) will in reality vary from year to year; however, in the sensitivity analysis framework a high precipitation rate is assigned in some model runs for every year of the 200-year simulation. In these cases, the higher-than-expected inflows to the West Pit in long-term closure require the long-term WWTF to treat and discharge at a higher rate every year of the simulation. Although the concentrations in the WWTF effluent are below the applicable water quality standards they are generally higher than the background water quality in the Partridge River; higher flows from the WWTF (driven by higher precipitation) therefore are positively correlated to the maximum modeled concentration for many constituents at SW004a and downstream.

Although the explanation is not immediately obvious, the input parameter that scales constituent release from waste and wall rock under acidic conditions (*Acid_Factor_DC*) emerges as an important input for many of the constituent-location pairings for the same reason as annual precipitation: because of changes to the discharge rate (rather than quality) from the long-term WWTF. In the baseline run (all inputs at their median values) the reclamation treatment of the East Pit is complete several years before the West Pit becomes flooded. This means that, in long-term closure, the WWTF monthly treatment rate is based solely on the natural water balance of the West Pit. The acidity scaling factor, however, is defined as a highly skewed beta distribution (see Figure 2-3 reproduced from Section 8.2.5 of Reference (6)). The acidity factor correlates directly to the amount of constituent load that must be removed from the East Pit backfill during reclamation, and therefore correlates to the treatment time required for the East Pit. When the acidity factor is large, the East Pit treatment time exceeds the time required to completely flood the West Pit. The resulting changes to the West Pit water balance, especially the discharge of "excess" treated water when East Pit reclamation treatment ceases, cause temporarily higher discharge rates from the long-term WWTF to the Partridge River (i.e., both East Pit and West Pit water are being treated and discharged). Thus the model sensitivity to the acidity factor is related to that for precipitation, with more treated water reaching the river during naturally low-flow conditions.

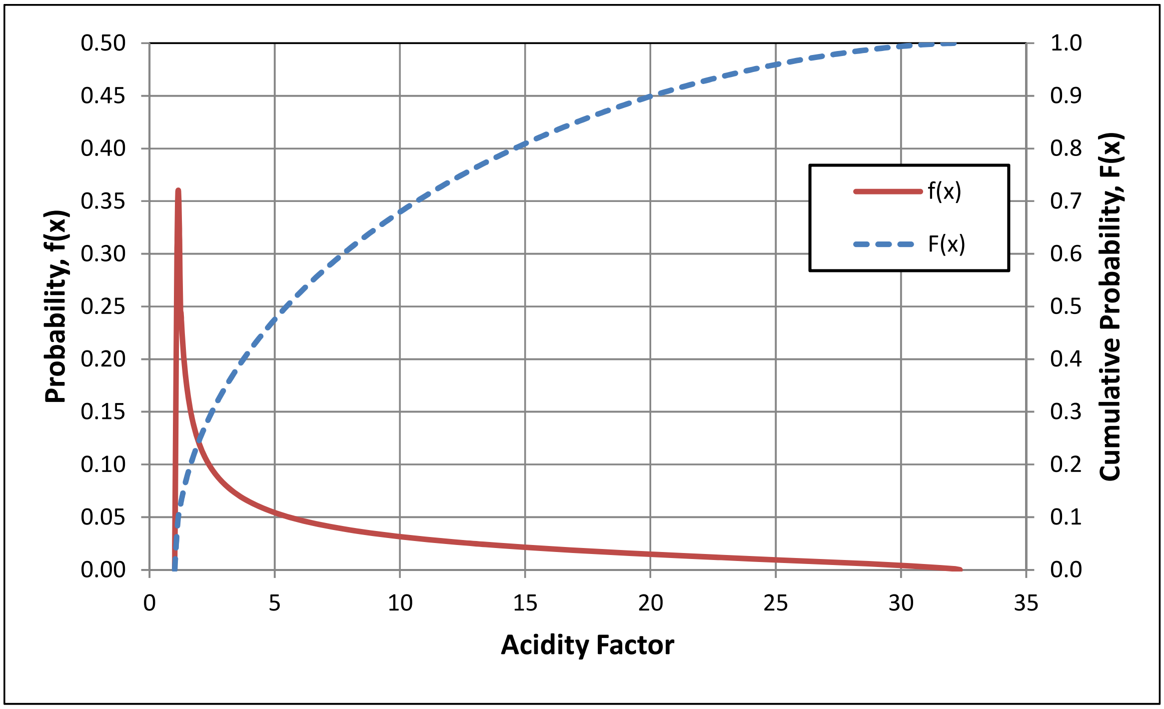



**Figure 2-3 Input Distribution for the Acidity Factor**

Because the majority of the water leaving the Mine Site is treated in the WWTF, the model results in the Partridge River are generally not sensitive to input parameters that govern the load generation in the stockpiles or pit walls. For constituents that are typically treated in the WWTF (As, Co, Cu, Ni, Pb, $SO_4$) the concentrations in the river are primarily sensitive only to the treated flow from the WWTF (cobalt has some exceptions as discussed in Section 2.3.4.2). As discussed above, the sensitivity of these outputs to the acidity factor (*Acid_Factor_DC*) is more related to the amount of flow from the WWTF than the quality of the water in the flooded West Pit. For other constituents, the estimated concentrations in the influent to the WWTF in long-term closure are below the treatment targets and are therefore passed untreated through the WWTF. These constituents include chloride, antimony and selenium; the peak concentrations of antimony and selenium in the river downstream of SW004a therefore show some sensitivity to release and concentration parameters as discussed in Section 2.3.4.3.

### 2.3.4 Discussion of Specific Constituents

#### 2.3.4.1 Arsenic

As shown in Large Table 2 and discussed in the screening-level sensitivity analysis, the largest increases in concentration for arsenic in Colby Lake produce results that exceed the surface water quality standard in the lake. Figure 2-4 shows the results of the detailed sensitivity analysis for arsenic in Colby Lake, which are clearly far more sensitive to the discharge from the Peter Mitchell Pit (*Flow_PMP*) than to any other input parameter. The arsenic standard in Colby Lake (2 µg/L) corresponds to a change from the baseline concentration of 144%, a threshold that is not approached by the sensitivity analysis runs for any other input parameters. At Peter Mitchell Pit discharges of 5 cfs and below, the maximum arsenic concentration does not exceed the surface water standard in Colby Lake. Note that this analysis assumes that the quality of the Peter Mitchell Pit discharge is constant regardless of the flow rate.

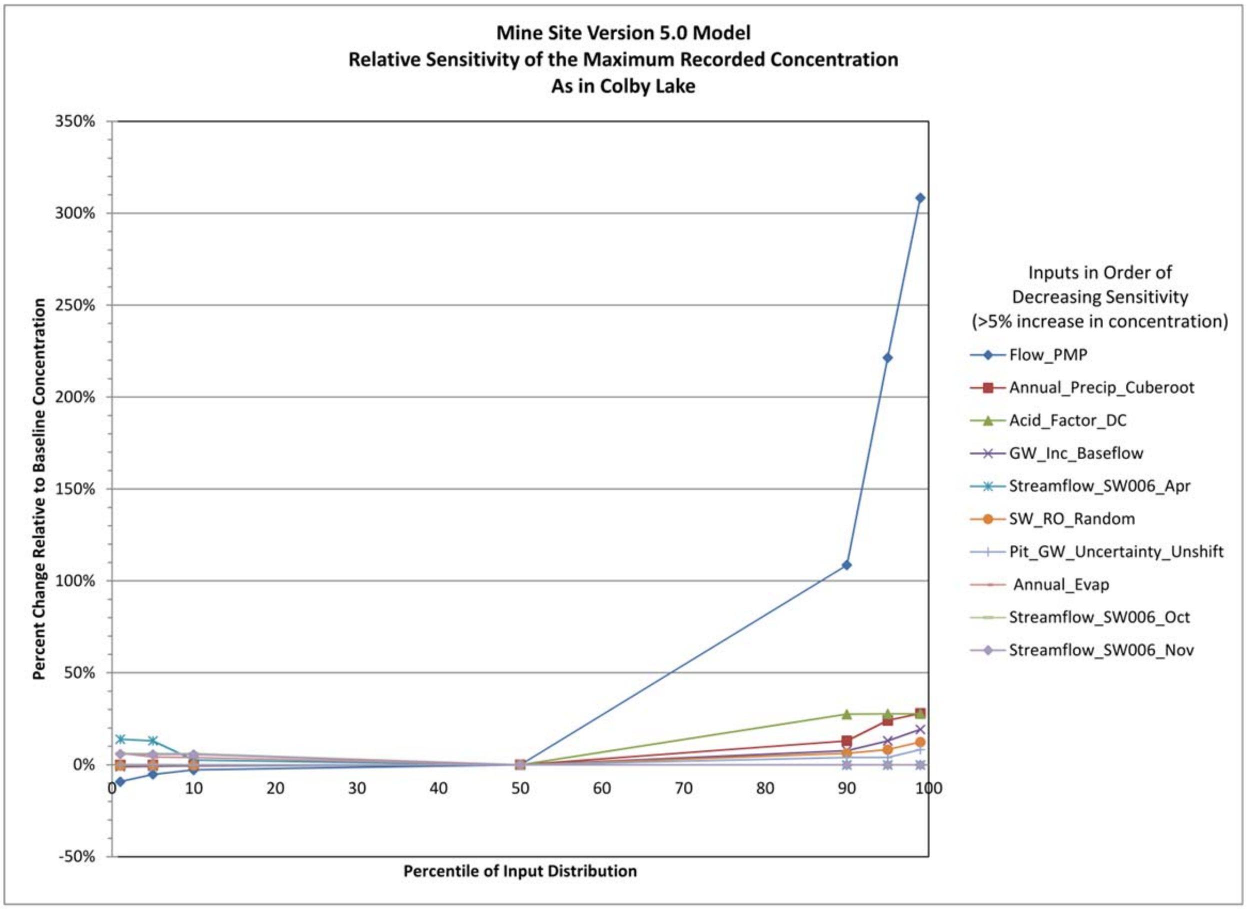



**Figure 2-4 Detailed Sensitivity Analysis Results for Arsenic in Colby Lake**

### 2.3.4.2 Cobalt

Throughout the development of the Mine Site model cobalt has been used as an indicator of model behavior because it is released in relatively high quantities from Duluth Complex rock, is not concentration-capped in the mine pits, and is not modeled with sorption in the groundwater flow paths. These characteristics are seen in the sensitivity analysis results, with the inputs that affect cobalt load generation in the stockpiles and mine pits having a positive correlation with cobalt concentrations in the Partridge River and Colby Lake. Cobalt is the only constituent that is sensitive to the hydraulic conductivity of the East Pit/Category 2/3 surficial flow path downstream of SW004, indicating that loading from this flow path is detectable in the Partridge River maximum concentrations even downstream of the WWTF discharge at SW004a. Of the constituents that are treated in the long-term WWTF and therefore show low sensitivity to the concentrations in the West Pit, cobalt alone shows sensitivity to the input variables that control the decaying release rates in the pit walls. This indicates that enough cobalt is reaching the Partridge River via the groundwater flow paths to influence the peak concentrations in the river, even if to a small degree.

As with many of the constituents, the model input variables that have an impact on background surface water flows tend to be negatively correlated to maximum cobalt concentrations. Stream flow inputs are consistently negatively correlated with cobalt, even if they do not meet the 5% increase threshold; high cobalt concentrations occur during the lowest-flow periods.

As discussed above, higher flows from the long-term WWTF can lead to higher maximum cobalt concentrations in the Partridge River and Colby Lake. Cobalt is consistently discharged from the WWTF at the treatment target of 5 µg/L (equal to the surface water standard); higher discharge rates lead to the effluent being less diluted by the background surface and groundwater, especially during low-flow conditions.

### 2.3.4.3 Antimony and Selenium

Neither antimony nor selenium is expected to be treated in the long-term WWTF, because their estimated concentrations in the WWTF influent are below the established treatment targets. See for example Figure 2-5 and Figure 2-6, reproduced from Attachment H of Reference (1).

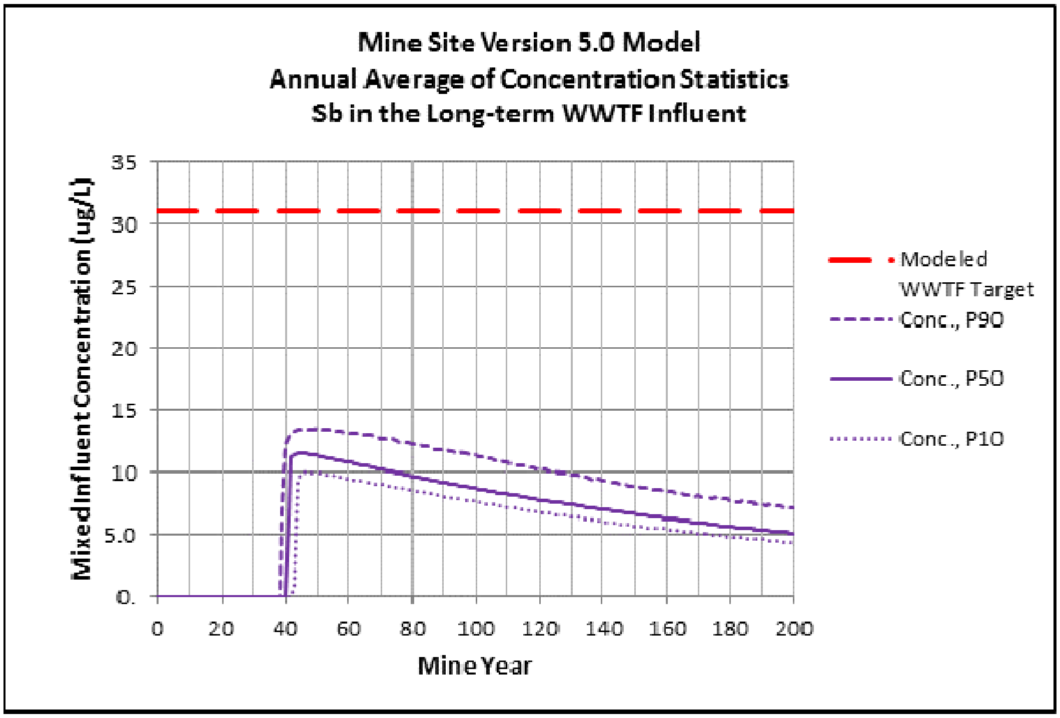



**Figure 2-5 Estimated Antimony Concentration in the WWTF Influent**

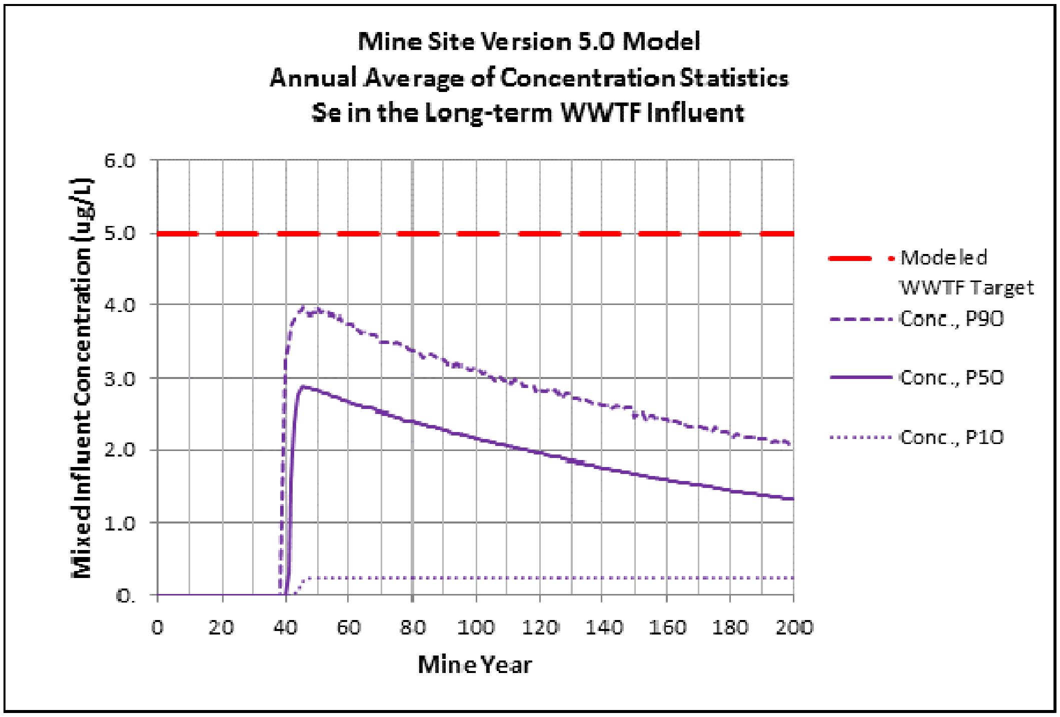



**Figure 2-6 Estimated Selenium Concentration in the WWTF Influent**

The sensitivity analysis results for these two constituents, therefore, show that the maximum concentrations in the Partridge River are sensitive and positively correlated to the model inputs that affect load generation and concentrations in the West Pit and the Category 1 Waste Rock Stockpile. Conversely, concentrations of both constituents are negatively correlated to flow from the Peter Mitchell Pit, which acts as a source of dilution water for these constituents.

Selenium concentrations are also sensitive to the background surface water runoff concentrations (*SW_RO_Random*) in the lower reaches of the Partridge River. Due to the lognormal input distribution as noted above, the model is quite sensitive to this input. For SW005 at Colby Lake, the surface water runoff concentration is the only variable that causes maximum concentrations to increase beyond the initial model concentration in the sensitivity analysis outputs.

### 2.3.4.4 Sulfate

Sulfate is a constituent of concern due the 10 mg/L sulfate standard for wild rice at SW005. The sensitivity analysis shows that sulfate at SW005 is not sensitive to changes in most inputs. Generally sulfate concentrations are sensitive to the flow rate from the Peter Mitchell Pit and are highly sensitive to the surface water runoff concentration. As previously discussed, the distribution for the surface runoff concentration can be significantly skewed and result in very large values at high percentiles. Figure 2-7 (reproduced from Figure 6-130 of Reference (1)) shows the modeled distribution for the sulfate concentration in surface runoff; at the 99th percentile the modeled value is 78 mg/L.

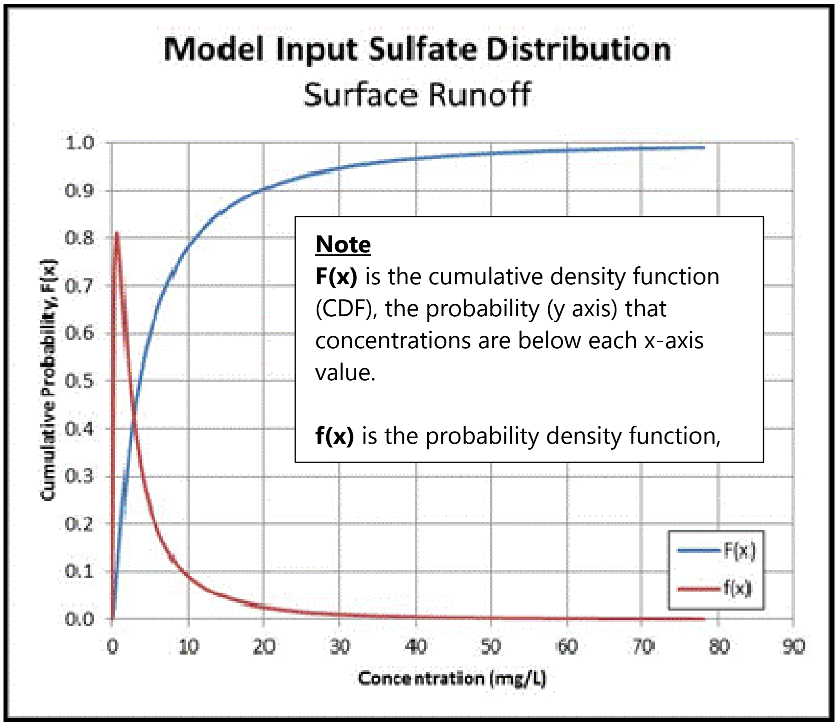



**Figure 2-7 Simulated Distribution of Sulfate Concentration in Surface Runoff**

## 2.4 Conclusions

As previously discussed, the proposed engineering controls and the adaptive water management strategy for the Project make it unlikely that concentrations in the Partridge River will be sensitive to most of the input variables for the Mine Site water quality modeling, except those related to natural background conditions. This expectation has been confirmed in this two-phase sensitivity analysis as discussed above. For most of the constituent-location combinations assessed here, the input variables to which the maximum modeled concentrations are most sensitive are those relating to background conditions, because the Project has a relatively small impact on concentrations in the Partridge River. Although the model may be sensitive to the input variables relating to background conditions, the prediction of potential impacts from the Project is largely not sensitive to these variables. Within the constraints of the system being considered in the water quality model, there is little likelihood that reasonably expected events or mischaracterized input variables would result in unforeseen environmental outcomes or exceedances of surface water quality standards.

# 3.0 Mine Site - Background Groundwater Quality

## 3.1 Introduction

In a letter from the USEPA to the Co-lead Agency project managers (Reference (5)), a concern was raised regarding the treatment of recharge to groundwater at the Plant Site:

> *"It is not clear why the decision was made to use the sample means in lieu of the complete sample. More commonly, upper confidence limits are calculated and used to represent the uncertainty in groundwater sampling data. It seems that upper confidence limits could have been calculated and used similarly to the regulatory standard values listed for ground water and surface water. The procedures for calculating upper confidence limits are well established and easy to follow. They may be a more appropriate approach for this project. Essentially, using the sample means reduces the natural variability of background concentrations and may eliminate those potential "worst-case" scenario conditions that, in combination with the proposed actions, could lead to environmental impact (e.g., exceedance of a contaminant standard). Additional information and rationale for this approach should be provided."*

The Co-lead Agencies provided a written response to these questions, in which it was agreed that Poly Met Minting Inc. (PolyMet) would perform a sensitivity analysis to assess the sensitivity of the model results to the definition of the distribution of the background groundwater concentrations. This section provides the referenced analysis.

The NorthMet Mine Site water quality model, Version 5.0 (Reference (1)), simulates the impact of water leaving the Mine Site via groundwater on the groundwater and surface water concentrations of 27 chemical constituents. Project-impacted water will enter the surficial aquifer generally via dispersed sources (covering tens to hundreds of acres) rather than "point" sources. These sources include leakage through geomembrane liners beneath temporary stockpiles, infiltration into the temporary Overburden Storage and Laydown Area, and seepage from the mine pits. Water from these sources will flow within the surficial aquifer southeast towards the Partridge River, where the water from the Mine Site will combine with groundwater from other portions of the watershed to make up the base flow in the river. The estimated travel time in groundwater from the Mine Site to the Partridge River varies by flow path but is typically greater than 100 years. Water quality is evaluated in the model at several intermediate evaluation locations and within the Partridge River itself.

Because the groundwater travel times at the Mine Site are relatively long and the simulated sources are dispersed in nature, it is appropriate to use the mean background groundwater quality to simulate the concentration of recharge to natural areas. Background water quality is certainly not homogeneous throughout the surficial aquifer; however, water leaving the Mine Site will pass through areas of higher and lower concentrations on its way to the Partridge River. The cumulative effect will be to add the project-related loading to groundwater that approximates the mean background groundwater quality.

## 3.2 Version 5.0 Model Groundwater Quality Modeling Method

The results of the current version of the probabilistic model for the Mine Site (Version 5.0) are discussed in Reference (1) and are used as the basis for comparison in this section. Based on the above conceptual model of groundwater flow at the Mine Site, the probabilistic water quality model uses distributions for background groundwater quality that are intended to represent the uncertainty in the mean groundwater concentrations. Section 5.2.3.8.1 of Reference (1), which states:

> *"The groundwater distributions developed from the Mine Site groundwater data are defined by three parameters: α, β, and $\alpha_{stdev}$. The parameter α represents the mean of the log-transformed groundwater data; β represents the variability of the log-transformed groundwater data; and $\alpha_{stdev}$ is a parameter describing the uncertainty in the true mean value of the log-transformed groundwater data. In the probabilistic modeling, background groundwater quality is estimated by first randomly sampling a mean value in log-transformed space (normally distributed with parameters α and $\alpha_{stdev}$), and then transforming the value using the parameter β."*

The input distribution parameters used in the Version 5.0 model (α, β, and $\alpha_{stdev}$) for the surficial groundwater are shown in Table 3-1 (copy of Table 5-10 of Reference (1)). The distributions for the uncertainty in the mean groundwater concentrations are shown on the plots in Appendix C (reproduced from Attachment D of Reference (1)). Note that the plots show all of the observed concentrations (points) along with the distribution for the mean (dashed lines). A similar method is used to define the distributions of the bedrock groundwater quality for the Version 5.0 model, with distribution parameters that are defined in Table 1-12 of Attachment B of Reference (1).

In the Version 5.0 model, groundwater concentrations are randomly selected once per realization from the distribution of the mean surficial groundwater quality. These concentrations are applied to all recharge to the surficial aquifers, base flow to the Partridge River, and inflow to the mine pits from surficial deposits.

### Table 3-1 Summary of Surficial Groundwater Distribution Input Parameters

| Constituent | Model input parameters (log-transformed) | | | Un-transformed values | |
|---|---|---|---|---|---|
| | $\alpha$ (log mean) | $\alpha_{stdev}$ (log mean std. error) | $\beta$ (log std. dev.) | $\mu$ (pop. mean, µg/L) | $\sigma$ (pop. std. dev., µg/L) |
| Ag | -2.20E+00 | 2.69E-02 | 3.57E-01 | 1.18E-01 | 4.36E-02 |
| Al | 3.32E+00 | 9.34E-02 | 1.24E+00 | 5.94E+01 | 1.13E+02 |
| Alkalinity | 1.09E+01 | 4.44E-02 | 5.89E-01 | 6.30E+04 | 4.06E+04 |
| As | -6.65E-01 | 6.26E-02 | 8.02E-01 | 7.10E-01 | 6.74E-01 |
| B | 3.26E+00 | 1.57E-02 | 2.09E-01 | 2.67E+01 | 5.65E+00 |
| Ba | 3.20E+00 | 6.65E-02 | 8.82E-01 | 3.62E+01 | 3.92E+01 |
| Be | -2.16E+00 | 3.42E-02 | 4.54E-01 | 1.28E-01 | 6.10E-02 |
| Ca | 9.54E+00 | 3.97E-02 | 5.27E-01 | 1.59E+04 | 9.01E+03 |
| Cd | -2.30E+00 | 1.43E-02 | 1.90E-01 | 1.03E-01 | 1.96E-02 |
| Cl | 6.18E+00 | 5.76E-02 | 7.64E-01 | 6.47E+02 | 5.75E+02 |
| Co | -8.79E-01 | 1.00E-01 | 1.23E+00 | 8.82E-01 | 1.65E+00 |
| Cr | -2.71E-01 | 4.88E-02 | 6.48E-01 | 9.41E-01 | 6.80E-01 |
| Cu | 5.12E-01 | 8.25E-02 | 1.09E+00 | 3.04E+00 | 4.61E+00 |
| F | 4.16E+00 | 3.56E-02 | 4.73E-01 | 7.19E+01 | 3.60E+01 |
| Fe | 4.85E+00 | 1.56E-01 | 1.99E+00 | 9.34E+02 | 6.75E+03 |
| K | 7.39E+00 | 3.16E-02 | 4.19E-01 | 1.77E+03 | 7.74E+02 |
| Mg | 8.72E+00 | 3.98E-02 | 5.28E-01 | 7.04E+03 | 4.00E+03 |
| Mn | 4.63E+00 | 1.31E-01 | 1.69E+00 | 4.31E+02 | 1.76E+03 |
| Na | 8.41E+00 | 4.33E-02 | 5.74E-01 | 5.31E+03 | 3.32E+03 |
| Ni | 2.06E-01 | 7.80E-02 | 1.03E+00 | 2.10E+00 | 2.90E+00 |
| Pb | -7.00E-01 | 7.73E-02 | 1.03E+00 | 8.40E-01 | 1.15E+00 |
| Sb | -1.39E+00 | 0.00E+00 | 0.00E+00 | 2.50E-01 | 0.00E+00 |
| Se | -6.69E-01 | 2.14E-02 | 2.84E-01 | 5.33E-01 | 1.55E-01 |
| $SO_4$ | 9.02E+00 | 4.81E-02 | 6.38E-01 | 1.01E+04 | 7.18E+03 |
| Tl | -2.19E+00 | 3.38E-02 | 4.49E-01 | 1.23E-01 | 5.82E-02 |
| V | 1.24E+00 | 3.45E-02 | 4.21E-01 | 3.77E+00 | 1.66E+00 |
| Zn | 1.42E+00 | 4.25E-02 | 5.64E-01 | 4.83E+00 | 2.96E+00 |

Table reproduced from Table 5-10 of Reference (1)

The log-transformed parameters $\alpha$ and $\beta$ describe the lognormal distribution fit to the entire population of observed groundwater quality data. These parameters can be converted to the more-familiar mean ($\mu$) and standard deviation parameters ($\sigma$), in units of µg/L, using Equations Eq**. 3-1** and Eq**. 3-2**:

$$\mu = e^{\left(\alpha+\frac{\beta^2}{2}\right)} \quad \textbf{Eq. 3-1}$$

$$\sigma = \mu\sqrt{e^{\beta^2} - 1} \quad \textbf{Eq. 3-2}$$

The converted values of $\mu$ and $\sigma$, using the previously-defined input distributions for the surficial groundwater quality in the Mine Site Version 5.0 model, are also shown in Table 3-1.

## 3.3 Sensitivity Model Groundwater Quality Modeling Method

In order to address the questions presented in Section 3.1 about the influence of extreme observed concentrations on the estimated environmental impacts of the Project, an additional sensitivity model run has been performed. This analysis is not a classical "sensitivity analysis" in the sense of a deterministic model run in which one input parameter value is changed at a time. Rather, the complete probabilistic simulation was repeated (500 realizations) using an alternative definition for the distribution of background groundwater quality. This probabilistic simulation is referred to as the "sensitivity model" in the remainder of this section, and is compared to the "Version 5.0 model" documented in Reference (1).

The Mine Site model was run using the lognormal distributions fit to the full range of observed groundwater concentrations, as defined by the parameters $\mu$ and $\sigma$ in Table 3-1, rather than the distribution of the mean that is used in the Version 5.0 model. Similar to the Version 5.0 model, groundwater concentrations were randomly selected once per realization from the distribution of surficial groundwater quality (here defined as the distribution of the population rather than the mean). These concentrations are applied to all recharge to the surficial aquifers, base flow to the Partridge River, and inflow to the mine pits from surficial deposits. This alternate simulation effectively assumes that any individual observation of groundwater quality could apply to all areas of the Mine Site and the Partridge River watershed simultaneously, even if it has only been observed in a single well or with low likelihood. This is an unrealistic scenario, because it is highly unlikely that water leaving the Mine Site will pass through areas of only higher or only lower recharge concentrations on its way to the Partridge River.

The distributions for the full population of groundwater concentrations have been added to the plots in Appendix C (reproduced from Attachment D of Reference (1)). Note that the plots show all of the observed concentrations (points), the distribution for the mean (dashed lines), and the underlying distribution for the full population (solid red lines). The population distributions were fit mathematically by assuming that the concentrations of all constituents follow lognormal distributions, and match the data better for some constituents than others. A similar method was used to model the full range of the background bedrock groundwater quality.

## 3.4 Sensitivity Model Results - Groundwater

Mine Site model results for the sensitivity model, using the full range of observed background groundwater concentrations rather than the uncertainty in the mean concentration, show a wider range of estimated groundwater quality for both the Project model and the model of existing conditions. This behavior is demonstrated in Figure 3-1 for cobalt in the East Pit/Category 2/3 surficial flow path at the Property Boundary. In the early years of mining, when no Project load has reached the Property Boundary and concentrations are identical to the background concentration, the sensitivity model (green lines) shows a wider range of concentrations than the Version 5.0 model (purple lines). However, the peak concentrations of cobalt at this evaluation location are driven by Project loading from sources which are at concentrations that are orders of magnitude higher than the background concentrations in either modeled case. Therefore, the maximum estimated 90th percentile concentration is nearly unchanged between the two model runs despite the differences in background recharge quality.

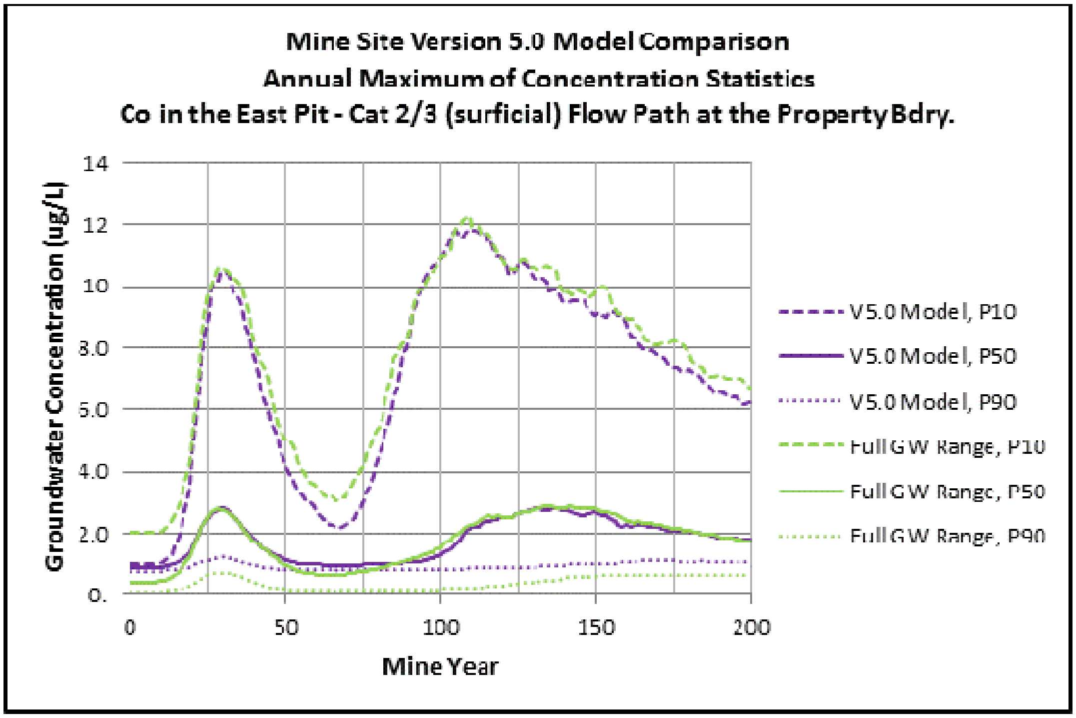



**Figure 3-1 Cobalt Concentration Comparison in the East Pit/Category 2/3 Surficial Flow Path**

For some constituents, the difference between the two model runs is more visible at the peak concentration. Figure 3-2 shows the modeled concentrations of sulfate in the East Pit/Category 2/3 surficial flow path at the Property Boundary. The sources of sulfate loading to the flow path are much closer in magnitude to the background groundwater concentrations than for cobalt, leading to a noticeable increase in the peak concentration in the sensitivity model run. The difference between the two model runs at the peak 90th percentile concentration is approximately 2.5 mg/L, less than a 10% change in concentration.

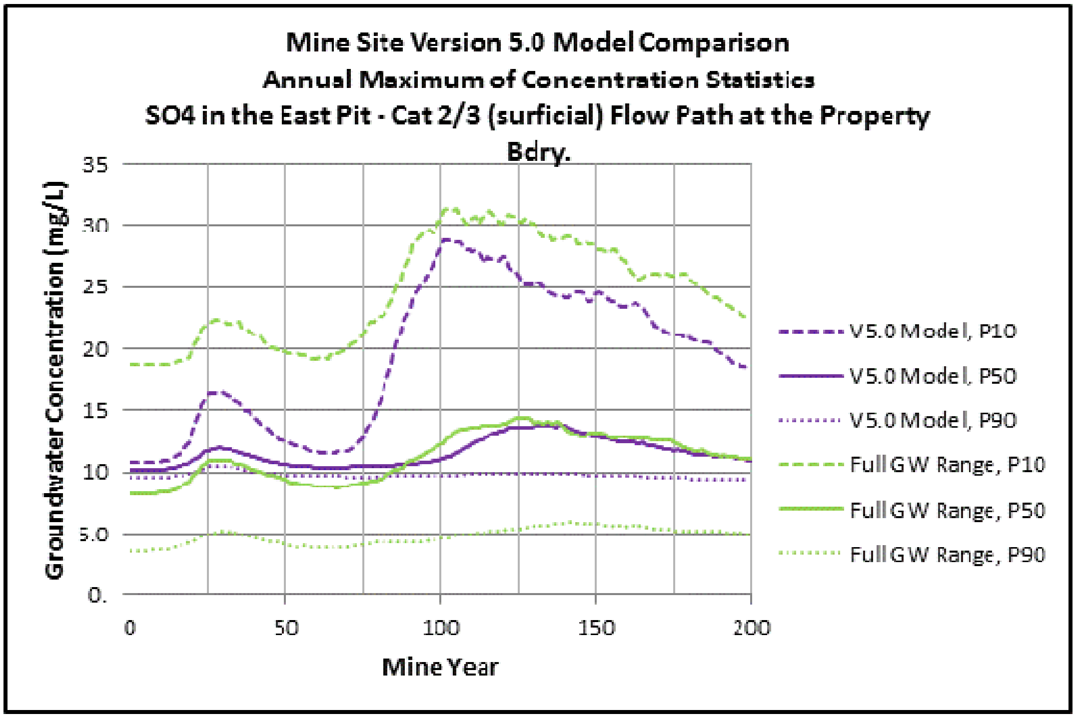



**Figure 3-2 Sulfate Concentration Comparison in the East Pit/Category 2/3 Surficial Flow Path**

The range of estimated concentrations for each groundwater evaluation location at the Property Boundary is shown in the figures in Appendix D. The plots are reproduced with modifications from Large Figures 47-54 in Reference (1) and show:

- Range from the maximum of the 90th percentile to the minimum of the 10th percentile for the Version 5.0 Mine Site model (black bars)
- Range from the maximum of the 90th percentile to the minimum of the 10th percentile for the sensitivity model with the full range of background concentrations (orange bars)
- Applicable water quality standard (red bars)

Although the range of estimated concentrations in the sensitivity model is (as expected) wider for many constituents, in no case does this scenario cause a new exceedance of a groundwater quality standard at the 90th percentile concentration. Manganese in all of the groundwater flow paths appears to be near the site-specific evaluation criteria in the sensitivity model; this result is expected because the site-specific criteria were defined from the upper end of the observed groundwater quality data. The sensitivity model in effect forces the background groundwater quality to approach the site-specific criteria at all evaluation locations in some model realizations.

## 3.5 Sensitivity Model Results – Surface Water

Due to the wider range of estimated groundwater concentrations in the sensitivity model, the sensitivity model results also show a wider range of estimated surface water quality for both the Project model and the model of existing conditions. This behavior is shown in Figure 3-3 for cobalt at SW004, in which the sensitivity model (green lines) shows a wider range of concentrations than the Version 5.0 model (purple lines). In this example, the difference between the two models appears to be approximately consistent both in the early years of mining, when no Project loading will have arrived at the river, and later when loading from the groundwater flow paths has reached the river. In neither model does the estimated peak concentration approach the surface water quality standard of 5 µg/L.

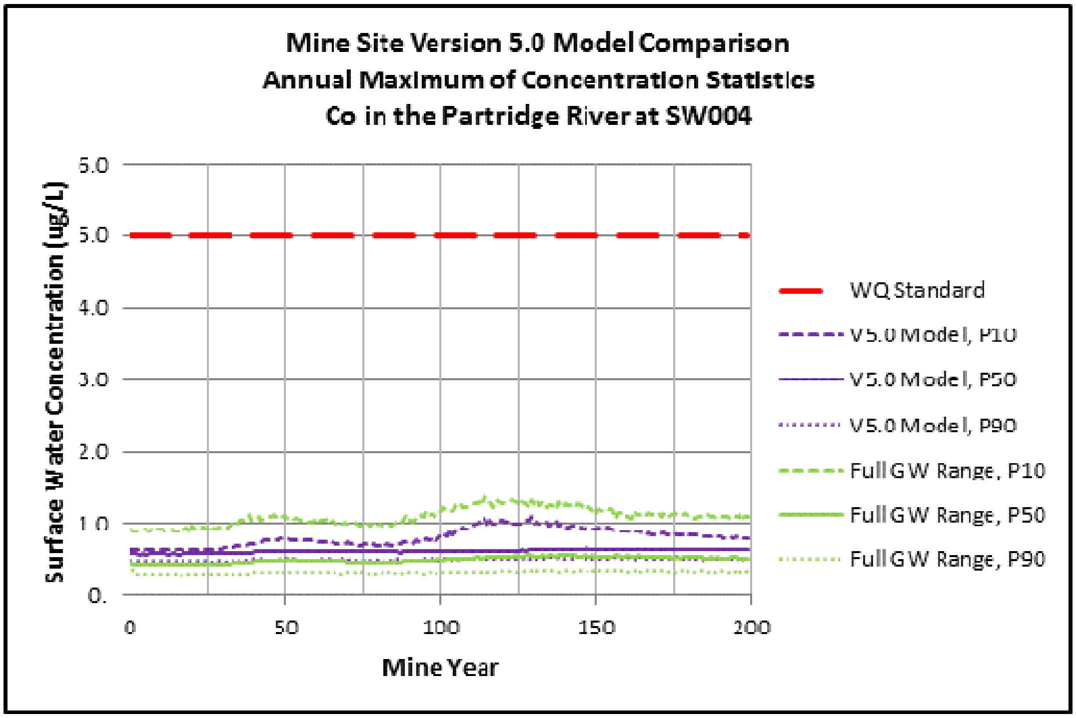



**Figure 3-3 Cobalt Concentration Comparison in the Partridge River at SW004**

The range of estimated concentrations for each surface water evaluation location is shown in the figures in Appendix E. The plots are reproduced with modifications from Large Figures 55-62 in Reference (1).

Similar to the results presented for the groundwater flow paths, the range of estimated concentrations in the sensitivity model results for the surface water is wider for many constituents than in the Version 5.0 model results. However, there is less of a difference between the two model runs for the range of surface water concentrations compared to the results for groundwater quality. This similarity between the models is due to the fact that downstream of SW004a, the peak concentrations for many constituents occur when low flows in the Partridge River mix with the discharge from the long-term WWTF. The discharge quantity and quality are essentially unchanged in the sensitivity model from the Version 5.0 model; only the quality of base flow in the Partridge River would vary in these situations. As shown in Figure 3-4 for the cobalt concentration at SW004a, the difference between the 90th percentile concentrations in the two models after the WWTF begins discharging (at approximately Mine Year 40) is small. The difference between the two model runs at the peak 90th percentile concentration is 0.26 µg/L, approximately a 12% change in concentration.

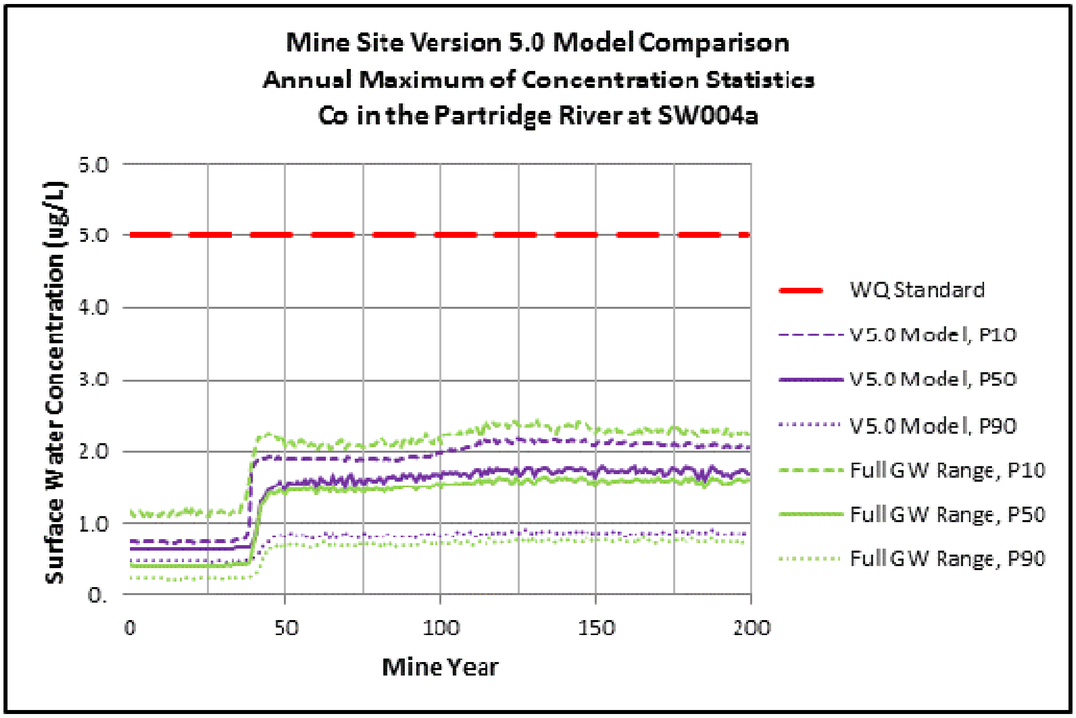



**Figure 3-4 Cobalt Concentration Comparison in the Partridge River at SW004a**

In no case does the sensitivity model cause a new exceedance of a surface water quality standard at the 90th percentile concentration. The exceedances for aluminum at all surface water evaluation locations, iron and manganese in Colby Lake, and sulfate at SW005 remain as the only modeled exceedances of applicable water quality standards. Each of these constituents is discussed in detail in Section 6.4.6 of Reference (1) for the Version 5.0 model; the conclusions for the sensitivity model are identical.

In particular, the likelihood of an exceedance of the 10 mg/L sulfate standard is actually reduced in the sensitivity model compared to the Version 5.0 model, both for the Project and existing conditions. Figure 3-5 shows the probability of an exceedance in the Version 5.0 model, while Figure 3-6 shows the same model output for the sensitivity model.

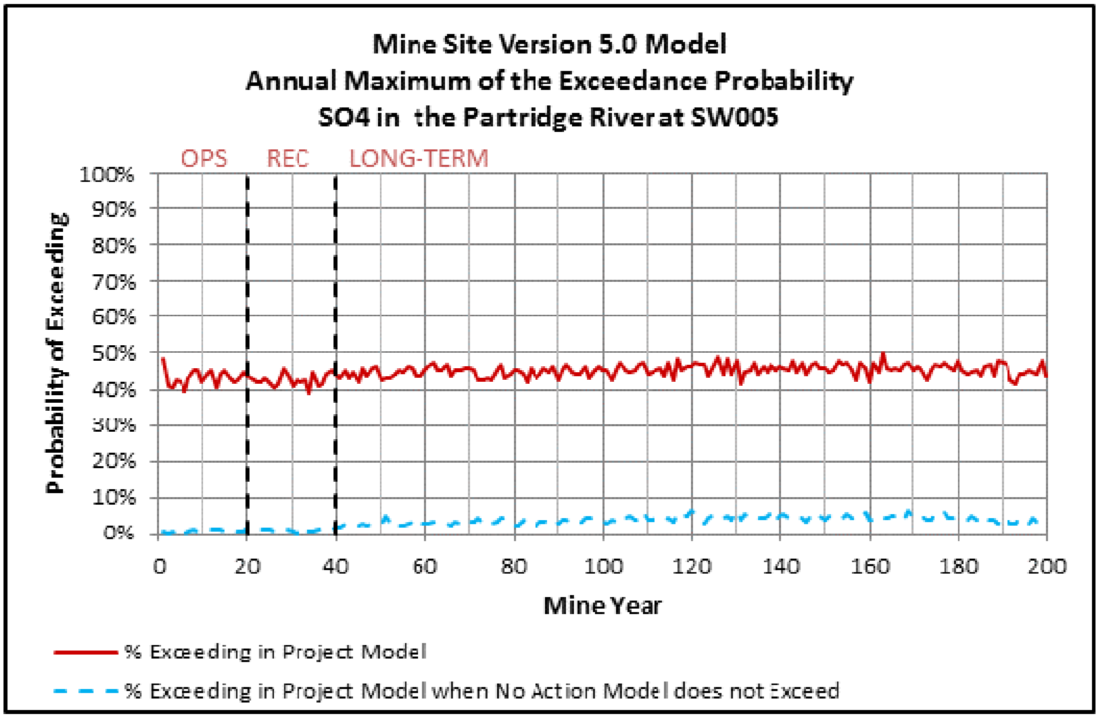



**Figure 3-5** **Probability of a Sulfate Exceedance in the Partridge River at SW005 (Version 5.0 Model)**

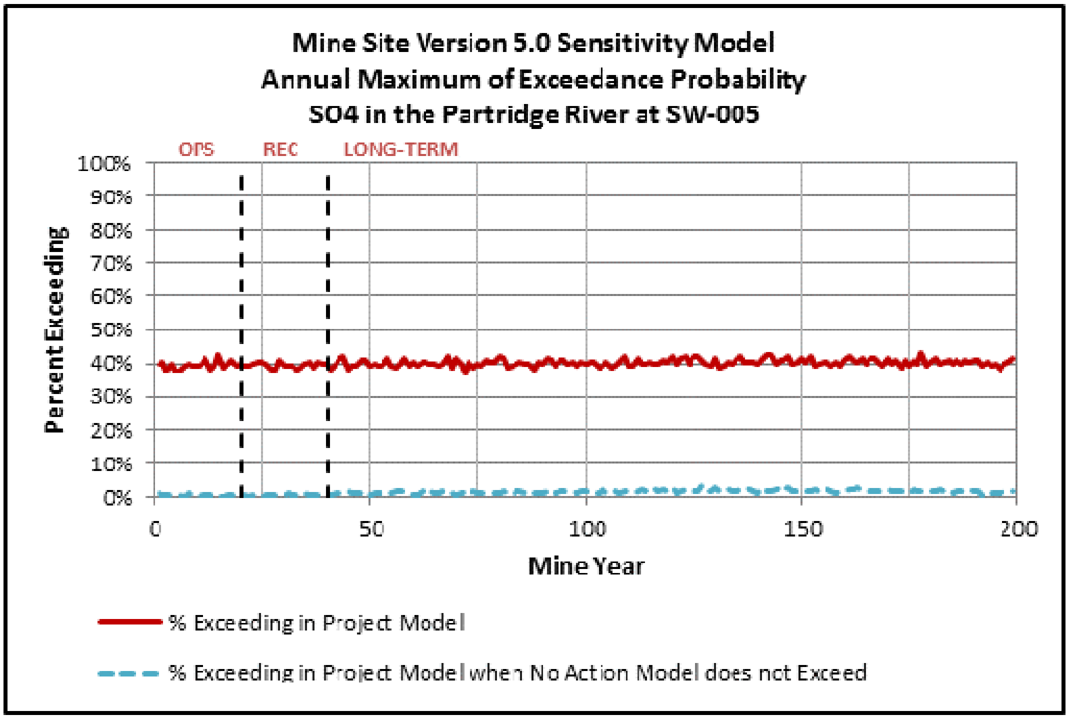



**Figure 3-6** **Probability of a Sulfate Exceedance in the Partridge River at SW005 (Sensitivity Model)**

Including the distribution of the full population of groundwater quality samples in the Mine Site model results in a slight decrease in the probability that sulfate in groundwater will be less than 10 mg/L, because the modeled distribution for sulfate is skewed towards smaller values (see the distribution figure in Appendix C).

## 3.6 Conclusions

The sensitivity model assessed here represents the unrealistic assumption that any of the individual samples of background groundwater quality could represent the quality of recharge and base flow throughout the Partridge River watershed for the entire modeled period. The results show that the estimated concentrations in the groundwater and surface water are sensitive to this model change to the extent that there are observable differences between the sensitivity model and the Version 5.0 model, typically on the order of a 10% change in peak concentrations. The Project's ability to comply with the applicable groundwater and surface water quality standards, however, is not sensitive to the choice of distribution for the background groundwater quality. The estimated Project impact on the environment is unchanged in the sensitivity model, despite its extreme nature.

# 4.0 Plant Site – Recharge to Groundwater

## 4.1 Introduction

In a letter from the USEPA to the Co-lead Agency project managers (Reference (5)), a concern was raised regarding the treatment of recharge to groundwater at the Plant Site:

> *"Recharge is assumed to be a triangular distribution with a minimum, mode, and maximum of 0.3, 0.6 and 1.5 [in/yr]. We have two concerns with this approach:*
>
> *It makes recharge independent of precipitation, which is separately modeled with a normal distribution. In reality, years with high precipitation will have high recharge and vice versa. There is a correlation between recharge and precipitation which is not accounted for in the GoldSim model.*
>
> *Triangular distributions are only correct for random processes that have defined values for minimum, maximum and most common values, such as interest rates that cannot fall below zero or exceed 1 and generally have a modal value. Thus, the selection of the triangular distribution to model recharge appears to be arbitrary and could lead to inaccurate results in the GoldSim model. We request additional rationale be provided concerning the determination of minimum and maximum recharge."*

The Co-lead Agencies provided a written response to these questions, in which it was agreed that PolyMet would perform sensitivity analyses to assess the sensitivity of the model results to the definition of the recharge in the NorthMet Plant Site water quality model. Presented in this section are two separate sensitivity analyses: the first to assess the use of a lognormal distribution (rather than triangular) to define recharge (Section 4.2), and the second to assess the correlation of recharge to precipitation while using a lognormal distribution for recharge (Section 4.3). In the following sections, the term "sensitivity analysis" is used generically, as a method that tests the sensitivity of a model prediction to a model input. Section 2.0 presents a more traditional sensitivity analysis in that the model is run deterministically, with all inputs at the mean value and a single input is varied one at a time. In contrast, the approach employed in this section is to redefine the recharge input, rerun the entire probabilistic simulation (500 realizations, 200 years of monthly time steps), and then compare the summary statistics of the output to see how sensitive the model results are to alternative definitions for the distribution of recharge to groundwater.

## 4.2 Step 1: Recharge Distribution Definition

The distribution used to represent the net recharge rate to each flow path in the current version of the probabilistic model (Version 5.0, Reference (2)) is a triangular distribution with 0.6 in/yr as the most likely value, based on the estimated base flow in the Embarrass River. The lower bound was assumed to be half of the most likely value (0.3 in/yr) and the upper bound is five times the lower bound (1.5 in/yr). This range was based on collective professional judgment developed and agreed to during the Impact Assessment Planning (IAP) process. A triangular distribution is commonly used in probabilistic modeling where data are limited but uncertainty is relatively low (less than a factor of 10) and there is knowledge about a most likely value or midpoint, in addition to a range (see Reference (7)).

In order to address the concern presented in Section 4.1, the model input was redefined to be a lognormal distribution with a mean of 0.812 in/yr and a standard deviation of 0.29 in/yr. The mean and standard deviations were selected to most closely match the cumulative distribution function of the triangular distribution. Figure 4-1 shows the comparison of the cumulative distribution functions of the triangular and lognormal distributions. The probabilistic simulation using the lognormal distribution is referred to as the "sensitivity model" in the remainder of this section, and is compared to the "Version 5.0 model" documented in Reference (2).

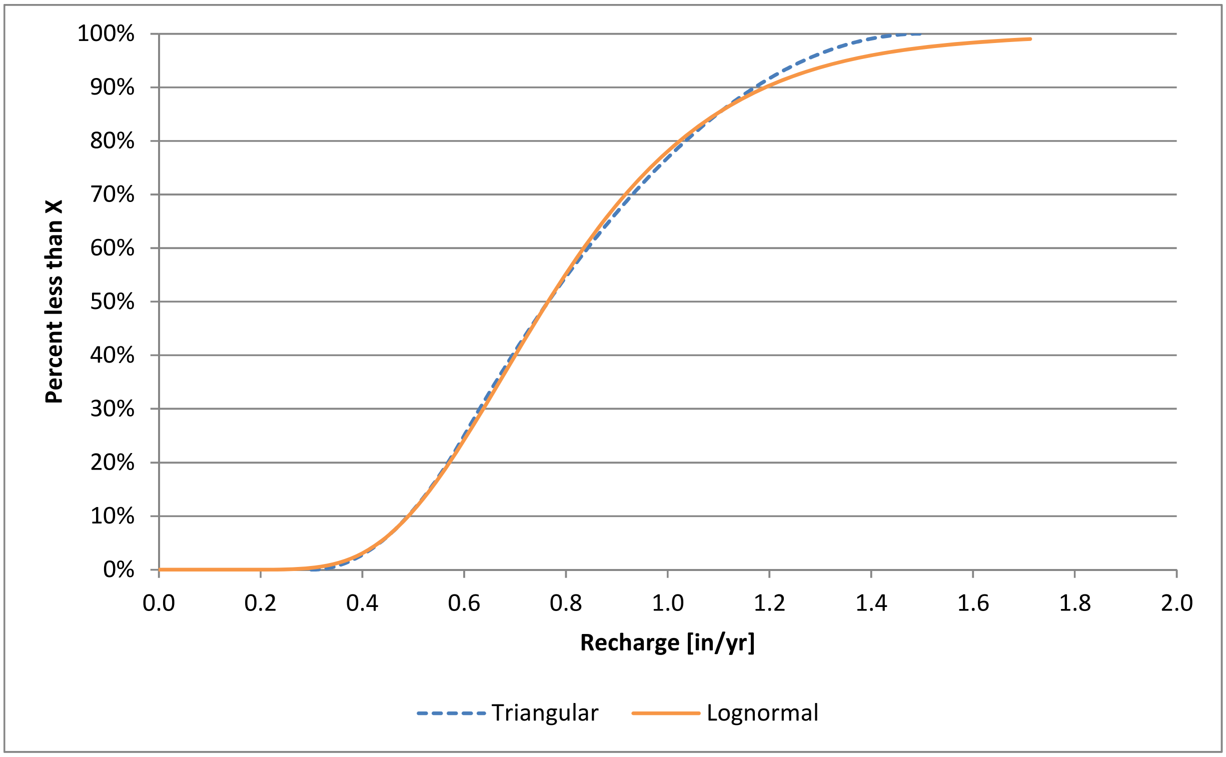



**Figure 4-1 Comparison of the Recharge Distribution in the Version 5.0 and Sensitivity Models**

### 4.2.1 Groundwater Results

Model results for this sensitivity analysis are provided in Appendix F, which contains summary plots of estimated groundwater concentrations for each groundwater flow path at the property boundary. In these plots, the black bars are the values that are presented in the Version 5.0 model (Reference (2)) and the orange bars are the values from the sensitivity model redefining recharge using a lognormal distribution. In general terms, the lognormal distribution allows for some realizations to have higher recharge rates than were allowable in the Version 5.0 model (~2.6% of the realizations have a recharge rate greater than 1.5 in/yr). The potential for higher recharge rates results in a potential for higher groundwater flows and faster travel times. Figure 4-2 shows a time-series plot of estimated sulfate concentrations in the north flow path under both recharge distribution assumptions (triangular and lognormal). In the Version 5.0 model run, due to the FTB Containment Systems, the water quality in the flow paths trend towards natural background groundwater quality. Modifying the recharge definition in the way described in this section still shows the same response for trending toward background concentrations, but simply occurring slightly faster. Figure 4-3 shows a similar response for chloride. For lead, shown in Figure 4-4, the response is different in that the Project water is clearly visible as a pulse. Because the Project water is relatively dominant during that time, the change in the model results is nearly imperceptible. In the following figures, the green lines, labeled "LN Recharge", represent the sensitivity model where recharge is redefined as lognormal. The purple lines, labeled "v5.0 Model", are the same as the results presented in for the Version 5.0 model (Reference (2)).

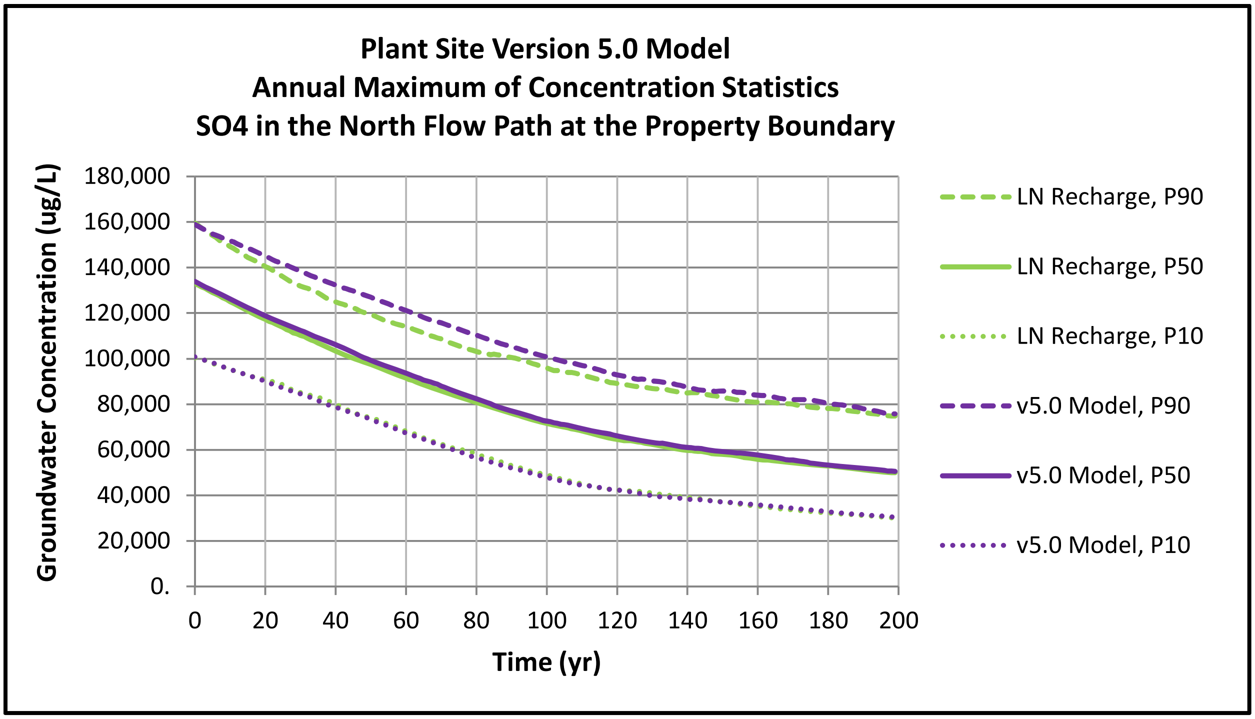



**Figure 4-2 Range of Sulfate Concentrations in the North Flow Path at the Property Boundary**

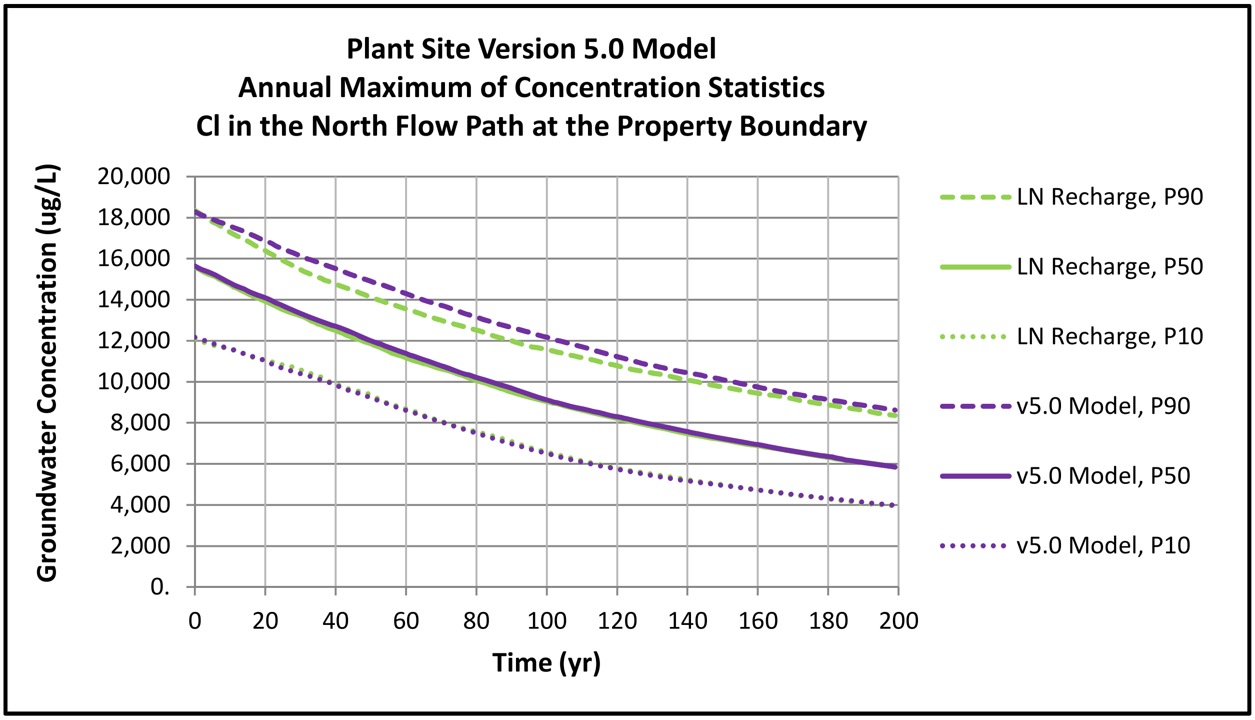



**Figure 4-3 Range of Chloride Concentrations in the North Flow Path at the Property Boundary**

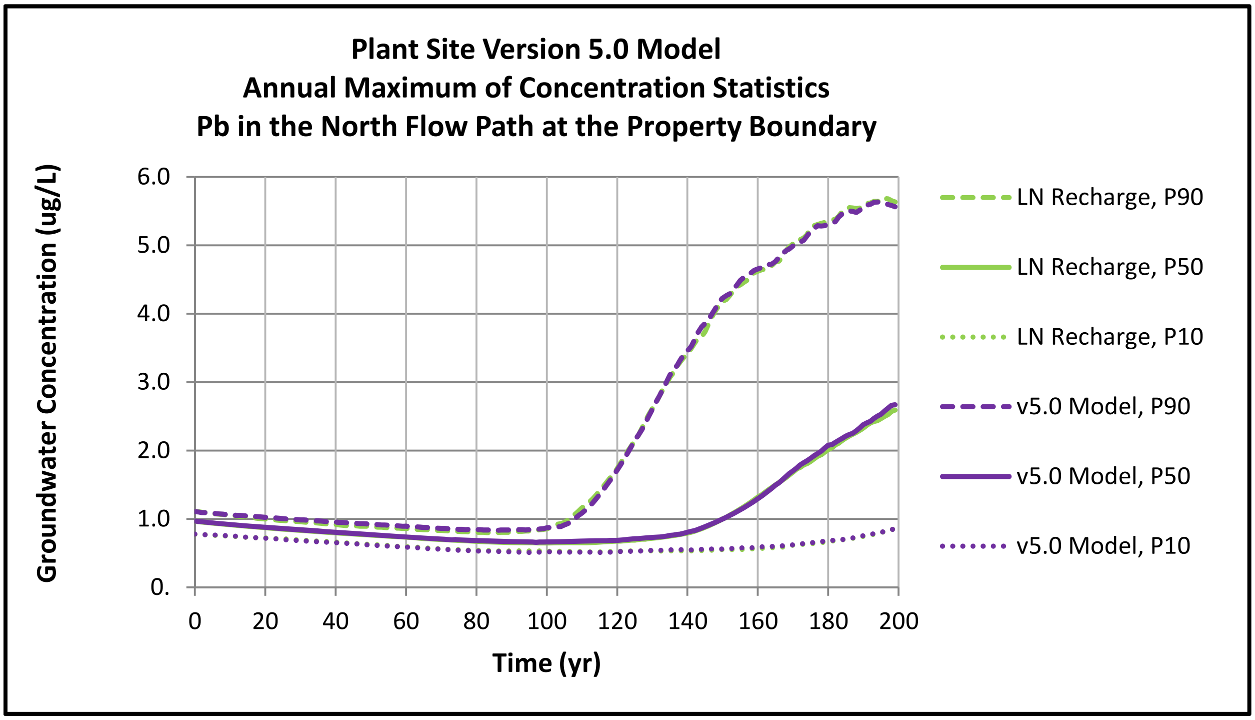



**Figure 4-4 Range of Lead Concentrations in the North Flow Path at the Property Boundary**

### 4.2.2 Surface Water Results

As a result of modifying the distribution used for recharge (lognormal versus triangular), the surface water quality results show similar magnitudes of variation as the groundwater quality results showed (see Appendix G). Additionally, the model results show that the probability of exceedances occurring in receiving surface waters is not sensitive to using a lognormal distribution for recharge as opposed to triangular. In the following figures, the green lines, labeled "LN Recharge", represent the sensitivity model where recharge is redefined as lognormal. The purple lines, labeled "v5.0 Model", are the same as the results presented for the Version 5.0 model (Reference (2)). In Mud Lake Creek at MLC-2 (where the north flow path discharges to surface water) the effect of redefining recharge is visible in the water quality results, more so for sulfate than for lead (see Figure 4-5 and Figure 4-6). The visible effect in sulfate reinforces that higher concentrations of sulfate exist during low flow conditions when groundwater flow dominates in the creek; allowing for higher recharge values widens the range of concentrations in earlier years and narrows the range in later years. In Trimble Creek at PM-19, the effect of redefining recharge is nearly invisible in the water quality results, particularly with lead (see Figure 4-7 and Figure 4-8). The water quality in Trimble Creek is mostly dominated by augmentation water (either the WWTP effluent or the transfer from Colby Lake). Finally, in the Embarrass River at PM-13, the effect of redefining recharge is even less visible in the water quality results if at all (see Figure 4-9 and Figure 4-10).

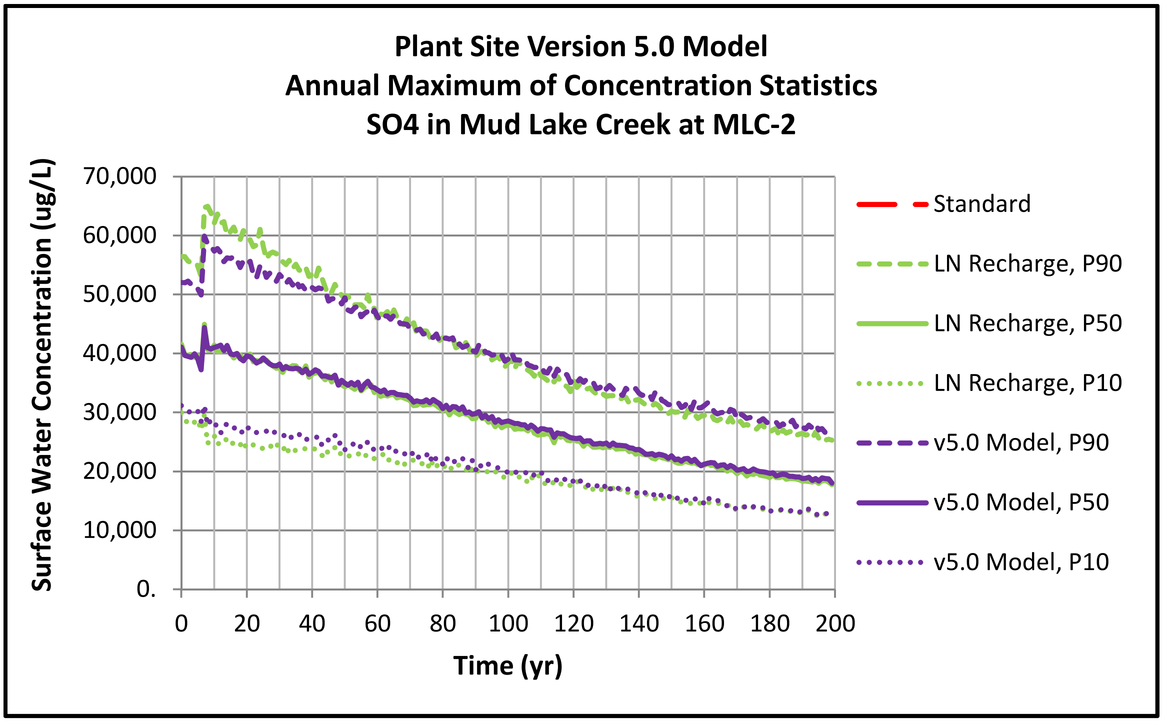



**Figure 4-5 Range of Sulfate Concentrations in Mud Lake Creek at MLC-2**

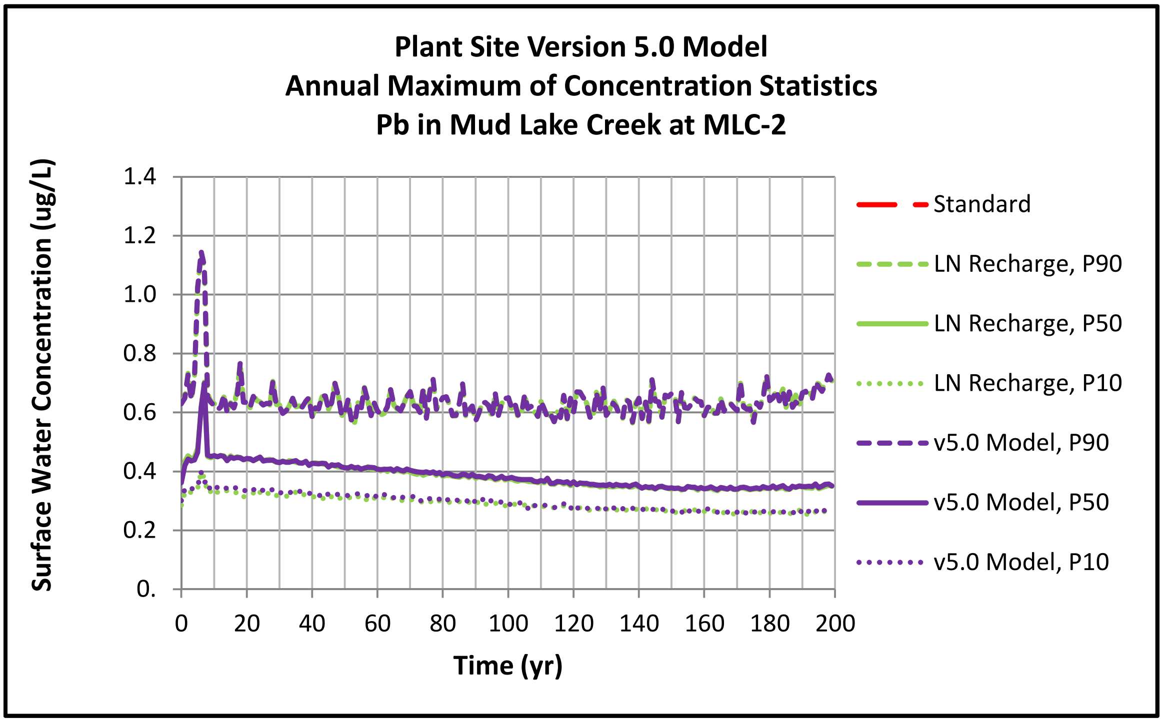



**Figure 4-6 Range of Lead Concentrations in Mud Lake Creek at MLC-2**

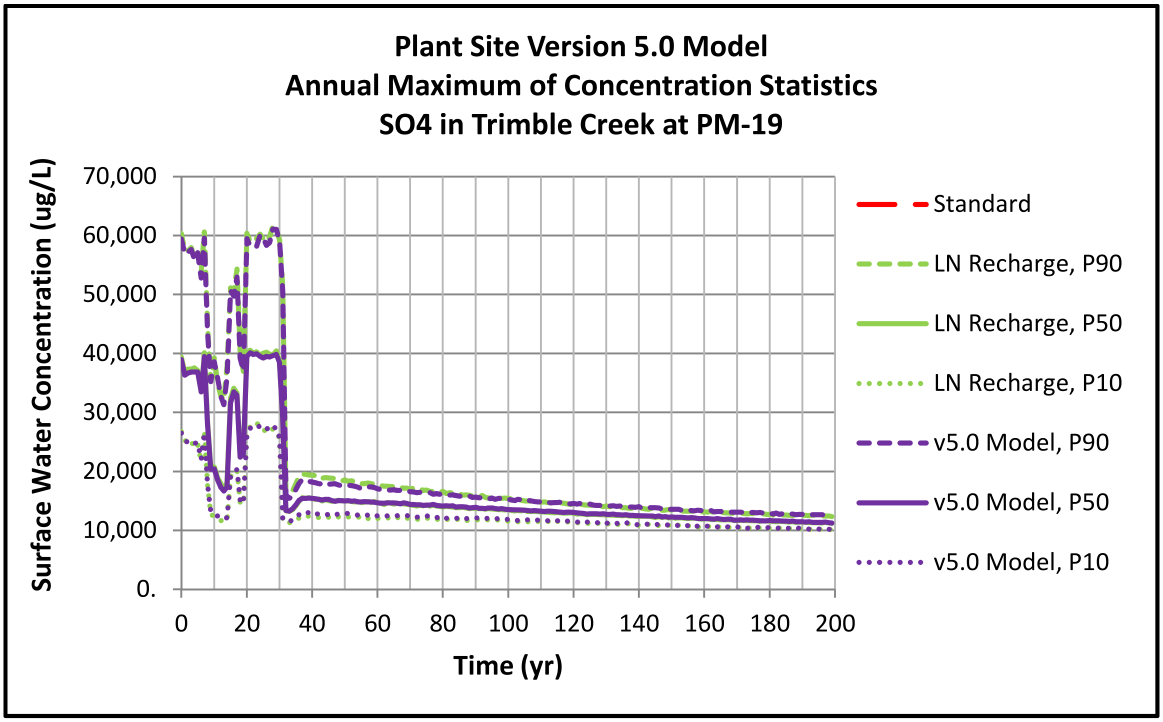



Figure 4-7 Range of Sulfate Concentrations in Trimble Creek at PM-19

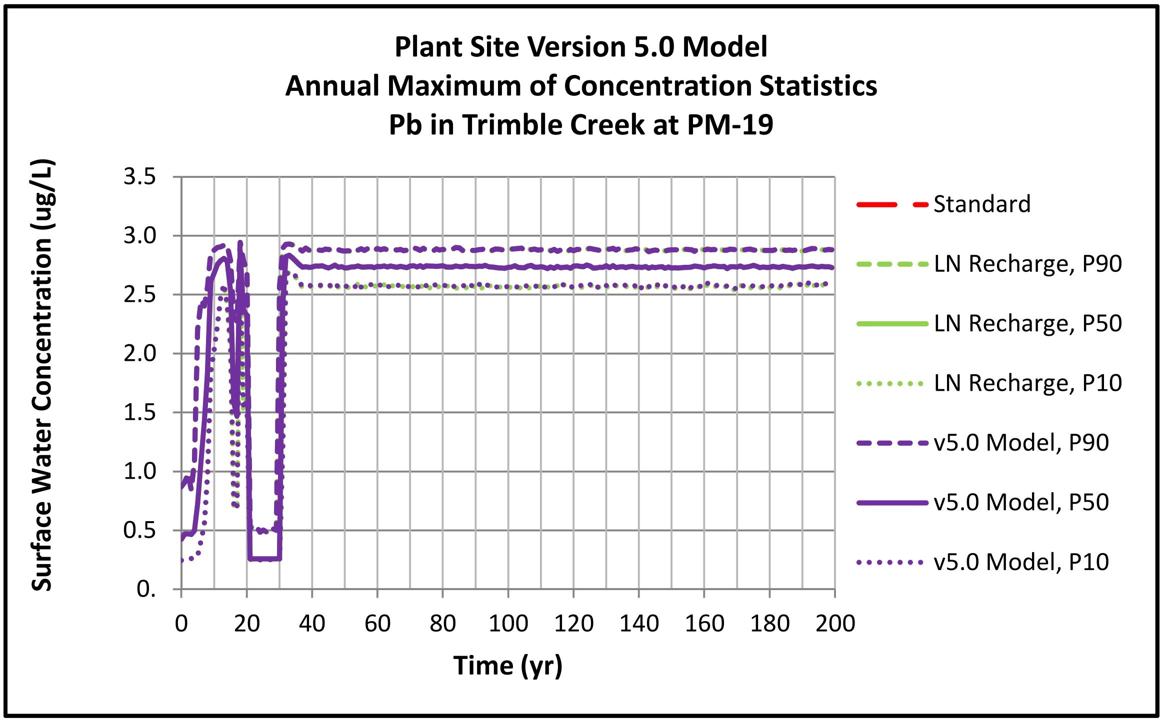



Figure 4-8 Range of Lead Concentrations in Trimble Creek at PM-19

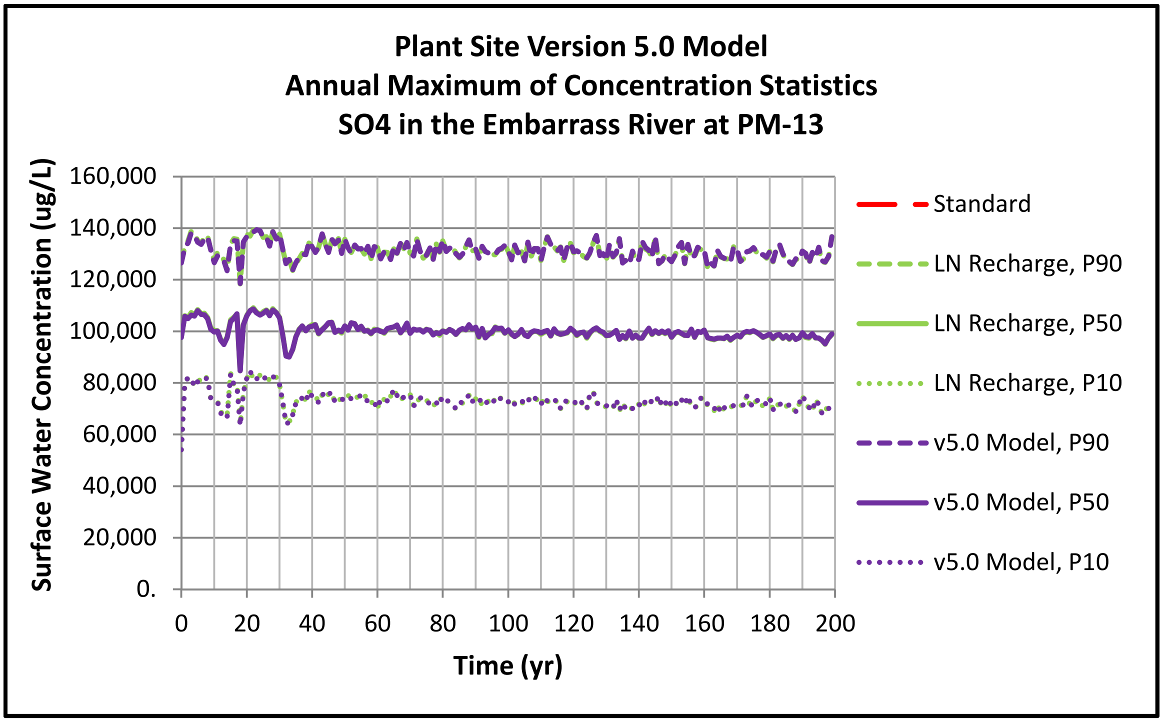



**Figure 4-9** Range of Sulfate Concentrations in the Embarrass River at PM-13

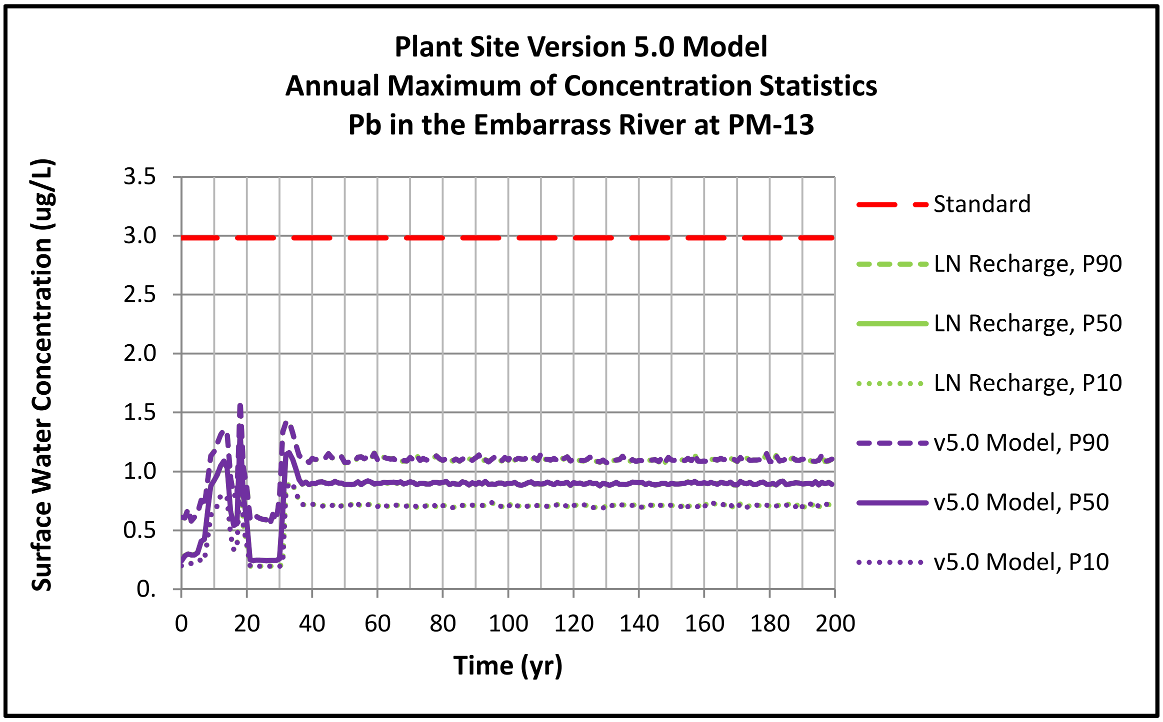



**Figure 4-10** Range of Lead Concentrations in the Embarrass River at PM-13

## 4.3 Step 2: Correlation to Precipitation

In the first part of the USEPA comment referenced in Section 4.1, concern is expressed over the lack of modeled correlation between precipitation and aquifer recharge. A correlation between precipitation and recharge is not included in the model because there is not strong evidence to support such a correlation in this hydrologic setting. It was decided during model development to not include correlations unless clearly required by theory or empirical evidence.

The definition of recharge in the probabilistic model was intended to represent the spatial and temporal average of recharge throughout the watershed. As a result, a recharge value is randomly sampled for an entire flow path and for the entire realization. In order to correlate recharge to precipitation, it would be necessary to select a recharge value for each year (rather than for the entire period of simulation as is done in the Version 5.0 model). Annual variations in recharge within the prescribed distribution are not expected to affect the assessment of impacts. Annual variations will be smoothed out or integrated given the long travel times of decades to centuries in the groundwater flow paths. Therefore, as values are randomly chosen more frequently from the same distribution, each realization will tend to have a tighter range of flow around the mean (defined by 0.812 in/yr). Increasing the sampling frequency from once per realization to annually will cause the time-averaged total flow in groundwater to be close to the mean flow for each realization.

In order to address concern over the lack of correlation between precipitation and recharge, the model input for recharge was redefined as described in Section 4.2, the recharge distribution was resampled annually, and recharge was correlated to precipitation with a correlation coefficient of +1 (as an extreme case of correlation).

### 4.3.1 Groundwater Results

The figures in Appendix H show the summary of output statistics for the groundwater evaluation locations, comparing the Version 5.0 model with the sensitivity analysis model. As expected the water quality results of the sensitivity model run vary slightly from the water quality results of the Version 5.0 model. However, the variation is still very small and tends to raise the minimum 10th percentile value while not altering the maximum 90th percentile value. In the following figures, the green lines, labeled "Correlated LN Recharge", represent the sensitivity model where recharge is redefined as lognormal and correlated to precipitation. The purple lines, labeled "v5.0 Model", are the same as the results presented for the Version 5.0 model (Reference (2)). The north flow path is generally shown because it is most significantly affected by the Flotation Tailings Basin.

As is discussed in Section 4.2, the proposed FTB Containment System that is part of the Project causes estimated groundwater concentrations to trend towards natural background groundwater quality. For most modeled constituents, this means moving from the current elevated concentration to a lower background concentration in the long-term. For these constituents, the result is that the maximum P90 values (90th percentile concentrations) occur at the beginning of the simulation and the minimum P10 values occur near the end of the simulation. Adding a correlation between recharge and precipitation has little effect on the estimated concentrations at the beginning of the simulation, which is why the maximum P90 value is similar for the Version 5.0 model and the sensitivity model.

The minimum P10 value does increase for some constituents (i.e., Cl, F, Na, and $SO_4$). This is the result of a narrower range in estimated concentrations due to the increased frequency in which recharge is sampled from the distribution. That is, the long-term range of concentrations in the flow paths is narrower in the sensitivity model relative to the Version 5.0 model. This can be seen in Figure 4-11 which shows estimated concentrations of sulfate in the north flow path at the property boundary.

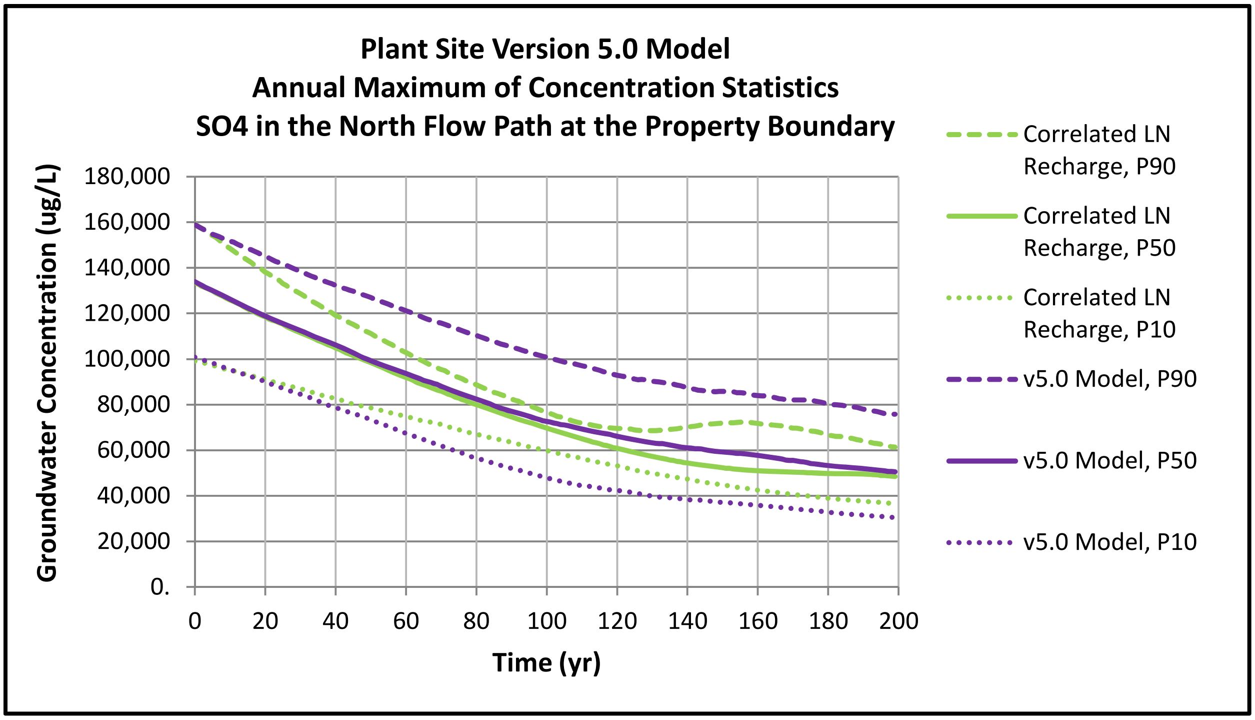



**Figure 4-11 Range of Sulfate Concentrations in the North Flow Path at the Property Boundary**

Lead and cobalt (Pb and Co) appear to be the only constituents that show an increase in the maximum P90 value in the plots in Appendix H. These are the only constituents that actually show a visible "pulse" of impacted water from the Project in the groundwater flow paths at the property boundary (for all other constituents, the FTB Containment Systems effectively reduces the loading to the groundwater flow path from the Tailings Basin relative to existing conditions). The slightly faster travel times of the Project water through the groundwater flow paths due to the increase in recharge at high percentiles (see Figure 4-1) results in higher concentrations of lead and cobalt when the Project water peaks at the property boundary (see Figure 4-12 for an example showing lead in the north flow path).

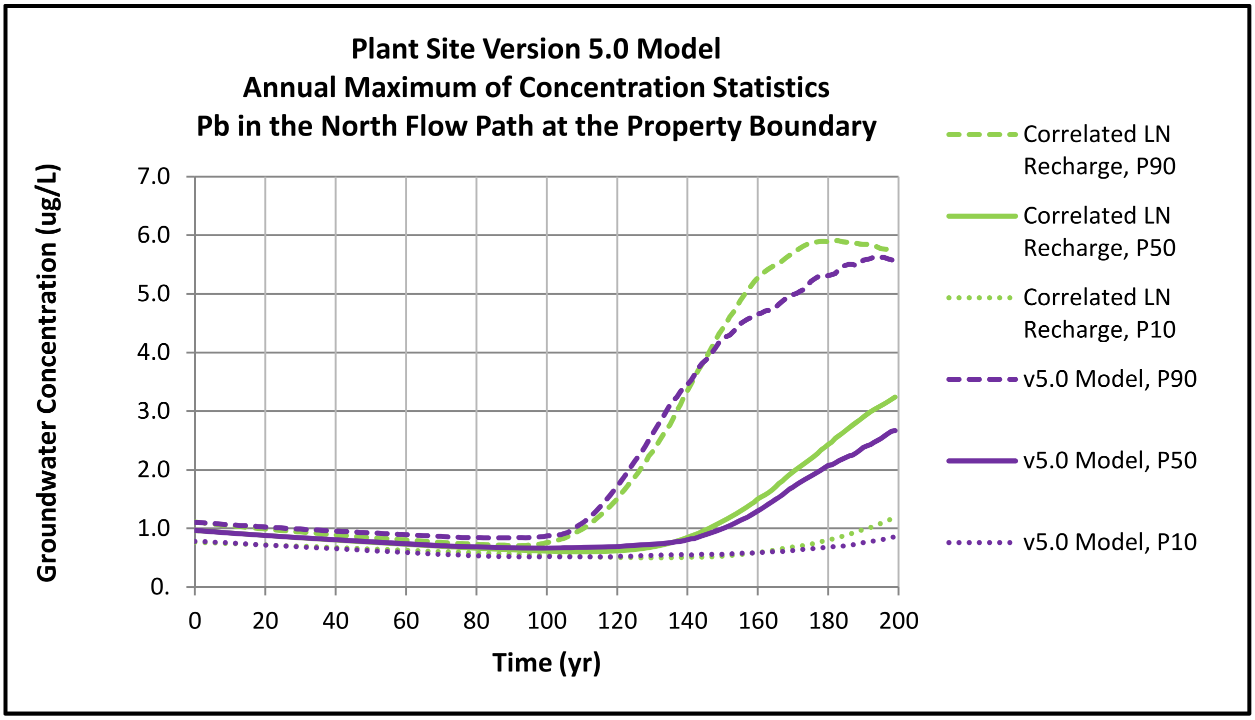



**Figure 4-12 Range of Lead Concentrations in the North Flow Path at the Property Boundary**

### 4.3.2 Surface Water Results

Although the model results show that groundwater quality does vary due to including correlation to precipitation (with a coefficient of +1), the same magnitude of the water quality variations do not appear in the surface water quality results of the receiving surface water bodies (see Appendix I). Additionally, the model results show that the probability of exceedances occurring in receiving surface waters is not sensitive to the modeled correlation between recharge and precipitation. In the following figures, the green lines, labeled "Correlated LN Recharge", represent the sensitivity model where recharge is redefined as lognormal and correlated to precipitation. The purple lines, labeled "v5.0 Model", are the same as the results presented for the Version 5.0 model (Reference (2)). In Mud Lake Creek at MLC-2 (where the north flow path discharges to surface water) the effect of correlating recharge to precipitation is visible in the water quality results (see Figure 4-13 and Figure 4-14). The changes in flow from the groundwater flow paths to the receiving surface water bodies actually causes the lead water quality statistics presented to decrease. In Trimble Creek at PM-19, the effect of correlating recharge to precipitation is less visible in the water quality results, particularly with lead (see Figure 4-15 and Figure 4-16). The water quality in Trimble Creek is mostly dominated by augmentation water (either the WWTP effluent or the transfer from Colby Lake). Finally, in the Embarrass River at PM-13, the effect of correlating recharge to precipitation is even less visible in the water quality results if at all (see Figure 4-17 and Figure 4-18).

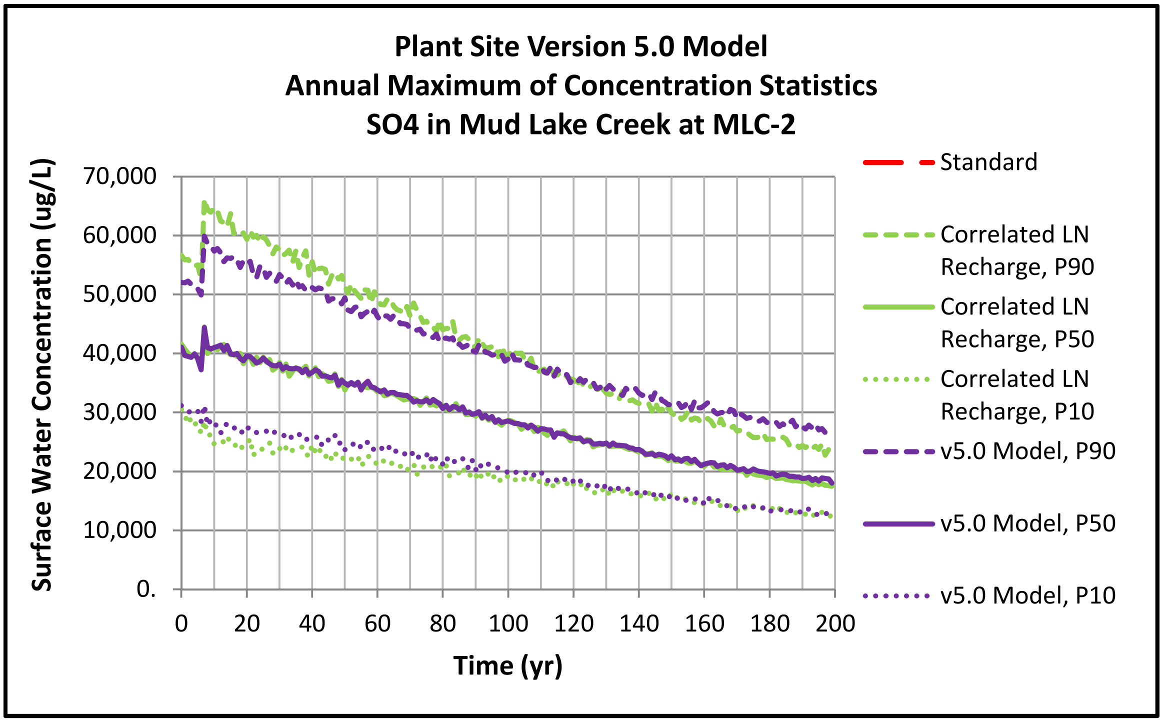



**Figure 4-13 Range of Sulfate Concentrations in Mud Lake Creek at MLC-2**

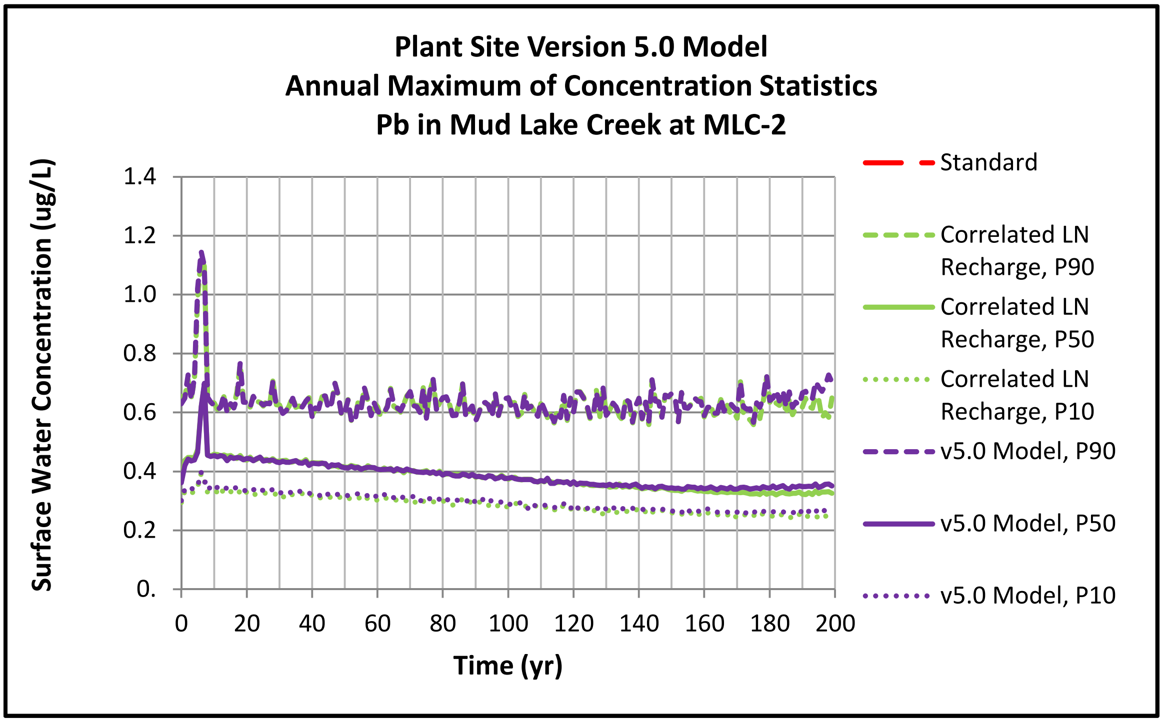



**Figure 4-14 Range of Lead Concentrations in Mud Lake Creek at MLC-2**

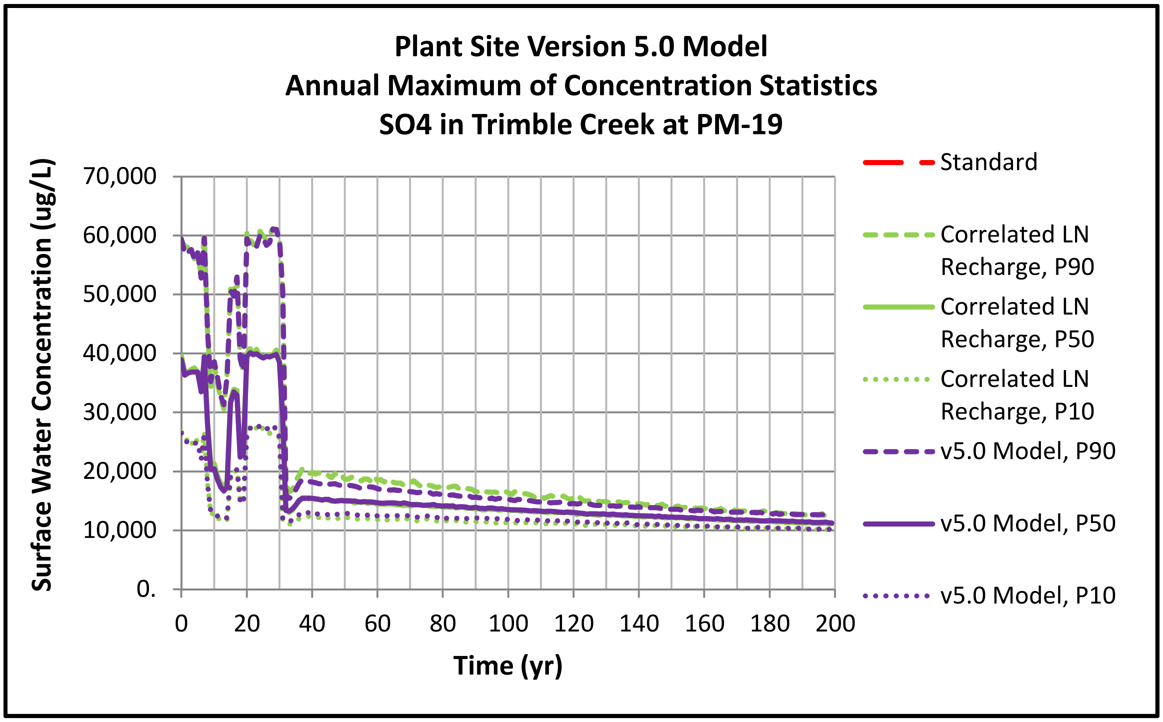



**Figure 4-15 Range of Sulfate Concentrations in Trimble Creek at PM-19**

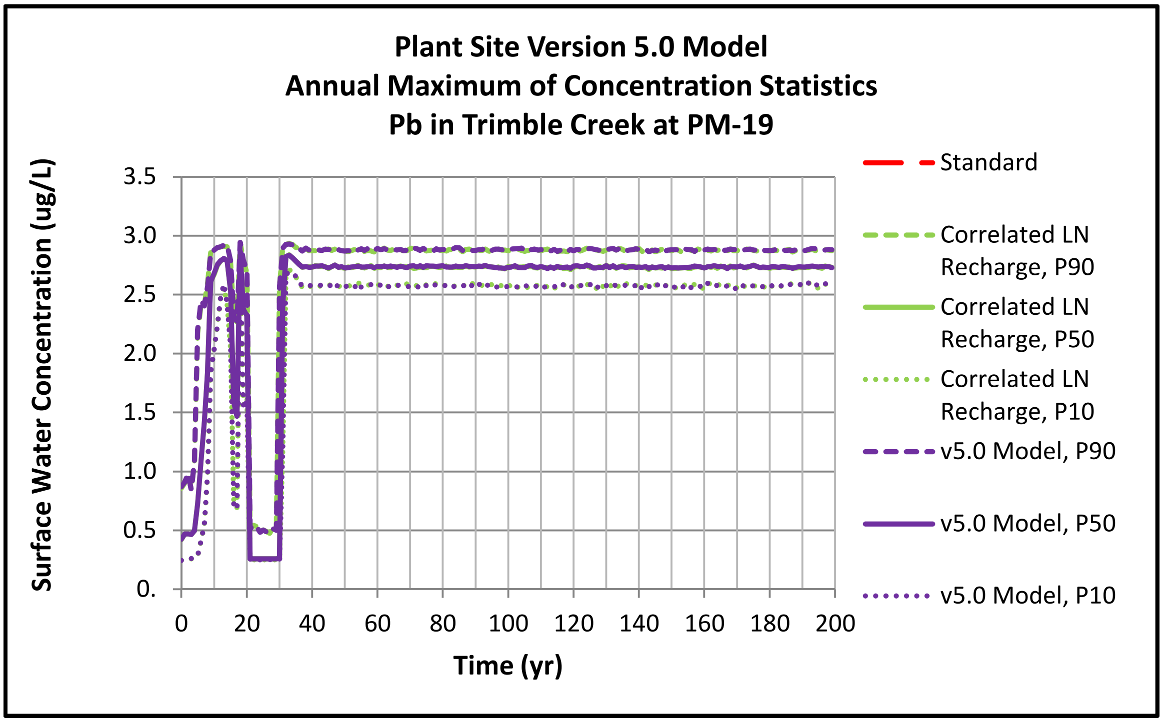



**Figure 4-16 Range of Lead Concentrations in Trimble Creek at PM-19**

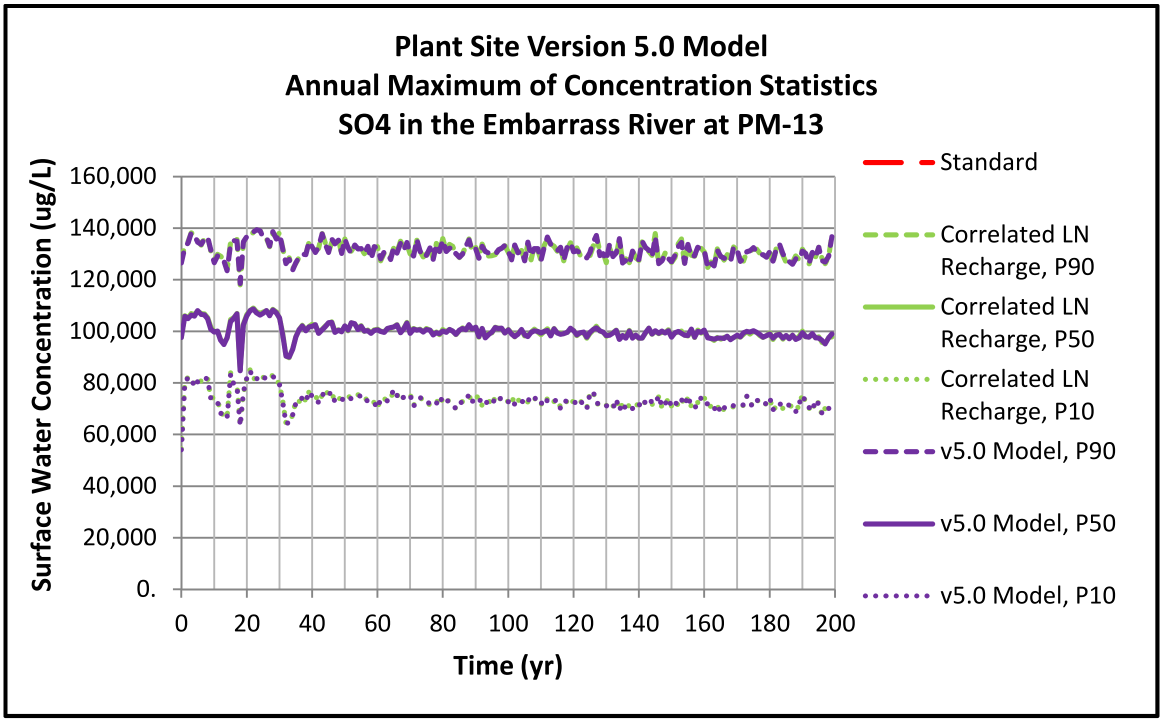



**Figure 4-17** Range of Sulfate Concentrations in the Embarrass River at PM-13

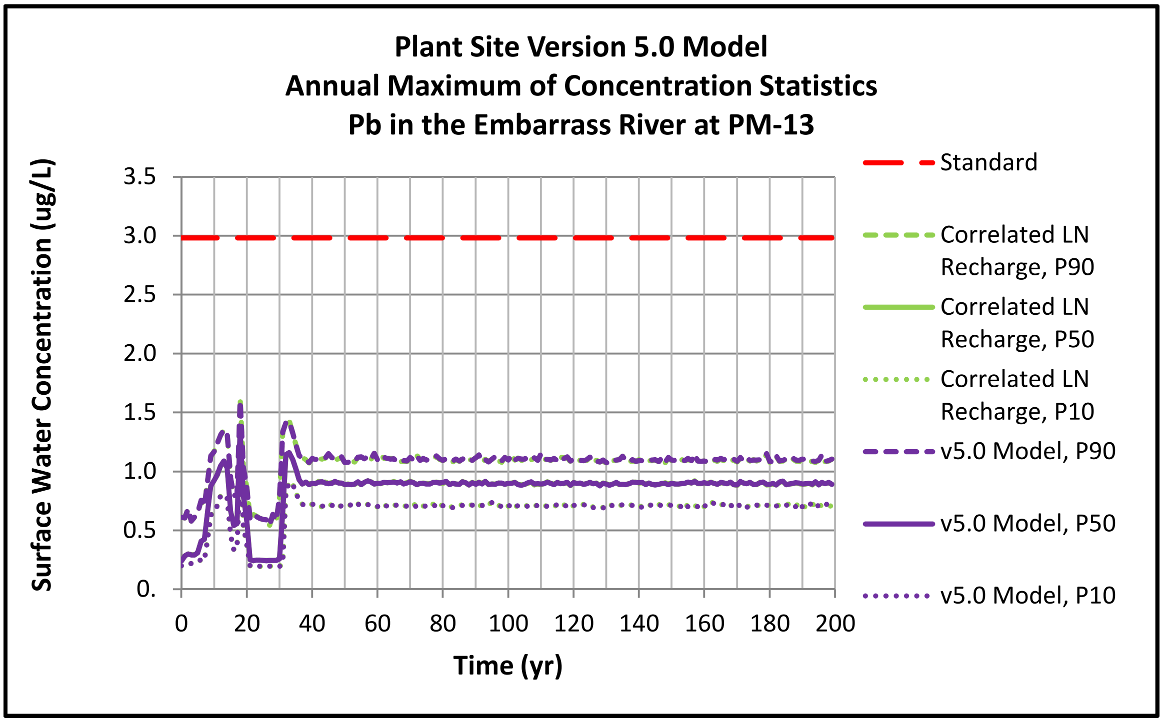



**Figure 4-18** Range of Lead Concentrations in the Embarrass River at PM-13

## 4.4 Conclusions

Changing the distribution used for aquifer recharge from triangular to lognormal and correlating recharge to precipitation does result in minor changes to the estimated 10th percentile, 50th percentile, and 90th percentile groundwater and surface water concentrations. However, the changes are minimal. Further, the estimation of the potential to exceed an applicable groundwater or surface water standard is not sensitive to these model input changes. As shown in the figures in Appendix F through Appendix I, the highest 90th percentile values have not changed from being under the standard to being over the standard.

# 5.0 Mine Site – Climate Change

At the direction of the Co-lead Agencies, the potential effects of climate change on water quality and quantity estimates for the Project are considered by conducting a sensitivity analysis using the Project and Continuation of Existing Conditions Models developed for the Supplemental Draft Environmental Impact Statement (Version 5.0 model). The sensitivity analysis involved varying certain temperature and precipitation inputs to the probabilistic model from values representing current conditions to values representing possible future conditions affected by climate change. Modification to the probabilistic model is limited to the Mine Site. That is, quantitative modeling of potential climate change is not continued downstream of the Mine Site (e.g., changes in Partridge River flow are not assessed). The probabilistic model (Version 5.0 model) of the Project is used for this sensitivity analysis. The No Action Model is not used because the quantitative impact analysis is limited to Mine Site features, which do not exist in the No Action Model. This section describes the modifications made to the probabilistic model to perform the climate change sensitivity analysis and presents the results. Given the lack of sensitivity of model predictions to the input changes, as presented in Section 5.2, this analysis was not updated using the updated models developed for the Final Environmental Impact Statement (Version 6.0 model).

## 5.1 Modifications to Probabilistic Model

The Mine Site Project probabilistic model is a continuous time series model of 200 years starting at Mine Year 1 (the start of the first year of mining). The model inputs described in this section and presented in Table 5-1 are gradually varied through time between Mine Year 1 and Mine Year 60; beyond Mine Year 60, model inputs remain at Mine Year 60 values. Changes in model inputs are assumed to be linear with respect to time. Table 5-1 summarizes the input parameter variations for the climate change sensitivity analysis. The temperature and precipitation ranges selected as inputs for the climate change sensitivity analysis are based on guidance from the Co-Lead Agencies (Reference (8)). The following sections provide additional detail on each parameter modified for the climate change sensitivity analysis. In summary, the mean annual temperature is increased from 2.004 degrees Celsius to 5.2 degrees Celsius, the mean annual precipitation amount is increased from 28.1 in/yr to 29.8 in/yr, and the mean annual open water evaporation is increased by 6.5%.

**Table 5-1 Source of temperature and precipitation inputs for climate change sensitivity analysis**

| Period | Mean Annual Temperature (°C) | Mean Annual Precipitation (mm) | Mean Summer Temperature (°C) | Mean Summer Precipitation (mm) |
|---|---|---|---|---|
| 1970 – 1990 | 2.0 – 4.5 | 1.8 – 2.1 | 14 – 17.5 | 3.0 – 3.3 |
| 2030 – 2039 | 3.7 – 6.2 | 1.9 – 2.2 | 15.6 – 19.1 | 3.0 – 3.3 |
| 2060 – 2069 | 5.2 – 7.7 | 1.9 – 2.2 | 17.3 – 20.9 | 3.0 – 3.3 |

Reference (9)

### 5.1.1 Mean Annual Temperature

Mean annual temperature is a direct input in the probabilistic model (Field_Temp). This input is used in waste rock scaling calculations. To model climate change, the mean annual temperature is increased from the current conditions value of 2.004 ºC to the lower end of the 2060-2069 estimate, 5.2 ºC. Use of the lower end of the estimated future range is based on the current Mine Site climate-normal value (2.004 ºC) relative to the 1970-1990 range presented in the Table 5-1. Mean annual temperature is given a normal distribution in the probabilistic model; the future distribution of temperature relative to the mean is not modified (i.e., the standard deviation derived from the current climate normal period is used).

### 5.1.2 Mean Annual Precipitation

Mean annual precipitation is an input in the probabilistic model (Annual_Precip_Cuberoot) as part of the site-wide water balance. The mean value at the Mine Site based on the current climate normal period is 28.4 inches per year, or 2.0 mm/day. For the climate change sensitivity analysis, the mean annual precipitation is linearly increased to 2.1 mm/day (the middle of the 2060-2069 range shown in Table 5-1), or 29.8 inches per year. The cubed root of mean annual precipitation is assigned a normal distribution in the probabilistic model; the current distribution relative to the cubed root of the mean is not adjusted for this sensitivity analysis.

The seasonal (monthly) distribution of precipitation is a constant, deterministic input to the probabilistic model. The seasonal distribution of precipitation is not modified for this sensitivity analysis, based on similar summer precipitation rates for future conditions presented in Table 5-1.

### 5.1.3 Mean Summer Temperature

Mean summer temperature is not a direct input in the probabilistic model. Indirectly, monthly temperature values are used to estimate the distribution of open water evaporation using the Thornthwaite method. The percentiles of this distribution are then scaled by the ratio of the mean evaporation calculated using the Thornthwaite method (19.7 inches/year based on current climate normal input data) to observed evaporation rates. This method is detailed in Section 5.2.1.2 of Reference (1).

The range of summer temperatures presented in Table 5-1 shows an approximately 20% increase in future summer temperatures. Applying a 20% increase in June – August temperatures to the current climate normal data and re-calculating the distribution of open water evaporation using the Thornthwaite method results in an increase of annual open water evaporation of 6.5%. For this sensitivity analysis, the average open water evaporation used in the probabilistic model (20.8 inches/year) is increased by 6.5% to 22.2 inches/year. The distribution of mean annual evaporation is based on the 30 years of climate normal data with summer temperatures modified as described above.

## 5.2 Climate Change Sensitivity Analysis Results

The Climate Change Sensitivity Analysis model, which incorporates the input parameter modifications described in this section, was for a 200-year period similar to the Project Model (Section 3.4 of Reference (1)). Changes in estimated flows and concentrations between the Climate Change Sensitivity

Analysis model and the Project Model are evaluated to make quantitative assessments of potential climate change impacts in the East Pit pore water, West Pit Lake, and uncaptured drainage (i.e., leakage) from the stockpiles.

Impacts from potential climate change downstream of these locations (e.g., along groundwater flow paths, the Partridge River) is described qualitatively, taking into account the quantitative results at the Mine Site. The results of this analysis are presented in Sections 5.2.5 and 5.2.6.

### 5.2.1 Water Quality in the East Pit pore water and West Pit Lake

Climate change could affect the water quality at the East Pit pore water and West Pit Lake in a variety of ways. Temperature increases will cause the release rates to increase due to the use of the scaling factor for temperature in modeling release rates from wall and waste rock (Section 8.2 of Reference (6)). The increases in release rates will likely increase load released to water in contact with the pit walls, blasted ore rock, and/or backfilled waste rock depending on the phase of the project. The same is true for runoff and leakage from the stockpiles to the pits. An increase in precipitation will increase flows to the pits from runoff and leakage as well as directly falling on the pits themselves. However, the evaporation rate from any open water will also increase and the increase in temperature should also increase the evaporation from the rock walls and backfill material. The increase in precipitation modeled is slightly greater than the increase in evaporation from open water modeled.

The impacts of the modeled changes in temperature and precipitation are analyzed for lead (Pb), sulfate ($SO_4$), copper (Cu), and iron (Fe) in the East Pit porewater and West Pit Lake by comparing the Project Model results with and without the modeled climate change conditions. The greatest changes in concentrations occur during long-term closure (approximately Mine Year 45 and beyond), as expected, because temperature and precipitation variations for the climate change scenario do not take full effect until Mine Year 60. The differences between the modeled concentrations of lead, sulfate, copper and iron for the East Pit pore water and West Pit Lake, with and without climate change, were averaged over the operations (generally Mine Years 0 to 20), reclamation (generally Mine Years 21 to 45) and long-term closure periods ( generally Mine Years 45 and beyond).

#### 5.2.1.1 Lead

Under the climate change scenario, lead concentrations change very little in East and West Pits as shown in Table 5-2. There is no change in the East Pit Sump, lower porewater or wetland concentrations because lead reaches the concentration cap in both scenarios. The concentrations in the West Pit do show a slight increase due to the climate changes, especially during the reclamation phase which experienced an increase of 0.5 µg/L at 90th percentile probability (4.1%). The time series plot comparing the West Pit concentrations both with and without climate change is shown in Figure 5-1. Increased release of lead from the pit walls due to the temperature increase is likely the reason for the slight increase in lead concentrations during this phase.

**Table 5-2 Changes in Lead Concentrations in the East Pit Porewater and West Pit Lake**

| Location | Time Period | Change (µg/L) | | | Percent Change (%) | | |
|---|---|---|---|---|---|---|---|
| | | P10 | P50 | P90 | P10 | P50 | P90 |
| East Pit Sump | Operations (yr 0-16) | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| East Pit Lower Porewater | Operations (yr 11-20) | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| | Reclamation | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| | Long-Term Closure | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| East Pit Upper/Wetland Porewater | Reclamation | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| | Long-Term Closure | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| West Pit | Operations | 0.01 | 0.02 | 0.02 | 0.6% | 0.5% | 0.3% |
| | Reclamation | 0.1 | 0.2 | 0.5 | 2.5% | 2.9% | 4.1% |
| | Long-Term Closure | 0.1 | 0.1 | 0.3 | 1.9% | 3.0% | 3.9% |

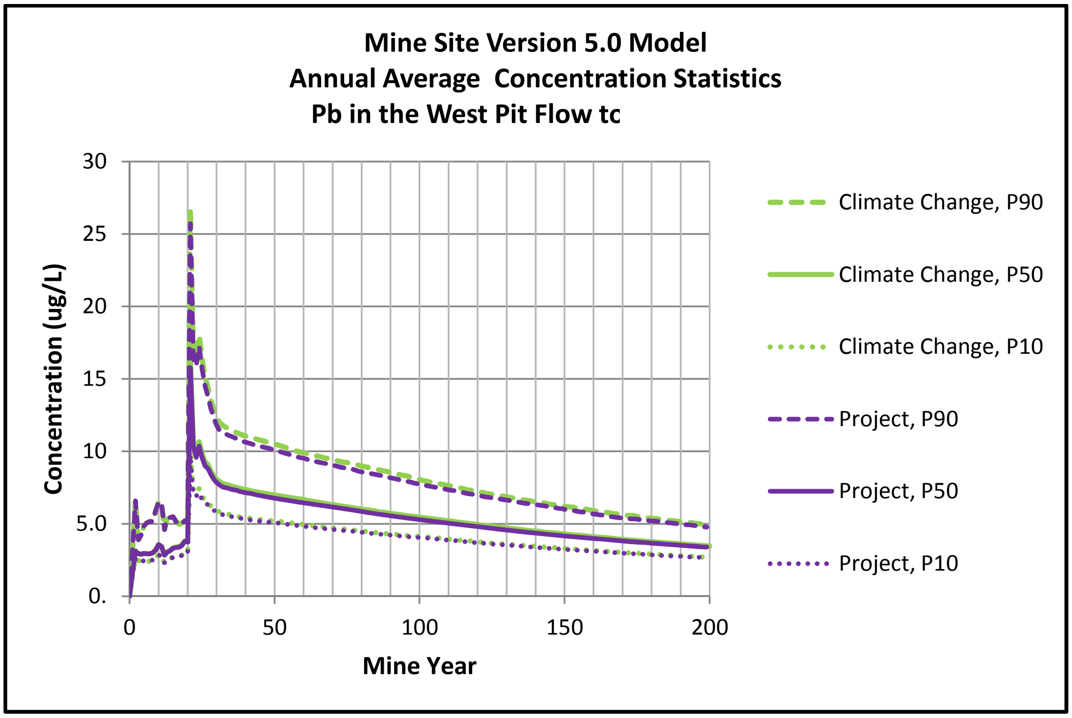



**Figure 5-1 Lead in the West Pit; with and without modeled Climate Change**

### 5.2.1.2 Sulfate

Under the climate change scenario, the largest increase in sulfate concentration of 10.3% at the 50th percentile occurs in the East Pit Wetland during Long-Term Closure. Results for all the locations are summarized in Table 5-3. The modeled change in climate has a greater effect on the sulfate concentrations in the pits than it does on lead, but with the exception of the East Pit Wetland in long-term closure these changes are still very small. The East Pit Lower Porewater actually experiences a decrease in sulfate concentrations at all phases of the project. The concentrations in the East Pit Wetland also decreased during the reclamation phase as shown in Figure 5-2 before increasing in long-term closure as shown in Figure 5-3. The increase in the wetland sulfate concentration could be due to increased release of sulfate from the pit walls due to the temperature increase. Increased precipitation also increases runoff into the wetland from the surrounding watershed.

**Table 5-3 Changes in Sulfate Concentrations in the East Pit Porewater and West Pit Lake**

| Location | Time Period | Change (µg/L) | | | Percent Change (%) | | |
|---|---|---|---|---|---|---|---|
| | | P10 | P50 | P90 | P10 | P50 | P90 |
| East Pit Sump | Operations (yr 0-16) | 1477 | 3410 | 6538 | 0.9% | 1.2% | 1.5% |
| East Pit Lower Porewater | Operations (yr 11-20) | -2078 | -585 | -1099 | -0.1% | -0.02% | -0.03% |
| | Reclamation | -1791 | -10846 | -9587 | -0.4% | -1.4% | -0.6% |
| | Long-Term Closure | -131 | -102 | -177 | -0.1% | -0.04% | -0.1% |
| East Pit Upper/Wetland Porewater | Reclamation | -149 | -5456 | -9612 | -0.2% | -2.8% | -2.0% |
| | Long-Term Closure | 390 | 681 | 929 | 8.9% | 10.3% | 7.9% |
| West Pit | Operations | 2998 | 5350 | 8610 | 1.0% | 1.1% | 1.2% |
| | Reclamation | 465 | 513 | 1265 | 0.6% | 0.6% | 1.2% |
| | Long-Term Closure | 173 | 186 | 349 | 0.4% | 0.4% | 0.6% |

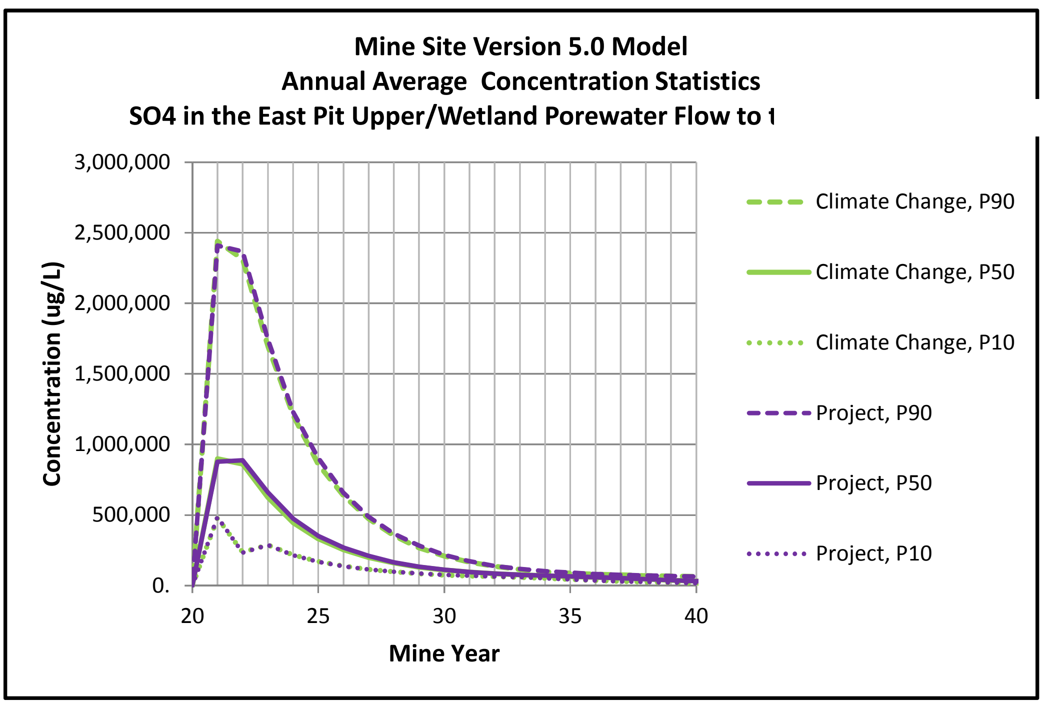



**Figure 5-2 Sulfate in the East Pit Upper/Wetland Porewater During Reclamation; with and without Climate Change**

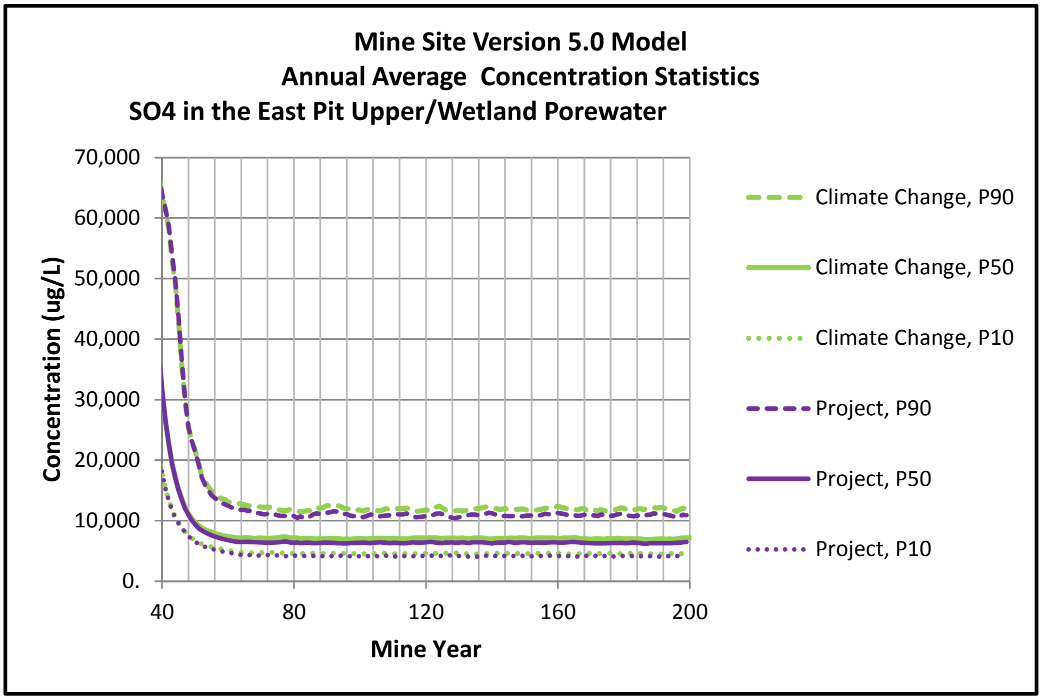



**Figure 5-3 Sulfate in the East Pit Upper/Wetland Porewater during Long-Term Closure; with and without Climate Change**

#### 5.2.1.3 Copper

The changes in copper concentration due to the climate changes are shown in Table 5-4. Under the climate change scenario, copper concentrations changed very little in the East and West Pits with the exception of the East Pit Wetland which shows both increases and decreases in concentration depending on the project phase and the statistic being examined. The East Pit Wetland concentration during long-term closure experienced the largest changes and these can be seen in Figure 5-4. The 10th percentile value increased by over 15% during this phase. The East Pit Wetland also saw a decrease in the 50th percentile copper concentration during both the reclamation and long-term phases (-3.6% and -0.5% respectively) and a decrease in the 90th percentile values during these phases as well (-0.8% and -2.3% respectively). The concentration also increased slightly in the East Pit Sump during operations as shown in Figure 5-5. Increased release of copper from the pit walls due to the temperature increase is likely the reason for the slight increase in concentrations.

**Table 5-4 Changes in Copper Concentrations in the East Pit porewater and West Pit**

| Location | Time Period | Change (µg/L) | | | Percent Change (%) | | |
|---|---|---|---|---|---|---|---|
| | | P10 | P50 | P90 | P10 | P50 | P90 |
| East Pit Sump | Operations (yr 0-16) | 0.0 | 38.2 | 61.6 | 0.0% | 1.6% | 1.2% |
| East Pit Lower Porewater | Operations (yr 11-20) | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| | Reclamation | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| | Long-Term Closure | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| East Pit Upper/Wetland Porewater | Reclamation | 0.3 | -145.8 | -89.7 | 0.2% | -3.6% | -0.8% |
| | Long-Term Closure | 6.7 | -1.2 | -109.6 | 15.8% | -0.5% | -2.3% |
| West Pit | Operations | 0.0 | 0.0 | 0.3 | 0.0% | 0.0% | 0.1% |
| | Reclamation | 0.0 | 0.0 | 2.2 | 0.0% | 0.0% | 0.3% |
| | Long-Term Closure | 0.0 | 0.1 | 3.3 | 0.0% | 0.03% | 0.5% |

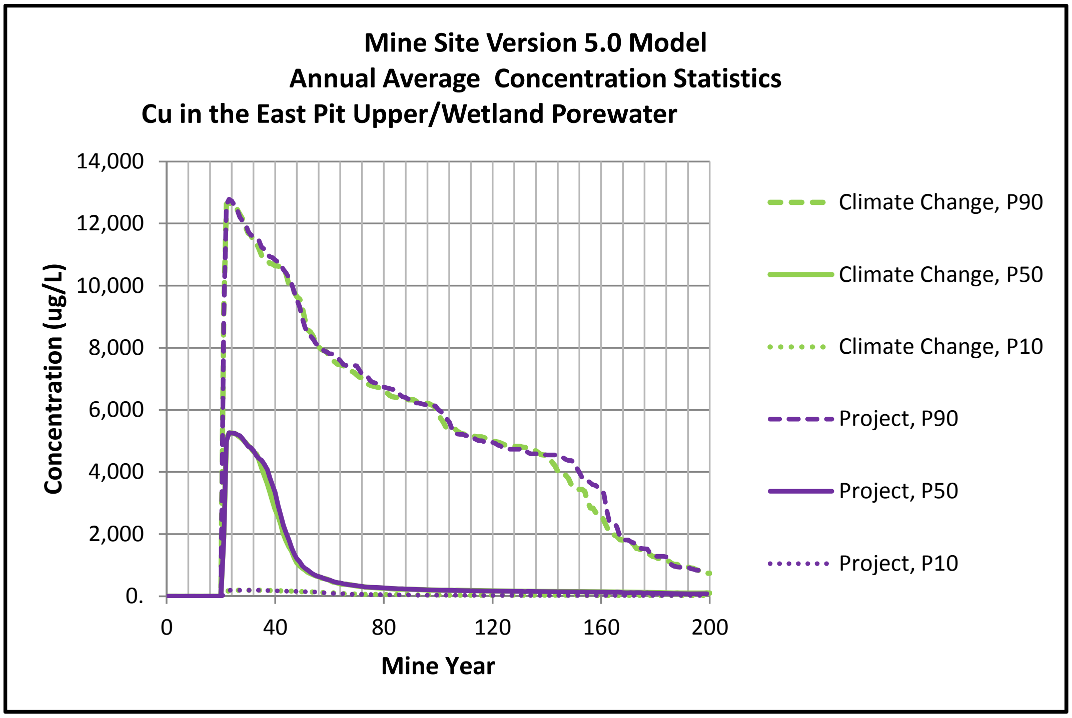



**Figure 5-4 Copper in the East Pit Upper/Wetland Porewater; with and without Climate Change**

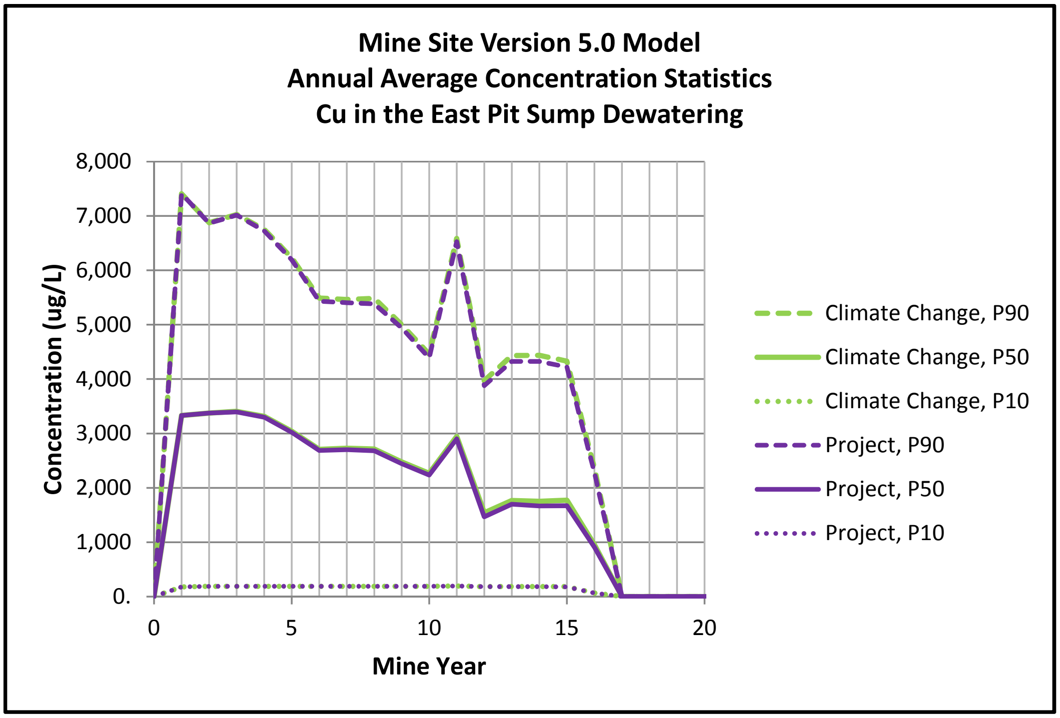



**Figure 5-5 Copper in the East Pit Sump; with and without Climate Change**

#### 5.2.1.4 Iron

There were no significant (>0.1%) changes in iron concentration at any of the locations at any time due to the Climate Changes due to the iron concentrations being capped in the pit waters. The concentrations were already at this cap under the current Project conditions so they could not increase under the climate change scenario. The climate change conditions also did not produce a decrease in iron concentrations below the cap values.

### 5.2.2 Water Quality in the Drainage from the Stockpiles

Climate change could affect the water quality in the stockpile drainage in similar ways to the mine pit water. Increases in temperature will cause the release rates to increase due to the use of the scaling factor for temperature in modeling release rates from waste rock (Section 8.2 of Reference (6)). The increases in release rates will likely increase load released to water as it infiltrates down through the stockpile material or runs off over its surface. An increase in precipitation will increase the volume of water infiltrating into or running off of the waste rock stockpiles. A change in open water evaporation will not affect the waste rock stockpiles because they are not in contact with open water.

The impacts of changes in temperature and precipitation are analyzed for lead, sulfate, copper, and iron in the Category 1, Category 2/3, and Category 4 Waste Rock Stockpiles and the Ore Surge Pile (OSP) by comparing the Project Model results with and without the modeled climate change conditions. The climate changes should have the greatest impact on the Category 1 Waste Rock Stockpile as it is the only stockpile that will still exist when the modeled climate changes reach their maximum affect in Mine Year 60. The other three stockpiles will be removed prior to the end of the operations phase in Mine Year 20. The differences between the modeled concentrations of lead, sulfate, copper and iron for the Category 1

Waste Rock Stockpile, with and without climate change, were averaged over the operations (Mine Years 0 to 20), reclamation (Mine Years 21 to 45) and long-term closure periods (Mine Years 45 and beyond). The differences for the other three piles are averaged over the period of their existence during the operations phase.

#### 5.2.2.1 Lead

The climate changes scenario produced very little change in lead concentrations in stockpile drainage as shown in Table 5-5. There was no change in the OSP or the Category 2/3 or Category 4 Waste Rock Stockpiles and a very small decrease in the Category 1 Waste Rock Stockpile lead concentrations during operations (approximately 0.9%). The Category 1 Waste Rock Stockpile 10th percentile values continued to decrease through reclamation and long-term closure by up to 1.0 µg/L or 5.1%. The 50th and 90th percentile values did not change during long-term closure because they have reached the concentration cap of 100 µg/L and so cannot increase any further and a decrease in concentration at these percentiles was not observed. The capping of the lead concentration, as well as the slight decrease in the 10th percentile values, is shown in Figure 5-6.

**Table 5-5 Changes in Lead Concentrations in the Stockpile Drainage**

| Waste Rock Stockpile | Time Period | Change (µg/L) | | | Percent Change (%) | | |
|---|---|---|---|---|---|---|---|
| | | P10 | P50 | P90 | P10 | P50 | P90 |
| Category 1 | Operations | -0.002 | -0.02 | -0.1 | -0.9% | -0.8% | -0.9% |
| | Reclamation | -0.5 | 0.1 | 0.0 | -2.5% | 0.1% | 0.0% |
| | Long-Term Closure | -1.0 | 0.0 | 0.0 | -5.1% | 0.0% | 0.0% |
| Category 2/3 | Operations | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| Category 4 | Operations (yr 0-11) | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| OSP | Operations | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |

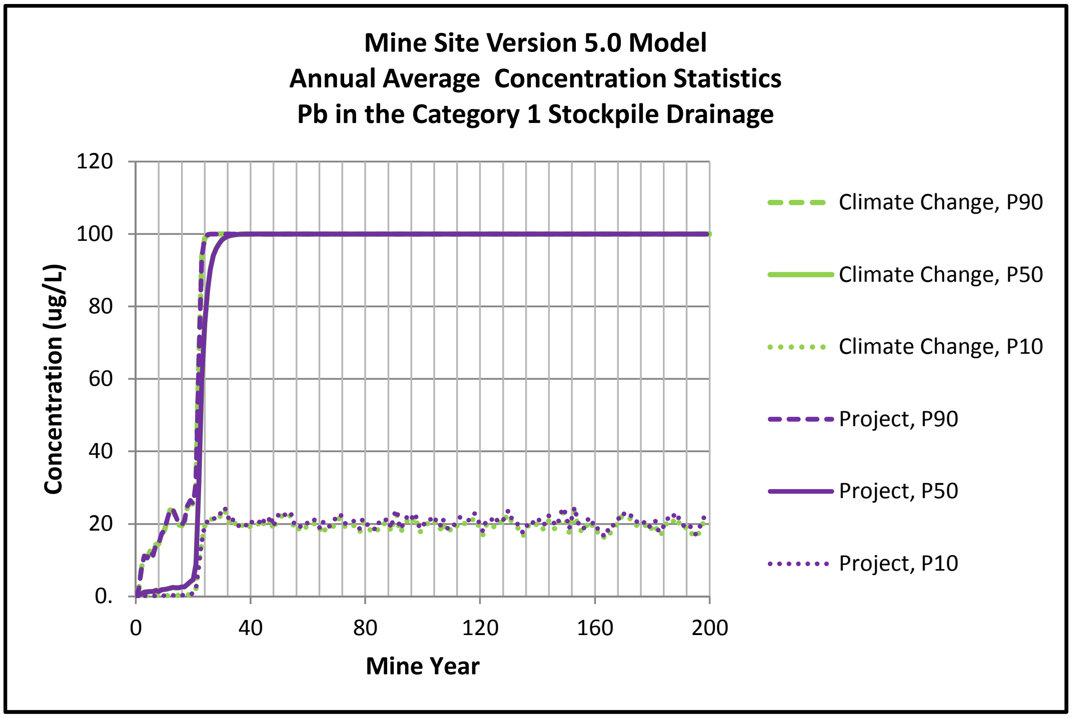



**Figure 5-6 Lead in the Category 1 Waste Rock Stockpile drainage with and without modeled Climate Change**

#### 5.2.2.2 Sulfate

The changes in the stockpile drainage concentrations due to the climate changes are summarized in Table 5-6. The climate changes produce decrease in the sulfate concentrations in all four stockpiles during the operations phase, although none of these decreases is greater than 1%. The Category 1 Waste Rock Stockpile concentrations increase slightly during the reclamation and long-term operations but these increases are extremely small, less than 0.1%, and should have virtually no impact on water quality. The close match between the Project Model with and without climate change concentrations in the Category 1 Waste Rock Stockpile are shown in Figure 5-7. This figure also shows how small these concentration changes are relative to the actual concentration values. Based on these results, the climate changes will have virtually no impact on sulfate concentrations in drainage from the stockpiles.

**Table 5-6 Changes in Sulfate Concentrations in the Stockpile Drainage**

| Waste Rock Stockpile | Time Period | Change (µg/L) | | | Percent Change (%) | | |
|---|---|---|---|---|---|---|---|
| | | P10 | P50 | P90 | P10 | P50 | P90 |
| Category 1 | Operations | -4140 | -7486 | -12866 | -0.9% | -0.7% | -0.6% |
| | Reclamation | 674 | 80 | 924 | 0.03% | 0.003% | 0.02% |
| | Long-Term Closure | 0 | 252 | 0 | 0.0% | 0.009% | 0.0% |
| Category 2/3 | Operations | -8270 | -13314 | -11706 | -0.6% | -0.4% | -0.2% |
| Category 4 | Operations (yr 0-11) | -480 | -14221 | -67500 | -0.01% | -0.2% | -0.2% |
| OSP | Operations | -11354 | -18751 | -6110 | -0.5% | -0.4% | -0.1% |

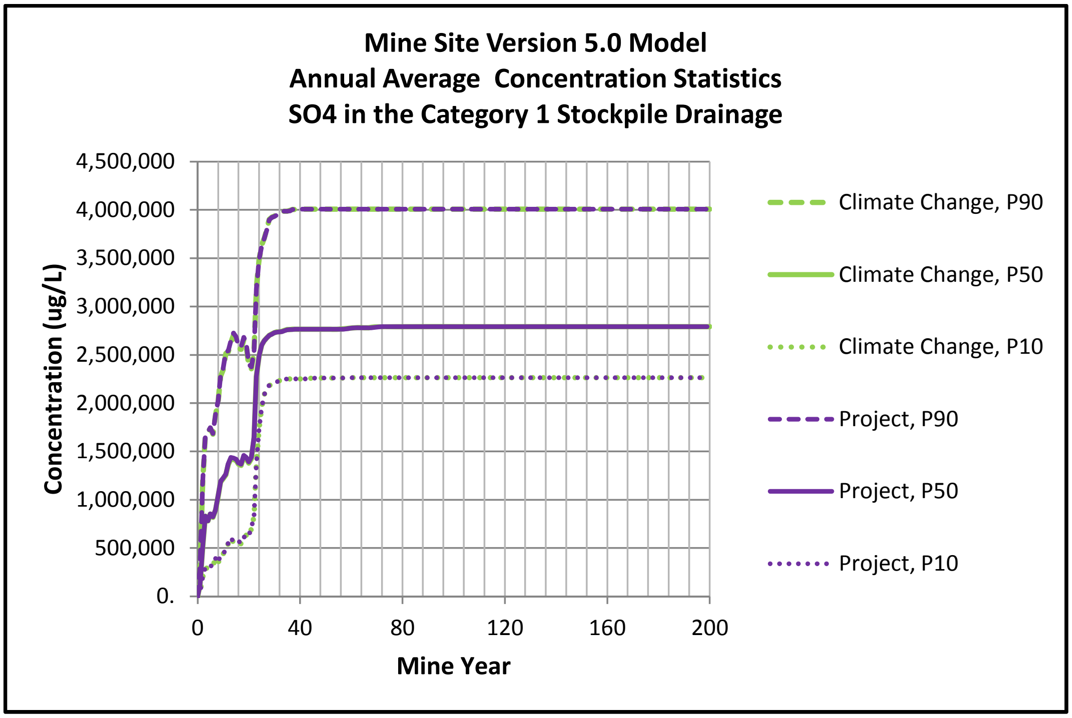



**Figure 5-7 Sulfate in the Category 1 Waste Rock Stockpile drainage; with and without modeled Climate Change**

### 5.2.2.3 Copper

The effect of the climate changes on the concentration of copper in the stockpile drainage is summarized in Table 5-7. There is no change in the Category 1 Waste Rock Stockpile concentrations the copper concentration is fixed at the concentration cap in both scenarios. The concentrations in the OSP and the Category 2/3, and Category 4 Waste Rock Stockpiles show some changes due to the climate changes but the largest of these changes is a 0.3% decrease in the Category 4 Waste Rock Stockpile 10th percentile concentrations. Figure 5-8 shows the lack of change between the current and climate change conditions in the Category 4 Waste Rock Stockpile. Based on these results, the climate changes will have virtually no impact on copper concentrations in drainage from the stockpiles.

**Table 5-7 Changes in Copper Concentrations in the Stockpile drainage**

| Waste Rock Stockpile | Time Period | Change (µg/L) | | | Percent Change (%) | | |
|---|---|---|---|---|---|---|---|
| | | P10 | P50 | P90 | P10 | P50 | P90 |
| Category 1 | Operations | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| | Reclamation | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| | Long-Term Closure | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| Category 2/3 | Operations | -2.3 | 1.9 | 2.5 | -0.005% | 0.003% | 0.004% |
| Category 4 | Operations (yr 0-11) | -12.7 | -0.7 | -0.1 | -0.3% | -0.01% | -0.002% |
| OSP | Operations | 2.8 | 5.0 | 5.1 | 0.004% | 0.006% | 0.005% |

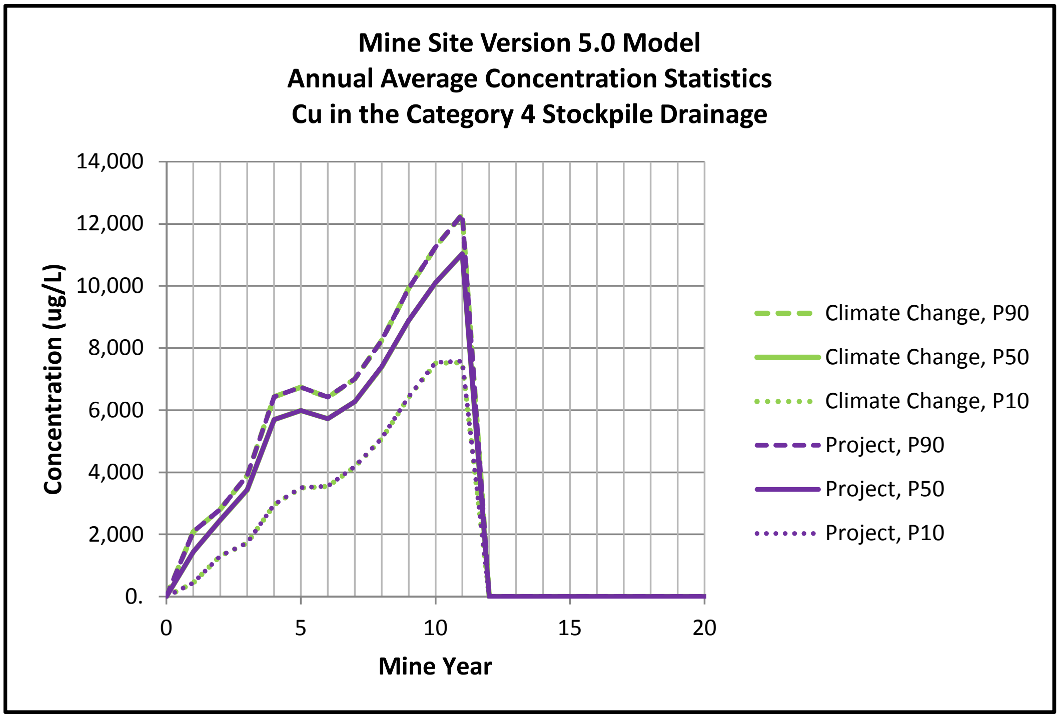



**Figure 5-8 Copper in the Category 4 Waste Rock Stockpile drainage; with and without modeled Climate Change**

### 5.2.2.4 Iron

The changes in iron concentration in the stockpile drainage due to the climate changes are very similar to the changes in copper concentrations and are summarized in Table 5-8. There are no changes in the Category 1 Waste Rock Stockpile concentrations, and very little changes in the other stockpiles. The largest change occurs in the Category 4 Waste Rock Stockpile, which experienced a 0.2% decrease in the

90th percentile value. The Category 2/3 Waste Rock Stockpile had increases of approximately 0.1% while the OSP changes were essentially zero on a percentage basis. Figure 5-9 shows the lack of change between the current and climate change conditions in the Category 4 Waste Rock Stockpile. Based on these results, the climate changes will have virtually no impact on iron concentrations in drainage escaping from the waste rock stockpiles.

**Table 5-8 Changes in Iron Concentrations in the Stockpile Drainage**

| Stockpile | Time Period | Change (µg/L) | | | Percent Change (%) | | |
|---|---|---|---|---|---|---|---|
| | | P10 | P50 | P90 | P10 | P50 | P90 |
| Category 1 | Operations | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| | Reclamation | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| | Long-Term Closure | 0.0 | 0.0 | 0.0 | 0.0% | 0.0% | 0.0% |
| Category 2/3 | Operations | 1.3 | 3.6 | 7.0 | 0.1% | 0.1% | 0.1% |
| Category 4 | Operations (yr 0-11) | 0.0 | -64.8 | -3176 | 0.0% | -0.02% | -0.2% |
| OSP | Operations | 0.9 | 2.7 | 5.3 | 0.003% | 0.003% | 0.004% |

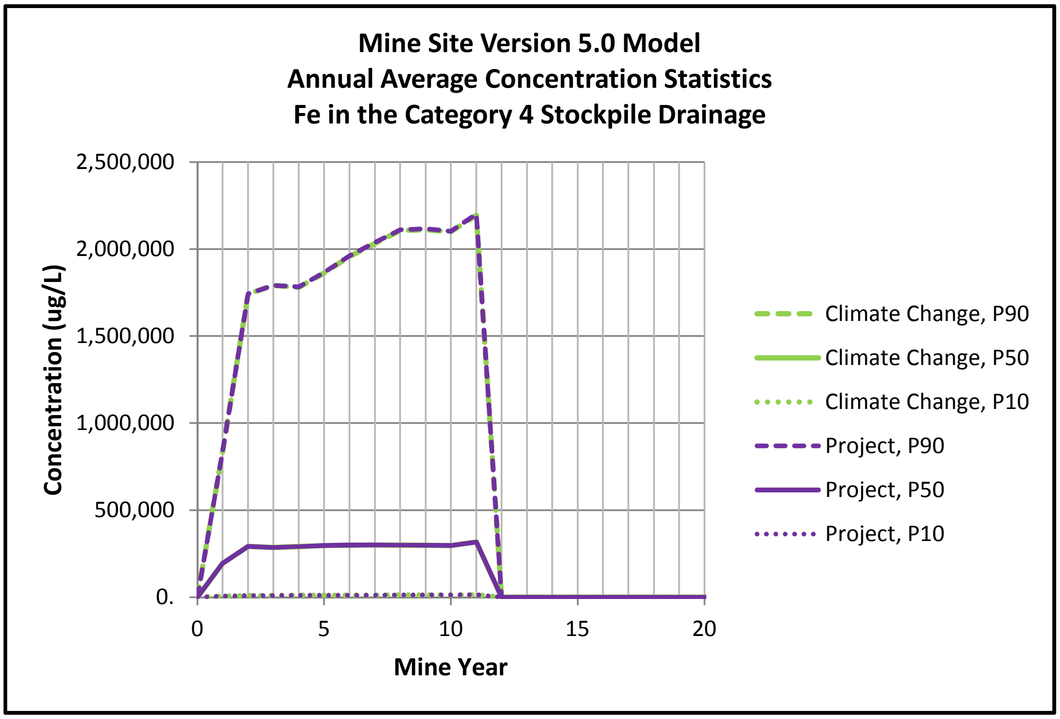



**Figure 5-9 Iron in the Category 4 Waste Rock Stockpile drainage; with and without modeled Climate Change**

## 5.2.3 Flows from the East and West Pits

The changes in dewatering volumes due to the climate change scenarios are very small. Table 5-9 shows the change in annual average mean dewatering flows for the Project Model compared to the dewatering flows for the Climate Change Sensitivity Analysis model during the three phases of the Project. The only flow to have a difference greater than 1 gpm is the West Pit dewatering and this difference increases gradually from 1.8 gpm during operations to 5.2 gpm during long-term closure, which is less than 2% of the current West Pit long-term dewatering flow of approximately 320 gpm. The increase in annual precipitation is the mostly likely cause for this increase in West Pit dewatering because more water will have to be withdrawn to prevent the pits from overflowing. The other differences in flow are very small and should have minimal impact.

**Table 5-9 Changes in Dewatering Flows from the Mine Pits to the WWTF due to Climate Change**

| Time Period | Average Change in Pit Dewatering Flows (gpm) | | | |
|---|---|---|---|---|
| | East Pit Sump | East Pit Lower Porewater | East Pit Upper Porewater | West Pit |
| Operations | 0.4 | 0.4 | NA | 1.8 |
| Reclamation | NA | -0.5 | -0.02 | 3.6 |
| Long-Term Closure | NA | -0.3 | -0.02 | 5.2 |

The model changes associated with the climate change scenario have virtually no effect on the flows to any of the bedrock or surficial aquifer flow paths from the West Pit or East Pit as shown in Figure 5-10. These flows are controlled by the water levels in the pits which do not change in the climate change scenario. There is a change in flow from the East Pit Wetland Overflow to the West Pit, which increases by an average of 3.4 gpm (2.2%) after Mine Year 60. This increase in flow is caused by the increased precipitation, both through direct precipitation falling on its surface and increased runoff from its watershed.

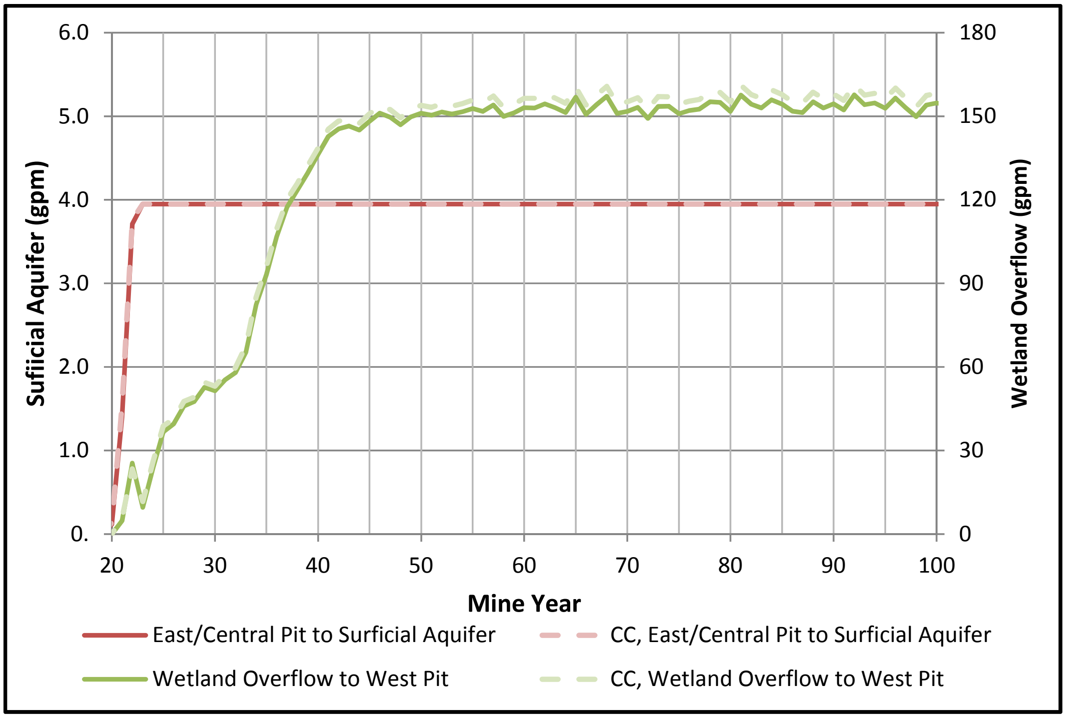



**Figure 5-10 Flows from the Combined East/Central Pits to the surficial aquifer groundwater and the West Pit; with and without Climate Change**

### 5.2.4 Leakage Flows from the Stockpiles

The change in leakage flows from the OSP and the Category 1, Category 23, and Category 4 Waste Rock Stockpiles due to the climate changes are shown in Table 5-10. There are very small increases in the leakage due to the climate changes, the largest being the 0.14 gpm increase in the Category 1 Waste Rock Stockpile leakage during operations. However, this increase is less than 1% of the total leakage flow from the Category 1 Waste Rock Stockpile. The increases in leakage from the other waste rock stockpiles are very small and should not significantly impact groundwater flows either.

**Table 5-10 Changes in Leakage from the Stockpiles due to Climate Change**

| Time Period | Average Change in Leakage Flows (gpm) | | | |
|---|---|---|---|---|
| | Category 1 Waste Rock Stockpile | Category 2/3 Waste Rock Stockpile | Category 4 Waste Rock Stockpile | OSP |
| Operations | 0.14 | 0.0002 | 0.00001 | 0.00001 |
| Reclamation | 0.01 | NA | NA | NA |
| Long-Term Closure | 0.01 | NA | NA | NA |

### 5.2.5 Groundwater Quality

Climate change is not expected to cause significant changes to groundwater concentrations. The volume of flow from the East, Central and West Pits to the surficial aquifer and bedrock groundwater flow paths are not significantly affected by the climate changes. This is due to these flows being driven by the water levels in the pits and the water levels are controlled for the most part by mining operations, not by climate. There is a slight increase in the volume of water that escapes from the waste rock stockpile containment systems but this increase is very small. There is also very little change in the constituent concentrations in both the pit water and the waste rock stockpile leakage. In addition, most of the concentration changes that are seen are negative in magnitude, further minimizing any impacts to groundwater downstream from the mine features.

### 5.2.6 Surface Water Quality

Surface water quality in the Partridge River is expected to be minimally effected by the Project under climate change conditions. There is a 3.4 gpm increase in Wetland Overflow from the East/Central Pit to the West Pit due to the climate change scenario. Water from the West Pit is treated prior to discharge, so any changes in West Pit water quality will not affect concentrations in the Partridge River. There is virtually no increase in flow to the bedrock or surficial aquifer flow paths from the mine pits and no significant increase in constituent concentration in these pits either so the climate changes are unlikely to affect the Partridge River water quality through these pathways. The increase in leakage from the waste rock stockpile containment systems due to the climate changes is also minimal, totaling less than 1gpm, and should not have a noticeable effect on surface water quality.

There is likely to be an increase in the amount of water that will need to be treated by the WWTF. There is a slight increase in the amount of drainage collected by the stockpile liner and containment systems, due to increased precipitation on the stockpiles. Also, because the increase in precipitation is slightly greater than the amount lost to increased open-water evaporation, the amount that needs to be removed from the pits during operations to keep them dry and long-term closure to keep the West Pit from overflowing will increase. However, the increase in total dewatering for the East/Central and West Pits when the modeled climate change is fully mature (beyond Mine Year 60) is only about 5 gpm in total. The increase in contained runoff and drainage from the stockpiles will add less than 2 gpm to the treatment total beyond Mine Year 60. These are small increases relative to the approximately 320 gpm influent expected to the WWTF in long-term closure.

# 6.0 Plant Site – Climate Change

At the direction of the Co-lead Agencies, the potential effects of climate change on water quality and quantity estimates for the Project were considered by conducting a sensitivity analysis using the Project and No Action models developed for the Supplemental Draft Environmental Impact Statement (Version 5.0 model). The sensitivity analysis involved varying certain temperature and precipitation inputs to the probabilistic model from values representing current conditions to values representing possible future conditions affected by climate change. The sensitivity of model results to these input changes is quantitatively assessed at the toes of the Tailings Basin and qualitatively assessed at other locations in the model (i.e., groundwater, Embarrass River and tributaries, etc.). This section describes the modifications made to the probabilistic model (Version 5.0 model) to perform the climate change sensitivity analysis and presents the results. Given the lack of sensitivity of model predictions to the input changes, as presented in Section 6.2, this analysis was not updated using the updated models developed for the Final Environmental Impact Statement (Version 6.0 model).

## 6.1 Modifications to Probabilistic Model

Temperature and precipitation inputs to the probabilistic model were varied to explore the potential effects of climate change. Consistent with the direction provided by the Co-lead Agencies (Reference (8)), modification to the probabilistic model was limited to the Tailings Basin. That is, quantitative modeling of potential climate change was not continued downstream of the Plant Site (e.g., changes in Embarrass River flow were not assessed).

The Plant Site Project Model is a continuous time series model of 200 years starting at Mine Year 0 (start of Plant Site development). The model inputs are gradually varied through time between Mine Year 0 and Mine Year 60; beyond Mine Year 60, model inputs remain at Mine Year 60 values. Changes in model inputs were assumed linear with respect to time. Table 6-1 summarizes the input parameter variations for the climate change sensitivity analysis. The temperature and precipitation ranges selected as inputs for the climate change sensitivity analysis are based on Reference (8). The following sections provide additional detail on each parameter modified for the climate change sensitivity analysis. In summary, the mean annual temperature is increased from 2.004 degrees Celsius to 5.2 degrees Celsius, the mean annual precipitation amount is increased from 28.1 in/yr to 29.8 in/yr, and the mean annual open water evaporation is increased by 6.5%.

**Table 6-1 Temperature and Precipitation Inputs for Climate Change Sensitivity Analysis**

| Period | Mean Annual Temperature (°C) | Mean Annual Precipitation (mm/day) | Mean Summer Temperature (°C) | Mean Summer Precipitation (mm/day) |
|---|---|---|---|---|
| 1970 – 1990 | 2.0 – 4.5 | 1.8 – 2.1 | 14 – 17.5 | 3.0 – 3.3 |
| 2030 – 2039 | 3.7 – 6.2 | 1.9 – 2.2 | 15.6 – 19.1 | 3.0 – 3.3 |
| 2060 – 2069 | 5.2 – 7.7 | 1.9 – 2.2 | 17.3 – 20.9 | 3.0 – 3.3 |

### 6.1.1 Mean Annual Temperature

Mean annual temperature is a direct input in the probabilistic model (Field_Temp). This input is used to scale LTV Steel Mining Company (LTVSMC) tailings and Flotation Tailings loading. To model climate change, the mean annual temperature was increased from the current conditions value of 2.004 °C to the lower end of the 2060-2069 estimate, 5.2 °C. Use of the lower end of the estimated future range is based on the current Plant Site climate-normal value (2.004 °C) relative to the 1970-1999 range presented in the Table 6-1. Mean annual temperature is given a normal distribution in the probabilistic model; the climate change sensitivity analysis uses this same normal distribution (i.e., the standard deviation derived from the current climate normal period was used).

### 6.1.2 Mean Annual Precipitation

Mean annual precipitation (via its cubed root) is an input in the probabilistic model (Precip_Cuberoot) as part of the Plant Site water balance. The mean value at the Plant Site based on the current climate normal period is 28.1 inches per year, or 1.95 mm/day. The mean annual precipitation was linearly increased to 2.1 mm/day (the middle of the 2060-2069 range shown in Table 6-1), or 29.8 inches per year. The cubed root of the mean annual precipitation is assigned a normal distribution in the probabilistic model; the climate change sensitivity analysis uses this same normal distribution.

The seasonal (monthly) distribution of precipitation is a constant, deterministic input to the probabilistic model. The seasonal distribution of precipitation is not modified for the climate change sensitivity analysis, based on similar summer precipitation rates for future conditions presented in Table 6-1.

### 6.1.3 Mean Summer Temperature

Mean summer temperature is not a direct input in the probabilistic model. In reality, changes in temperature may impact the distribution of open water evaporation (calculated from the Meyer model for the Plant Site). Estimates of evaporation at the Mine Site using the Thornthwaite method (Section 5.2.1.2 of Reference (1)) suggest increased summer temperatures will increase open water evaporation by 6.5%. A 6.5% increase in open water evaporation is linearly applied to the open water evaporation over time. The distribution of evaporation is based on the results of the Meyer model used for the Plant Site model. Any increase due to climate change will be made after a value is sampled from that distribution.

## 6.2 Climate Change Sensitivity Analysis Results

The Climate Change Sensitivity Analysis Project Model was run for a 200-year period, just like the No Action Model and the Project Model (Section 3.4 of Reference (2)). Changes in estimated flows and concentrations due to the Climate Change Sensitivity Analysis are evaluated to make quantitative assessments of potential climate change impacts to water quality at the toes (north, northwest, west, and south) of the Tailings Basin. Impacts from potential climate change downstream of the Tailings Basin (e.g., along groundwater flow paths, the Embarrass River) are described qualitatively, taking into account the quantitative results at the Tailings Basin.

### 6.2.1 Water Quality at the toes of the Tailings Basin

Climate change could affect the water quality at the Tailings Basin toes in a variety of ways. Increases in temperature would cause the release rates to increase due to the Arrhenius equation. An increases in release rates would likely increase load released from the Flotation Tailings and the LTVSMC tailings. For the Flotation Tailings, some of the constituents are concentration capped and an increase in temperature would not result in an increase in the concentration in water passing through the Flotation Tailings. However, an increase in precipitation would cause an increase in the infiltration through the LTVSMC tailings and the Flotation Tailings throughout the Tailings Basin. An increased infiltration rate would increase the loading rate of constituent mass to the toes of the Tailings Basin for constituents whether they are concentration capped or not.

The impacts of potential changes in temperature and precipitation are analyzed for lead (Pb), sulfate (SO4), copper (Cu), and iron (Fe) at each of the Tailings Basin toes by comparing the modeled Project results with and without the modeled climate change conditions. The greatest changes in concentrations occur during long-term closure (Mine Year 30 and on), as expected, because temperature and precipitation variations for the climate change scenario do not take full effect until Mine Year 60. The differences between the modeled concentrations of lead, sulfate, copper and iron at the Flotation Tailings Basin (FTB) toes, with and without the modeled climate change, were averaged over the operations (Mine Years 0 to 20), reclamation (Mine Years 21 to 30) and long-term closure periods (Mine Years 31 and beyond).

#### 6.2.1.1 Lead

Under the climate change scenario, lead concentrations increase by less than 13%. Results are summarized in Table 6-2. Lead concentrations at the north toe are essentially unaffected by the modeled changes in climate as shown in Figure 6-1. There appears to be a very slight increase in the 90th percentile, 50th percentile and 10th percentile concentrations by Mine Year 100 but these increases are less than 1 µg/L (<2% increase). The small change in lead concentration due to climate change is expected because lead is modeled to be at concentration caps in the Flotation Tailings in both the Project Model and the Climate Change Model. The slight estimated increases are most likely due to the increase in infiltration through the Tailings Basin under the modeled climate change scenario. Slightly larger lead concentration increases at the northwest and west toes (Figure 6-2) are expected because the seepage at these toes is dominated by the existing LTVSMC tailings (not concentration capped) while the seepage at the other two toes is dominated by the Flotation Tailings and the FTB Pond.

### Table 6-2 Changes in Lead Concentrations at the Tailings Basin Toes

| Toe Location | Time Period | Change (µg/L) | | | Percent Change (%) | | |
|---|---|---|---|---|---|---|---|
| | | P10 | P50 | P90 | P10 | P50 | P90 |
| North Toe | Operations | 0.25 | 0.20 | 0.16 | 0.6% | 0.4% | 0.3% |
| | Reclamation | 0.42 | 0.39 | 0.39 | 1.0% | 0.9% | 0.8% |
| | Long-Term Closure | 0.28 | 0.32 | 0.36 | 1.6% | 1.6% | 1.6% |
| Northwest Toe | Operations | 0.00 | 0.01 | 0.01 | 0.1% | 0.1% | 0.2% |
| | Reclamation | 0.06 | 0.05 | 0.05 | 0.4% | 0.3% | 0.3% |
| | Long-Term Closure | 0.01 | 0.02 | 0.04 | 11.3% | 10.7% | 10.3% |
| West Toe | Operations | 0.00 | 0.00 | 0.00 | 0.1% | 0.1% | 0.1% |
| | Reclamation | 0.02 | 0.01 | 0.01 | 0.2% | 0.1% | 0.0% |
| | Long-Term Closure | 0.01 | 0.02 | 0.05 | 12.9% | 12.7% | 12.0% |
| South Toe | Operations | 0.08 | 0.10 | 0.10 | 0.3% | 0.3% | 0.3% |
| | Reclamation | 0.06 | 0.05 | 0.05 | 0.1% | 0.1% | 0.1% |
| | Long-Term Closure | 0.29 | 0.32 | 0.36 | 1.3% | 1.3% | 1.2% |

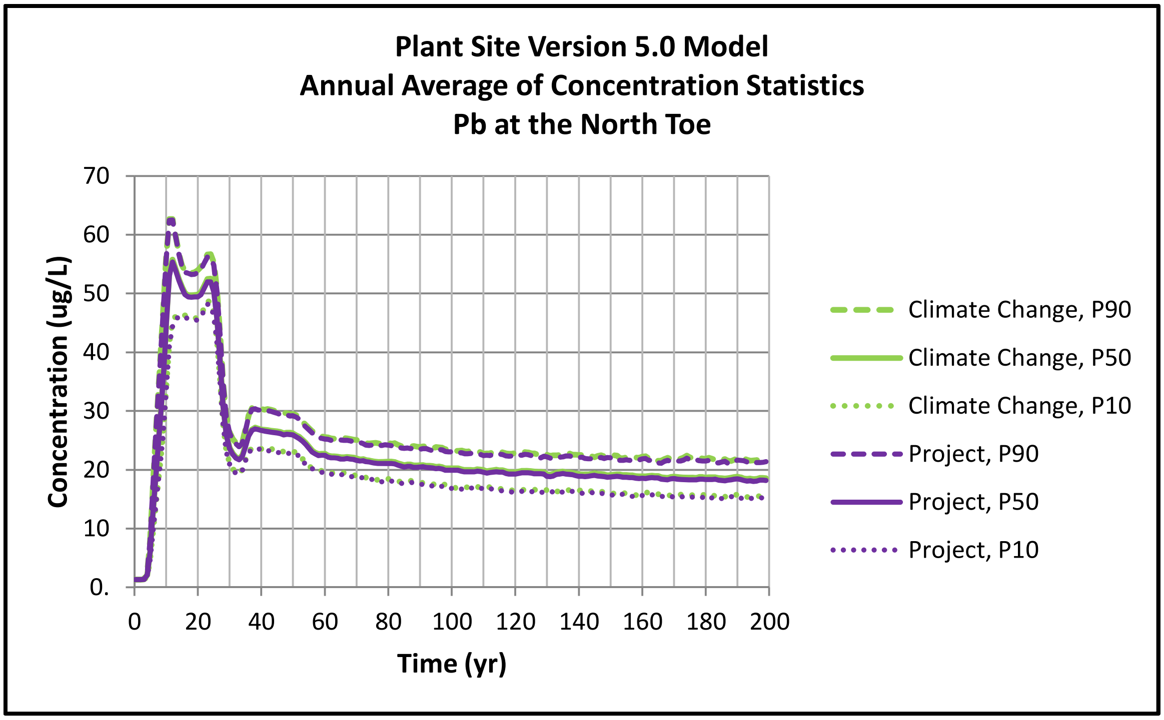



**Figure 6-1 Lead Concentrations at the North Toe; with and without Modeled Climate Change**

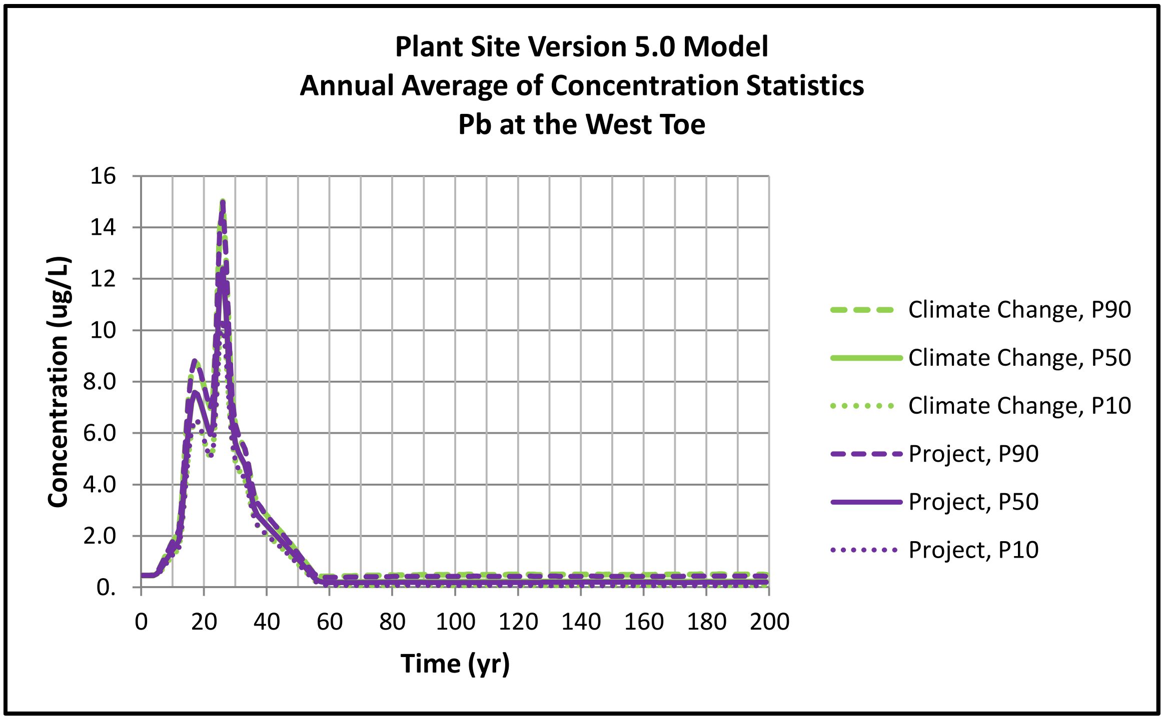



**Figure 6-2 Lead Concentrations at the West Toe; with and without Modeled Climate Change**

#### 6.2.1.2 Sulfate

Under the climate change scenario, sulfate concentrations increase less than 15%. Results are summarized in Table 6-3. Sulfate concentrations at the north toe are shown in Figure 6-3. Sulfate concentrations at the other three toes showed results similar to those at the north toe (concentrations at the west toe shown on

Figure 6-4). The modeled change in climate has a greater effect on the sulfate concentrations at the toes of the Tailings Basin than it does on lead, especially during the long-term closure period. This is expected because sulfate is not modeled to be at concentration caps within the Flotation Tailings. As a result, the increase in temperature, which increases sulfate loading rates, causes increased sulfate concentrations in the water seeping through the Flotation Tailings. Increased precipitation also increases infiltration, causing more water at higher concentrations to report to the toes of the Tailings Basin.

**Table 6-3 Changes in Sulfate Concentrations at the Tailings Basin Toes**

| Toe Location | Time Period | Change (µg/L) | | | Percent Change (%) | | |
|---|---|---|---|---|---|---|---|
| | | P10 | P50 | P90 | P10 | P50 | P90 |
| North Toe | Operations | 1783 | 1995 | 2073 | 0.5% | 0.5% | 0.5% |
| | Reclamation | 9518 | 10542 | 10012 | 2.2% | 2.2% | 1.9% |
| | Long-Term Closure | 12678 | 17847 | 18510 | 9.5% | 10.7% | 9.4% |
| Northwest Toe | Operations | 107 | 197 | 255 | 0.0% | 0.1% | 0.1% |
| | Reclamation | 3461 | 4058 | 4547 | 1.2% | 1.2% | 1.2% |
| | Long-Term Closure | 24716 | 35743 | 35854 | 12.7% | 12.1% | 9.8% |
| West Toe | Operations | 213 | 314 | 407 | 0.1% | 0.1% | 0.1% |
| | Reclamation | 3327 | 4231 | 4934 | 1.3% | 1.3% | 1.3% |
| | Long-Term Closure | 31822 | 47614 | 47800 | 14.7% | 14.0% | 11.1% |
| South Toe | Operations | 2200 | 2708 | 3239 | 0.5% | 0.5% | 0.6% |
| | Reclamation | 16262 | 19806 | 22462 | 3.1% | 3.4% | 3.3% |
| | Long-Term Closure | 25135 | 36311 | 34266 | 14.2% | 14.7% | 11.2% |

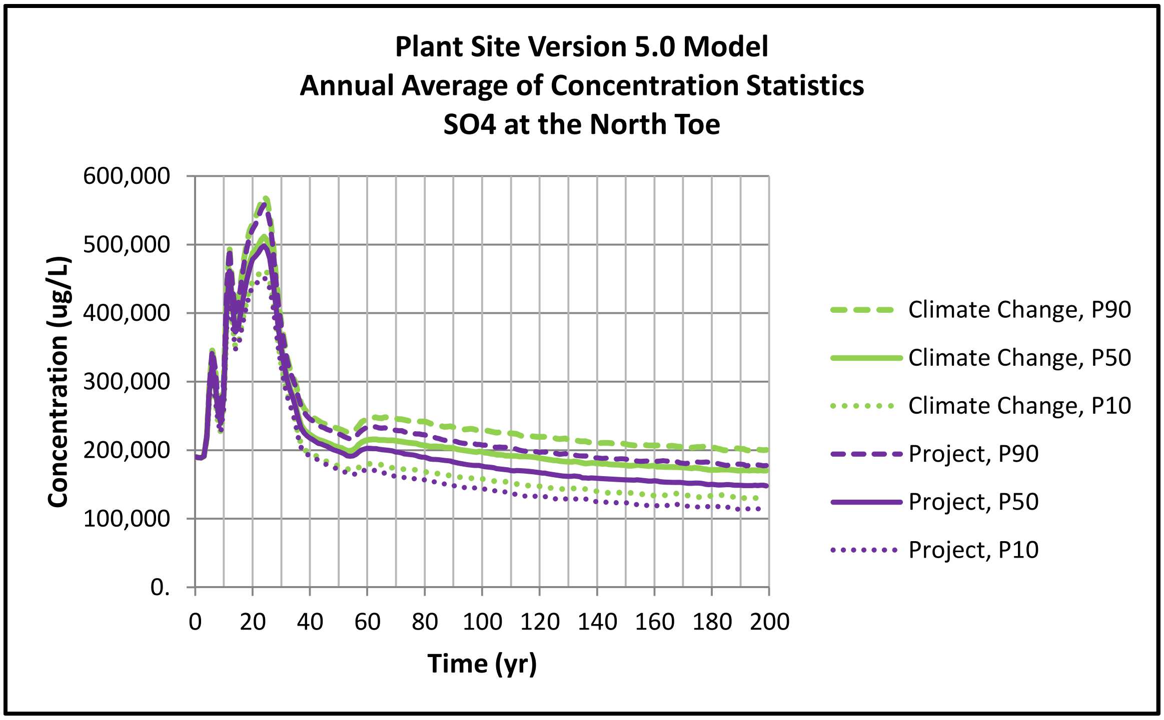



**Figure 6-3** **Sulfate Concentrations at the North Toe; with and without Modeled Climate Change**

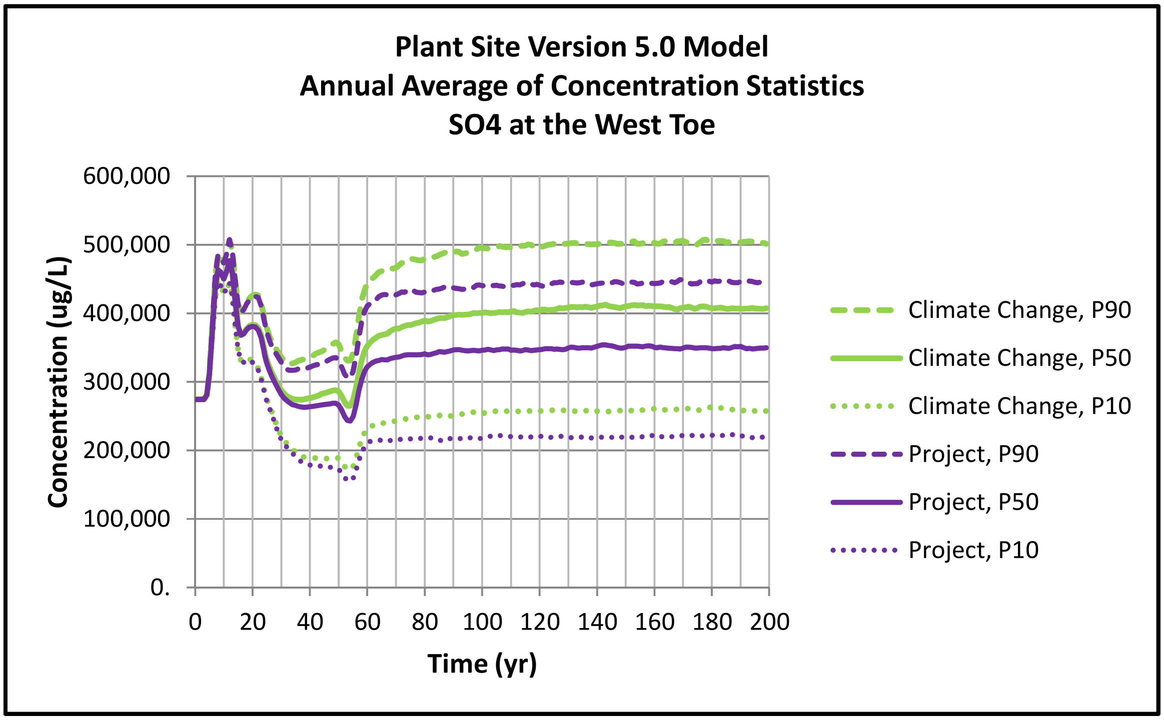



**Figure 6-4** **Sulfate Concentrations at the West Toe; with and without Modeled Climate Change**

### 6.2.1.3 Copper

Under the climate change scenario, copper concentrations increase by less than 13%. Results are summarized in Table 6-4. Copper concentrations at the north toe are essentially unaffected by the modeled changes in climate, as shown in Figure 6-5. The other three toes show similar results to lead (concentrations at the west toe shown on Figure 6-6). The limited change in copper concentration due to climate change is expected because copper is modeled to be at concentration caps in the Flotation Tailings and Project Model results are significantly dominated by the Flotation Tailings and the FTB Pond.

**Table 6-4 Changes in Copper Concentrations at the Tailings Basin Toes**

| Toe Location | Time Period | Change (µg/L) | | | Percent Change (%) | | |
|---|---|---|---|---|---|---|---|
| | | P10 | P50 | P90 | P10 | P50 | P90 |
| North Toe | Operations | 0.03 | 0.27 | 0.22 | 0.0% | 0.1% | 0.0% |
| | Reclamation | 0.24 | 0.53 | 0.86 | 0.1% | 0.1% | 0.1% |
| | Long-Term Closure | 3.05 | 2.51 | -1.99 | 2.4% | 1.1% | -0.5% |
| Northwest Toe | Operations | -0.05 | -0.04 | -0.42 | 0.0% | 0.0% | -0.1% |
| | Reclamation | -0.80 | -0.75 | -1.52 | -0.6% | -0.4% | -0.6% |
| | Long-Term Closure | 0.02 | 0.12 | 0.41 | 9.9% | 10.9% | 11.1% |
| West Toe | Operations | -0.08 | -0.11 | -0.29 | -0.1% | -0.1% | -0.2% |
| | Reclamation | -0.54 | -0.67 | -1.20 | -0.7% | -0.6% | -0.7% |
| | Long-Term Closure | 0.05 | 0.17 | 0.61 | 11.7% | 12.2% | 12.7% |
| South Toe | Operations | -0.01 | 0.07 | 0.08 | 0.0% | 0.0% | 0.0% |
| | Reclamation | 0.04 | 0.40 | 0.30 | 0.0% | 0.1% | 0.0% |
| | Long-Term Closure | 2.08 | 1.78 | -1.57 | 1.5% | 0.8% | -0.4% |

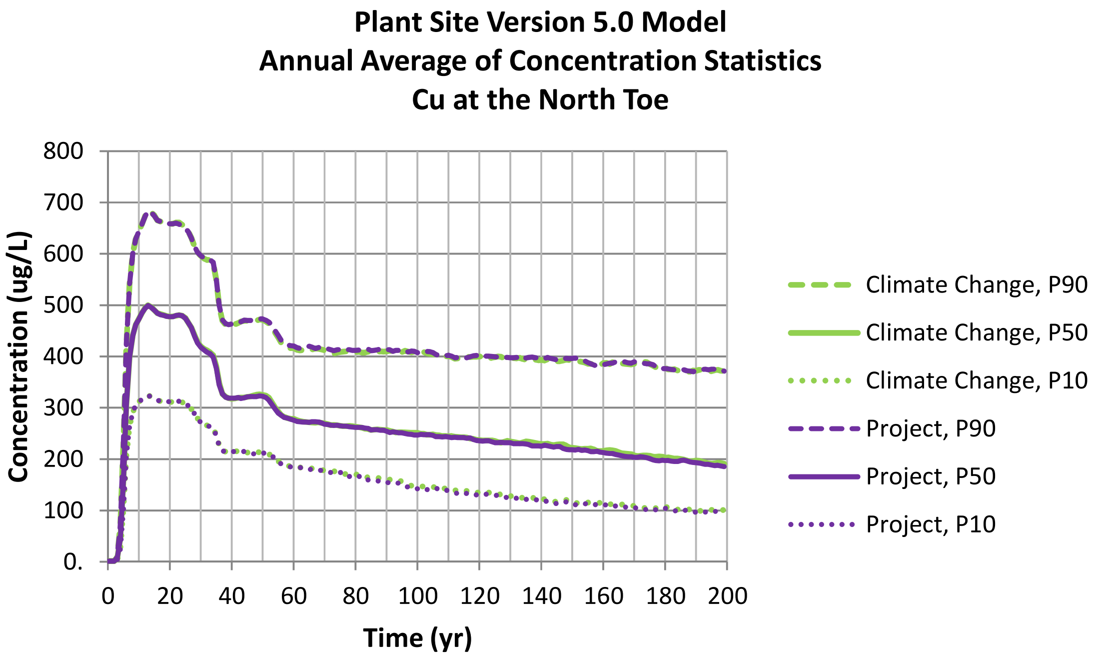



**Figure 6-5** **Copper Concentrations at the North Toe; with and without Modeled Climate Change**

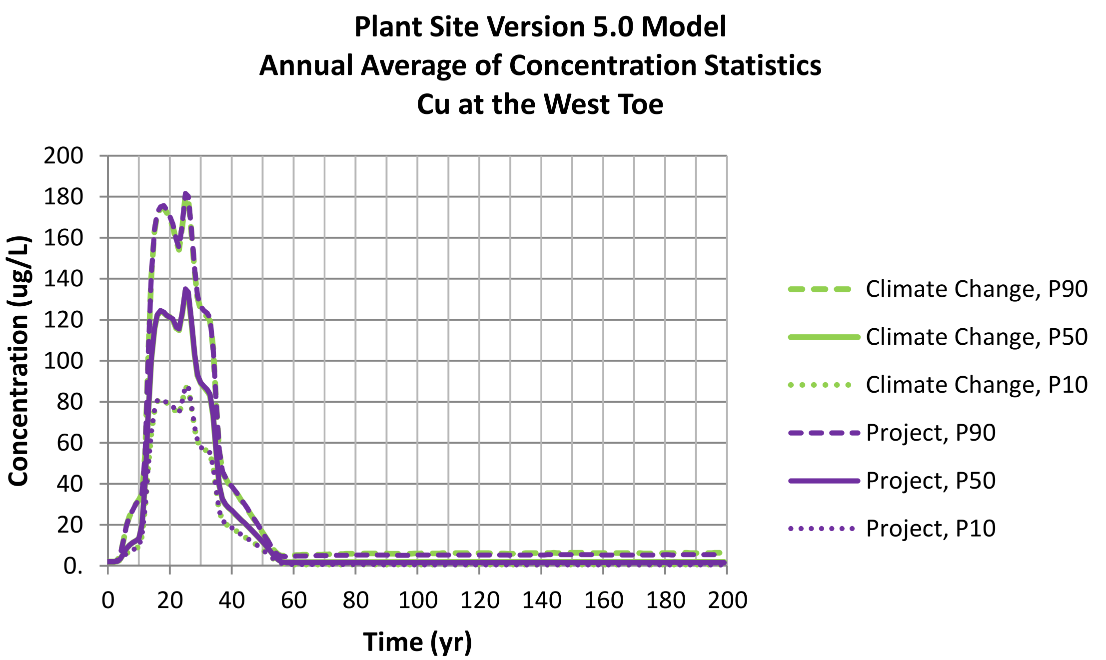



**Figure 6-6** **Copper Concentrations at the West Toe; with and without Modeled Climate Change**

#### 6.2.1.4 Iron

Under the climate change scenario, iron concentrations increase up to 20%. Results are summarized in Table 6-5. The changes in the iron concentrations at the Tailings Basin toes from the modeled climate changes were similar to those seen in the sulfate concentrations (Figure 6-7 and Figure 6-8). Iron, unlike sulfate, is capped in the Floatation Tailings but it is not in the LTVSMC tailings. Increased runoff and seepage flows from these LTVSMC tailings to the north toe due to increased precipitation probably account for most of the increase seen in Figure 6-7. Increased air temperatures could also contribute to this increase by increasing the reaction rates and decreasing the period of time when the tailings are frozen, allowing more iron to dissolve into the seepage water. The difference between the modeled Project results with and without climate change remains fairly consistent after Mine Year 60.

**Table 6-5 Changes in Iron Concentrations at the Tailings Basin Toes**

| Toe Location | Time Period | Change (µg/L) | | | Percent Change (%) | | |
|---|---|---|---|---|---|---|---|
| | | P10 | P50 | P90 | P10 | P50 | P90 |
| North Toe | Operations | 0.1 | 0.2 | 0.2 | 0.1% | 0.1% | 0.1% |
| | Reclamation | 2.0 | 3.3 | 4.3 | 0.7% | 1.1% | 1.3% |
| | Long-Term Closure | 120.5 | 190.3 | 204.7 | 15.0% | 15.8% | 13.5% |
| Northwest Toe | Operations | 3.2 | 4.7 | 5.7 | 0.1% | 0.1% | 0.1% |
| | Reclamation | 36.1 | 43.2 | 49.4 | 1.8% | 1.7% | 1.6% |
| | Long-Term Closure | 326.3 | 470.6 | 478.1 | 12.7% | 12.1% | 9.9% |
| West Toe | Operations | 2.3 | 4.0 | 5.5 | 0.1% | 0.1% | 0.1% |
| | Reclamation | 42.2 | 54.1 | 61.4 | 1.7% | 1.7% | 1.6% |
| | Long-Term Closure | 420.9 | 626.8 | 635.7 | 14.7% | 13.9% | 11.2% |
| South Toe | Operations | 2.3 | 3.2 | 4.0 | 0.2% | 0.2% | 0.2% |
| | Reclamation | 6.5 | 11.3 | 14.0 | 1.5% | 2.2% | 2.3% |
| | Long-Term Closure | 268.7 | 417.3 | 400.3 | 20.4% | 19.0% | 14.0% |

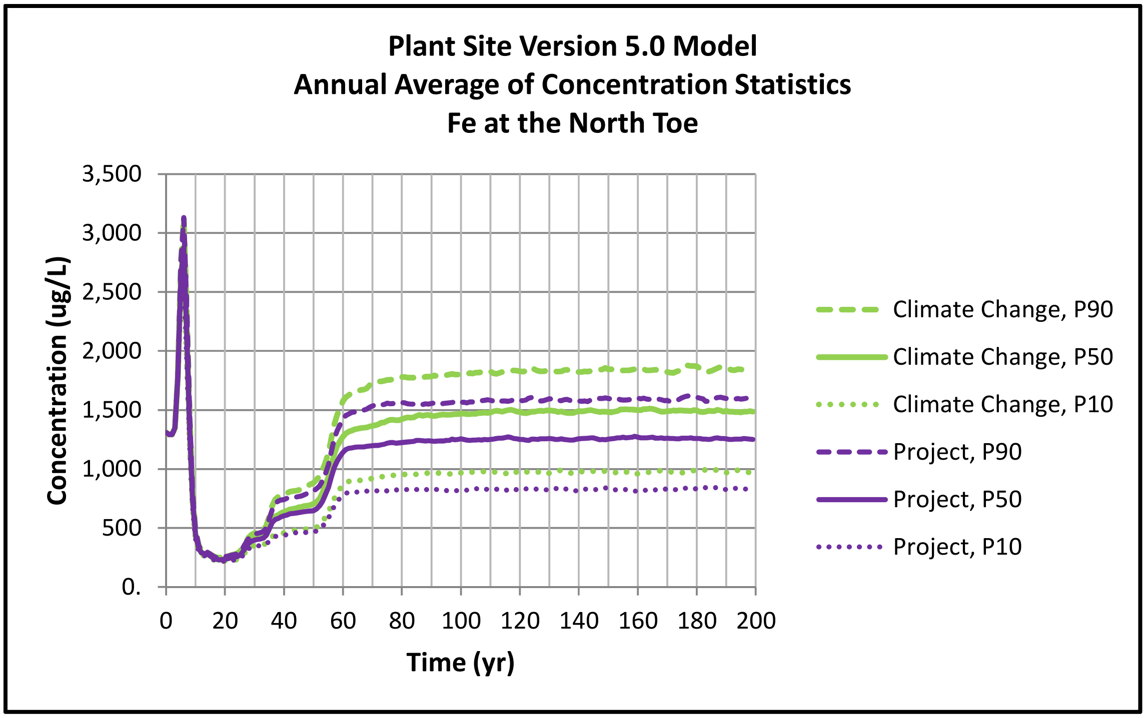



**Figure 6-7 Iron Concentrations at the North Toe; with and without Modeled Climate Change**

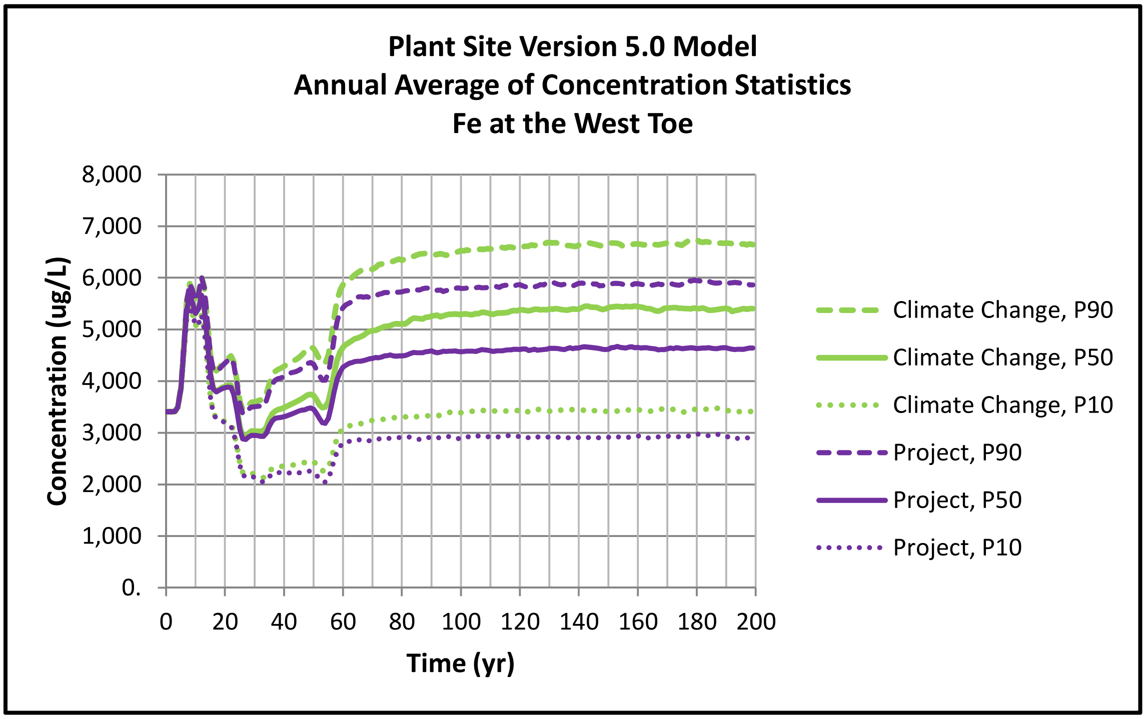



**Figure 6-8 Iron Concentrations at the West Toe; with and without Modeled Climate Change**

### 6.2.2 Flow at the toes of the Flotation Tailings Basin

Seepage at the toes of the Tailings Basin is expected to increase slightly due to the increase in infiltration throughout the Tailings Basin. Figure 6-9 shows the seepage in the Project Model compared to the seepage in the Climate Change Model. The increases are quite small and not even discernible on Figure 6-9; the increased flow totals about 60 gpm between the four toes.

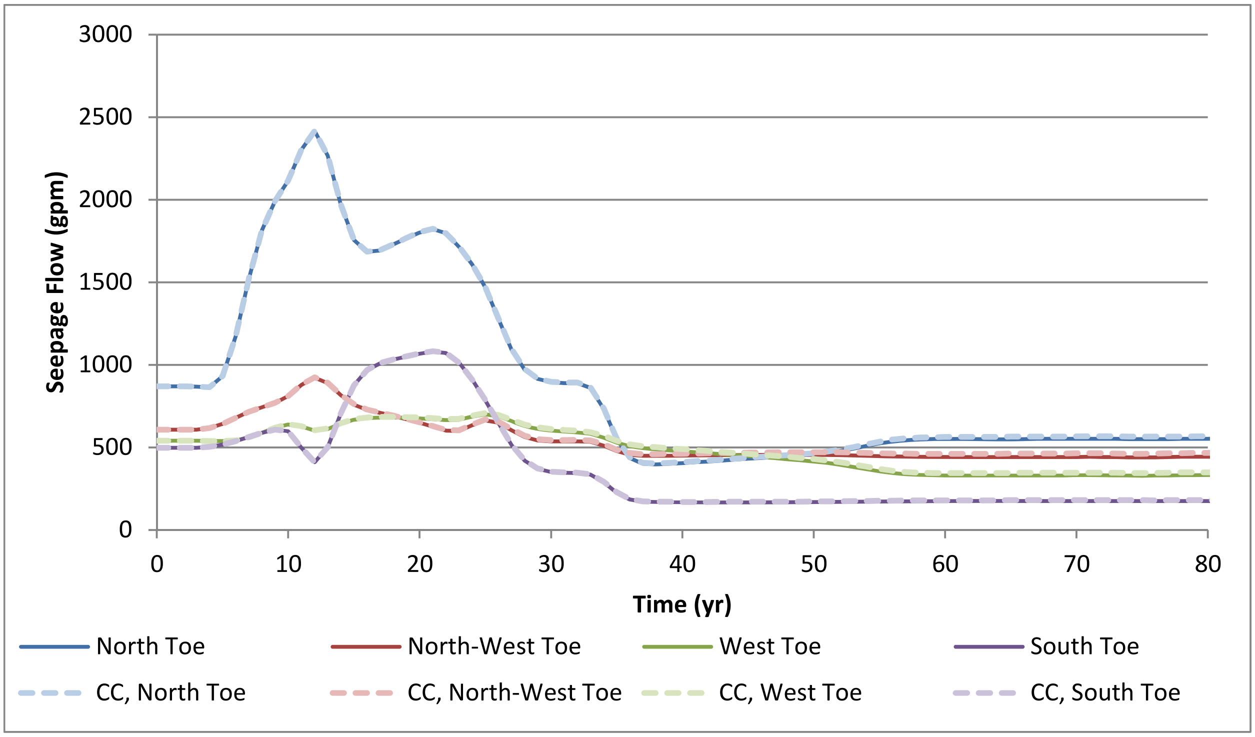



**Figure 6-9 Seepage at the Toes of the Tailings Basin; with and without Modeled Climate Change**

### 6.2.3 Groundwater Quality

Climate change is not expected to cause significant changes to groundwater concentrations. This is mostly due to the installation of the FTB Containment System. Even though climate change could cause slight concentration increases in seepage at the toes of the Tailings Basin, nearly all this seepage is collected and does not affect groundwater quality. For constituents where the groundwater concentrations at the Property Boundary showed a declining trend through the modeled 200-year period, the same response would be expected with modeled climate change. Although concentrations may not return as close to a more natural state as in the Project Model, the differences due to climate change would be expected to be essentially unnoticeable.

### 6.2.4 Surface Water Quality

Surface water quality in the Embarrass River and its tributaries is expected to be minimally effected by the Project under climate change conditions. All water leaving the Tailings Basin footprint is treated by the WWTP except for approximately 21 gpm of seepage that escapes the FTB Containment System and runoff from the exterior of the East Dam which is relatively inert. As discussed in Section 6.2.1, while the concentrations of constituents in this escaped seepage may increase, the volume of escaped seepage is so small that any increase in concentration due to climate change will be negligible by the time it Project water discharges to the tributaries or the Embarrass River.

There is likely to be an increase in the amount of treated by the WWTP, because the increase in precipitation is slightly greater than the amount lost to increased evaporation. This will result in a slight increase in the amount of seepage collected by the seepage capture systems. However, as shown in Section 6.2.2, the increase in seepage from the Tailings Basin when the modeled climate change is fully mature (beyond Mine Year 60) is only about 60 gpm in total. The differential between increased precipitation and increased evaporation will also require the WWTP to treat slightly more water from the FTB Pond to prevent overflow in long-term closure. These are small increases relative to the approximately 2,000 gpm influent expected to the WWTP in long-term closure.

# 7.0 Mine Site – High Baseflow

## 7.1 Introduction

The Minnesota Department of Natural Resources has collected continuous flow data in the Partridge River at the Dunka Road crossing (SW003, PM-3) beginning in 2011. Cooperating agencies have cited this data set as demonstrating that the baseflow assumptions used in the probabilistic model (and as calibration targets for the MODFLOW model) are up to three times less than observed baseflow in the vicinity of the Mine Site. However, data collected from this gaging station was not used for the SDEIS water quality impact assessment and is not proposed for use in the FEIS as directed by the Co-Lead Agencies (Reference (10).

To respond to the comments that baseflows should be higher than were assumed in the Mine Site GoldSim model, and to better understand the dependence of water quality projections on this model input, the Co-Lead Agencies have determined that it is appropriate to conduct a sensitivity analysis with higher groundwater baseflows. The sensitivity analysis described below is based on the work plan approved by the Co-Lead Agencies (Reference (11).

## 7.2 Model Inputs Adjusted

As described in Reference (11), the objective of this sensitivity analysis is to comprehensively address the effects on the Mine Site model from an increase in Partridge River baseflow. A number of model inputs are directly or indirectly affected by the selection of a baseflow value, as shown in Table 7-1. The adjustment of these inputs for the high baseflow sensitivity analysis is described in the following sections.

Except for the changes to the GoldSim model and input tables described in Sections 7.2.1 through 7.2.3, the Mine Site GoldSim model was not altered from that described in Reference (1) (Version 6.0 model). The input tables adjusted for this analysis are provided in Appendix J.

**Table 7-1 Mine Site GoldSim Model Inputs Affected by Baseflow**

| Model Input[(1)] | Description | Dependence on Baseflow | Adjustment for High Baseflow |
|---|---|---|---|
| SW_Conc_RO | Calibrated surface runoff concentrations in the Partridge River watershed | Baseflow affects calibration to observed concentrations | Recalibrated, see Section 7.2.3 |
| I_ops | Average hydraulic gradient along aquifer | Derived from MODFLOW model calibrated to baseflow | Set to deterministic values based on MODFLOW, see Section 7.2.2 |
| I_close | Average hydraulic gradient along aquifer in closure | | |
| K_Flowpath | Hydraulic conductivity of the surficial and bedrock material | Calculated from bounding recharge and gradient values | Set to deterministic values based on MODFLOW, see Section 7.2.2 |
| Recharge_min | Minimum allowed recharge in surficial aquifer (for checking calculated value) | Defined as ½ the average recharge, defined by the expected baseflow | Set to deterministic value, see Section 7.2.2 |
| Recharge_max | Maximum allowed recharge in surficial aquifer (for checking calculated value) | Defined as 2.5x the average recharge, defined by the expected baseflow | Set to deterministic value, see Section 7.2.2 |
| GW_Inc_Baseflow | Baseflow adding to evaluation points via natural groundwater | Baseflow input to the model as a deterministic time series (changes due to watershed changes) | Adjusted as directed by the Co-Lead Agencies, see Section 7.2.1 |
| WP_GW_Inflow, EP_GW_Inflow, CP_GW_Inflow | Groundwater inflow to the pit as a function of time or elevation | Derived from MODFLOW model calibrated to baseflow | Adjusted based on MODFLOW, see Section 7.2.2 |
| WP_GW_Surf, EP_GW_Surf, CP_GW_Surf | Surficial fraction of inflow to the pit as a function of elevation | | |
| CP_to_WP | Flow through bedrock from East Pit porewater to West Pit during pit filling (0 after West Pit is full) | | Not changed, see Section 7.2.2 |

(1) Model inputs as identified in Table 1-1 of the Mine Site GoldSim model inputs, included as Attachment C to Reference (1).

### 7.2.1 Partridge River Baseflow

As directed by the Co-Lead Agencies (Reference (10)), the Partridge River baseflow used for this analysis is a value four times larger than that used in Version 6.0 of the Mine Site model (see Section 5.2.4.3.5 of Reference (1)). The change in baseflow is applied uniformly across the entire length of the Partridge River, with the resulting total baseflow for existing conditions at each evaluation location shown in Table 7-2. The modeled changes to baseflow through time as a result of Mine Site development are shown in Table 1-21 in Appendix J. In addition to the modified input table, the model element GW_Inc_Baseflow_NoAct was adjusted to match the input baseflow values for Mine Year 0 (this element is used for modeling the Continuation of Existing Conditions Scenario in the Partridge River).

**Table 7-2 Total Groundwater Inflow (Baseflow) to each Evaluation Point (Existing Conditions)**

| Model | SW001 | SW002 | SW003 | SW004 | SW004a | SW004b | SW005 | SW006 |
|---|---|---|---|---|---|---|---|---|
| Version 6.0 | 0.065 | 0.41 | 0.51 | 0.92 | 2.44 | 3.81 | 4.91 | 5.27 |
| High Baseflow | 0.260 | 1.62 | 2.04 | 3.66 | 9.77 | 15.25 | 19.64 | 21.10 |

### 7.2.2 Groundwater Flow Parameters

The MODFLOW model of the Mine Site was recalibrated for the increased baseflow target value as described in Appendix K. Predictive simulations for various time periods during development of the Mine Site were simulated from the recalibrated model in order to develop the inputs to the GoldSim model. Groundwater inflow to the mine pits (rate and fraction from the surficial aquifer) was updated as shown in Tables 1-22a and 1-22b in Appendix J. The MODFLOW model did not indicate a significant change in the volume of flow from the Central Pit to the West Pit via bedrock (model element CP_to_WP) and the GoldSim model input was not adjusted.

Adjustments were made to the modeling of the surficial groundwater flow paths in GoldSim based on the recalibrated MODFLOW model. The recharge to groundwater in each flow path, which is simulated with a range to capture uncertainty in Version 6.0 of the Mine Site model (see Section 5.2.3.4 of Reference (1)), was made deterministic at a value of 2.9 inches per year (Recharge_min set equal to Recharge_max). Using this recharge value and the hydraulic gradient extracted from MODFLOW, the corresponding hydraulic conductivity for each flow path was calculated using the methods described in Section 5.2.3.1 of Reference (1). These combined changes effectively remove any variability in modeling the flow and constituent mass transport through each surficial flow path. The adjusted gradient and conductivity values are shown in Table 1-15 in Appendix J.

### 7.2.3 Calibrated Surface Runoff Water Quality and Colby Lake Loading

Because the adjustment of the assumed groundwater baseflow values in the Partridge River changes the ratio of groundwater to surface runoff in the river, the calibration process for determining distributions for surface runoff water quality (see Section 5.2.4.7 of Reference (1)) was repeated for this analysis. The estimated flow and load from the upstream Peter Mitchell Pit dewatering was not adjusted.

Table 7-3 presents the runoff distributions and goodness-of-fit results for the Version 6.0 model (Section 5.2.4.7.1 of Reference (1)) and the high baseflow model. In general, satisfactory calibration was achieved for most constituents with the higher baseflow model assumptions, with normalized RMSE values typically below 30%. For several constituents indicated in Table 7-3, most notably manganese, the best fit occurred with a surface runoff concentration of zero and a nominal value was used for the modeled concentration.

**Table 7-3 Calibrated Surface Runoff Concentration Comparison**

| Constituent | Version 6.0 Model | | | High Baseflow Model | | |
|---|---|---|---|---|---|---|
| | Runoff Mean (mg/L) | Runoff Std. Deviation (mg/L) | Normalized RMSE | Runoff Mean (mg/L) | Runoff Std. Deviation (mg/L) | Normalized RMSE |
| Ag | 1.01E-04 | 5.80E-06 | 6.6% | 9.30E-05 | 9.30E-07 | 6.9% |
| Al | 1.42E-01 | 1.20E-01 | 6.0% | 2.30E-01 | 2.00E-01 | 21.5% |
| Alkalinity | 6.50E+01 | 6.80E+01 | 2.1% | 7.80E+01 | 1.38E+02 | 11.2% |
| As | 9.60E-04 | 2.00E-03 | 12.0% | 1.17E-03 | 2.10E-03 | 25.9% |
| B | 7.30E-02 | 1.30E-01 | 23.3% | 1.07E-01 | 1.70E-01 | 25.4% |
| Ba | 2.50E-03 | 1.20E-03 | 17.6% | **1.00E-06** | **1.00E-08** | 68.0% |
| Be | 9.60E-05 | 9.60E-07 | 3.5% | 8.00E-05 | 8.00E-07 | 11.4% |
| Ca | 1.68E+01 | 1.60E+01 | 5.6% | 1.79E+01 | 2.50E+01 | 9.1% |
| Cd | 7.20E-05 | 6.90E-05 | 26.0% | 4.90E-05 | 9.30E-04 | 7.8% |
| Cl | 6.30E+00 | 1.30E+01 | 19.7% | 1.04E+01 | 1.50E+01 | 22.7% |
| Co | 4.20E-04 | 1.60E-03 | 1.7% | 7.80E-05 | 2.15E-03 | 15.6% |
| Cr | 6.30E-04 | 5.90E-04 | 26.2% | 4.40E-04 | 5.60E-04 | 38.3% |
| Cu | 1.36E-03 | 1.60E-03 | 17.1% | 5.00E-04 | 9.50E-04 | 22.1% |
| F | 8.80E-02 | 1.00E-01 | 11.2% | 9.40E-02 | 1.01E-01 | 23.4% |
| Fe | 2.30E+00 | 3.30E+00 | 10.9% | 2.90E+00 | 4.60E+00 | 17.0% |
| K | 1.80E+00 | 2.40E+00 | 4.2% | 1.75E+00 | 3.80E+00 | 17.5% |
| Mg | 7.50E+00 | 4.80E+00 | 3.8% | 7.90E+00 | 7.50E+00 | 3.4% |
| Mn | 4.00E-02 | 6.50E-01 | 9.4% | **1.00E-06** | **1.00E-08** | 68.5% |
| Na | 4.70E+00 | 1.10E+01 | 22.3% | 4.45E+00 | 2.10E+01 | 27.9% |
| Ni | 1.48E-03 | 3.50E-03 | 7.1% | 1.04E-03 | 3.70E-03 | 30.7% |
| Pb | 3.80E-04 | 3.30E-03 | 13.7% | 2.40E-04 | 3.00E-03 | 21.2% |
| Sb | 2.50E-04 | 2.50E-07 | 0.3% | 2.40E-04 | 2.60E-06 | 2.0% |
| Se | 6.40E-04 | 6.90E-04 | 29.6% | 7.30E-04 | 6.50E-04 | 42.3% |
| SO4 | 7.60E+00 | 8.00E+00 | 1.1% | 5.90E+00 | 8.10E+00 | 6.1% |
| Tl | **1.00E-06** | **1.00E-08** | 341.4% | **1.00E-06** | **1.00E-08** | 760.8% |
| V | 9.70E-04 | 9.70E-06 | 28.3% | **1.00E-06** | **1.00E-08** | 71.2% |
| Zn | 9.00E-03 | 2.10E-02 | 16.2% | 1.45E-02 | 2.90E-02 | 15.9% |

**Bold** values indicate constituents with a best-fit concentration of zero. A nominal mean value of 0.001 µg/L and standard deviation of 1% of the mean were used.

Following the surface runoff calibration, the additional loading to Colby Lake was estimated following the methods discussed in Section 5.2.4.8 of Reference (1). The resulting loading to Colby Lake is shown along with the surface runoff distributions in Table 1-13 of Appendix J.

## 7.3 High Baseflow Model Results

The GoldSim model for the high baseflow sensitivity analysis was run in the same fashion as for the Version 6.0 model (see Section 3.4 of Reference (1)), with a duration of 200 years and 500 realizations. Model results are summarized in the following sections and compared with the results presented in Reference (1).

### 7.3.1 Mine Pit Water Quality and Flows

The only Mine Site features affected by the assumption of higher baseflow are the mine pits, which experience an increase in groundwater inflow up to a maximum increase of 100 gpm in the East Pit based on the recalibrated MODFLOW model (see Appendix K). During operations, the increased pit inflow results in increased dewatering flow to the WWTF East Equalization Basin, with a peak 90th percentile flow increasing approximately 190 gpm compared to the Version 6.0 model results (Figure 7-1).

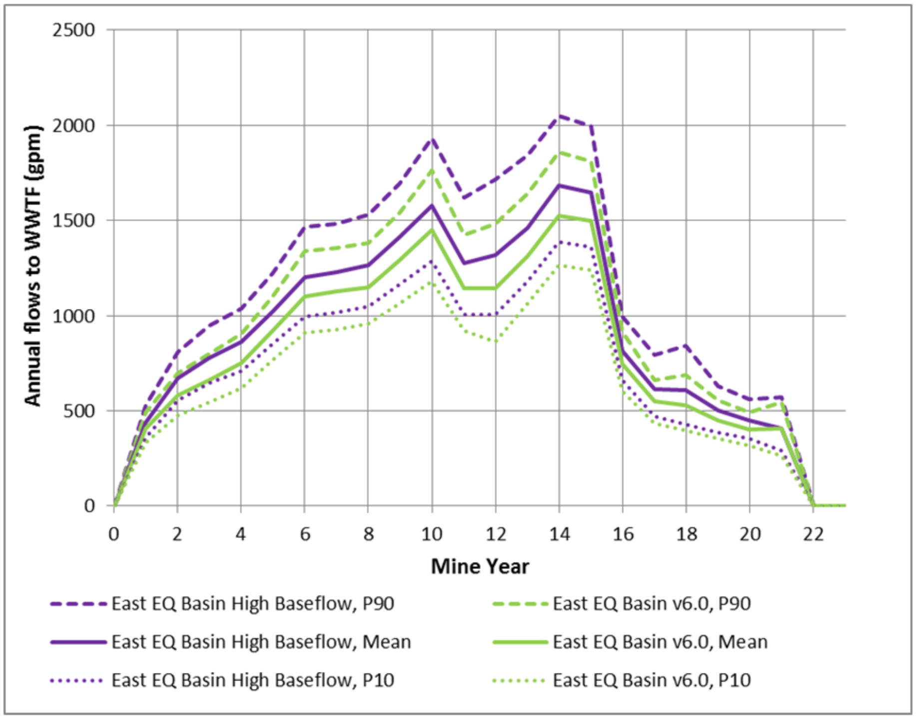



**Figure 7-1 Annual Average Inflows to the WWTF East EQ Basin - High Baseflow Comparison**

The additional groundwater inflow to the mine pits results in lower concentrations of constituents in water from pit dewatering during operations, as shown by Figure 7-2 for West Pit sulfate. However, the effect on the long-term pit water concentrations is minimal for both the East and West Pits (for example see Figure 7-3). In the West Pit long-term 90th percentile concentrations for most constituents decline (range from 25% decrease to 4% increase), with the only exceptions being manganese and thallium. The loading to the West Pit for these two constituents is dominated by groundwater inflow; the 90th percentile concentration at Mine Year 200 is 48% higher for manganese and 20% higher for thallium than in the Version 6.0 model results.

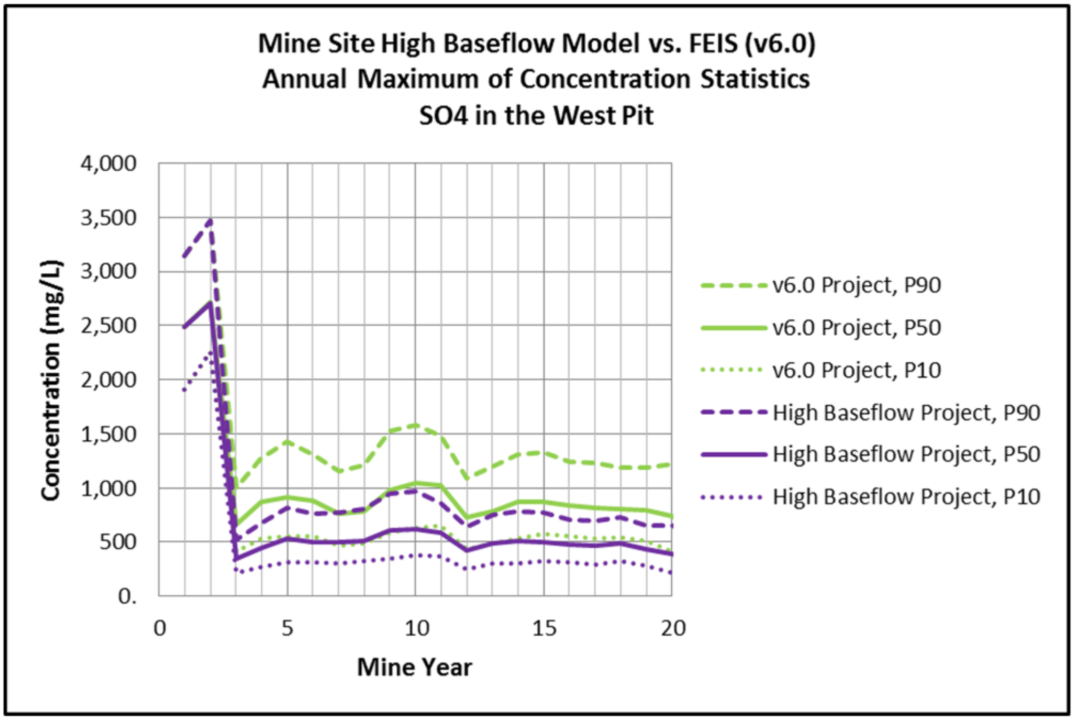



**Figure 7-2 Sulfate Concentrations in West Pit During Operations - High Baseflow Comparison**

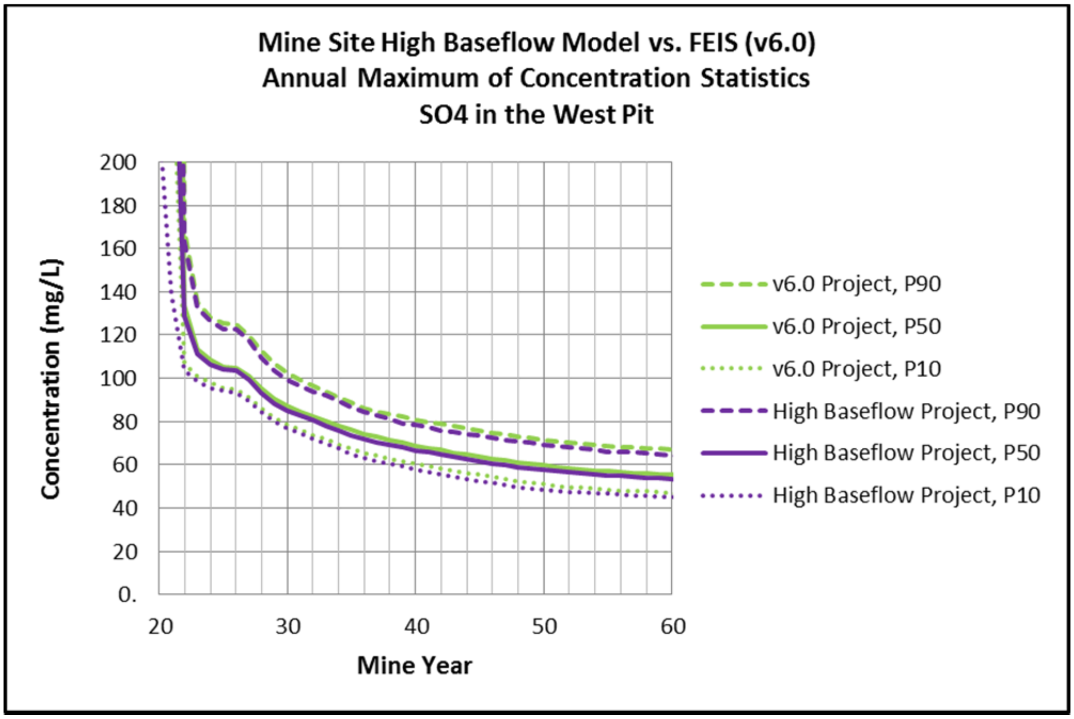



**Figure 7-3 Sulfate Concentrations in West Pit During Flooding - High Baseflow Comparison**

Due to the additional groundwater inflow to the mine pits in the high baseflow model, the reclamation period ends slightly sooner for both pits than in the results presented in Section 6.1.2 of Reference (1). The East Pit porewater treatment is complete on average by midway through Mine Year 34 (end of Mine

Year 34 in Version 6.0). West Pit flooding is complete on average by midway through Mine Year 50 (end of Mine Year 52 in Version 6.0).

Finally, the groundwater flow changes associated with the high baseflow model result in increased flow from both mine pits to groundwater in long-term closure, as well as from the West Pit to the WWTF in long-term closure (Table 7-4). The effects of these changes on the receiving groundwater and surface water systems are evaluated in Sections 7.3.2 and 7.3.3.

**Table 7-4 Outflows to Surficial Groundwater and the WWTF from the Mine Pits (gpm)**

| Outflow | Version 6.0 Model | | | High Baseflow Model | | |
|---|---|---|---|---|---|---|
| | P10 | Average | P90 | P10 | Average | P90 |
| East Pit to East Pit / Category 2/3 surficial flow path | 2.1 | 3.9 | 6.2 | 12.0[1] | | |
| West Pit to surficial flow path | 3.1 | 6.5 | 10.7 | 21.4[1] | | |
| West Pit to WWTF | 291 | 321 | 416 | 294 | 385 | 529 |

1) Pit outflow, like other flow path flows, is simulated as non-varying (deterministic) in the high baseflow model.

### 7.3.2 Groundwater Quality

The increased recharge and hydraulic conductivity in the high baseflow model cause more-rapid transport of constituent mass from the Mine Site sources to the groundwater evaluation locations. The loading from the Mine Site sources does not change (compared to the Version 6.0 model) except for the flows from the mine pits as shown in Table 7-4. Higher aquifer recharge rates provide more water that mixes with the Mine Site loads. The net effect of the higher baseflow is to decrease the time to breakthrough while increasing the peak concentrations along each flow path to varying degrees; the peak 90th percentile concentrations at the Property Boundary range from 0.9 to 2.3 times the concentrations in the Version 6.0 results (except for antimony as discussed below). The range of estimated concentrations for each groundwater evaluation location at the Property Boundary is shown in the figures in Appendix L.

Although the range of estimated concentrations in the sensitivity model is (as expected) wider for some constituents, especially in the surficial flow paths that exit the mine pits, in no case does this scenario cause a new exceedance of a groundwater quality standard at the 90th percentile concentration.

The constituent with the largest increase relative to the Version 6.0 model results is antimony, which shows a peak 90th percentile concentrations at the Property Boundary that is 12.6 times greater than in Version 6.0. This change is due to the effects of sorption and travel times rather than loading; the increased recharge decreases the time to breakthrough for antimony, which had not reached peak concentrations along the West Pit surficial flow path at the Property Boundary by Mine Year 200 in the Version 6.0 results (see Section 6.3.3.1 of Reference (1)). In the high baseflow model, the antimony concentration at the Property Boundary peaks well below the groundwater quality standard at approximately Mine Year 180, as shown in Figure 7-4.

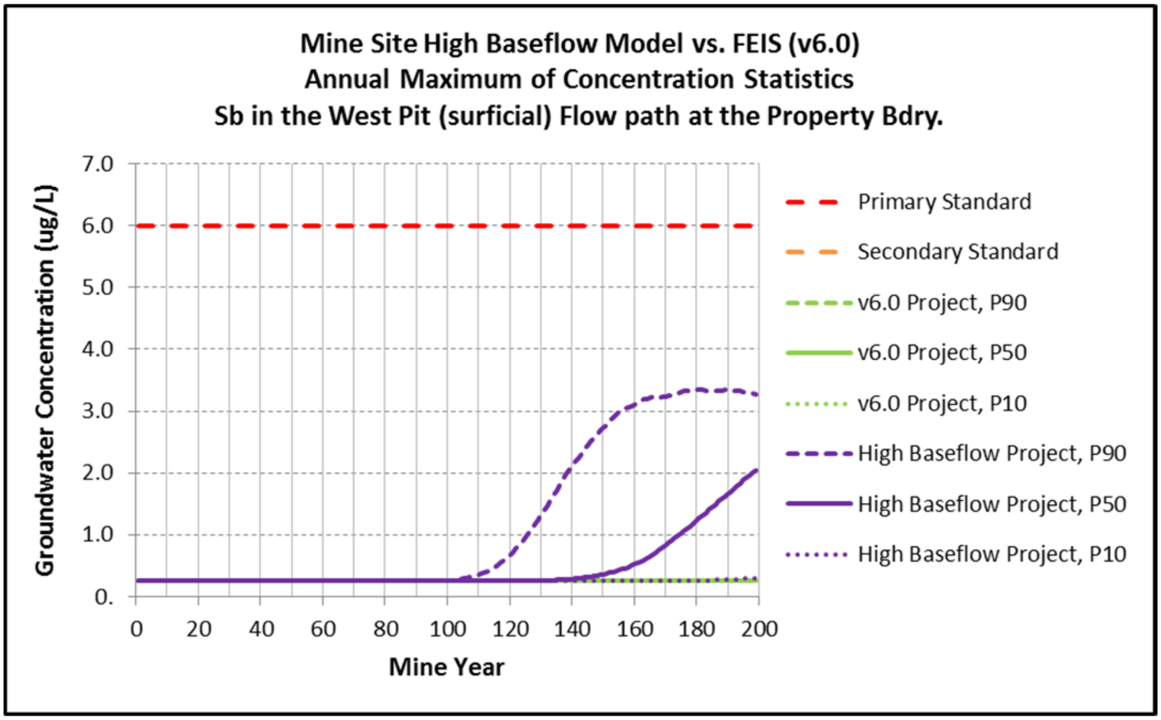



**Figure 7-4 Antimony Concentrations in the West Pit Surficial Flow Path at the Property Boundary - High Baseflow Comparison**

Figure 7-5 through Figure 7-9 present example plots of cobalt concentrations at the downstream end of each surficial flow path (i.e., at the Partridge River), comparing the results of the high baseflow model with Version 6.0. Note that for all flow paths the peak concentrations occur at the river between Mine Years 60 and 80 in the high baseflow model.

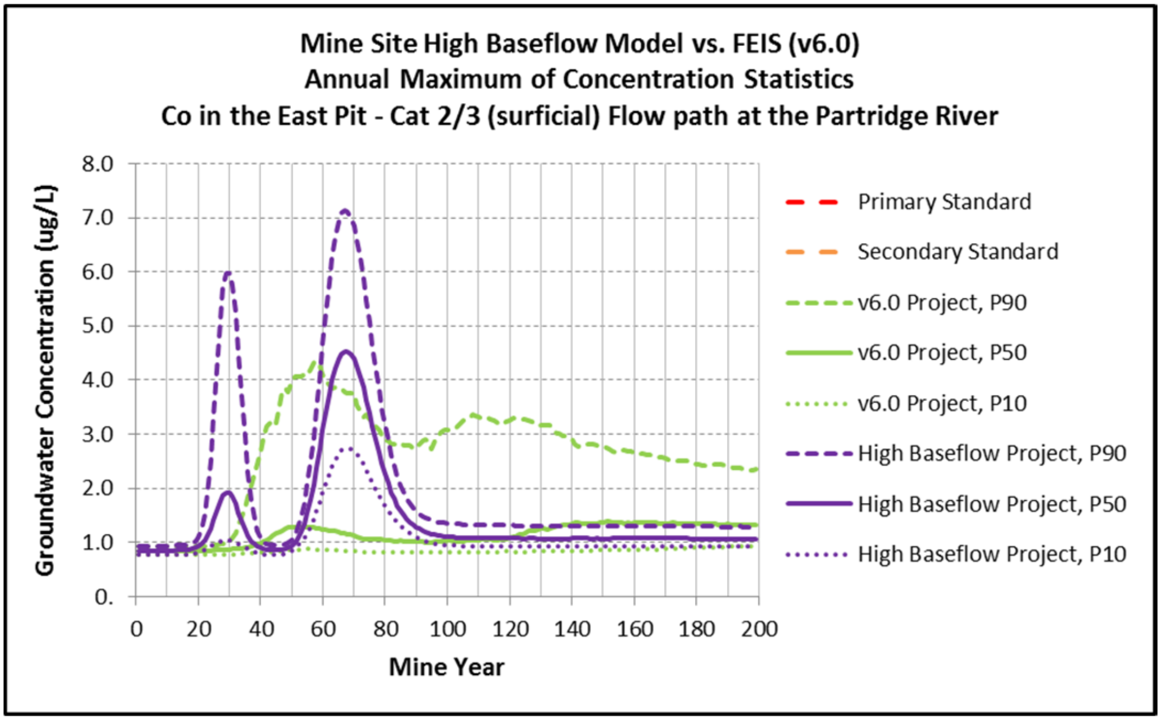



**Figure 7-5** **Cobalt Concentrations in the East Pit - Category 2/3 Surficial Flow Path at the Partridge River - High Baseflow Comparison**

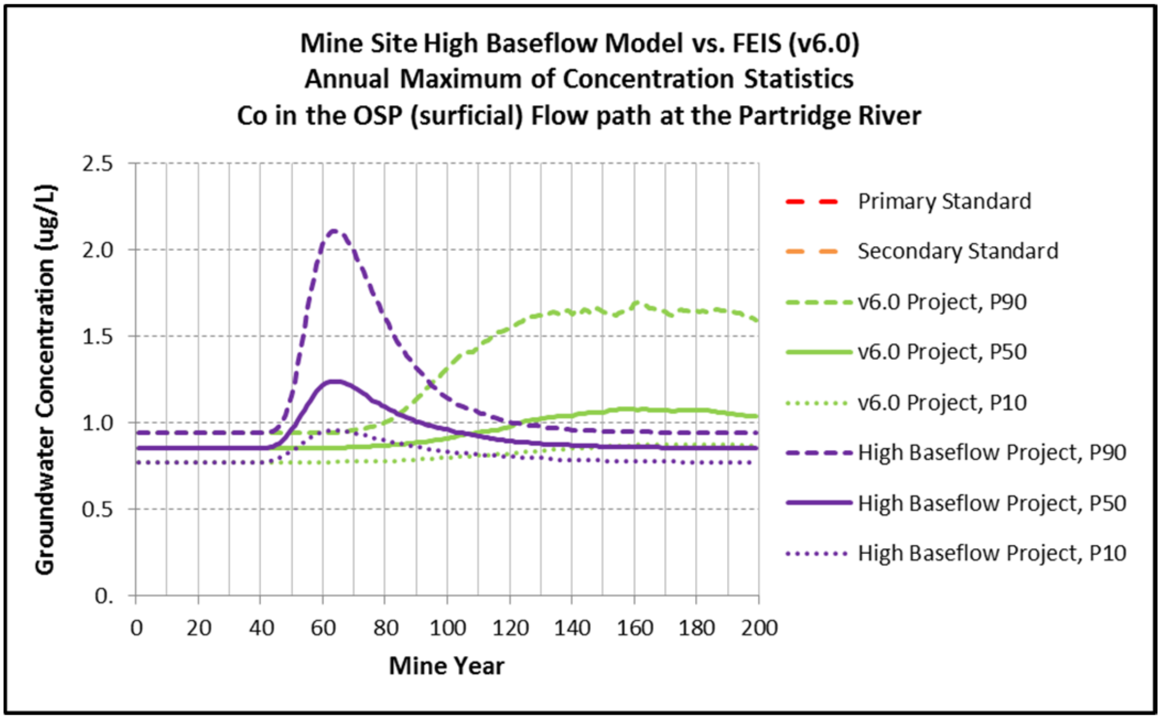



**Figure 7-6** **Cobalt Concentrations in the Ore Surge Pile Surficial Flow Path at the Partridge River - High Baseflow Comparison**

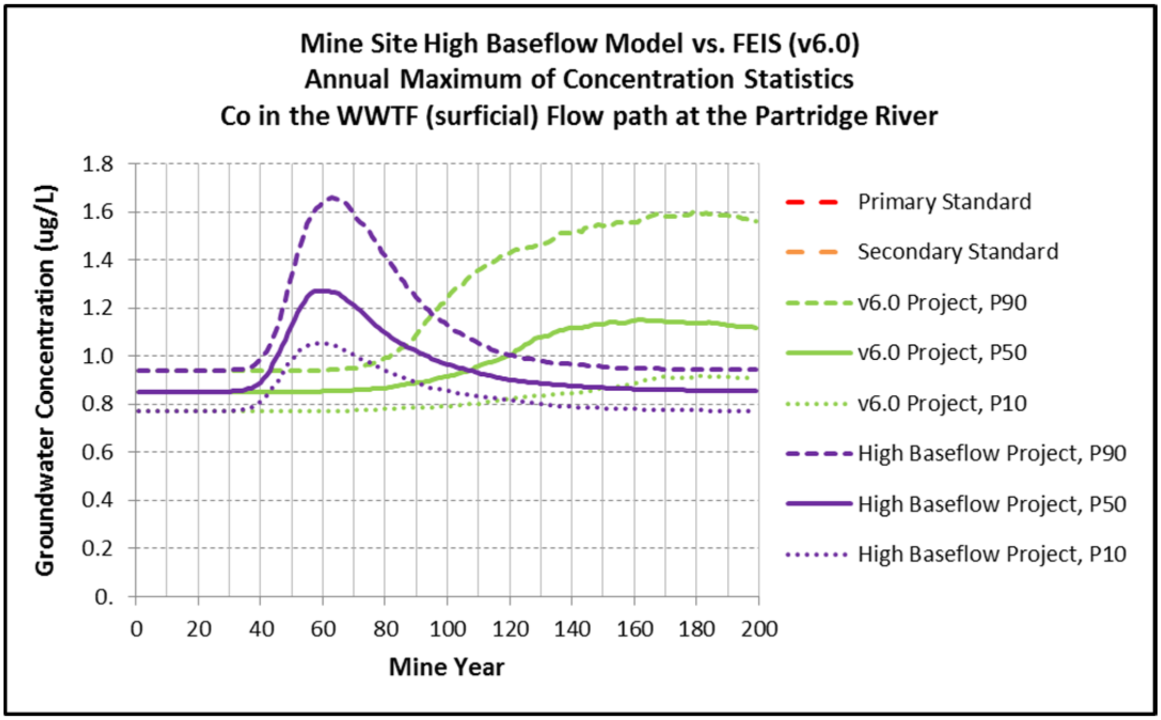



**Figure 7-7 Cobalt Concentrations in the WWTF Surficial Flow Path at the Partridge River - High Baseflow Comparison**

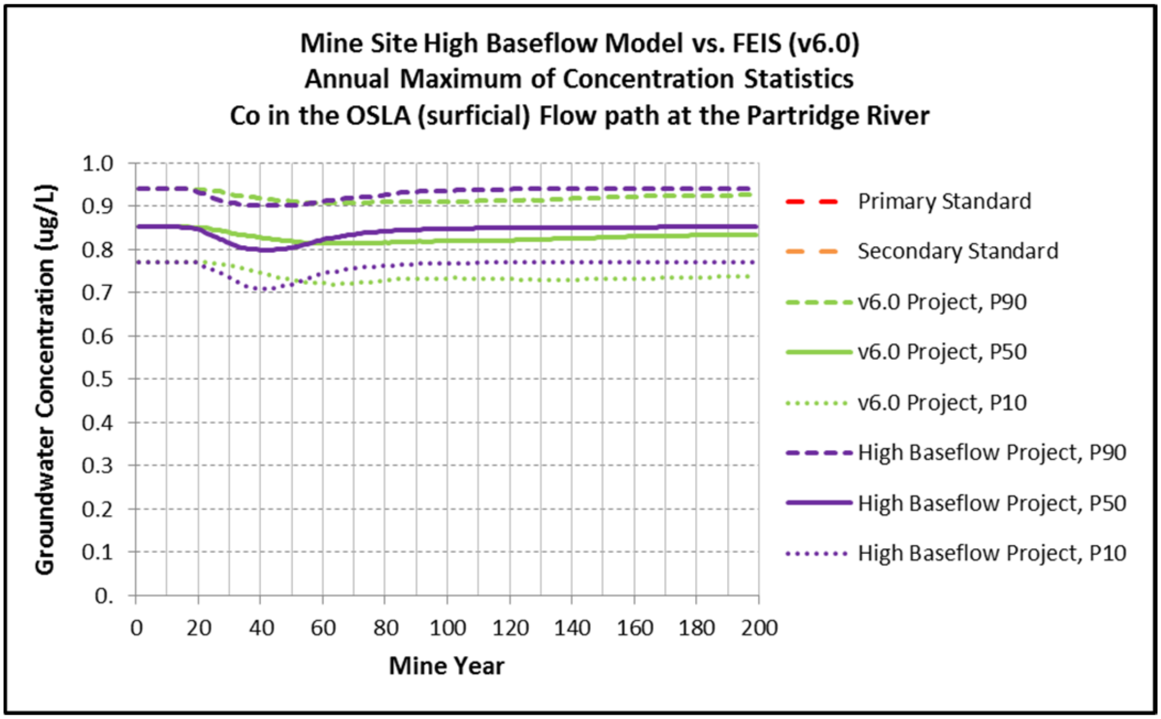



**Figure 7-8 Cobalt Concentrations in the Overburden Storage and Laydown Area Surficial Flow Path at the Partridge River - High Baseflow Comparison**

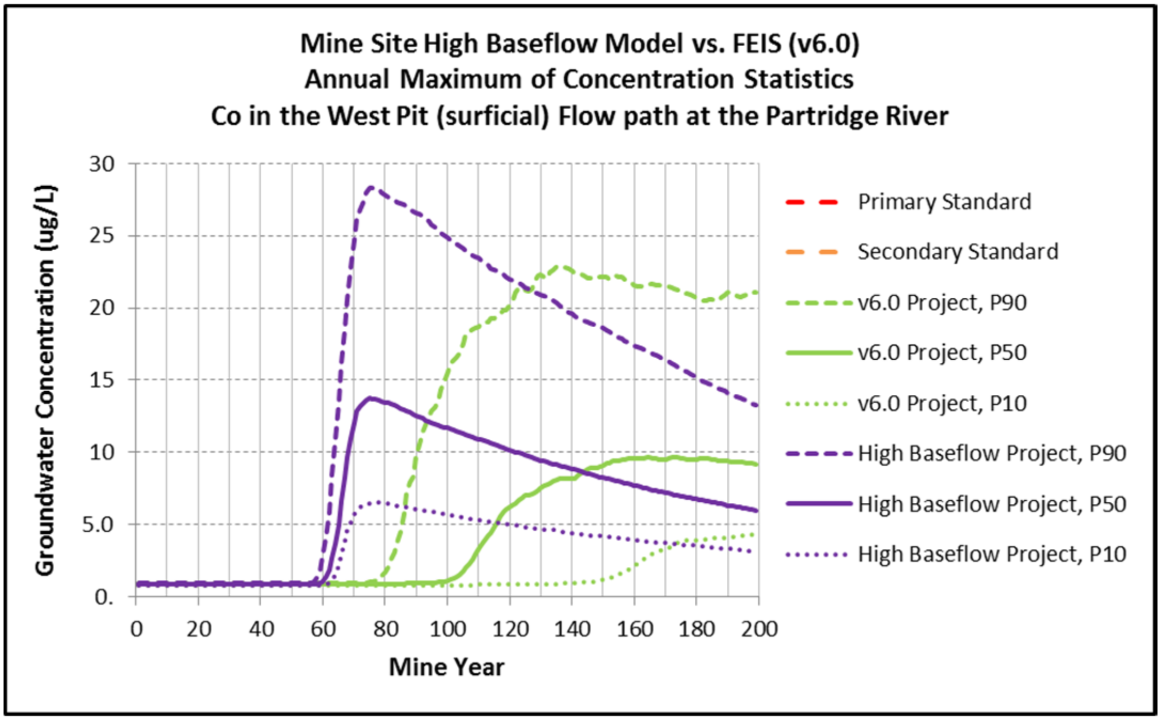



**Figure 7-9 Cobalt Concentrations in the West Pit Surficial Flow Path at the Partridge River - High Baseflow Comparison**

### 7.3.3 Surface Water Quality

The changes to the surface runoff calibration as well as the altered timing of the peak groundwater loading from the Mine Site result in visible changes to the water quality results for the Partridge River and Colby Lake. In general, however, the conditions observed in the Version 6.0 model results and discussed in detail in Section 6.5 of Reference (1) remain unchanged. There remain exceedances of some surface water quality standards, caused primarily by background conditions rather than the influence of the Project. Individual constituents are discussed briefly in Sections 7.3.3.1 through 7.3.3.3 below. The range of estimated concentrations for each surface water evaluation location is shown in the figures in Appendix M.

Similar to the results presented for the groundwater flow paths, the range of estimated concentrations in the sensitivity model results for the surface water is wider for many constituents than in the Version 6.0 model results. However, there is less of a difference between the two model runs for the range of surface water concentrations compared to the results for groundwater quality. The peak 90th percentile concentrations in the Partridge River range from 0.6 to 1.4 times the concentrations in the Version 6.0 results (except for manganese as discussed in Section 7.3.3.3).

As a general example of the observed difference in model results between Version 6.0 and the high baseflow model, Figure 7-10 presents the modeled cobalt concentrations in the Partridge River at SW004. The differences in concentration between the two models before Mine Year 55 are primarily due to the revised surface runoff calibration for the high baseflow model. Both models show a discontinuity in the results at Mine Year 55 when the discharge from the Peter Mitchell Pit ends, though it is more distinct for the high baseflow model. The high baseflow model clearly demonstrates the effect of loading from the surficial flow paths on the concentrations in the river between Mine Years 60 and 80, while the same effect is much more subtle and distributed over many more years in the Version 6.0 model results.

Downstream of the WWTF discharge, at SW004a, the increased flow from the West Pit to the WWTF and the corresponding increase in WWTF discharge causes a slight increase in the peak concentrations, especially for constituents that are at the WWTF treatment targets such as cobalt (Figure 7-11). No constituents exceed their surface water quality standards in the high baseflow model other than those discussed below.

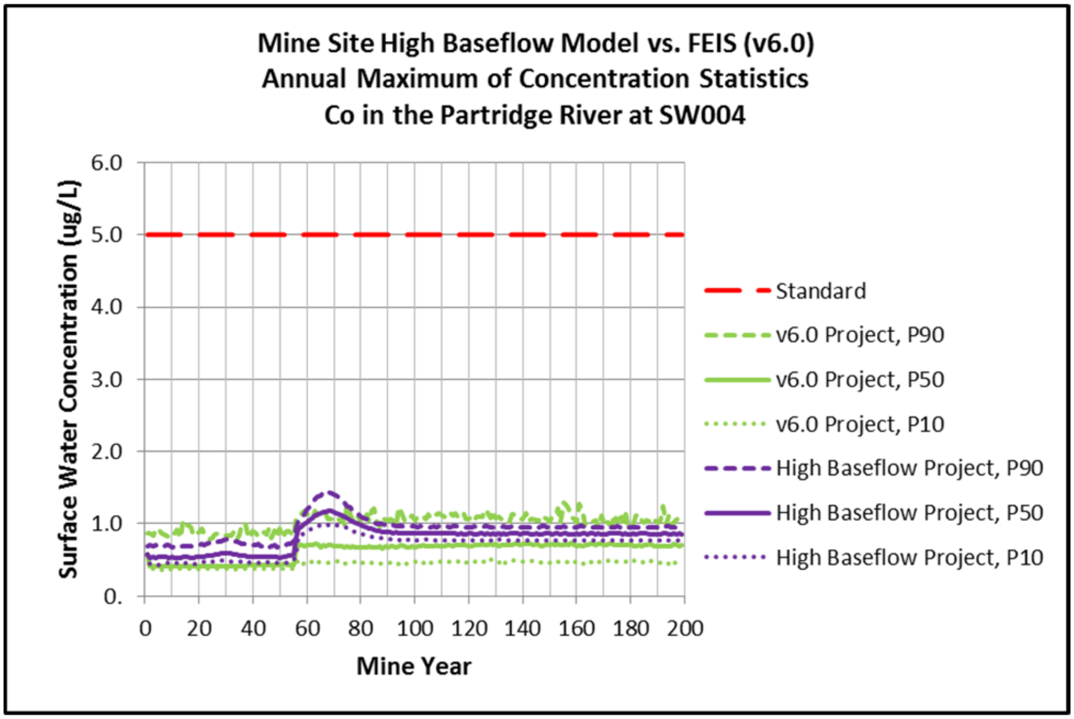



**Figure 7-10** **Cobalt Concentrations in the Partridge River at SW004 - High Baseflow Comparison**

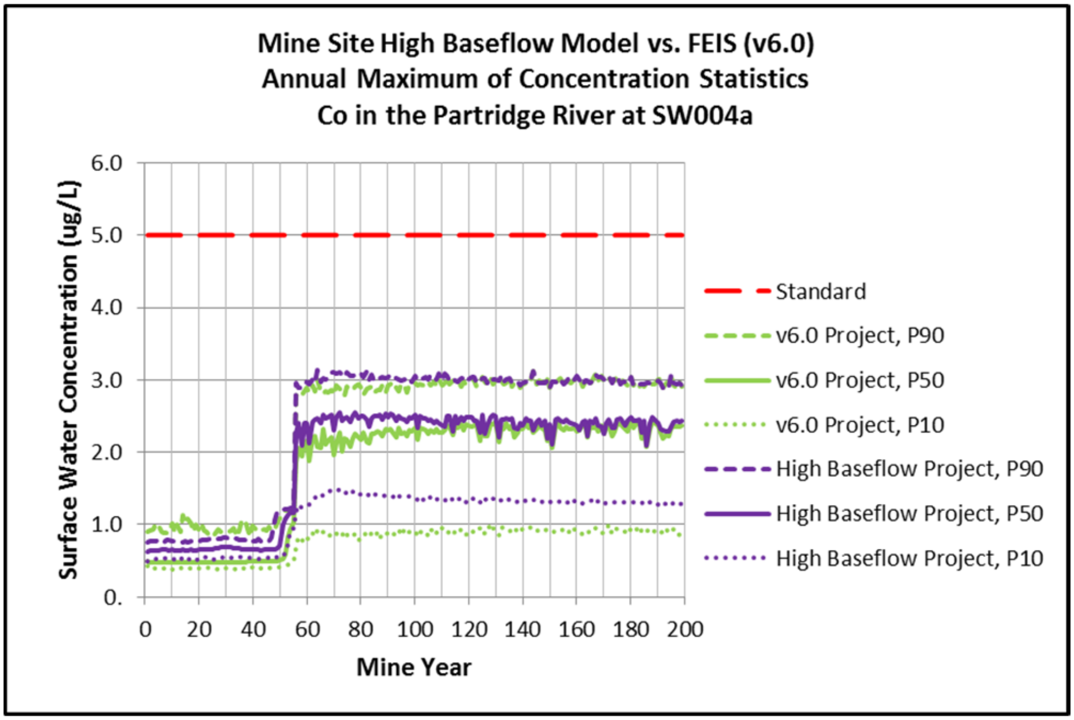



**Figure 7-11 Cobalt Concentrations in the Partridge River at SW004a - High Baseflow Comparison**

### 7.3.3.1 Aluminum

Similar to the Version 6.0 model results (see Section 6.5.6.1 in Reference (1)), model time steps with high surface runoff contributions show exceedances of the water quality standard for aluminum in the high baseflow model. As shown in Figure 7-12, the 50th and 90th percentile aluminum concentrations in the high baseflow model are higher than those in the Version 6.0 model, but the concentrations do not change throughout the modeled period. The difference is entirely due to the surface runoff calibration differences between the two models. Figure 7-13 demonstrates that the likelihood of an exceedance in the high baseflow model is nearly identical between the Project model and the Continuation of Existing Conditions Scenario model (the peak value of the blue line is 1.6%).

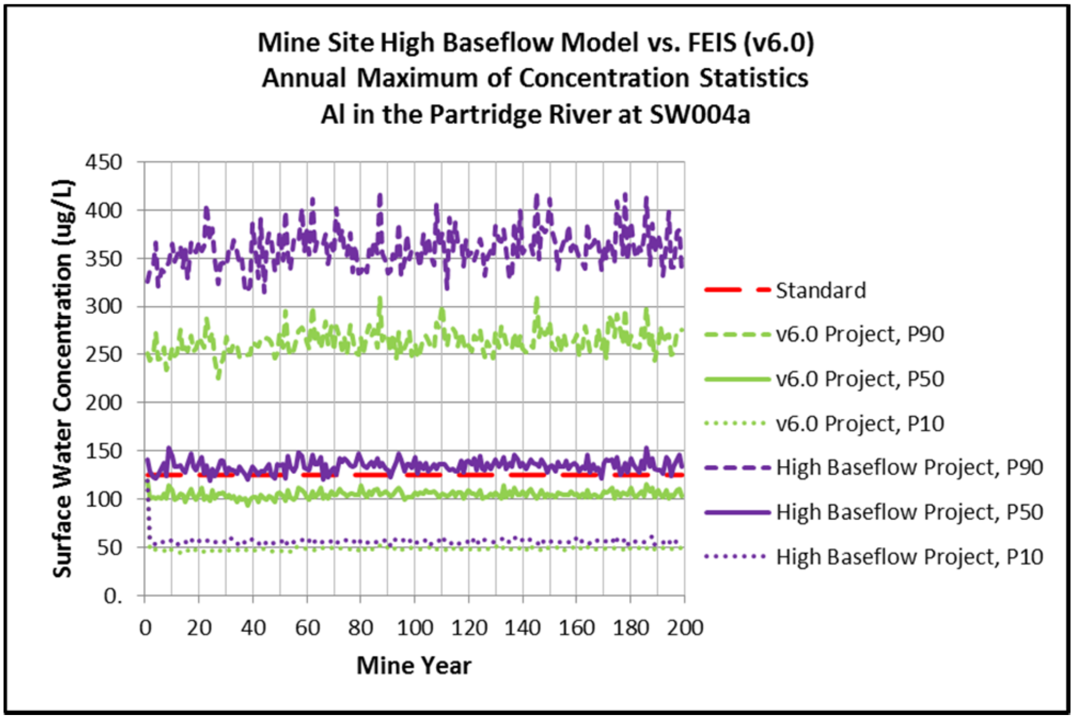



**Figure 7-12 Aluminum Concentrations in the Partridge River at SW004a - High Baseflow Comparison**

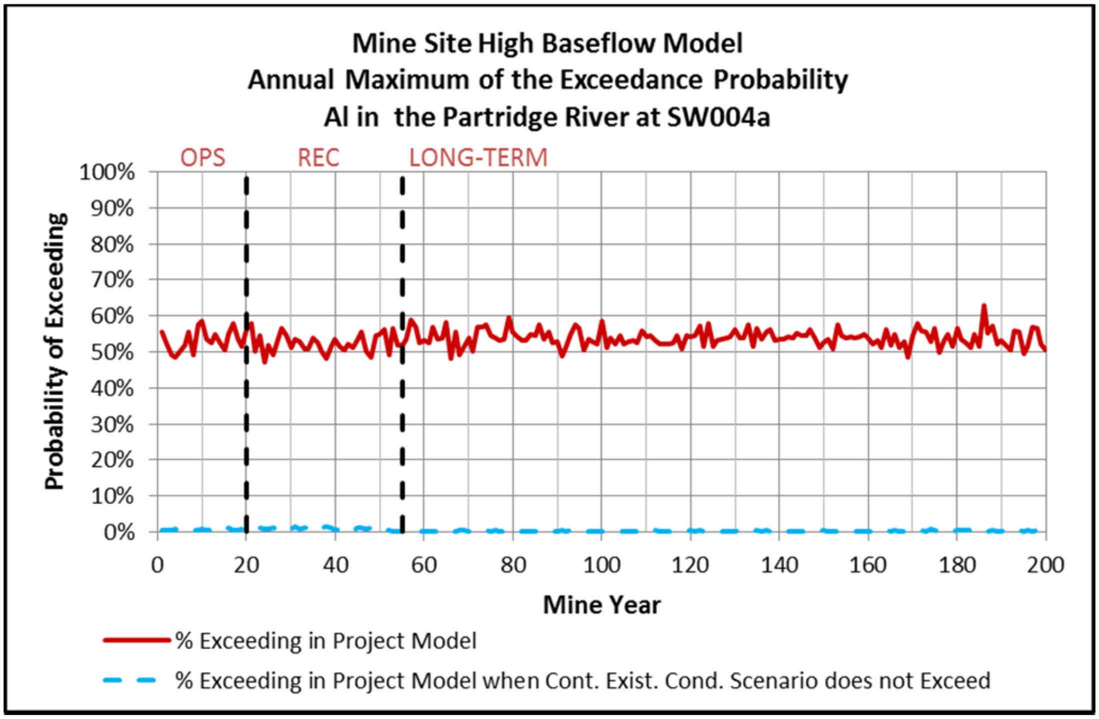



**Figure 7-13 Probability of an Aluminum Exceedance in the Partridge River at SW004a - High Baseflow Model**

### 7.3.3.2 Sulfate in the Partridge River at SW005

Due to the assumed high baseflow in the sensitivity analysis model, the calibrated surface runoff concentration for sulfate decreases from a mean of 7.6 mg/L to 5.9 mg/L (Table 7-3). During times of high flow in the Partridge River, therefore, the sulfate concentration is generally lower than in the Version 6.0 model results. However, because of the larger contributions from groundwater especially during low- and moderate-flow conditions, the sulfate concentrations during these time periods increase to approach the average background surficial groundwater concentration of approximately 9.6 mg/L (see Figure 6-131 in Reference (1)). These combined influences cause the pattern shown in Figure 7-14, where the 90th percentile concentrations in long-term closure decrease but the 10th and 50th percentile concentrations increase.

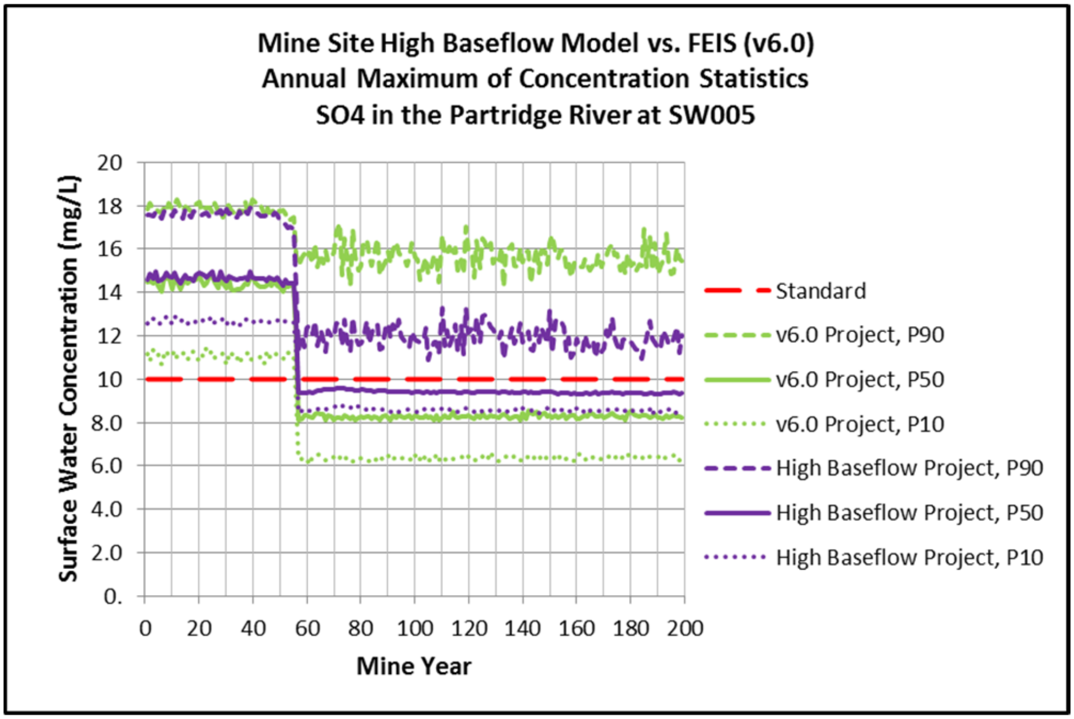



**Figure 7-14 Sulfate Concentrations in the Partridge River at SW005 - High Baseflow Comparison**

As discussed for the Version 6.0 model results (see Section 6.5.6.2 in Reference (1)), the primary cause of Project-related changes in the sulfate concentration at SW005 changes over time. During operations, the only effect of the Project is to decrease the watershed area tributary to SW005. This has a minimal effect on sulfate concentrations and almost no change in the likelihood of an exceedance of the 10 mg/L standard relative to the Continuation of Existing Conditions Scenario Model for high baseflow, as shown in Figure 7-15. During this period the assumption of high baseflow conditions (flows up to 19.6 cfs assumed to be 100% groundwater, see Table 7-2) combined with the constant dewatering from the Peter Mitchell Pit of 2.6 cfs result in exceedances of the 10 mg/L standard during every year of the Continuation of Existing Conditions Scenario and Project models.

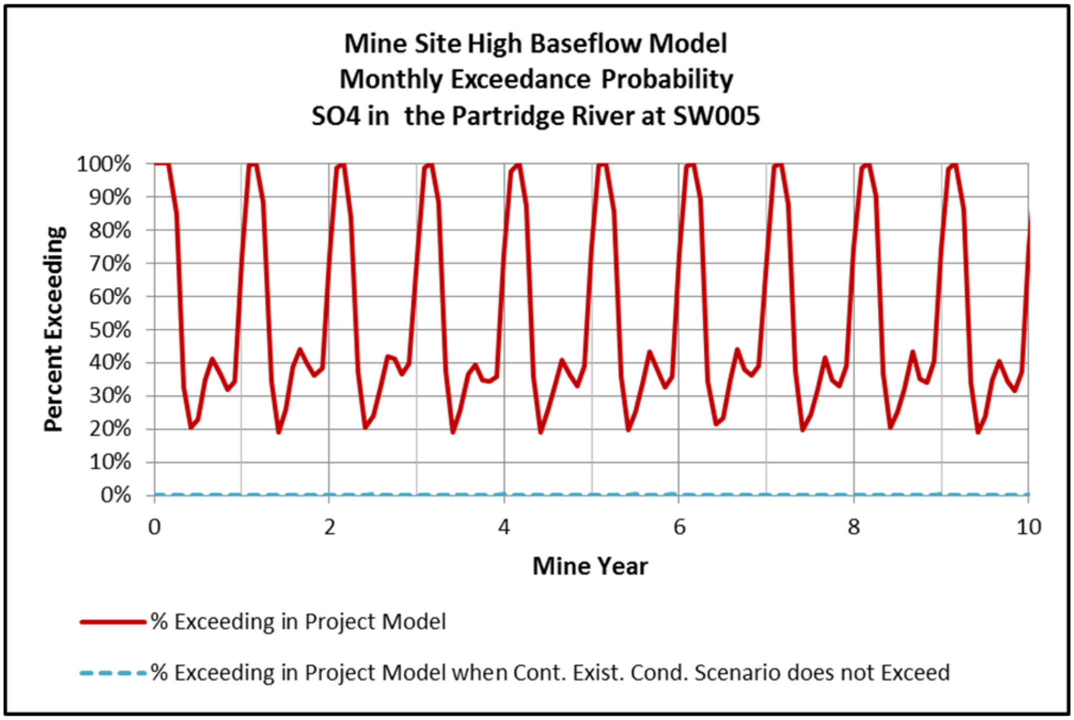



**Figure 7-15 Probability of a Sulfate Exceedance in the Partridge River at SW005 - High Baseflow Model, Mine Years 0 to 10**

During long-term closure, the Project adds sulfate load to the Partridge River via the WWTF discharge and the groundwater flow paths. Because the treatment target for the WWTF discharge is 9 mg/L (less than the surface water quality standard at SW005), this flow has a diluting effect during times of low river flows. The groundwater flow paths, however, have the potential to increase concentrations in the river especially when the flow in the river is at or below the assumed baseflow level. As discussed in Section 7.3.2, the peak concentrations in the flow path discharge to the Partridge River occur between Mine Years 60 and 80 for all flow paths in the high baseflow model. The effect of this load is an increase in the likelihood of an exceedance of the 10 mg/L sulfate standard in the Project Model relative to the Continuation of Existing Conditions Scenario Model, as shown in Figure 7-16.

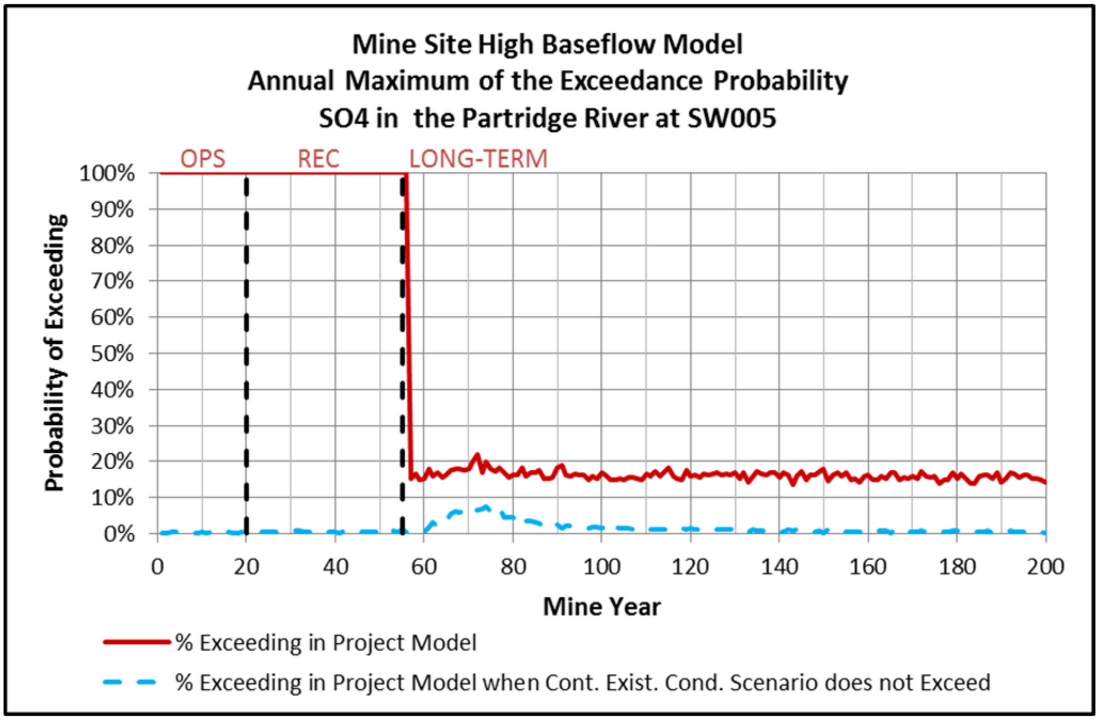



**Figure 7-16 Probability of a Sulfate Exceedance in the Partridge River at SW005 - High Baseflow Model**

In the high baseflow model, the peak probability of an exceedance of the sulfate standard in the Project Model that does not correspond to an exceedance in the Continuation of Existing Conditions Scenario Model (the blue line in Figure 7-16) is 7.4%, which occurs several times between Mine Years 70 and 80. This period is shown in more detail in Figure 7-17. Although this represents an increase in the likelihood of an exceedance compared to the Version 6.0 model (the comparable maximum value in Figure 6-138 of Reference (1) is 1.0%), there remains a less than 10% probability that the Project will cause an additional exceedance beyond that caused by natural conditions.

Despite the extreme conditions represented by the high baseflow model, the Project does not significantly impact water quality as it relates to the sulfate standard at SW005. During operations there will be ongoing monitoring of surface water (including low flows) and groundwater quality downgradient of mine features. If future modeling, informed by the results of the groundwater monitoring, shows exceedances of the applicable water quality standard for sulfate then contingency mitigation could be implemented and adapted as necessary to decrease the effects of groundwater on the Partridge River prior to an actual impact occurring.

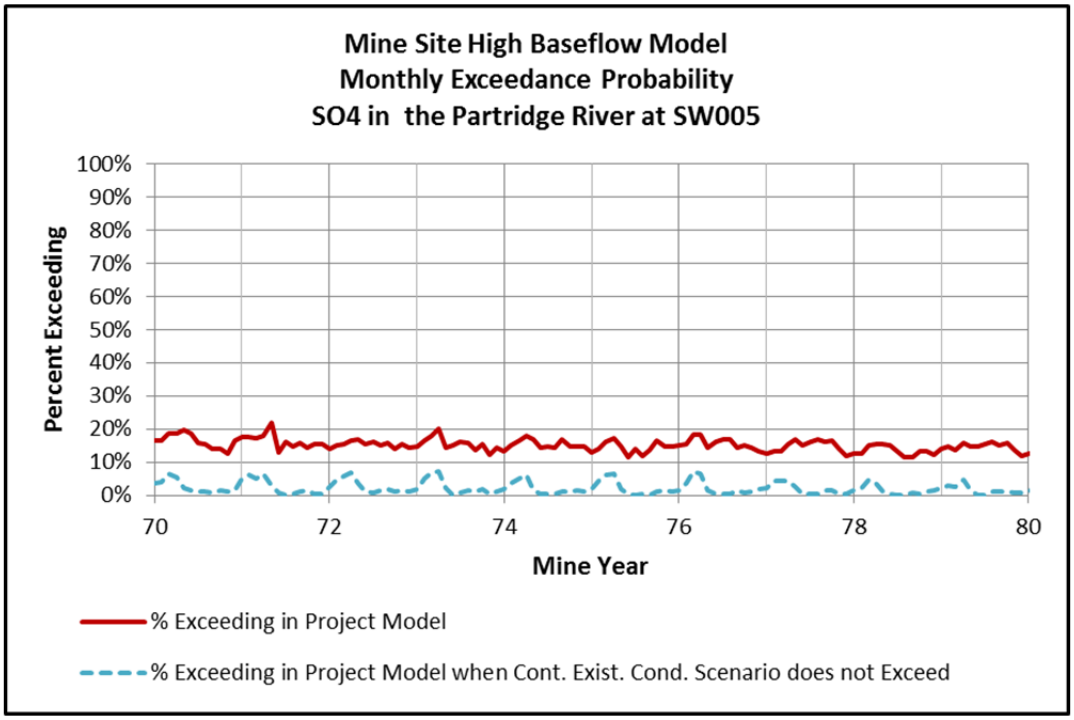



**Figure 7-17 Probability of a Sulfate Exceedance in the Partridge River at SW005 - High Baseflow Model, Mine Years 70 to 80**

#### 7.3.3.3 Arsenic, Copper, Iron and Manganese in Colby Lake

Several constituents were shown in the Version 6.0 model results to have estimated exceedances of the surface water quality standards applicable to Colby Lake that are caused by background conditions rather than the Project. Iron and manganese are discussed in Section 6.5.6.3 and arsenic and copper are discussed in Section 6.5.6.4 of Reference (1). For all of these constituents, the high baseflow model shows similar results, with exceedances in Colby Lake that are caused by background conditions.

Figure 7-18 through Figure 7-25 present the estimated concentrations as well as the probability of an exceedance in Colby Lake for these four constituents. The maximum probability of an exceedance caused by the Project (blue lines) is as follows: 1.4% for arsenic, 3.6% for copper, 0.2% for iron, 0.6% for manganese.

For all of these constituents, the differences between the Version 6.0 and the high baseflow model results are largely due to changes in the calibrated surface runoff concentration and additional loading to Colby Lake (Section 7.2.3). Most notably, the significant increase in estimated manganese concentrations for the high baseflow model is due to an inability to reproduce the observed concentrations in the Partridge River with a non-zero concentration for surface runoff. Simply put, the high baseflow model estimates more manganese loading from groundwater than appears to be present in the Partridge River or Colby Lake.

The likelihood of the Project causing an exceedance that will not occur without the Project under these high baseflow conditions (defined using the Continuation of Existing Conditions Scenario Model) is less than 10%. Therefore the Project does not significantly impact water quality as it relates to the water quality standards for arsenic, copper, iron, and manganese in Colby Lake.

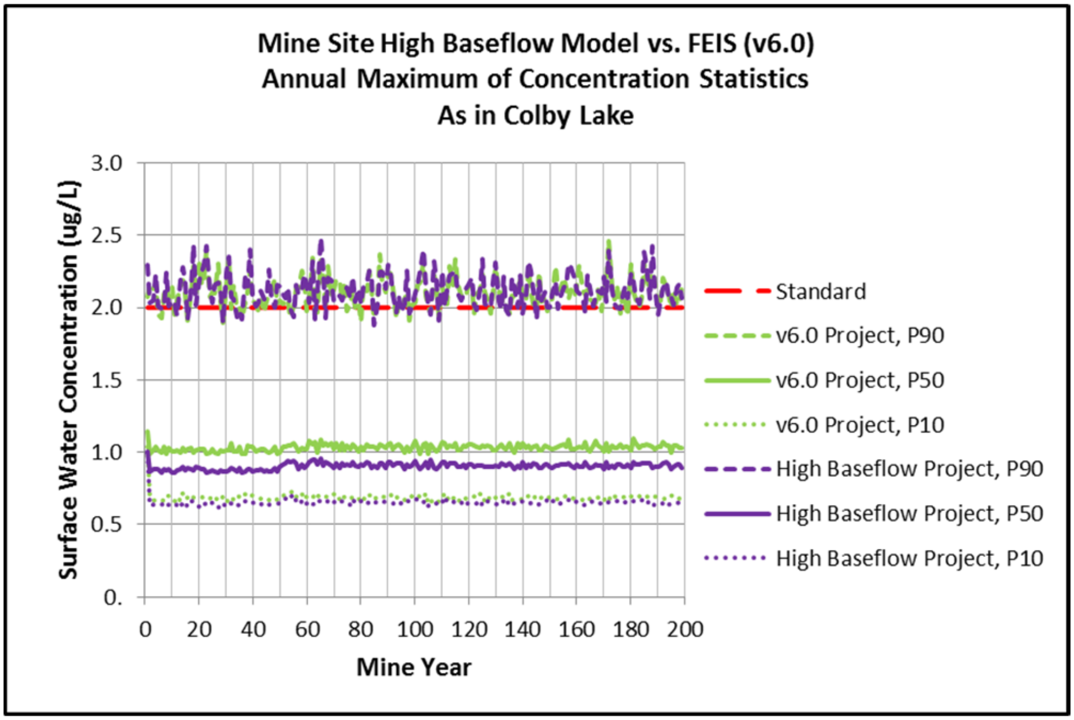



**Figure 7-18** Arsenic Concentrations in Colby Lake - High Baseflow Comparison

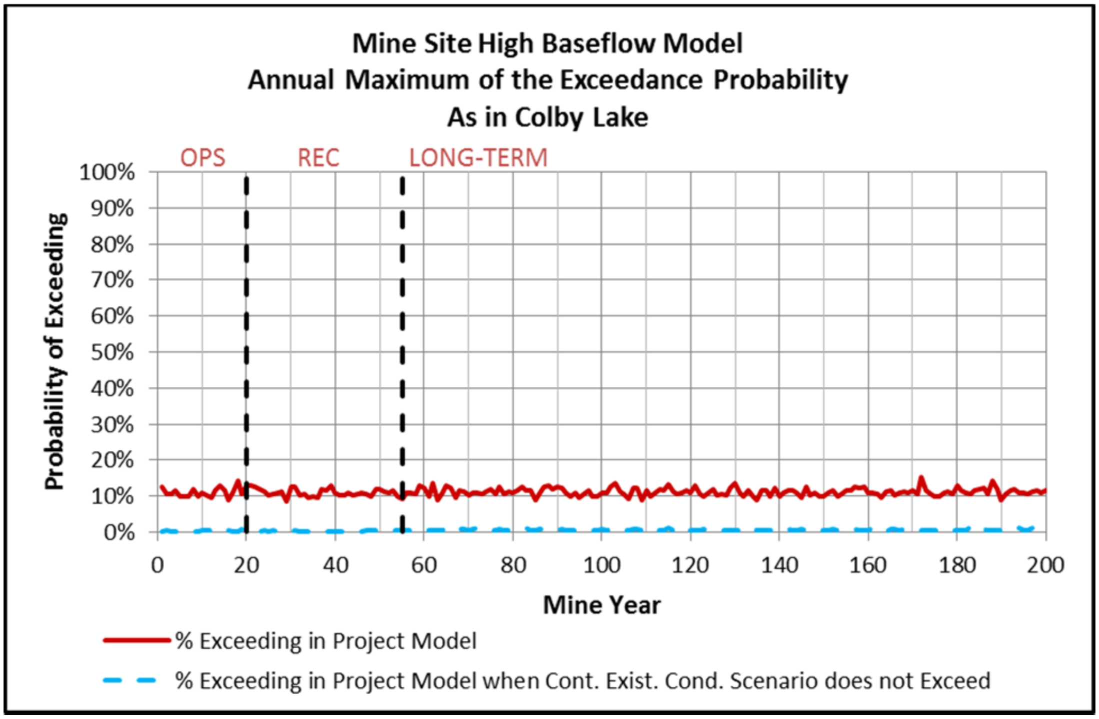



**Figure 7-19** Probability of an Arsenic Exceedance in Colby Lake - High Baseflow Model

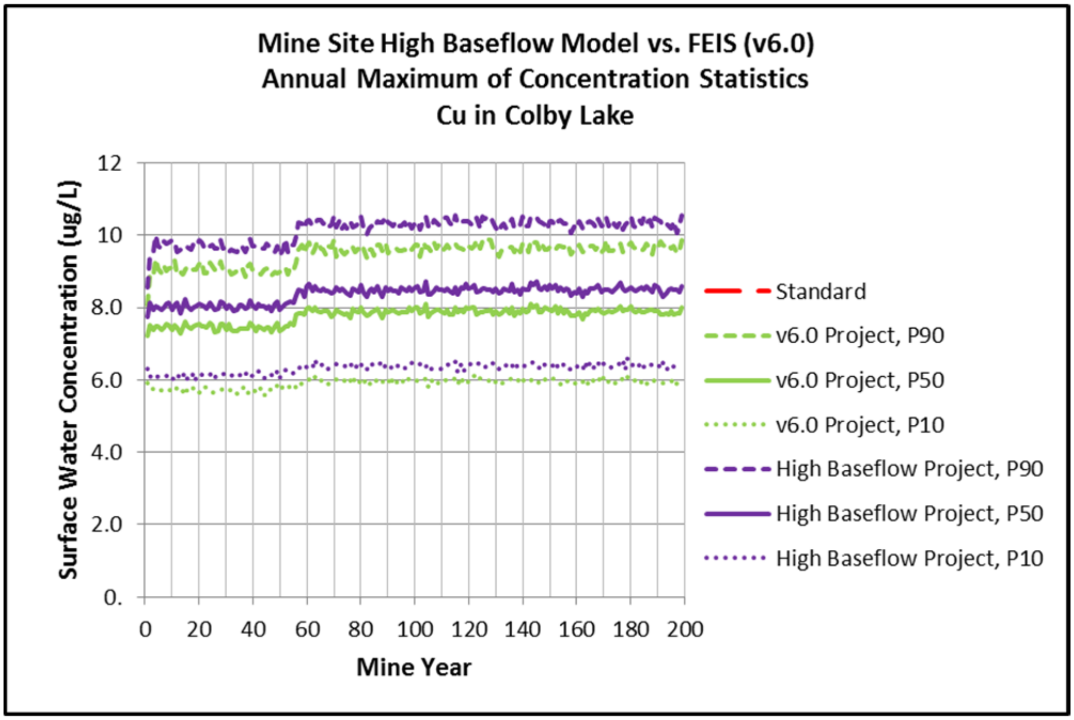



**Figure 7-20 Copper Concentrations in Colby Lake - High Baseflow Comparison**

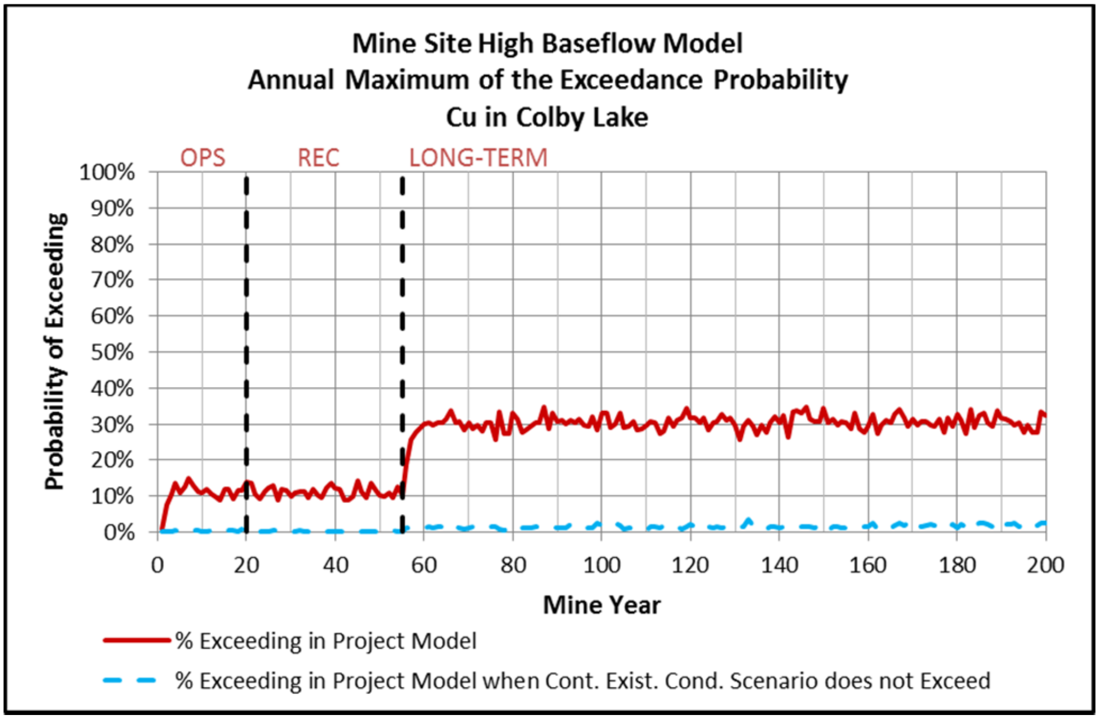



**Figure 7-21 Probability of a Copper Exceedance in Colby Lake - High Baseflow Model**

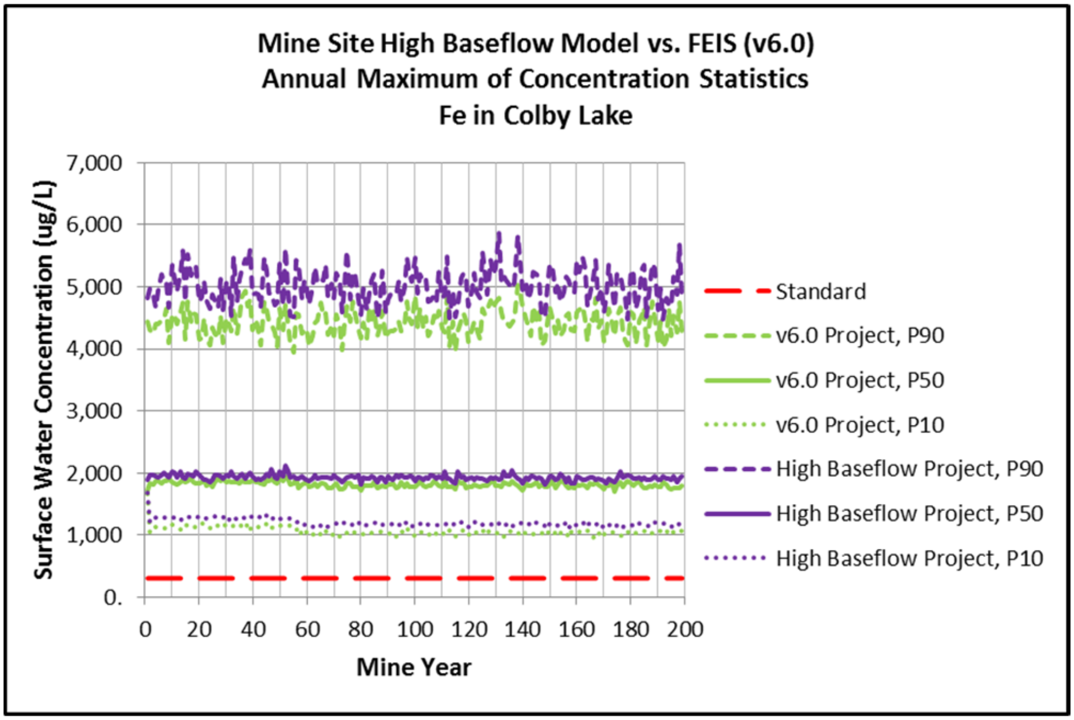



**Figure 7-22 Iron Concentrations in Colby Lake - High Baseflow Comparison**

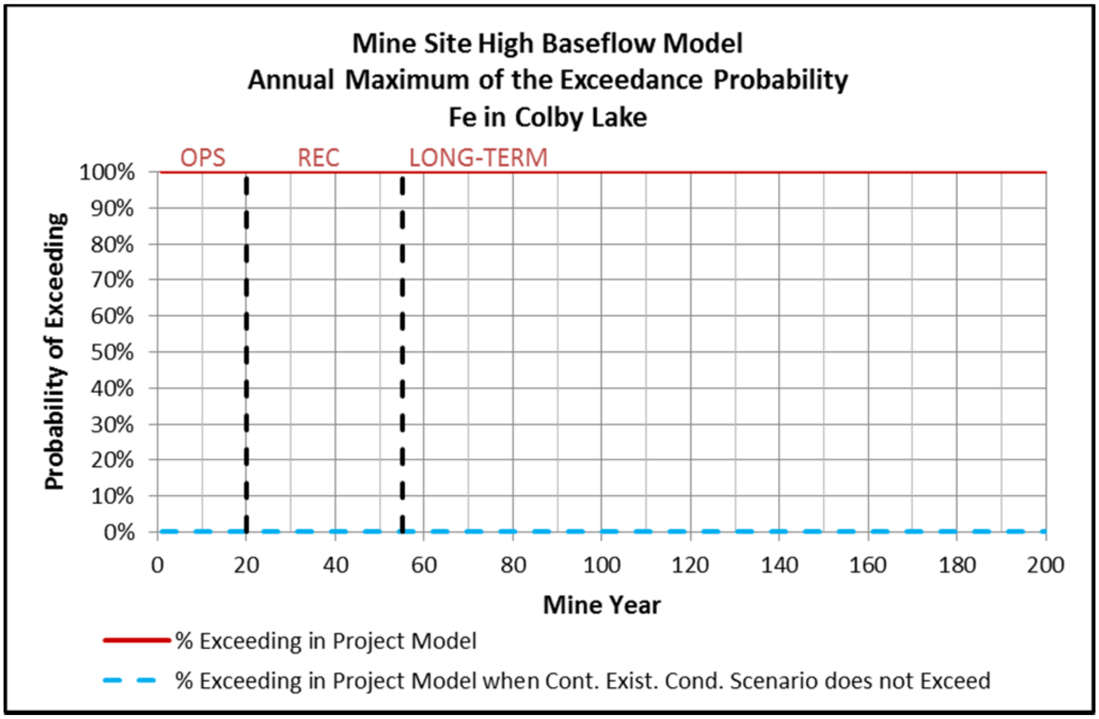



**Figure 7-23 Probability of an Iron Exceedance in Colby Lake - High Baseflow Model**

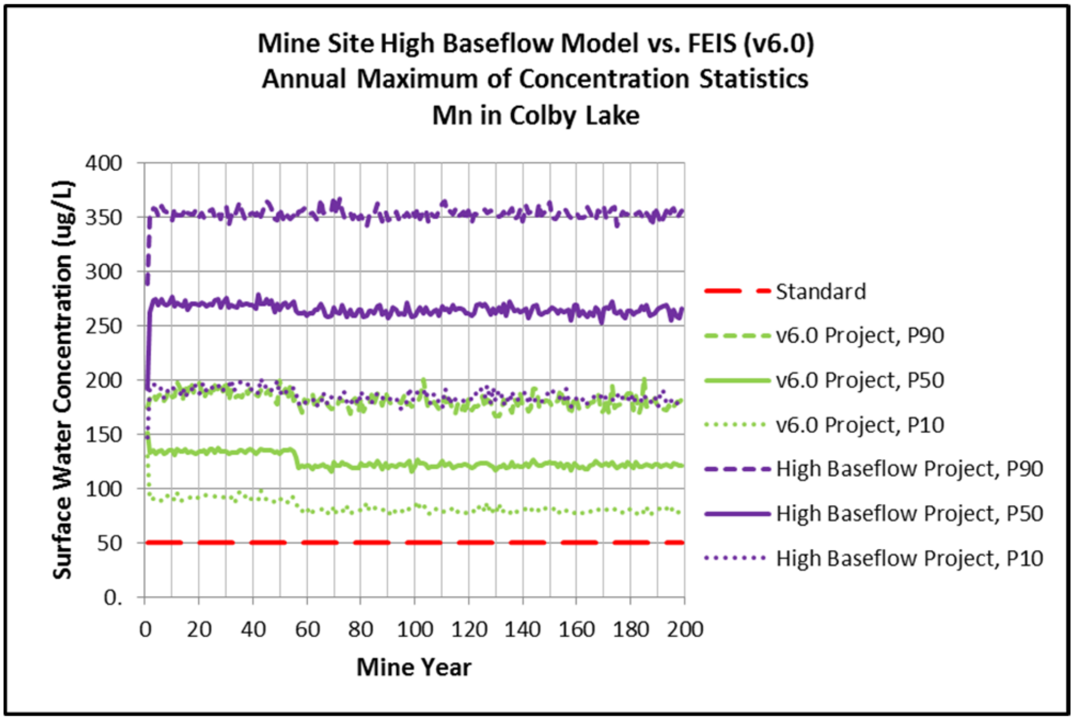



**Figure 7-24 Manganese Concentrations in Colby Lake - High Baseflow Comparison**

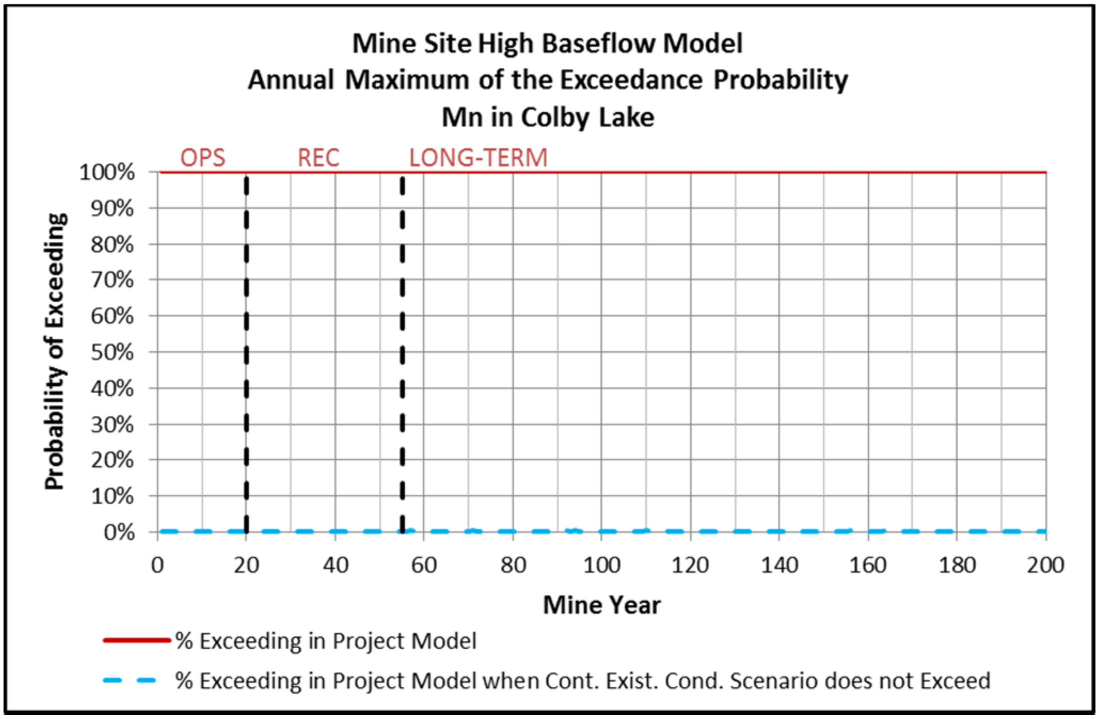



**Figure 7-25 Probability of a Manganese Exceedance in Colby Lake - High Baseflow Model**

## 7.4 Conclusions

The high baseflow model assessed here represents the unrealistic assumption that groundwater baseflow throughout the Partridge River is four times greater than indicated by the stream flow data collected by the USGS and used for the Version 6.0 model. The results show that the estimated concentrations in the groundwater and surface water are sensitive to this model change to the extent that there are observable differences between the high baseflow model and the Version 6.0 model, with peak 90th percentile concentrations typically increasing by a factor of no more than 2.4. The Project's ability to comply with the applicable groundwater and surface water quality standards, however, is not sensitive to the choice of the baseflow value. The estimated Project impact on the environment is unchanged in the high baseflow model, despite its extreme nature.

# References

1. **Poly Met Mining Inc.** NorthMet Project Water Modeling Data Package Volume 1 - Mine Site (v14). January 2015.

2. —. NorthMet Project Water Modeling Data Package - Plant Site (v11). January 2015. Ver. 11.

3. **Hinck, P. and Pint, T.** Proposed sensitivity analysis of the NorthMet Mine Site GoldSim model. [Memorandum to PolyMet]. December 12, 2012.

4. **Hinck, P., Warren, C. and Pint, C.** Initial Sensitivity Analysis Results of the NorthMet MineSite GoldSim Model (Version 2). [Memorandum to the Co-lead Agencies]. March 28, 2013.

5. **Walts, A.** EPA Detailed Comments on the GoldSim Model Review. [Letter from USEPA to B. Johnson, T. Hale, and T. Hingsberger]. May 5, 2013.

6. **Poly Met Mining Inc.** NorthMet Project Waste Characterization Data Package (v12). January 2015. Ver. 12.

7. **Hammonds, J.S., Hoffman, F.O. and Bartell, S.M.** An Introductory Guide to Uncertainty Analysis in Environmental and Health Risk Assessment. [Prepared for the U.S. Department of Energy]. 1994. ES/ER/TM-35/R1.

8. **Kellogg, Chev.** Climate Change Conditions for Use in Mining Geochemical Environmental Review. June 16, 2011.

9. **Galatowitsch, S., Frelich, L., Phillips-Mao, L.** Regional climate change adaptation strategies for biodiversity conservation in a midcontinental region of North America. *Biological Conservation.* 2009, 142: 2012-2022.

10. **Minnesota Department of Natural Resources, U.S. Army Corps of Engineers, U.S. Forest Service, and ERM Water Team.** Partridge River Groundwater Baseflow & Sensitivity Analysis Background and Rantionale for Agency Recommendations. November 17, 2014.

11. **Barr Engineering Co.** Partridge River Baseflow Sensitivity Analysis – Work Plan (Version 2) Memorandum to Jennifer Saran, Poly Met Mining Inc. November 19, 2014.

# Large Tables

Large Table 1: Input Variables for the Mine Site Sensitivity Analysis (Including Descriptions)

| # | Run Name | GoldSim Description | Variable Match in Workplan | Description of Input Variable from Workplan |
|---|---|---|---|---|
| 1 | GW_Bed_Random | Bedrock mean water quality uncertainty (ln ug/L) | GW_Conc_Bed | Bedrock groundwater concentrations in the Partridge River watershed |
| 2 | GW_Surf_Random | Surficial aquifer mean water quality uncertainty (ln ug/L) | GW_Conc_Surf | Surficial groundwater concentrations in the Partridge River watershed |
| 3 | SW_RO_Random | Surface water runoff concentrations in the Partridge River watershed; by constituent | SW_Conc_RO | Calibrated surface runoff concentrations in the Partridge River watershed |
| 4 | Annual_Evap | Annual evaporation from open water | Annual_Evap | Annual evaporation from open water |
| 5 | Annual_Precip_Cuberoot | Cube root of the annual precipitation | Annual_Precip_Cuberoot | Cube root of the annual precipitation |
| 6* | I_Close_EP23surf | Hydraulic gradient by flowpath | - | Varies by Flowpath. Reference Table 1-15 |
| 7* | I_close_Epbed | Hydraulic gradient by flowpath | - | Varies by Flowpath. Reference Table 1-15 |
| 8* | I_close_WPbed4 | Hydraulic gradient by flowpath | - | Varies by Flowpath. Reference Table 1-15 |
| 9* | I_close_WPbed4a | Hydraulic gradient by flowpath | - | Varies by Flowpath. Reference Table 1-15 |
| 10* | I_close_WP_Surf | Hydraulic gradient by flowpath | - | Varies by Flowpath. Reference Table 1-15 |
| 11* | I_ops_EP23surf | Hydraulic gradient by flowpath | - | Varies by Flowpath. Reference Table 1-15 |
| 12* | I_ops_OSLAsurf | Hydraulic gradient by flowpath | - | Varies by Flowpath. Reference Table 1-15 |
| 13* | I_ops_OSPsurf | Hydraulic gradient by flowpath | - | Varies by Flowpath. Reference Table 1-15 |
| 14* | I_ops_Wpsurf | Hydraulic gradient by flowpath | - | Varies by Flowpath. Reference Table 1-15 |
| 15* | I_ops_WWTFsurf | Hydraulic gradient by flowpath | - | Varies by Flowpath. Reference Table 1-15 |
| 16* | K_EP23surf | Hydraulic conductivity by flowpath | K_Flowpath | Hydraulic conductivity of the surficial and bedrock material |
| 17* | K_Epbed | Hydraulic conductivity by flowpath | K_Flowpath | Hydraulic conductivity of the surficial and bedrock material |
| 18* | K_OSLA | Hydraulic conductivity by flowpath | K_Flowpath | Hydraulic conductivity of the surficial and bedrock material |
| 19* | K_OSP | Hydraulic conductivity by flowpath | K_Flowpath | Hydraulic conductivity of the surficial and bedrock material |
| 20* | K_WPbed4 | Hydraulic conductivity by flowpath | K_Flowpath | Hydraulic conductivity of the surficial and bedrock material |
| 21* | K_WPbed4a | Hydraulic conductivity by flowpath | K_Flowpath | Hydraulic conductivity of the surficial and bedrock material |
| 22* | K_Wpsurf | Hydraulic conductivity by flowpath | K_Flowpath | Hydraulic conductivity of the surficial and bedrock material |
| 23* | K_WWTF | Hydraulic conductivity by flowpath | K_Flowpath | Hydraulic conductivity of the surficial and bedrock material |
| 24 | Kd_Sb | Sorption coefficients for the surficial aquifer | Kd_Surficial | Sorption coefficients for the surficial aquifer (Sb) |
| 25 | Cat1_Cap_Percent | Percentile for generating concentration caps from AMAX data | - | Lookup Table by Constituent. Reference Table 1-30 |
| 26 | Cat1_Cap_Sb | Concentration cap range from NorthMet lab data | Sb | Category 1 Concentration Cap Distributions |
| 27 | Cat1_pH | Assumed distribution of porewater pH in the Category 1 stockpile | Cat1_pH | Assumed distribution of porewater pH in the Category 1 stockpile |
| 28 | Cat1_Ratio_Cu_S | Release rates and ratios by constituent | Cat1_Release | Vector by Constituent. Reference Table 1-24 |
| 29 | Cat_1_Release_As | Release rate independent of sulfur content, updated analysis of non-detections | Cat1_Release | Vector by Constituent. Reference Table 1-24 |
| 30 | Cat_1_Release_Ca | Release rate independent of sulfur content | Cat1_Release | Vector by Constituent. Reference Table 1-24 |
| 31 | Cat_1_Release_K | Release rate independent of sulfur content | Cat1_Release | Vector by Constituent. Reference Table 1-24 |
| 32 | Cat_1_Release_Mg | Release rate independent of sulfur content | Cat1_Release | Vector by Constituent. Reference Table 1-24 |
| 33 | Cat_1_Release_Na | Release rate independent of sulfur content | Cat1_Release | Vector by Constituent. Reference Table 1-24 |
| 34 | Cat_1_Release_Pb | Release rate independent of sulfur content, updated analysis of non-detections | Cat1_Release | Vector by Constituent. Reference Table 1-24 |
| 35 | Cat_1_Release_Sb | Release rates and ratios by constituent | Cat1_Release | Vector by Constituent. Reference Table 1-24 |
| 36 | Cat1_Ratio_Co_Ni | Release rates and ratios by constituent | Cat1_Release | Vector by Constituent. Reference Table 1-24 |
| 37 | Cat1_Ratio_Ni_Mg | Release rates and ratios by constituent | Cat1_Release | Vector by Constituent. Reference Table 1-24 |
| 38 | Cat1_Ratio_Ni_S | Release rates and ratios by constituent | Cat1_Release | Vector by Constituent. Reference Table 1-24 |
| 39 | Cat1_Ratio_Se_SO4 | Release ratio to be multiplied by simulated sulfate release, updated analysis of non-detects | Cat1_Release | Vector by Constituent. Reference Table 1-24 |
| 40 | ALL Elements in Cat234_acid_Caps_Random | Concentration caps from Whistle Mine data, Concentration caps from AMAX pile and Vangorda Mine data | Cat234_acid_ConcCaps | Vector by Constituent. Reference Table 1-32 |
| 41 | Cat23_Ratio_As_S | Metal-to-sulfur aqua regia ratios | Cat23_Release | Vector by Constituent. Reference Table 1-25 |
| 42 | Cat23_Ratio_Cu_S | Metal-to-sulfur aqua regia ratios | Cat23_Release | Vector by Constituent. Reference Table 1-25 |
| 43 | Cat23_Ratio_Pb_S | Metal-to-sulfur aqua regia ratios | Cat23_Release | Vector by Constituent. Reference Table 1-25 |
| 44 | Cat23_Ratio_Sb_S | Metal-to-sulfur aqua regia ratios | Cat23_Release | Vector by Constituent. Reference Table 1-25 |
| 45 | Cat23_Release_Alk_nonacid | Release rate independent of sulfur content | Cat23_Release | Vector by Constituent. Reference Table 1-25 |
| 46 | Cat23_Ratio_Ca_SO4 | Release ratio to be multiplied by simulated sulfate release | Cat23_Release | Vector by Constituent. Reference Table 1-25 |
| 47 | Cat23_Ratio_Co_Ni | Release rates and ratios by constituent | Cat23_Release | Vector by Constituent. Reference Table 1-25 |
| 48 | Cat23_Ratio_K_SO4 | Release ratio to be multiplied by simulated sulfate release | Cat23_Release | Vector by Constituent. Reference Table 1-25 |
| 49 | Cat23_Ratio_Mg_SO4 | Release ratio to be multiplied by simulated sulfate release | Cat23_Release | Vector by Constituent. Reference Table 1-25 |
| 50 | Cat23_Ratio_Na_SO4 | Release ratio to be multiplied by simulated sulfate release | Cat23_Release | Vector by Constituent. Reference Table 1-25 |
| 51 | Cat23_Ratio_Ni_Mg | Release rates and ratios by constituent | Cat23_Release | Vector by Constituent. Reference Table 1-25 |
| 52 | Cat23_Ratio_Ni_S | Release rates and ratios by constituent | Cat23_Release | Vector by Constituent. Reference Table 1-25 |
| 53 | Cat23_Ratio_Se_SO4 | Release ratio to be multiplied by simulated sulfate release | Cat23_Release | Vector by Constituent. Reference Table 1-25 |
| 54 | Cat4DC_Ratio_As_S | Release rates and ratios by constituent | Cat4DC_Release | Vector by Constituent. Reference Table 1-26 |
| 55 | Cat4DC_Ratio_Cu_S | Release rates and ratios by constituent | Cat4DC_Release | Vector by Constituent. Reference Table 1-26 |
| 56 | Cat4DC_Ratio_Pb_S | Release rates and ratios by constituent | Cat4DC_Release | Vector by Constituent. Reference Table 1-26 |
| 57 | Cat4DC_Ratio_Sb_S | Release rates and ratios by constituent | Cat4DC_Release | Vector by Constituent. Reference Table 1-26 |
| 58 | Cat4DC_Ratio_Ca_SO4 | Release rates and ratios by constituent | Cat4DC_Release | Vector by Constituent. Reference Table 1-26 |
| 59 | Cat4DC_Ratio_Co_Ni | Release rates and ratios by constituent | Cat4DC_Release | Vector by Constituent. Reference Table 1-26 |
| 60 | Cat4DC_Ratio_K_SO4 | Release ratio to be multiplied by simulated sulfate release | Cat4DC_Release | Vector by Constituent. Reference Table 1-26 |
| 61 | Cat4DC_Ratio_Mg_SO4 | Release ratio to be multiplied by simulated sulfate release | Cat4DC_Release | Vector by Constituent. Reference Table 1-26 |
| 62 | Cat4DC_Ratio_Na_SO4 | Release ratio to be multiplied by simulated sulfate release | Cat4DC_Release | Vector by Constituent. Reference Table 1-26 |
| 63 | Cat4DC_Ratio_Mn_SO4 | Release ratio to be multiplied by simulated sulfate release | Cat4DC_Release | Vector by Constituent. Reference Table 1-26 |
| 64 | Cat4DC_Ratio_Ni_Mg | Release rates and ratios by constituent | Cat4DC_Release | Vector by Constituent. Reference Table 1-26 |
| 65 | Cat4DC_Ratio_Ni_S | Release rates and ratios by constituent | Cat4DC_Release | Vector by Constituent. Reference Table 1-26 |
| 66 | Cat4DC_Ratio_Se_SO4 | Release ratio to be multiplied by simulated sulfate release | Cat4DC_Release | Vector by Constituent. Reference Table 1-26 |

* Items not included in the December 17th , 2012 Workplan memo

Large Table 1: Input Variables for the Mine Site Sensitivity Analysis (Including Descriptions)

| # | Run Name | GoldSim Description | Variable Match in Workplan | Description of Input Variable from Workplan |
|---|---|---|---|---|
| 67 | Cat4DC_Release_SO4 | Duluth Complex Catetory 4 non-acidic release rate (does not vary with sulfur content) | Cat4DC_Release | Vector by Constituent. Reference Table 1-26 |
| 68 | ALL elements in Cat4VF_acid_caps_Random | Solubility limits by constituent | Cat4VF_COncCAps | Vector by Constituent. Refernece Table 1-33 |
| 69 | Cat4VF_Ratio_As_S | Release rates and ratios by constituent | Cat4VF_Release | Vector by Constituent. Reference Table 1-28 |
| 70 | Cat4VF_Ratio_Co_S | Release rates and ratios by constituent | Cat4VF_Release | Vector by Constituent. Reference Table 1-28 |
| 71 | Cat4VF_Ratio_Cu_S | Release rates and ratios by constituent | Cat4VF_Release | Vector by Constituent. Reference Table 1-28 |
| 72 | Cat4VF_Ratio_Ni_S | Release rates and ratios by constituent | Cat4VF_Release | Vector by Constituent. Reference Table 1-28 |
| 73 | Cat4VF_Ratio_Pb_S | Release rates and ratios by constituent | Cat4VF_Release | Vector by Constituent. Reference Table 1-28 |
| 74 | Cat4VF_Ratio_Sb_S | Release rates and ratios by constituent | Cat4VF_Release | Vector by Constituent. Reference Table 1-28 |
| 75 | Cat4VF_Ratio_SE_SO4 | Release ratio to be multiplied by simulated sulfate release | Cat4VF_Release | Vector by Constituent. Reference Table 1-28 |
| 76 | Cat4VF_Release_SO4 | Virginia Formation Catetory 4 acidic release rate (does not vary with sulfur content) | Cat4VF_Release | Vector by Constituent. Reference Table 1-28 |
| 77 | Ore_Ratio_As_S | Release rates and ratios by constituent | Ore_Release | Vector by Constituent. Reference Table 1-27 |
| 78 | Ore_Ratio_Cu_S | Release rates and ratios by constituent | Ore_Release | Vector by Constituent. Reference Table 1-27 |
| 79 | Ore_ratio_Pb_S | Release rates and ratios by constituent | Ore_Release | Vector by Constituent. Reference Table 1-27 |
| 80 | Ore_Ratio_Sb_S | Release rates and ratios by constituent | Ore_Release | Vector by Constituent. Reference Table 1-27 |
| 81 | Ore_Ratio_Ca_SO4 | Release rates and ratios by constituent | Ore_Release | Vector by Constituent. Reference Table 1-27 |
| 82 | Ore_Ratio_Co_NI | Release rates and ratios by constituent | Ore_Release | Vector by Constituent. Reference Table 1-27 |
| 83 | Ore_Ratio_K_SO4 | Release ratio to be multiplied by simulated sulfate release | Ore_Release | Vector by Constituent. Reference Table 1-27 |
| 84 | Ore_Ratio_Mg_SO4 | Release ratio to be multiplied by simulated sulfate release | Ore_Release | Vector by Constituent. Reference Table 1-27 |
| 85 | Ore_Ratio_Na_SO4 | Release ratio to be multiplied by simulated sulfate release | Ore_Release | Vector by Constituent. Reference Table 1-27 |
| 86 | Ore_Ratio_Ni_Mg | Release rates and ratios by constituent | Ore_Release | Vector by Constituent. Reference Table 1-27 |
| 87 | Ore_Ratio_Ni_S | Release rates and ratios by constituent | Ore_Release | Vector by Constituent. Reference Table 1-27 |
| 88 | Ore_Ratio_Se_SO4 | Release ratio to be multiplied by simulated sulfate release | Ore_Release | Vector by Constituent. Reference Table 1-27 |
| 89 | ALL elements in OB_Peat_Random | Overburden seepage concentrations by constituent | OB_Concs_Peat | Vector by Constituent. Reference Table 1-23 |
| 90 | ALL elements in OB_Unsat_Random | Overburden seepage concentrations by constituent | OB_Concs_Unsat | Vector by Constituent. Reference Table 1-23 |
| 91 | Decay_a0 | Parameter to define shape of decay of sulfate release in wall rock | Decay_a0 | Parameter to define shape of decay of sulfate release in wall rock (correlation to a1 = -0.989) |
| 92 | Decay_a1 | Parameter to define shape of decay of sulfate release in wall rock | Decay_a1 | Parameter to define shape of decay of sulfate release in wall rock (correlated to acid factor and a0) |
| 93 | Size_Factor_walls | Scaling factor to adjust to field scale wall rock | Size_factor_walls | Scaling factor to adjust to field scale wall rock |
| 94 | Acid_Factor_DC | Increase in sulfate release when Duluth Complex rock goes acidic | Acid_Factor_DC | Increase in sulfate release when Duluth Complex rock goes acidic (correlation to a1 = -0.831) |
| 95 | Acid_Onset_Time_23 | Time for Category 2/3 rock to go acidic in the laboratory | Acid_Onset_Time_23 | Time for Category 2/3 rock to go acidic in the laboratory |
| 96 | Acid_Onset_Time_4DC | Time for Duluth Complex Category 4 rock to go acidic in the laboratory | Acid_Onset_Time_4DC | Time for Duluth Complex Category 4 rock to go acidic in the laboratory |
| 97 | Activation_Energy | Activation energy of pyrrhotite for the Arrhenius equation | Activation_Energy | Activation energy of pyrrhotite for the Arrhenius equation |
| 98 | Contact_Factor | Fraction of waste rock contacted by water | Contact_Factor | Fraction of waste rock contacted by water |
| 99 | Field_Temp | Annual stockpile or wall internal temperature, same as air temperature | Field_Temp | Stockpile or wall internal temperature, same as air temperature |
| 100 | Field_Temp_Mean | Average annual temperature, used for acid onset timing | Field_Temp_Mean | Average annual temperature, used for acid onset timing |
| 101 | Scale_Factor_CDF011 | Bulk scale factor from Dunka data, revised | Scale_Factor_MDNR | Scaling factor for Category 1 stockpile |
| 102 | Size_Factor | Scaling factor to adjust to field scale waste rock | Size_Factor | Scaling factor to adjust to field scale waste rock |
| 103 | All_Release_Cl | Release from newly-exposed waste rock (one-time) | Multiple Places | Release Rate for Cl. Reference Tables 1-24, 1-25, 1-26, and 1-27 |
| 104 | SO4_S_Regression | Sulfate release as a function of sulfur content (%S) | Multiple Places | Sulfate Release as a function of S. Reference Tables 1-24, 1-25, and 1-27 |
| 105 | Wall_Depth_DC | Average depth of oxidizing Duluth Complex wall rock | Wall_Depth_DC | Average depth of oxidizing Duluth Complex wall rock |
| 106 | Wall_Depth_VF | Average depth of oxidizing Virginia Formation wall rock | Wall_Depth_VF | Average depth of oxidizing Virginia Formation wall rock |
| 107 | Natural_RO_Summer | Runoff (open water period) from non-stockpile areas as a fraction of precipitation | Natural_RO_Summer | Runoff (open water period) from non-stockpile areas as a fraction of precipitation |
| 108 | Natural_RO_Winter | Runoff (frozen period) from non-stockpile areas as a fraction of precipitation | Natural_RO_Winter | Runoff (frozen period) from non-stockpile areas as a fraction of precipitation |
| 109 | Pit_GW_Uncertainty_Unshift | Uncertainty multiplier for the groundwater flow into the pits | Pit_GW_Uncertainty_unshift | Uncertainty multiplier for the groundwater flow into the pits (un-shifted) |
| 110 | TB_toWP_Conc_Rand | Randomly-generated monthly concentrations | TB_toWP_Conc | Water quality returned from the Plant Site to the West Pit in closure |
| 111 | TB_toWP_Flow_Rand | Randomly-generated monthly flow | TB_toWP_Flow_Rand | Flow returned from the Plant Site to the West Pit in closure (autocorrelation = 0.9) |
| 112 | Wall_RO | Runoff from bare pit walls as a fraction of precipitation | Wall_RO | Runoff from bare pit walls as a fraction of precipitation |
| 113 | Bare_ET | ET from bare waste rock as a fraction of precipitation | Bare_ET | ET from bare waste rock as a fraction of precipitation |
| 114 | Cat1SP_Geomem_Perc | Percolation through membrane-covered stockpile as a fraction of precipitation | Cat1SP_Geomem_Perc | Percolation through membrane-covered stockpile as a fraction of precipitation |
| 115 | Liner_Leak_23 | Fraction of water from the top of the liner that leaks (Cat 2/3 stockpile) | Liner_Leak_23 | Fraction of water from the top of the liner that leaks (Cat 2/3 stockpile) |
| 116 | Liner_Leak_4_OSP | Fraction of water from the top of the liner that leaks (Cat 4 stockpile & OSP) | Liner_Leak_4_OSP | Fraction of water from the top of the liner that leaks (Cat 4 and OSP) |
| 117 | Reclaim_ET | ET from reclaimed waste rock as a fraction of precipitation | Reclaim_ET | ET from reclaimed waste rock as a fraction of precipitation |
| 118 | Reclaim_RO | Runoff from reclaimed waste rock as a fraction of precipitation | Reclaim_RO | Runoff from reclaimed waste rock as a fraction of precipitation |
| 119* | Streamflow_SW006_Apr | Randomly sampled daily streamflow at SW-006 | Streamflow_SW006_(Month) | Randomly sampled daily streamflow at SW006 for each month |
| 120* | Streamflow_SW006_Aug | Randomly sampled daily streamflow at SW-006 | Streamflow_SW006_(Month) | Randomly sampled daily streamflow at SW006 for each month |
| 121* | Streamflow_SW006_Dec | Randomly sampled daily streamflow at SW-006 | Streamflow_SW006_(Month) | Randomly sampled daily streamflow at SW006 for each month |
| 122* | Streamflow_SW006_Feb | Randomly sampled daily streamflow at SW-006 | Streamflow_SW006_(Month) | Randomly sampled daily streamflow at SW006 for each month |

* Items not included in the December 17th , 2012 Workplan memo

**Large Table 1: Input Variables for the Mine Site Sensitivity Analysis (Including Descriptions)**

| # | Run Name | GoldSim Description | Variable Match in Workplan | Description of Input Variable from Workplan |
|---|---|---|---|---|
| 123* | Streamflow_SW006_Jan | Randomly sampled daily streamflow at SW-006 | Streamflow_SW006_(Month) | Randomly sampled daily streamflow at SW006 for each month |
| 124* | Streamflow_SW006_Jul | Randomly sampled daily streamflow at SW-006 | Streamflow_SW006_(Month) | Randomly sampled daily streamflow at SW006 for each month |
| 125* | Streamflow_SW006_Jun | Randomly sampled daily streamflow at SW-006 | Streamflow_SW006_(Month) | Randomly sampled daily streamflow at SW006 for each month |
| 126* | Streamflow_SW006_Mar | Randomly sampled daily streamflow at SW-006 | Streamflow_SW006_(Month) | Randomly sampled daily streamflow at SW006 for each month |
| 127* | Streamflow_SW006_May | Randomly sampled daily streamflow at SW-006 | Streamflow_SW006_(Month) | Randomly sampled daily streamflow at SW006 for each month |
| 128* | Streamflow_SW006_Nov | Randomly sampled daily streamflow at SW-006 | Streamflow_SW006_(Month) | Randomly sampled daily streamflow at SW006 for each month |
| 129* | Streamflow_SW006_Oct | Randomly sampled daily streamflow at SW-006 | Streamflow_SW006_(Month) | Randomly sampled daily streamflow at SW006 for each month |
| 130* | Streamflow_SW006_Sep | Randomly sampled daily streamflow at SW-006 | Streamflow_SW006_(Month) | Randomly sampled daily streamflow at SW006 for each month |
| 131* | Concentrate_toWWTF_Conc_rand | Randomly-generated monthly concentrations | Concentrate_toWWTF_Conc | Vector by Constituent. Reference Table 1-39 & 1-40 |
| 132* | Concentrate_toWWTF_Flow_Rand | Randomly-generated monthly flow | Concentrate_toWWTF_Flow | Vector by Constituent. Reference Table 1-38 |
| 133* | Flow_PMP | Flow from Peter Mitchell Pit dewatering to SW-001 | Flow_PMP | Flow from Peter Mitchell Pit dewatering to SW-001 |
| 134* | GW_Inc_Baseflow | Baseflow adding to evaluation points via natural groundwater | GW_Inc_Baseflow | Imported from worksheet. Reference Table 1-21 |

* Items not included in the December 17th , 2012 Workplan memo

**Large Table 2: Baseline Values and Largest Percent Change from Screening-Level Analysis**

| Location | Constituent | Largest % Increase | Input Variable Causing Change | Baseline Value (mg/L) | Concentration Represented by Change (mg/L) | Standard (mg/L) |
|---|---|---|---|---|---|---|
| SW-004 | As | 45% | Flow_PMP | 4.36E-03 | 6.31E-03 | 5.30E-02 |
| | Cl | 338% | SW_RO_Random | 9.77E+00 | 4.28E+01 | 2.30E+02 |
| | Co | 86% | K_EP23_Srf | 9.14E-04 | 1.70E-03 | 5.00E-03 |
| | Cu[1] | 191% | SW_RO_Random | 2.05E-03 | 5.98E-03 | 8.59E+00 |
| | Ni[1] | 337% | SW_RO_Random | 1.66E-03 | 7.27E-03 | 4.81E+01 |
| | Pb[1] | 31% | GW_Inc_Baseflow | 4.87E-04 | 6.38E-04 | 2.81E+00 |
| | Sb | 2% | SW_RO_Random | 1.62E-03 | 1.66E-03 | 3.10E-02 |
| | Se | 214% | SW_RO_Random | 5.20E-04 | 1.63E-03 | 5.00E-03 |
| | SO4 | 316% | SW_RO_Random | 1.78E+01 | 7.39E+01 | -- |
| SW-004a | As | 33% | Flow_PMP | 4.67E-03 | 6.18E-03 | 5.30E-02 |
| | Cl | 191% | SW_RO_Random | 1.50E+01 | 4.38E+01 | 2.30E+02 |
| | Co | 24% | Annual_Precip_Cuberoot | 1.96E-03 | 2.42E-03 | 5.00E-03 |
| | Cu[2] | 73% | Annual_Precip_Cuberoot | 3.89E-03 | 6.73E-03 | 9.49E+00 |
| | Ni[2] | 54% | Annual_Precip_Cuberoot | 1.30E-02 | 2.01E-02 | 5.30E+01 |
| | Pb[2] | 29% | Annual_Precip_Cuberoot | 1.19E-03 | 1.53E-03 | 3.26E+00 |
| | Sb | 54% | Acid_Factor_DC | 3.25E-03 | 5.01E-03 | 3.10E-02 |
| | Se | 50% | SW_RO_Random | 1.11E-03 | 1.67E-03 | 5.00E-03 |
| | SO4 | 373% | SW_RO_Random | 1.59E+01 | 7.51E+01 | -- |
| SW-004b | As | 72% | Flow_PMP | 3.37E-03 | 5.80E-03 | 5.30E-02 |
| | Cl | 339% | SW_RO_Random | 1.00E+01 | 4.39E+01 | 2.30E+02 |
| | Co | 26% | Annual_Precip_Cuberoot | 1.55E-03 | 1.95E-03 | 5.00E-03 |
| | Cu[3] | 84% | SW_RO_Random | 3.32E-03 | 6.13E-03 | 9.33E-03 |
| | Ni[3] | 62% | Annual_Precip_Cuberoot | 9.40E-03 | 1.52E-02 | 5.22E-02 |
| | Pb[3] | 28% | Annual_Precip_Cuberoot | 9.98E-04 | 1.28E-03 | 3.18E-03 |
| | Sb | 58% | Acid_Factor_DC | 2.45E-03 | 3.87E-03 | 3.10E-02 |
| | Se | 88% | SW_RO_Random | 8.88E-04 | 1.67E-03 | 5.00E-03 |
| | SO4 | 520% | SW_RO_Random | 1.21E+01 | 7.53E+01 | -- |
| SW-005 | As | 124% | Flow_PMP | 2.26E-03 | 5.07E-03 | 5.30E-02 |
| | Cl | 339% | SW_RO_Random | 1.00E+01 | 4.40E+01 | 2.30E+02 |
| | Co | 23% | Annual_Precip_Cuberoot | 1.17E-03 | 1.44E-03 | 5.00E-03 |
| | Cu[3] | 120% | SW_RO_Random | 2.78E-03 | 6.13E-03 | 9.33E-03 |
| | Ni[3] | 61% | Annual_Precip_Cuberoot | 6.09E-03 | 9.83E-03 | 5.22E-02 |
| | Pb[3] | 0% | Annual_Precip_Cuberoot | 1.27E-03 | 1.27E-03 | 3.18E-03 |
| | Sb | 50% | Acid_Factor_DC | 1.82E-03 | 2.72E-03 | 3.10E-02 |
| | Se | 48% | SW_RO_Random | 1.13E-03 | 1.67E-03 | 5.00E-03 |
| | SO4 | 620% | SW_RO_Random | 1.05E+01 | 7.55E+01 | 1.00E+01 |
| Colby Lake | As | 221% | Flow_PMP | 8.19E-04 | 2.63E-03 | 2.00E-03 |
| | Cl | 338% | SW_RO_Random | 9.79E+00 | 4.29E+01 | 2.30E+02 |
| | Co | 59% | SW_RO_Random | 5.48E-04 | 8.74E-04 | 2.80E-03 |
| | Cu[3] | 124% | SW_RO_Random | 2.70E-03 | 6.05E-03 | 9.33E-03 |
| | Ni[3] | 226% | SW_RO_Random | 2.34E-03 | 7.63E-03 | 5.22E-02 |
| | Pb[3] | 48% | GW_Inc_Baseflow | 3.63E-04 | 5.35E-04 | 3.18E-03 |
| | Sb | 11% | Acid_factor_DC | 1.65E-03 | 1.83E-03 | 5.50E-03 |
| | Se | 212% | SW_RO_Random | 5.28E-04 | 1.65E-03 | 5.00E-03 |
| | SO4 | 116% | SW_RO_Random | 3.41E+01 | 7.38E+01 | 2.50E+02 |

[1] Standard is hardness-based and evaluated at 90.8 mg/L hardness

[2] Standard is hardness-based and evaluated at 102 mg/L hardness

[3] Standard is hardness-based and varies, value shown for 100 mg/L hardness

**Pink-shaded cells indicate a value that exceeds the relevant water quality standard**

Large Table 3: Input Variables for the Mine Site Detailed Sensitivity Analysis

| # | Run Name | GoldSim Description | Description of Input Variable from Workplan |
|---|---|---|---|
| 1 | Acid_Factor_DC | Increase in sulfate release when Duluth Complex rock goes acidic | Increase in sulfate release when Duluth Complex rock goes acidic (correlation to a1 = -0.831) |
| 2 | Annual_Evap | Annual open-water evaporation | Annual open-water evaporation |
| 3 | Annual_Precip_Cuberoot | Cube root of the annual precipitation | Cube root of the annual precipitation |
| 4 | Cat_1_Release_Sb | Release rates and ratios by constituent | Vector by Constituent. Reference Table 1-24 |
| 5 | Cat1_Ratio_Se_SO4 | Release ratio to be multiplied by simulated sulfate release, updated analysis of non-detects | Vector by Constituent. Reference Table 1-24 |
| 6 | Cat1SP_Geomem_Perc | Percolation through membrane-covered stockpile as a fraction of precipitation | Percolation through membrane-covered stockpile as a fraction of precipitation |
| 7 | Cat23_Ratio_Co_Ni | Release rates and ratios by constituent | Vector by Constituent. Reference Table 1-25 |
| 8 | Cat23_Ratio_Se_SO4 | Release ratio to be multiplied by simulated sulfate release | Vector by Constituent. Reference Table 1-25 |
| 9 | Contact_Factor | Fraction of waste rock contacted by water | Fraction of waste rock contacted by water |
| 10 | Decay_a0 | Parameter to define shape of decay of sulfate release in wall rock | Parameter to define shape of decay of sulfate release in wall rock (correlation to a1 = -0.989) |
| 11 | Decay_a1 | Parameter to define shape of decay of sulfate release in wall rock | Parameter to define shape of decay of sulfate release in wall rock (correlated to acid factor and a0) |
| 12 | Flow_PMP | Flow from Peter Mitchell Pit dewatering to SW-001 | Flow from Peter Mitchell Pit dewatering to SW-001 |
| 13 | GW_Inc_Baseflow | Baseflow adding to evaluation points via natural groundwater | Imported from worksheet. Reference Table 1-21 |
| 14 | GW_Surf_Random* | Surficial aquifer mean water quality uncertainty (ln ug/L); by constituent | Surficial groundwater concentrations in the Partridge River watershed |
| 15 | I_Close_EP23surf | Hydraulic gradient by flowpath | Varies by Flowpath. Reference Table 1-15 |
| 16 | I_ops_EP23surf | Hydraulic gradient by flowpath | Varies by Flowpath. Reference Table 1-20 |
| 17 | K_EP23surf | Hydraulic conductivity by flowpath | Hydraulic conductivity of the surficial and bedrock material |
| 18 | Liner_Leak_23 | Fraction of water from the top of the liner that leaks (Cat 2/3 stockpile) | Fraction of water from the top of the liner that leaks (Cat 2/3 stockpile) |
| 19 | Natural_RO_Summer | Runoff (open water period) from non-stockpile areas as a fraction of precipitation | Runoff (open water period) from non-stockpile areas as a fraction of precipitation |
| 20 | Pit_GW_Uncertainty_Unshift | Uncertainty multiplier for the groundwater flow into the pits | Uncertainty multiplier for the groundwater flow into the pits (un-shifted) |
| 21 | Size_Factor | Scaling factor to adjust to field scale waste rock | Scaling factor to adjust to field scale waste rock |
| 22 | Streamflow_SW006_Apr | Randomly sampled daily streamflow at SW-006 | Randomly sampled daily streamflow at SW-006 for each month |
| 23 | Streamflow_SW006_Aug | Randomly sampled daily streamflow at SW-006 | Randomly sampled daily streamflow at SW-006 for each month |
| 24 | Streamflow_SW006_Feb | Randomly sampled daily streamflow at SW-006 | Randomly sampled daily streamflow at SW-006 for each month |
| 25 | Streamflow_SW006_Jan | Randomly sampled daily streamflow at SW-006 | Randomly sampled daily streamflow at SW-006 for each month |
| 26 | Streamflow_SW006_Jul | Randomly sampled daily streamflow at SW-006 | Randomly sampled daily streamflow at SW-006 for each month |
| 27 | Streamflow_SW006_Mar | Randomly sampled daily streamflow at SW-006 | Randomly sampled daily streamflow at SW-006 for each month |
| 28 | Streamflow_SW006_Nov | Randomly sampled daily streamflow at SW-006 | Randomly sampled daily streamflow at SW-006 for each month |
| 29 | Streamflow_SW006_Oct | Randomly sampled daily streamflow at SW-006 | Randomly sampled daily streamflow at SW-006 for each month |
| 30 | SW_RO_Random* | Surface water runoff concentrations in the Partridge River watershed; by constituent | Calibrated surface runoff concentrations in the Partridge River watershed |
| 31 | TB_toWP_Conc_Rand* | Randomly-generated monthly concentrations; by constituent | Water quality returned from the Plant Site to the West Pit in closure |

* All applicable constituents to be included in the sensitivity analysis

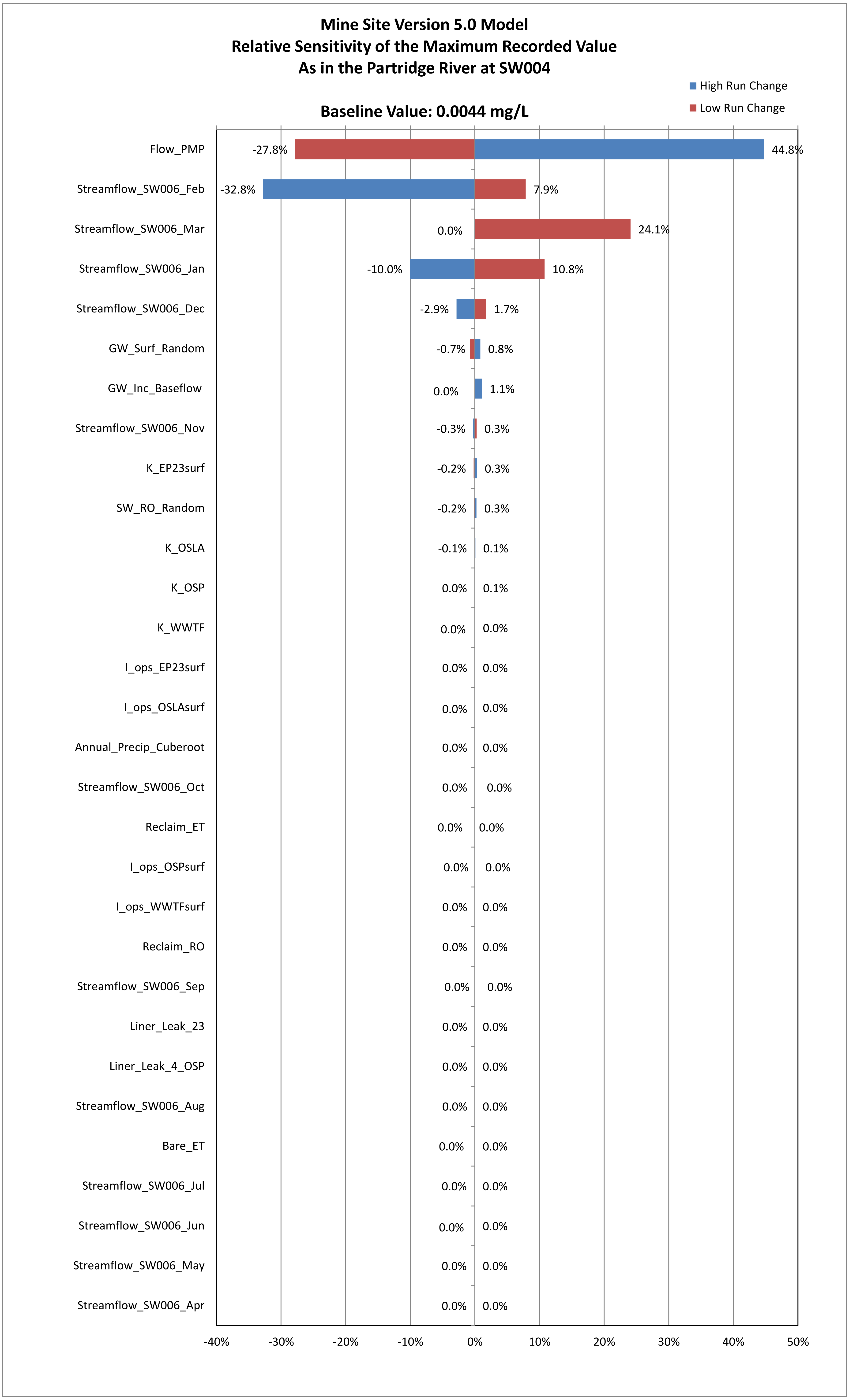
Large Table 4: Input Variables Causing a 5% or Greater Increase in Concentration

| | Location | SW004 | | | | | | | | | SW004a | | | | | | | | | SW004b | | | | | | | | | SW005 | | | | | | | | | Colby Lake | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Constituent | As | Cl | Co | Cu | Ni | Pb | Sb[4] | Se | SO4 | As | Cl[3] | Co | Cu | Ni | Pb | Sb | Se | SO4[3] | As | Cl | Co | Cu | Ni | Pb | Sb | Se | SO4 | As | Cl | Co | Cu | Ni | Pb[3] | Sb | Se[3] | SO4 | As | Cl | Co | Cu[3] | Ni | Pb | Sb | Se | SO4[3] |
| Transport rate in East Pit/Cat 2/3 flow path | Liner_Leak_23 | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | I_Close_EP23surf | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | I_ops_EP23surf | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | K_EP23surf | | | x | | | x | | x | x | | | x | | | | | | | | | x | | | | | | | | | x | | | | | | | | | x | | | | | | |
| Loading from Temp. Stockpiles & East Pit | Contact_Factor | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Size_Factor | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Cat23_Ratio_Co_Ni | | | x | | | | | | | | | x | | | | | | | | | x | | | | | | | | | x | | | | | | | | | | | | | | | |
| | Annual_Precip_Cuberoot[1] | | | x | | | | | | | x | | x | x | x | x | x | x | | x | | x | x | x | x | x | x | | x | | x | x | x | x | x | x | | x | | x | x | x | x | x | | |
| | Acid_Factor_DC[2] | | | x | | | | | x | x | x | | x | x | x | x | x | x | | x | | x | x | x | x | x | x | | x | | x | x | x | x | x | x | | x | | x | x | x | x | x | | |
| Flow from Long-term WWTF | Annual_Evap | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | x | | | | x | | | | |
| | Natural_RO_Summer | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | x | | | | |
| | Pit_GW_Uncertainty_Unshift | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | x | | | x | x | | | | |
| Concentration of West Pit and Long-term WWTF Influent | Cat_1_Release_Sb | | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | | | | | | | | | | | | | | | | | |
| | Cat1_Ratio_Se_SO4 | | | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | | | | | | x | | | | | | | | | | |
| | Cat23_Ratio_Se_SO4 | | | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | | | | | | x | | | | | | | | | | |
| | Decay_a0 | | | | | | | | | | | | x | | | | x | x | | | | x | | | | x | x | | | | x | | | | x | x | | | | | | | | | | |
| | Decay_a1 | | | | | | | | | | | | x | | | | x | x | | | | x | | | | x | x | | | | x | | | | x | | | | | | | | | | | |
| | TB_toWP_Conc_Rand | | | | | | | | | | | | | | | | x | x | | | | | | | | x | x | | | | | | | | x | x | | | | | | | | | | |
| | Cat1SP_Geomem_Perc | | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | | | | | | x | | | | | | | x | | | | |
| Load from Background Sources | GW_Surf_Random | | | x | x | x | x | | | | | | | x | | x | | | | | | x | x | | x | | | x | | | x | x | | x | | | x | | | x | x | | x | | | |
| | SW_RO_Random | | x | | x | x | | | x | x | | x | | x | | | | x | x | | x | | x | x | | | x | x | | x | x | x | x | | | x | x | x | x | x | x | x | x | | x | x |
| | Flow_PMP | x | | x | x | x | x | | | x | x | | x | x | x | x | x | x | x | x | | x | x | x | x | x | x | x | x | | x | | x | x | | | x | x | | | x | | | | | x |
| | GW_Inc_Baseflow | | | x | x | x | x | | x | | | | | x | | x | | | x | | | x | x | | x | | x | x | | | x | x | | x | x | x | x | x | | x | x | x | x | | | x |
| River Flows | Streamflow_SW006_Jan | x | | | | | | | | x | x | | | | | | | | x | x | | x | x | x | x | x | x | x | x | | x | | x | | x | | | | | | | | | | | |
| | Streamflow_SW006_Feb | x | | | | | | | | x | x | | x | x | x | x | x | x | x | x | | x | | x | | x | x | | | | | | | | x | | | | | | | | | | | |
| | Streamflow_SW006_Mar | x | | x | | | | | x | x | x | | x | x | x | x | x | x | x | x | | x | x | x | x | x | x | x | x | | x | | x | x | x | x | | | | | | | | | | |
| | Streamflow_SW006_Apr | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | x | | x | x | x | x | | | x |
| | Streamflow_SW006_May | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Streamflow_SW006_Jun | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Streamflow_SW006_Jul | | | | | | | | | | x | | x | | x | | x | x | | | | | | | | x | | | | | | | | | x | | | | | | | | | | | |
| | Streamflow_SW006_Aug | | | | | | | | | | | | | | x | | x | | | | | | | | | x | | | | | | | | | x | | | | | | | | | | | |
| | Streamflow_SW006_Sep | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Streamflow_SW006_Oct | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | x | | | x | x | | | | |
| | Streamflow_SW006_Nov | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | x | | | x | x | | | | |
| | Streamflow_SW006_Dec | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

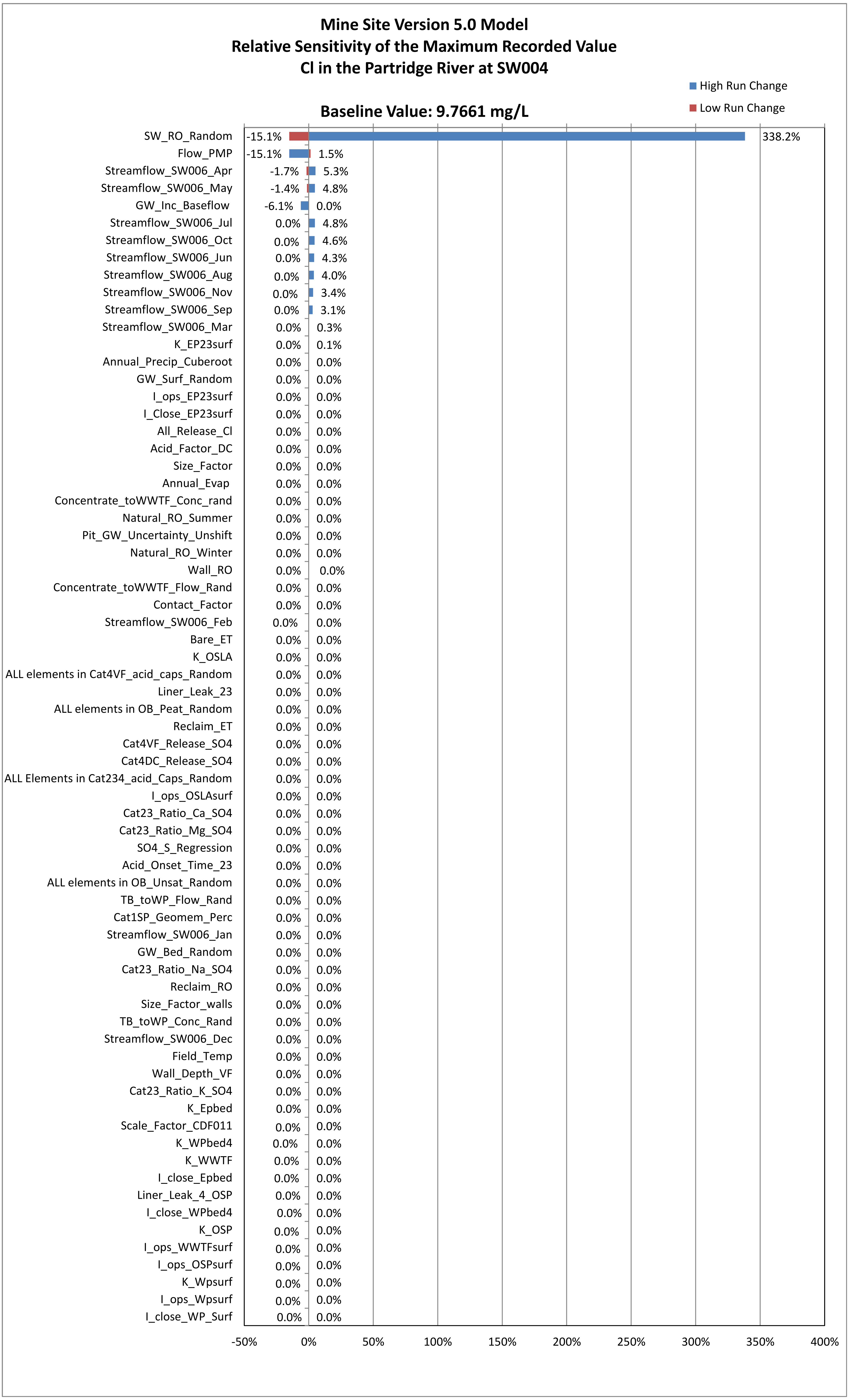
(1) Annual precipitation influences concentrations in the Partridge River via increased liner leakag from the Category 2/3 Waste Rock Stockpile and increased discharge from the long-term WWTF.
(2) The acidity scaling factor influences concentrations in the Partridge River via increased constituent release from the waste rock stockpiles and pit walls and by changing the time required to treat the East Pit porewater, which increases WWTF effluent flows.
(3) For several constituent-location combinations, the initial timestep was found to limit the reported maximum values. For these outputs, the maximum value for the detailed analysis excluded the first year of the simulation.
(4) For antimony at SW004, no inputs cause a 5% or greater increase in concentrations.

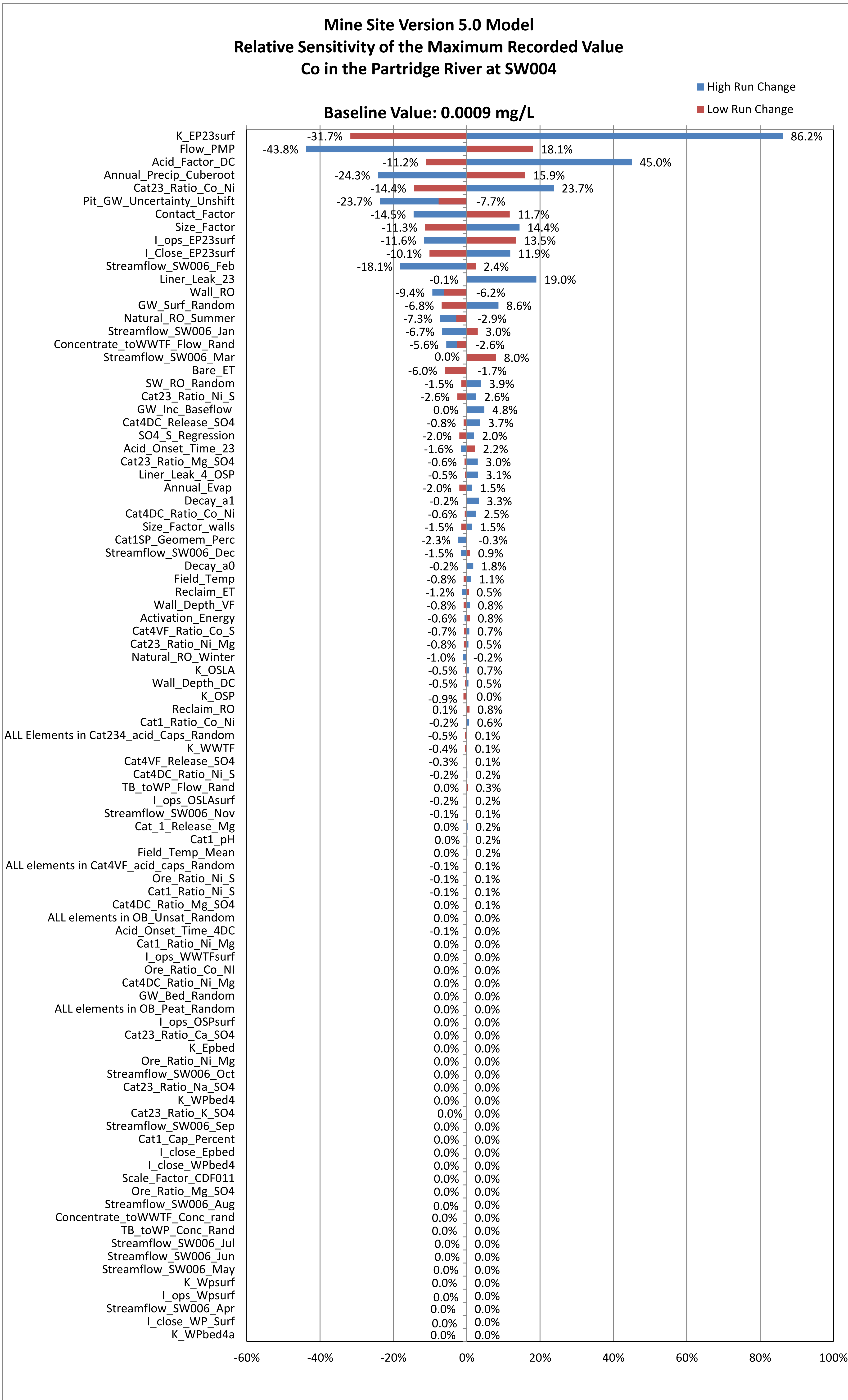
# Appendix A

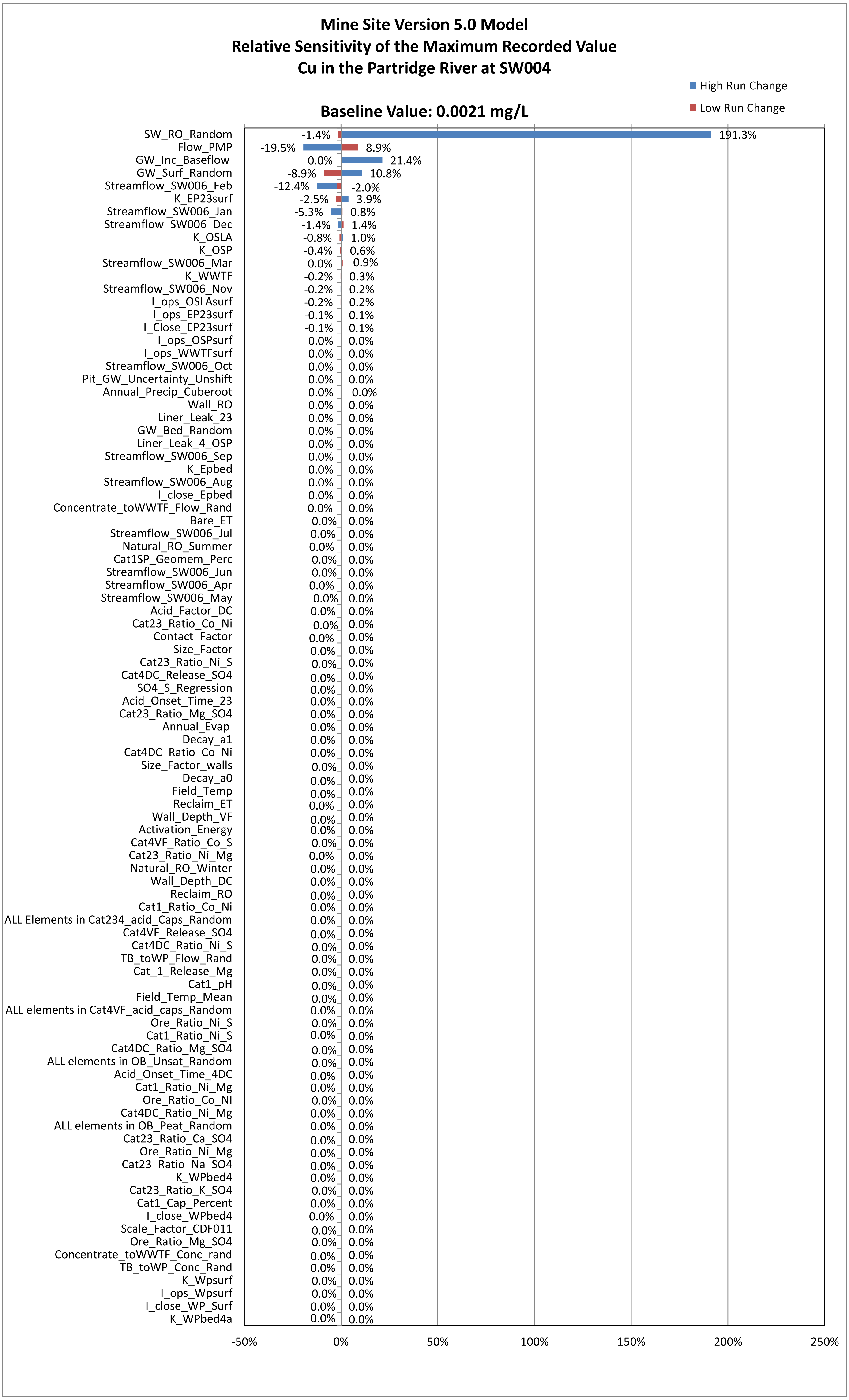
## Tornado Plots from Mine Site Screening-level Sensitivity Analysis

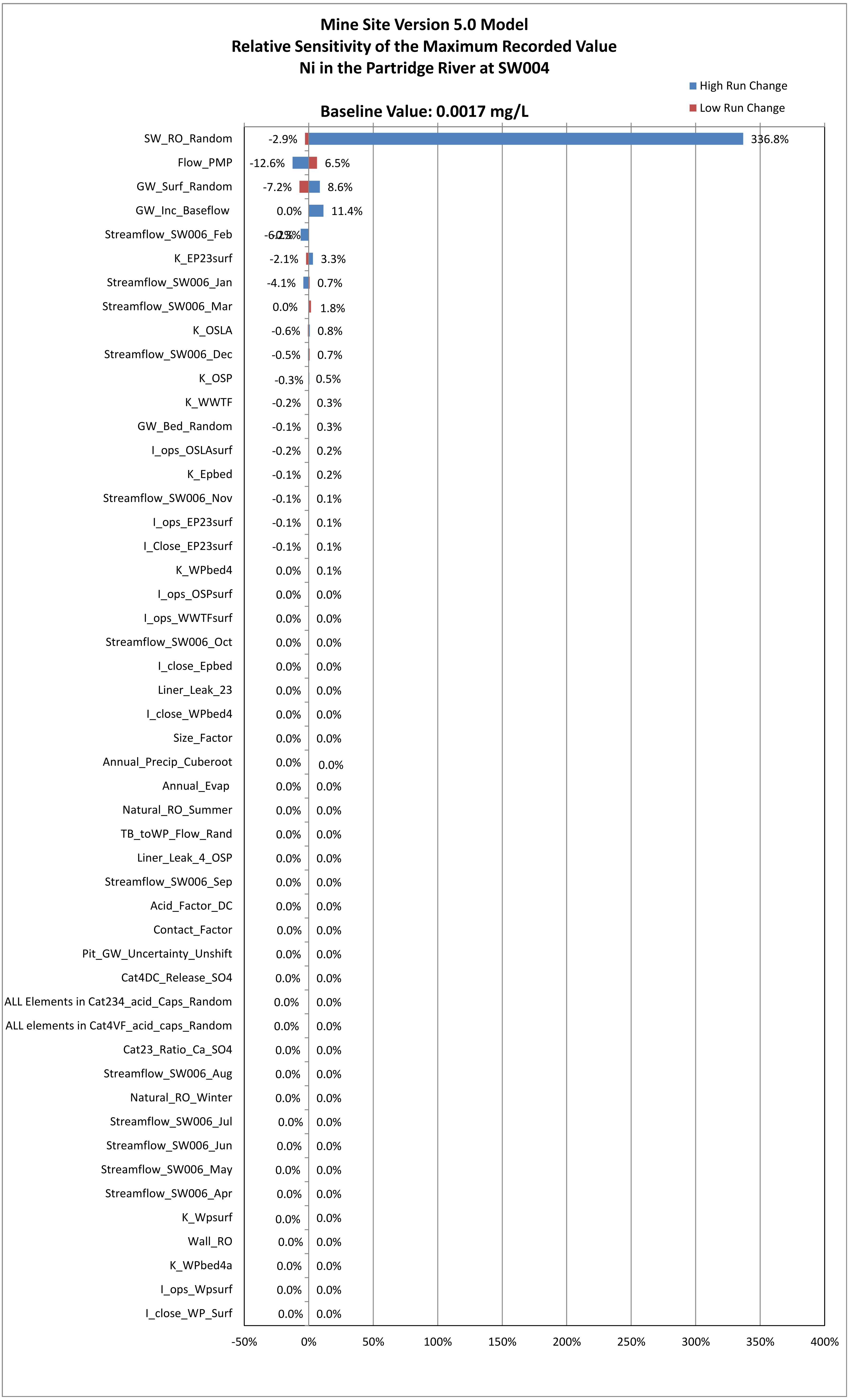


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
As in the Partridge River at SW004
Baseline Value: 0.0044 mg/L
High Run Change
Low Run Change
Flow_PMP -27.8% 44.8%
Streamflow_SW006_Feb -32.8% 7.9%
Streamflow_SW006_Mar 0.0% 24.1%
Streamflow_SW006_Jan -10.0% 10.8%
Streamflow_SW006_Dec -2.9% 1.7%
GW_Surf_Random -0.7% 0.8%
GW_Inc_Baseflow 0.0% 1.1%
Streamflow_SW006_Nov -0.3% 0.3%
K_EP23surf -0.2% 0.3%
SW_RO_Random -0.2% 0.3%
K_OSLA -0.1% 0.1%
K_OSP 0.0% 0.1%
K_WWTF 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Annual_Precip_Cuberoot 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Streamflow_SW006_Aug 0.0% 0.0%
Bare_ET 0.0% 0.0%
Streamflow_SW006_Jul 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
-40% -30% -20% -10% 0% 10% 20% 30% 40% 50%


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Cl in the Partridge River at SW004
High Run Change
Low Run Change
Baseline Value: 9.7661 mg/L
SW_RO_Random -15.1% 338.2%
Flow_PMP -15.1% 1.5%
Streamflow_SW006_Apr -1.7% 5.3%
Streamflow_SW006_May -1.4% 4.8%
GW_Inc_Baseflow -6.1% 0.0%
Streamflow_SW006_Jul 0.0% 4.8%
Streamflow_SW006_Oct 0.0% 4.6%
Streamflow_SW006_Jun 0.0% 4.3%
Streamflow_SW006_Aug 0.0% 4.0%
Streamflow_SW006_Nov 0.0% 3.4%
Streamflow_SW006_Sep 0.0% 3.1%
Streamflow_SW006_Mar 0.0% 0.3%
K_EP23surf 0.0% 0.1%
Annual_Precip_Cuberoot 0.0% 0.0%
GW_Surf_Random 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
I_Close_EP23surf 0.0% 0.0%
All_Release_Cl 0.0% 0.0%
Acid_Factor_DC 0.0% 0.0%
Size_Factor 0.0% 0.0%
Annual_Evap 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
Natural_RO_Summer 0.0% 0.0%
Pit_GW_Uncertainty_Unshift 0.0% 0.0%
Natural_RO_Winter 0.0% 0.0%
Wall_RO 0.0% 0.0%
Concentrate_toWWTF_Flow_Rand 0.0% 0.0%
Contact_Factor 0.0% 0.0%
Streamflow_SW006_Feb 0.0% 0.0%
Bare_ET 0.0% 0.0%
K_OSLA 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
ALL elements in OB_Peat_Random 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
Cat4VF_Release_SO4 0.0% 0.0%
Cat4DC_Release_SO4 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Cat23_Ratio_Mg_SO4 0.0% 0.0%
SO4_S_Regression 0.0% 0.0%
Acid_Onset_Time_23 0.0% 0.0%
ALL elements in OB_Unsat_Random 0.0% 0.0%
TB_toWP_Flow_Rand 0.0% 0.0%
Cat1SP_Geomem_Perc 0.0% 0.0%
Streamflow_SW006_Jan 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
Size_Factor_walls 0.0% 0.0%
TB_toWP_Conc_Rand 0.0% 0.0%
Streamflow_SW006_Dec 0.0% 0.0%
Field_Temp 0.0% 0.0%
Wall_Depth_VF 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
K_Epbed 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
K_WPbed4 0.0% 0.0%
K_WWTF 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
K_OSP 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
-50%
0%
50%
100%
150%
200%
250%
300%
350%
400%


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Co in the Partridge River at SW004
Baseline Value: 0.0009 mg/L
High Run Change
Low Run Change
K_EP23surf -31.7% 86.2%
Flow_PMP -43.8% 18.1%
Acid_Factor_DC -11.2% 45.0%
Annual_Precip_Cuberoot -24.3% 15.9%
Cat23_Ratio_Co_Ni -14.4% 23.7%
Pit_GW_Uncertainty_Unshift -23.7% -7.7%
Contact_Factor -14.5% 11.7%
Size_Factor -11.3% 14.4%
I_ops_EP23surf -11.6% 13.5%
I_Close_EP23surf -10.1% 11.9%
Streamflow_SW006_Feb -18.1% 2.4%
Liner_Leak_23 -0.1% 19.0%
Wall_RO -9.4% -6.2%
GW_Surf_Random -6.8% 8.6%
Natural_RO_Summer -7.3% -2.9%
Streamflow_SW006_Jan -6.7% 3.0%
Concentrate_toWWTF_Flow_Rand -5.6% -2.6%
Streamflow_SW006_Mar 0.0% 8.0%
Bare_ET -6.0% -1.7%
SW_RO_Random -1.5% 3.9%
Cat23_Ratio_Ni_S -2.6% 2.6%
GW_Inc_Baseflow 0.0% 4.8%
Cat4DC_Release_SO4 -0.8% 3.7%
SO4_S_Regression -2.0% 2.0%
Acid_Onset_Time_23 -1.6% 2.2%
Cat23_Ratio_Mg_SO4 -0.6% 3.0%
Liner_Leak_4_OSP -0.5% 3.1%
Annual_Evap -2.0% 1.5%
Decay_a1 -0.2% 3.3%
Cat4DC_Ratio_Co_Ni -0.6% 2.5%
Size_Factor_walls -1.5% 1.5%
Cat1SP_Geomem_Perc -2.3% -0.3%
Streamflow_SW006_Dec -1.5% 0.9%
Decay_a0 -0.2% 1.8%
Field_Temp -0.8% 1.1%
Reclaim_ET -1.2% 0.5%
Wall_Depth_VF -0.8% 0.8%
Activation_Energy -0.6% 0.8%
Cat4VF_Ratio_Co_S -0.7% 0.7%
Cat23_Ratio_Ni_Mg -0.8% 0.5%
Natural_RO_Winter -1.0% -0.2%
K_OSLA -0.5% 0.7%
Wall_Depth_DC -0.5% 0.5%
K_OSP -0.9% 0.0%
Reclaim_RO 0.1% 0.8%
Cat1_Ratio_Co_Ni -0.2% 0.6%
ALL Elements in Cat234_acid_Caps_Random -0.5% 0.1%
K_WWTF -0.4% 0.1%
Cat4VF_Release_SO4 -0.3% 0.1%
Cat4DC_Ratio_Ni_S -0.2% 0.2%
TB_toWP_Flow_Rand 0.0% 0.3%
I_ops_OSLAsurf -0.2% 0.2%
Streamflow_SW006_Nov -0.1% 0.1%
Cat_1_Release_Mg 0.0% 0.2%
Cat1_pH 0.0% 0.2%
Field_Temp_Mean 0.0% 0.2%
ALL elements in Cat4VF_acid_caps_Random -0.1% 0.1%
Ore_Ratio_Ni_S -0.1% 0.1%
Cat1_Ratio_Ni_S -0.1% 0.1%
Cat4DC_Ratio_Mg_SO4 0.0% 0.1%
ALL elements in OB_Unsat_Random 0.0% 0.0%
Acid_Onset_Time_4DC -0.1% 0.0%
Cat1_Ratio_Ni_Mg 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Ore_Ratio_Co_NI 0.0% 0.0%
Cat4DC_Ratio_Ni_Mg 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
ALL elements in OB_Peat_Random 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
K_Epbed 0.0% 0.0%
Ore_Ratio_Ni_Mg 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
K_WPbed4 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
Cat1_Cap_Percent 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
Ore_Ratio_Mg_SO4 0.0% 0.0%
Streamflow_SW006_Aug 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
TB_toWP_Conc_Rand 0.0% 0.0%
Streamflow_SW006_Jul 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
-60%
-40%
-20%
0%
20%
40%
60%
80%
100%

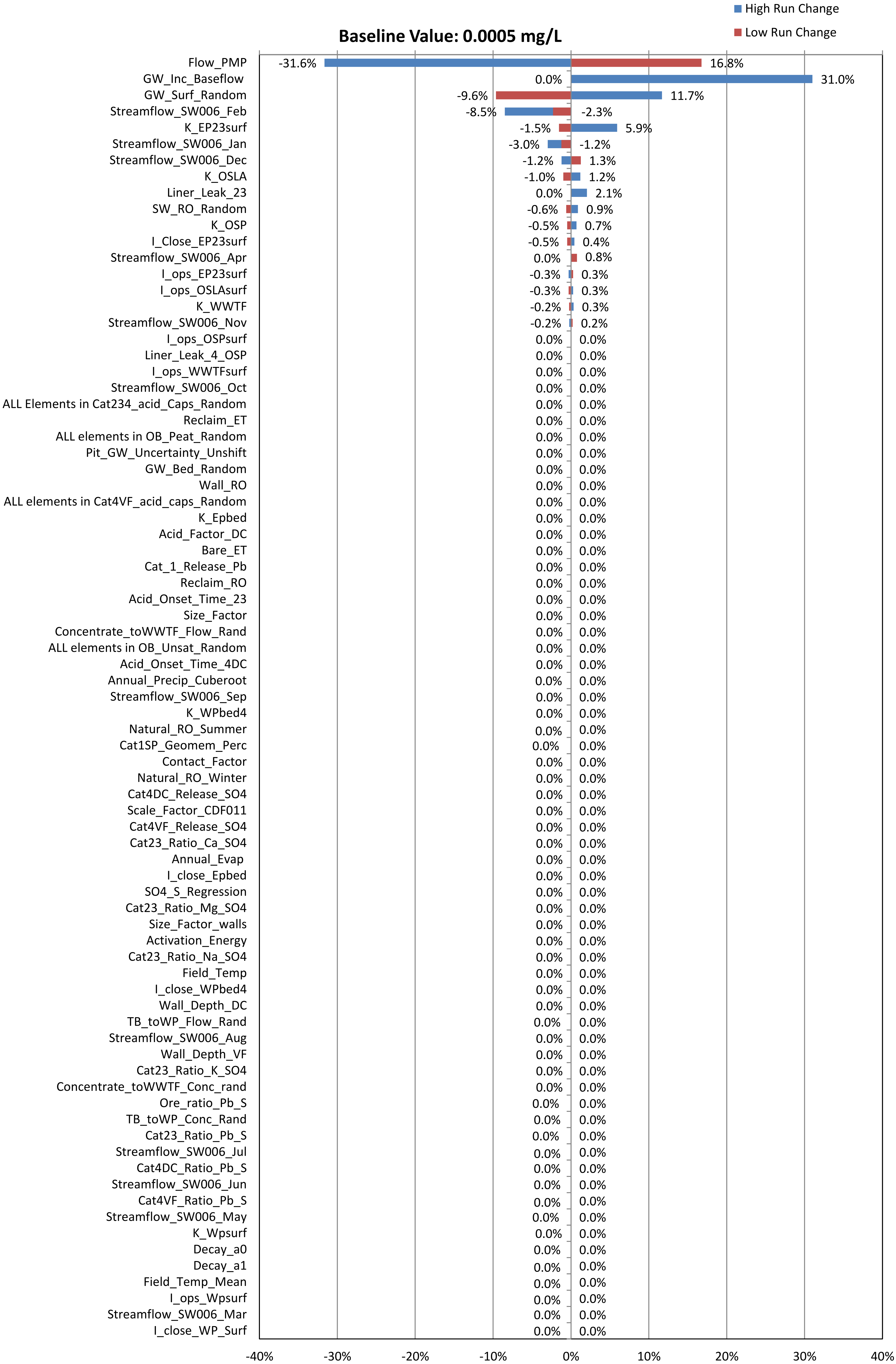

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Cu in the Partridge River at SW004
High Run Change
Low Run Change
Baseline Value: 0.0021 mg/L
SW_RO_Random -1.4% 191.3%
Flow_PMP -19.5% 8.9%
GW_Inc_Baseflow 0.0% 21.4%
GW_Surf_Random -8.9% 10.8%
Streamflow_SW006_Feb -12.4% -2.0%
K_EP23surf -2.5% 3.9%
Streamflow_SW006_Jan -5.3% 0.8%
Streamflow_SW006_Dec -1.4% 1.4%
K_OSLA -0.8% 1.0%
K_OSP -0.4% 0.6%
Streamflow_SW006_Mar 0.0% 0.9%
K_WWTF -0.2% 0.3%
Streamflow_SW006_Nov -0.2% 0.2%
I_ops_OSLAsurf -0.2% 0.2%
I_ops_EP23surf -0.1% 0.1%
I_Close_EP23surf -0.1% 0.1%
I_ops_OSPsurf 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
Pit_GW_Uncertainty_Unshift 0.0% 0.0%
Annual_Precip_Cuberoot 0.0% 0.0%
Wall_RO 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
K_Epbed 0.0% 0.0%
Streamflow_SW006_Aug 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
Concentrate_toWWTF_Flow_Rand 0.0% 0.0%
Bare_ET 0.0% 0.0%
Streamflow_SW006_Jul 0.0% 0.0%
Natural_RO_Summer 0.0% 0.0%
Cat1SP_Geomem_Perc 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Acid_Factor_DC 0.0% 0.0%
Cat23_Ratio_Co_Ni 0.0% 0.0%
Contact_Factor 0.0% 0.0%
Size_Factor 0.0% 0.0%
Cat23_Ratio_Ni_S 0.0% 0.0%
Cat4DC_Release_SO4 0.0% 0.0%
SO4_S_Regression 0.0% 0.0%
Acid_Onset_Time_23 0.0% 0.0%
Cat23_Ratio_Mg_SO4 0.0% 0.0%
Annual_Evap 0.0% 0.0%
Decay_a1 0.0% 0.0%
Cat4DC_Ratio_Co_Ni 0.0% 0.0%
Size_Factor_walls 0.0% 0.0%
Decay_a0 0.0% 0.0%
Field_Temp 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
Wall_Depth_VF 0.0% 0.0%
Activation_Energy 0.0% 0.0%
Cat4VF_Ratio_Co_S 0.0% 0.0%
Cat23_Ratio_Ni_Mg 0.0% 0.0%
Natural_RO_Winter 0.0% 0.0%
Wall_Depth_DC 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
Cat1_Ratio_Co_Ni 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.0%
Cat4VF_Release_SO4 0.0% 0.0%
Cat4DC_Ratio_Ni_S 0.0% 0.0%
TB_toWP_Flow_Rand 0.0% 0.0%
Cat_1_Release_Mg 0.0% 0.0%
Cat1_pH 0.0% 0.0%
Field_Temp_Mean 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Ore_Ratio_Ni_S 0.0% 0.0%
Cat1_Ratio_Ni_S 0.0% 0.0%
Cat4DC_Ratio_Mg_SO4 0.0% 0.0%
ALL elements in OB_Unsat_Random 0.0% 0.0%
Acid_Onset_Time_4DC 0.0% 0.0%
Cat1_Ratio_Ni_Mg 0.0% 0.0%
Ore_Ratio_Co_NI 0.0% 0.0%
Cat4DC_Ratio_Ni_Mg 0.0% 0.0%
ALL elements in OB_Peat_Random 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Ore_Ratio_Ni_Mg 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
K_WPbed4 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
Cat1_Cap_Percent 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
Ore_Ratio_Mg_SO4 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
TB_toWP_Conc_Rand 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
-50%
0%
50%
100%
150%
200%
250%

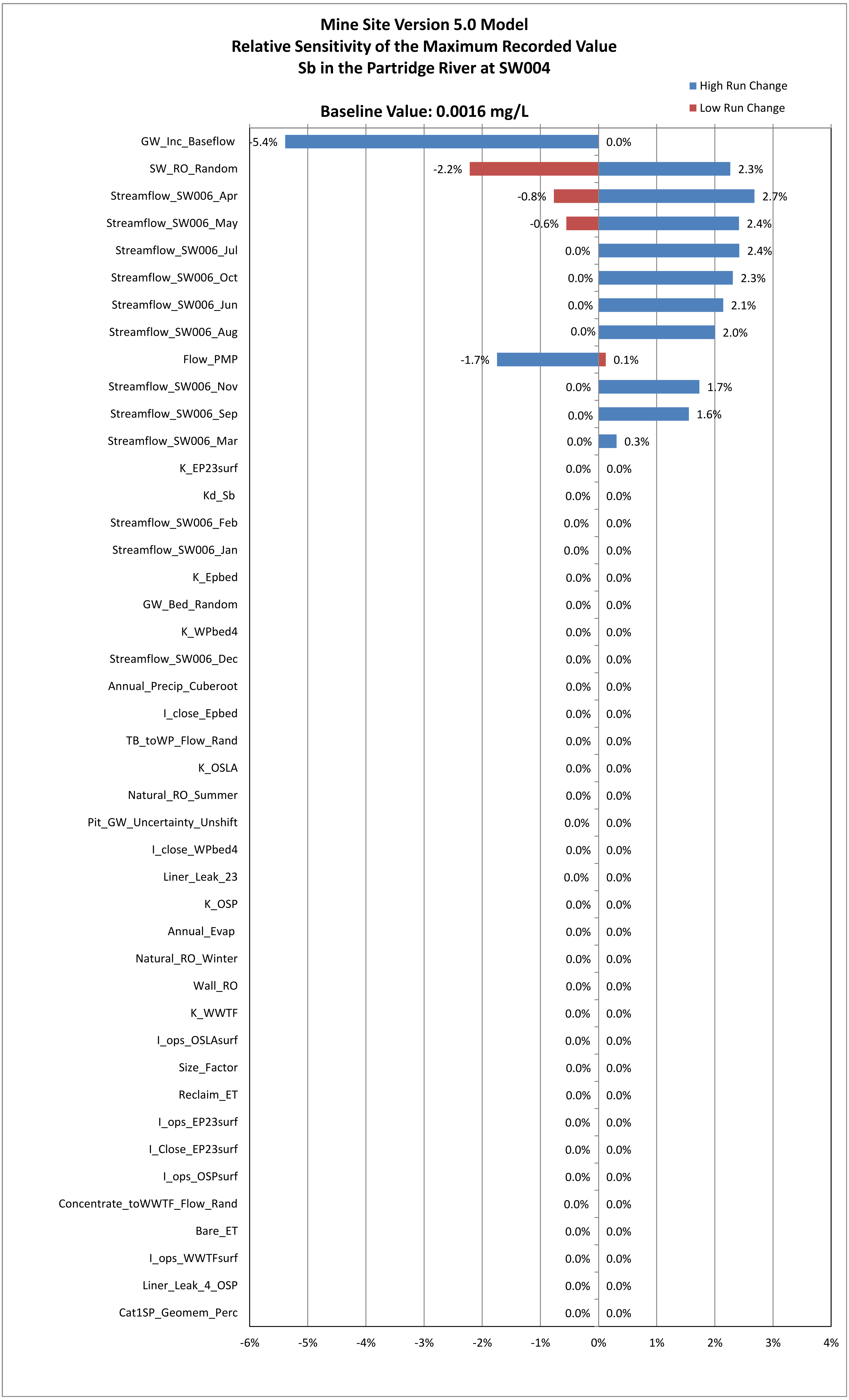


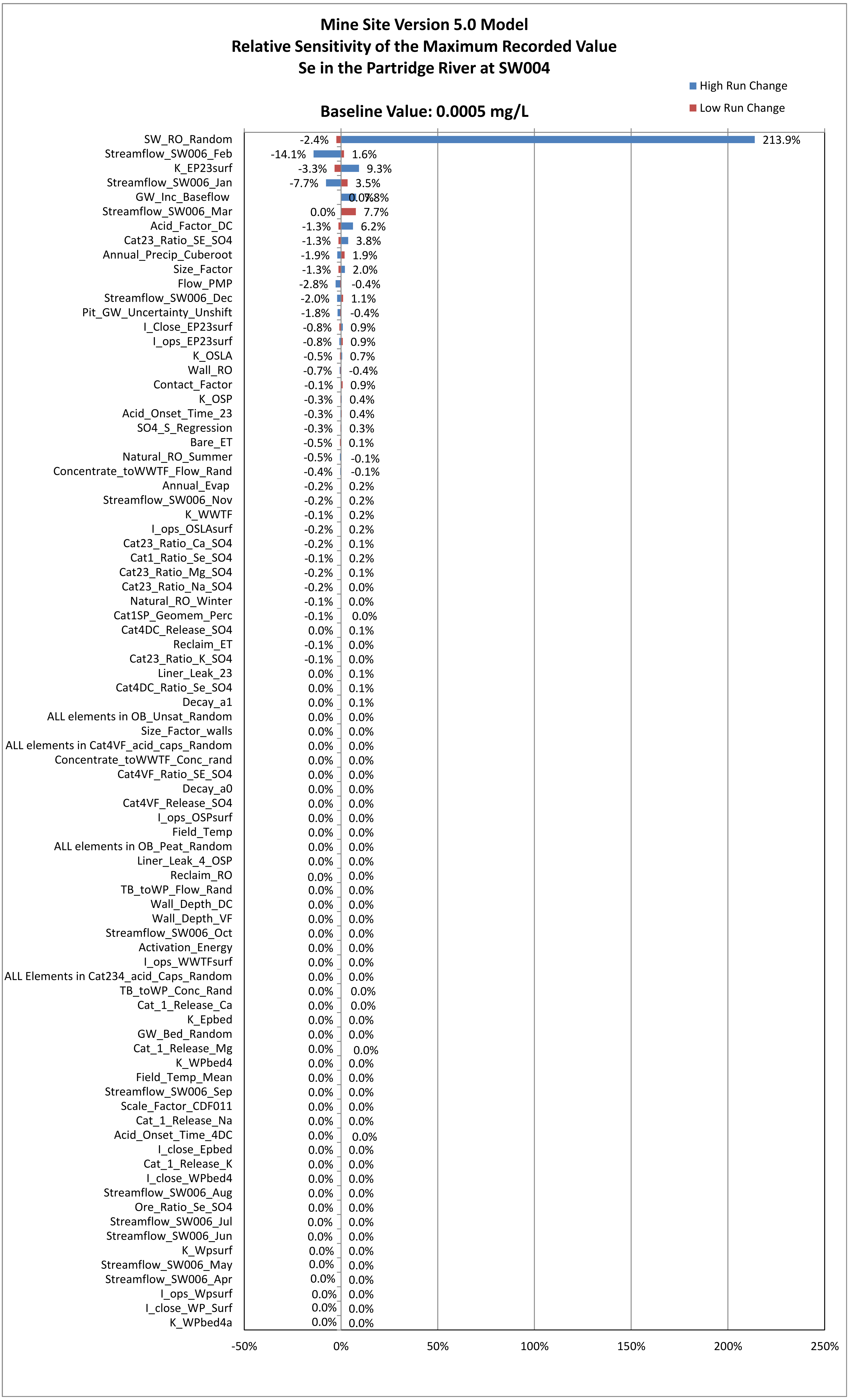
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Ni in the Partridge River at SW004
High Run Change
Low Run Change
Baseline Value: 0.0017 mg/L
SW_RO_Random -2.9% 336.8%
Flow_PMP -12.6% 6.5%
GW_Surf_Random -7.2% 8.6%
GW_Inc_Baseflow 0.0% 11.4%
Streamflow_SW006_Feb
K_EP23surf -2.1% 3.3%
Streamflow_SW006_Jan -4.1% 0.7%
Streamflow_SW006_Mar 0.0% 1.8%
K_OSLA -0.6% 0.8%
Streamflow_SW006_Dec -0.5% 0.7%
K_OSP -0.3% 0.5%
K_WWTF -0.2% 0.3%
GW_Bed_Random -0.1% 0.3%
I_ops_OSLAsurf -0.2% 0.2%
K_Epbed -0.1% 0.2%
Streamflow_SW006_Nov -0.1% 0.1%
I_ops_EP23surf -0.1% 0.1%
I_Close_EP23surf -0.1% 0.1%
K_WPbed4 0.0% 0.1%
I_ops_OSPsurf 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Size_Factor 0.0% 0.0%
Annual_Precip_Cuberoot 0.0% 0.0%
Annual_Evap 0.0% 0.0%
Natural_RO_Summer 0.0% 0.0%
TB_toWP_Flow_Rand 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
Acid_Factor_DC 0.0% 0.0%
Contact_Factor 0.0% 0.0%
Pit_GW_Uncertainty_Unshift 0.0% 0.0%
Cat4DC_Release_SO4 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Streamflow_SW006_Aug 0.0% 0.0%
Natural_RO_Winter 0.0% 0.0%
Streamflow_SW006_Jul 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
Wall_RO 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
-50%
0%
50%
100%
150%
200%
250%
300%
350%
400%

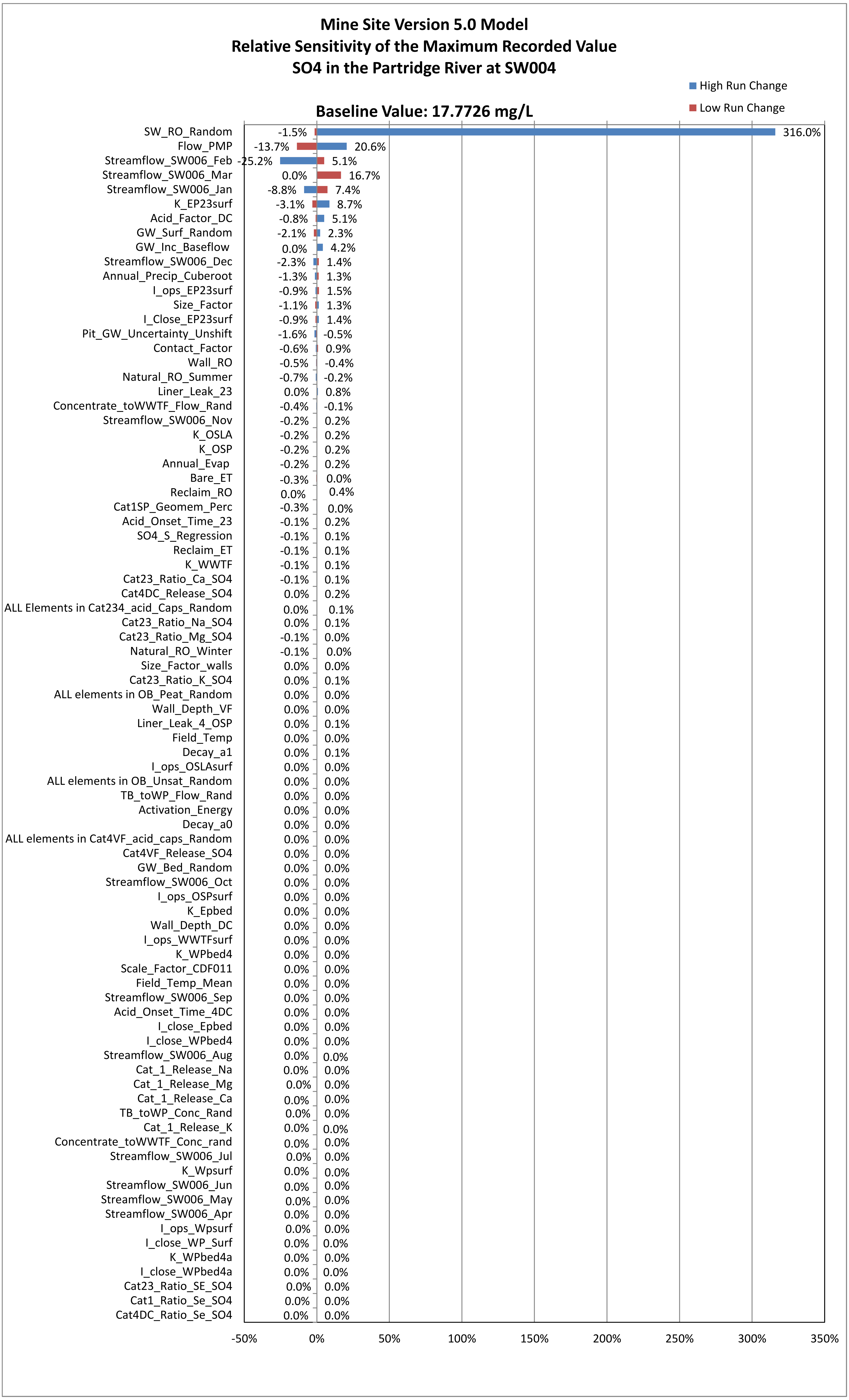
## Mine Site Version 5.0 Model
## Relative Sensitivity of the Maximum Recorded Value
## Pb in the Partridge River at SW004

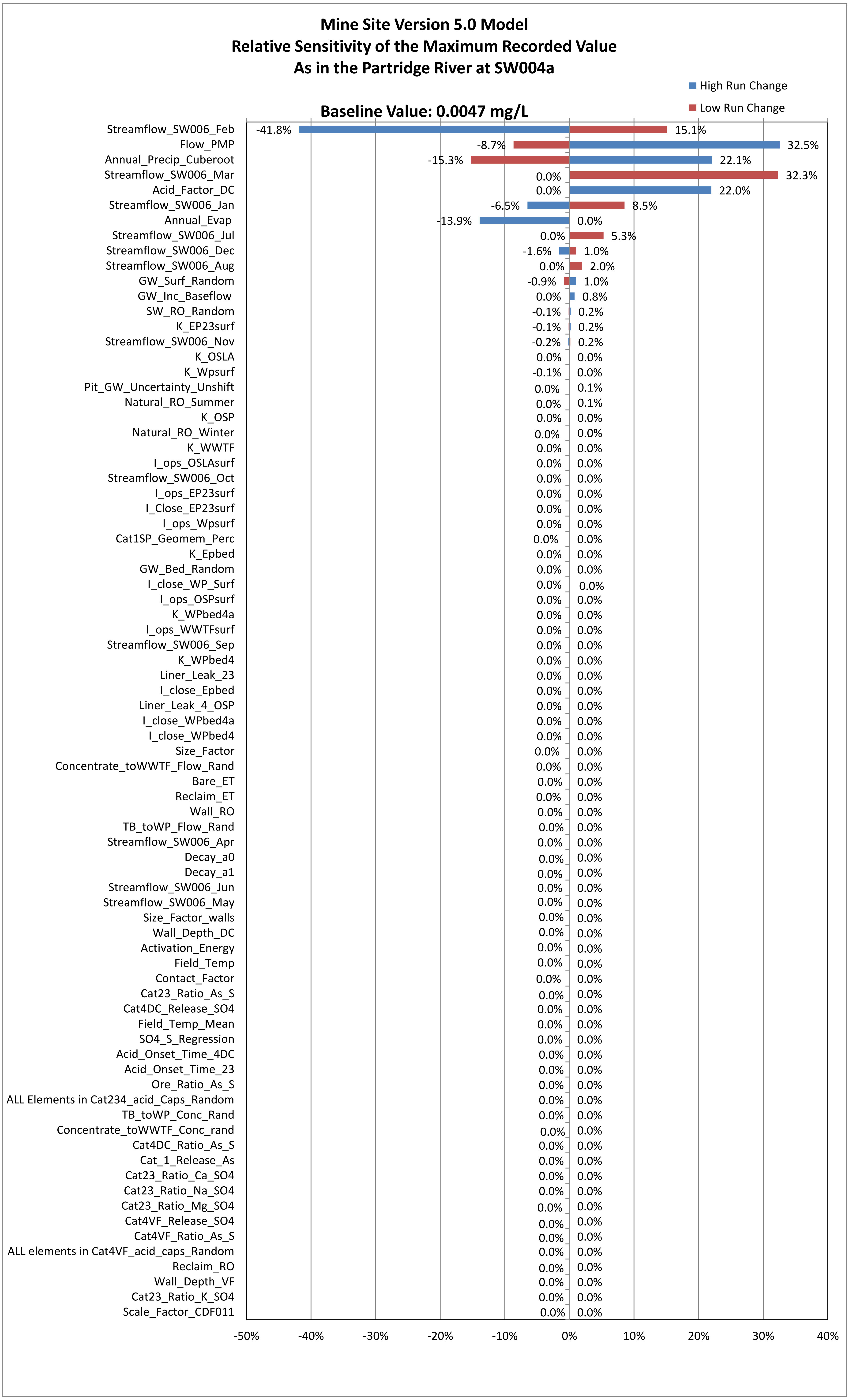
### Baseline Value: 0.0005 mg/L



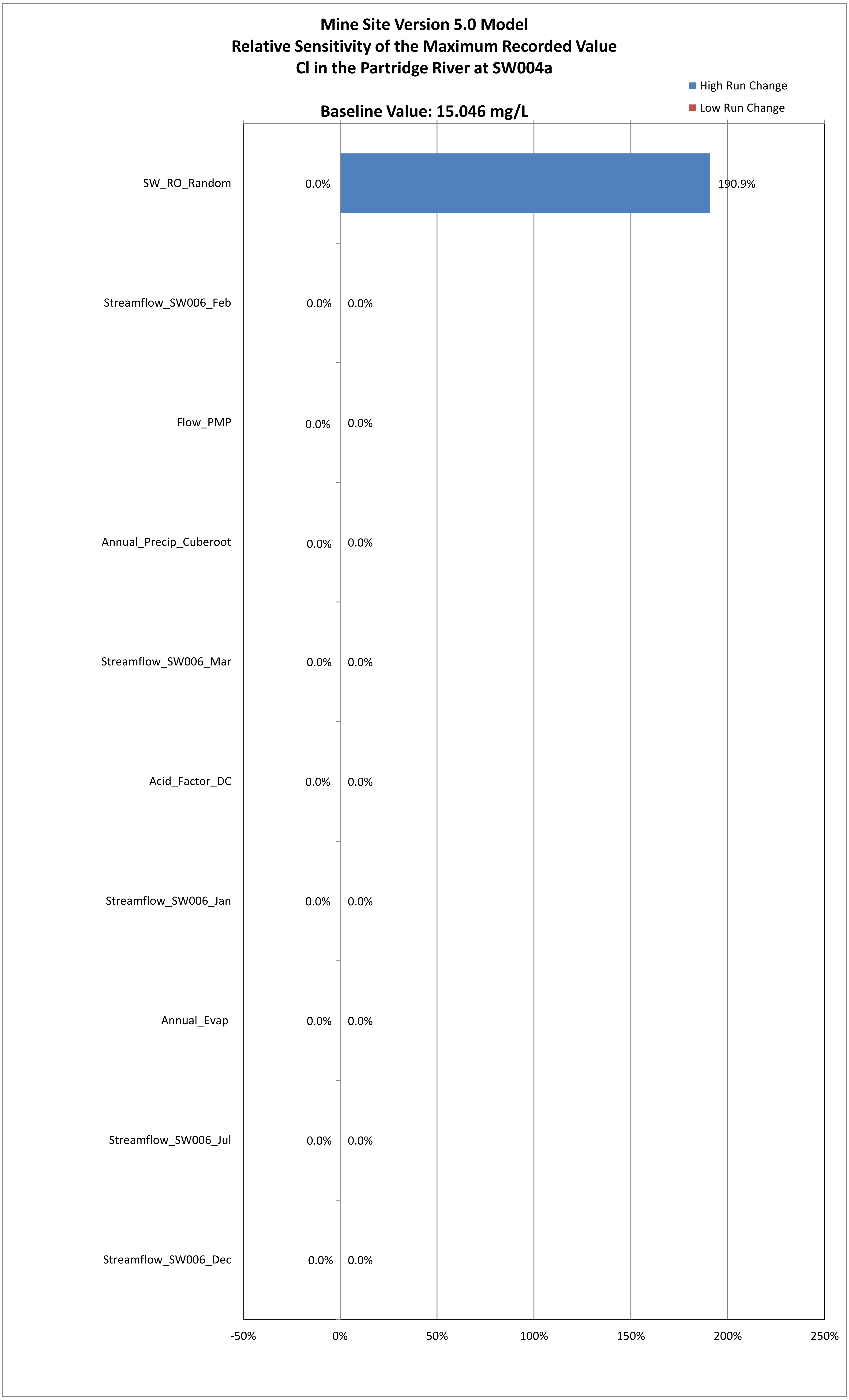

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Sb in the Partridge River at SW004
Baseline Value: 0.0016 mg/L
High Run Change
Low Run Change
GW_Inc_Baseflow -5.4% 0.0%
SW_RO_Random -2.2% 2.3%
Streamflow_SW006_Apr -0.8% 2.7%
Streamflow_SW006_May -0.6% 2.4%
Streamflow_SW006_Jul 0.0% 2.4%
Streamflow_SW006_Oct 0.0% 2.3%
Streamflow_SW006_Jun 0.0% 2.1%
Streamflow_SW006_Aug 0.0% 2.0%
Flow_PMP -1.7% 0.1%
Streamflow_SW006_Nov 0.0% 1.7%
Streamflow_SW006_Sep 0.0% 1.6%
Streamflow_SW006_Mar 0.0% 0.3%
K_EP23surf 0.0% 0.0%
Kd_Sb 0.0% 0.0%
Streamflow_SW006_Feb 0.0% 0.0%
Streamflow_SW006_Jan 0.0% 0.0%
K_Epbed 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
K_WPbed4 0.0% 0.0%
Streamflow_SW006_Dec 0.0% 0.0%
Annual_Precip_Cuberoot 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
TB_toWP_Flow_Rand 0.0% 0.0%
K_OSLA 0.0% 0.0%
Natural_RO_Summer 0.0% 0.0%
Pit_GW_Uncertainty_Unshift 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
K_OSP 0.0% 0.0%
Annual_Evap 0.0% 0.0%
Natural_RO_Winter 0.0% 0.0%
Wall_RO 0.0% 0.0%
K_WWTF 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Size_Factor 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
I_Close_EP23surf 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
Concentrate_toWWTF_Flow_Rand 0.0% 0.0%
Bare_ET 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Cat1SP_Geomem_Perc 0.0% 0.0%
-6% -5% -4% -3% -2% -1% 0% 1% 2% 3% 4%


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Se in the Partridge River at SW004
High Run Change
Low Run Change
Baseline Value: 0.0005 mg/L
SW_RO_Random -2.4% 213.9%
Streamflow_SW006_Feb -14.1% 1.6%
K_EP23surf -3.3% 9.3%
Streamflow_SW006_Jan -7.7% 3.5%
GW_Inc_Baseflow 0.0% 7.8%
Streamflow_SW006_Mar 0.0% 7.7%
Acid_Factor_DC -1.3% 6.2%
Cat23_Ratio_SE_SO4 -1.3% 3.8%
Annual_Precip_Cuberoot -1.9% 1.9%
Size_Factor -1.3% 2.0%
Flow_PMP -2.8% -0.4%
Streamflow_SW006_Dec -2.0% 1.1%
Pit_GW_Uncertainty_Unshift -1.8% -0.4%
I_Close_EP23surf -0.8% 0.9%
I_ops_EP23surf -0.8% 0.9%
K_OSLA -0.5% 0.7%
Wall_RO -0.7% -0.4%
Contact_Factor -0.1% 0.9%
K_OSP -0.3% 0.4%
Acid_Onset_Time_23 -0.3% 0.4%
SO4_S_Regression -0.3% 0.3%
Bare_ET -0.5% 0.1%
Natural_RO_Summer -0.5% -0.1%
Concentrate_toWWTF_Flow_Rand -0.4% -0.1%
Annual_Evap -0.2% 0.2%
Streamflow_SW006_Nov -0.2% 0.2%
K_WWTF -0.1% 0.2%
I_ops_OSLAsurf -0.2% 0.2%
Cat23_Ratio_Ca_SO4 -0.2% 0.1%
Cat1_Ratio_Se_SO4 -0.1% 0.2%
Cat23_Ratio_Mg_SO4 -0.2% 0.1%
Cat23_Ratio_Na_SO4 -0.2% 0.0%
Natural_RO_Winter -0.1% 0.0%
Cat1SP_Geomem_Perc -0.1% 0.0%
Cat4DC_Release_SO4 0.0% 0.1%
Reclaim_ET -0.1% 0.0%
Cat23_Ratio_K_SO4 -0.1% 0.0%
Liner_Leak_23 0.0% 0.1%
Cat4DC_Ratio_Se_SO4 0.0% 0.1%
Decay_a1 0.0% 0.1%
ALL elements in OB_Unsat_Random 0.0% 0.0%
Size_Factor_walls 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
Cat4VF_Ratio_SE_SO4 0.0% 0.0%
Decay_a0 0.0% 0.0%
Cat4VF_Release_SO4 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
Field_Temp 0.0% 0.0%
ALL elements in OB_Peat_Random 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
TB_toWP_Flow_Rand 0.0% 0.0%
Wall_Depth_DC 0.0% 0.0%
Wall_Depth_VF 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
Activation_Energy 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.0%
TB_toWP_Conc_Rand 0.0% 0.0%
Cat_1_Release_Ca 0.0% 0.0%
K_Epbed 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Cat_1_Release_Mg 0.0% 0.0%
K_WPbed4 0.0% 0.0%
Field_Temp_Mean 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
Cat_1_Release_Na 0.0% 0.0%
Acid_Onset_Time_4DC 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
Cat_1_Release_K 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Streamflow_SW006_Aug 0.0% 0.0%
Ore_Ratio_Se_SO4 0.0% 0.0%
Streamflow_SW006_Jul 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
-50%
0%
50%
100%
150%
200%
250%

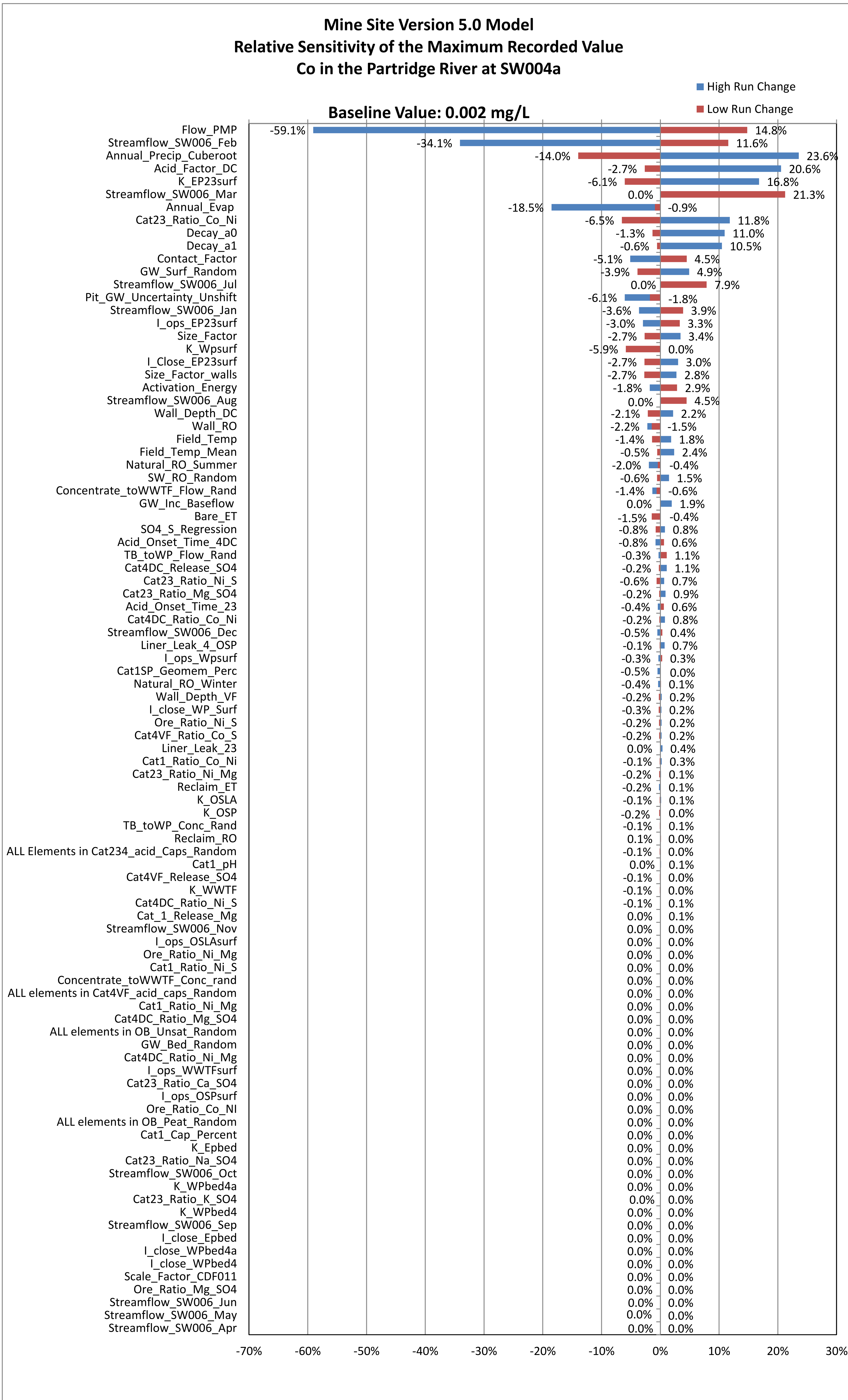

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
SO4 in the Partridge River at SW004
High Run Change
Low Run Change
Baseline Value: 17.7726 mg/L
SW_RO_Random -1.5% 316.0%
Flow_PMP -13.7% 20.6%
Streamflow_SW006_Feb -25.2% 5.1%
Streamflow_SW006_Mar 0.0% 16.7%
Streamflow_SW006_Jan -8.8% 7.4%
K_EP23surf -3.1% 8.7%
Acid_Factor_DC -0.8% 5.1%
GW_Surf_Random -2.1% 2.3%
GW_Inc_Baseflow 0.0% 4.2%
Streamflow_SW006_Dec -2.3% 1.4%
Annual_Precip_Cuberoot -1.3% 1.3%
I_ops_EP23surf -0.9% 1.5%
Size_Factor -1.1% 1.3%
I_Close_EP23surf -0.9% 1.4%
Pit_GW_Uncertainty_Unshift -1.6% -0.5%
Contact_Factor -0.6% 0.9%
Wall_RO -0.5% -0.4%
Natural_RO_Summer -0.7% -0.2%
Liner_Leak_23 0.0% 0.8%
Concentrate_toWWTF_Flow_Rand -0.4% -0.1%
Streamflow_SW006_Nov -0.2% 0.2%
K_OSLA -0.2% 0.2%
K_OSP -0.2% 0.2%
Annual_Evap -0.2% 0.2%
Bare_ET -0.3% 0.0%
Reclaim_RO 0.0% 0.4%
Cat1SP_Geomem_Perc -0.3% 0.0%
Acid_Onset_Time_23 -0.1% 0.2%
SO4_S_Regression -0.1% 0.1%
Reclaim_ET -0.1% 0.1%
K_WWTF -0.1% 0.1%
Cat23_Ratio_Ca_SO4 -0.1% 0.1%
Cat4DC_Release_SO4 0.0% 0.2%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.1%
Cat23_Ratio_Na_SO4 0.0% 0.1%
Cat23_Ratio_Mg_SO4 -0.1% 0.0%
Natural_RO_Winter -0.1% 0.0%
Size_Factor_walls 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.1%
ALL elements in OB_Peat_Random 0.0% 0.0%
Wall_Depth_VF 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.1%
Field_Temp 0.0% 0.0%
Decay_a1 0.0% 0.1%
I_ops_OSLAsurf 0.0% 0.0%
ALL elements in OB_Unsat_Random 0.0% 0.0%
TB_toWP_Flow_Rand 0.0% 0.0%
Activation_Energy 0.0% 0.0%
Decay_a0 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Cat4VF_Release_SO4 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
K_Epbed 0.0% 0.0%
Wall_Depth_DC 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
K_WPbed4 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
Field_Temp_Mean 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
Acid_Onset_Time_4DC 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Streamflow_SW006_Aug 0.0% 0.0%
Cat_1_Release_Na 0.0% 0.0%
Cat_1_Release_Mg 0.0% 0.0%
Cat_1_Release_Ca 0.0% 0.0%
TB_toWP_Conc_Rand 0.0% 0.0%
Cat_1_Release_K 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
Streamflow_SW006_Jul 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
Cat23_Ratio_SE_SO4 0.0% 0.0%
Cat1_Ratio_Se_SO4 0.0% 0.0%
Cat4DC_Ratio_Se_SO4 0.0% 0.0%
-50%
0%
50%
100%
150%
200%
250%
300%
350%

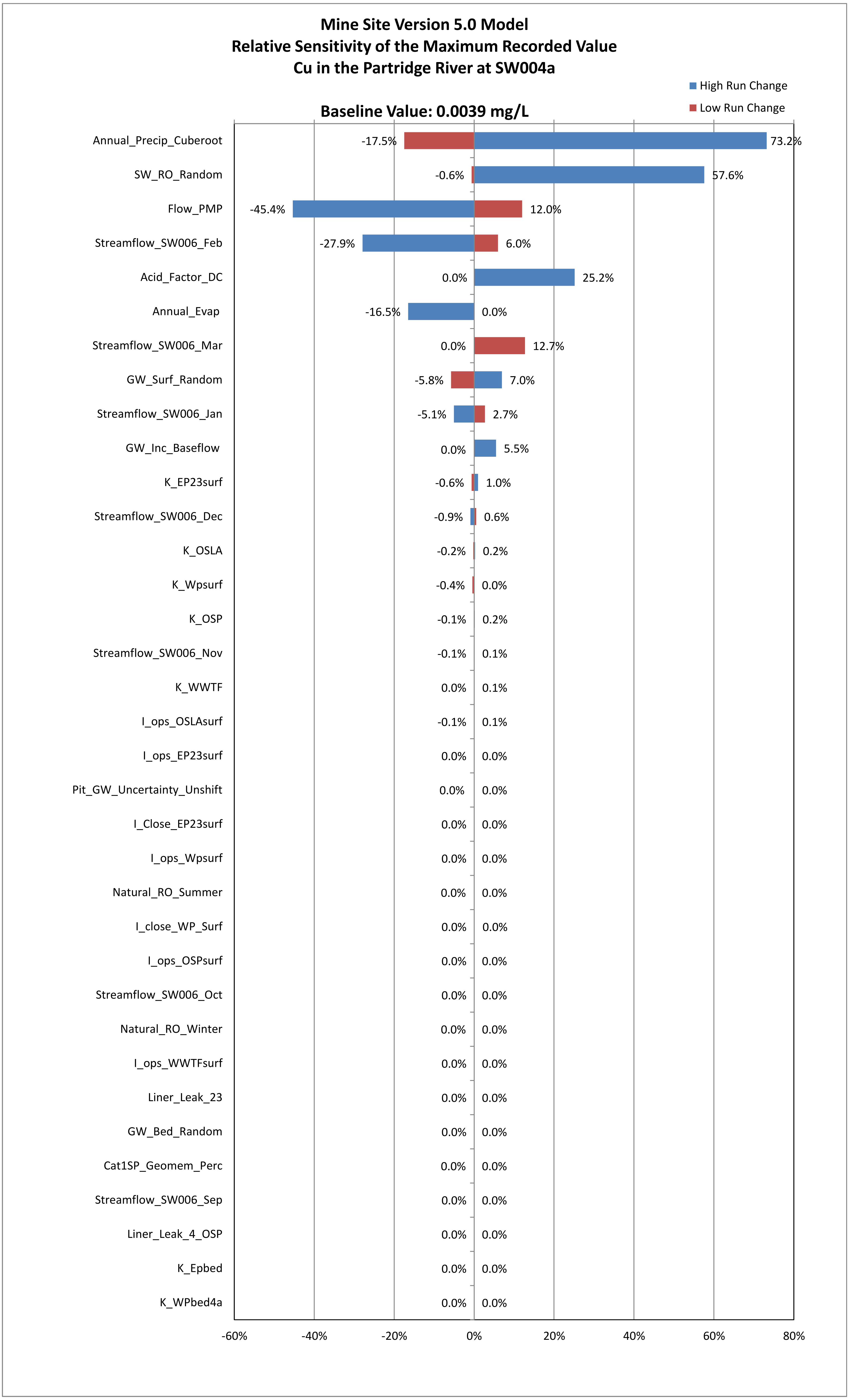


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
As in the Partridge River at SW004a
High Run Change
Low Run Change
Baseline Value: 0.0047 mg/L
Streamflow_SW006_Feb -41.8% 15.1%
Flow_PMP -8.7% 32.5%
Annual_Precip_Cuberoot -15.3% 22.1%
Streamflow_SW006_Mar 0.0% 32.3%
Acid_Factor_DC 0.0% 22.0%
Streamflow_SW006_Jan -6.5% 8.5%
Annual_Evap -13.9% 0.0%
Streamflow_SW006_Jul 0.0% 5.3%
Streamflow_SW006_Dec -1.6% 1.0%
Streamflow_SW006_Aug 0.0% 2.0%
GW_Surf_Random -0.9% 1.0%
GW_Inc_Baseflow 0.0% 0.8%
SW_RO_Random -0.1% 0.2%
K_EP23surf -0.1% 0.2%
Streamflow_SW006_Nov -0.2% 0.2%
K_OSLA 0.0% 0.0%
K_Wpsurf -0.1% 0.0%
Pit_GW_Uncertainty_Unshift 0.0% 0.1%
Natural_RO_Summer 0.0% 0.1%
K_OSP 0.0% 0.0%
Natural_RO_Winter 0.0% 0.0%
K_WWTF 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
I_Close_EP23surf 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
Cat1SP_Geomem_Perc 0.0% 0.0%
K_Epbed 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
K_WPbed4 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Size_Factor 0.0% 0.0%
Concentrate_toWWTF_Flow_Rand 0.0% 0.0%
Bare_ET 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
Wall_RO 0.0% 0.0%
TB_toWP_Flow_Rand 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
Decay_a0 0.0% 0.0%
Decay_a1 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Size_Factor_walls 0.0% 0.0%
Wall_Depth_DC 0.0% 0.0%
Activation_Energy 0.0% 0.0%
Field_Temp 0.0% 0.0%
Contact_Factor 0.0% 0.0%
Cat23_Ratio_As_S 0.0% 0.0%
Cat4DC_Release_SO4 0.0% 0.0%
Field_Temp_Mean 0.0% 0.0%
SO4_S_Regression 0.0% 0.0%
Acid_Onset_Time_4DC 0.0% 0.0%
Acid_Onset_Time_23 0.0% 0.0%
Ore_Ratio_As_S 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.0%
TB_toWP_Conc_Rand 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
Cat4DC_Ratio_As_S 0.0% 0.0%
Cat_1_Release_As 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
Cat23_Ratio_Mg_SO4 0.0% 0.0%
Cat4VF_Release_SO4 0.0% 0.0%
Cat4VF_Ratio_As_S 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
Wall_Depth_VF 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
-50%
-40%
-30%
-20%
-10%
0%
10%
20%
30%
40%

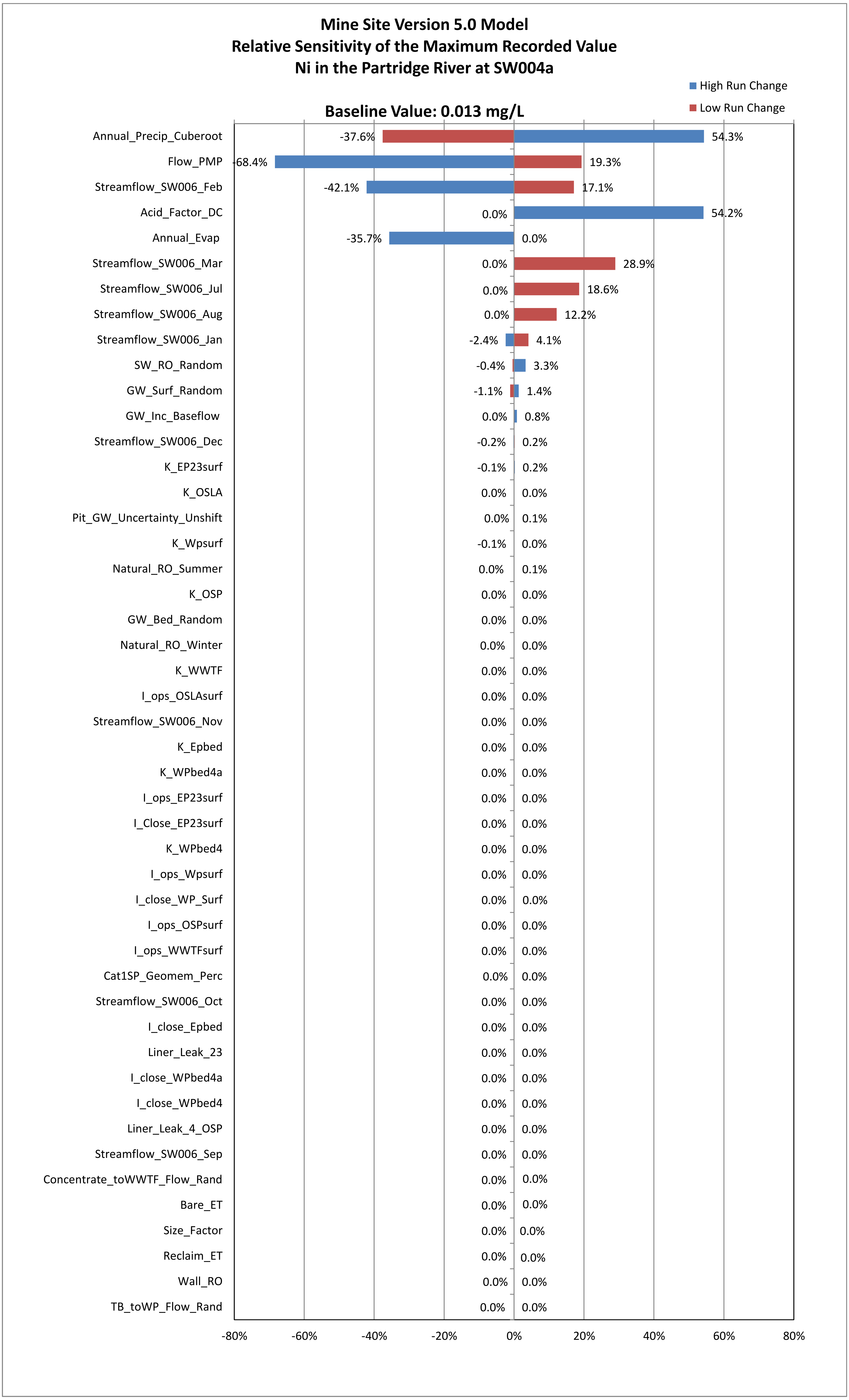


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Cl in the Partridge River at SW004a
Baseline Value: 15.046 mg/L
High Run Change
Low Run Change
SW_RO_Random
0.0%
190.9%
Streamflow_SW006_Feb
0.0%
0.0%
Flow_PMP
0.0%
0.0%
Annual_Precip_Cuberoot
0.0%
0.0%
Streamflow_SW006_Mar
0.0%
0.0%
Acid_Factor_DC
0.0%
0.0%
Streamflow_SW006_Jan
0.0%
0.0%
Annual_Evap
0.0%
0.0%
Streamflow_SW006_Jul
0.0%
0.0%
Streamflow_SW006_Dec
0.0%
0.0%
-50%
0%
50%
100%
150%
200%
250%

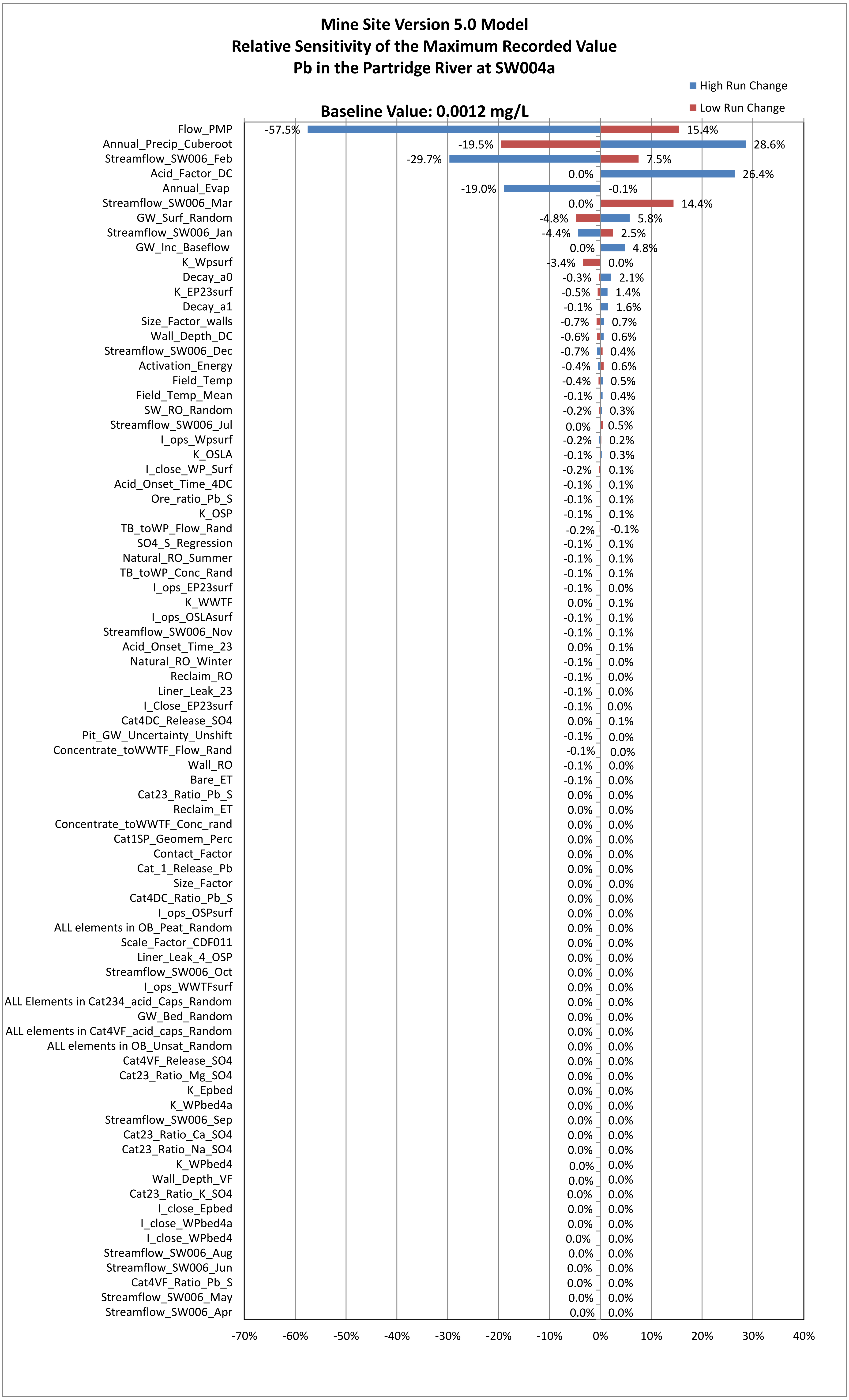

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Co in the Partridge River at SW004a
High Run Change
Low Run Change
Baseline Value: 0.002 mg/L
Flow_PMP -59.1% 14.8%
Streamflow_SW006_Feb -34.1% 11.6%
Annual_Precip_Cuberoot -14.0% 23.6%
Acid_Factor_DC -2.7% 20.6%
K_EP23surf -6.1% 16.8%
Streamflow_SW006_Mar 0.0% 21.3%
Annual_Evap -18.5% -0.9%
Cat23_Ratio_Co_Ni -6.5% 11.8%
Decay_a0 -1.3% 11.0%
Decay_a1 -0.6% 10.5%
Contact_Factor -5.1% 4.5%
GW_Surf_Random -3.9% 4.9%
Streamflow_SW006_Jul 0.0% 7.9%
Pit_GW_Uncertainty_Unshift -6.1% -1.8%
Streamflow_SW006_Jan -3.6% 3.9%
I_ops_EP23surf -3.0% 3.3%
Size_Factor -2.7% 3.4%
K_Wpsurf -5.9% 0.0%
I_Close_EP23surf -2.7% 3.0%
Size_Factor_walls -2.7% 2.8%
Activation_Energy -1.8% 2.9%
Streamflow_SW006_Aug 0.0% 4.5%
Wall_Depth_DC -2.1% 2.2%
Wall_RO -2.2% -1.5%
Field_Temp -1.4% 1.8%
Field_Temp_Mean -0.5% 2.4%
Natural_RO_Summer -2.0% -0.4%
SW_RO_Random -0.6% 1.5%
Concentrate_toWWTF_Flow_Rand -1.4% -0.6%
GW_Inc_Baseflow 0.0% 1.9%
Bare_ET -1.5% -0.4%
SO4_S_Regression -0.8% 0.8%
Acid_Onset_Time_4DC -0.8% 0.6%
TB_toWP_Flow_Rand -0.3% 1.1%
Cat4DC_Release_SO4 -0.2% 1.1%
Cat23_Ratio_Ni_S -0.6% 0.7%
Cat23_Ratio_Mg_SO4 -0.2% 0.9%
Acid_Onset_Time_23 -0.4% 0.6%
Cat4DC_Ratio_Co_Ni -0.2% 0.8%
Streamflow_SW006_Dec -0.5% 0.4%
Liner_Leak_4_OSP -0.1% 0.7%
I_ops_Wpsurf -0.3% 0.3%
Cat1SP_Geomem_Perc -0.5% 0.0%
Natural_RO_Winter -0.4% 0.1%
Wall_Depth_VF -0.2% 0.2%
I_close_WP_Surf -0.3% 0.2%
Ore_Ratio_Ni_S -0.2% 0.2%
Cat4VF_Ratio_Co_S -0.2% 0.2%
Liner_Leak_23 0.0% 0.4%
Cat1_Ratio_Co_Ni -0.1% 0.3%
Cat23_Ratio_Ni_Mg -0.2% 0.1%
Reclaim_ET -0.2% 0.1%
K_OSLA -0.1% 0.1%
K_OSP -0.2% 0.0%
TB_toWP_Conc_Rand -0.1% 0.1%
Reclaim_RO 0.1% 0.0%
ALL Elements in Cat234_acid_Caps_Random -0.1% 0.0%
Cat1_pH 0.0% 0.1%
Cat4VF_Release_SO4 -0.1% 0.0%
K_WWTF -0.1% 0.0%
Cat4DC_Ratio_Ni_S -0.1% 0.1%
Cat_1_Release_Mg 0.0% 0.1%
Streamflow_SW006_Nov 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Ore_Ratio_Ni_Mg 0.0% 0.0%
Cat1_Ratio_Ni_S 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Cat1_Ratio_Ni_Mg 0.0% 0.0%
Cat4DC_Ratio_Mg_SO4 0.0% 0.0%
ALL elements in OB_Unsat_Random 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Cat4DC_Ratio_Ni_Mg 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
Ore_Ratio_Co_NI 0.0% 0.0%
ALL elements in OB_Peat_Random 0.0% 0.0%
Cat1_Cap_Percent 0.0% 0.0%
K_Epbed 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
K_WPbed4 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
Ore_Ratio_Mg_SO4 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
-70% -60% -50% -40% -30% -20% -10% 0% 10% 20% 30%

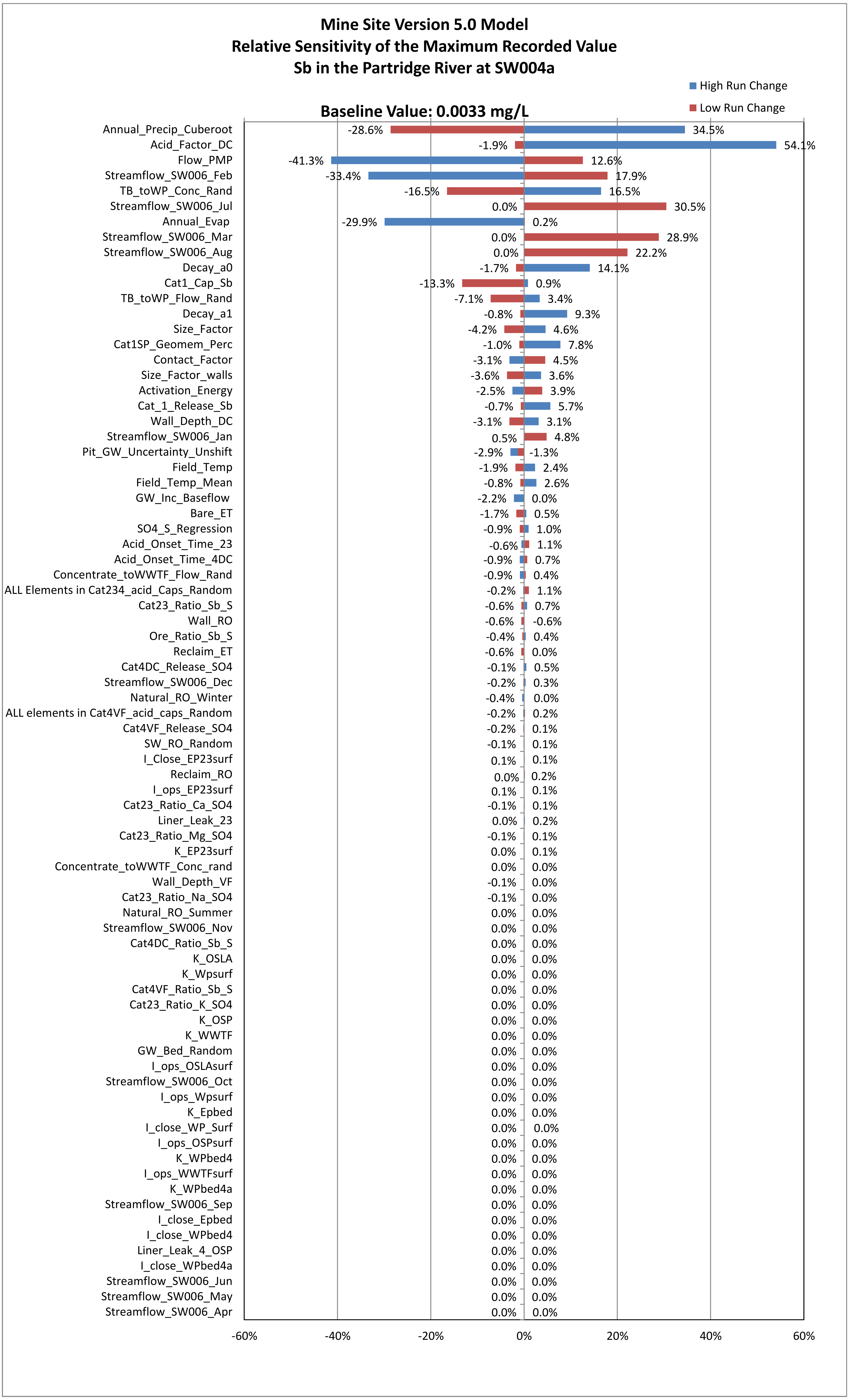


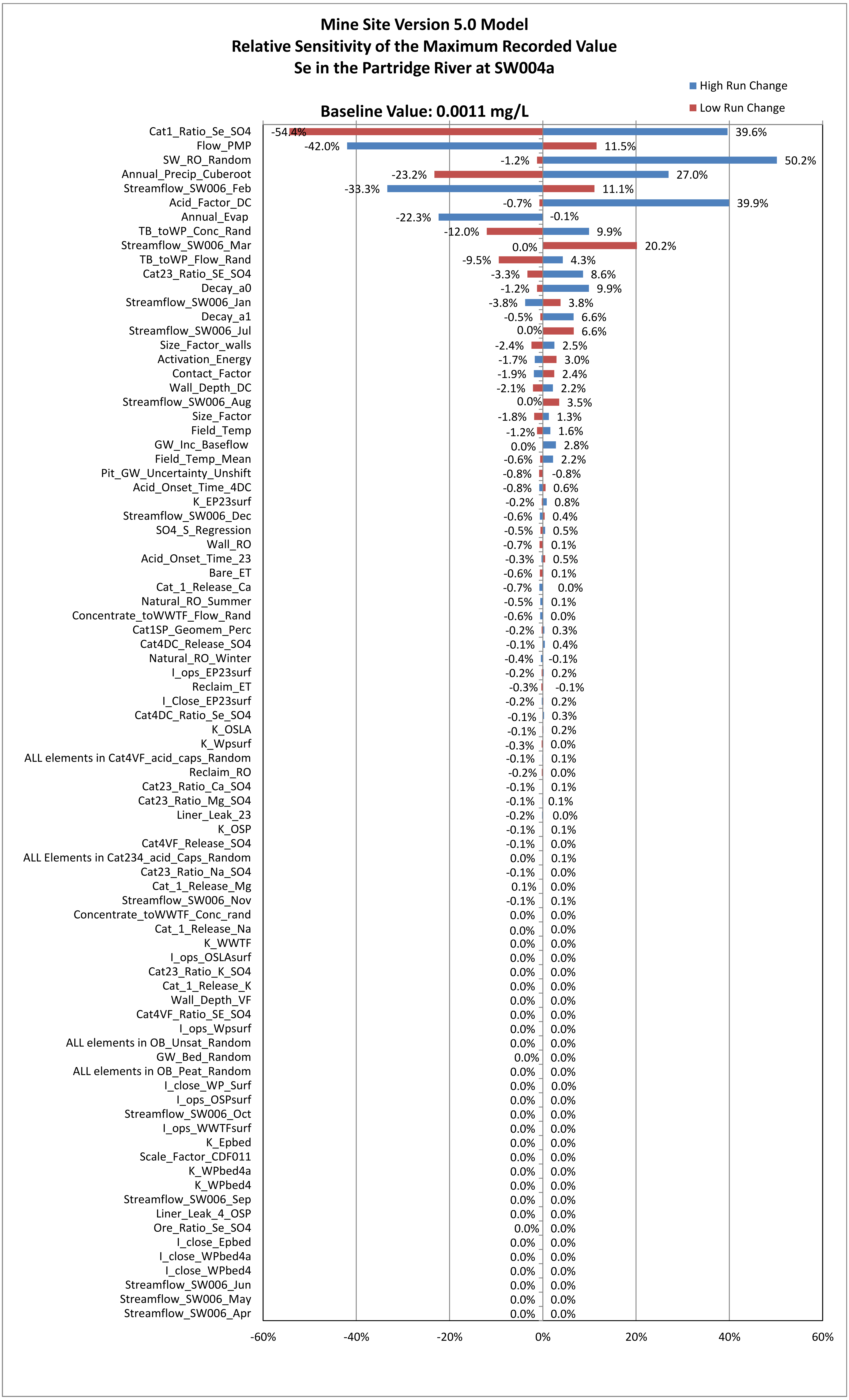
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Cu in the Partridge River at SW004a
Baseline Value: 0.0039 mg/L
High Run Change
Low Run Change
Annual_Precip_Cuberoot -17.5% 73.2%
SW_RO_Random -0.6% 57.6%
Flow_PMP -45.4% 12.0%
Streamflow_SW006_Feb -27.9% 6.0%
Acid_Factor_DC 0.0% 25.2%
Annual_Evap -16.5% 0.0%
Streamflow_SW006_Mar 0.0% 12.7%
GW_Surf_Random -5.8% 7.0%
Streamflow_SW006_Jan -5.1% 2.7%
GW_Inc_Baseflow 0.0% 5.5%
K_EP23surf -0.6% 1.0%
Streamflow_SW006_Dec -0.9% 0.6%
K_OSLA -0.2% 0.2%
K_Wpsurf -0.4% 0.0%
K_OSP -0.1% 0.2%
Streamflow_SW006_Nov -0.1% 0.1%
K_WWTF 0.0% 0.1%
I_ops_OSLAsurf -0.1% 0.1%
I_ops_EP23surf 0.0% 0.0%
Pit_GW_Uncertainty_Unshift 0.0% 0.0%
I_Close_EP23surf 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
Natural_RO_Summer 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
Natural_RO_Winter 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Cat1SP_Geomem_Perc 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
K_Epbed 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
-60% -40% -20% 0% 20% 40% 60% 80%



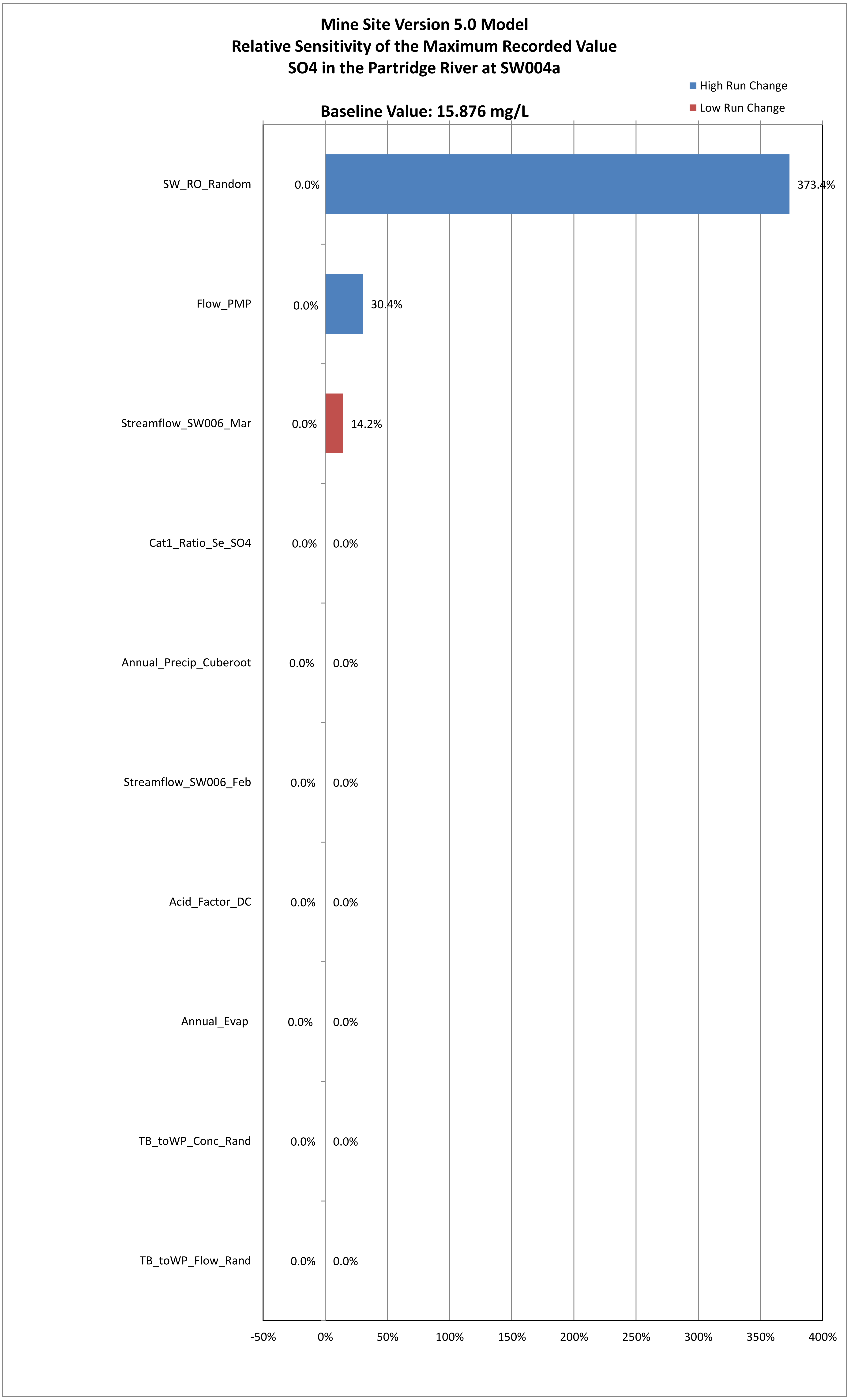
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Ni in the Partridge River at SW004a
Baseline Value: 0.013 mg/L
High Run Change
Low Run Change
Annual_Precip_Cuberoot -37.6% 54.3%
Flow_PMP -68.4% 19.3%
Streamflow_SW006_Feb -42.1% 17.1%
Acid_Factor_DC 0.0% 54.2%
Annual_Evap -35.7% 0.0%
Streamflow_SW006_Mar 0.0% 28.9%
Streamflow_SW006_Jul 0.0% 18.6%
Streamflow_SW006_Aug 0.0% 12.2%
Streamflow_SW006_Jan -2.4% 4.1%
SW_RO_Random -0.4% 3.3%
GW_Surf_Random -1.1% 1.4%
GW_Inc_Baseflow 0.0% 0.8%
Streamflow_SW006_Dec -0.2% 0.2%
K_EP23surf -0.1% 0.2%
K_OSLA 0.0% 0.0%
Pit_GW_Uncertainty_Unshift 0.0% 0.1%
K_Wpsurf -0.1% 0.0%
Natural_RO_Summer 0.0% 0.1%
K_OSP 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Natural_RO_Winter 0.0% 0.0%
K_WWTF 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Streamflow_SW006_Nov 0.0% 0.0%
K_Epbed 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
I_Close_EP23surf 0.0% 0.0%
K_WPbed4 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Cat1SP_Geomem_Perc 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
Concentrate_toWWTF_Flow_Rand 0.0% 0.0%
Bare_ET 0.0% 0.0%
Size_Factor 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
Wall_RO 0.0% 0.0%
TB_toWP_Flow_Rand 0.0% 0.0%
-80% -60% -40% -20% 0% 20% 40% 60% 80%

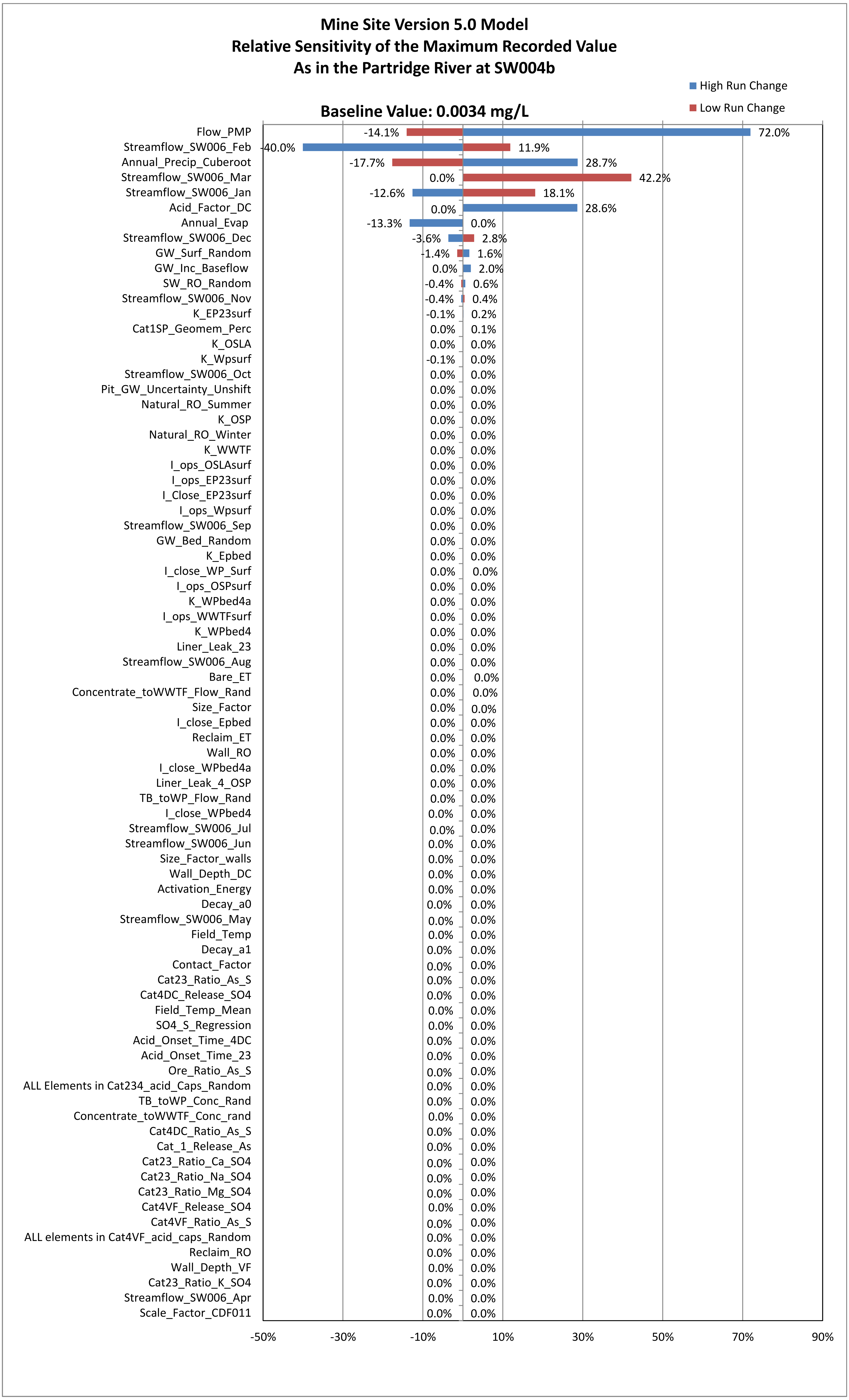

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Pb in the Partridge River at SW004a
High Run Change
Low Run Change
Baseline Value: 0.0012 mg/L
Flow_PMP -57.5% 15.4%
Annual_Precip_Cuberoot -19.5% 28.6%
Streamflow_SW006_Feb -29.7% 7.5%
Acid_Factor_DC 0.0% 26.4%
Annual_Evap -19.0% -0.1%
Streamflow_SW006_Mar 0.0% 14.4%
GW_Surf_Random -4.8% 5.8%
Streamflow_SW006_Jan -4.4% 2.5%
GW_Inc_Baseflow 0.0% 4.8%
K_Wpsurf -3.4% 0.0%
Decay_a0 -0.3% 2.1%
K_EP23surf -0.5% 1.4%
Decay_a1 -0.1% 1.6%
Size_Factor_walls -0.7% 0.7%
Wall_Depth_DC -0.6% 0.6%
Streamflow_SW006_Dec -0.7% 0.4%
Activation_Energy -0.4% 0.6%
Field_Temp -0.4% 0.5%
Field_Temp_Mean -0.1% 0.4%
SW_RO_Random -0.2% 0.3%
Streamflow_SW006_Jul 0.0% 0.5%
I_ops_Wpsurf -0.2% 0.2%
K_OSLA -0.1% 0.3%
I_close_WP_Surf -0.2% 0.1%
Acid_Onset_Time_4DC -0.1% 0.1%
Ore_ratio_Pb_S -0.1% 0.1%
K_OSP -0.1% 0.1%
TB_toWP_Flow_Rand -0.2% -0.1%
SO4_S_Regression -0.1% 0.1%
Natural_RO_Summer -0.1% 0.1%
TB_toWP_Conc_Rand -0.1% 0.1%
I_ops_EP23surf -0.1% 0.0%
K_WWTF 0.0% 0.1%
I_ops_OSLAsurf -0.1% 0.1%
Streamflow_SW006_Nov -0.1% 0.1%
Acid_Onset_Time_23 0.0% 0.1%
Natural_RO_Winter -0.1% 0.0%
Reclaim_RO -0.1% 0.0%
Liner_Leak_23 -0.1% 0.0%
I_Close_EP23surf -0.1% 0.0%
Cat4DC_Release_SO4 0.0% 0.1%
Pit_GW_Uncertainty_Unshift -0.1% 0.0%
Concentrate_toWWTF_Flow_Rand -0.1% 0.0%
Wall_RO -0.1% 0.0%
Bare_ET -0.1% 0.0%
Cat23_Ratio_Pb_S 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
Cat1SP_Geomem_Perc 0.0% 0.0%
Contact_Factor 0.0% 0.0%
Cat_1_Release_Pb 0.0% 0.0%
Size_Factor 0.0% 0.0%
Cat4DC_Ratio_Pb_S 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
ALL elements in OB_Peat_Random 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
ALL elements in OB_Unsat_Random 0.0% 0.0%
Cat4VF_Release_SO4 0.0% 0.0%
Cat23_Ratio_Mg_SO4 0.0% 0.0%
K_Epbed 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
K_WPbed4 0.0% 0.0%
Wall_Depth_VF 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Streamflow_SW006_Aug 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Cat4VF_Ratio_Pb_S 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
-70% -60% -50% -40% -30% -20% -10% 0% 10% 20% 30% 40%

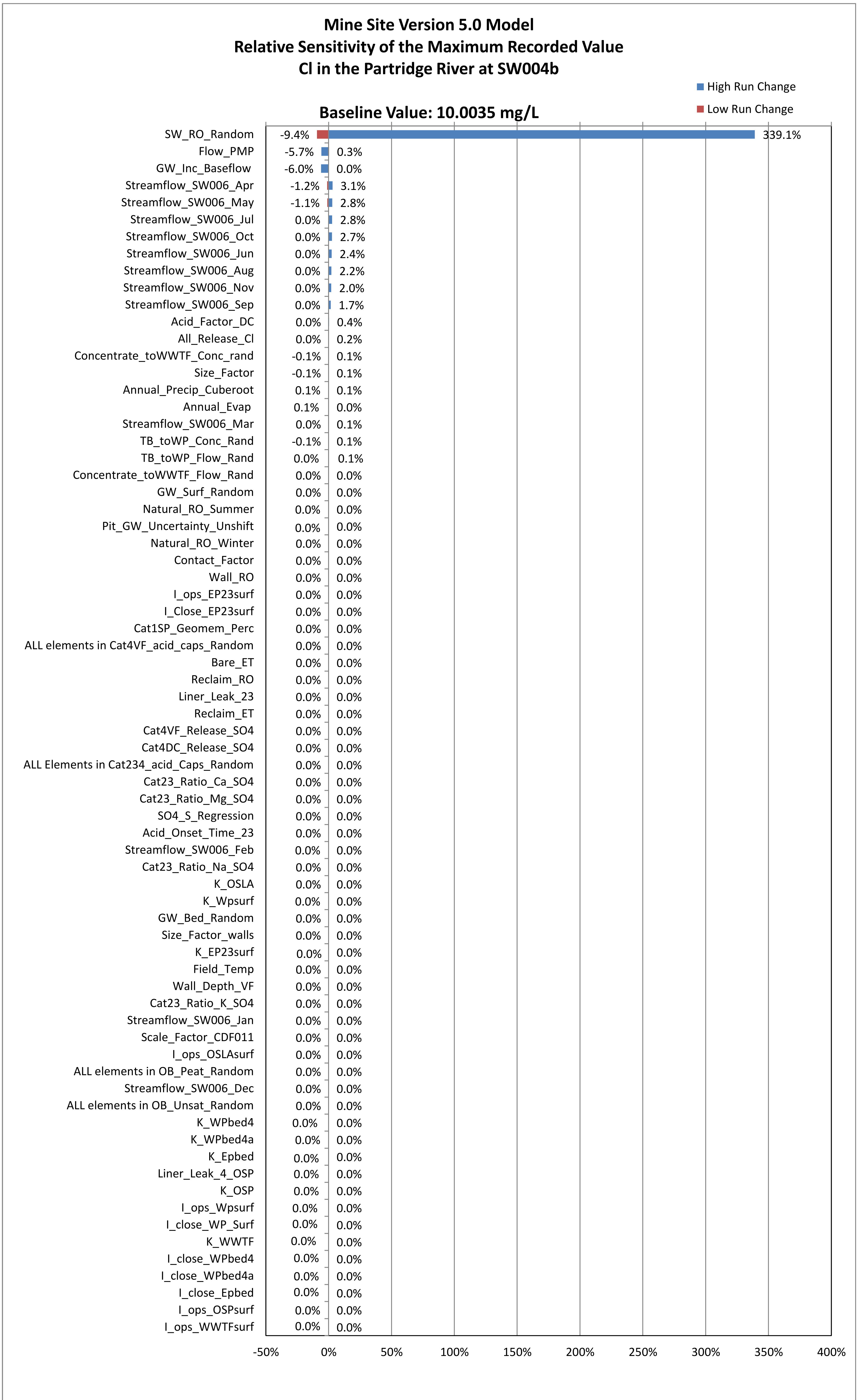

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Sb in the Partridge River at SW004a
High Run Change
Low Run Change
Baseline Value: 0.0033 mg/L
Annual_Precip_Cuberoot -28.6% 34.5%
Acid_Factor_DC -1.9% 54.1%
Flow_PMP -41.3% 12.6%
Streamflow_SW006_Feb -33.4% 17.9%
TB_toWP_Conc_Rand -16.5% 16.5%
Streamflow_SW006_Jul 0.0% 30.5%
Annual_Evap -29.9% 0.2%
Streamflow_SW006_Mar 0.0% 28.9%
Streamflow_SW006_Aug 0.0% 22.2%
Decay_a0 -1.7% 14.1%
Cat1_Cap_Sb -13.3% 0.9%
TB_toWP_Flow_Rand -7.1% 3.4%
Decay_a1 -0.8% 9.3%
Size_Factor -4.2% 4.6%
Cat1SP_Geomem_Perc -1.0% 7.8%
Contact_Factor -3.1% 4.5%
Size_Factor_walls -3.6% 3.6%
Activation_Energy -2.5% 3.9%
Cat_1_Release_Sb -0.7% 5.7%
Wall_Depth_DC -3.1% 3.1%
Streamflow_SW006_Jan 0.5% 4.8%
Pit_GW_Uncertainty_Unshift -2.9% -1.3%
Field_Temp -1.9% 2.4%
Field_Temp_Mean -0.8% 2.6%
GW_Inc_Baseflow -2.2% 0.0%
Bare_ET -1.7% 0.5%
SO4_S_Regression -0.9% 1.0%
Acid_Onset_Time_23 -0.6% 1.1%
Acid_Onset_Time_4DC -0.9% 0.7%
Concentrate_toWWTF_Flow_Rand -0.9% 0.4%
ALL Elements in Cat234_acid_Caps_Random -0.2% 1.1%
Cat23_Ratio_Sb_S -0.6% 0.7%
Wall_RO -0.6% -0.6%
Ore_Ratio_Sb_S -0.4% 0.4%
Reclaim_ET -0.6% 0.0%
Cat4DC_Release_SO4 -0.1% 0.5%
Streamflow_SW006_Dec -0.2% 0.3%
Natural_RO_Winter -0.4% 0.0%
ALL elements in Cat4VF_acid_caps_Random -0.2% 0.2%
Cat4VF_Release_SO4 -0.2% 0.1%
SW_RO_Random -0.1% 0.1%
I_Close_EP23surf 0.1% 0.1%
Reclaim_RO 0.0% 0.2%
I_ops_EP23surf 0.1% 0.1%
Cat23_Ratio_Ca_SO4 -0.1% 0.1%
Liner_Leak_23 0.0% 0.2%
Cat23_Ratio_Mg_SO4 -0.1% 0.1%
K_EP23surf 0.0% 0.1%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
Wall_Depth_VF -0.1% 0.0%
Cat23_Ratio_Na_SO4 -0.1% 0.0%
Natural_RO_Summer 0.0% 0.0%
Streamflow_SW006_Nov 0.0% 0.0%
Cat4DC_Ratio_Sb_S 0.0% 0.0%
K_OSLA 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
Cat4VF_Ratio_Sb_S 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
K_OSP 0.0% 0.0%
K_WWTF 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
K_Epbed 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
K_WPbed4 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
-60%
-40%
-20%
0%
20%
40%
60%

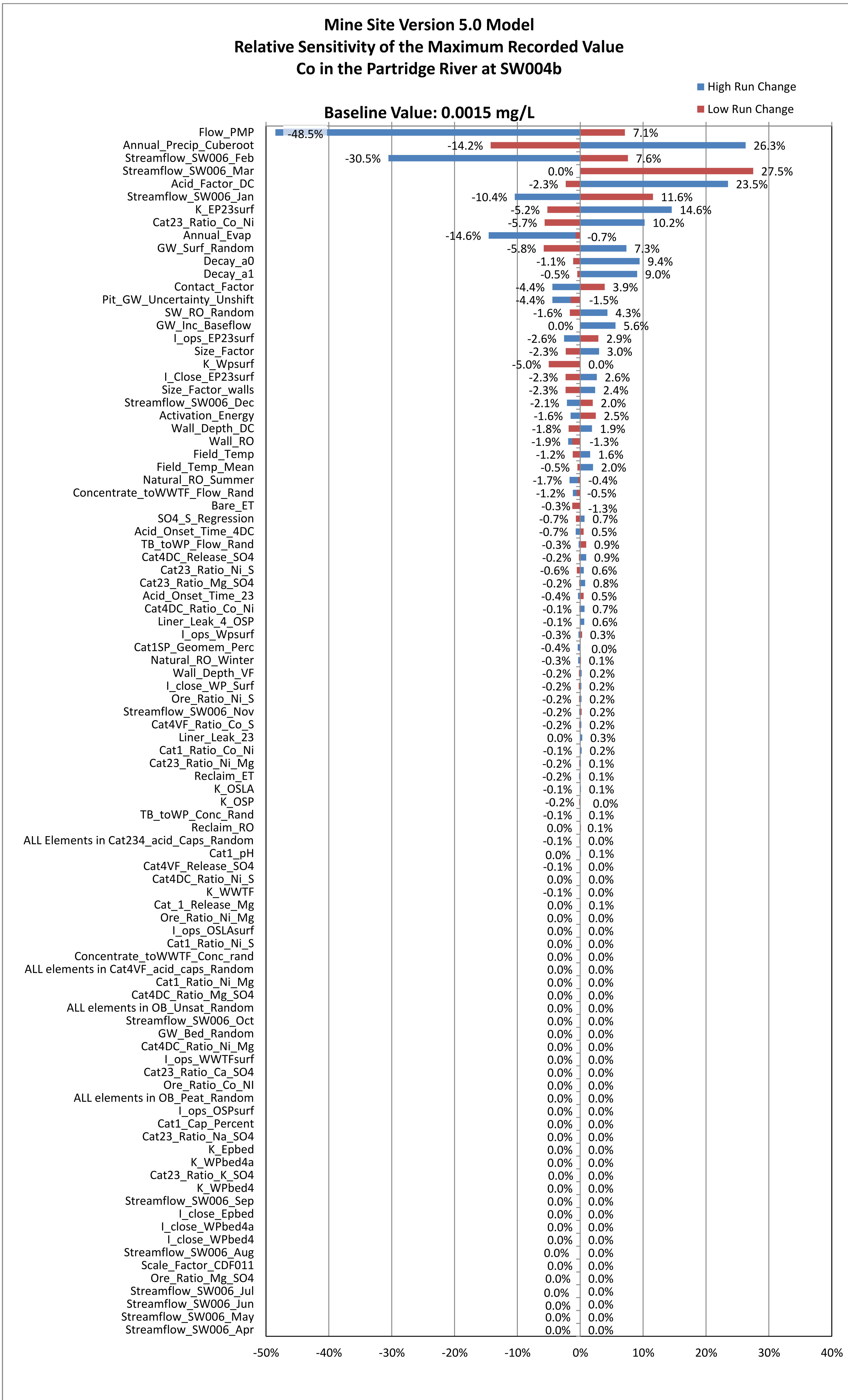


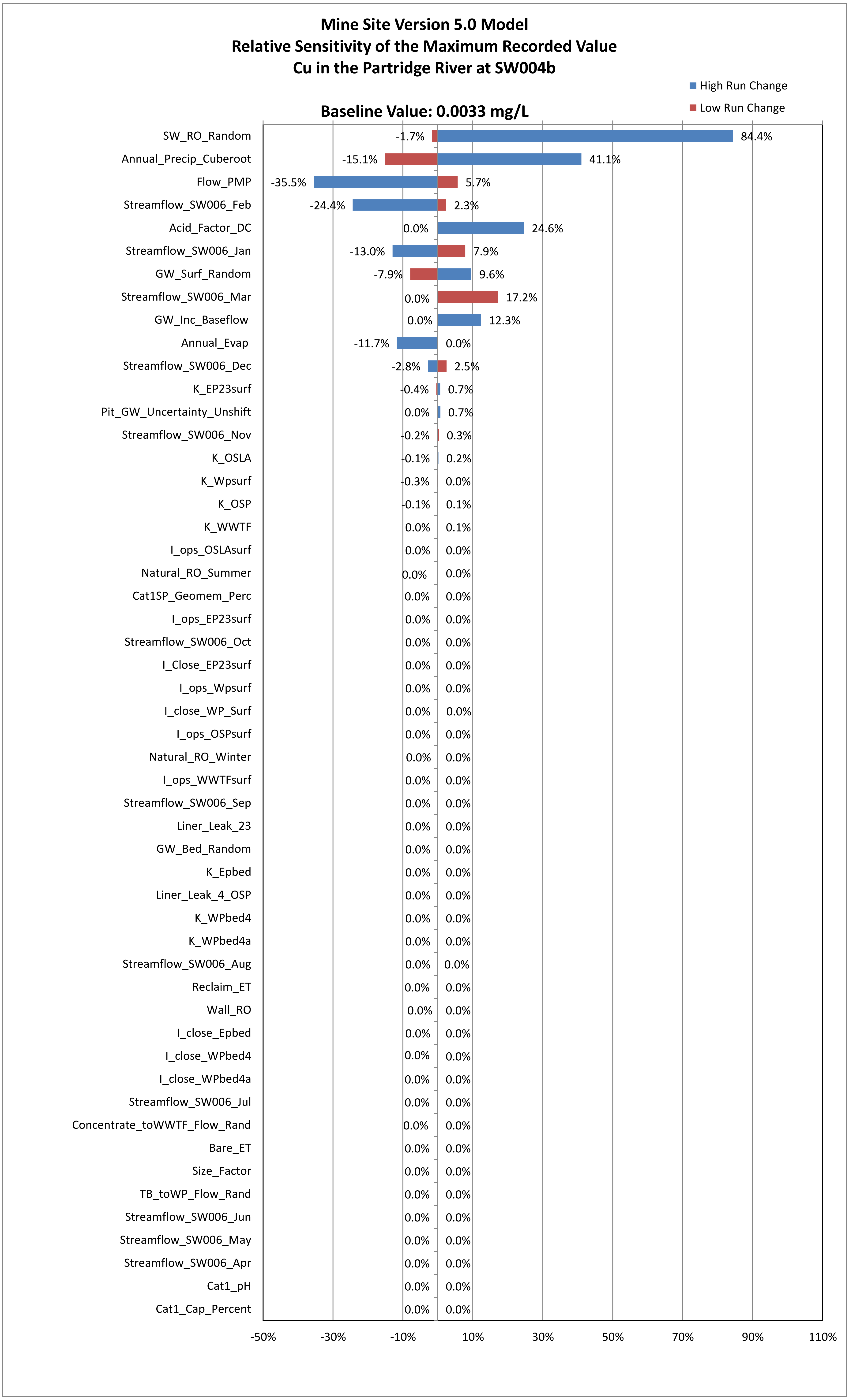
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Se in the Partridge River at SW004a
High Run Change
Low Run Change
Baseline Value: 0.0011 mg/L
Cat1_Ratio_Se_SO4 -54.4% 39.6%
Flow_PMP -42.0% 11.5%
SW_RO_Random -1.2% 50.2%
Annual_Precip_Cuberoot -23.2% 27.0%
Streamflow_SW006_Feb -33.3% 11.1%
Acid_Factor_DC -0.7% 39.9%
Annual_Evap -22.3% -0.1%
TB_toWP_Conc_Rand -12.0% 9.9%
Streamflow_SW006_Mar 0.0% 20.2%
TB_toWP_Flow_Rand -9.5% 4.3%
Cat23_Ratio_SE_SO4 -3.3% 8.6%
Decay_a0 -1.2% 9.9%
Streamflow_SW006_Jan -3.8% 3.8%
Decay_a1 -0.5% 6.6%
Streamflow_SW006_Jul 0.0% 6.6%
Size_Factor_walls -2.4% 2.5%
Activation_Energy -1.7% 3.0%
Contact_Factor -1.9% 2.4%
Wall_Depth_DC -2.1% 2.2%
Streamflow_SW006_Aug 0.0% 3.5%
Size_Factor -1.8% 1.3%
Field_Temp -1.2% 1.6%
GW_Inc_Baseflow 0.0% 2.8%
Field_Temp_Mean -0.6% 2.2%
Pit_GW_Uncertainty_Unshift -0.8% -0.8%
Acid_Onset_Time_4DC -0.8% 0.6%
K_EP23surf -0.2% 0.8%
Streamflow_SW006_Dec -0.6% 0.4%
SO4_S_Regression -0.5% 0.5%
Wall_RO -0.7% 0.1%
Acid_Onset_Time_23 -0.3% 0.5%
Bare_ET -0.6% 0.1%
Cat_1_Release_Ca -0.7% 0.0%
Natural_RO_Summer -0.5% 0.1%
Concentrate_toWWTF_Flow_Rand -0.6% 0.0%
Cat1SP_Geomem_Perc -0.2% 0.3%
Cat4DC_Release_SO4 -0.1% 0.4%
Natural_RO_Winter -0.4% -0.1%
I_ops_EP23surf -0.2% 0.2%
Reclaim_ET -0.3% -0.1%
I_Close_EP23surf -0.2% 0.2%
Cat4DC_Ratio_Se_SO4 -0.1% 0.3%
K_OSLA -0.1% 0.2%
K_Wpsurf -0.3% 0.0%
ALL elements in Cat4VF_acid_caps_Random -0.1% 0.1%
Reclaim_RO -0.2% 0.0%
Cat23_Ratio_Ca_SO4 -0.1% 0.1%
Cat23_Ratio_Mg_SO4 -0.1% 0.1%
Liner_Leak_23 -0.2% 0.0%
K_OSP -0.1% 0.1%
Cat4VF_Release_SO4 -0.1% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.1%
Cat23_Ratio_Na_SO4 -0.1% 0.0%
Cat_1_Release_Mg 0.1% 0.0%
Streamflow_SW006_Nov -0.1% 0.1%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
Cat_1_Release_Na 0.0% 0.0%
K_WWTF 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
Cat_1_Release_K 0.0% 0.0%
Wall_Depth_VF 0.0% 0.0%
Cat4VF_Ratio_SE_SO4 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
ALL elements in OB_Unsat_Random 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
ALL elements in OB_Peat_Random 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
K_Epbed 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
K_WPbed4 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Ore_Ratio_Se_SO4 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
-60% -40% -20% 0% 20% 40% 60%


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
SO4 in the Partridge River at SW004a
High Run Change
Low Run Change
Baseline Value: 15.876 mg/L
SW_RO_Random
0.0%
373.4%
Flow_PMP
0.0%
30.4%
Streamflow_SW006_Mar
0.0%
14.2%
Cat1_Ratio_Se_SO4
0.0%
0.0%
Annual_Precip_Cuberoot
0.0%
0.0%
Streamflow_SW006_Feb
0.0%
0.0%
Acid_Factor_DC
0.0%
0.0%
Annual_Evap
0.0%
0.0%
TB_toWP_Conc_Rand
0.0%
0.0%
TB_toWP_Flow_Rand
0.0%
0.0%
-50%
0%
50%
100%
150%
200%
250%
300%
350%
400%

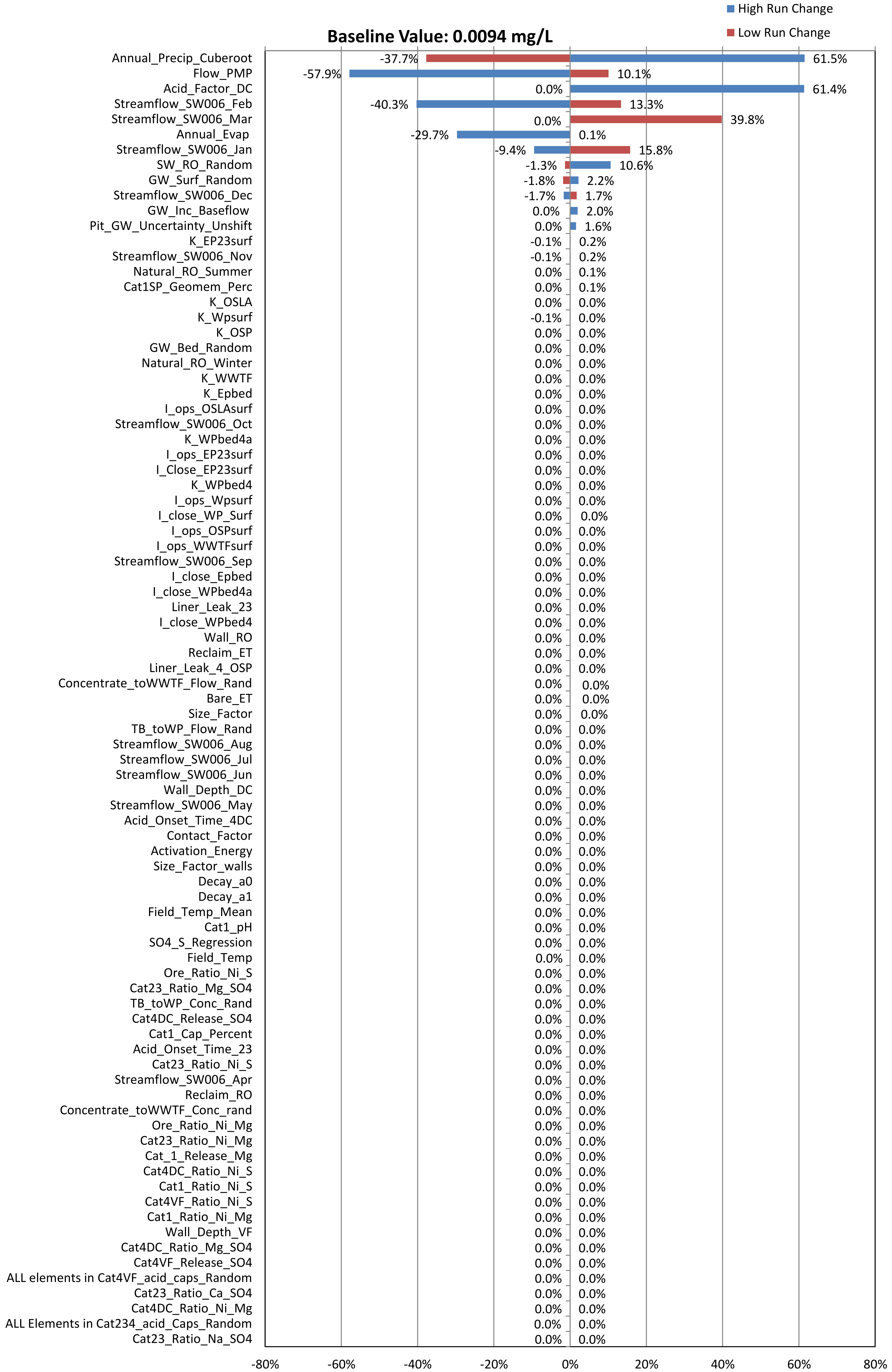

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
As in the Partridge River at SW004b
Baseline Value: 0.0034 mg/L
High Run Change
Low Run Change
Flow_PMP -14.1% 72.0%
Streamflow_SW006_Feb -40.0% 11.9%
Annual_Precip_Cuberoot -17.7% 28.7%
Streamflow_SW006_Mar 0.0% 42.2%
Streamflow_SW006_Jan -12.6% 18.1%
Acid_Factor_DC 0.0% 28.6%
Annual_Evap -13.3% 0.0%
Streamflow_SW006_Dec -3.6% 2.8%
GW_Surf_Random -1.4% 1.6%
GW_Inc_Baseflow 0.0% 2.0%
SW_RO_Random -0.4% 0.6%
Streamflow_SW006_Nov -0.4% 0.4%
K_EP23surf -0.1% 0.2%
Cat1SP_Geomem_Perc 0.0% 0.1%
K_OSLA 0.0% 0.0%
K_Wpsurf -0.1% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
Pit_GW_Uncertainty_Unshift 0.0% 0.0%
Natural_RO_Summer 0.0% 0.0%
K_OSP 0.0% 0.0%
Natural_RO_Winter 0.0% 0.0%
K_WWTF 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
I_Close_EP23surf 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
K_Epbed 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
K_WPbed4 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
Streamflow_SW006_Aug 0.0% 0.0%
Bare_ET 0.0% 0.0%
Concentrate_toWWTF_Flow_Rand 0.0% 0.0%
Size_Factor 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
Wall_RO 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
TB_toWP_Flow_Rand 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Streamflow_SW006_Jul 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Size_Factor_walls 0.0% 0.0%
Wall_Depth_DC 0.0% 0.0%
Activation_Energy 0.0% 0.0%
Decay_a0 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Field_Temp 0.0% 0.0%
Decay_a1 0.0% 0.0%
Contact_Factor 0.0% 0.0%
Cat23_Ratio_As_S 0.0% 0.0%
Cat4DC_Release_SO4 0.0% 0.0%
Field_Temp_Mean 0.0% 0.0%
SO4_S_Regression 0.0% 0.0%
Acid_Onset_Time_4DC 0.0% 0.0%
Acid_Onset_Time_23 0.0% 0.0%
Ore_Ratio_As_S 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.0%
TB_toWP_Conc_Rand 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
Cat4DC_Ratio_As_S 0.0% 0.0%
Cat_1_Release_As 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
Cat23_Ratio_Mg_SO4 0.0% 0.0%
Cat4VF_Release_SO4 0.0% 0.0%
Cat4VF_Ratio_As_S 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
Wall_Depth_VF 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
-50% -30% -10% 10% 30% 50% 70% 90%

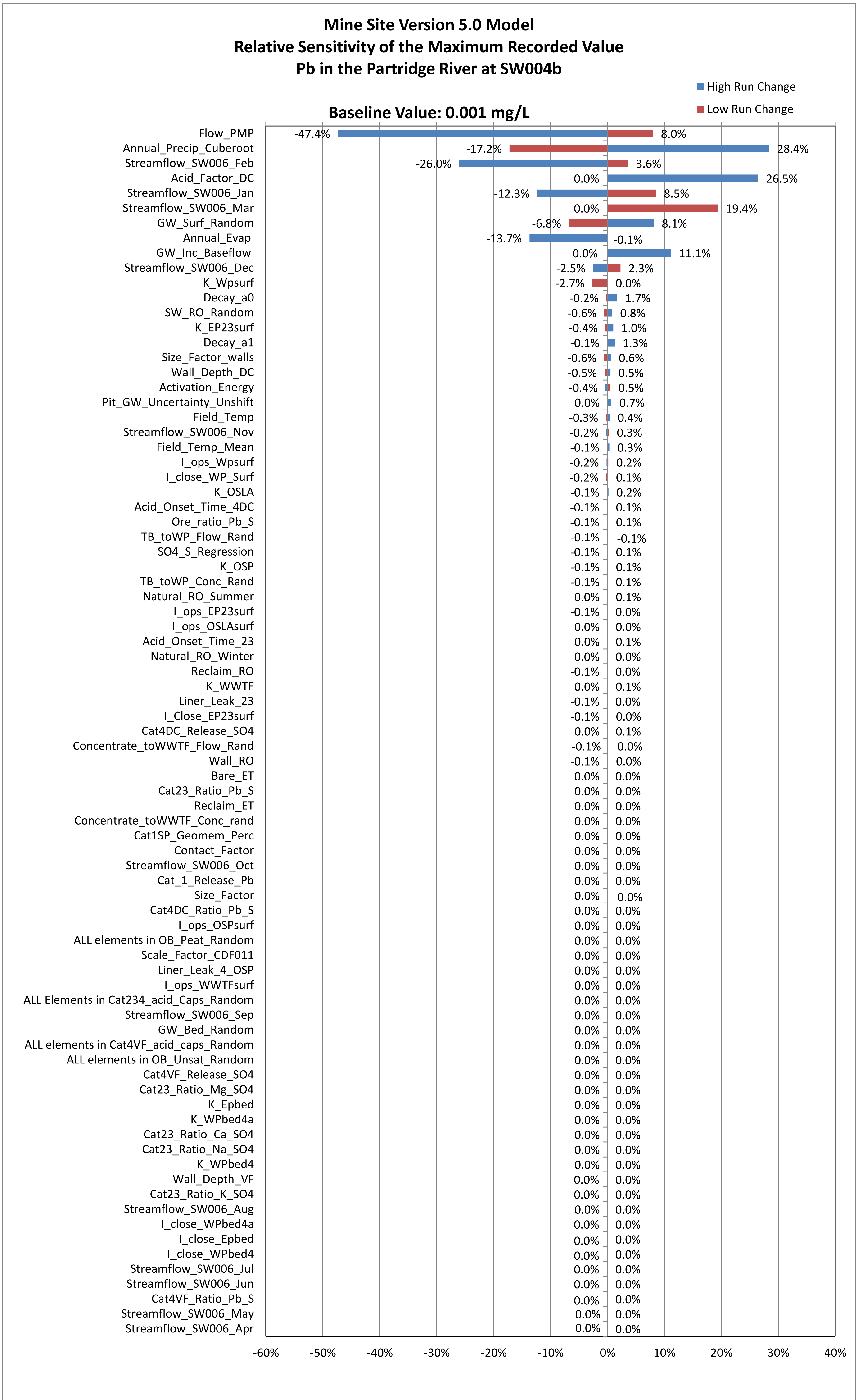

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Cl in the Partridge River at SW004b
High Run Change
Low Run Change
Baseline Value: 10.0035 mg/L
SW_RO_Random -9.4% 339.1%
Flow_PMP -5.7% 0.3%
GW_Inc_Baseflow -6.0% 0.0%
Streamflow_SW006_Apr -1.2% 3.1%
Streamflow_SW006_May -1.1% 2.8%
Streamflow_SW006_Jul 0.0% 2.8%
Streamflow_SW006_Oct 0.0% 2.7%
Streamflow_SW006_Jun 0.0% 2.4%
Streamflow_SW006_Aug 0.0% 2.2%
Streamflow_SW006_Nov 0.0% 2.0%
Streamflow_SW006_Sep 0.0% 1.7%
Acid_Factor_DC 0.0% 0.4%
All_Release_Cl 0.0% 0.2%
Concentrate_toWWTF_Conc_rand -0.1% 0.1%
Size_Factor -0.1% 0.1%
Annual_Precip_Cuberoot 0.1% 0.1%
Annual_Evap 0.1% 0.0%
Streamflow_SW006_Mar 0.0% 0.1%
TB_toWP_Conc_Rand -0.1% 0.1%
TB_toWP_Flow_Rand 0.0% 0.1%
Concentrate_toWWTF_Flow_Rand 0.0% 0.0%
GW_Surf_Random 0.0% 0.0%
Natural_RO_Summer 0.0% 0.0%
Pit_GW_Uncertainty_Unshift 0.0% 0.0%
Natural_RO_Winter 0.0% 0.0%
Contact_Factor 0.0% 0.0%
Wall_RO 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
I_Close_EP23surf 0.0% 0.0%
Cat1SP_Geomem_Perc 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Bare_ET 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
Cat4VF_Release_SO4 0.0% 0.0%
Cat4DC_Release_SO4 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Cat23_Ratio_Mg_SO4 0.0% 0.0%
SO4_S_Regression 0.0% 0.0%
Acid_Onset_Time_23 0.0% 0.0%
Streamflow_SW006_Feb 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
K_OSLA 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Size_Factor_walls 0.0% 0.0%
K_EP23surf 0.0% 0.0%
Field_Temp 0.0% 0.0%
Wall_Depth_VF 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
Streamflow_SW006_Jan 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
ALL elements in OB_Peat_Random 0.0% 0.0%
Streamflow_SW006_Dec 0.0% 0.0%
ALL elements in OB_Unsat_Random 0.0% 0.0%
K_WPbed4 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
K_Epbed 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
K_OSP 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
K_WWTF 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
-50%
0%
50%
100%
150%
200%
250%
300%
350%
400%

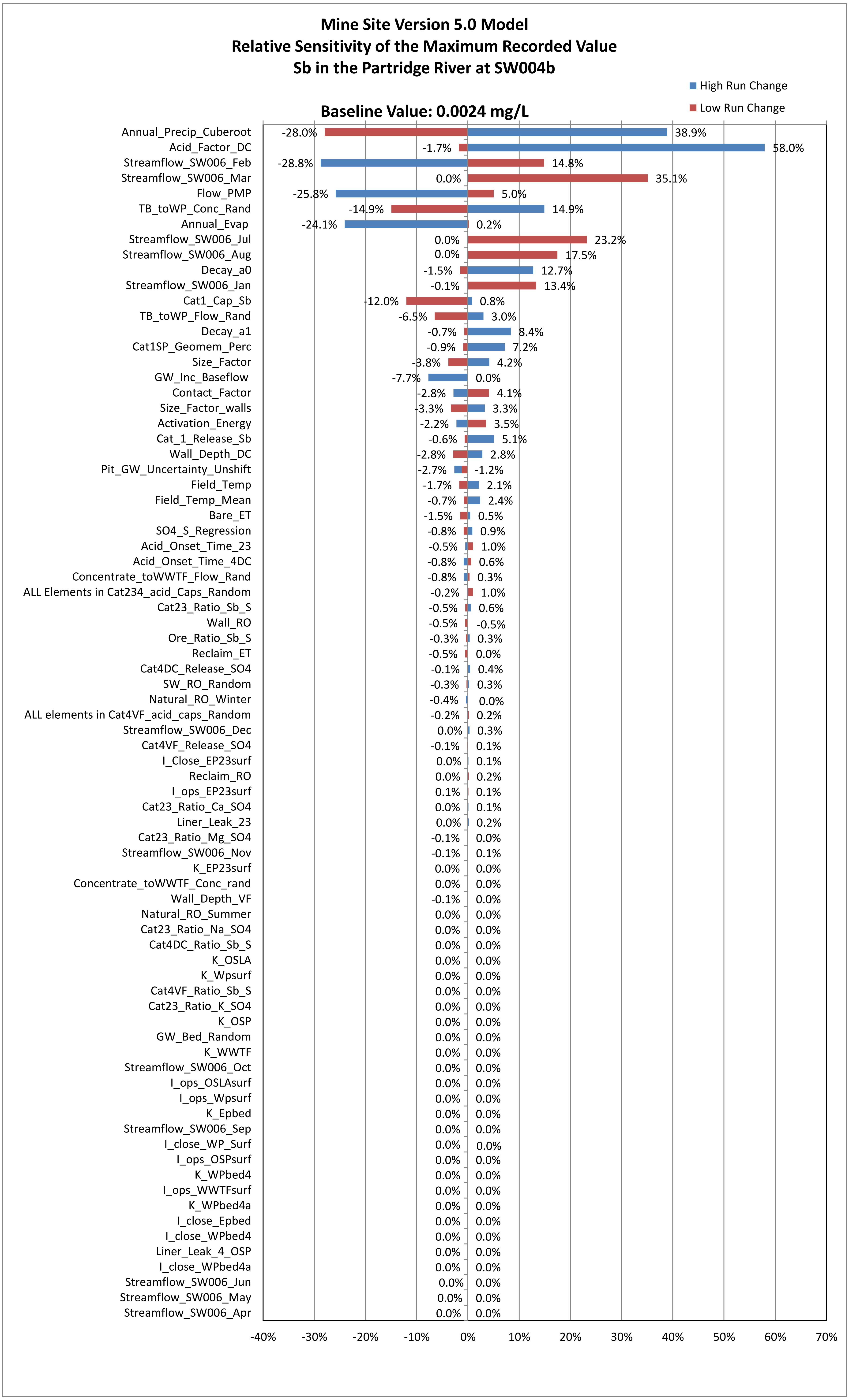

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Co in the Partridge River at SW004b
High Run Change
Low Run Change
Baseline Value: 0.0015 mg/L
Flow_PMP -48.5% 7.1%
Annual_Precip_Cuberoot -14.2% 26.3%
Streamflow_SW006_Feb -30.5% 7.6%
Streamflow_SW006_Mar 0.0% 27.5%
Acid_Factor_DC -2.3% 23.5%
Streamflow_SW006_Jan -10.4% 11.6%
K_EP23surf -5.2% 14.6%
Cat23_Ratio_Co_Ni -5.7% 10.2%
Annual_Evap -14.6% -0.7%
GW_Surf_Random -5.8% 7.3%
Decay_a0 -1.1% 9.4%
Decay_a1 -0.5% 9.0%
Contact_Factor -4.4% 3.9%
Pit_GW_Uncertainty_Unshift -4.4% -1.5%
SW_RO_Random -1.6% 4.3%
GW_Inc_Baseflow 0.0% 5.6%
I_ops_EP23surf -2.6% 2.9%
Size_Factor -2.3% 3.0%
K_Wpsurf -5.0% 0.0%
I_Close_EP23surf -2.3% 2.6%
Size_Factor_walls -2.3% 2.4%
Streamflow_SW006_Dec -2.1% 2.0%
Activation_Energy -1.6% 2.5%
Wall_Depth_DC -1.8% 1.9%
Wall_RO -1.9% -1.3%
Field_Temp -1.2% 1.6%
Field_Temp_Mean -0.5% 2.0%
Natural_RO_Summer -1.7% -0.4%
Concentrate_toWWTF_Flow_Rand -1.2% -0.5%
Bare_ET -0.3% -1.3%
SO4_S_Regression -0.7% 0.7%
Acid_Onset_Time_4DC -0.7% 0.5%
TB_toWP_Flow_Rand -0.3% 0.9%
Cat4DC_Release_SO4 -0.2% 0.9%
Cat23_Ratio_Ni_S -0.6% 0.6%
Cat23_Ratio_Mg_SO4 -0.2% 0.8%
Acid_Onset_Time_23 -0.4% 0.5%
Cat4DC_Ratio_Co_Ni -0.1% 0.7%
Liner_Leak_4_OSP -0.1% 0.6%
I_ops_Wpsurf -0.3% 0.3%
Cat1SP_Geomem_Perc -0.4% 0.0%
Natural_RO_Winter -0.3% 0.1%
Wall_Depth_VF -0.2% 0.2%
I_close_WP_Surf -0.2% 0.2%
Ore_Ratio_Ni_S -0.2% 0.2%
Streamflow_SW006_Nov -0.2% 0.2%
Cat4VF_Ratio_Co_S -0.2% 0.2%
Liner_Leak_23 0.0% 0.3%
Cat1_Ratio_Co_Ni -0.1% 0.2%
Cat23_Ratio_Ni_Mg -0.2% 0.1%
Reclaim_ET -0.2% 0.1%
K_OSLA -0.1% 0.1%
K_OSP -0.2% 0.0%
TB_toWP_Conc_Rand -0.1% 0.1%
Reclaim_RO 0.0% 0.1%
ALL Elements in Cat234_acid_Caps_Random -0.1% 0.0%
Cat1_pH 0.0% 0.1%
Cat4VF_Release_SO4 -0.1% 0.0%
Cat4DC_Ratio_Ni_S 0.0% 0.0%
K_WWTF -0.1% 0.0%
Cat_1_Release_Mg 0.0% 0.1%
Ore_Ratio_Ni_Mg 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Cat1_Ratio_Ni_S 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Cat1_Ratio_Ni_Mg 0.0% 0.0%
Cat4DC_Ratio_Mg_SO4 0.0% 0.0%
ALL elements in OB_Unsat_Random 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Cat4DC_Ratio_Ni_Mg 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Ore_Ratio_Co_NI 0.0% 0.0%
ALL elements in OB_Peat_Random 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
Cat1_Cap_Percent 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
K_Epbed 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
K_WPbed4 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Streamflow_SW006_Aug 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
Ore_Ratio_Mg_SO4 0.0% 0.0%
Streamflow_SW006_Jul 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
-50% -40% -30% -20% -10% 0% 10% 20% 30% 40%

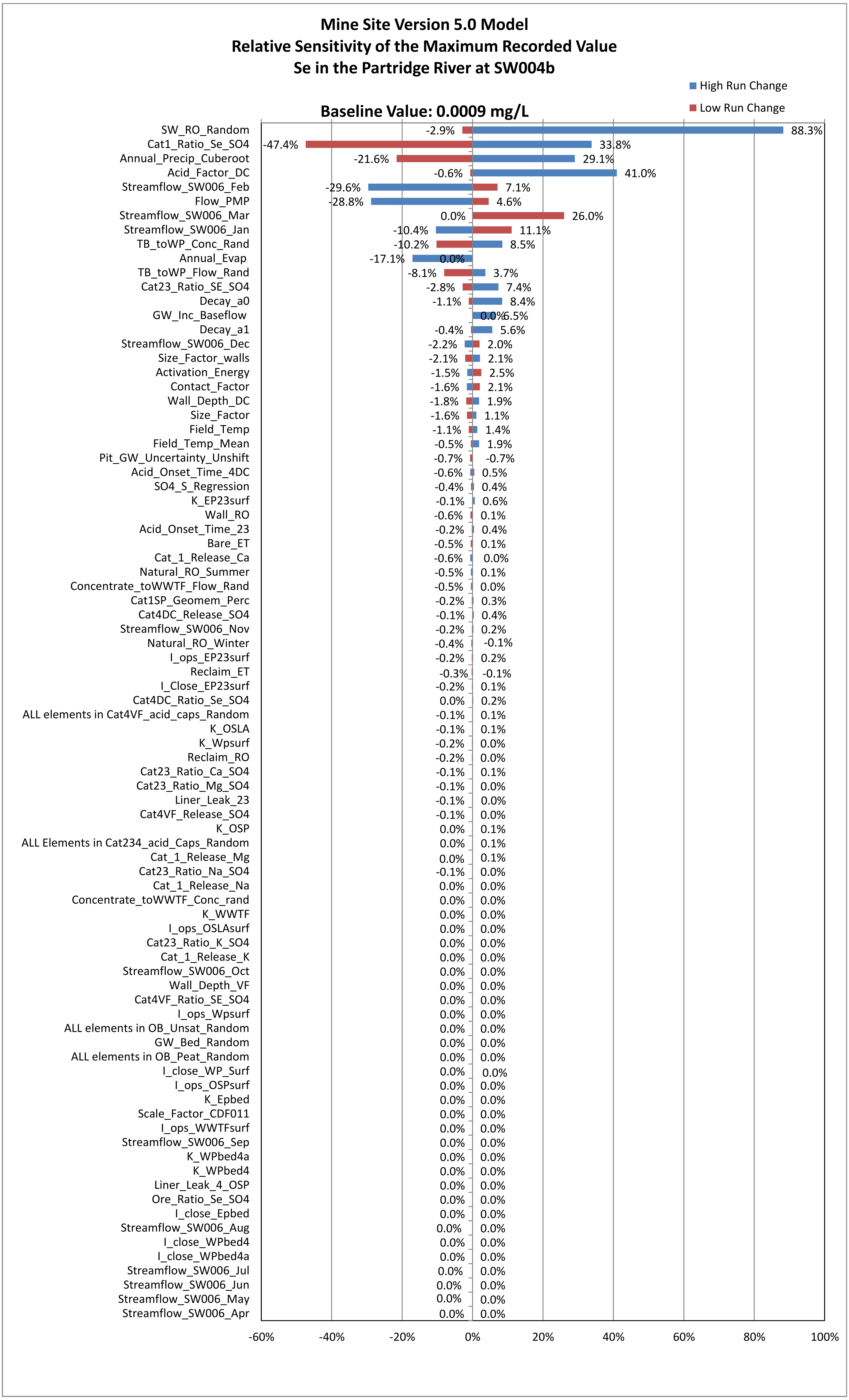

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Cu in the Partridge River at SW004b
Baseline Value: 0.0033 mg/L
High Run Change
Low Run Change
SW_RO_Random -1.7% 84.4%
Annual_Precip_Cuberoot -15.1% 41.1%
Flow_PMP -35.5% 5.7%
Streamflow_SW006_Feb -24.4% 2.3%
Acid_Factor_DC 0.0% 24.6%
Streamflow_SW006_Jan -13.0% 7.9%
GW_Surf_Random -7.9% 9.6%
Streamflow_SW006_Mar 0.0% 17.2%
GW_Inc_Baseflow 0.0% 12.3%
Annual_Evap -11.7% 0.0%
Streamflow_SW006_Dec -2.8% 2.5%
K_EP23surf -0.4% 0.7%
Pit_GW_Uncertainty_Unshift 0.0% 0.7%
Streamflow_SW006_Nov -0.2% 0.3%
K_OSLA -0.1% 0.2%
K_Wpsurf -0.3% 0.0%
K_OSP -0.1% 0.1%
K_WWTF 0.0% 0.1%
I_ops_OSLAsurf 0.0% 0.0%
Natural_RO_Summer 0.0% 0.0%
Cat1SP_Geomem_Perc 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
I_Close_EP23surf 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
Natural_RO_Winter 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
K_Epbed 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
K_WPbed4 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
Streamflow_SW006_Aug 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
Wall_RO 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
Streamflow_SW006_Jul 0.0% 0.0%
Concentrate_toWWTF_Flow_Rand 0.0% 0.0%
Bare_ET 0.0% 0.0%
Size_Factor 0.0% 0.0%
TB_toWP_Flow_Rand 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
Cat1_pH 0.0% 0.0%
Cat1_Cap_Percent 0.0% 0.0%
-50% -30% -10% 10% 30% 50% 70% 90% 110%

**Mine Site Version 5.0 Model**
**Relative Sensitivity of the Maximum Recorded Value**
**Ni in the Partridge River at SW004b**



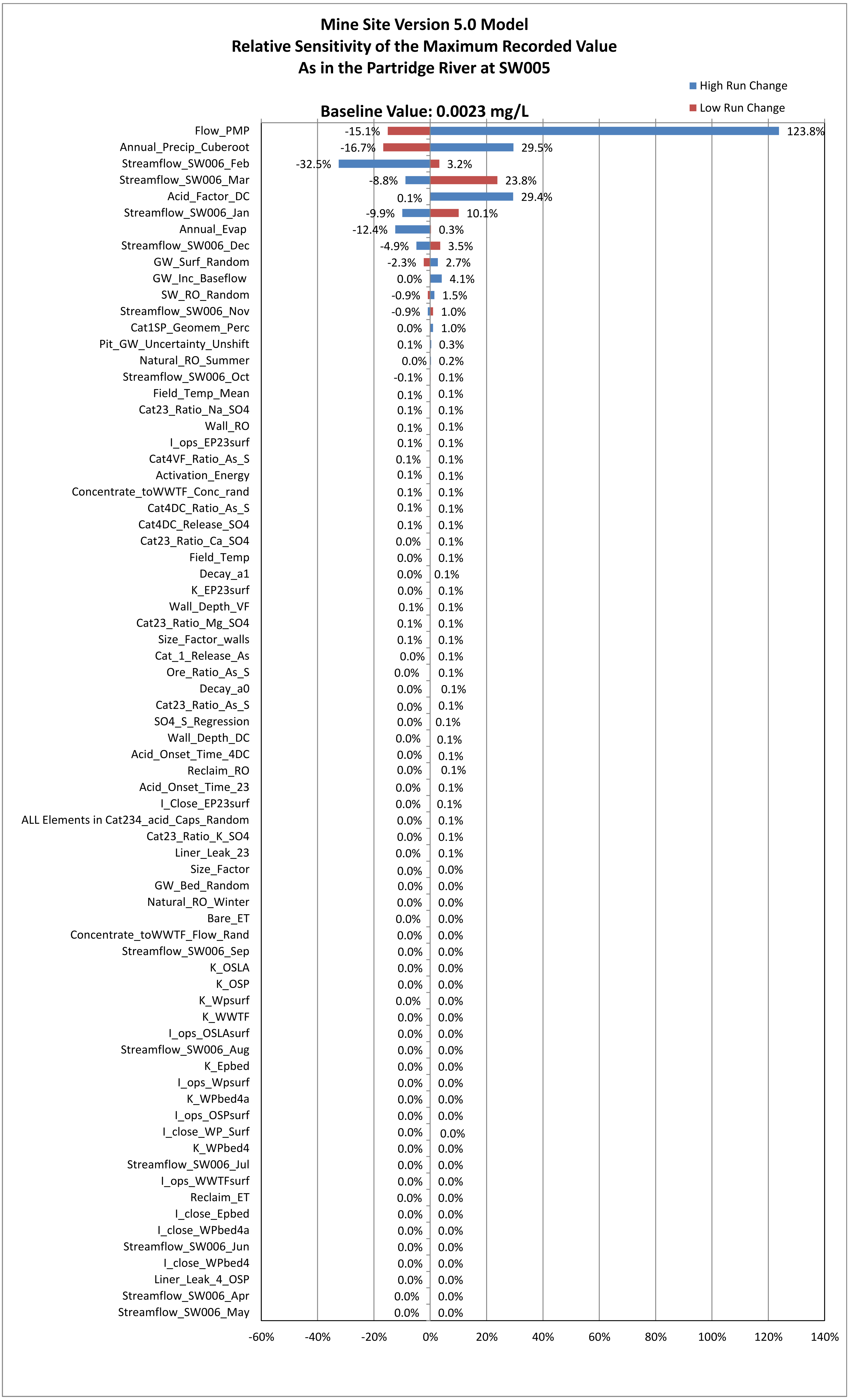

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Pb in the Partridge River at SW004b
High Run Change
Low Run Change
Baseline Value: 0.001 mg/L
Flow_PMP -47.4% 8.0%
Annual_Precip_Cuberoot -17.2% 28.4%
Streamflow_SW006_Feb -26.0% 3.6%
Acid_Factor_DC 0.0% 26.5%
Streamflow_SW006_Jan -12.3% 8.5%
Streamflow_SW006_Mar 0.0% 19.4%
GW_Surf_Random -6.8% 8.1%
Annual_Evap -13.7% -0.1%
GW_Inc_Baseflow 0.0% 11.1%
Streamflow_SW006_Dec -2.5% 2.3%
K_Wpsurf -2.7% 0.0%
Decay_a0 -0.2% 1.7%
SW_RO_Random -0.6% 0.8%
K_EP23surf -0.4% 1.0%
Decay_a1 -0.1% 1.3%
Size_Factor_walls -0.6% 0.6%
Wall_Depth_DC -0.5% 0.5%
Activation_Energy -0.4% 0.5%
Pit_GW_Uncertainty_Unshift 0.0% 0.7%
Field_Temp -0.3% 0.4%
Streamflow_SW006_Nov -0.2% 0.3%
Field_Temp_Mean -0.1% 0.3%
I_ops_Wpsurf -0.2% 0.2%
I_close_WP_Surf -0.2% 0.1%
K_OSLA -0.1% 0.2%
Acid_Onset_Time_4DC -0.1% 0.1%
Ore_ratio_Pb_S -0.1% 0.1%
TB_toWP_Flow_Rand -0.1% -0.1%
SO4_S_Regression -0.1% 0.1%
K_OSP -0.1% 0.1%
TB_toWP_Conc_Rand -0.1% 0.1%
Natural_RO_Summer 0.0% 0.1%
I_ops_EP23surf -0.1% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Acid_Onset_Time_23 0.0% 0.1%
Natural_RO_Winter 0.0% 0.0%
Reclaim_RO -0.1% 0.0%
K_WWTF 0.0% 0.1%
Liner_Leak_23 -0.1% 0.0%
I_Close_EP23surf -0.1% 0.0%
Cat4DC_Release_SO4 0.0% 0.1%
Concentrate_toWWTF_Flow_Rand -0.1% 0.0%
Wall_RO -0.1% 0.0%
Bare_ET 0.0% 0.0%
Cat23_Ratio_Pb_S 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
Cat1SP_Geomem_Perc 0.0% 0.0%
Contact_Factor 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
Cat_1_Release_Pb 0.0% 0.0%
Size_Factor 0.0% 0.0%
Cat4DC_Ratio_Pb_S 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
ALL elements in OB_Peat_Random 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
ALL elements in OB_Unsat_Random 0.0% 0.0%
Cat4VF_Release_SO4 0.0% 0.0%
Cat23_Ratio_Mg_SO4 0.0% 0.0%
K_Epbed 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
K_WPbed4 0.0% 0.0%
Wall_Depth_VF 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
Streamflow_SW006_Aug 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Streamflow_SW006_Jul 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Cat4VF_Ratio_Pb_S 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
-60%
-50%
-40%
-30%
-20%
-10%
0%
10%
20%
30%
40%


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Sb in the Partridge River at SW004b
Baseline Value: 0.0024 mg/L
High Run Change
Low Run Change
Annual_Precip_Cuberoot -28.0% 38.9%
Acid_Factor_DC -1.7% 58.0%
Streamflow_SW006_Feb -28.8% 14.8%
Streamflow_SW006_Mar 0.0% 35.1%
Flow_PMP -25.8% 5.0%
TB_toWP_Conc_Rand -14.9% 14.9%
Annual_Evap -24.1% 0.2%
Streamflow_SW006_Jul 0.0% 23.2%
Streamflow_SW006_Aug 0.0% 17.5%
Decay_a0 -1.5% 12.7%
Streamflow_SW006_Jan -0.1% 13.4%
Cat1_Cap_Sb -12.0% 0.8%
TB_toWP_Flow_Rand -6.5% 3.0%
Decay_a1 -0.7% 8.4%
Cat1SP_Geomem_Perc -0.9% 7.2%
Size_Factor -3.8% 4.2%
GW_Inc_Baseflow -7.7% 0.0%
Contact_Factor -2.8% 4.1%
Size_Factor_walls -3.3% 3.3%
Activation_Energy -2.2% 3.5%
Cat_1_Release_Sb -0.6% 5.1%
Wall_Depth_DC -2.8% 2.8%
Pit_GW_Uncertainty_Unshift -2.7% -1.2%
Field_Temp -1.7% 2.1%
Field_Temp_Mean -0.7% 2.4%
Bare_ET -1.5% 0.5%
SO4_S_Regression -0.8% 0.9%
Acid_Onset_Time_23 -0.5% 1.0%
Acid_Onset_Time_4DC -0.8% 0.6%
Concentrate_toWWTF_Flow_Rand -0.8% 0.3%
ALL Elements in Cat234_acid_Caps_Random -0.2% 1.0%
Cat23_Ratio_Sb_S -0.5% 0.6%
Wall_RO -0.5% -0.5%
Ore_Ratio_Sb_S -0.3% 0.3%
Reclaim_ET -0.5% 0.0%
Cat4DC_Release_SO4 -0.1% 0.4%
SW_RO_Random -0.3% 0.3%
Natural_RO_Winter -0.4% 0.0%
ALL elements in Cat4VF_acid_caps_Random -0.2% 0.2%
Streamflow_SW006_Dec 0.0% 0.3%
Cat4VF_Release_SO4 -0.1% 0.1%
I_Close_EP23surf 0.0% 0.1%
Reclaim_RO 0.0% 0.2%
I_ops_EP23surf 0.1% 0.1%
Cat23_Ratio_Ca_SO4 0.0% 0.1%
Liner_Leak_23 0.0% 0.2%
Cat23_Ratio_Mg_SO4 -0.1% 0.0%
Streamflow_SW006_Nov -0.1% 0.1%
K_EP23surf 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
Wall_Depth_VF -0.1% 0.0%
Natural_RO_Summer 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
Cat4DC_Ratio_Sb_S 0.0% 0.0%
K_OSLA 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
Cat4VF_Ratio_Sb_S 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
K_OSP 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
K_WWTF 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
K_Epbed 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
K_WPbed4 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
-40% -30% -20% -10% 0% 10% 20% 30% 40% 50% 60% 70%

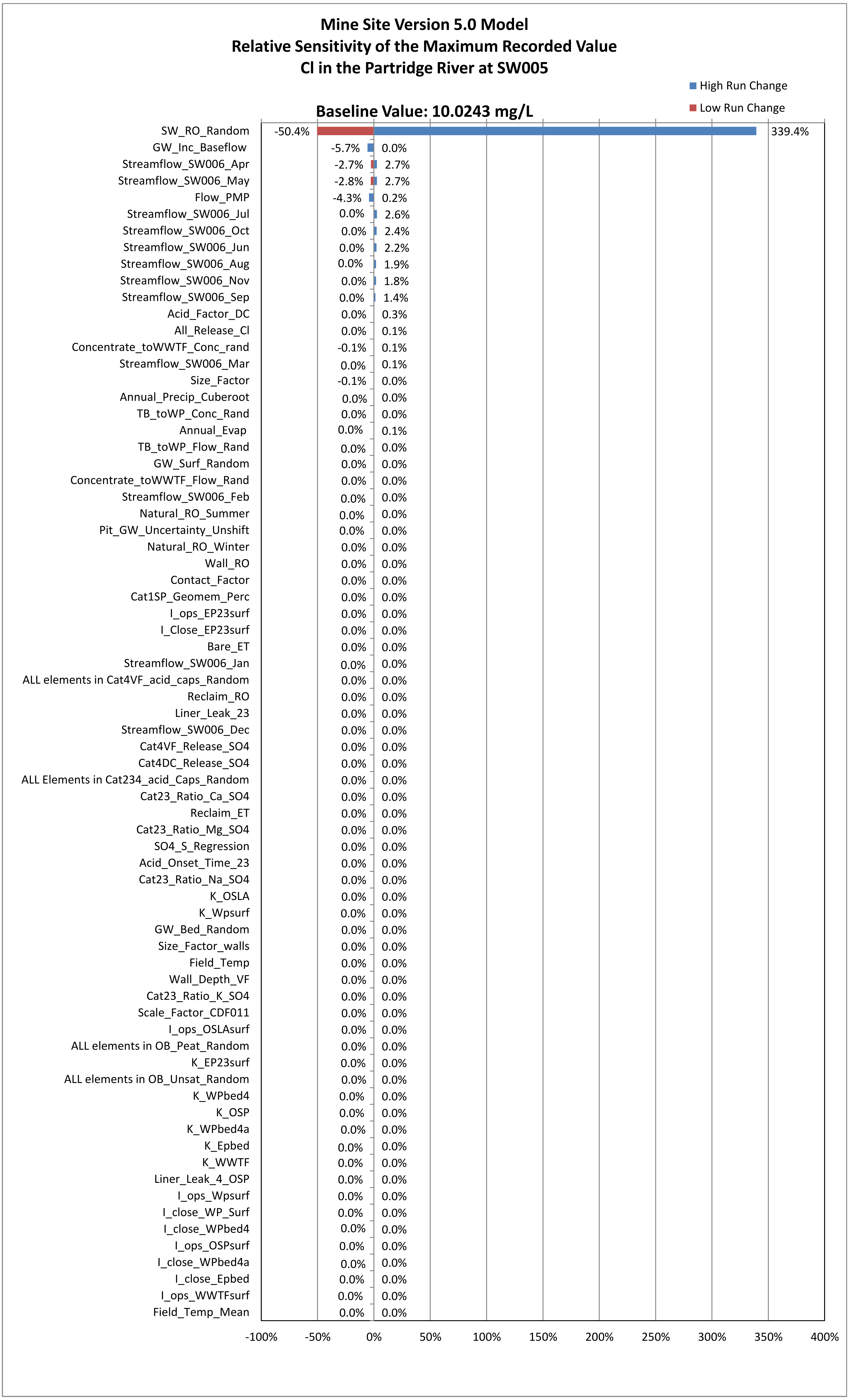


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Se in the Partridge River at SW004b
Baseline Value: 0.0009 mg/L
High Run Change
Low Run Change
SW_RO_Random
Cat1_Ratio_Se_SO4
Annual_Precip_Cuberoot
Acid_Factor_DC
Streamflow_SW006_Feb
Flow_PMP
Streamflow_SW006_Mar
Streamflow_SW006_Jan
TB_toWP_Conc_Rand
Annual_Evap
TB_toWP_Flow_Rand
Cat23_Ratio_SE_SO4
Decay_a0
GW_Inc_Baseflow
Decay_a1
Streamflow_SW006_Dec
Size_Factor_walls
Activation_Energy
Contact_Factor
Wall_Depth_DC
Size_Factor
Field_Temp
Field_Temp_Mean
Pit_GW_Uncertainty_Unshift
Acid_Onset_Time_4DC
SO4_S_Regression
K_EP23surf
Wall_RO
Acid_Onset_Time_23
Bare_ET
Cat_1_Release_Ca
Natural_RO_Summer
Concentrate_toWWTF_Flow_Rand
Cat1SP_Geomem_Perc
Cat4DC_Release_SO4
Streamflow_SW006_Nov
Natural_RO_Winter
I_ops_EP23surf
Reclaim_ET
I_Close_EP23surf
Cat4DC_Ratio_Se_SO4
ALL elements in Cat4VF_acid_caps_Random
K_OSLA
K_Wpsurf
Reclaim_RO
Cat23_Ratio_Ca_SO4
Cat23_Ratio_Mg_SO4
Liner_Leak_23
Cat4VF_Release_SO4
K_OSP
ALL Elements in Cat234_acid_Caps_Random
Cat_1_Release_Mg
Cat23_Ratio_Na_SO4
Cat_1_Release_Na
Concentrate_toWWTF_Conc_rand
K_WWTF
I_ops_OSLAsurf
Cat23_Ratio_K_SO4
Cat_1_Release_K
Streamflow_SW006_Oct
Wall_Depth_VF
Cat4VF_Ratio_SE_SO4
I_ops_Wpsurf
ALL elements in OB_Unsat_Random
GW_Bed_Random
ALL elements in OB_Peat_Random
I_close_WP_Surf
I_ops_OSPsurf
K_Epbed
Scale_Factor_CDF011
I_ops_WWTFsurf
Streamflow_SW006_Sep
K_WPbed4a
K_WPbed4
Liner_Leak_4_OSP
Ore_Ratio_Se_SO4
I_close_Epbed
Streamflow_SW006_Aug
I_close_WPbed4
I_close_WPbed4a
Streamflow_SW006_Jul
Streamflow_SW006_Jun
Streamflow_SW006_May
Streamflow_SW006_Apr
-2.9% 88.3%
-47.4% 33.8%
-21.6% 29.1%
-0.6% 41.0%
-29.6% 7.1%
-28.8% 4.6%
0.0% 26.0%
-10.4% 11.1%
-10.2% 8.5%
-17.1% 0.0%
-8.1% 3.7%
-2.8% 7.4%
-1.1% 8.4%
0.0% 6.5%
-0.4% 5.6%
-2.2% 2.0%
-2.1% 2.1%
-1.5% 2.5%
-1.6% 2.1%
-1.8% 1.9%
-1.6% 1.1%
-1.1% 1.4%
-0.5% 1.9%
-0.7% -0.7%
-0.6% 0.5%
-0.4% 0.4%
-0.1% 0.6%
-0.6% 0.1%
-0.2% 0.4%
-0.5% 0.1%
-0.6% 0.0%
-0.5% 0.1%
-0.5% 0.0%
-0.2% 0.3%
-0.1% 0.4%
-0.2% 0.2%
-0.4% -0.1%
-0.2% 0.2%
-0.3% -0.1%
-0.2% 0.1%
0.0% 0.2%
-0.1% 0.1%
-0.1% 0.1%
-0.2% 0.0%
-0.2% 0.0%
-0.1% 0.1%
-0.1% 0.0%
-0.1% 0.0%
-0.1% 0.0%
0.0% 0.1%
0.0% 0.1%
0.0% 0.1%
-0.1% 0.0%
0.0% 0.0%
-60% -40% -20% 0% 20% 40% 60% 80% 100%

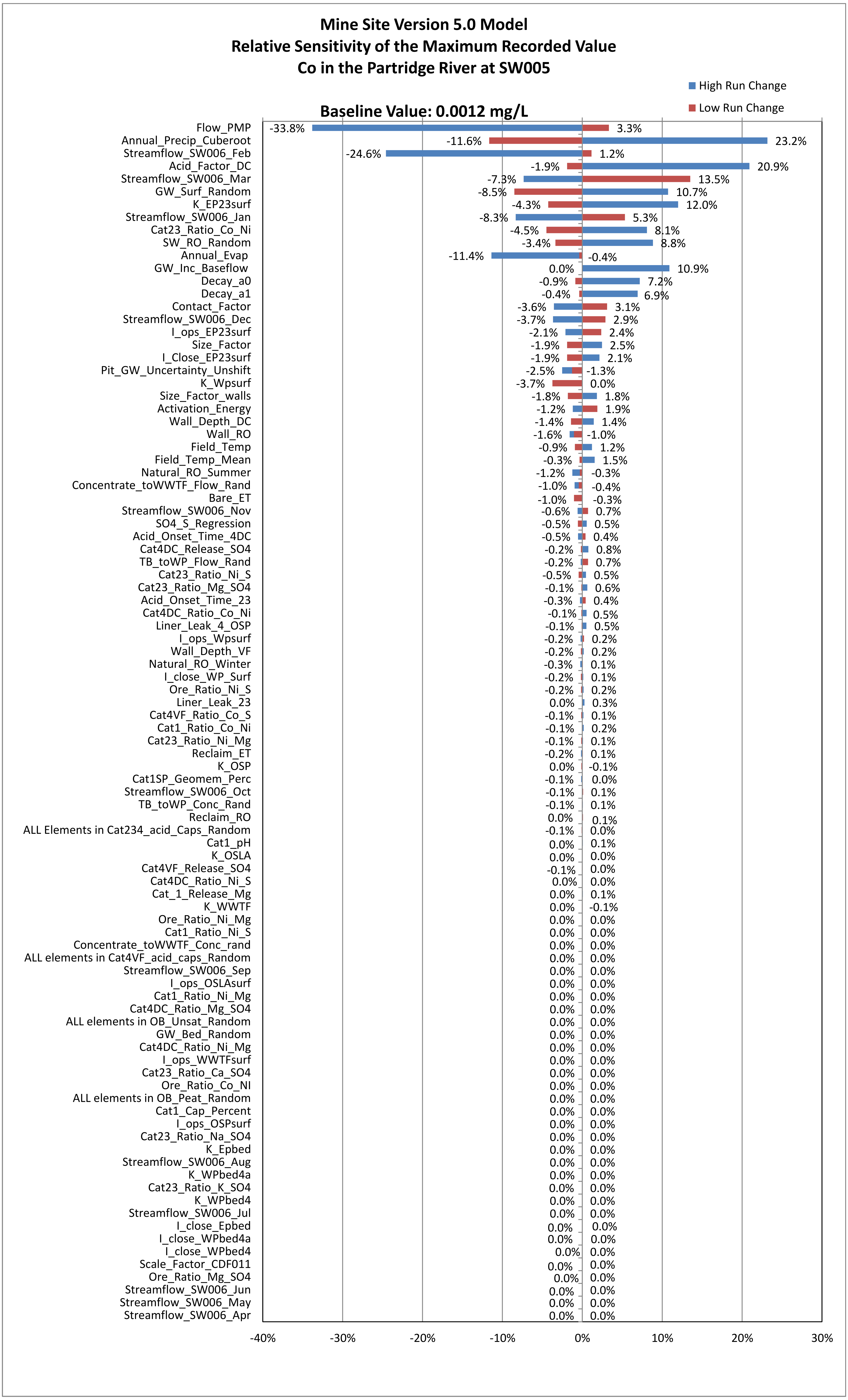

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
SO4 in the Partridge River at SW004b
High Run Change
Low Run Change
Baseline Value: 12.1428 mg/L
SW_RO_Random -3.2% 520.5%
Flow_PMP -12.4% 63.1%
Streamflow_SW006_Jan -10.9% 12.4%
Streamflow_SW006_Feb -18.7% 2.4%
Streamflow_SW006_Mar 0.0% 21.0%
GW_Surf_Random -4.8% 5.4%
GW_Inc_Baseflow 0.0% 9.4%
K_EP23surf -0.3% 2.0%
Streamflow_SW006_Dec 0.0% 2.0%
Annual_Precip_Cuberoot 0.0% 1.1%
Acid_Factor_DC 0.0% 1.0%
K_OSLA -0.1% 0.1%
K_OSP -0.1% 0.1%
Annual_Evap 0.0% 0.1%
K_WWTF 0.0% 0.1%
I_ops_EP23surf 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Bare_ET 0.0% 0.0%
-100%
0%
100%
200%
300%
400%
500%
600%

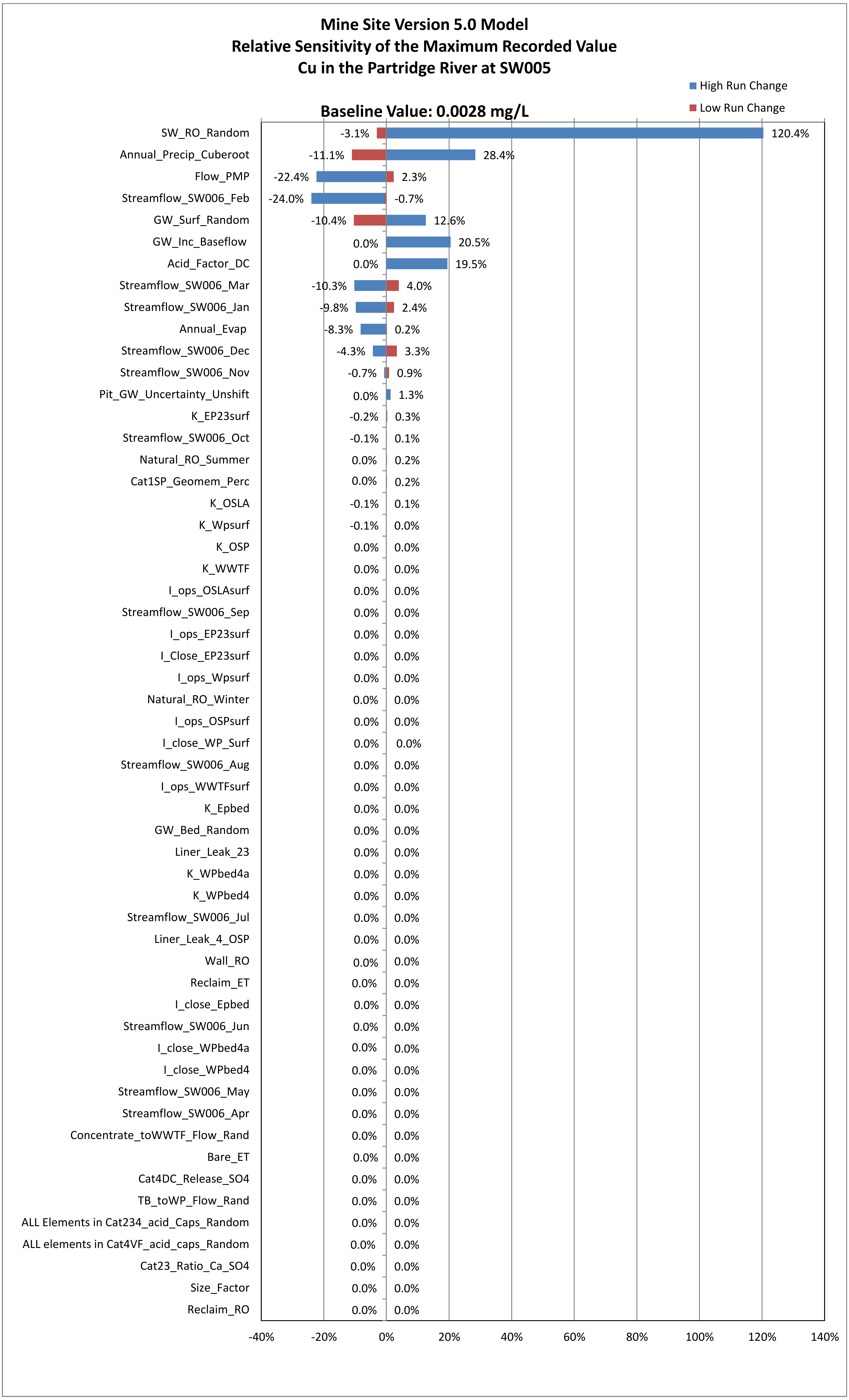


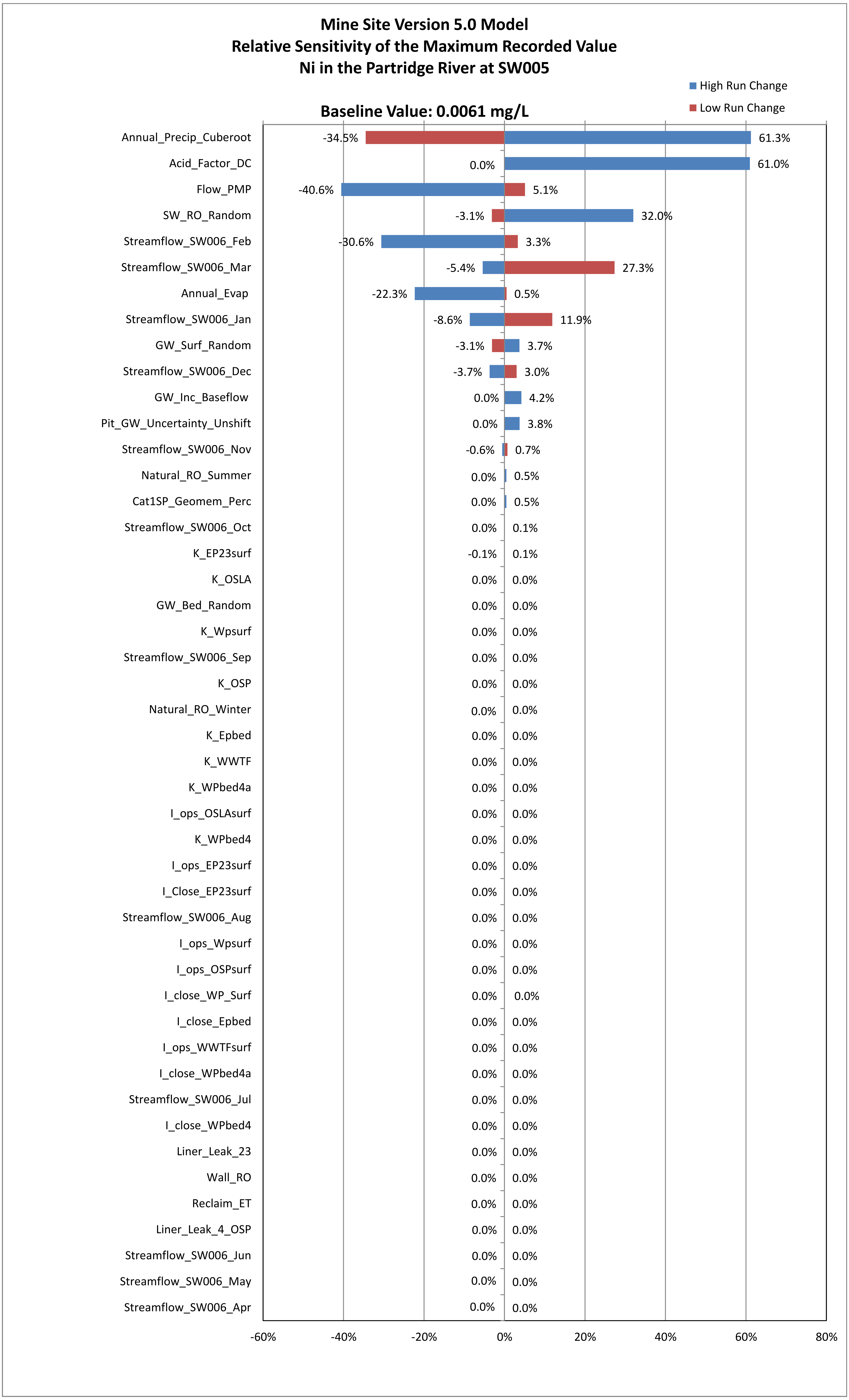
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
As in the Partridge River at SW005
High Run Change
Low Run Change
Baseline Value: 0.0023 mg/L
Flow_PMP -15.1% 123.8%
Annual_Precip_Cuberoot -16.7% 29.5%
Streamflow_SW006_Feb -32.5% 3.2%
Streamflow_SW006_Mar -8.8% 23.8%
Acid_Factor_DC 0.1% 29.4%
Streamflow_SW006_Jan -9.9% 10.1%
Annual_Evap -12.4% 0.3%
Streamflow_SW006_Dec -4.9% 3.5%
GW_Surf_Random -2.3% 2.7%
GW_Inc_Baseflow 0.0% 4.1%
SW_RO_Random -0.9% 1.5%
Streamflow_SW006_Nov -0.9% 1.0%
Cat1SP_Geomem_Perc 0.0% 1.0%
Pit_GW_Uncertainty_Unshift 0.1% 0.3%
Natural_RO_Summer 0.0% 0.2%
Streamflow_SW006_Oct -0.1% 0.1%
Field_Temp_Mean 0.1% 0.1%
Cat23_Ratio_Na_SO4 0.1% 0.1%
Wall_RO 0.1% 0.1%
I_ops_EP23surf 0.1% 0.1%
Cat4VF_Ratio_As_S 0.1% 0.1%
Activation_Energy 0.1% 0.1%
Concentrate_toWWTF_Conc_rand 0.1% 0.1%
Cat4DC_Ratio_As_S 0.1% 0.1%
Cat4DC_Release_SO4 0.1% 0.1%
Cat23_Ratio_Ca_SO4 0.0% 0.1%
Field_Temp 0.0% 0.1%
Decay_a1 0.0% 0.1%
K_EP23surf 0.0% 0.1%
Wall_Depth_VF 0.1% 0.1%
Cat23_Ratio_Mg_SO4 0.1% 0.1%
Size_Factor_walls 0.1% 0.1%
Cat_1_Release_As 0.0% 0.1%
Ore_Ratio_As_S 0.0% 0.1%
Decay_a0 0.0% 0.1%
Cat23_Ratio_As_S 0.0% 0.1%
SO4_S_Regression 0.0% 0.1%
Wall_Depth_DC 0.0% 0.1%
Acid_Onset_Time_4DC 0.0% 0.1%
Reclaim_RO 0.0% 0.1%
Acid_Onset_Time_23 0.0% 0.1%
I_Close_EP23surf 0.0% 0.1%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.1%
Cat23_Ratio_K_SO4 0.0% 0.1%
Liner_Leak_23 0.0% 0.1%
Size_Factor 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Natural_RO_Winter 0.0% 0.0%
Bare_ET 0.0% 0.0%
Concentrate_toWWTF_Flow_Rand 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
K_OSLA 0.0% 0.0%
K_OSP 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
K_WWTF 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Streamflow_SW006_Aug 0.0% 0.0%
K_Epbed 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
K_WPbed4 0.0% 0.0%
Streamflow_SW006_Jul 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
-60% -40% -20% 0% 20% 40% 60% 80% 100% 120% 140%

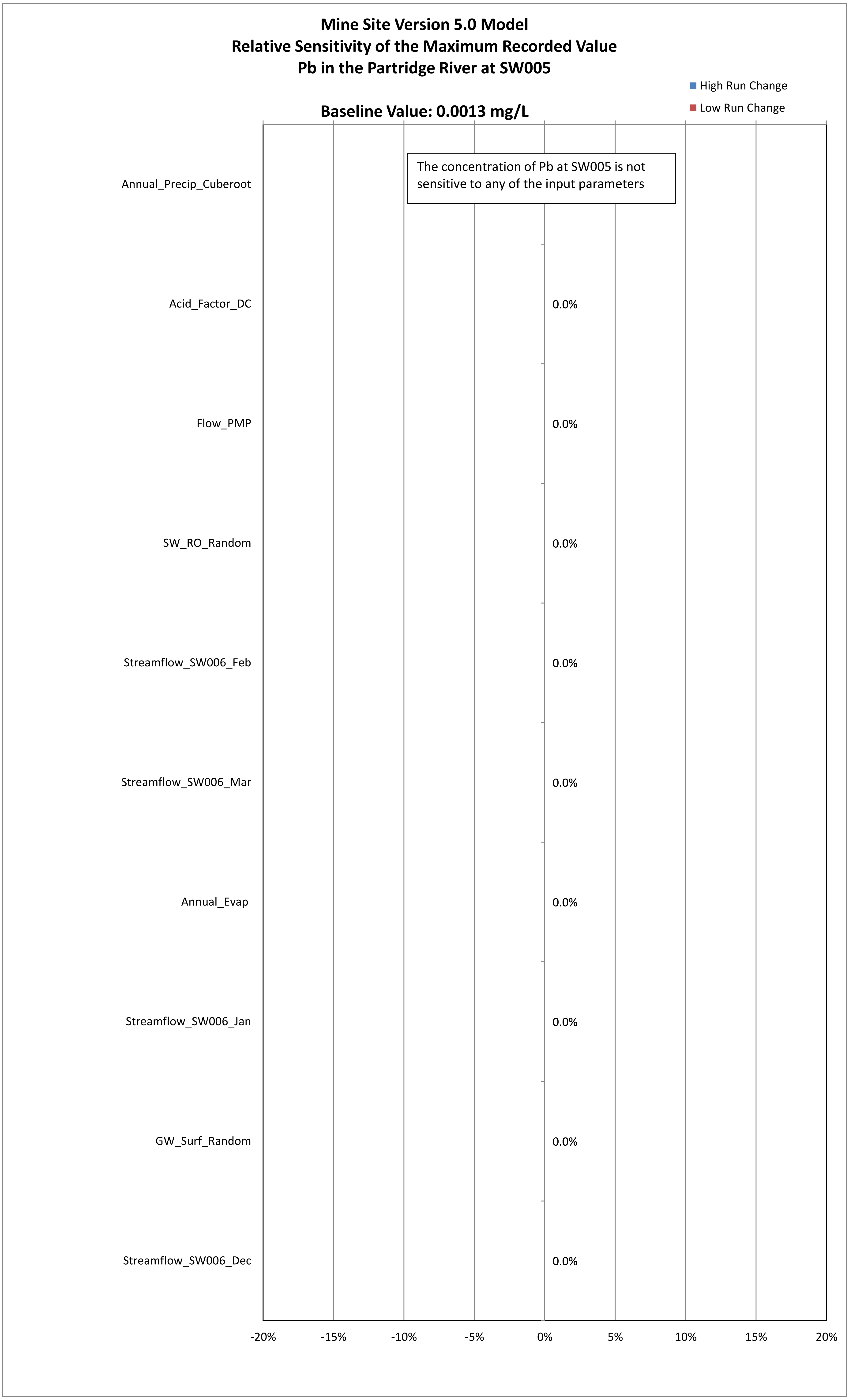


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Cl in the Partridge River at SW005
High Run Change
Low Run Change
Baseline Value: 10.0243 mg/L
SW_RO_Random -50.4% 339.4%
GW_Inc_Baseflow -5.7% 0.0%
Streamflow_SW006_Apr -2.7% 2.7%
Streamflow_SW006_May -2.8% 2.7%
Flow_PMP -4.3% 0.2%
Streamflow_SW006_Jul 0.0% 2.6%
Streamflow_SW006_Oct 0.0% 2.4%
Streamflow_SW006_Jun 0.0% 2.2%
Streamflow_SW006_Aug 0.0% 1.9%
Streamflow_SW006_Nov 0.0% 1.8%
Streamflow_SW006_Sep 0.0% 1.4%
Acid_Factor_DC 0.0% 0.3%
All_Release_Cl 0.0% 0.1%
Concentrate_toWWTF_Conc_rand -0.1% 0.1%
Streamflow_SW006_Mar 0.0% 0.1%
Size_Factor -0.1% 0.0%
Annual_Precip_Cuberoot 0.0% 0.0%
TB_toWP_Conc_Rand 0.0% 0.0%
Annual_Evap 0.0% 0.1%
TB_toWP_Flow_Rand 0.0% 0.0%
GW_Surf_Random 0.0% 0.0%
Concentrate_toWWTF_Flow_Rand 0.0% 0.0%
Streamflow_SW006_Feb 0.0% 0.0%
Natural_RO_Summer 0.0% 0.0%
Pit_GW_Uncertainty_Unshift 0.0% 0.0%
Natural_RO_Winter 0.0% 0.0%
Wall_RO 0.0% 0.0%
Contact_Factor 0.0% 0.0%
Cat1SP_Geomem_Perc 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
I_Close_EP23surf 0.0% 0.0%
Bare_ET 0.0% 0.0%
Streamflow_SW006_Jan 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
Streamflow_SW006_Dec 0.0% 0.0%
Cat4VF_Release_SO4 0.0% 0.0%
Cat4DC_Release_SO4 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
Cat23_Ratio_Mg_SO4 0.0% 0.0%
SO4_S_Regression 0.0% 0.0%
Acid_Onset_Time_23 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
K_OSLA 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Size_Factor_walls 0.0% 0.0%
Field_Temp 0.0% 0.0%
Wall_Depth_VF 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
ALL elements in OB_Peat_Random 0.0% 0.0%
K_EP23surf 0.0% 0.0%
ALL elements in OB_Unsat_Random 0.0% 0.0%
K_WPbed4 0.0% 0.0%
K_OSP 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
K_Epbed 0.0% 0.0%
K_WWTF 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Field_Temp_Mean 0.0% 0.0%
-100% -50% 0% 50% 100% 150% 200% 250% 300% 350% 400%

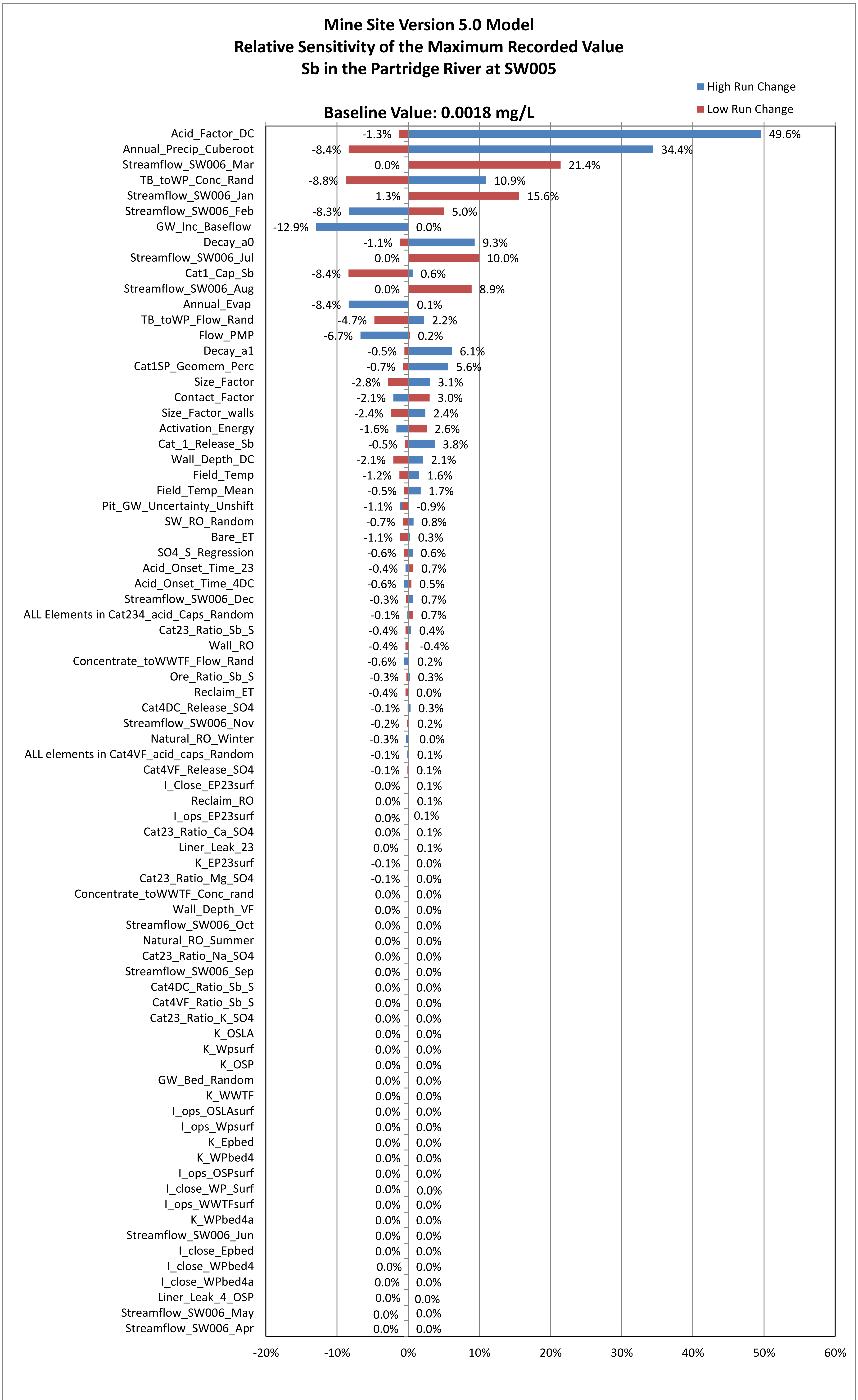

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Co in the Partridge River at SW005
High Run Change
Low Run Change
Baseline Value: 0.0012 mg/L
Flow_PMP -33.8% 3.3%
Annual_Precip_Cuberoot -11.6% 23.2%
Streamflow_SW006_Feb -24.6% 1.2%
Acid_Factor_DC -1.9% 20.9%
Streamflow_SW006_Mar -7.3% 13.5%
GW_Surf_Random -8.5% 10.7%
K_EP23surf -4.3% 12.0%
Streamflow_SW006_Jan -8.3% 5.3%
Cat23_Ratio_Co_Ni -4.5% 8.1%
SW_RO_Random -3.4% 8.8%
Annual_Evap -11.4% -0.4%
GW_Inc_Baseflow 0.0% 10.9%
Decay_a0 -0.9% 7.2%
Decay_a1 -0.4% 6.9%
Contact_Factor -3.6% 3.1%
Streamflow_SW006_Dec -3.7% 2.9%
I_ops_EP23surf -2.1% 2.4%
Size_Factor -1.9% 2.5%
I_Close_EP23surf -1.9% 2.1%
Pit_GW_Uncertainty_Unshift -2.5% -1.3%
K_Wpsurf -3.7% 0.0%
Size_Factor_walls -1.8% 1.8%
Activation_Energy -1.2% 1.9%
Wall_Depth_DC -1.4% 1.4%
Wall_RO -1.6% -1.0%
Field_Temp -0.9% 1.2%
Field_Temp_Mean -0.3% 1.5%
Natural_RO_Summer -1.2% -0.3%
Concentrate_toWWTF_Flow_Rand -1.0% -0.4%
Bare_ET -1.0% -0.3%
Streamflow_SW006_Nov -0.6% 0.7%
SO4_S_Regression -0.5% 0.5%
Acid_Onset_Time_4DC -0.5% 0.4%
Cat4DC_Release_SO4 -0.2% 0.8%
TB_toWP_Flow_Rand -0.2% 0.7%
Cat23_Ratio_Ni_S -0.5% 0.5%
Cat23_Ratio_Mg_SO4 -0.1% 0.6%
Acid_Onset_Time_23 -0.3% 0.4%
Cat4DC_Ratio_Co_Ni -0.1% 0.5%
Liner_Leak_4_OSP -0.1% 0.5%
I_ops_Wpsurf -0.2% 0.2%
Wall_Depth_VF -0.2% 0.2%
Natural_RO_Winter -0.3% 0.1%
I_close_WP_Surf -0.2% 0.1%
Ore_Ratio_Ni_S -0.2% 0.2%
Liner_Leak_23 0.0% 0.3%
Cat4VF_Ratio_Co_S -0.1% 0.1%
Cat1_Ratio_Co_Ni -0.1% 0.2%
Cat23_Ratio_Ni_Mg -0.1% 0.1%
Reclaim_ET -0.2% 0.1%
K_OSP 0.0% -0.1%
Cat1SP_Geomem_Perc -0.1% 0.0%
Streamflow_SW006_Oct -0.1% 0.1%
TB_toWP_Conc_Rand -0.1% 0.1%
Reclaim_RO 0.0% 0.1%
ALL Elements in Cat234_acid_Caps_Random -0.1% 0.0%
Cat1_pH 0.0% 0.1%
K_OSLA 0.0% 0.0%
Cat4VF_Release_SO4 -0.1% 0.0%
Cat4DC_Ratio_Ni_S 0.0% 0.0%
Cat_1_Release_Mg 0.0% 0.1%
K_WWTF 0.0% -0.1%
Ore_Ratio_Ni_Mg 0.0% 0.0%
Cat1_Ratio_Ni_S 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Cat1_Ratio_Ni_Mg 0.0% 0.0%
Cat4DC_Ratio_Mg_SO4 0.0% 0.0%
ALL elements in OB_Unsat_Random 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Cat4DC_Ratio_Ni_Mg 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Ore_Ratio_Co_NI 0.0% 0.0%
ALL elements in OB_Peat_Random 0.0% 0.0%
Cat1_Cap_Percent 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
K_Epbed 0.0% 0.0%
Streamflow_SW006_Aug 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
K_WPbed4 0.0% 0.0%
Streamflow_SW006_Jul 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
Ore_Ratio_Mg_SO4 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
-40%
-30%
-20%
-10%
0%
10%
20%
30%

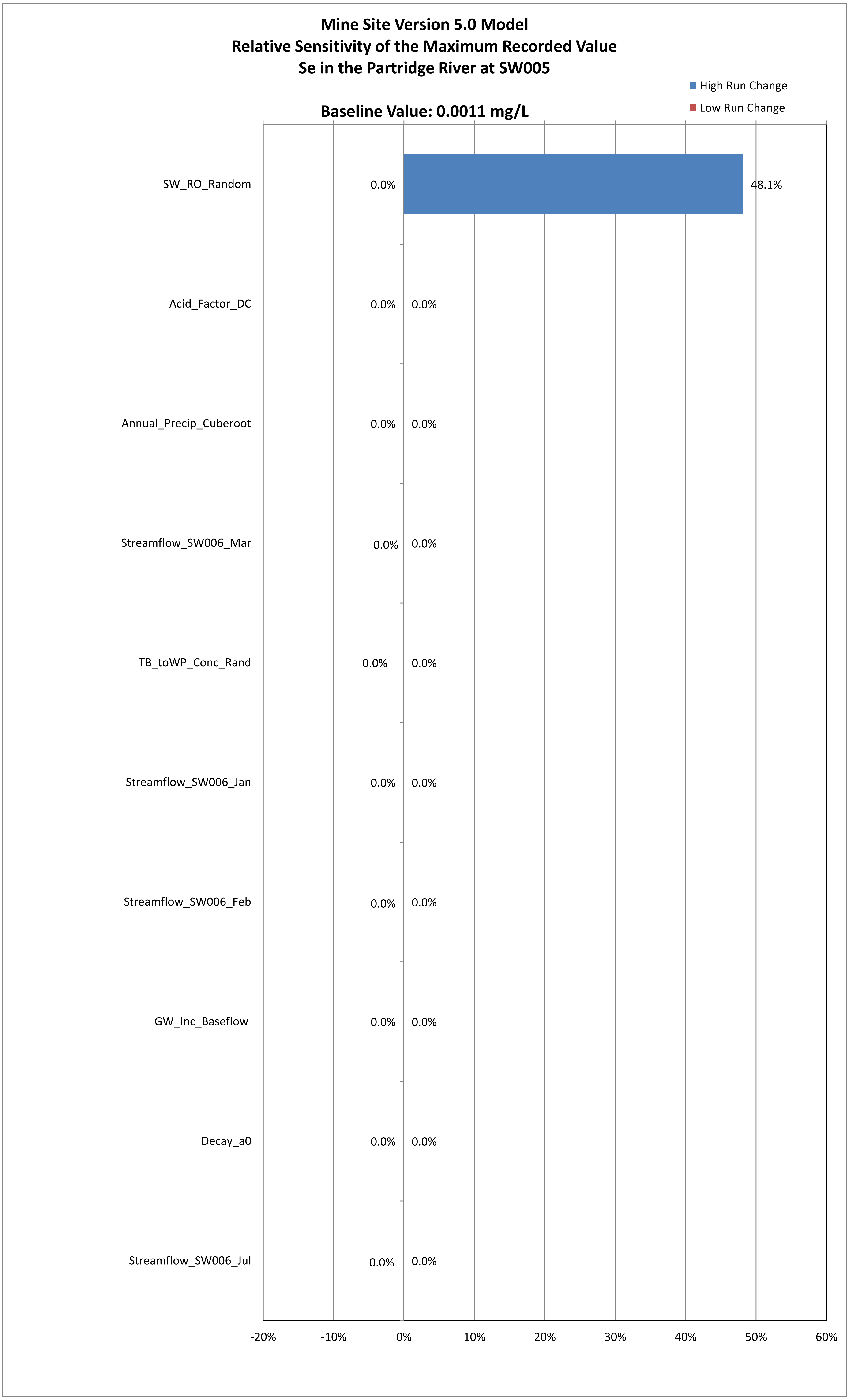

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Cu in the Partridge River at SW005
High Run Change
Low Run Change
Baseline Value: 0.0028 mg/L
SW_RO_Random -3.1% 120.4%
Annual_Precip_Cuberoot -11.1% 28.4%
Flow_PMP -22.4% 2.3%
Streamflow_SW006_Feb -24.0% -0.7%
GW_Surf_Random -10.4% 12.6%
GW_Inc_Baseflow 0.0% 20.5%
Acid_Factor_DC 0.0% 19.5%
Streamflow_SW006_Mar -10.3% 4.0%
Streamflow_SW006_Jan -9.8% 2.4%
Annual_Evap -8.3% 0.2%
Streamflow_SW006_Dec -4.3% 3.3%
Streamflow_SW006_Nov -0.7% 0.9%
Pit_GW_Uncertainty_Unshift 0.0% 1.3%
K_EP23surf -0.2% 0.3%
Streamflow_SW006_Oct -0.1% 0.1%
Natural_RO_Summer 0.0% 0.2%
Cat1SP_Geomem_Perc 0.0% 0.2%
K_OSLA -0.1% 0.1%
K_Wpsurf -0.1% 0.0%
K_OSP 0.0% 0.0%
K_WWTF 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
I_Close_EP23surf 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
Natural_RO_Winter 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
Streamflow_SW006_Aug 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
K_Epbed 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
K_WPbed4 0.0% 0.0%
Streamflow_SW006_Jul 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Wall_RO 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
Concentrate_toWWTF_Flow_Rand 0.0% 0.0%
Bare_ET 0.0% 0.0%
Cat4DC_Release_SO4 0.0% 0.0%
TB_toWP_Flow_Rand 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Size_Factor 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
-40%
-20%
0%
20%
40%
60%
80%
100%
120%
140%

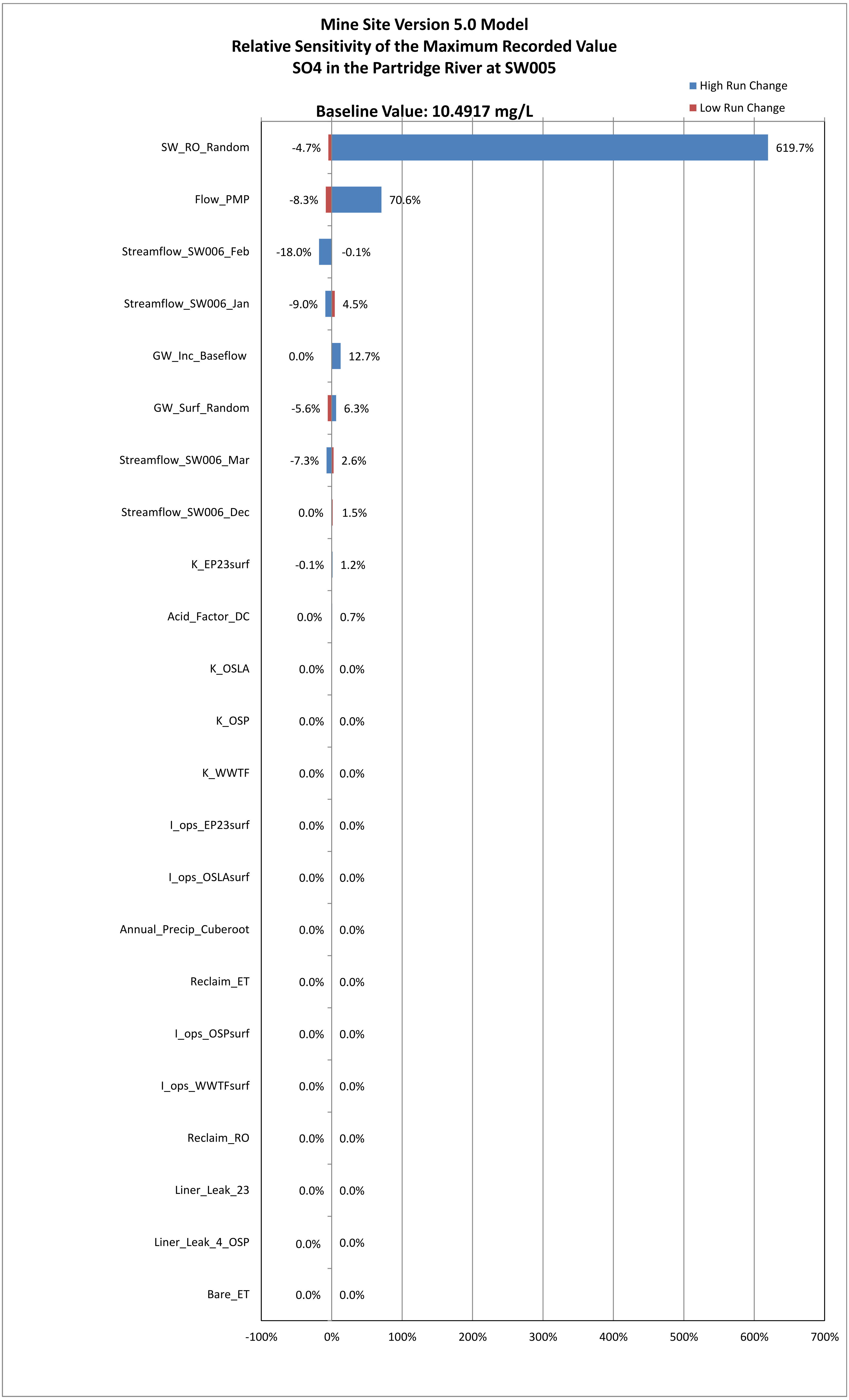

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Ni in the Partridge River at SW005
Baseline Value: 0.0061 mg/L
High Run Change
Low Run Change
Annual_Precip_Cuberoot -34.5% 61.3%
Acid_Factor_DC 0.0% 61.0%
Flow_PMP -40.6% 5.1%
SW_RO_Random -3.1% 32.0%
Streamflow_SW006_Feb -30.6% 3.3%
Streamflow_SW006_Mar -5.4% 27.3%
Annual_Evap -22.3% 0.5%
Streamflow_SW006_Jan -8.6% 11.9%
GW_Surf_Random -3.1% 3.7%
Streamflow_SW006_Dec -3.7% 3.0%
GW_Inc_Baseflow 0.0% 4.2%
Pit_GW_Uncertainty_Unshift 0.0% 3.8%
Streamflow_SW006_Nov -0.6% 0.7%
Natural_RO_Summer 0.0% 0.5%
Cat1SP_Geomem_Perc 0.0% 0.5%
Streamflow_SW006_Oct 0.0% 0.1%
K_EP23surf -0.1% 0.1%
K_OSLA 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
K_OSP 0.0% 0.0%
Natural_RO_Winter 0.0% 0.0%
K_Epbed 0.0% 0.0%
K_WWTF 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
K_WPbed4 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
I_Close_EP23surf 0.0% 0.0%
Streamflow_SW006_Aug 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
Streamflow_SW006_Jul 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
Wall_RO 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
-60% -40% -20% 0% 20% 40% 60% 80%

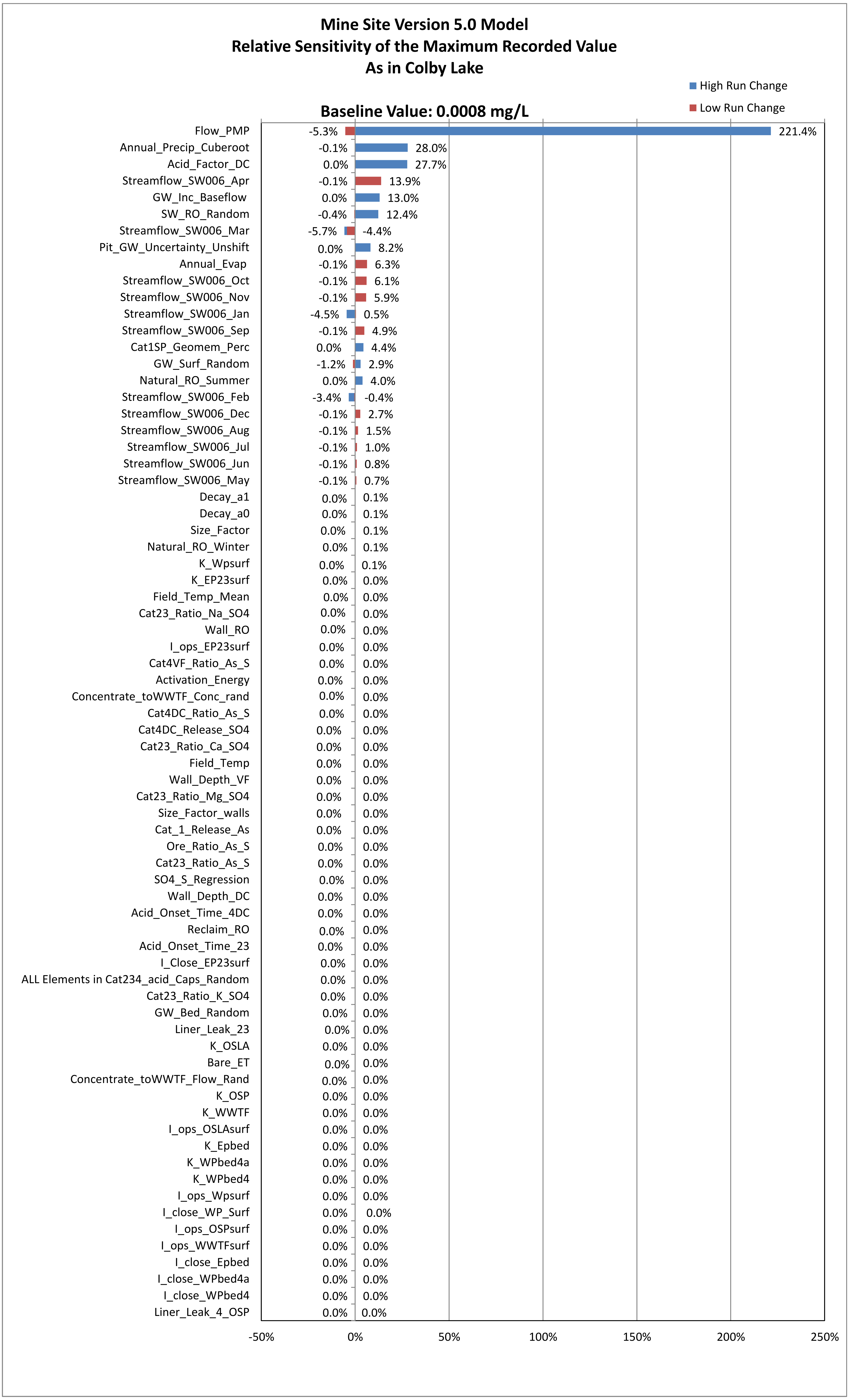


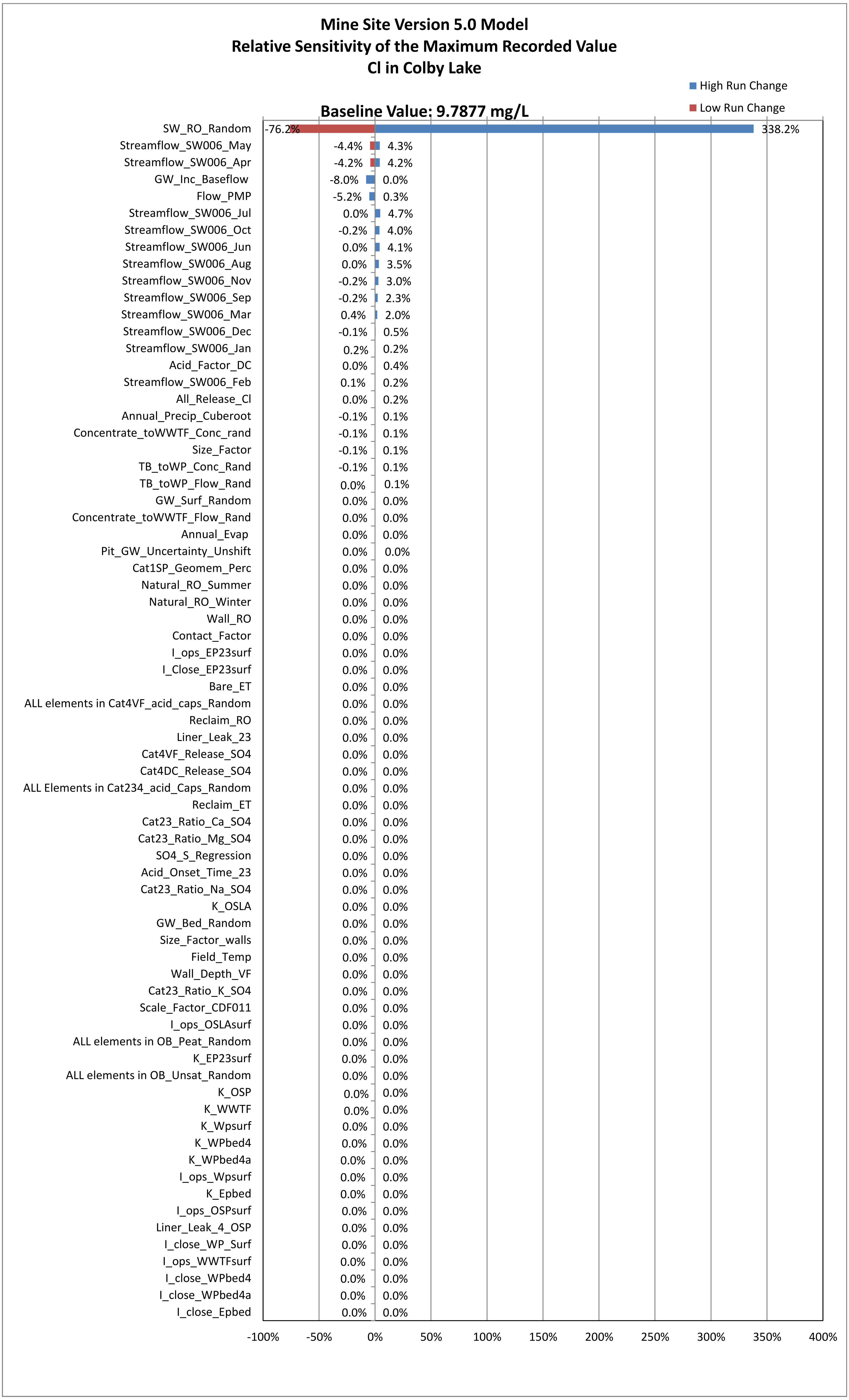
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Pb in the Partridge River at SW005
High Run Change
Low Run Change
Baseline Value: 0.0013 mg/L
The concentration of Pb at SW005 is not sensitive to any of the input parameters
Annual_Precip_Cuberoot
Acid_Factor_DC
0.0%
Flow_PMP
0.0%
SW_RO_Random
0.0%
Streamflow_SW006_Feb
0.0%
Streamflow_SW006_Mar
0.0%
Annual_Evap
0.0%
Streamflow_SW006_Jan
0.0%
GW_Surf_Random
0.0%
Streamflow_SW006_Dec
0.0%
-20%
-15%
-10%
-5%
0%
5%
10%
15%
20%


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Sb in the Partridge River at SW005
Baseline Value: 0.0018 mg/L
High Run Change
Low Run Change
Acid_Factor_DC -1.3% 49.6%
Annual_Precip_Cuberoot -8.4% 34.4%
Streamflow_SW006_Mar 0.0% 21.4%
TB_toWP_Conc_Rand -8.8% 10.9%
Streamflow_SW006_Jan 1.3% 15.6%
Streamflow_SW006_Feb -8.3% 5.0%
GW_Inc_Baseflow -12.9% 0.0%
Decay_a0 -1.1% 9.3%
Streamflow_SW006_Jul 0.0% 10.0%
Cat1_Cap_Sb -8.4% 0.6%
Streamflow_SW006_Aug 0.0% 8.9%
Annual_Evap -8.4% 0.1%
TB_toWP_Flow_Rand -4.7% 2.2%
Flow_PMP -6.7% 0.2%
Decay_a1 -0.5% 6.1%
Cat1SP_Geomem_Perc -0.7% 5.6%
Size_Factor -2.8% 3.1%
Contact_Factor -2.1% 3.0%
Size_Factor_walls -2.4% 2.4%
Activation_Energy -1.6% 2.6%
Cat_1_Release_Sb -0.5% 3.8%
Wall_Depth_DC -2.1% 2.1%
Field_Temp -1.2% 1.6%
Field_Temp_Mean -0.5% 1.7%
Pit_GW_Uncertainty_Unshift -1.1% -0.9%
SW_RO_Random -0.7% 0.8%
Bare_ET -1.1% 0.3%
SO4_S_Regression -0.6% 0.6%
Acid_Onset_Time_23 -0.4% 0.7%
Acid_Onset_Time_4DC -0.6% 0.5%
Streamflow_SW006_Dec -0.3% 0.7%
ALL Elements in Cat234_acid_Caps_Random -0.1% 0.7%
Cat23_Ratio_Sb_S -0.4% 0.4%
Wall_RO -0.4% -0.4%
Concentrate_toWWTF_Flow_Rand -0.6% 0.2%
Ore_Ratio_Sb_S -0.3% 0.3%
Reclaim_ET -0.4% 0.0%
Cat4DC_Release_SO4 -0.1% 0.3%
Streamflow_SW006_Nov -0.2% 0.2%
Natural_RO_Winter -0.3% 0.0%
ALL elements in Cat4VF_acid_caps_Random -0.1% 0.1%
Cat4VF_Release_SO4 -0.1% 0.1%
I_Close_EP23surf 0.0% 0.1%
Reclaim_RO 0.0% 0.1%
I_ops_EP23surf 0.0% 0.1%
Cat23_Ratio_Ca_SO4 0.0% 0.1%
Liner_Leak_23 0.0% 0.1%
K_EP23surf -0.1% 0.0%
Cat23_Ratio_Mg_SO4 -0.1% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
Wall_Depth_VF 0.0% 0.0%
Streamflow_SW006_Oct 0.0% 0.0%
Natural_RO_Summer 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
Streamflow_SW006_Sep 0.0% 0.0%
Cat4DC_Ratio_Sb_S 0.0% 0.0%
Cat4VF_Ratio_Sb_S 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
K_OSLA 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
K_OSP 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
K_WWTF 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
K_Epbed 0.0% 0.0%
K_WPbed4 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
Streamflow_SW006_Jun 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Streamflow_SW006_May 0.0% 0.0%
Streamflow_SW006_Apr 0.0% 0.0%
-20%
-10%
0%
10%
20%
30%
40%
50%
60%

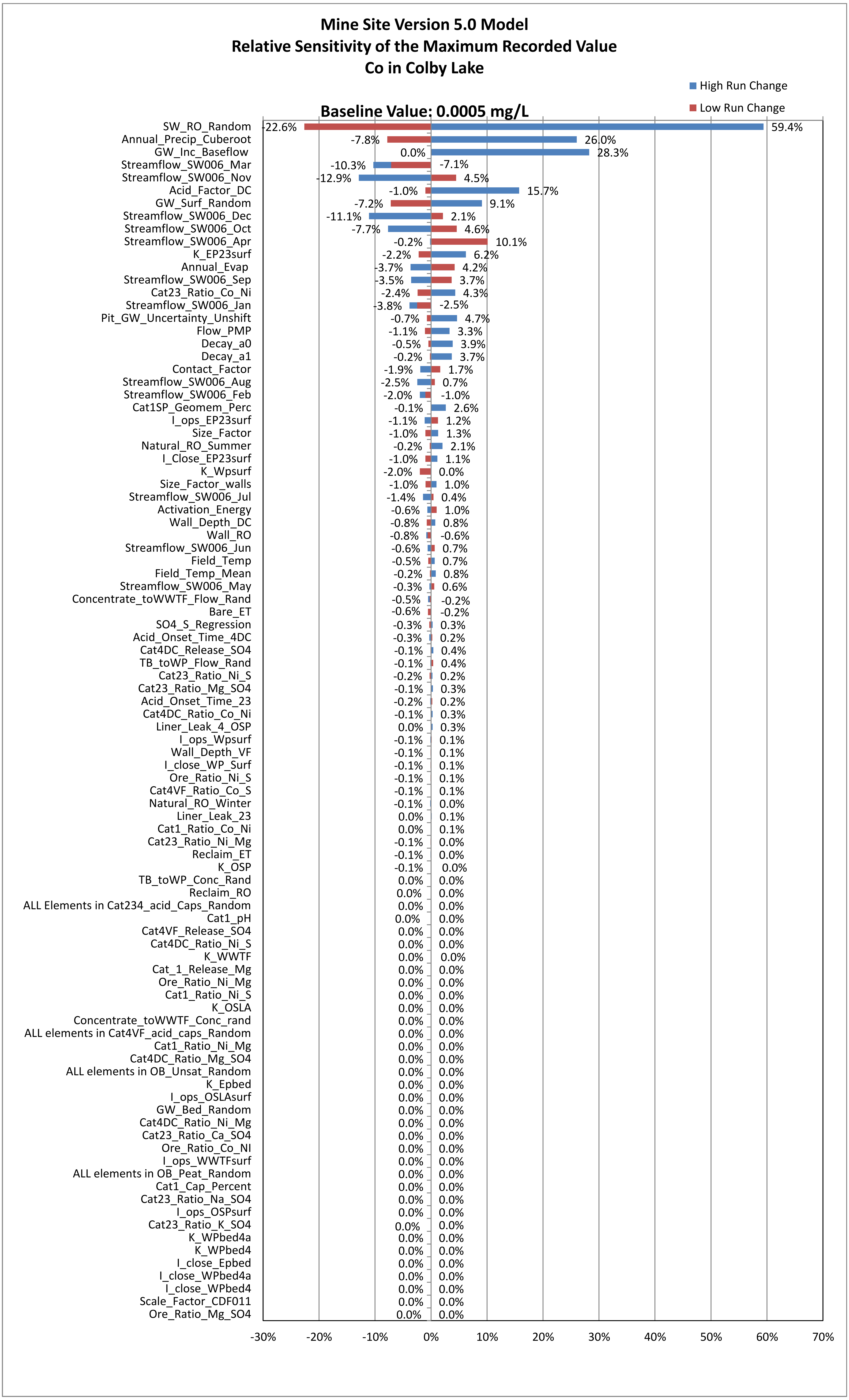

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Se in the Partridge River at SW005
Baseline Value: 0.0011 mg/L
High Run Change
Low Run Change
SW_RO_Random
0.0%
48.1%
Acid_Factor_DC
0.0%
0.0%
Annual_Precip_Cuberoot
0.0%
0.0%
Streamflow_SW006_Mar
0.0%
0.0%
TB_toWP_Conc_Rand
0.0%
0.0%
Streamflow_SW006_Jan
0.0%
0.0%
Streamflow_SW006_Feb
0.0%
0.0%
GW_Inc_Baseflow
0.0%
0.0%
Decay_a0
0.0%
0.0%
Streamflow_SW006_Jul
0.0%
0.0%
-20%
-10%
0%
10%
20%
30%
40%
50%
60%


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
SO4 in the Partridge River at SW005
Baseline Value: 10.4917 mg/L
High Run Change
Low Run Change
SW_RO_Random -4.7% 619.7%
Flow_PMP -8.3% 70.6%
Streamflow_SW006_Feb -18.0% -0.1%
Streamflow_SW006_Jan -9.0% 4.5%
GW_Inc_Baseflow 0.0% 12.7%
GW_Surf_Random -5.6% 6.3%
Streamflow_SW006_Mar -7.3% 2.6%
Streamflow_SW006_Dec 0.0% 1.5%
K_EP23surf -0.1% 1.2%
Acid_Factor_DC 0.0% 0.7%
K_OSLA 0.0% 0.0%
K_OSP 0.0% 0.0%
K_WWTF 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Annual_Precip_Cuberoot 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Bare_ET 0.0% 0.0%
-100% 0% 100% 200% 300% 400% 500% 600% 700%

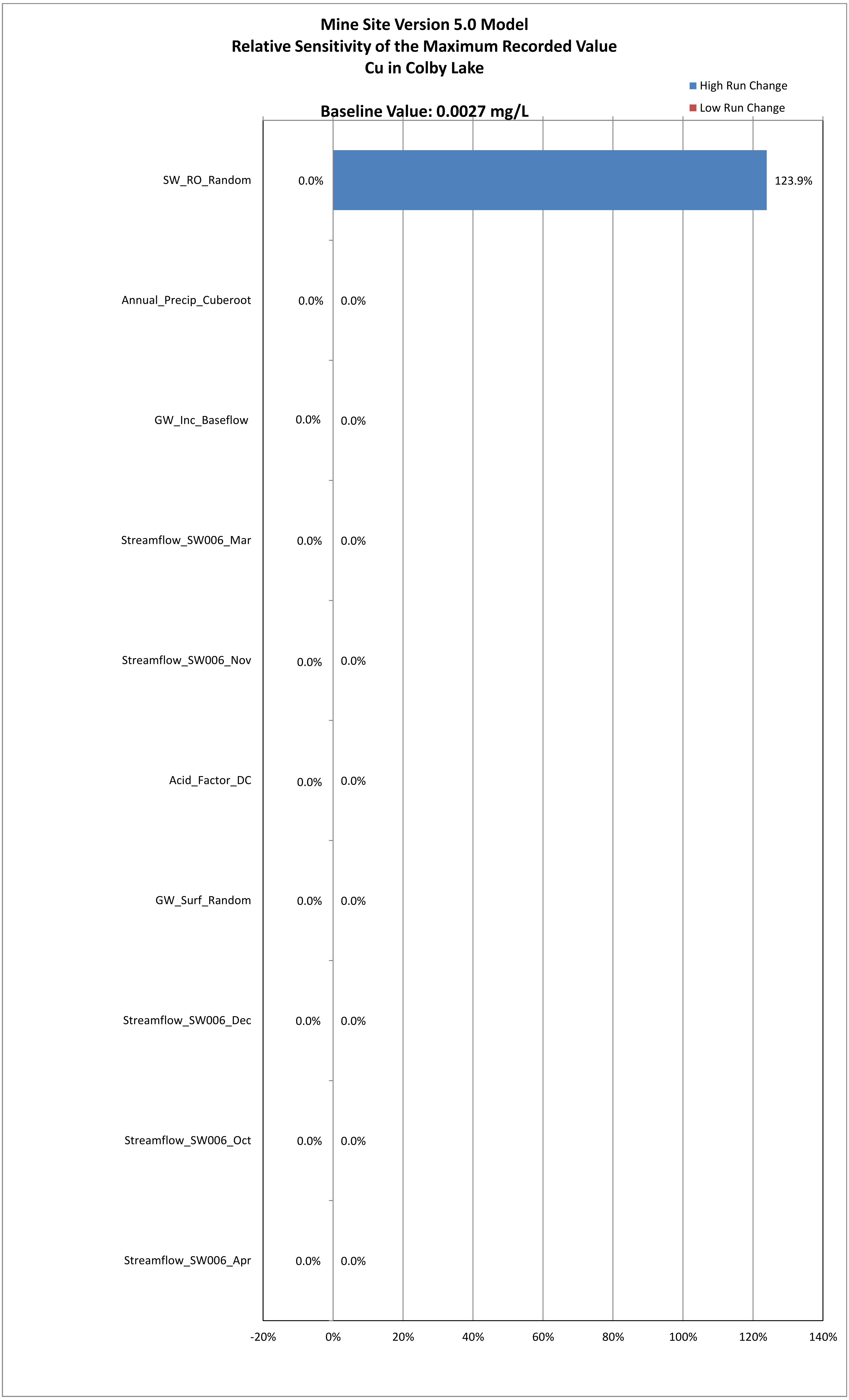

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
As in Colby Lake
High Run Change
Low Run Change
Baseline Value: 0.0008 mg/L
Flow_PMP -5.3% 221.4%
Annual_Precip_Cuberoot -0.1% 28.0%
Acid_Factor_DC 0.0% 27.7%
Streamflow_SW006_Apr -0.1% 13.9%
GW_Inc_Baseflow 0.0% 13.0%
SW_RO_Random -0.4% 12.4%
Streamflow_SW006_Mar -5.7% -4.4%
Pit_GW_Uncertainty_Unshift 0.0% 8.2%
Annual_Evap -0.1% 6.3%
Streamflow_SW006_Oct -0.1% 6.1%
Streamflow_SW006_Nov -0.1% 5.9%
Streamflow_SW006_Jan -4.5% 0.5%
Streamflow_SW006_Sep -0.1% 4.9%
Cat1SP_Geomem_Perc 0.0% 4.4%
GW_Surf_Random -1.2% 2.9%
Natural_RO_Summer 0.0% 4.0%
Streamflow_SW006_Feb -3.4% -0.4%
Streamflow_SW006_Dec -0.1% 2.7%
Streamflow_SW006_Aug -0.1% 1.5%
Streamflow_SW006_Jul -0.1% 1.0%
Streamflow_SW006_Jun -0.1% 0.8%
Streamflow_SW006_May -0.1% 0.7%
Decay_a1 0.0% 0.1%
Decay_a0 0.0% 0.1%
Size_Factor 0.0% 0.1%
Natural_RO_Winter 0.0% 0.1%
K_Wpsurf 0.0% 0.1%
K_EP23surf 0.0% 0.0%
Field_Temp_Mean 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
Wall_RO 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
Cat4VF_Ratio_As_S 0.0% 0.0%
Activation_Energy 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
Cat4DC_Ratio_As_S 0.0% 0.0%
Cat4DC_Release_SO4 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Field_Temp 0.0% 0.0%
Wall_Depth_VF 0.0% 0.0%
Cat23_Ratio_Mg_SO4 0.0% 0.0%
Size_Factor_walls 0.0% 0.0%
Cat_1_Release_As 0.0% 0.0%
Ore_Ratio_As_S 0.0% 0.0%
Cat23_Ratio_As_S 0.0% 0.0%
SO4_S_Regression 0.0% 0.0%
Wall_Depth_DC 0.0% 0.0%
Acid_Onset_Time_4DC 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
Acid_Onset_Time_23 0.0% 0.0%
I_Close_EP23surf 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
K_OSLA 0.0% 0.0%
Bare_ET 0.0% 0.0%
Concentrate_toWWTF_Flow_Rand 0.0% 0.0%
K_OSP 0.0% 0.0%
K_WWTF 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
K_Epbed 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
K_WPbed4 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
-50%
0%
50%
100%
150%
200%
250%

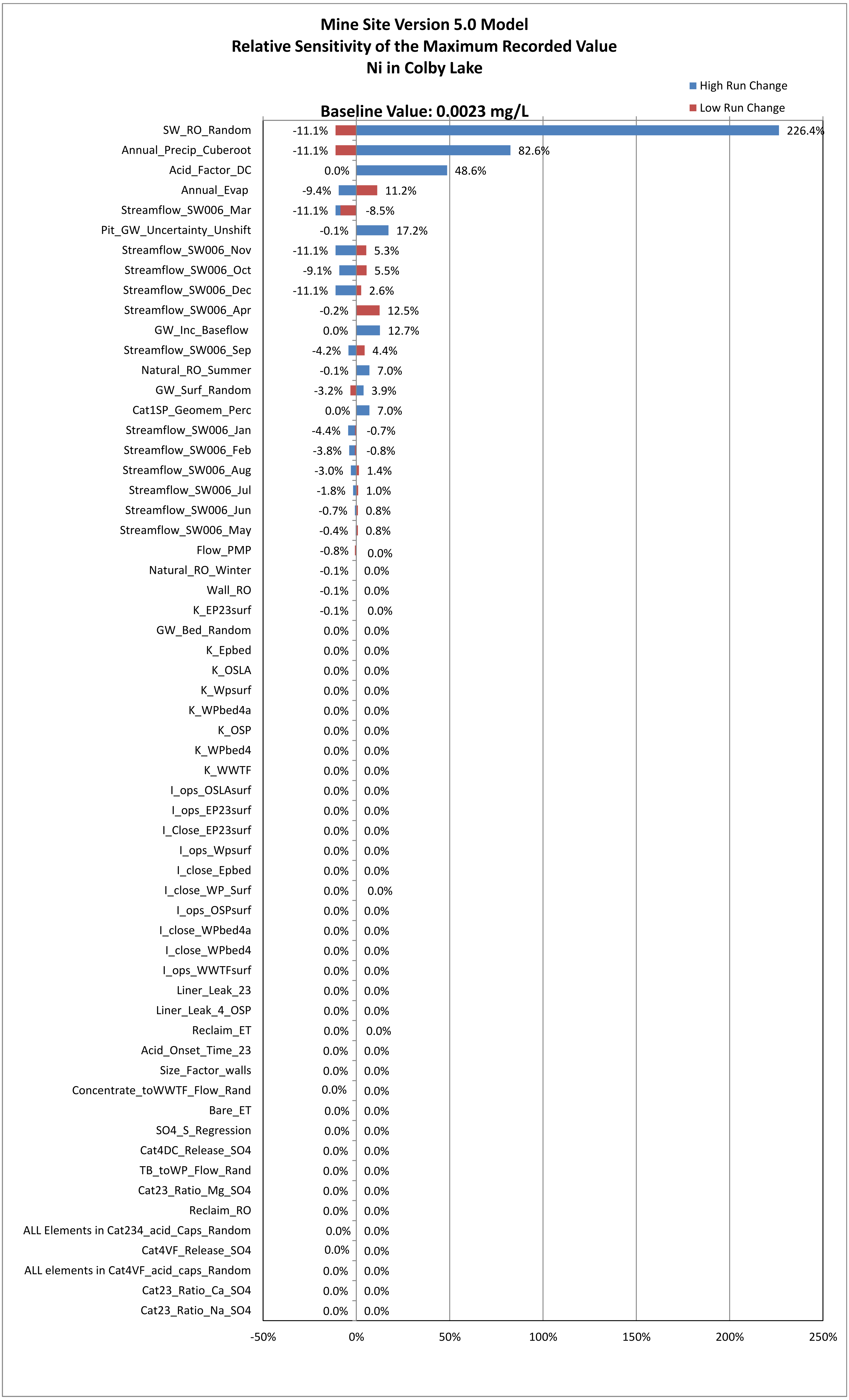


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Cl in Colby Lake
Baseline Value: 9.7877 mg/L
High Run Change
Low Run Change
SW_RO_Random -76.2% 338.2%
Streamflow_SW006_May -4.4% 4.3%
Streamflow_SW006_Apr -4.2% 4.2%
GW_Inc_Baseflow -8.0% 0.0%
Flow_PMP -5.2% 0.3%
Streamflow_SW006_Jul 0.0% 4.7%
Streamflow_SW006_Oct -0.2% 4.0%
Streamflow_SW006_Jun 0.0% 4.1%
Streamflow_SW006_Aug 0.0% 3.5%
Streamflow_SW006_Nov -0.2% 3.0%
Streamflow_SW006_Sep -0.2% 2.3%
Streamflow_SW006_Mar 0.4% 2.0%
Streamflow_SW006_Dec -0.1% 0.5%
Streamflow_SW006_Jan 0.2% 0.2%
Acid_Factor_DC 0.0% 0.4%
Streamflow_SW006_Feb 0.1% 0.2%
All_Release_Cl 0.0% 0.2%
Annual_Precip_Cuberoot -0.1% 0.1%
Concentrate_toWWTF_Conc_rand -0.1% 0.1%
Size_Factor -0.1% 0.1%
TB_toWP_Conc_Rand -0.1% 0.1%
TB_toWP_Flow_Rand 0.0% 0.1%
GW_Surf_Random 0.0% 0.0%
Concentrate_toWWTF_Flow_Rand 0.0% 0.0%
Annual_Evap 0.0% 0.0%
Pit_GW_Uncertainty_Unshift 0.0% 0.0%
Cat1SP_Geomem_Perc 0.0% 0.0%
Natural_RO_Summer 0.0% 0.0%
Natural_RO_Winter 0.0% 0.0%
Wall_RO 0.0% 0.0%
Contact_Factor 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
I_Close_EP23surf 0.0% 0.0%
Bare_ET 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
Cat4VF_Release_SO4 0.0% 0.0%
Cat4DC_Release_SO4 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Cat23_Ratio_Mg_SO4 0.0% 0.0%
SO4_S_Regression 0.0% 0.0%
Acid_Onset_Time_23 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
K_OSLA 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Size_Factor_walls 0.0% 0.0%
Field_Temp 0.0% 0.0%
Wall_Depth_VF 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
ALL elements in OB_Peat_Random 0.0% 0.0%
K_EP23surf 0.0% 0.0%
ALL elements in OB_Unsat_Random 0.0% 0.0%
K_OSP 0.0% 0.0%
K_WWTF 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
K_WPbed4 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
K_Epbed 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
-100% -50% 0% 50% 100% 150% 200% 250% 300% 350% 400%

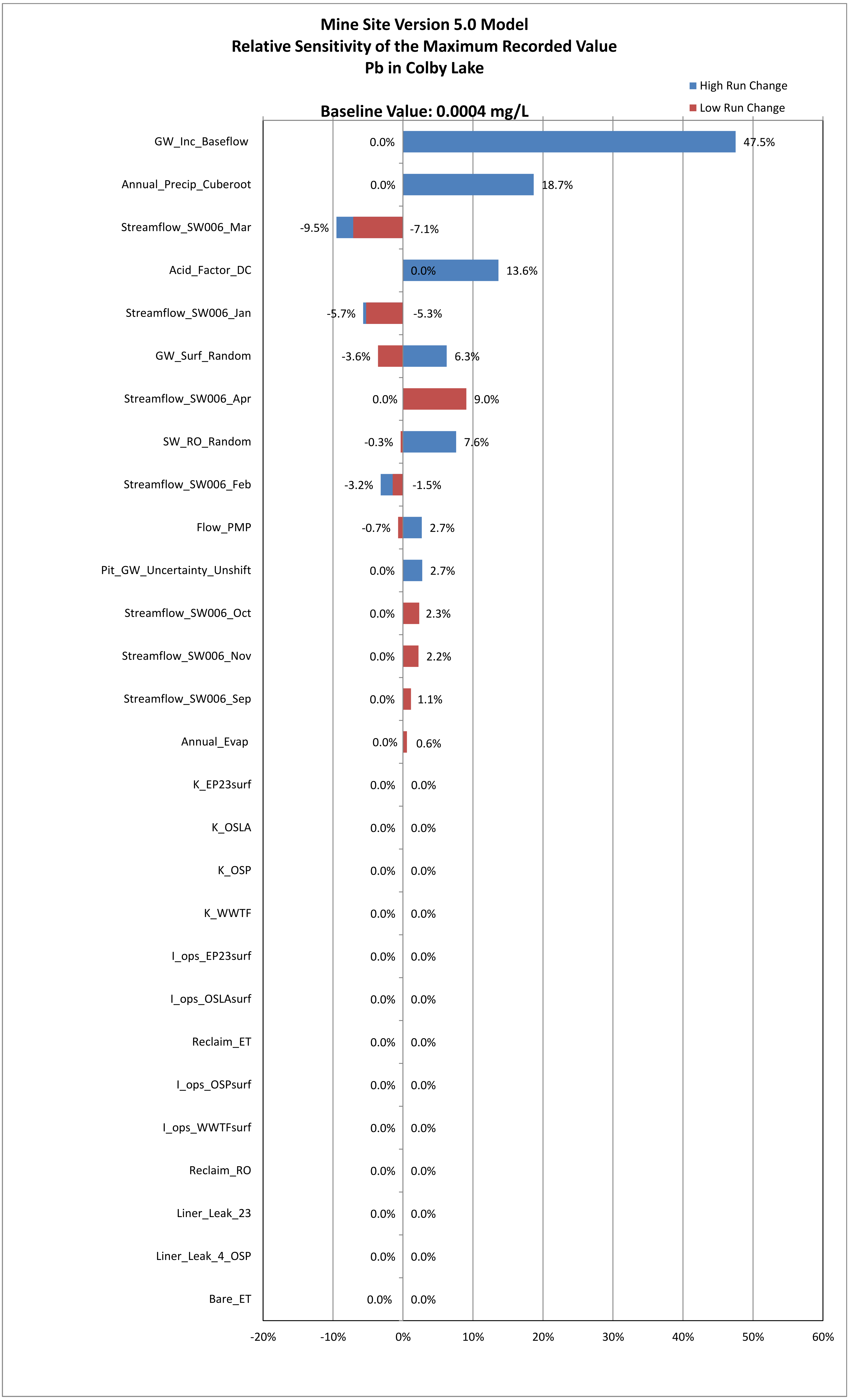


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Co in Colby Lake
Baseline Value: 0.0005 mg/L
High Run Change
Low Run Change
SW_RO_Random -22.6% 59.4%
Annual_Precip_Cuberoot -7.8% 26.0%
GW_Inc_Baseflow 0.0% 28.3%
Streamflow_SW006_Mar -10.3% -7.1%
Streamflow_SW006_Nov -12.9% 4.5%
Acid_Factor_DC -1.0% 15.7%
GW_Surf_Random -7.2% 9.1%
Streamflow_SW006_Dec -11.1% 2.1%
Streamflow_SW006_Oct -7.7% 4.6%
Streamflow_SW006_Apr -0.2% 10.1%
K_EP23surf -2.2% 6.2%
Annual_Evap -3.7% 4.2%
Streamflow_SW006_Sep -3.5% 3.7%
Cat23_Ratio_Co_Ni -2.4% 4.3%
Streamflow_SW006_Jan -3.8% -2.5%
Pit_GW_Uncertainty_Unshift -0.7% 4.7%
Flow_PMP -1.1% 3.3%
Decay_a0 -0.5% 3.9%
Decay_a1 -0.2% 3.7%
Contact_Factor -1.9% 1.7%
Streamflow_SW006_Aug -2.5% 0.7%
Streamflow_SW006_Feb -2.0% -1.0%
Cat1SP_Geomem_Perc -0.1% 2.6%
I_ops_EP23surf -1.1% 1.2%
Size_Factor -1.0% 1.3%
Natural_RO_Summer -0.2% 2.1%
I_Close_EP23surf -1.0% 1.1%
K_Wpsurf -2.0% 0.0%
Size_Factor_walls -1.0% 1.0%
Streamflow_SW006_Jul -1.4% 0.4%
Activation_Energy -0.6% 1.0%
Wall_Depth_DC -0.8% 0.8%
Wall_RO -0.8% -0.6%
Streamflow_SW006_Jun -0.6% 0.7%
Field_Temp -0.5% 0.7%
Field_Temp_Mean -0.2% 0.8%
Streamflow_SW006_May -0.3% 0.6%
Concentrate_toWWTF_Flow_Rand -0.5% -0.2%
Bare_ET -0.6% -0.2%
SO4_S_Regression -0.3% 0.3%
Acid_Onset_Time_4DC -0.3% 0.2%
Cat4DC_Release_SO4 -0.1% 0.4%
TB_toWP_Flow_Rand -0.1% 0.4%
Cat23_Ratio_Ni_S -0.2% 0.2%
Cat23_Ratio_Mg_SO4 -0.1% 0.3%
Acid_Onset_Time_23 -0.2% 0.2%
Cat4DC_Ratio_Co_Ni -0.1% 0.3%
Liner_Leak_4_OSP 0.0% 0.3%
I_ops_Wpsurf -0.1% 0.1%
Wall_Depth_VF -0.1% 0.1%
I_close_WP_Surf -0.1% 0.1%
Ore_Ratio_Ni_S -0.1% 0.1%
Cat4VF_Ratio_Co_S -0.1% 0.1%
Natural_RO_Winter -0.1% 0.0%
Liner_Leak_23 0.0% 0.1%
Cat1_Ratio_Co_Ni 0.0% 0.1%
Cat23_Ratio_Ni_Mg -0.1% 0.0%
Reclaim_ET -0.1% 0.0%
K_OSP -0.1% 0.0%
TB_toWP_Conc_Rand 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.0%
Cat1_pH 0.0% 0.0%
Cat4VF_Release_SO4 0.0% 0.0%
Cat4DC_Ratio_Ni_S 0.0% 0.0%
K_WWTF 0.0% 0.0%
Cat_1_Release_Mg 0.0% 0.0%
Ore_Ratio_Ni_Mg 0.0% 0.0%
Cat1_Ratio_Ni_S 0.0% 0.0%
K_OSLA 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Cat1_Ratio_Ni_Mg 0.0% 0.0%
Cat4DC_Ratio_Mg_SO4 0.0% 0.0%
ALL elements in OB_Unsat_Random 0.0% 0.0%
K_Epbed 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
Cat4DC_Ratio_Ni_Mg 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Ore_Ratio_Co_NI 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
ALL elements in OB_Peat_Random 0.0% 0.0%
Cat1_Cap_Percent 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
K_WPbed4 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Scale_Factor_CDF011 0.0% 0.0%
Ore_Ratio_Mg_SO4 0.0% 0.0%
-30%
-20%
-10%
0%
10%
20%
30%
40%
50%
60%
70%

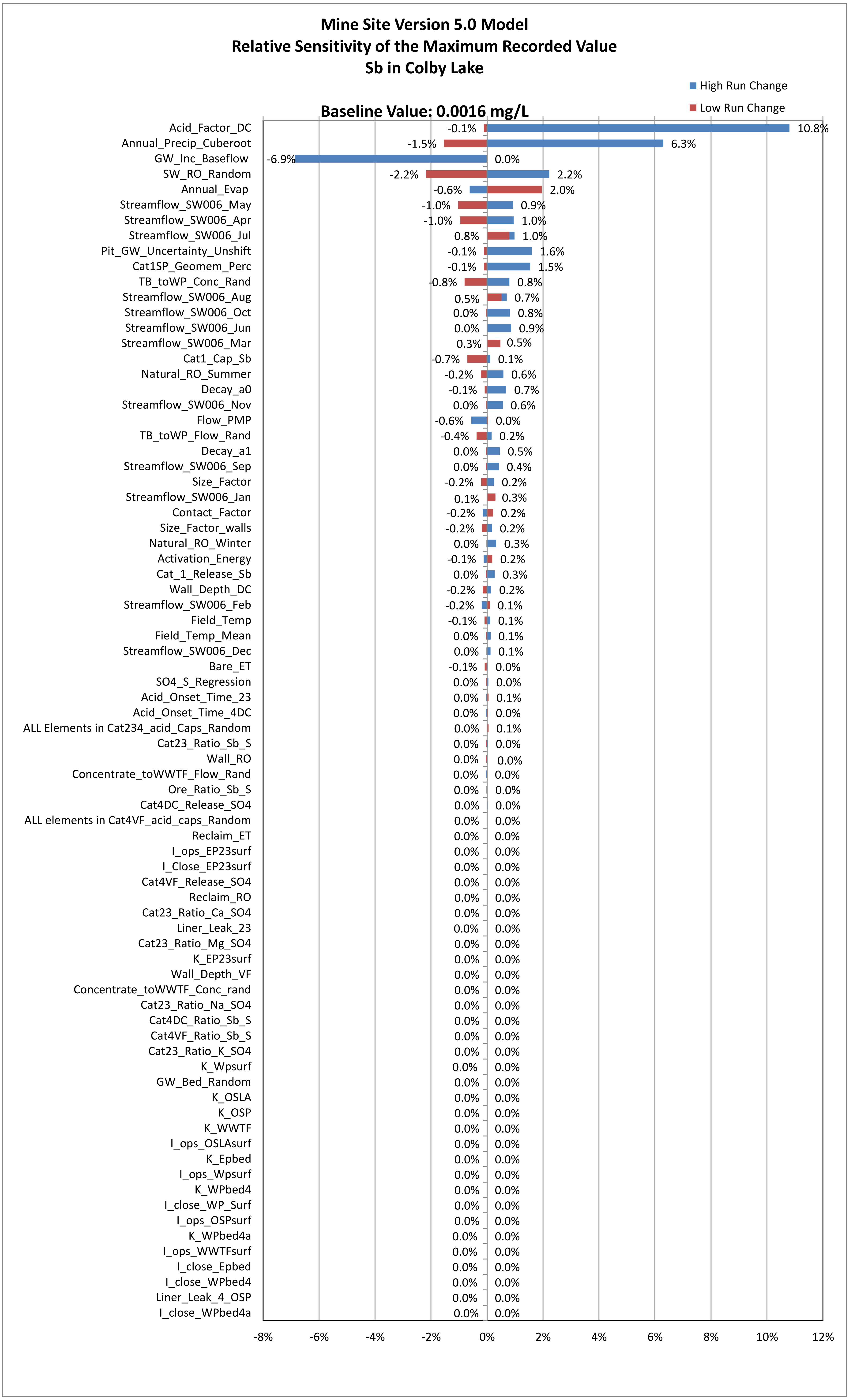

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Cu in Colby Lake
Baseline Value: 0.0027 mg/L
High Run Change
Low Run Change
SW_RO_Random
0.0%
123.9%
Annual_Precip_Cuberoot
0.0%
0.0%
GW_Inc_Baseflow
0.0%
0.0%
Streamflow_SW006_Mar
0.0%
0.0%
Streamflow_SW006_Nov
0.0%
0.0%
Acid_Factor_DC
0.0%
0.0%
GW_Surf_Random
0.0%
0.0%
Streamflow_SW006_Dec
0.0%
0.0%
Streamflow_SW006_Oct
0.0%
0.0%
Streamflow_SW006_Apr
0.0%
0.0%
-20%
0%
20%
40%
60%
80%
100%
120%
140%



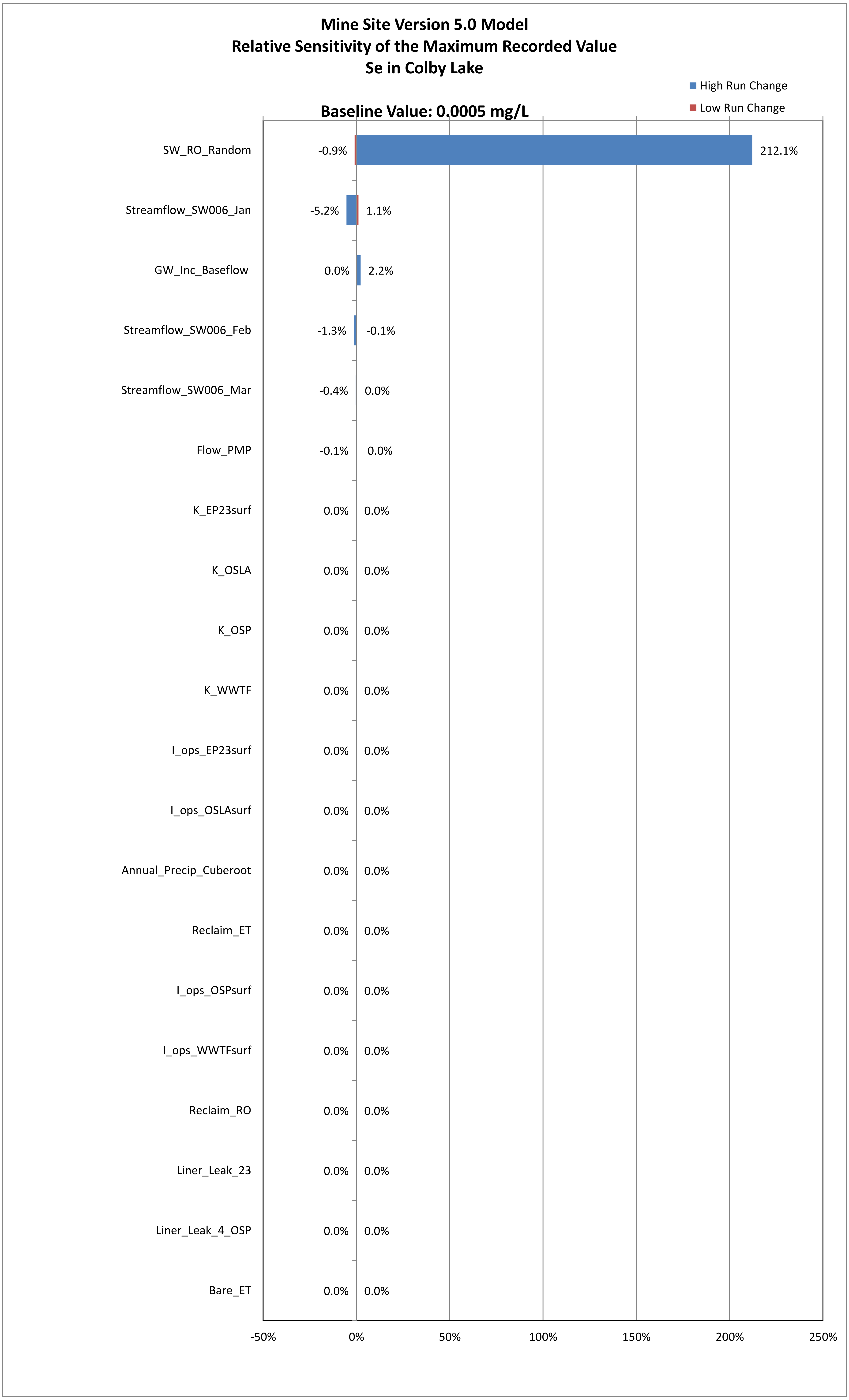
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Ni in Colby Lake
Baseline Value: 0.0023 mg/L
High Run Change
Low Run Change
SW_RO_Random -11.1% 226.4%
Annual_Precip_Cuberoot -11.1% 82.6%
Acid_Factor_DC 0.0% 48.6%
Annual_Evap -9.4% 11.2%
Streamflow_SW006_Mar -11.1% -8.5%
Pit_GW_Uncertainty_Unshift -0.1% 17.2%
Streamflow_SW006_Nov -11.1% 5.3%
Streamflow_SW006_Oct -9.1% 5.5%
Streamflow_SW006_Dec -11.1% 2.6%
Streamflow_SW006_Apr -0.2% 12.5%
GW_Inc_Baseflow 0.0% 12.7%
Streamflow_SW006_Sep -4.2% 4.4%
Natural_RO_Summer -0.1% 7.0%
GW_Surf_Random -3.2% 3.9%
Cat1SP_Geomem_Perc 0.0% 7.0%
Streamflow_SW006_Jan -4.4% -0.7%
Streamflow_SW006_Feb -3.8% -0.8%
Streamflow_SW006_Aug -3.0% 1.4%
Streamflow_SW006_Jul -1.8% 1.0%
Streamflow_SW006_Jun -0.7% 0.8%
Streamflow_SW006_May -0.4% 0.8%
Flow_PMP -0.8% 0.0%
Natural_RO_Winter -0.1% 0.0%
Wall_RO -0.1% 0.0%
K_EP23surf -0.1% 0.0%
GW_Bed_Random 0.0% 0.0%
K_Epbed 0.0% 0.0%
K_OSLA 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
K_OSP 0.0% 0.0%
K_WPbed4 0.0% 0.0%
K_WWTF 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
I_Close_EP23surf 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
Acid_Onset_Time_23 0.0% 0.0%
Size_Factor_walls 0.0% 0.0%
Concentrate_toWWTF_Flow_Rand 0.0% 0.0%
Bare_ET 0.0% 0.0%
SO4_S_Regression 0.0% 0.0%
Cat4DC_Release_SO4 0.0% 0.0%
TB_toWP_Flow_Rand 0.0% 0.0%
Cat23_Ratio_Mg_SO4 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.0%
Cat4VF_Release_SO4 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
-50%
0%
50%
100%
150%
200%
250%

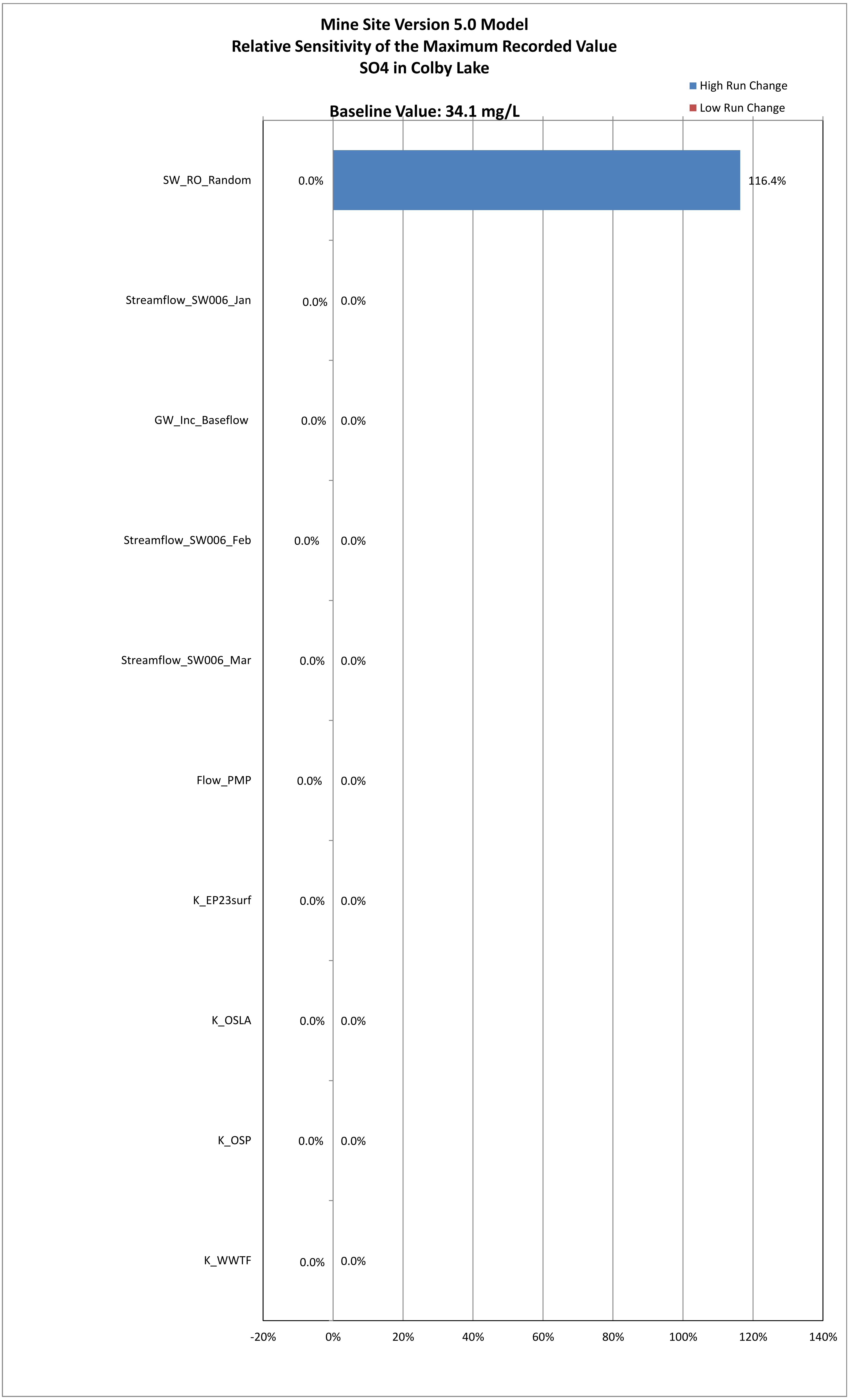


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Pb in Colby Lake
Baseline Value: 0.0004 mg/L
High Run Change
Low Run Change
GW_Inc_Baseflow 0.0% 47.5%
Annual_Precip_Cuberoot 0.0% 18.7%
Streamflow_SW006_Mar -9.5% -7.1%
Acid_Factor_DC 0.0% 13.6%
Streamflow_SW006_Jan -5.7% -5.3%
GW_Surf_Random -3.6% 6.3%
Streamflow_SW006_Apr 0.0% 9.0%
SW_RO_Random -0.3% 7.6%
Streamflow_SW006_Feb -3.2% -1.5%
Flow_PMP -0.7% 2.7%
Pit_GW_Uncertainty_Unshift 0.0% 2.7%
Streamflow_SW006_Oct 0.0% 2.3%
Streamflow_SW006_Nov 0.0% 2.2%
Streamflow_SW006_Sep 0.0% 1.1%
Annual_Evap 0.0% 0.6%
K_EP23surf 0.0% 0.0%
K_OSLA 0.0% 0.0%
K_OSP 0.0% 0.0%
K_WWTF 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
Bare_ET 0.0% 0.0%
-20%
-10%
0%
10%
20%
30%
40%
50%
60%



Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Sb in Colby Lake
Baseline Value: 0.0016 mg/L
High Run Change
Low Run Change
Acid_Factor_DC -0.1% 10.8%
Annual_Precip_Cuberoot -1.5% 6.3%
GW_Inc_Baseflow -6.9% 0.0%
SW_RO_Random -2.2% 2.2%
Annual_Evap -0.6% 2.0%
Streamflow_SW006_May -1.0% 0.9%
Streamflow_SW006_Apr -1.0% 1.0%
Streamflow_SW006_Jul 0.8% 1.0%
Pit_GW_Uncertainty_Unshift -0.1% 1.6%
Cat1SP_Geomem_Perc -0.1% 1.5%
TB_toWP_Conc_Rand -0.8% 0.8%
Streamflow_SW006_Aug 0.5% 0.7%
Streamflow_SW006_Oct 0.0% 0.8%
Streamflow_SW006_Jun 0.0% 0.9%
Streamflow_SW006_Mar 0.3% 0.5%
Cat1_Cap_Sb -0.7% 0.1%
Natural_RO_Summer -0.2% 0.6%
Decay_a0 -0.1% 0.7%
Streamflow_SW006_Nov 0.0% 0.6%
Flow_PMP -0.6% 0.0%
TB_toWP_Flow_Rand -0.4% 0.2%
Decay_a1 0.0% 0.5%
Streamflow_SW006_Sep 0.0% 0.4%
Size_Factor -0.2% 0.2%
Streamflow_SW006_Jan 0.1% 0.3%
Contact_Factor -0.2% 0.2%
Size_Factor_walls -0.2% 0.2%
Natural_RO_Winter 0.0% 0.3%
Activation_Energy -0.1% 0.2%
Cat_1_Release_Sb 0.0% 0.3%
Wall_Depth_DC -0.2% 0.2%
Streamflow_SW006_Feb -0.2% 0.1%
Field_Temp -0.1% 0.1%
Field_Temp_Mean 0.0% 0.1%
Streamflow_SW006_Dec 0.0% 0.1%
Bare_ET -0.1% 0.0%
SO4_S_Regression 0.0% 0.0%
Acid_Onset_Time_23 0.0% 0.1%
Acid_Onset_Time_4DC 0.0% 0.0%
ALL Elements in Cat234_acid_Caps_Random 0.0% 0.1%
Cat23_Ratio_Sb_S 0.0% 0.0%
Wall_RO 0.0% 0.0%
Concentrate_toWWTF_Flow_Rand 0.0% 0.0%
Ore_Ratio_Sb_S 0.0% 0.0%
Cat4DC_Release_SO4 0.0% 0.0%
ALL elements in Cat4VF_acid_caps_Random 0.0% 0.0%
Reclaim_ET 0.0% 0.0%
I_ops_EP23surf 0.0% 0.0%
I_Close_EP23surf 0.0% 0.0%
Cat4VF_Release_SO4 0.0% 0.0%
Reclaim_RO 0.0% 0.0%
Cat23_Ratio_Ca_SO4 0.0% 0.0%
Liner_Leak_23 0.0% 0.0%
Cat23_Ratio_Mg_SO4 0.0% 0.0%
K_EP23surf 0.0% 0.0%
Wall_Depth_VF 0.0% 0.0%
Concentrate_toWWTF_Conc_rand 0.0% 0.0%
Cat23_Ratio_Na_SO4 0.0% 0.0%
Cat4DC_Ratio_Sb_S 0.0% 0.0%
Cat4VF_Ratio_Sb_S 0.0% 0.0%
Cat23_Ratio_K_SO4 0.0% 0.0%
K_Wpsurf 0.0% 0.0%
GW_Bed_Random 0.0% 0.0%
K_OSLA 0.0% 0.0%
K_OSP 0.0% 0.0%
K_WWTF 0.0% 0.0%
I_ops_OSLAsurf 0.0% 0.0%
K_Epbed 0.0% 0.0%
I_ops_Wpsurf 0.0% 0.0%
K_WPbed4 0.0% 0.0%
I_close_WP_Surf 0.0% 0.0%
I_ops_OSPsurf 0.0% 0.0%
K_WPbed4a 0.0% 0.0%
I_ops_WWTFsurf 0.0% 0.0%
I_close_Epbed 0.0% 0.0%
I_close_WPbed4 0.0% 0.0%
Liner_Leak_4_OSP 0.0% 0.0%
I_close_WPbed4a 0.0% 0.0%
-8% -6% -4% -2% 0% 2% 4% 6% 8% 10% 12%

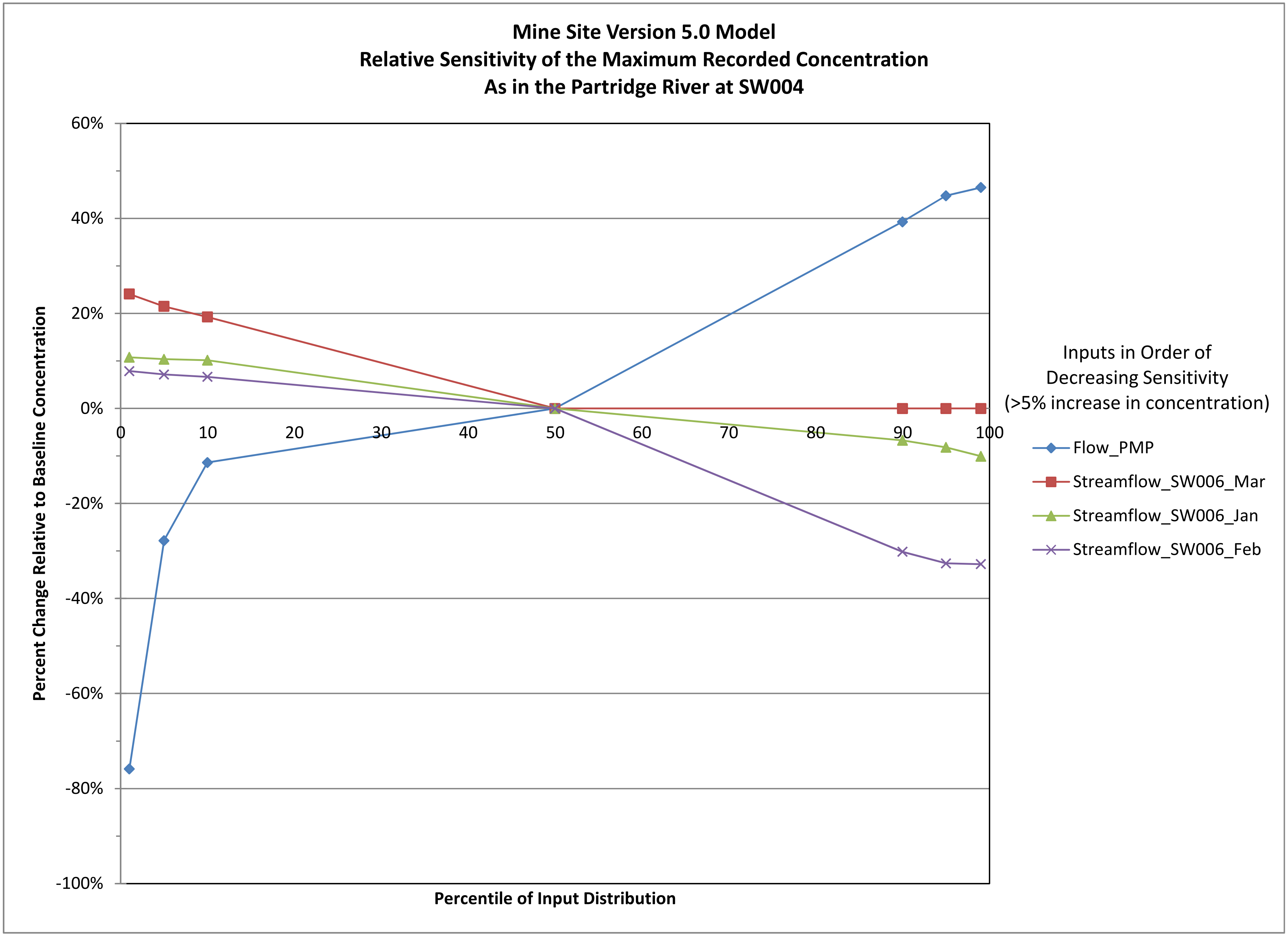

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
Se in Colby Lake
High Run Change
Low Run Change
Baseline Value: 0.0005 mg/L
SW_RO_Random
-0.9%
212.1%
Streamflow_SW006_Jan
-5.2%
1.1%
GW_Inc_Baseflow
0.0%
2.2%
Streamflow_SW006_Feb
-1.3%
-0.1%
Streamflow_SW006_Mar
-0.4%
0.0%
Flow_PMP
-0.1%
0.0%
K_EP23surf
0.0%
0.0%
K_OSLA
0.0%
0.0%
K_OSP
0.0%
0.0%
K_WWTF
0.0%
0.0%
I_ops_EP23surf
0.0%
0.0%
I_ops_OSLAsurf
0.0%
0.0%
Annual_Precip_Cuberoot
0.0%
0.0%
Reclaim_ET
0.0%
0.0%
I_ops_OSPsurf
0.0%
0.0%
I_ops_WWTFsurf
0.0%
0.0%
Reclaim_RO
0.0%
0.0%
Liner_Leak_23
0.0%
0.0%
Liner_Leak_4_OSP
0.0%
0.0%
Bare_ET
0.0%
0.0%
-50%
0%
50%
100%
150%
200%
250%



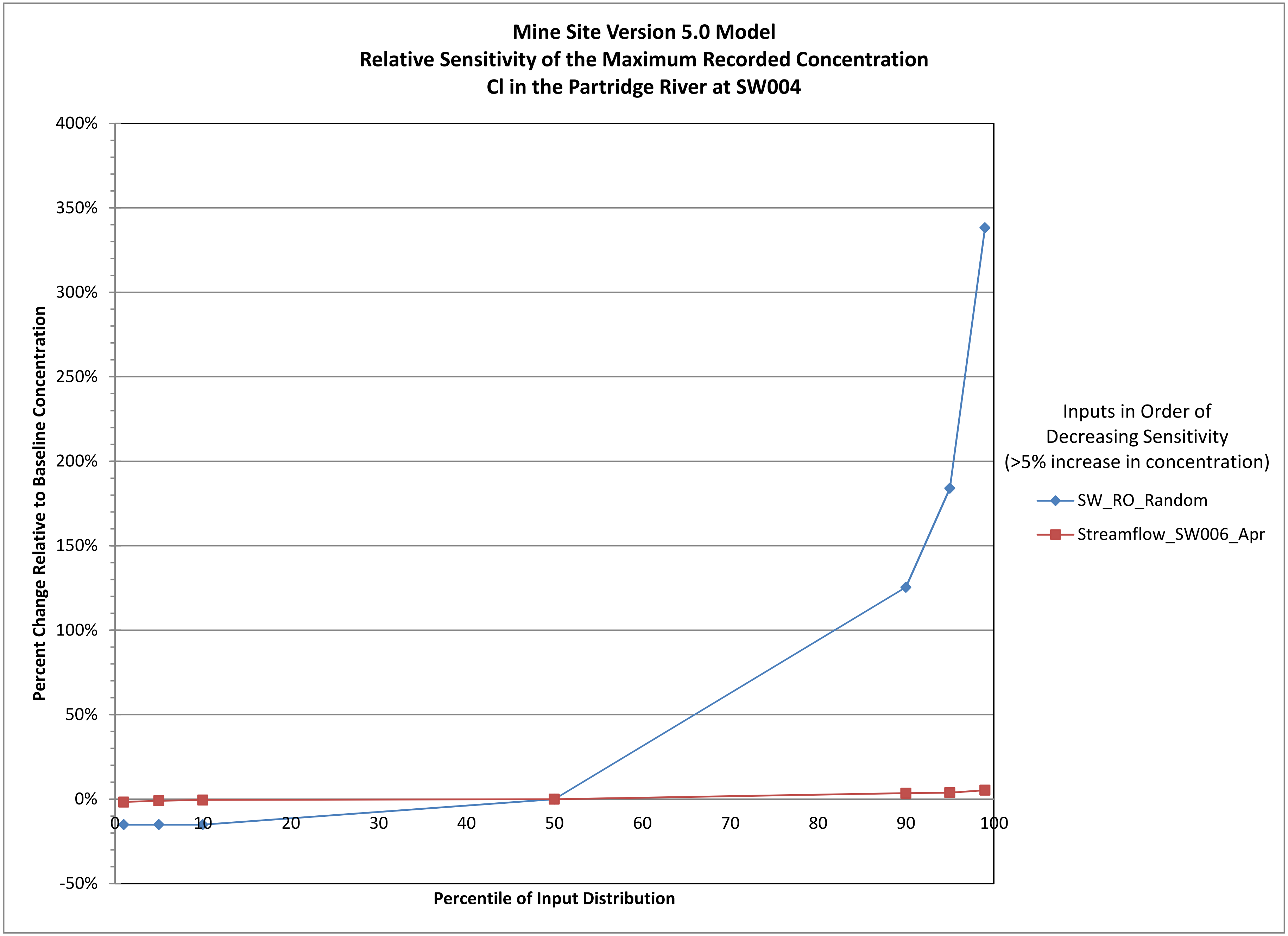
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Value
SO4 in Colby Lake
High Run Change
Low Run Change
Baseline Value: 34.1 mg/L
SW_RO_Random
0.0%
116.4%
Streamflow_SW006_Jan
0.0%
0.0%
GW_Inc_Baseflow
0.0%
0.0%
Streamflow_SW006_Feb
0.0%
0.0%
Streamflow_SW006_Mar
0.0%
0.0%
Flow_PMP
0.0%
0.0%
K_EP23surf
0.0%
0.0%
K_OSLA
0.0%
0.0%
K_OSP
0.0%
0.0%
K_WWTF
0.0%
0.0%
-20%
0%
20%
40%
60%
80%
100%
120%
140%

# Appendix B

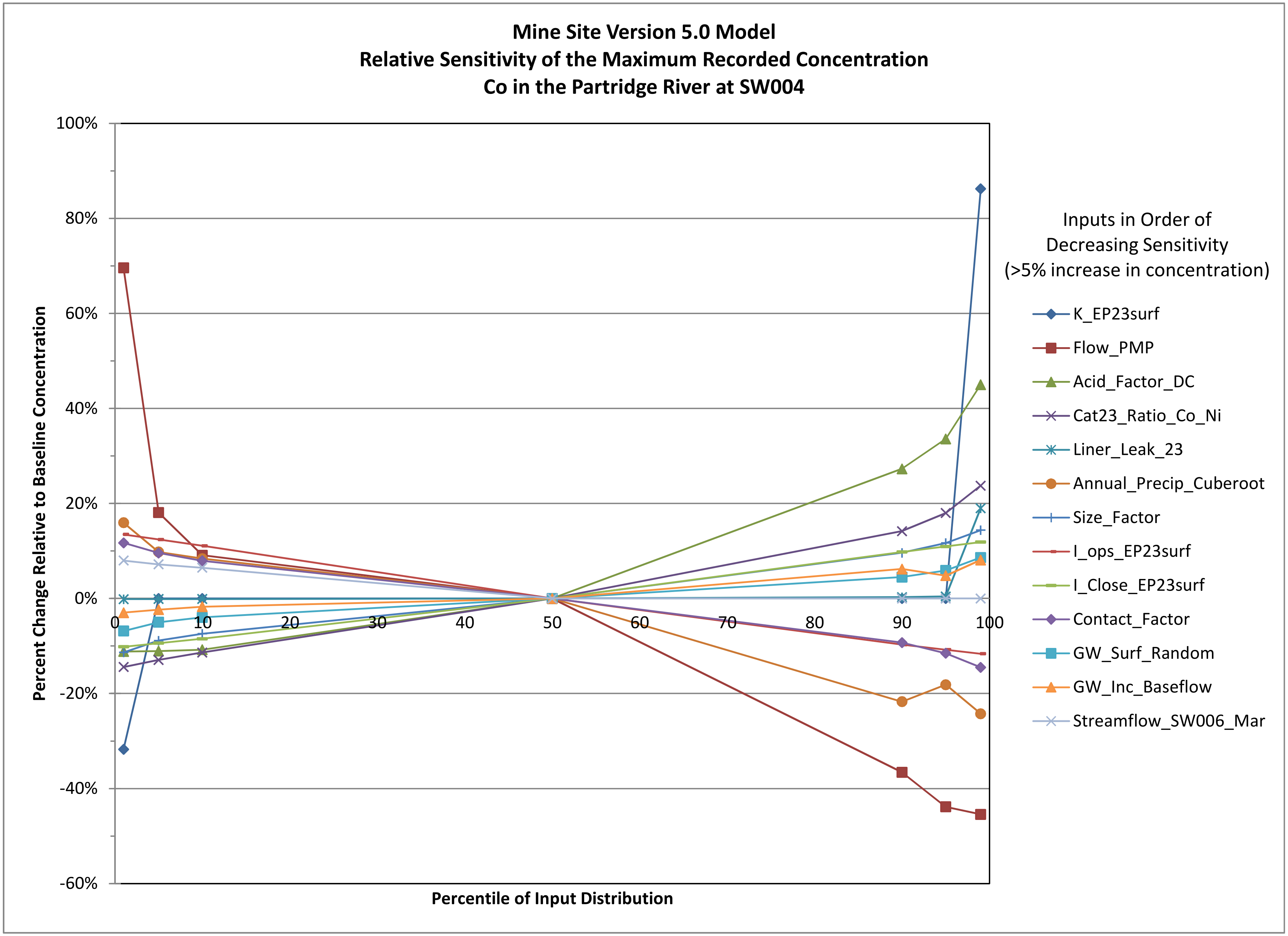
## Normalized X-Y Function Plots from Mine Site Detailed Sensitivity Analysis

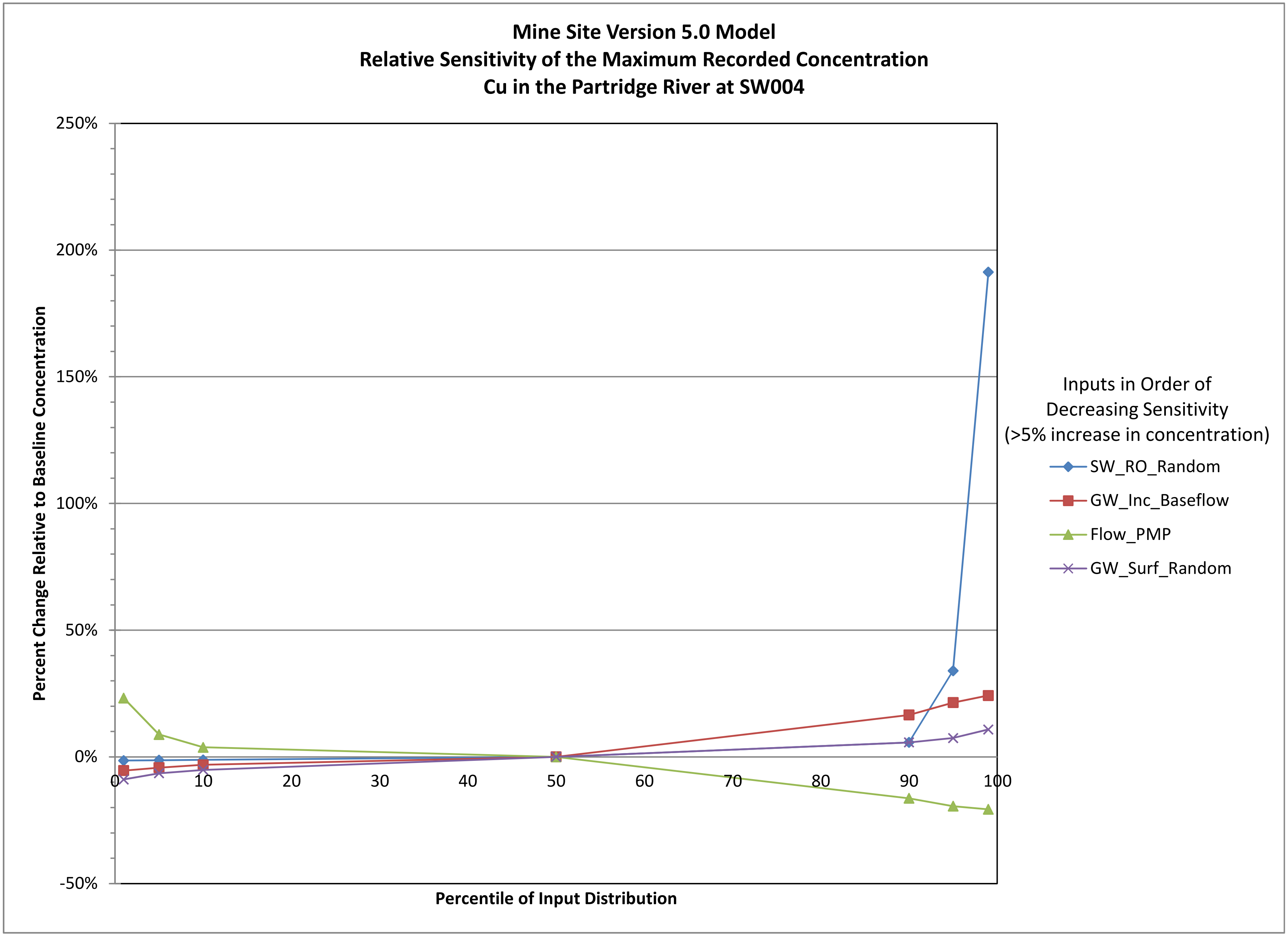


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
As in the Partridge River at SW004
Percent Change Relative to Baseline Concentration
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
Flow_PMP
Streamflow_SW006_Mar
Streamflow_SW006_Jan
Streamflow_SW006_Feb

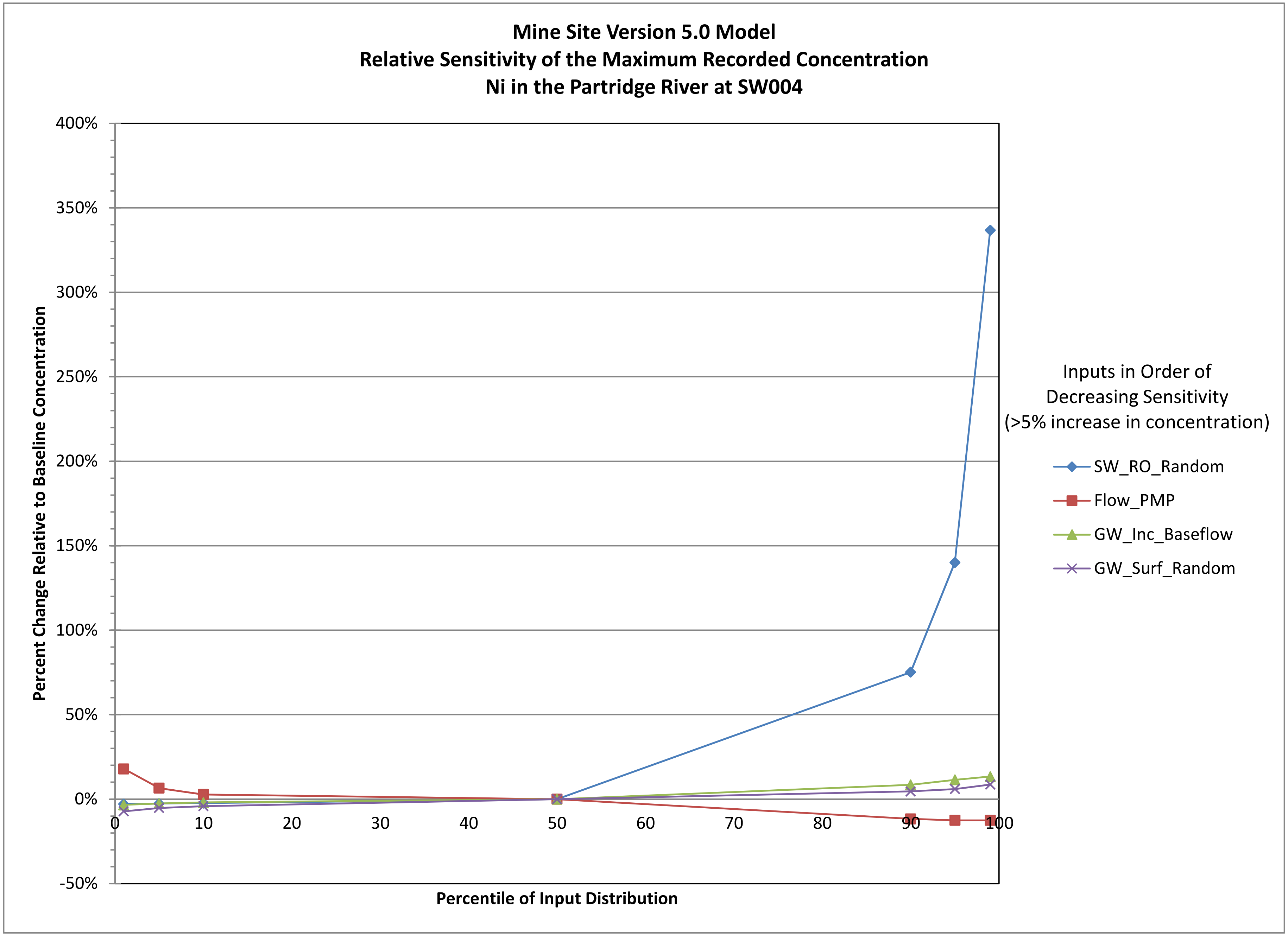


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Cl in the Partridge River at SW004
400%
350%
300%
250%
200%
150%
100%
50%
0%
-50%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
SW_RO_Random
Streamflow_SW006_Apr

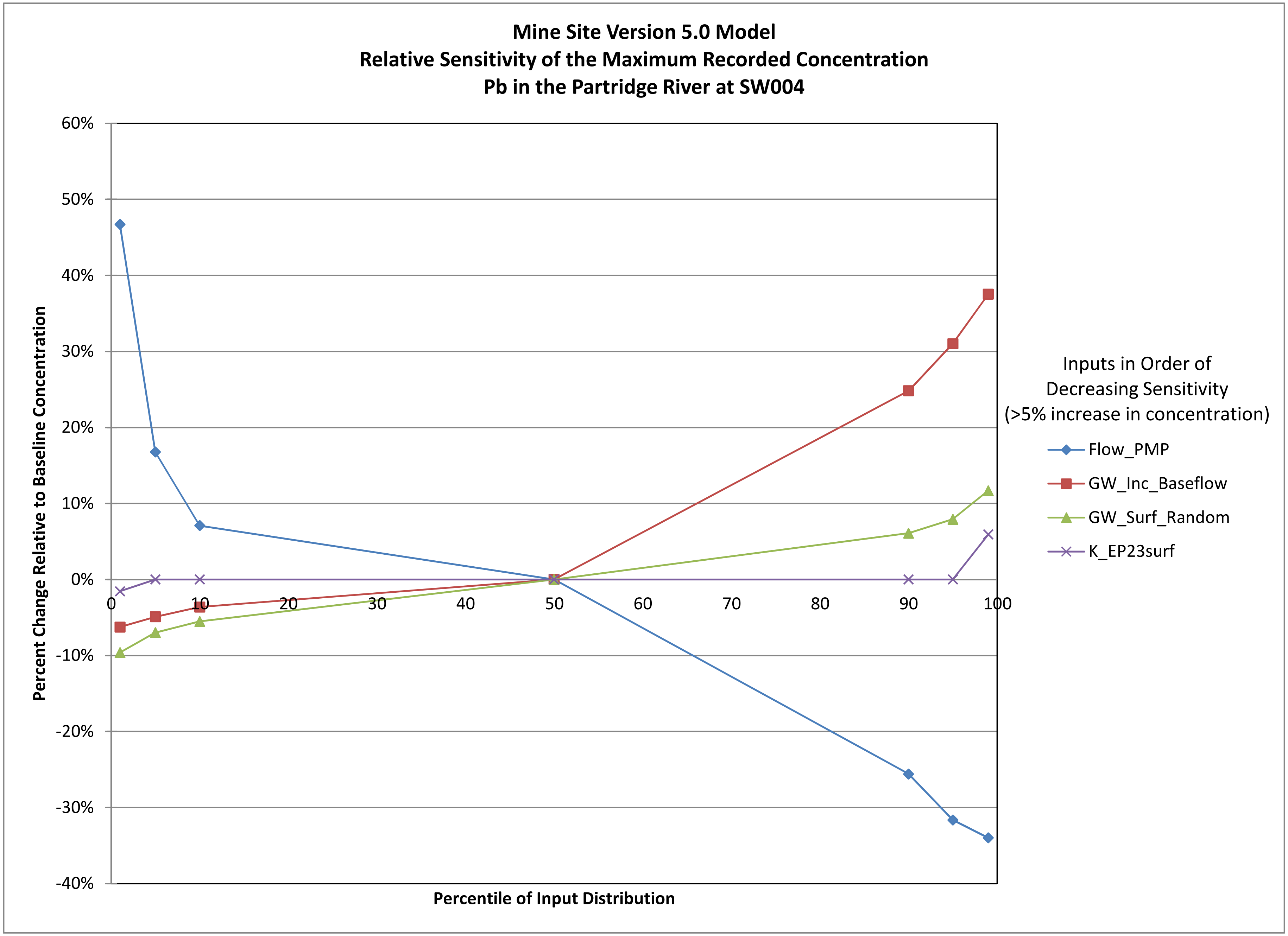

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Co in the Partridge River at SW004
100%
80%
60%
40%
20%
0%
-20%
-40%
-60%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
K_EP23surf
Flow_PMP
Acid_Factor_DC
Cat23_Ratio_Co_Ni
Liner_Leak_23
Annual_Precip_Cuberoot
Size_Factor
I_ops_EP23surf
I_Close_EP23surf
Contact_Factor
GW_Surf_Random
GW_Inc_Baseflow
Streamflow_SW006_Mar



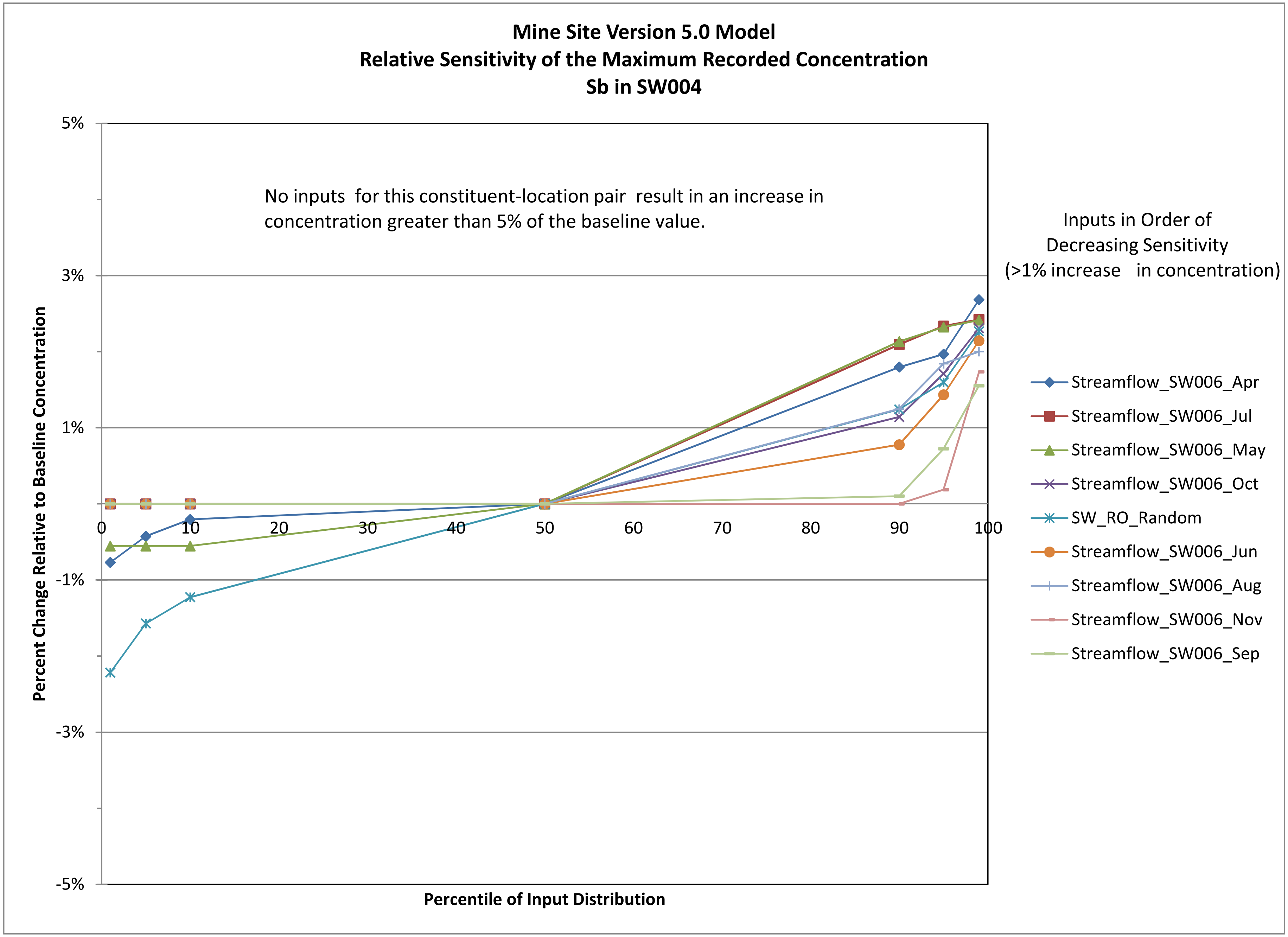
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Cu in the Partridge River at SW004
250%
200%
150%
100%
50%
0%
-50%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
SW_RO_Random
GW_Inc_Baseflow
Flow_PMP
GW_Surf_Random

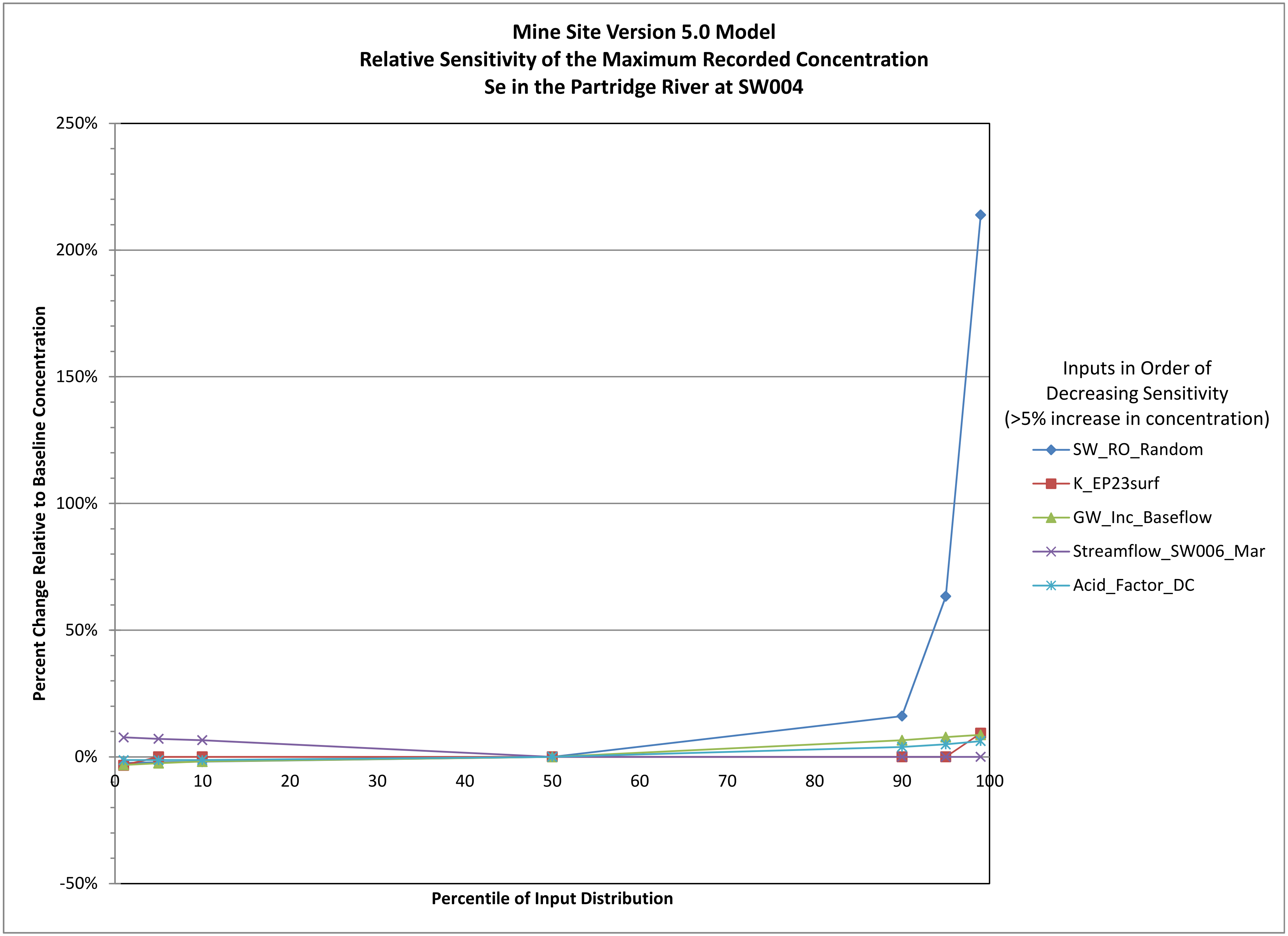


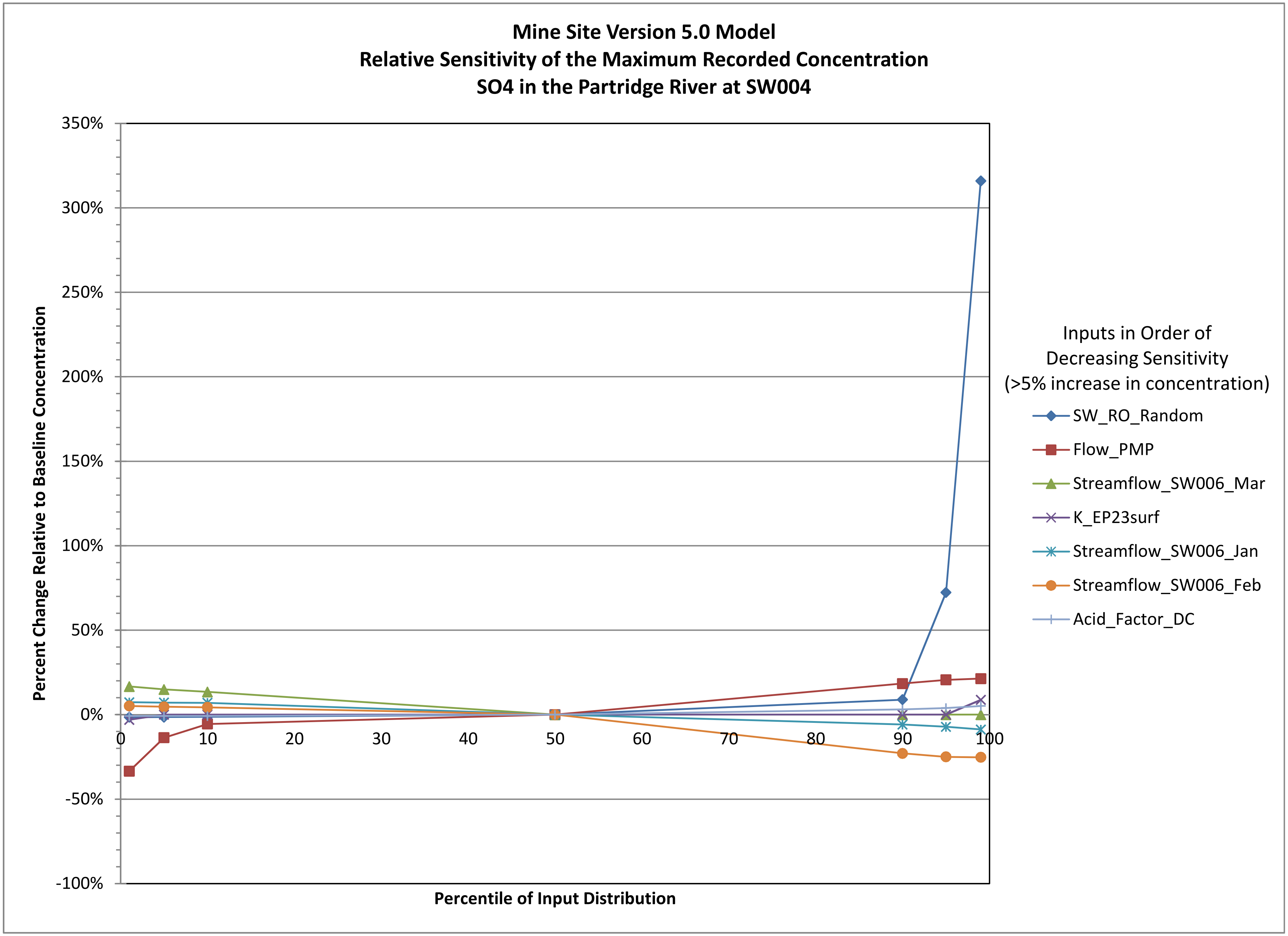
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Ni in the Partridge River at SW004
400%
350%
300%
250%
200%
150%
100%
50%
0%
-50%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
SW_RO_Random
Flow_PMP
GW_Inc_Baseflow
GW_Surf_Random



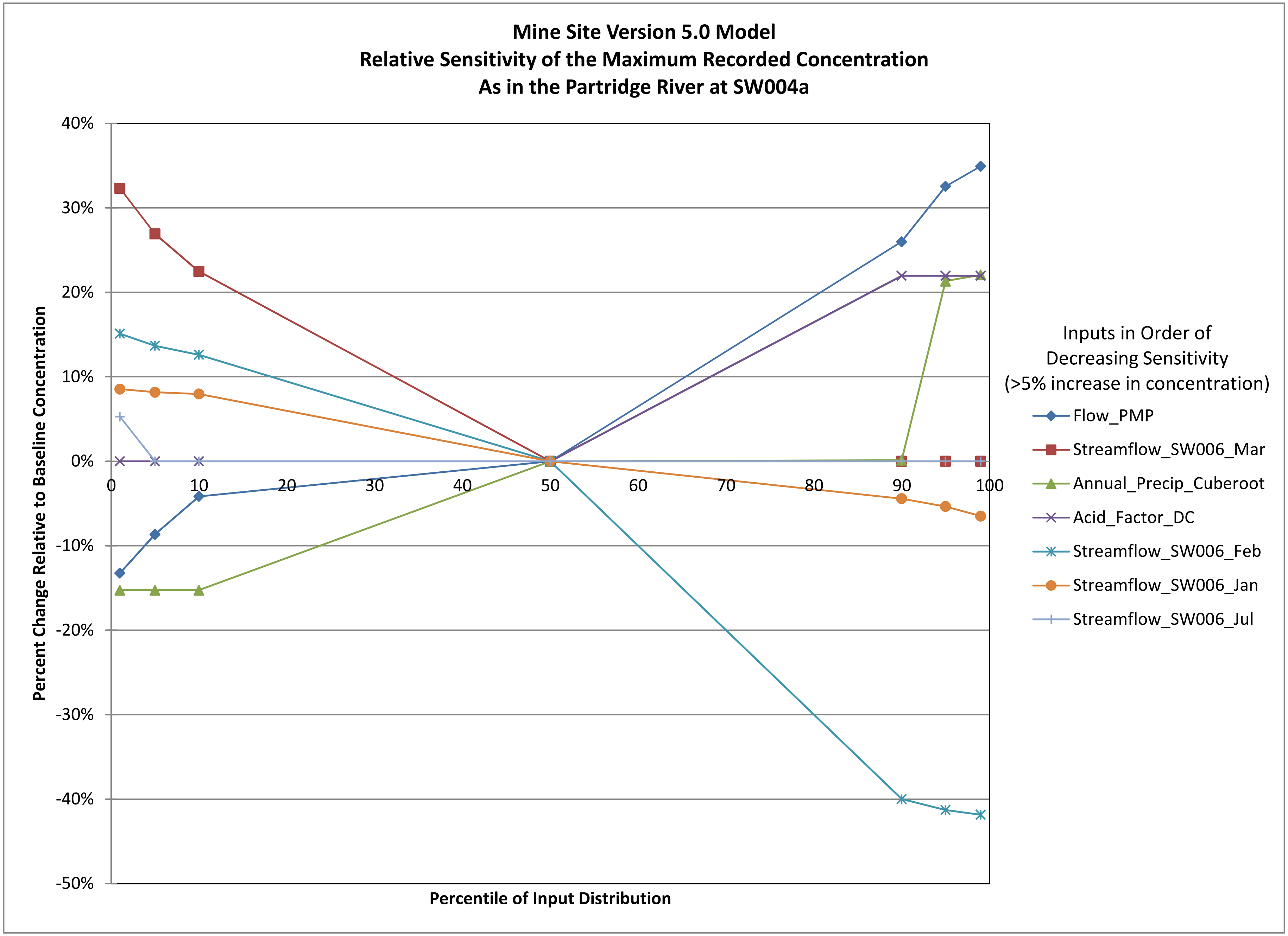
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Pb in the Partridge River at SW004
Percent Change Relative to Baseline Concentration
60%
50%
40%
30%
20%
10%
0%
-10%
-20%
-30%
-40%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
Flow_PMP
GW_Inc_Baseflow
GW_Surf_Random
K_EP23surf


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Sb in SW004
No inputs for this constituent-location pair result in an increase in concentration greater than 5% of the baseline value.
Inputs in Order of Decreasing Sensitivity (>1% increase in concentration)
Streamflow_SW006_Apr
Streamflow_SW006_Jul
Streamflow_SW006_May
Streamflow_SW006_Oct
SW_RO_Random
Streamflow_SW006_Jun
Streamflow_SW006_Aug
Streamflow_SW006_Nov
Streamflow_SW006_Sep
Percent Change Relative to Baseline Concentration
Percentile of Input Distribution
5%
3%
1%
-1%
-3%
-5%
0
10
20
30
40
50
60
70
80
90
100

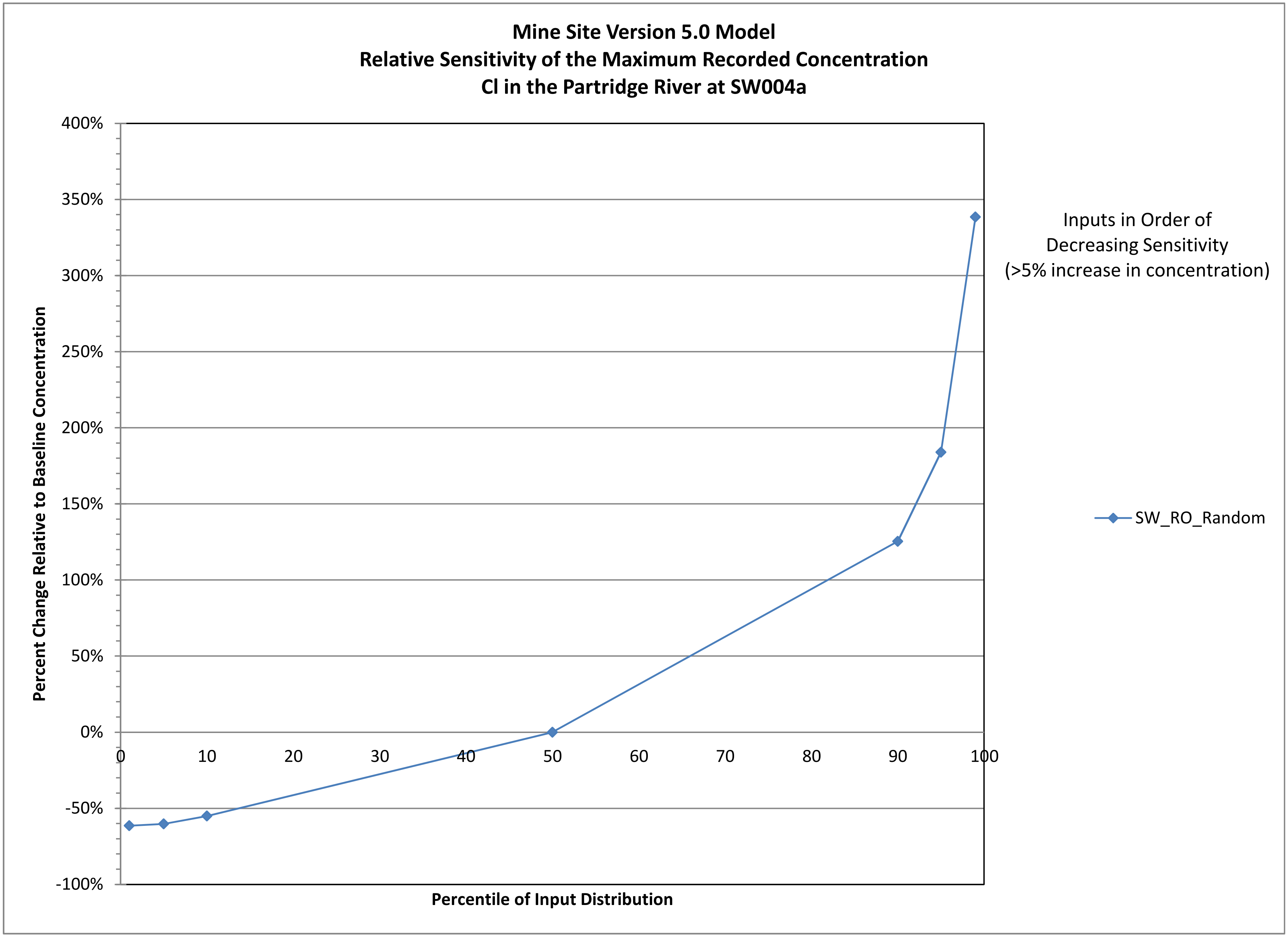

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Se in the Partridge River at SW004
250%
200%
150%
100%
50%
0%
-50%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
SW_RO_Random
K_EP23surf
GW_Inc_Baseflow
Streamflow_SW006_Mar
Acid_Factor_DC



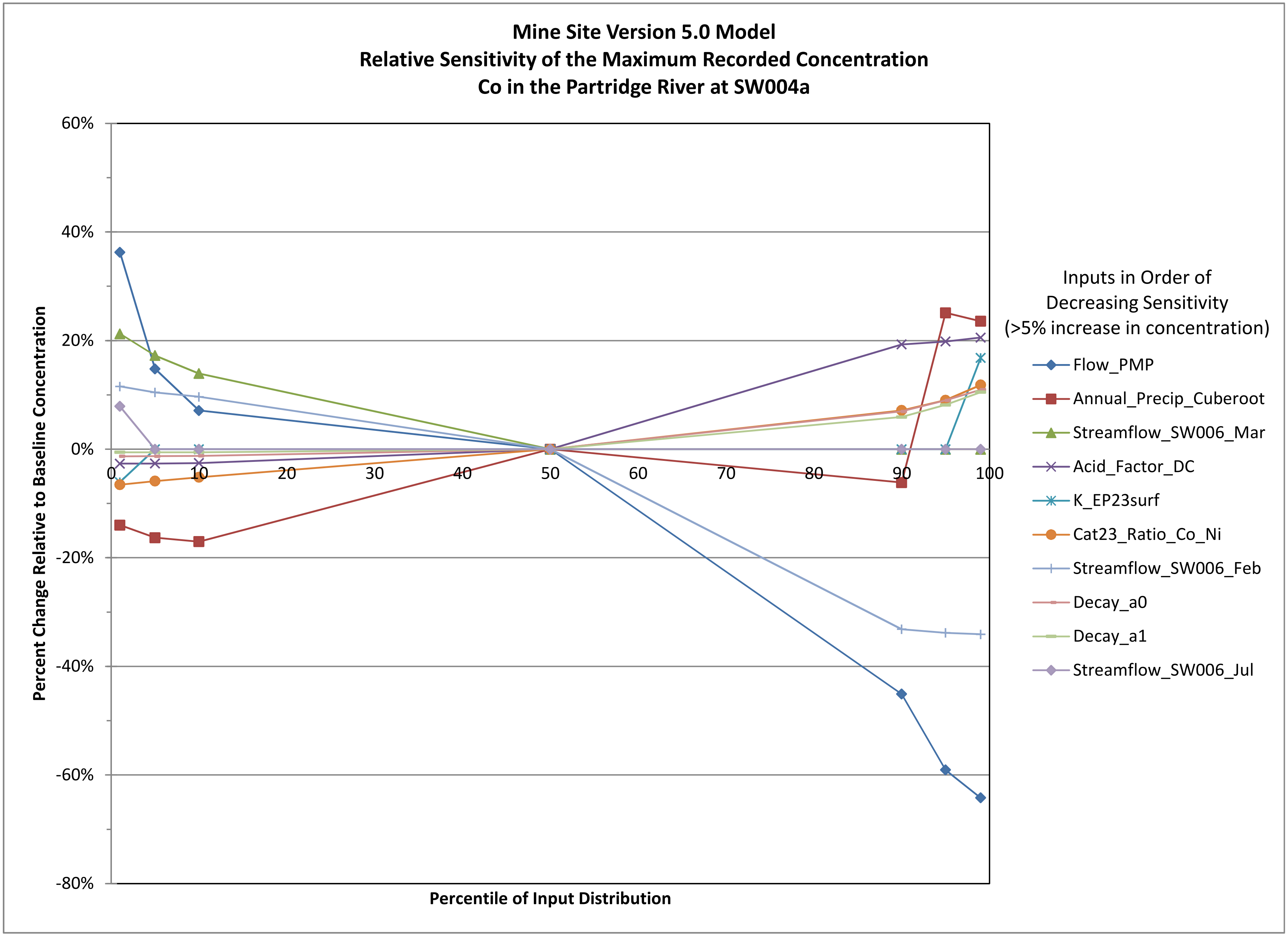
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
SO4 in the Partridge River at SW004
350%
300%
250%
200%
150%
100%
50%
0%
-50%
-100%
0
10
20
30
40
50
60
70
80
90
100
Percent Change Relative to Baseline Concentration
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
SW_RO_Random
Flow_PMP
Streamflow_SW006_Mar
K_EP23surf
Streamflow_SW006_Jan
Streamflow_SW006_Feb
Acid_Factor_DC



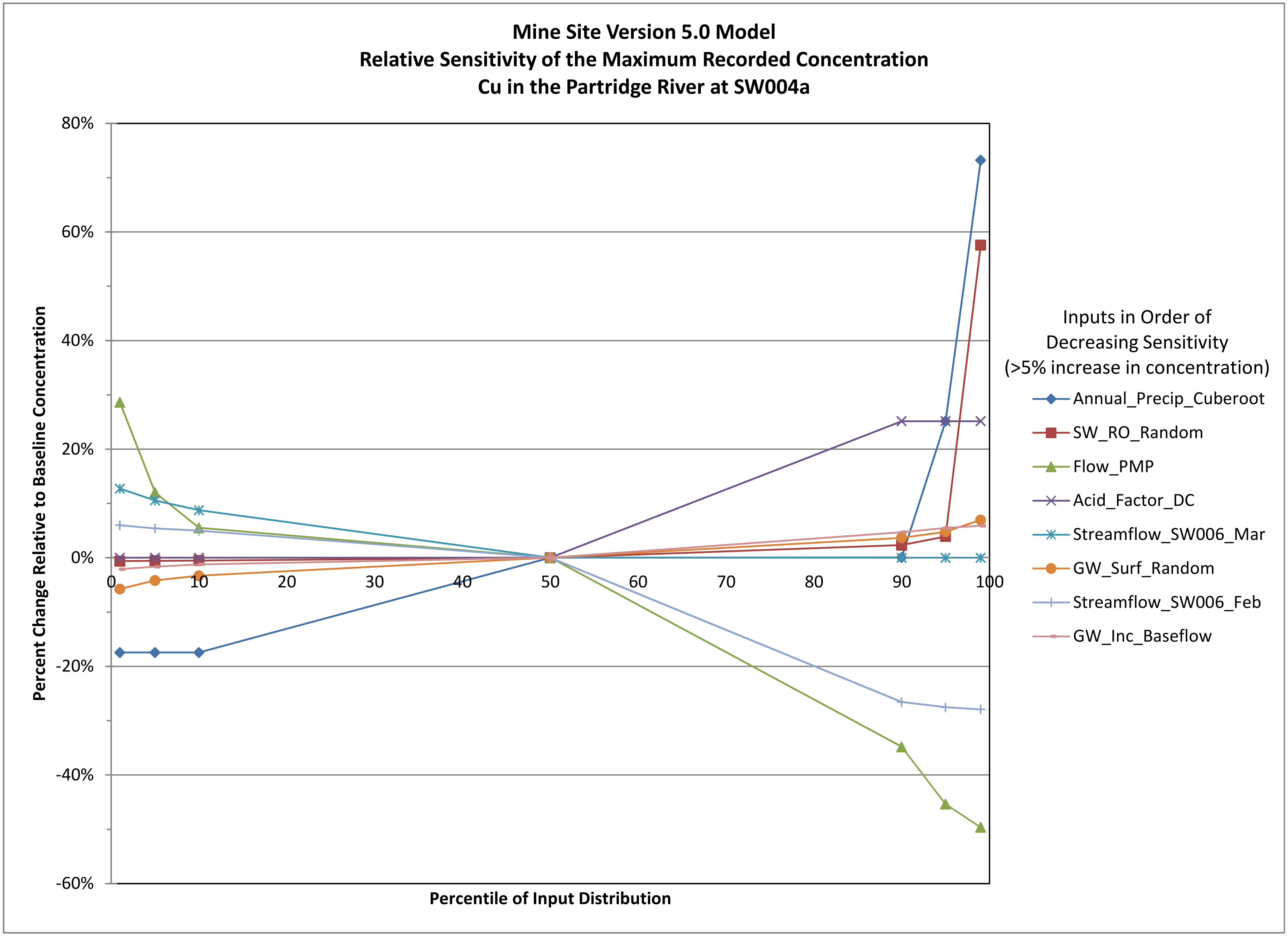
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
As in the Partridge River at SW004a
40%
30%
20%
10%
0%
-10%
-20%
-30%
-40%
-50%
0
10
20
30
40
50
60
70
80
90
100
Percent Change Relative to Baseline Concentration
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
Flow_PMP
Streamflow_SW006_Mar
Annual_Precip_Cuberoot
Acid_Factor_DC
Streamflow_SW006_Feb
Streamflow_SW006_Jan
Streamflow_SW006_Jul



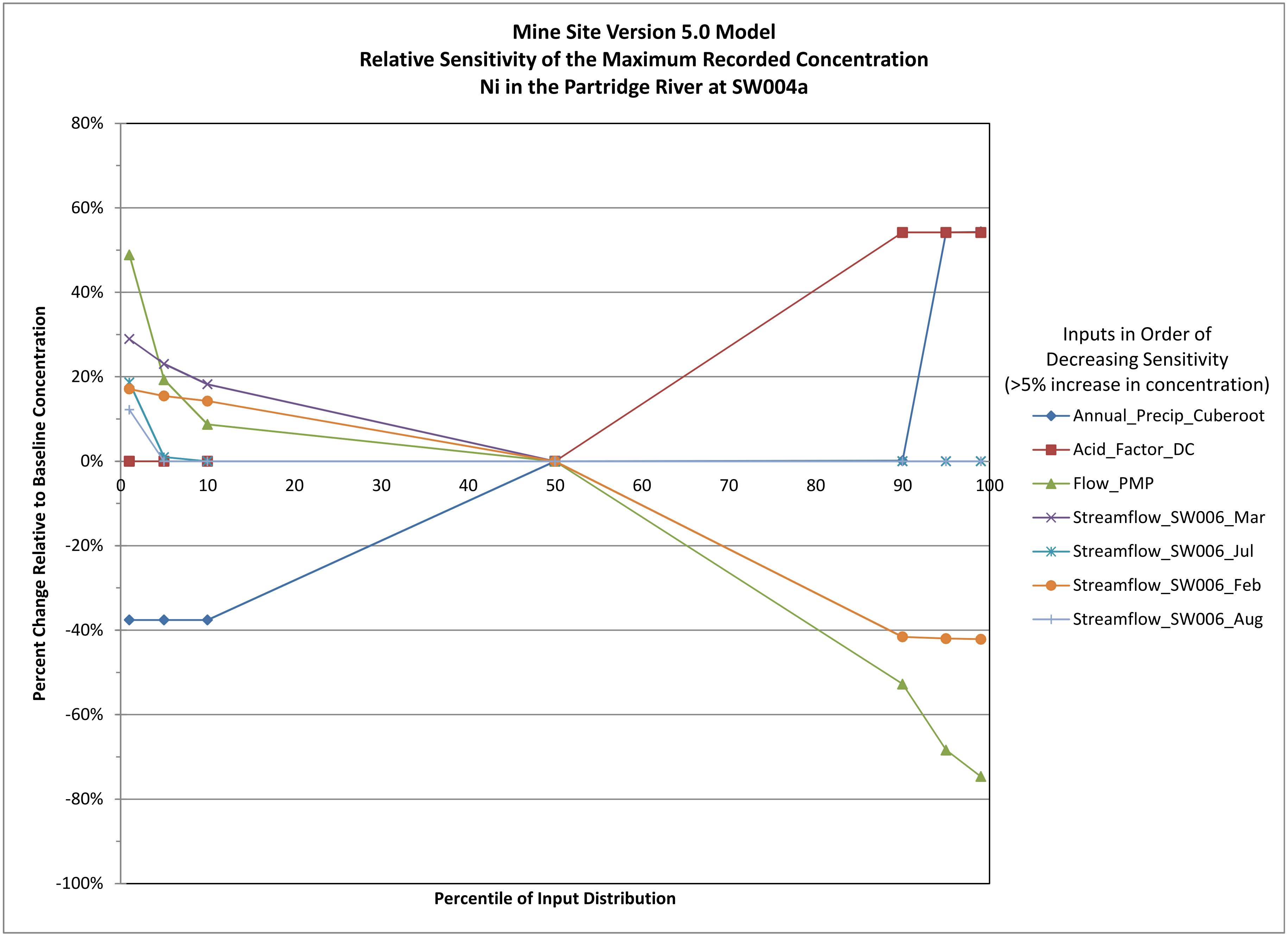
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Cl in the Partridge River at SW004a
Percent Change Relative to Baseline Concentration
400%
350%
300%
250%
200%
150%
100%
50%
0%
-50%
-100%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
SW_RO_Random

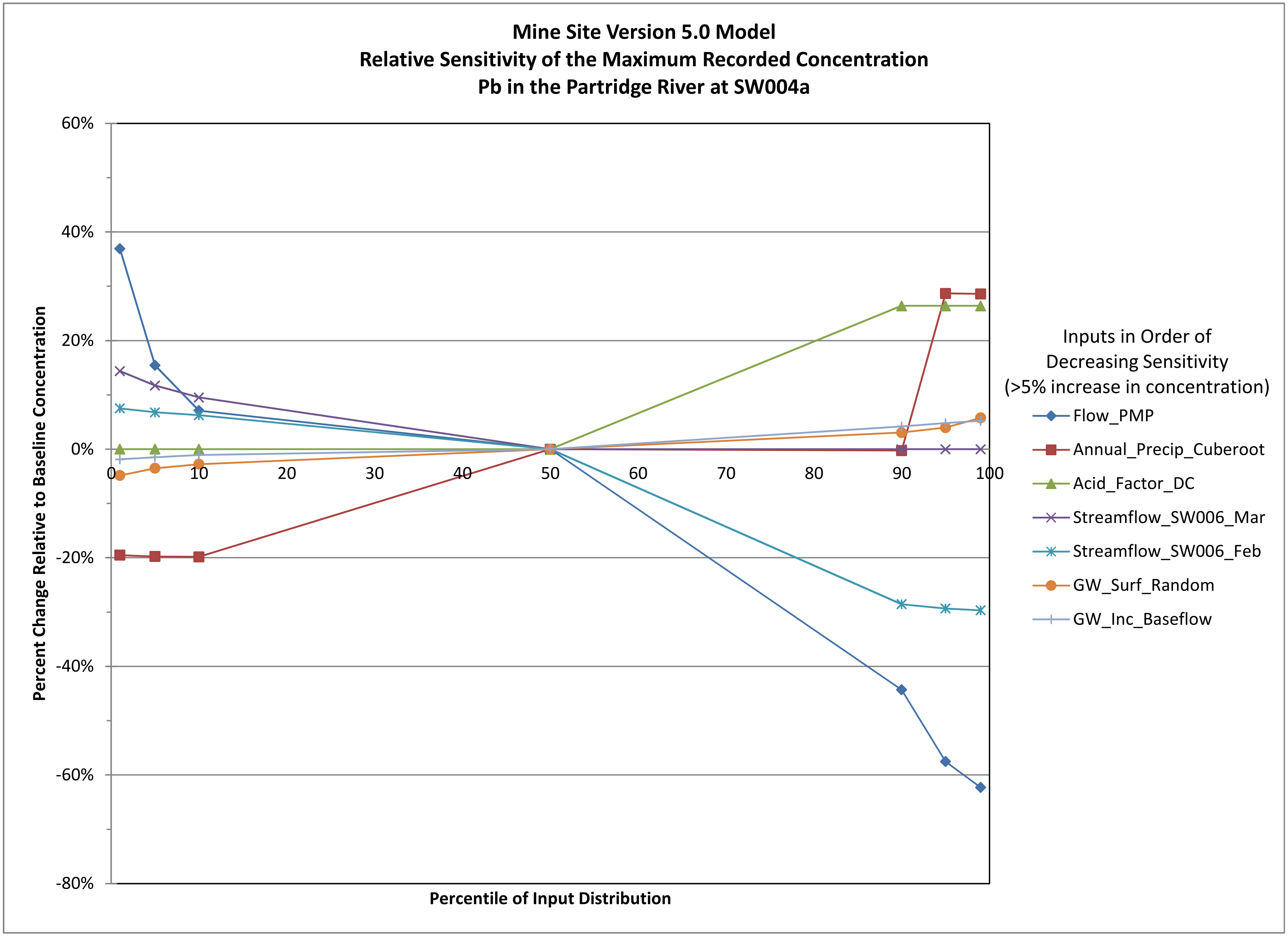


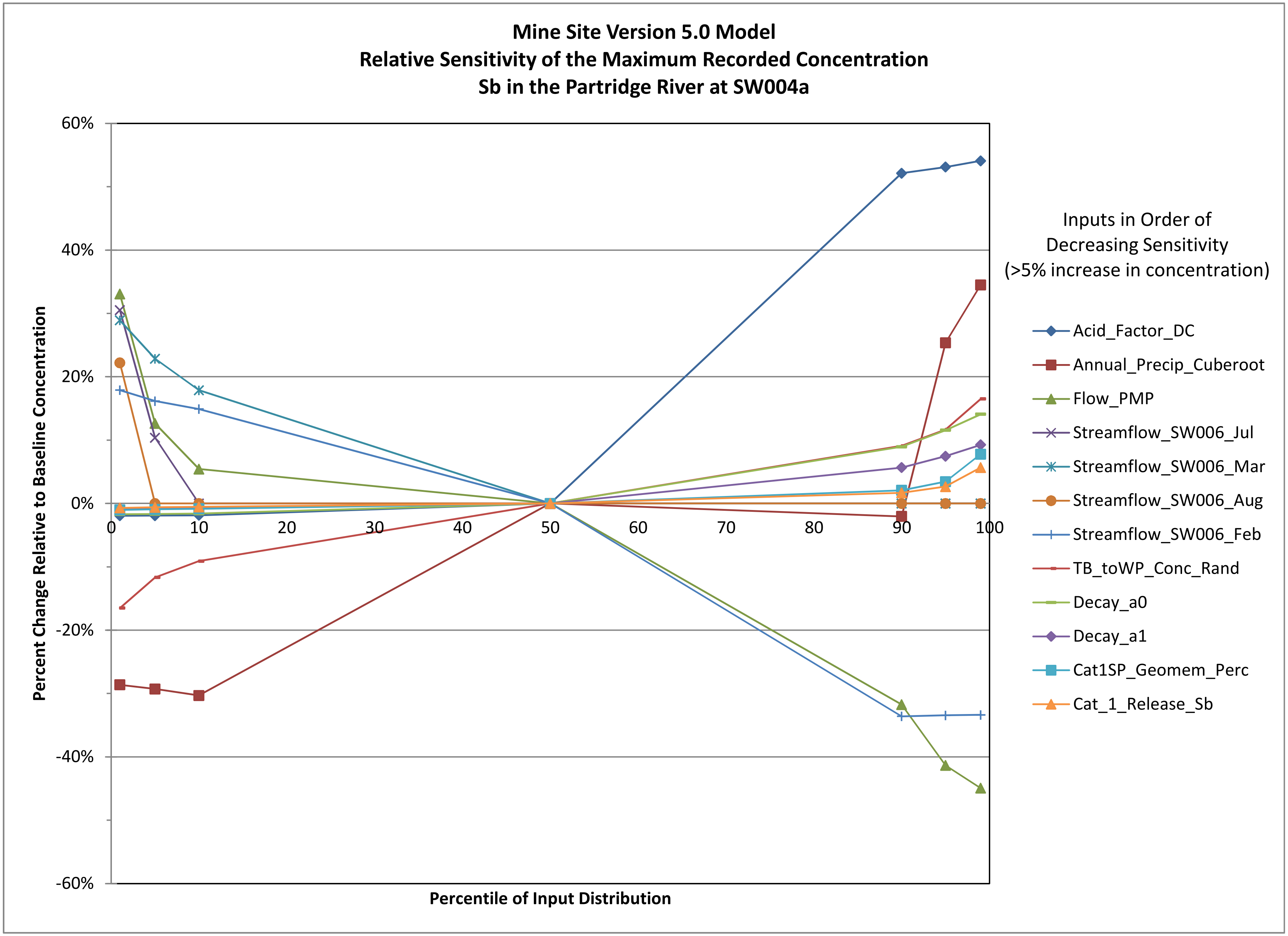
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Co in the Partridge River at SW004a
Percent Change Relative to Baseline Concentration
60%
40%
20%
0%
-20%
-40%
-60%
-80%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
Flow_PMP
Annual_Precip_Cuberoot
Streamflow_SW006_Mar
Acid_Factor_DC
K_EP23surf
Cat23_Ratio_Co_Ni
Streamflow_SW006_Feb
Decay_a0
Decay_a1
Streamflow_SW006_Jul

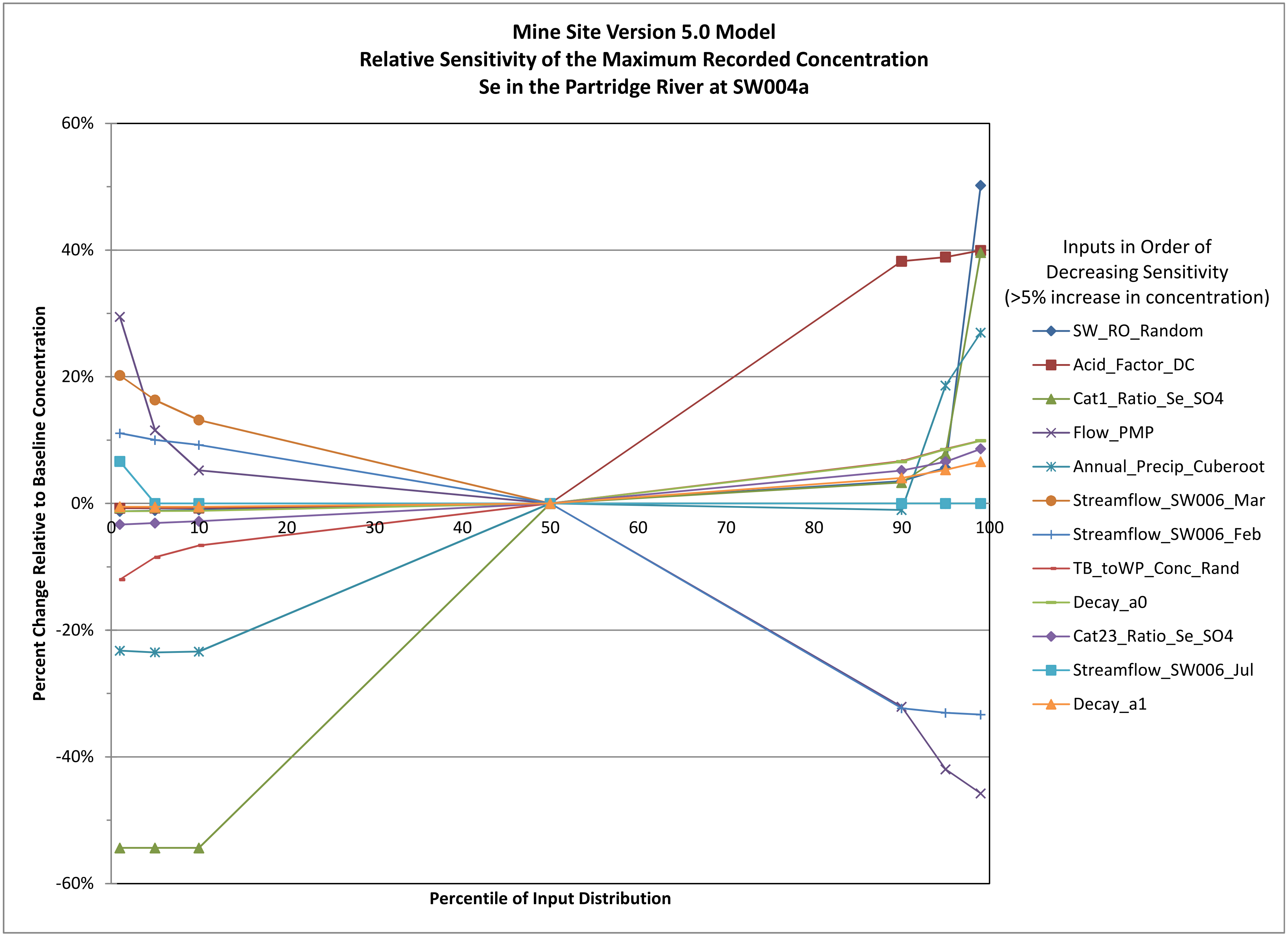


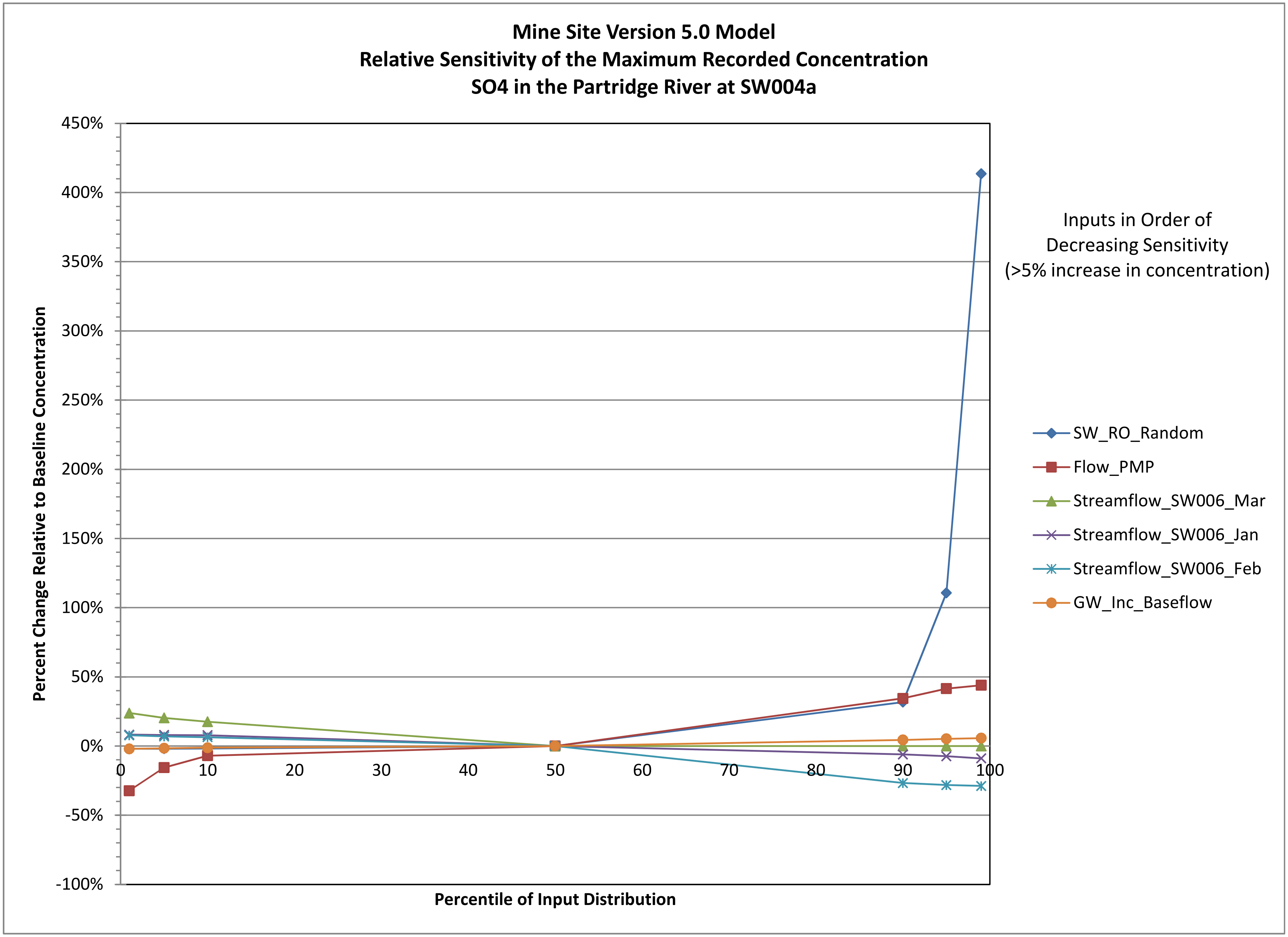
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Cu in the Partridge River at SW004a
80%
60%
40%
20%
0%
-20%
-40%
-60%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
Annual_Precip_Cuberoot
SW_RO_Random
Flow_PMP
Acid_Factor_DC
Streamflow_SW006_Mar
GW_Surf_Random
Streamflow_SW006_Feb
GW_Inc_Baseflow


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Ni in the Partridge River at SW004a
80%
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
Annual_Precip_Cuberoot
Acid_Factor_DC
Flow_PMP
Streamflow_SW006_Mar
Streamflow_SW006_Jul
Streamflow_SW006_Feb
Streamflow_SW006_Aug

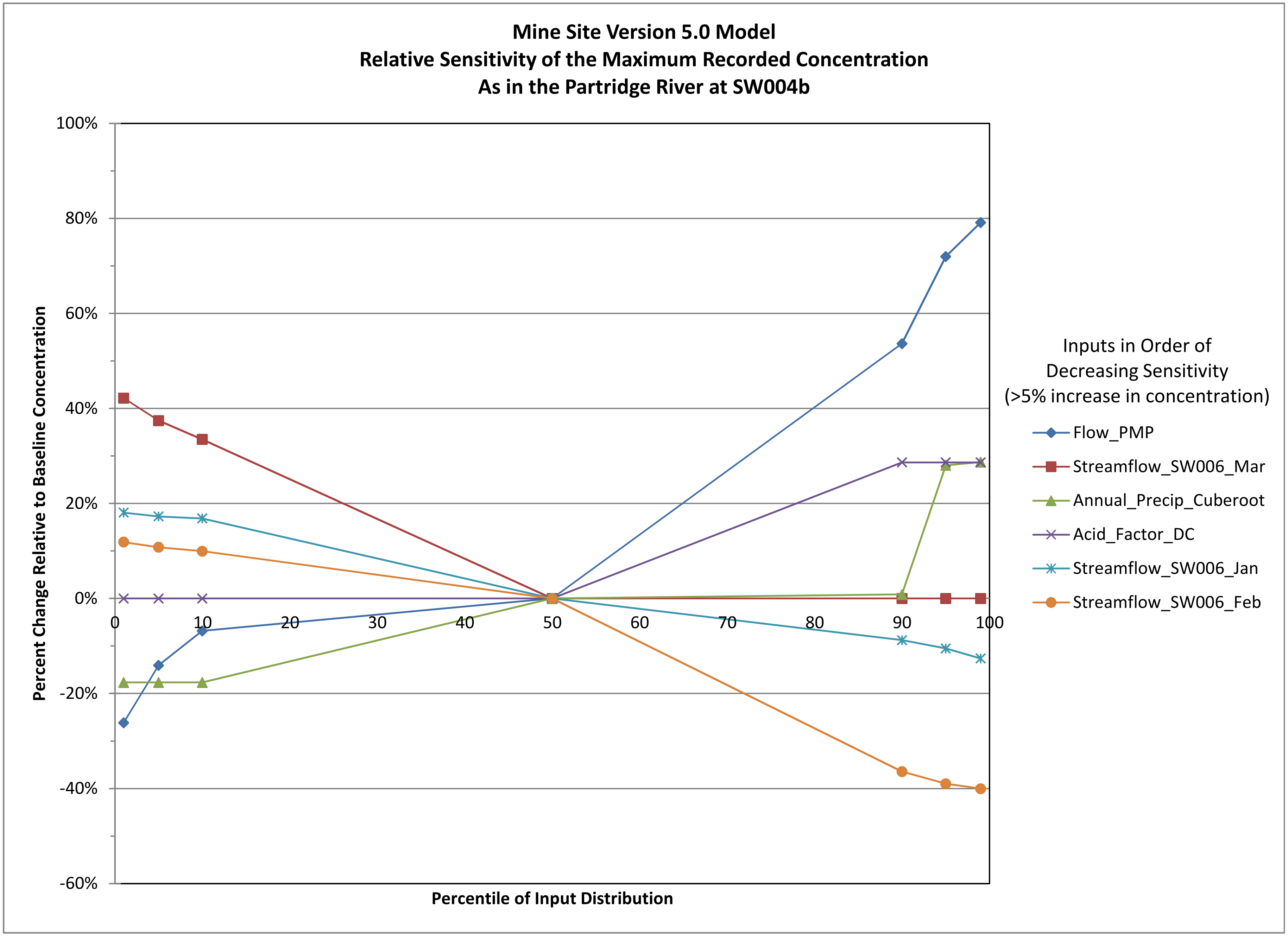

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Pb in the Partridge River at SW004a
60%
40%
20%
0%
-20%
-40%
-60%
-80%
0
10
20
30
40
50
60
70
80
90
100
Percent Change Relative to Baseline Concentration
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
Flow_PMP
Annual_Precip_Cuberoot
Acid_Factor_DC
Streamflow_SW006_Mar
Streamflow_SW006_Feb
GW_Surf_Random
GW_Inc_Baseflow

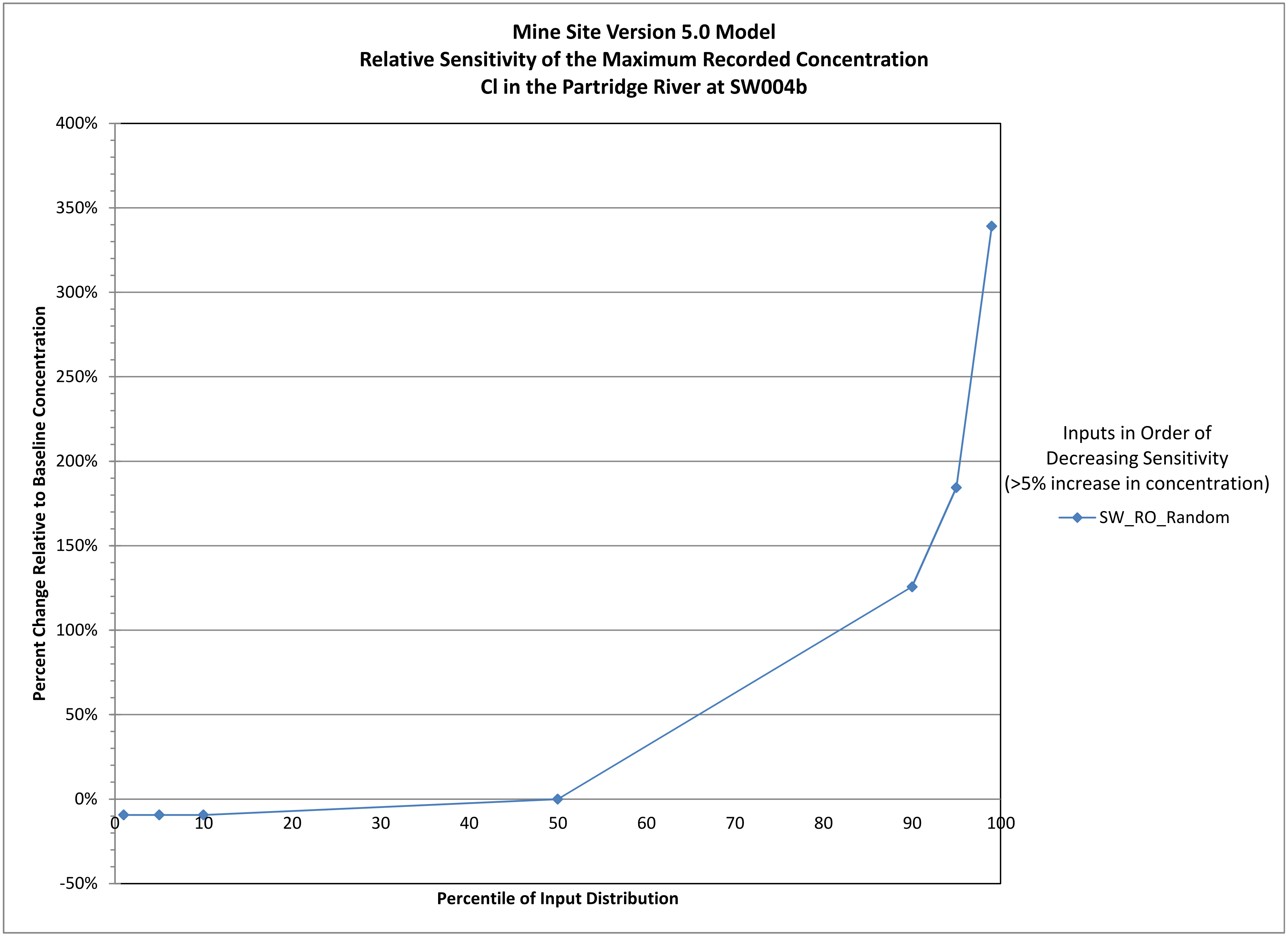

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Sb in the Partridge River at SW004a
60%
40%
20%
0%
-20%
-40%
-60%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
Acid_Factor_DC
Annual_Precip_Cuberoot
Flow_PMP
Streamflow_SW006_Jul
Streamflow_SW006_Mar
Streamflow_SW006_Aug
Streamflow_SW006_Feb
TB_toWP_Conc_Rand
Decay_a0
Decay_a1
Cat1SP_Geomem_Perc
Cat_1_Release_Sb

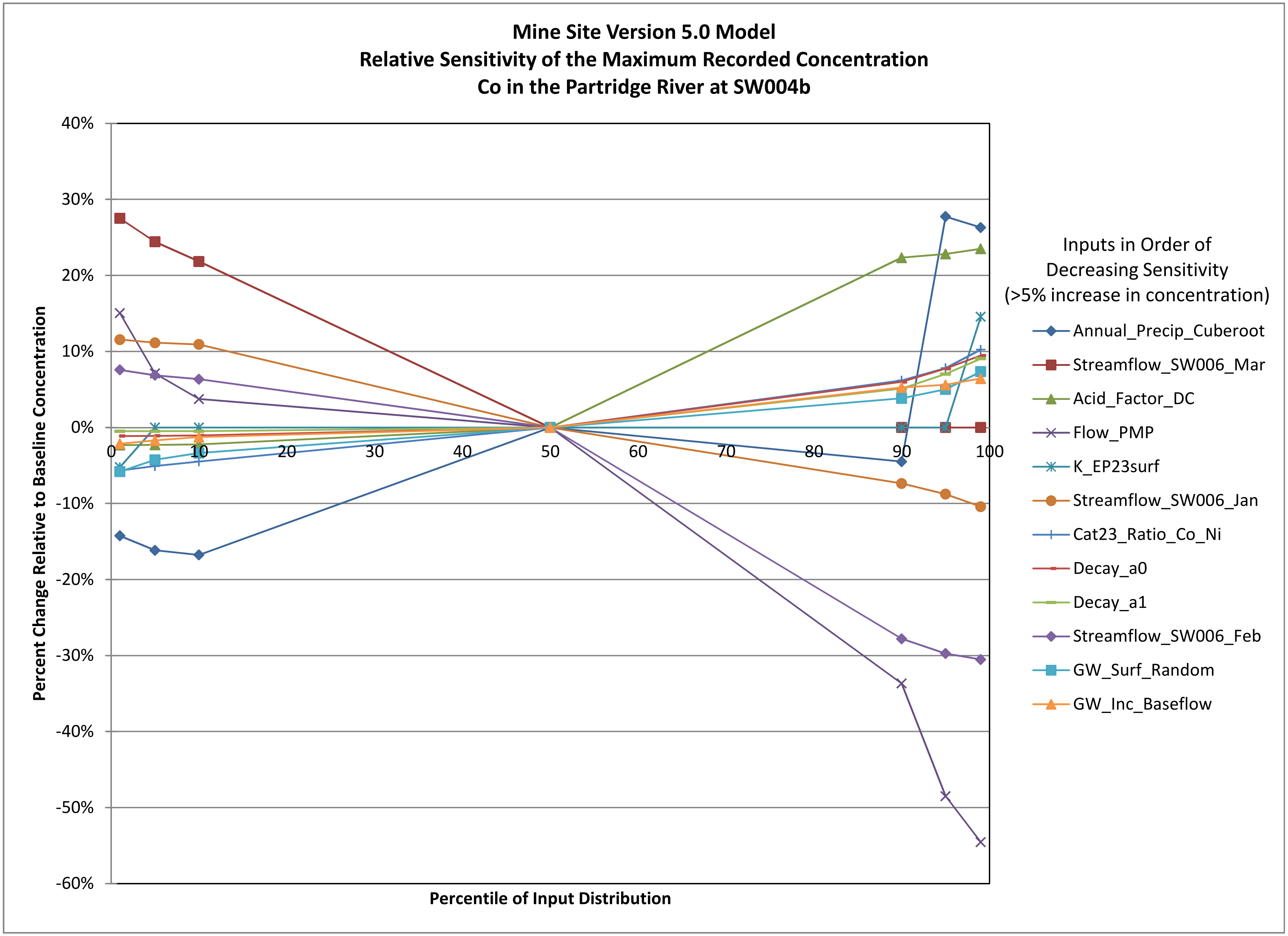

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Se in the Partridge River at SW004a
Percent Change Relative to Baseline Concentration
60%
40%
20%
0%
-20%
-40%
-60%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
SW_RO_Random
Acid_Factor_DC
Cat1_Ratio_Se_SO4
Flow_PMP
Annual_Precip_Cuberoot
Streamflow_SW006_Mar
Streamflow_SW006_Feb
TB_toWP_Conc_Rand
Decay_a0
Cat23_Ratio_Se_SO4
Streamflow_SW006_Jul
Decay_a1



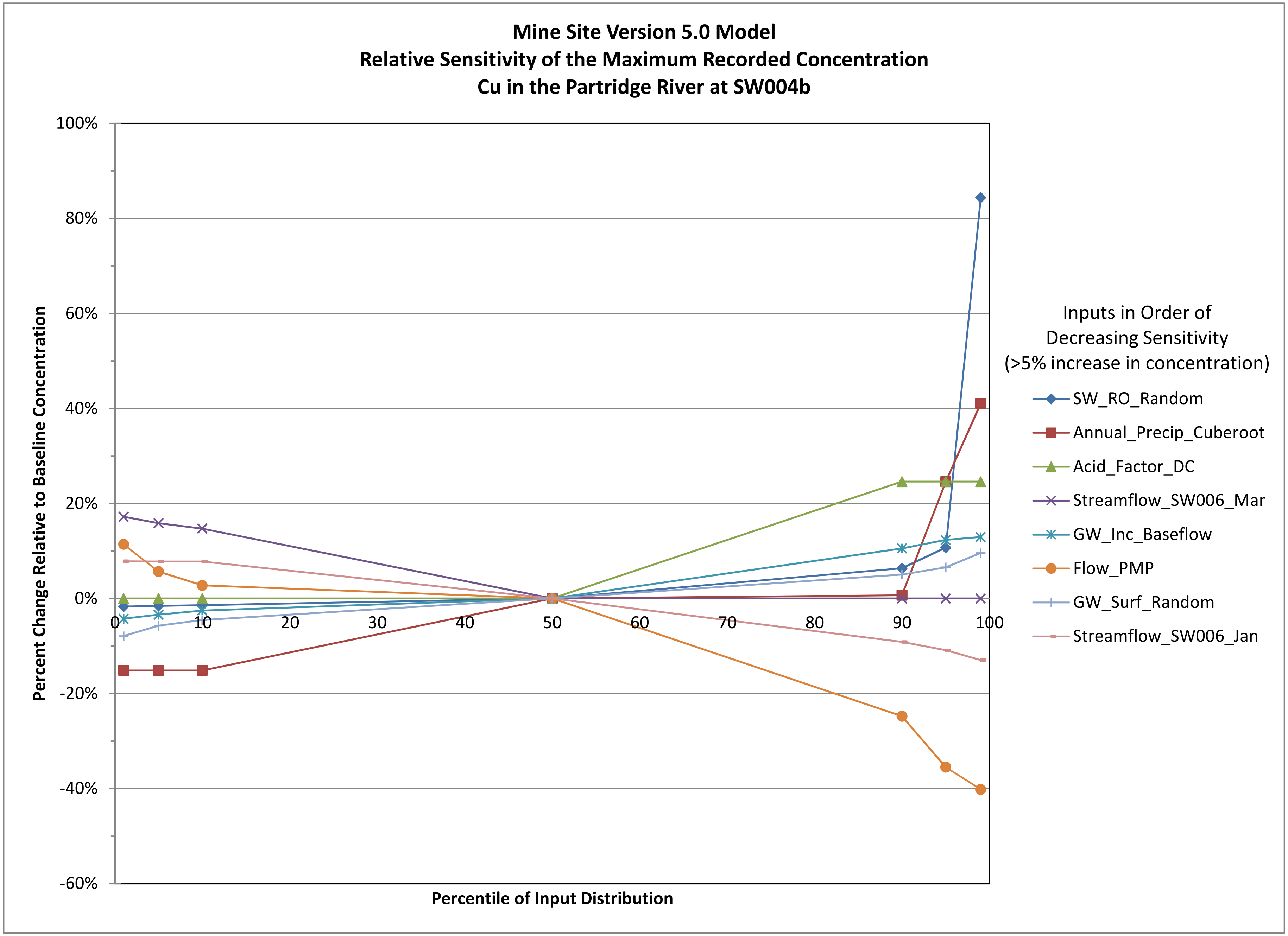
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
SO4 in the Partridge River at SW004a
Percent Change Relative to Baseline Concentration
450%
400%
350%
300%
250%
200%
150%
100%
50%
0%
-50%
-100%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
SW_RO_Random
Flow_PMP
Streamflow_SW006_Mar
Streamflow_SW006_Jan
Streamflow_SW006_Feb
GW_Inc_Baseflow


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
As in the Partridge River at SW004b
Percent Change Relative to Baseline Concentration
100%
80%
60%
40%
20%
0%
-20%
-40%
-60%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
Flow_PMP
Streamflow_SW006_Mar
Annual_Precip_Cuberoot
Acid_Factor_DC
Streamflow_SW006_Jan
Streamflow_SW006_Feb

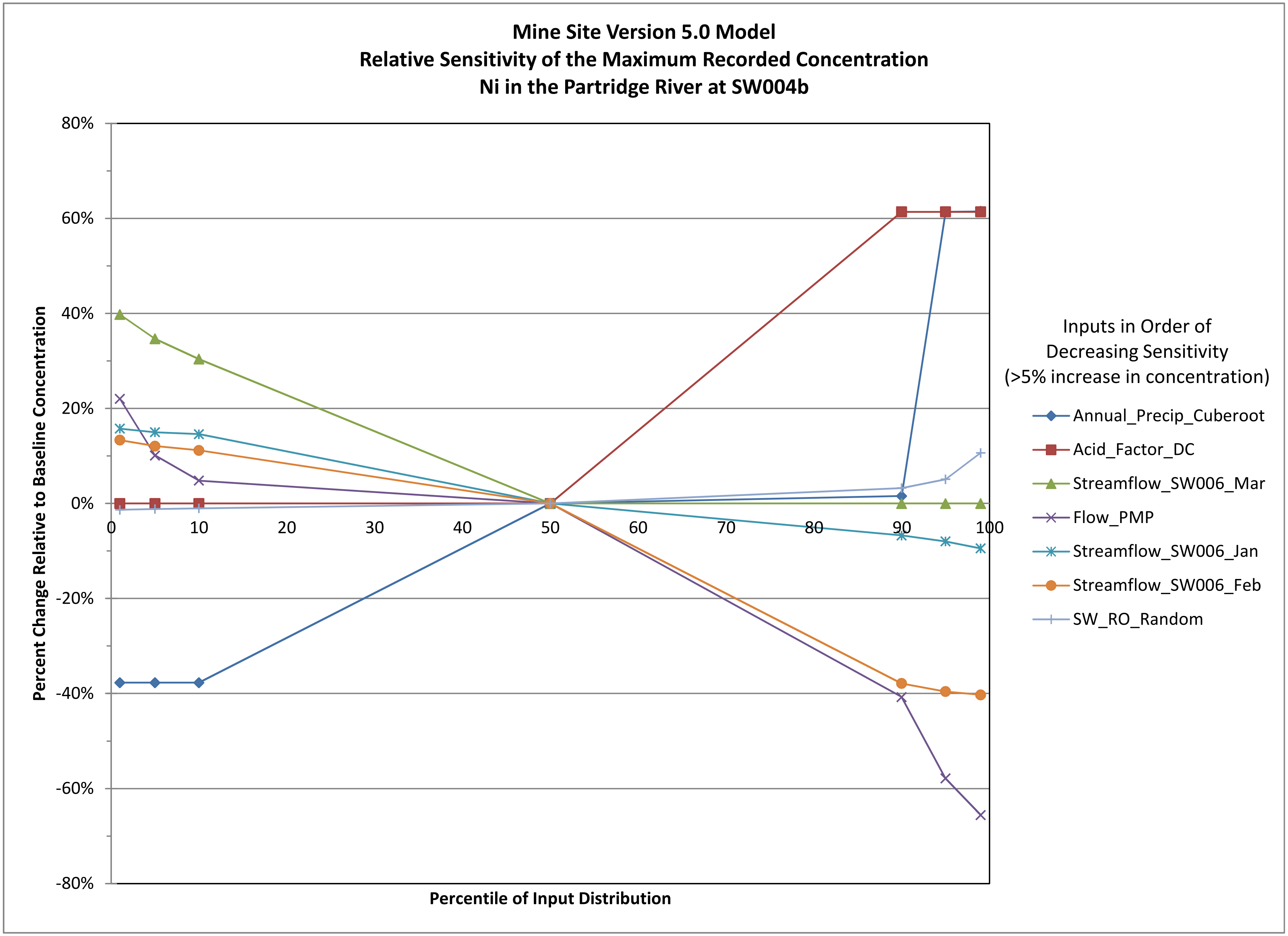

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Cl in the Partridge River at SW004b
400%
350%
300%
250%
200%
150%
100%
50%
0%
-50%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
SW_RO_Random

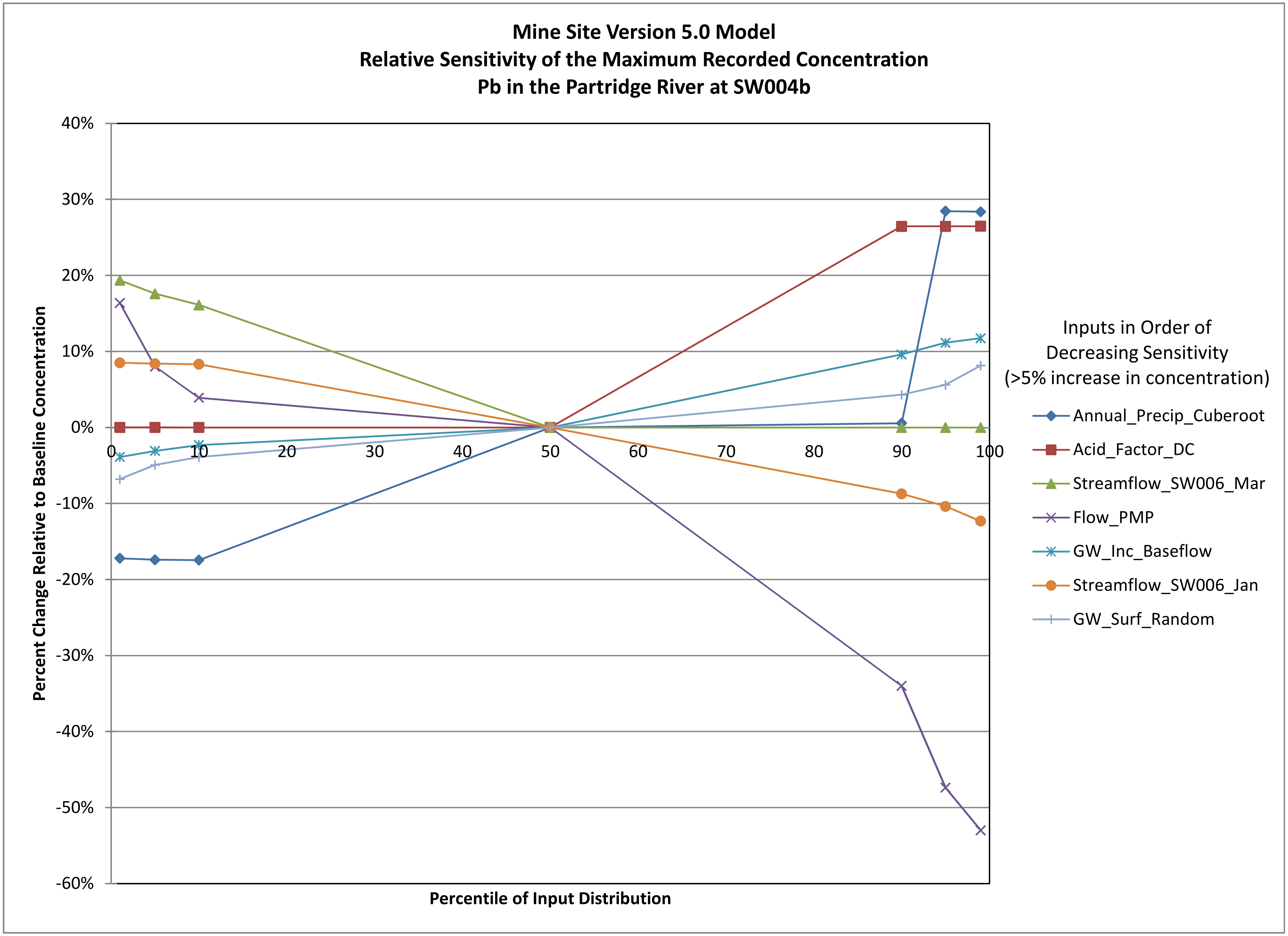


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Co in the Partridge River at SW004b
Percent Change Relative to Baseline Concentration
40%
30%
20%
10%
0%
-10%
-20%
-30%
-40%
-50%
-60%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
Annual_Precip_Cuberoot
Streamflow_SW006_Mar
Acid_Factor_DC
Flow_PMP
K_EP23surf
Streamflow_SW006_Jan
Cat23_Ratio_Co_Ni
Decay_a0
Decay_a1
Streamflow_SW006_Feb
GW_Surf_Random
GW_Inc_Baseflow

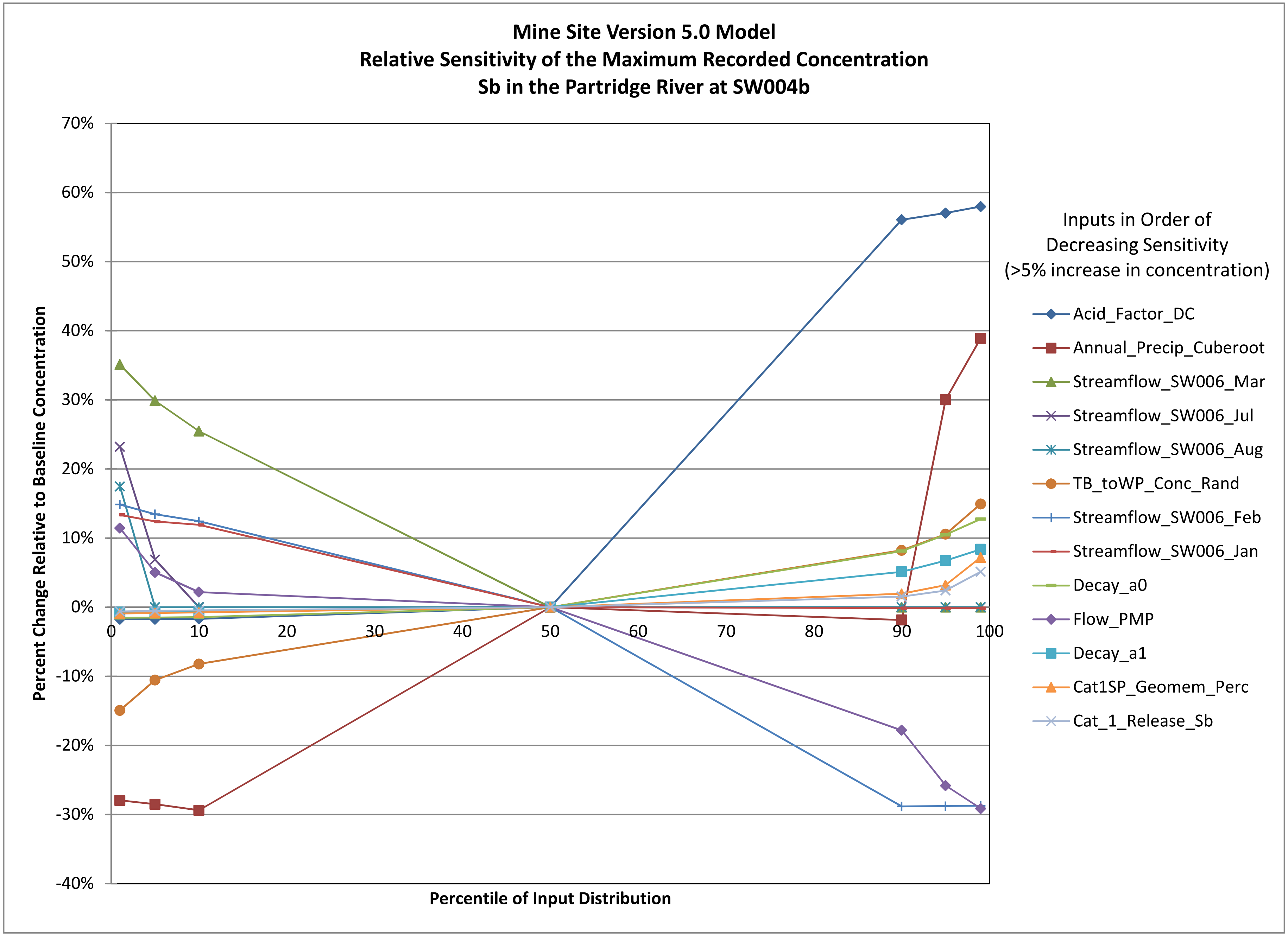


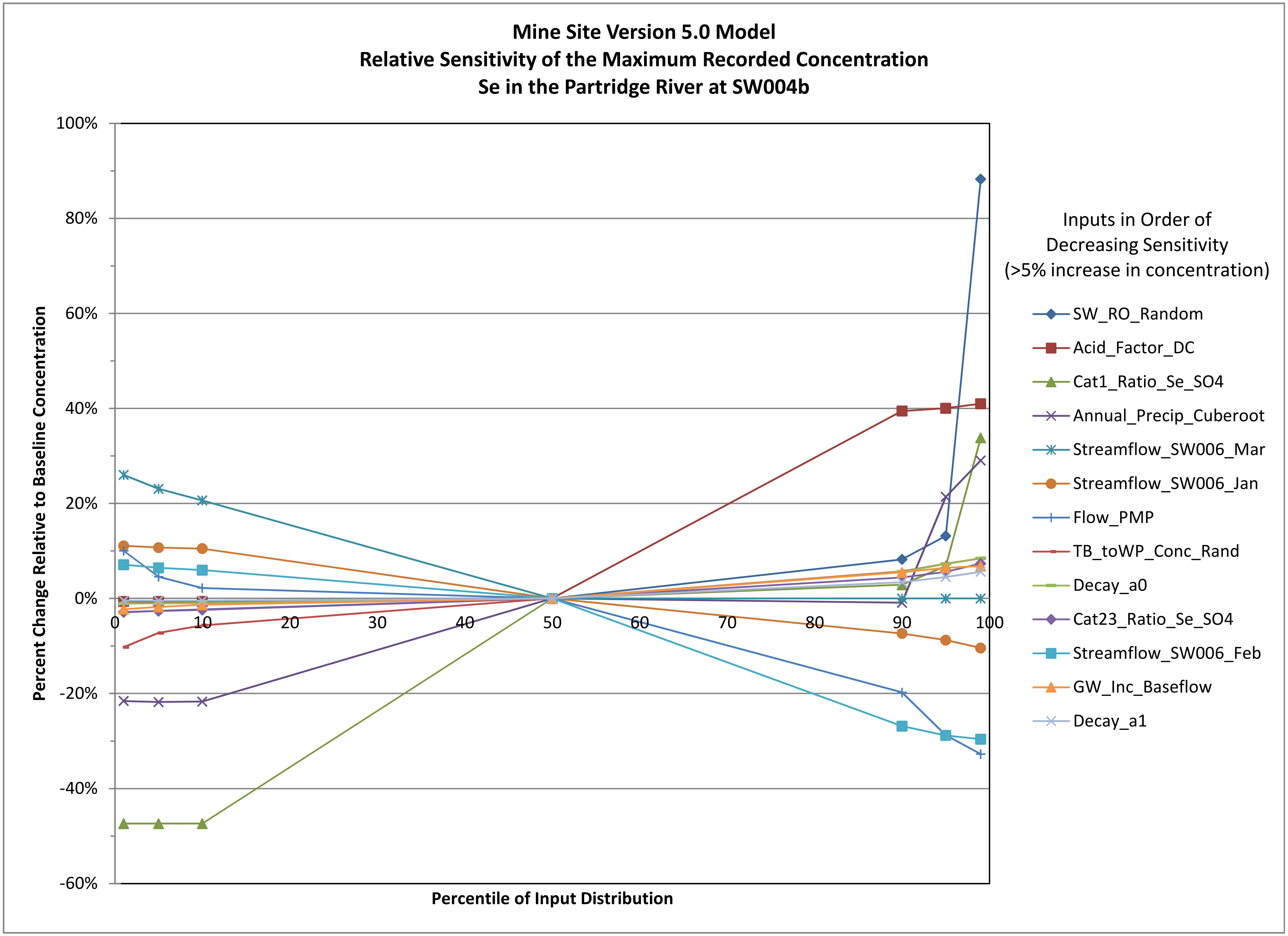
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Cu in the Partridge River at SW004b
100%
80%
60%
40%
20%
0%
-20%
-40%
-60%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
SW_RO_Random
Annual_Precip_Cuberoot
Acid_Factor_DC
Streamflow_SW006_Mar
GW_Inc_Baseflow
Flow_PMP
GW_Surf_Random
Streamflow_SW006_Jan

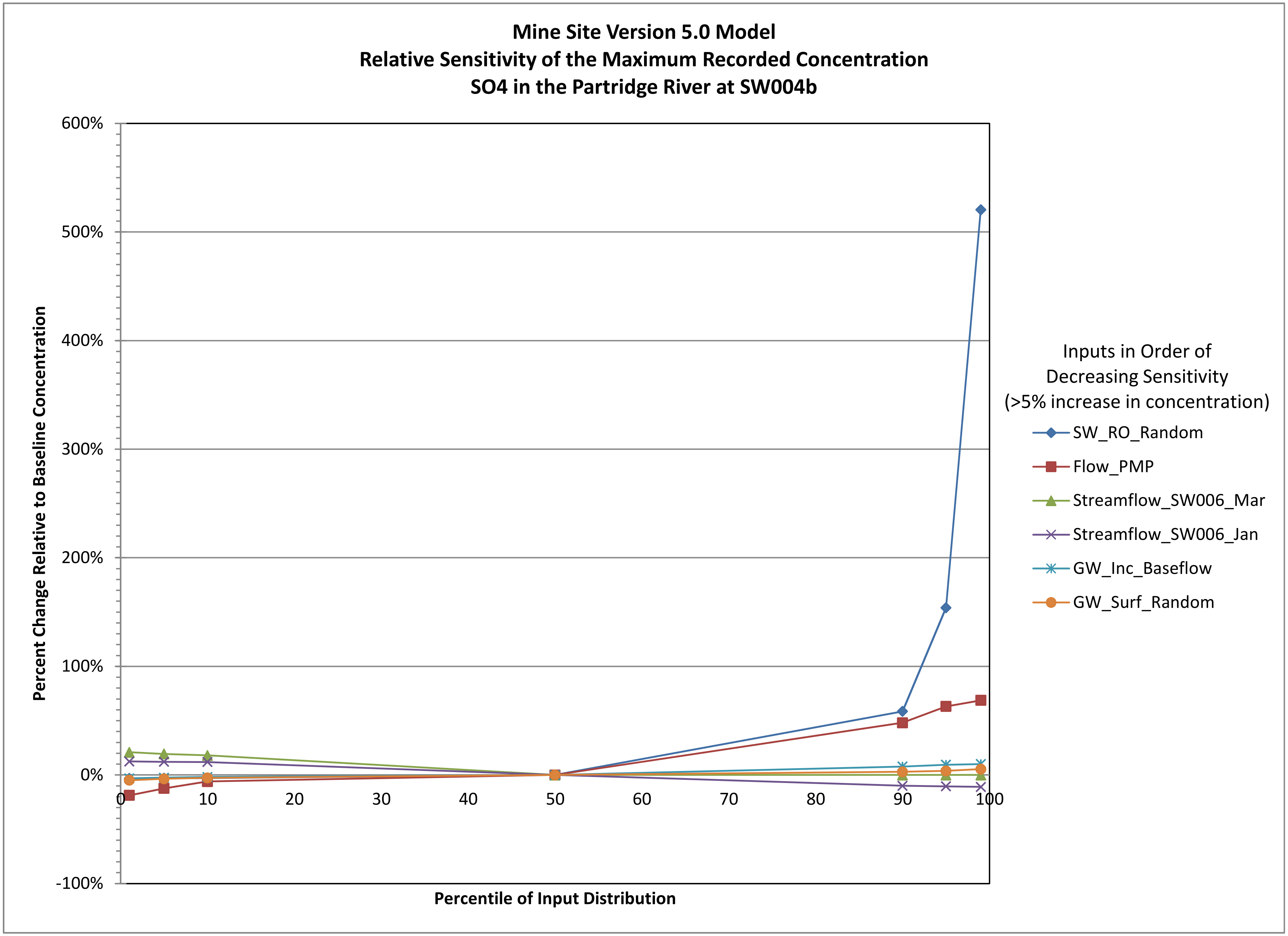

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Ni in the Partridge River at SW004b
Percent Change Relative to Baseline Concentration
80%
60%
40%
20%
0%
-20%
-40%
-60%
-80%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
Annual_Precip_Cuberoot
Acid_Factor_DC
Streamflow_SW006_Mar
Flow_PMP
Streamflow_SW006_Jan
Streamflow_SW006_Feb
SW_RO_Random

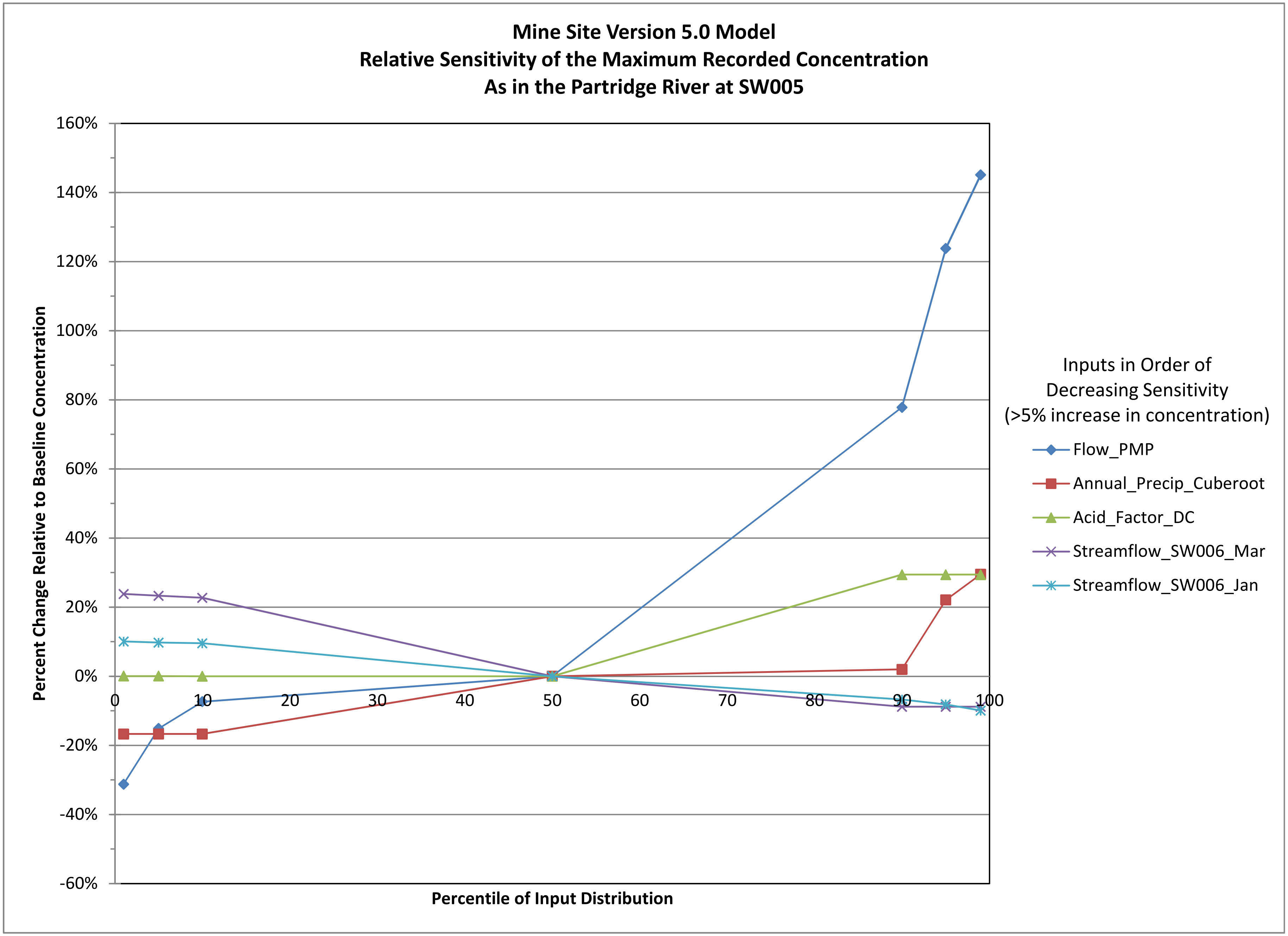


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Pb in the Partridge River at SW004b
40%
30%
20%
10%
0%
-10%
-20%
-30%
-40%
-50%
-60%
0
10
20
30
40
50
60
70
80
90
100
Percent Change Relative to Baseline Concentration
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
Annual_Precip_Cuberoot
Acid_Factor_DC
Streamflow_SW006_Mar
Flow_PMP
GW_Inc_Baseflow
Streamflow_SW006_Jan
GW_Surf_Random

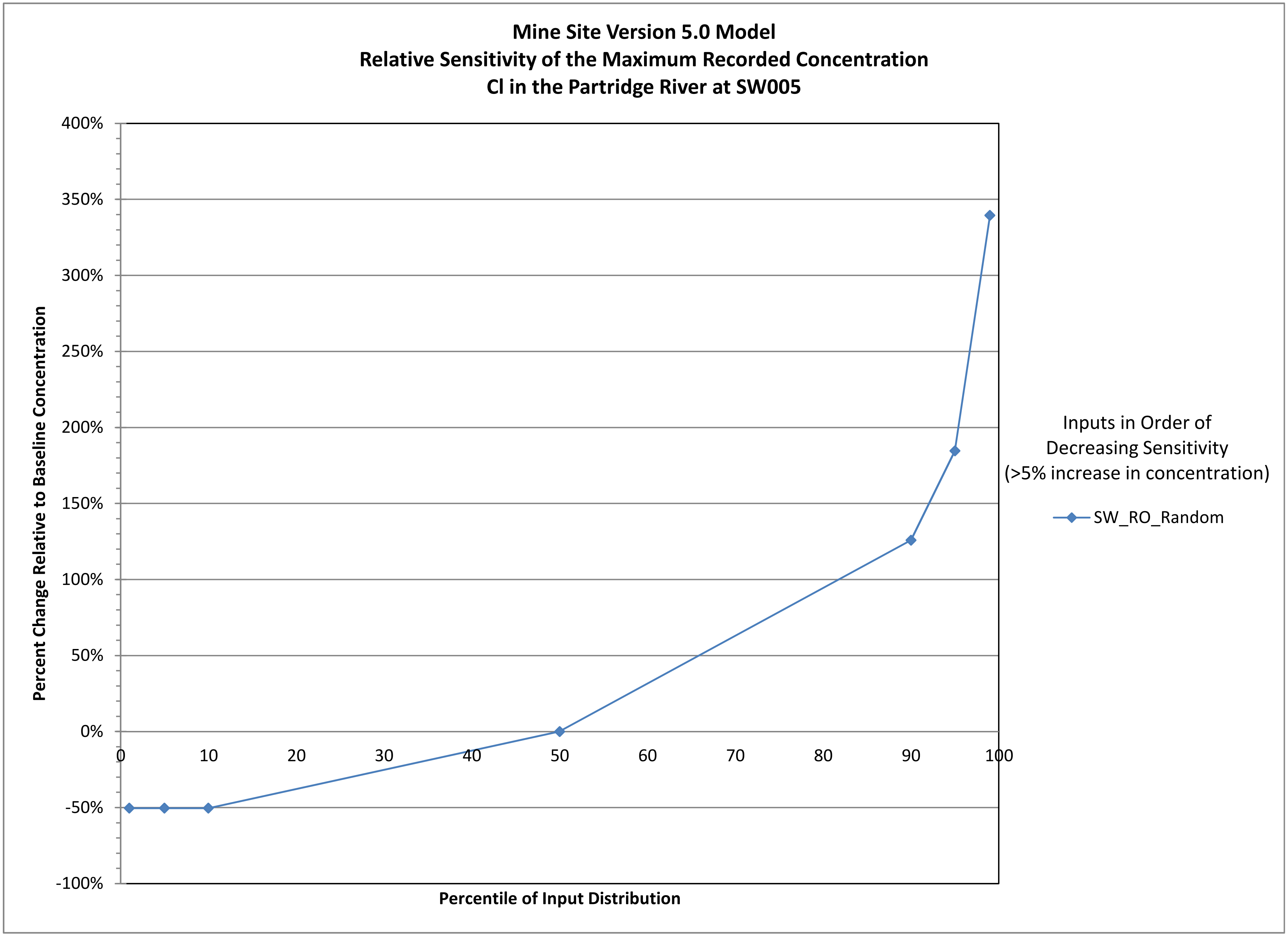

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Sb in the Partridge River at SW004b
Percent Change Relative to Baseline Concentration
70%
60%
50%
40%
30%
20%
10%
0%
-10%
-20%
-30%
-40%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
Acid_Factor_DC
Annual_Precip_Cuberoot
Streamflow_SW006_Mar
Streamflow_SW006_Jul
Streamflow_SW006_Aug
TB_toWP_Conc_Rand
Streamflow_SW006_Feb
Streamflow_SW006_Jan
Decay_a0
Flow_PMP
Decay_a1
Cat1SP_Geomem_Perc
Cat_1_Release_Sb

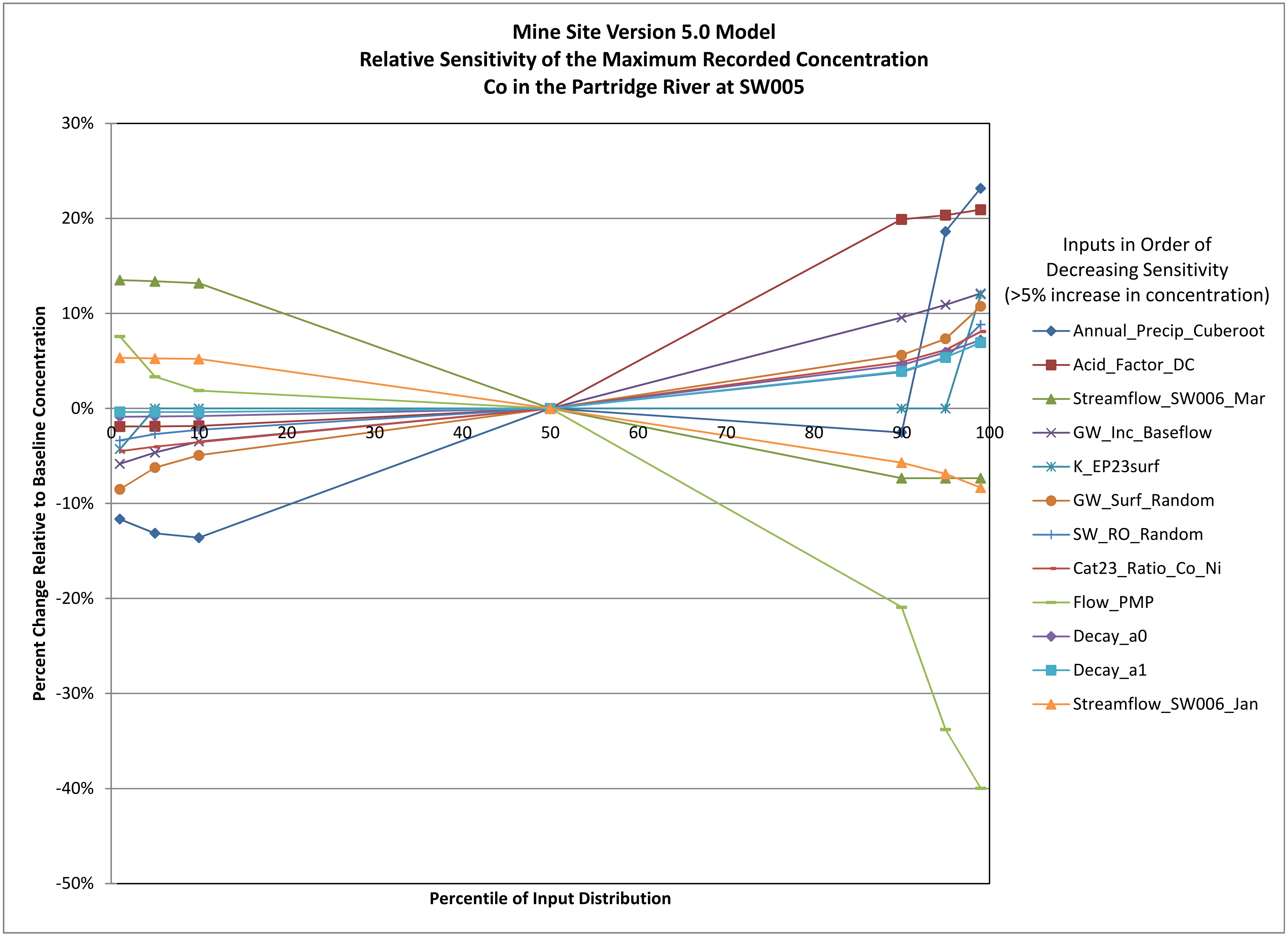

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Se in the Partridge River at SW004b
100%
80%
60%
40%
20%
0%
-20%
-40%
-60%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
SW_RO_Random
Acid_Factor_DC
Cat1_Ratio_Se_SO4
Annual_Precip_Cuberoot
Streamflow_SW006_Mar
Streamflow_SW006_Jan
Flow_PMP
TB_toWP_Conc_Rand
Decay_a0
Cat23_Ratio_Se_SO4
Streamflow_SW006_Feb
GW_Inc_Baseflow
Decay_a1


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
SO4 in the Partridge River at SW004b
600%
500%
400%
300%
200%
100%
0%
-100%
0
10
20
30
40
50
60
70
80
90
100
Percent Change Relative to Baseline Concentration
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
SW_RO_Random
Flow_PMP
Streamflow_SW006_Mar
Streamflow_SW006_Jan
GW_Inc_Baseflow
GW_Surf_Random

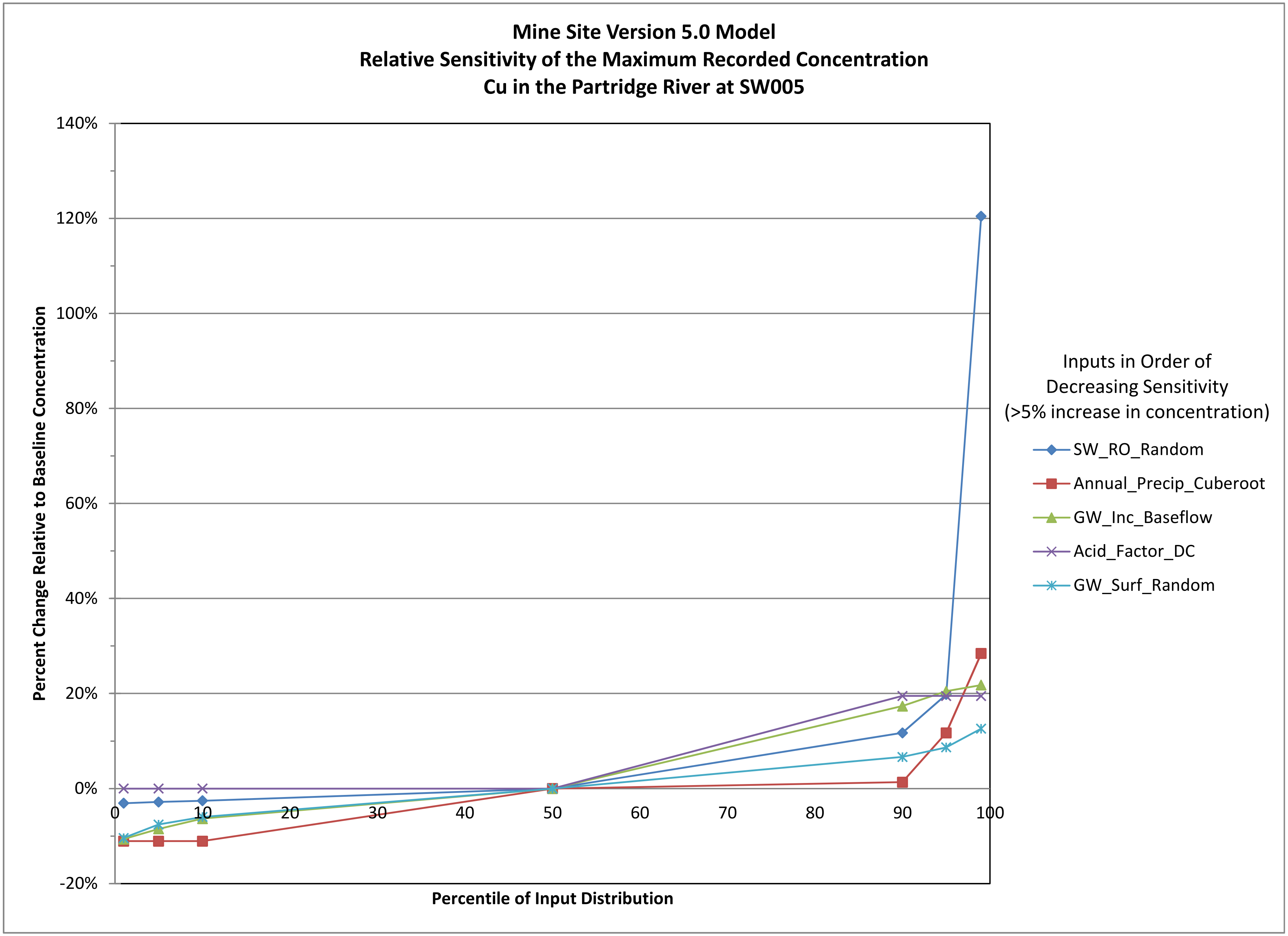


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
As in the Partridge River at SW005
160%
140%
120%
100%
80%
60%
40%
20%
0%
-20%
-40%
-60%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
Flow_PMP
Annual_Precip_Cuberoot
Acid_Factor_DC
Streamflow_SW006_Mar
Streamflow_SW006_Jan

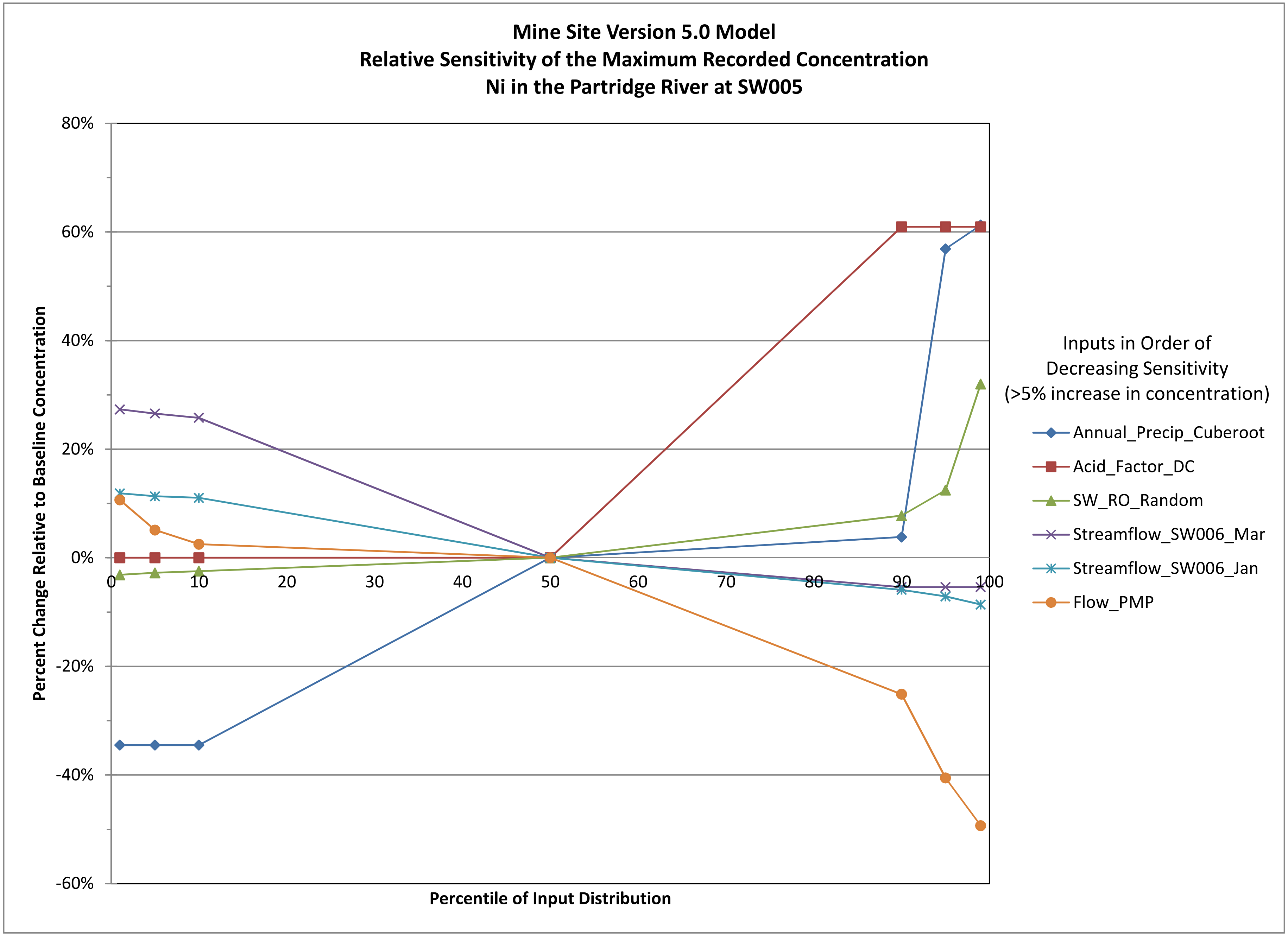

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Cl in the Partridge River at SW005
Percent Change Relative to Baseline Concentration
400%
350%
300%
250%
200%
150%
100%
50%
0%
-50%
-100%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
SW_RO_Random



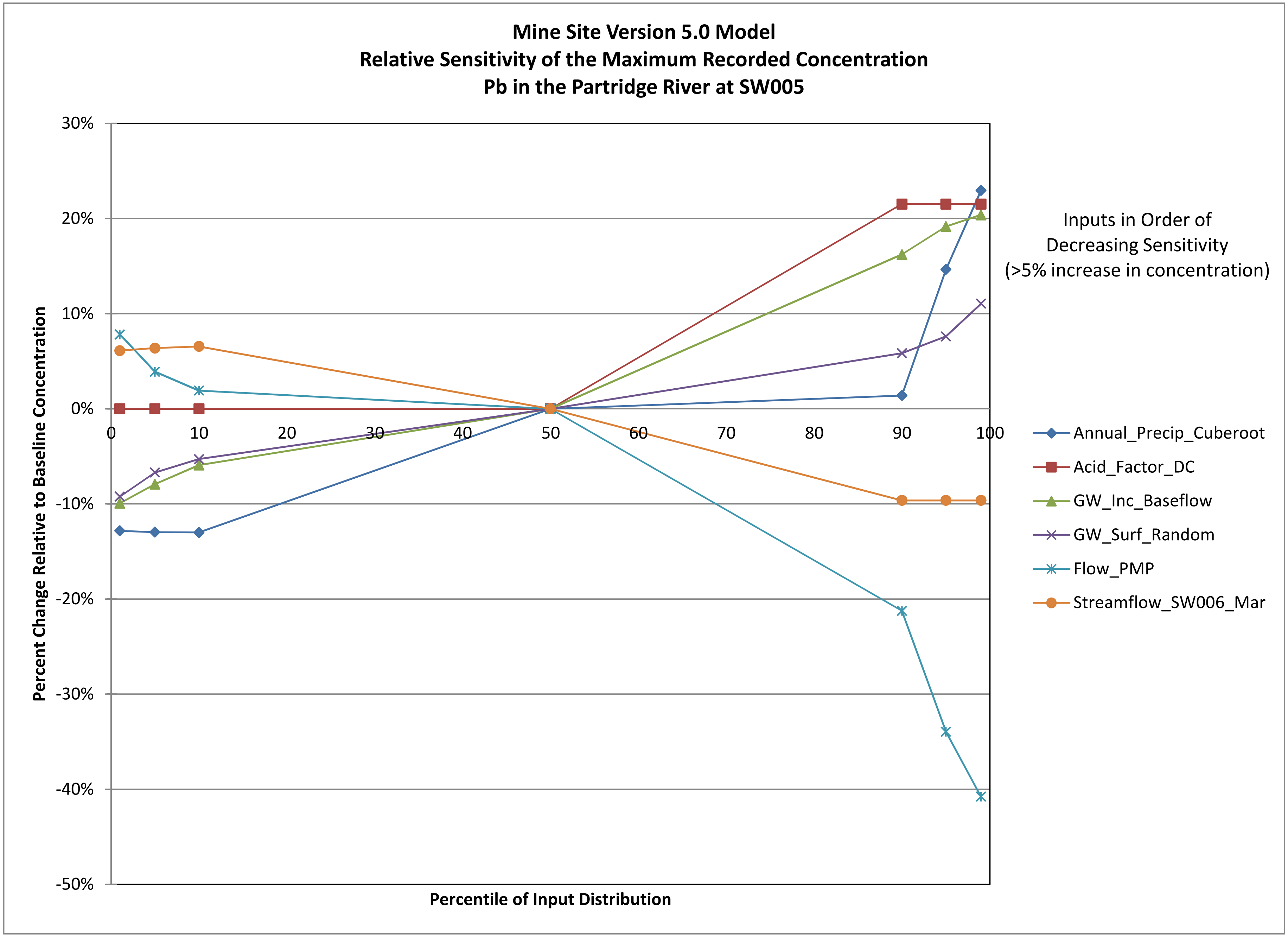
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Co in the Partridge River at SW005
Percent Change Relative to Baseline Concentration
30%
20%
10%
0%
-10%
-20%
-30%
-40%
-50%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
Annual_Precip_Cuberoot
Acid_Factor_DC
Streamflow_SW006_Mar
GW_Inc_Baseflow
K_EP23surf
GW_Surf_Random
SW_RO_Random
Cat23_Ratio_Co_Ni
Flow_PMP
Decay_a0
Decay_a1
Streamflow_SW006_Jan



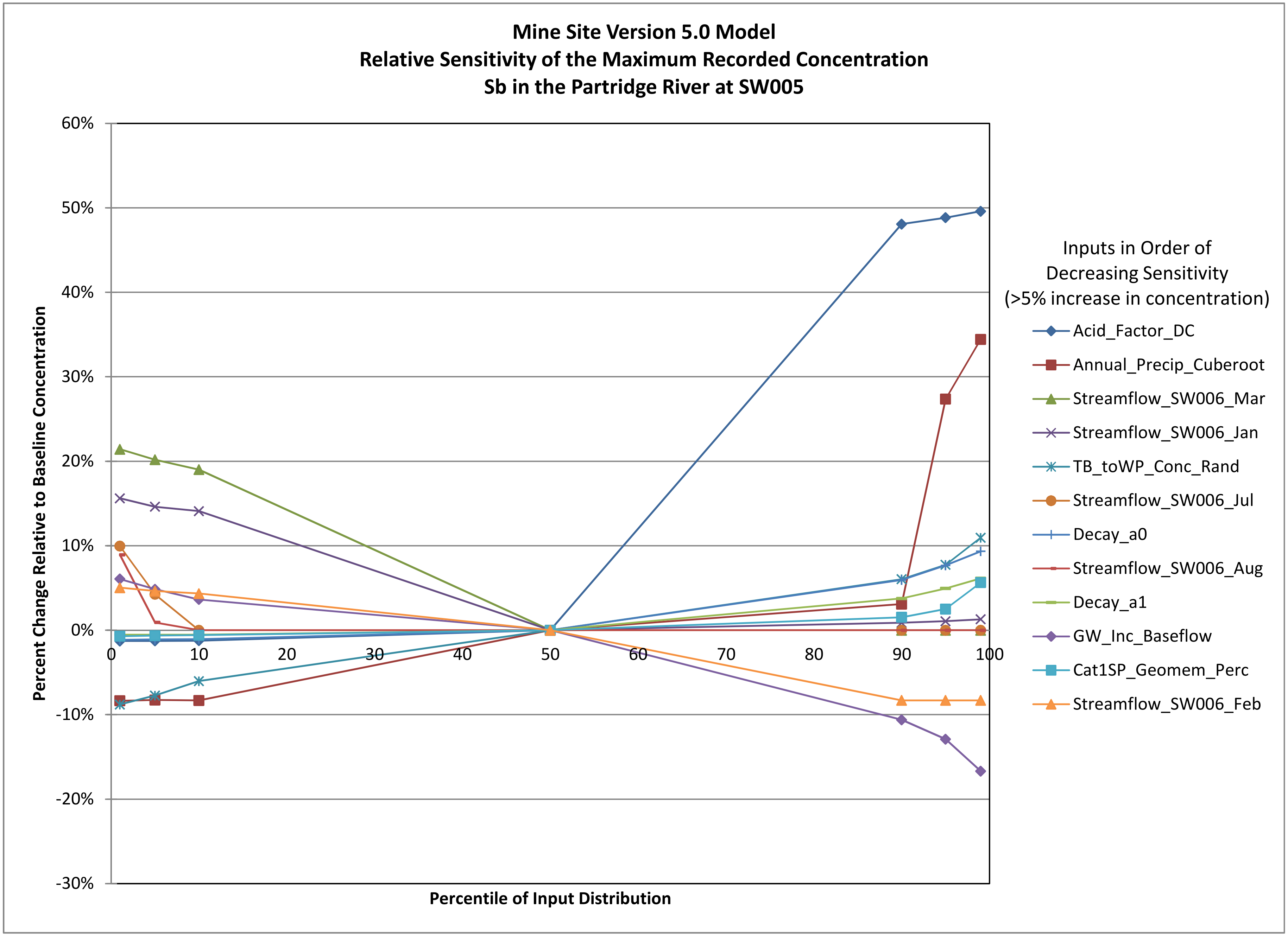
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Cu in the Partridge River at SW005
Percent Change Relative to Baseline Concentration
140%
120%
100%
80%
60%
40%
20%
0%
-20%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
SW_RO_Random
Annual_Precip_Cuberoot
GW_Inc_Baseflow
Acid_Factor_DC
GW_Surf_Random

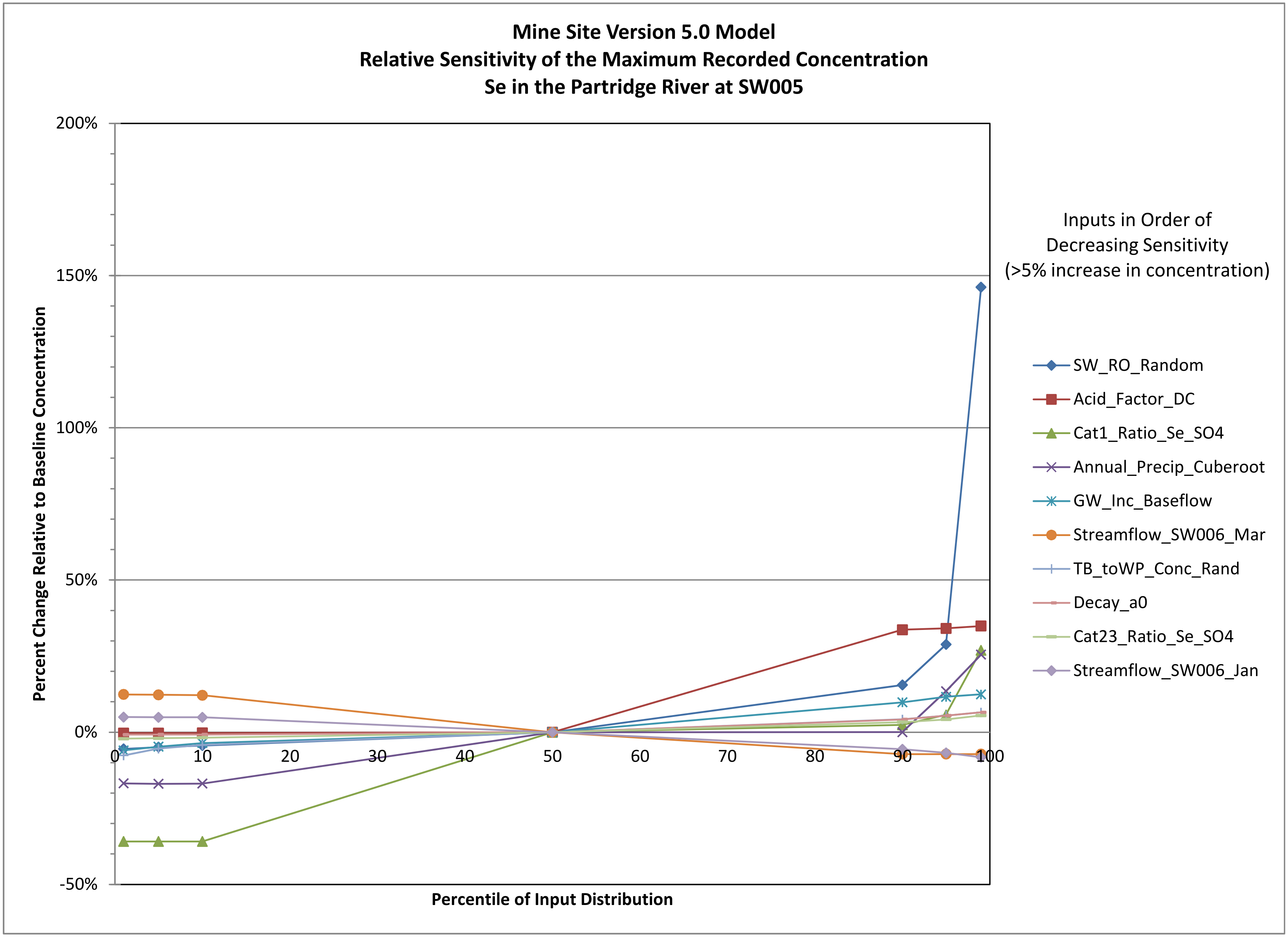


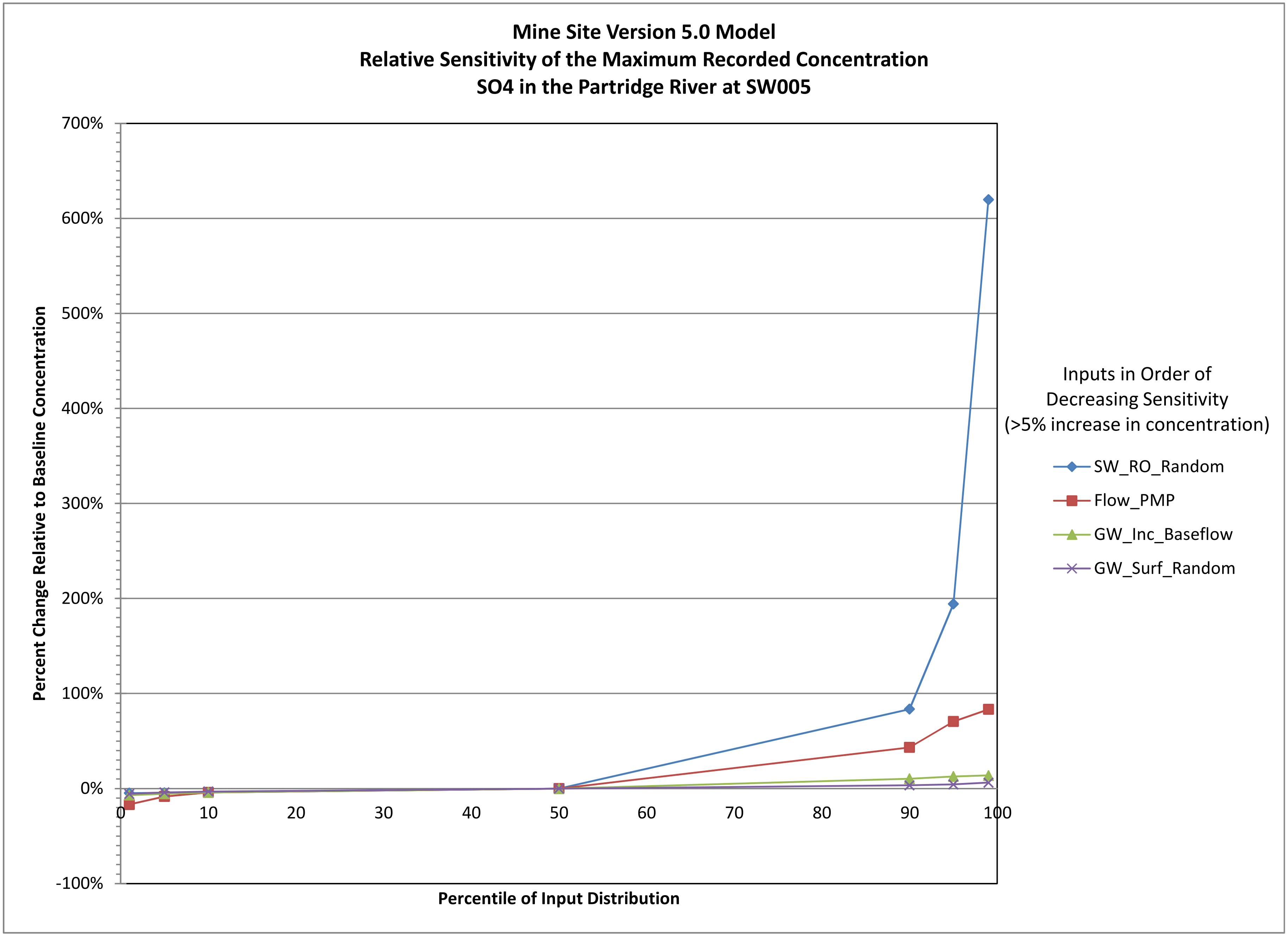
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Ni in the Partridge River at SW005
80%
60%
40%
20%
0%
-20%
-40%
-60%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
Annual_Precip_Cuberoot
Acid_Factor_DC
SW_RO_Random
Streamflow_SW006_Mar
Streamflow_SW006_Jan
Flow_PMP



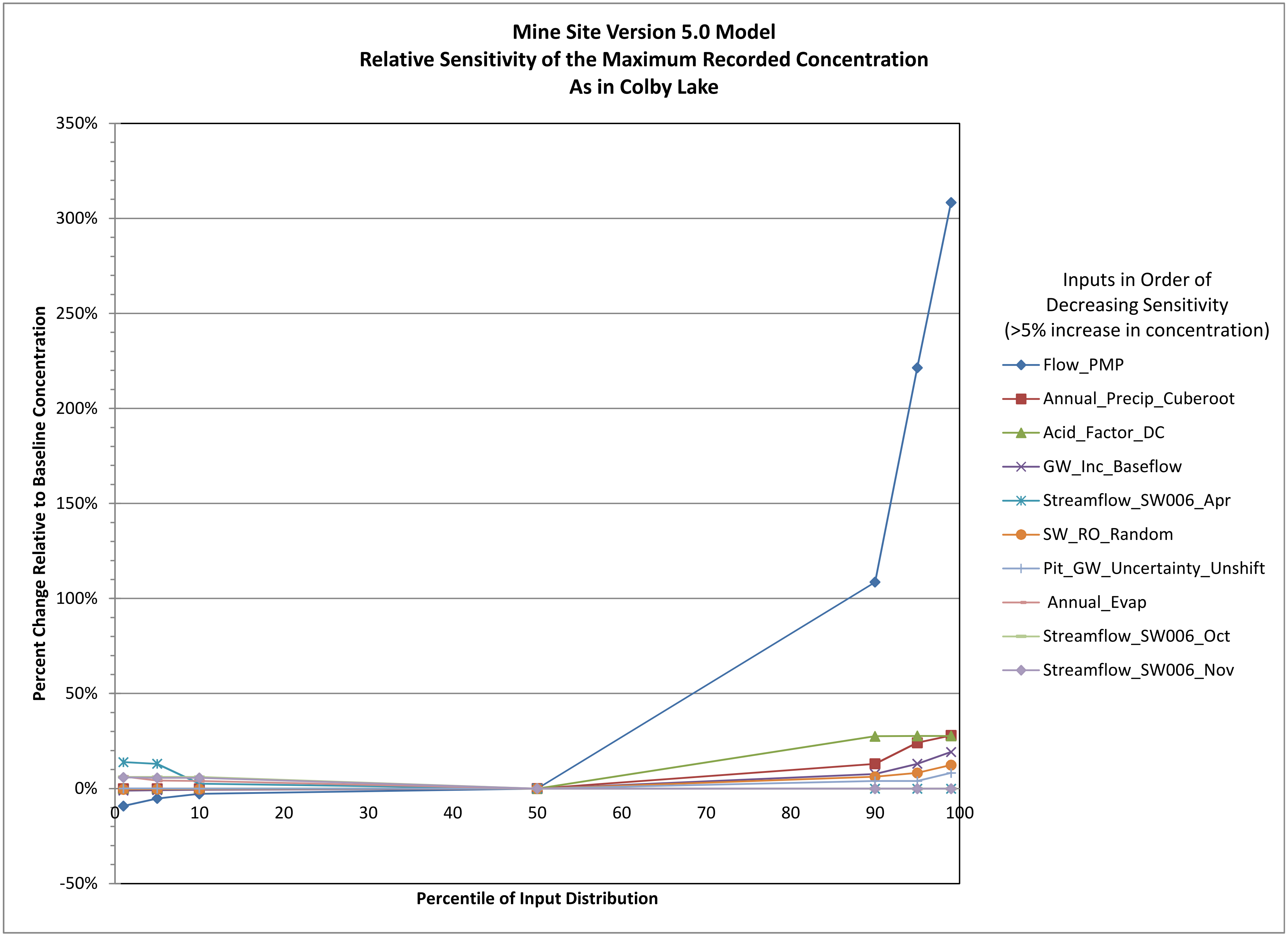
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Pb in the Partridge River at SW005
Percent Change Relative to Baseline Concentration
30%
20%
10%
0%
-10%
-20%
-30%
-40%
-50%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
Annual_Precip_Cuberoot
Acid_Factor_DC
GW_Inc_Baseflow
GW_Surf_Random
Flow_PMP
Streamflow_SW006_Mar

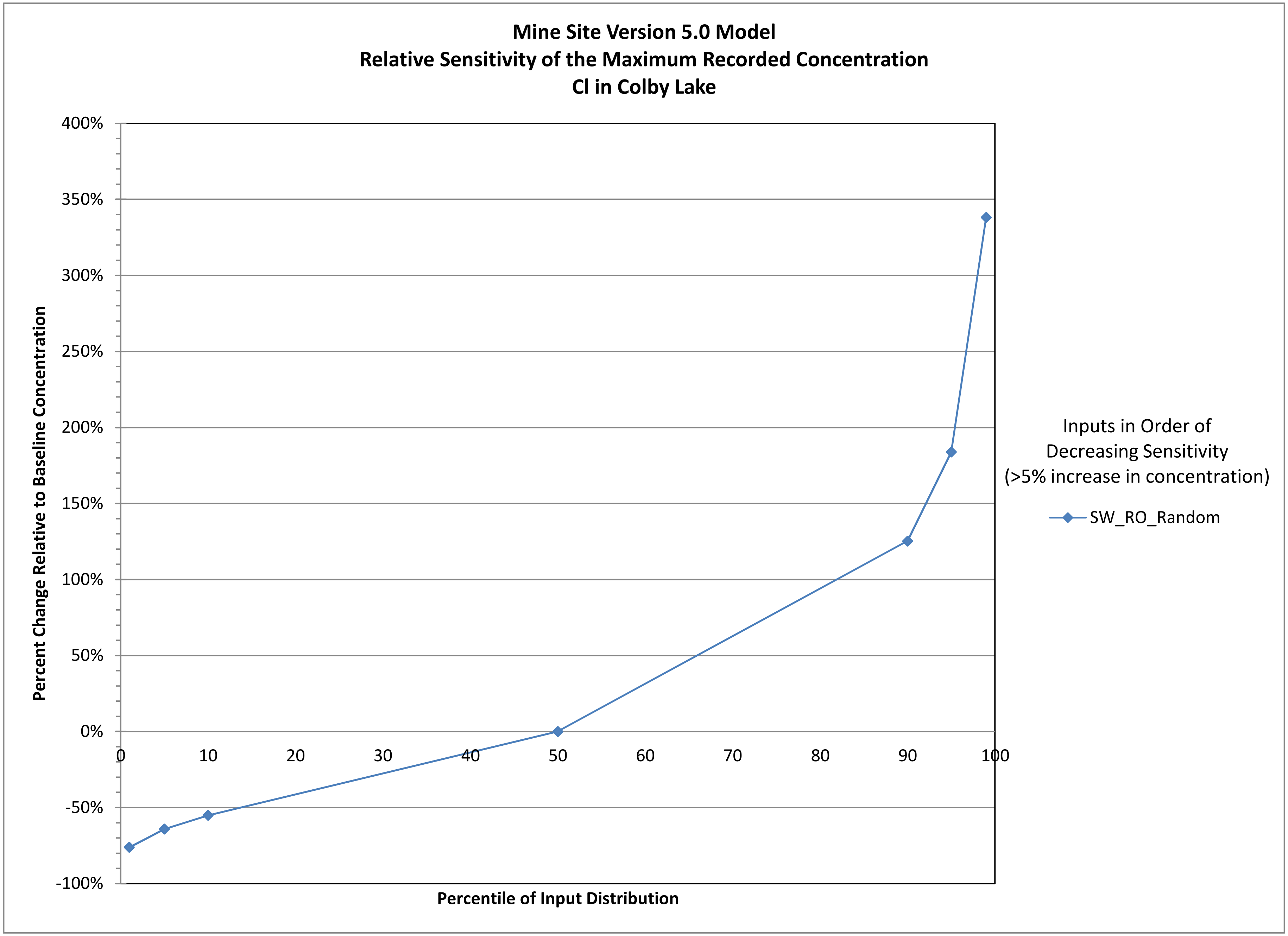

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Sb in the Partridge River at SW005
60%
50%
40%
30%
20%
10%
0%
-10%
-20%
-30%
0
10
20
30
40
50
60
70
80
90
100
Percent Change Relative to Baseline Concentration
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
Acid_Factor_DC
Annual_Precip_Cuberoot
Streamflow_SW006_Mar
Streamflow_SW006_Jan
TB_toWP_Conc_Rand
Streamflow_SW006_Jul
Decay_a0
Streamflow_SW006_Aug
Decay_a1
GW_Inc_Baseflow
Cat1SP_Geomem_Perc
Streamflow_SW006_Feb


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Se in the Partridge River at SW005
Percent Change Relative to Baseline Concentration
200%
150%
100%
50%
0%
-50%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
SW_RO_Random
Acid_Factor_DC
Cat1_Ratio_Se_SO4
Annual_Precip_Cuberoot
GW_Inc_Baseflow
Streamflow_SW006_Mar
TB_toWP_Conc_Rand
Decay_a0
Cat23_Ratio_Se_SO4
Streamflow_SW006_Jan

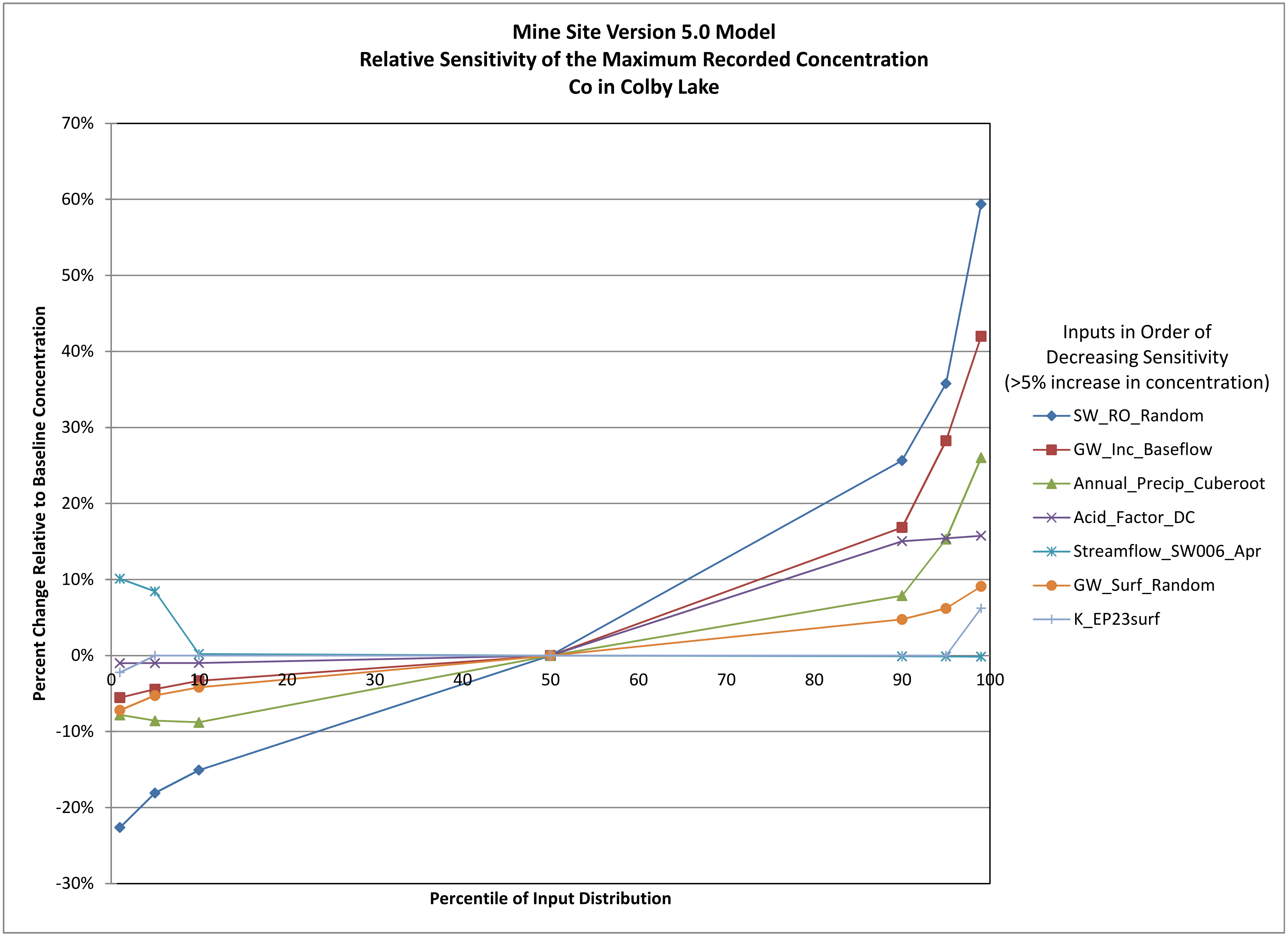


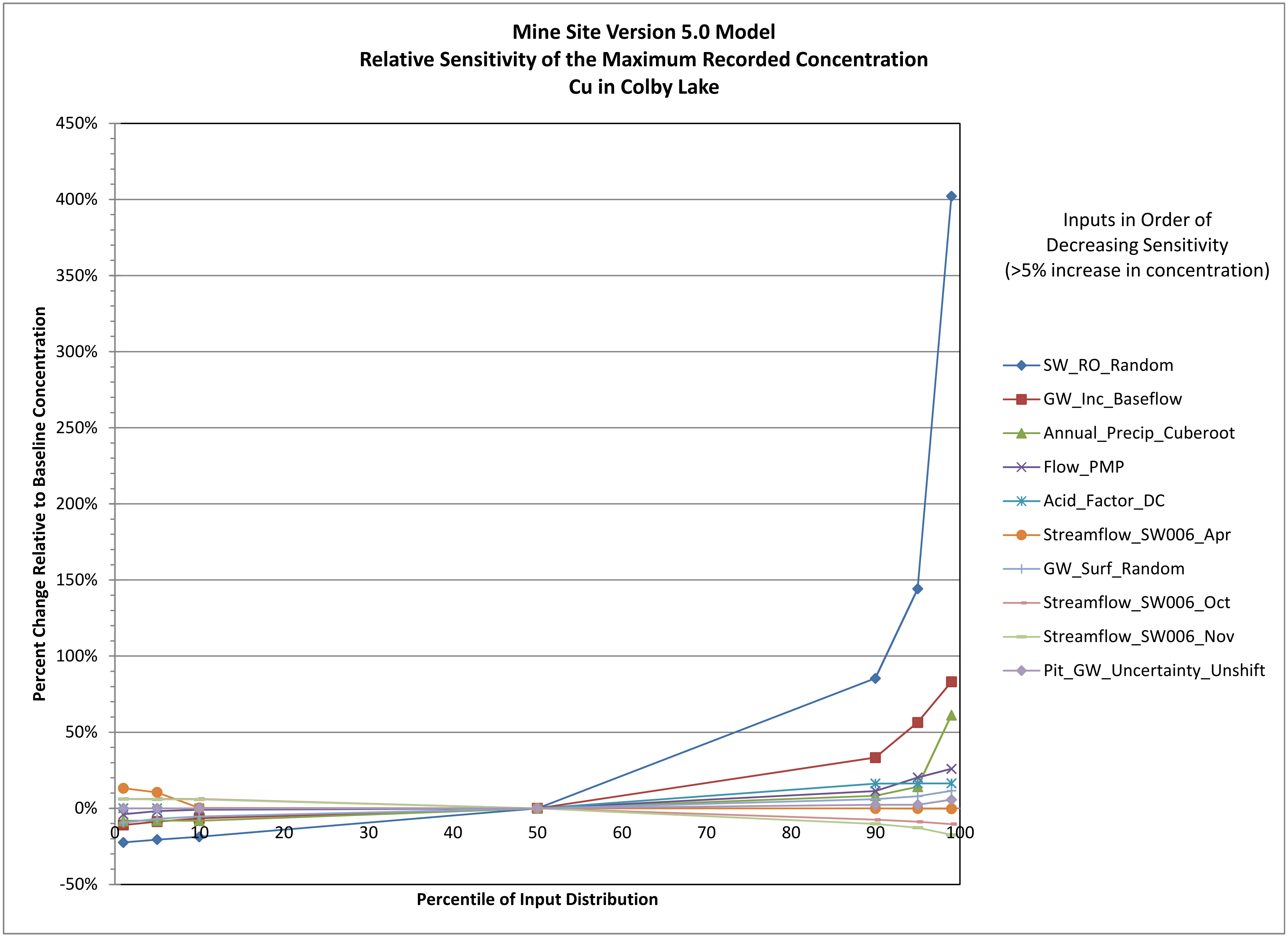
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
SO4 in the Partridge River at SW005
Percent Change Relative to Baseline Concentration
700%
600%
500%
400%
300%
200%
100%
0%
-100%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
SW_RO_Random
Flow_PMP
GW_Inc_Baseflow
GW_Surf_Random


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
As in Colby Lake
Percent Change Relative to Baseline Concentration
350%
300%
250%
200%
150%
100%
50%
0%
-50%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
Flow_PMP
Annual_Precip_Cuberoot
Acid_Factor_DC
GW_Inc_Baseflow
Streamflow_SW006_Apr
SW_RO_Random
Pit_GW_Uncertainty_Unshift
Annual_Evap
Streamflow_SW006_Oct
Streamflow_SW006_Nov

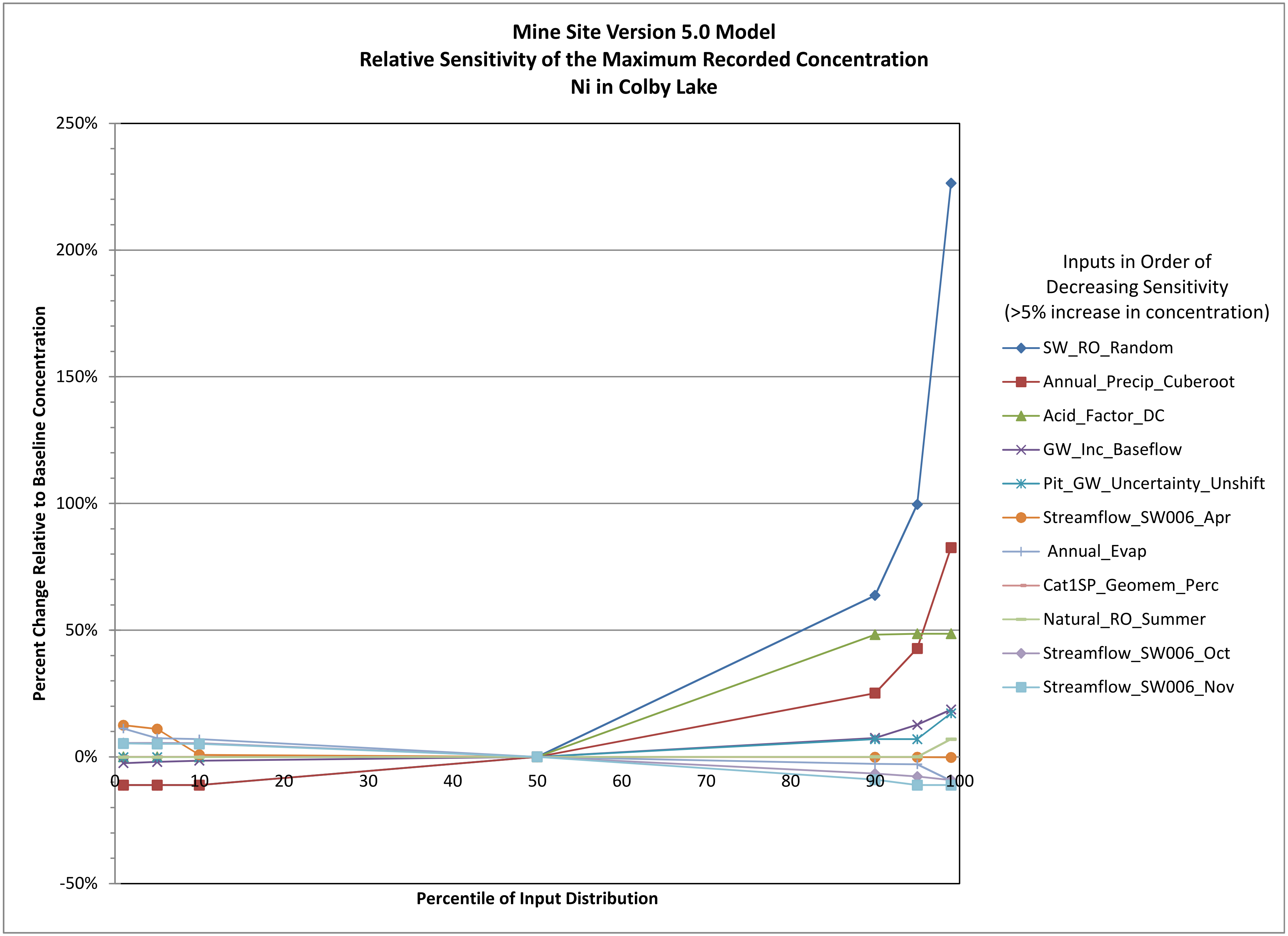


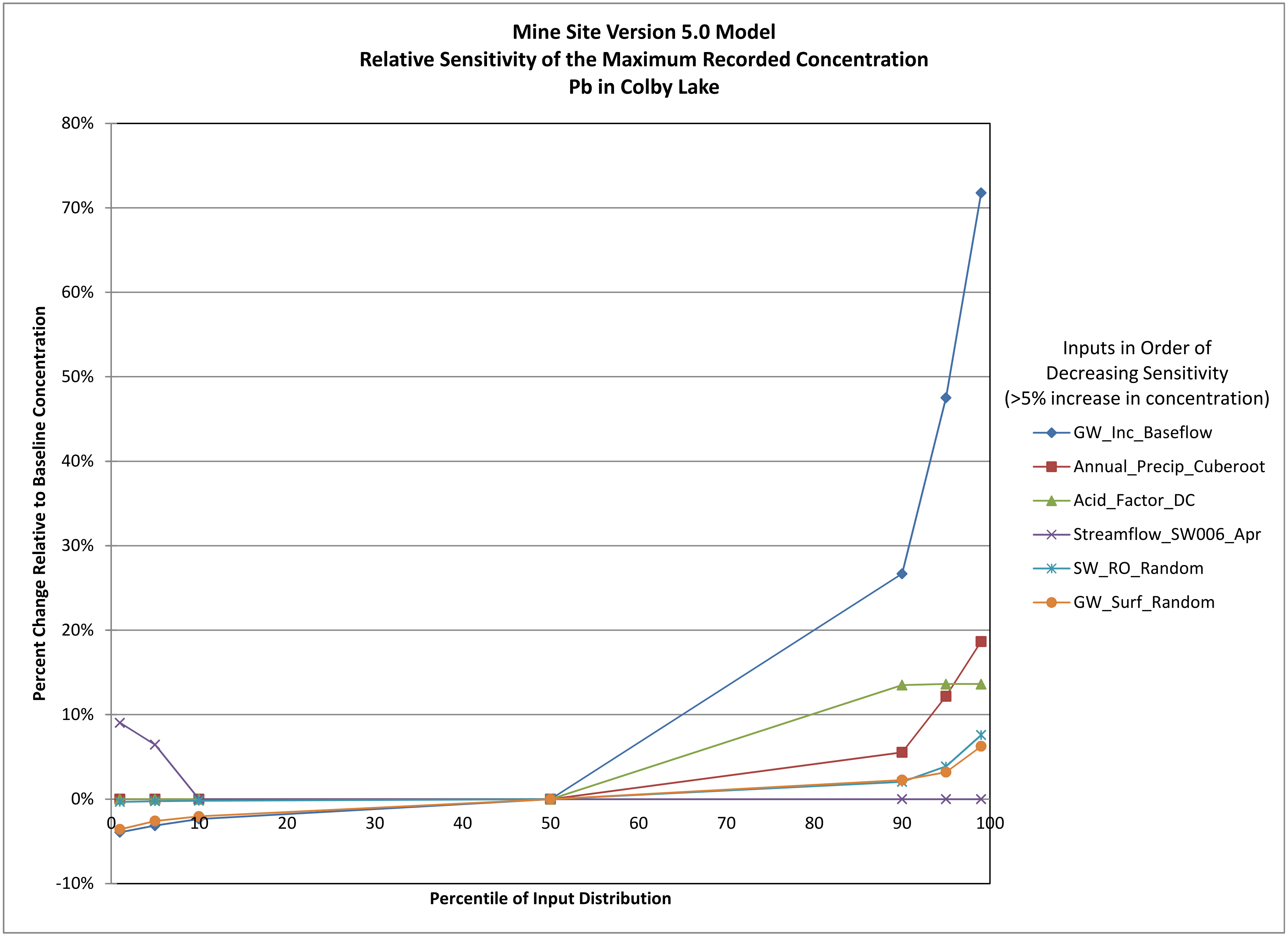
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Cl in Colby Lake
Percent Change Relative to Baseline Concentration
400%
350%
300%
250%
200%
150%
100%
50%
0%
-50%
-100%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
SW_RO_Random

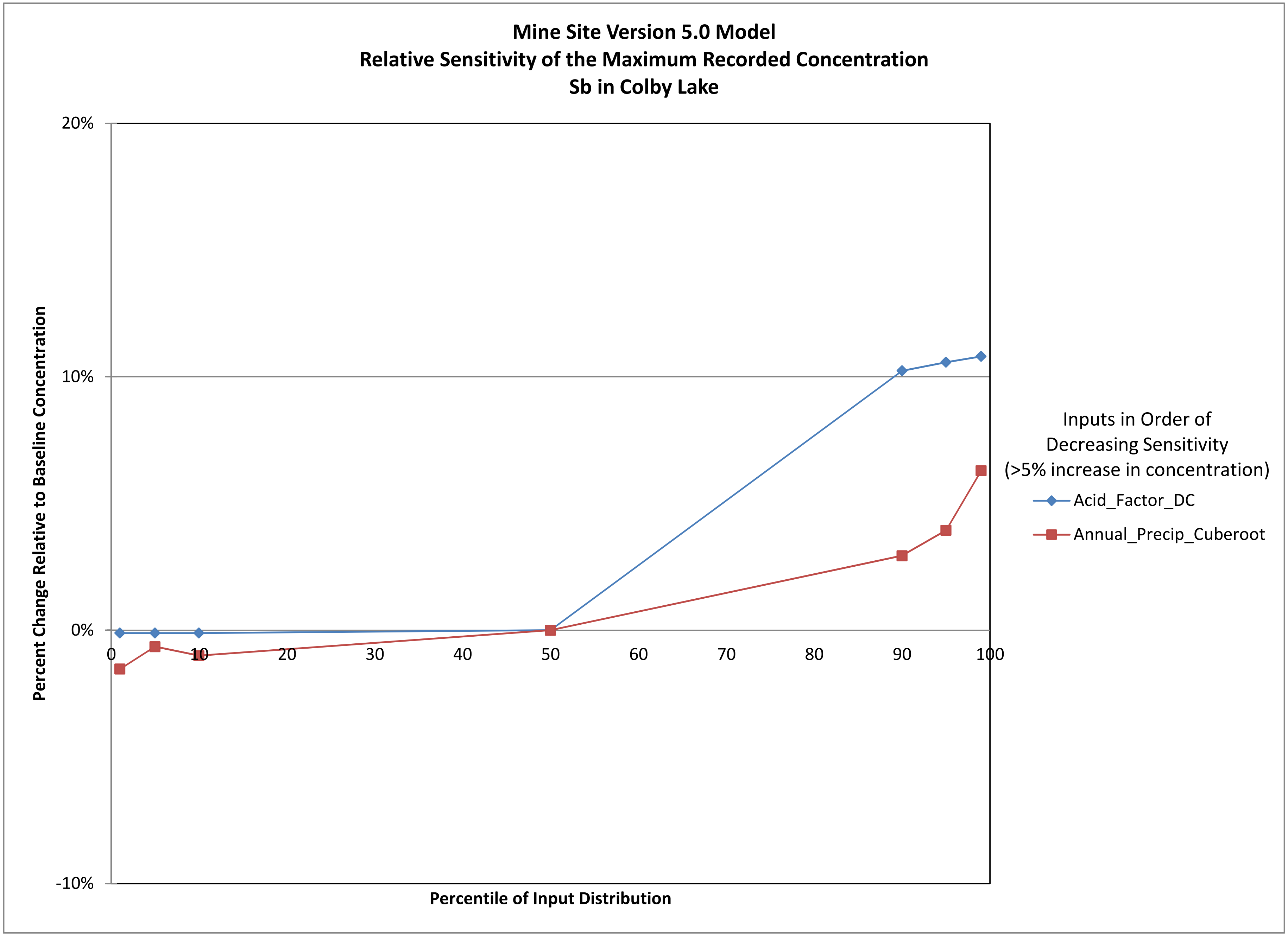

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Co in Colby Lake
70%
60%
50%
40%
30%
20%
10%
0%
-10%
-20%
-30%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
SW_RO_Random
GW_Inc_Baseflow
Annual_Precip_Cuberoot
Acid_Factor_DC
Streamflow_SW006_Apr
GW_Surf_Random
K_EP23surf



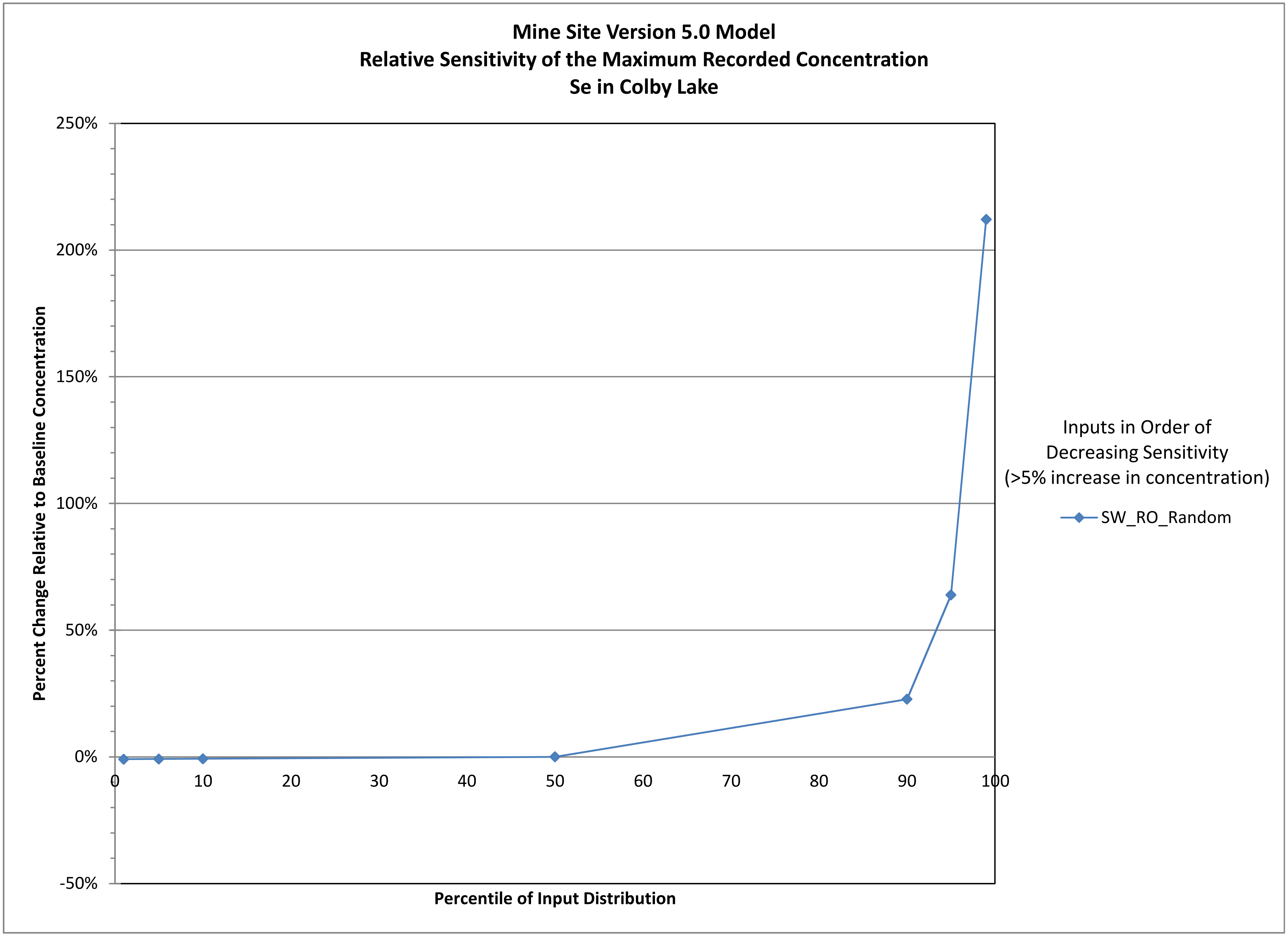
Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Cu in Colby Lake
450%
400%
350%
300%
250%
200%
150%
100%
50%
0%
-50%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
SW_RO_Random
GW_Inc_Baseflow
Annual_Precip_Cuberoot
Flow_PMP
Acid_Factor_DC
Streamflow_SW006_Apr
GW_Surf_Random
Streamflow_SW006_Oct
Streamflow_SW006_Nov
Pit_GW_Uncertainty_Unshift


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Ni in Colby Lake
250%
200%
150%
100%
50%
0%
-50%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
SW_RO_Random
Annual_Precip_Cuberoot
Acid_Factor_DC
GW_Inc_Baseflow
Pit_GW_Uncertainty_Unshift
Streamflow_SW006_Apr
Annual_Evap
Cat1SP_Geomem_Perc
Natural_RO_Summer
Streamflow_SW006_Oct
Streamflow_SW006_Nov

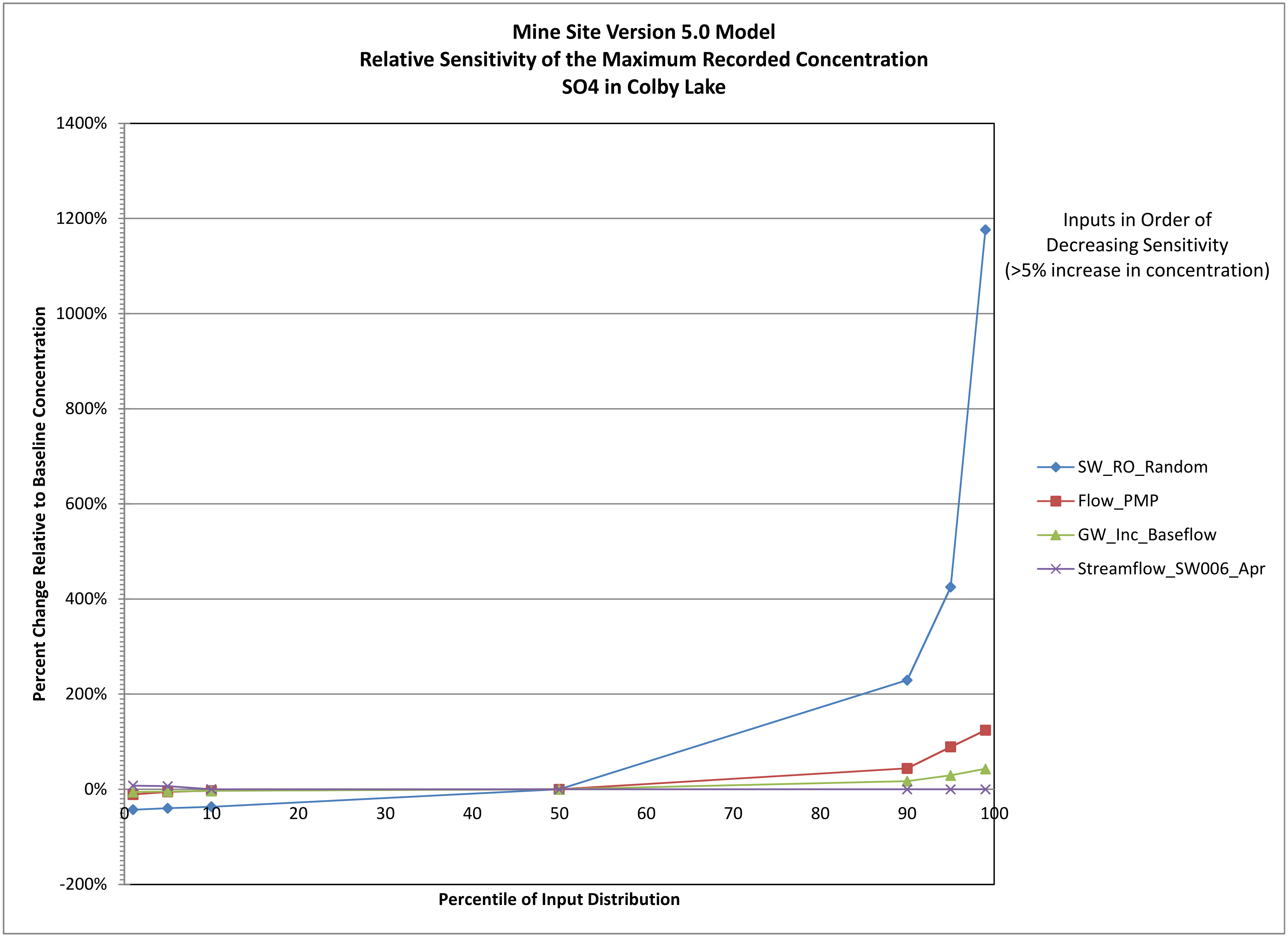

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Pb in Colby Lake
Percent Change Relative to Baseline Concentration
80%
70%
60%
50%
40%
30%
20%
10%
0%
-10%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
GW_Inc_Baseflow
Annual_Precip_Cuberoot
Acid_Factor_DC
Streamflow_SW006_Apr
SW_RO_Random
GW_Surf_Random



Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Sb in Colby Lake
20%
10%
0%
-10%
0
10
20
30
40
50
60
70
80
90
100
Percent Change Relative to Baseline Concentration
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
Acid_Factor_DC
Annual_Precip_Cuberoot

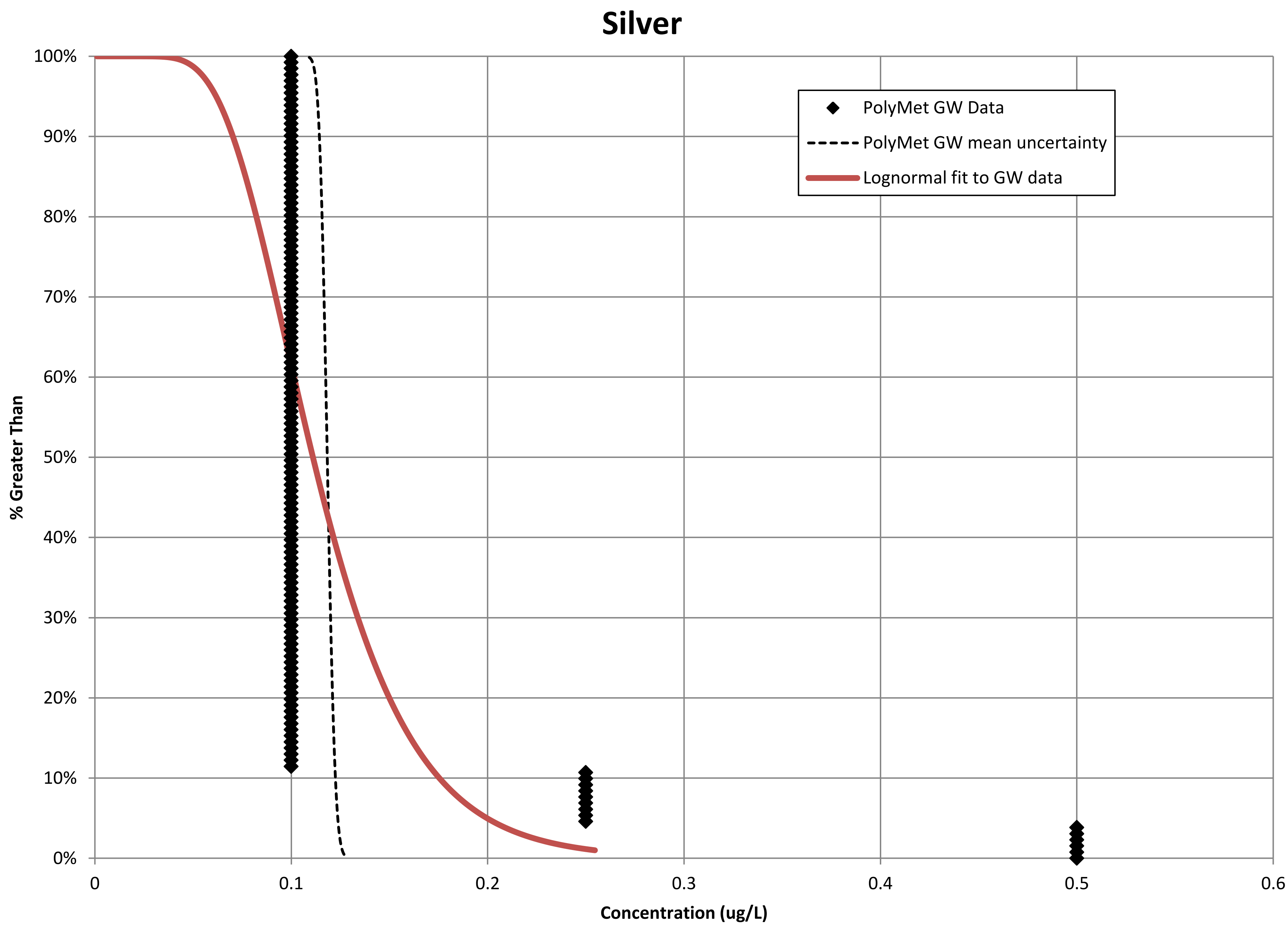


Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
Se in Colby Lake
250%
200%
150%
100%
50%
0%
-50%
Percent Change Relative to Baseline Concentration
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of Decreasing Sensitivity (>5% increase in concentration)
SW_RO_Random

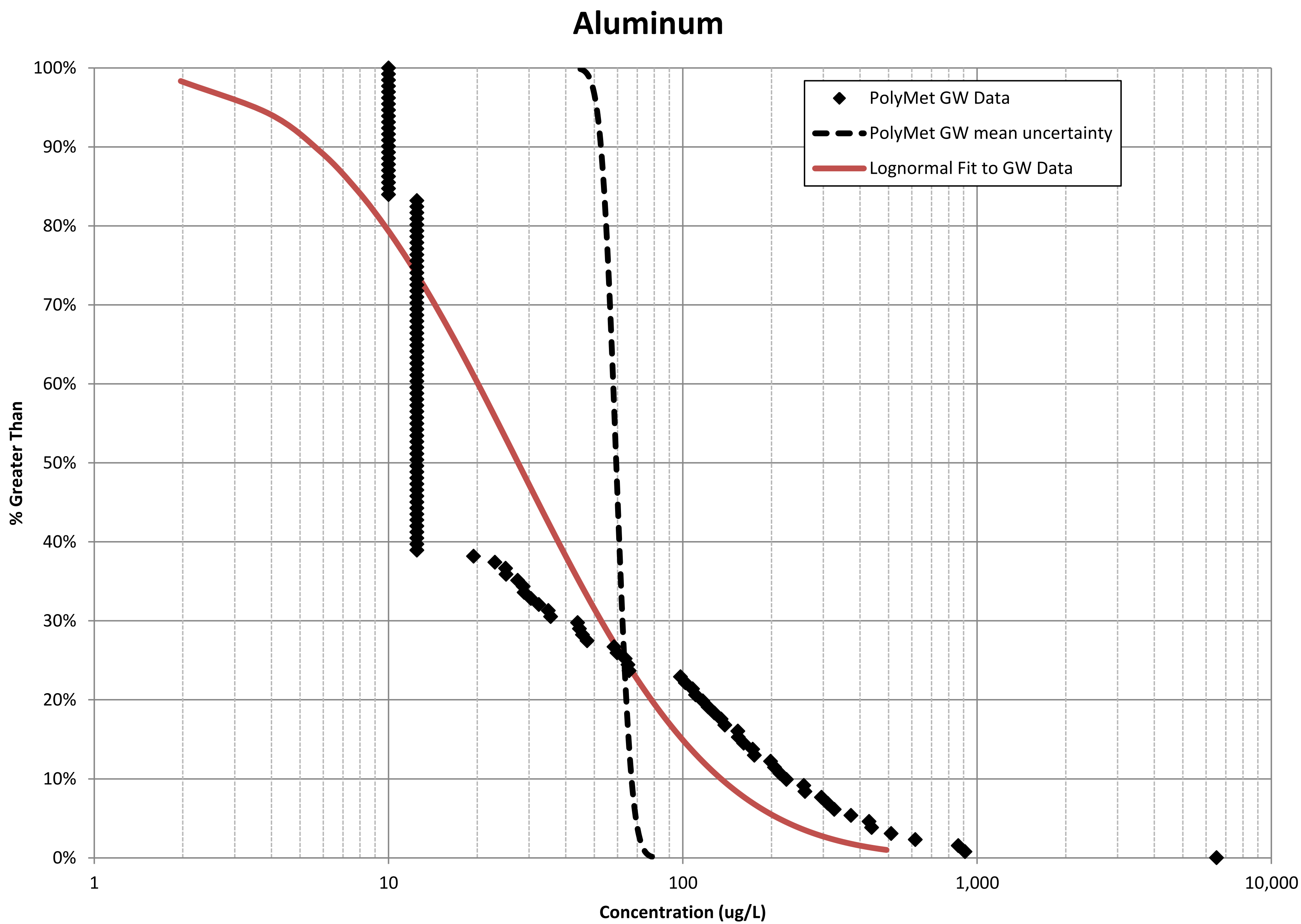

Mine Site Version 5.0 Model
Relative Sensitivity of the Maximum Recorded Concentration
SO4 in Colby Lake
Percent Change Relative to Baseline Concentration
1400%
1200%
1000%
800%
600%
400%
200%
0%
-200%
0
10
20
30
40
50
60
70
80
90
100
Percentile of Input Distribution
Inputs in Order of
Decreasing Sensitivity
(>5% increase in concentration)
SW_RO_Random
Flow_PMP
GW_Inc_Baseflow
Streamflow_SW006_Apr

# Appendix C

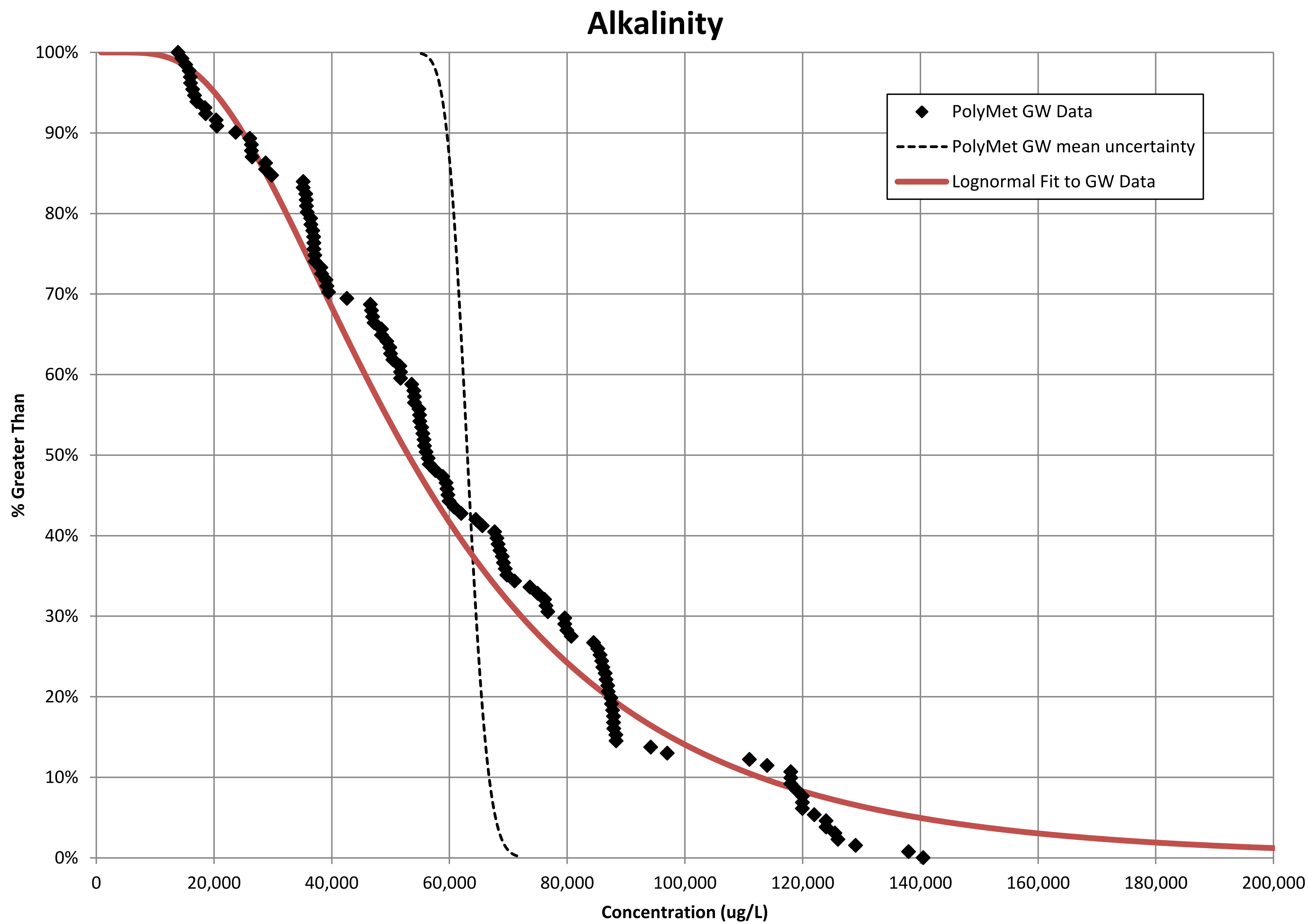
## Mine Site Surficial Groundwater Concentration Distributions



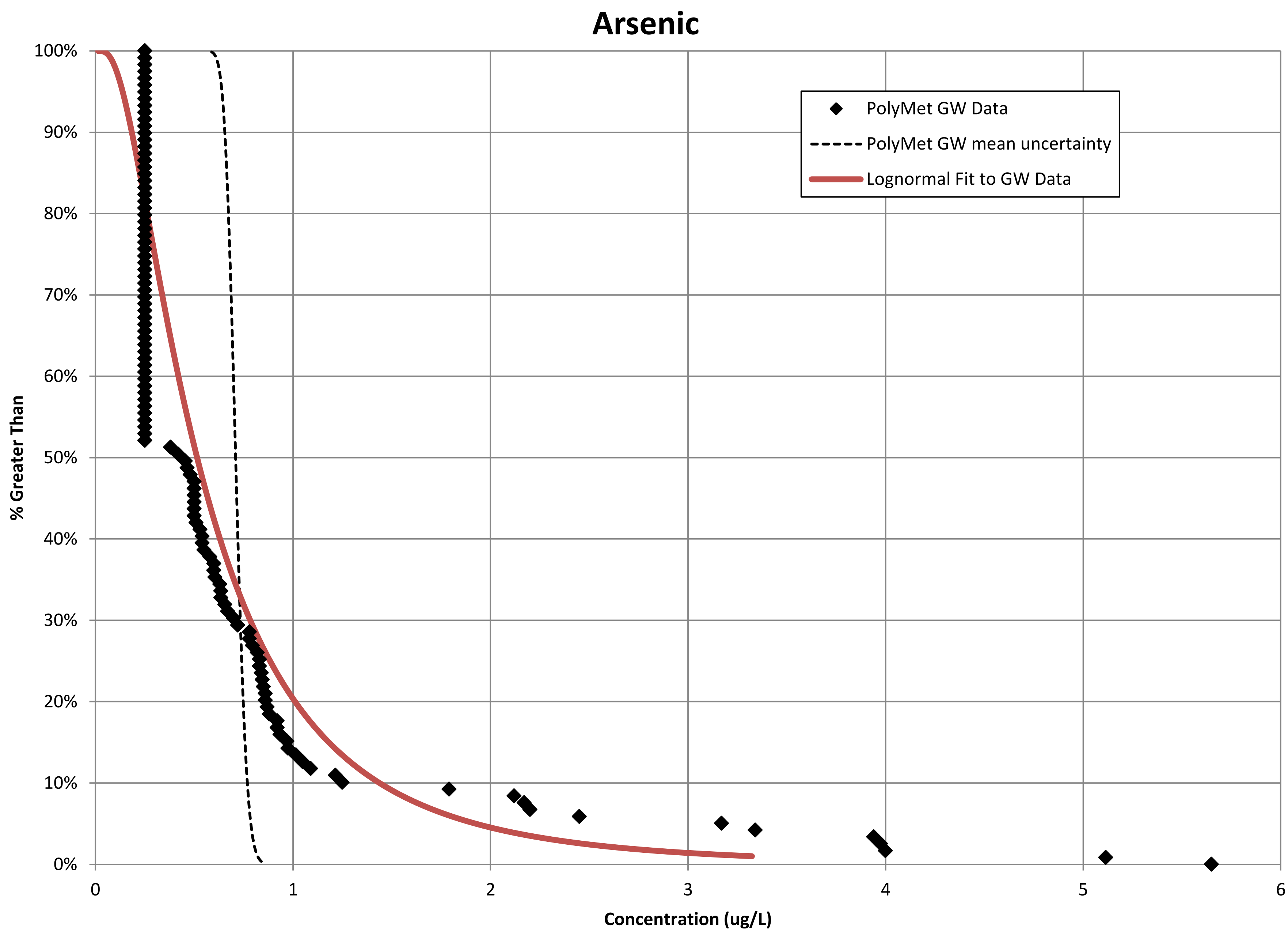
Silver
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
0.1
0.2
0.3
0.4
0.5
0.6
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal fit to GW data



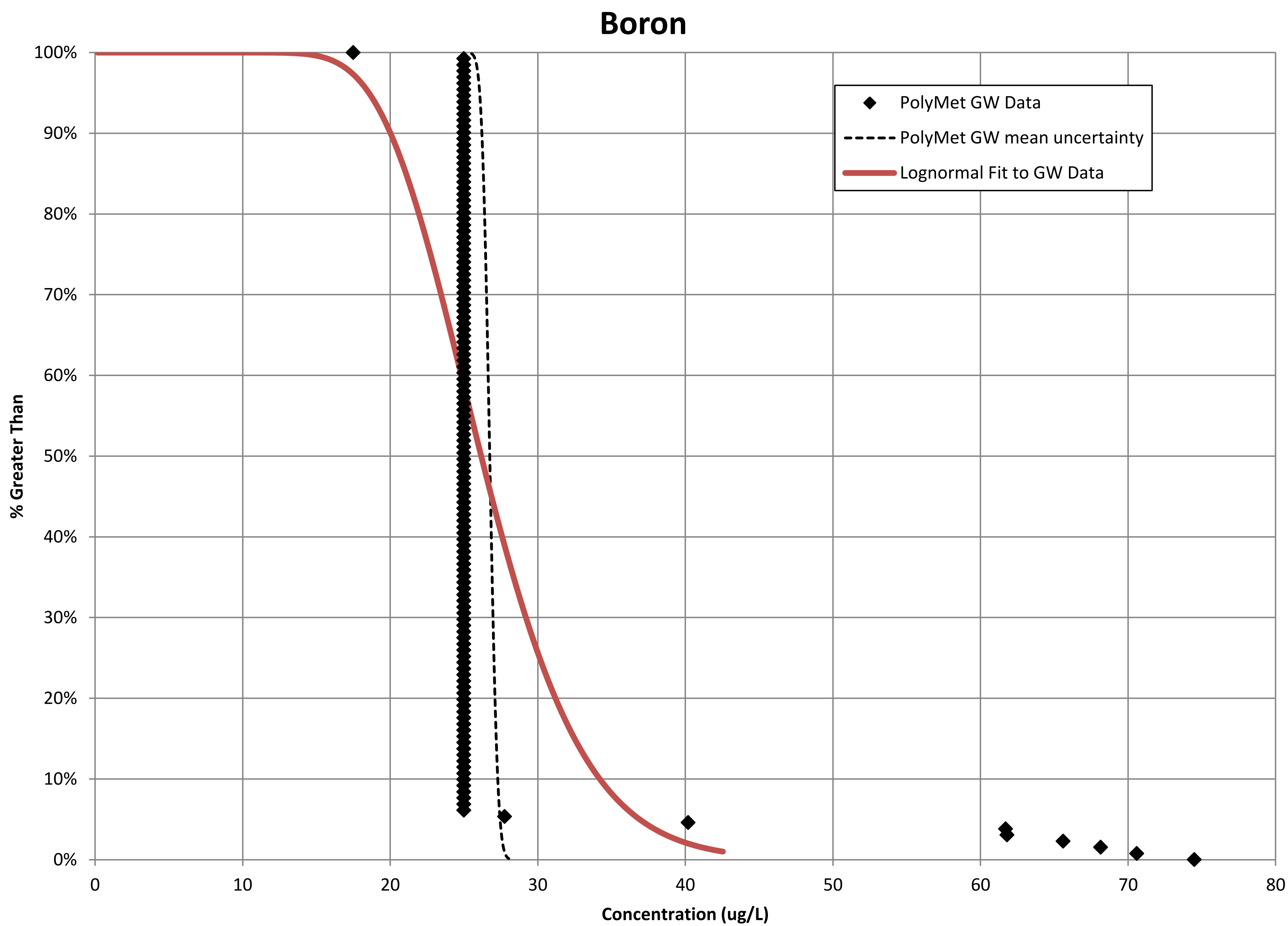
Aluminum
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
1
10
100
1,000
10,000
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data

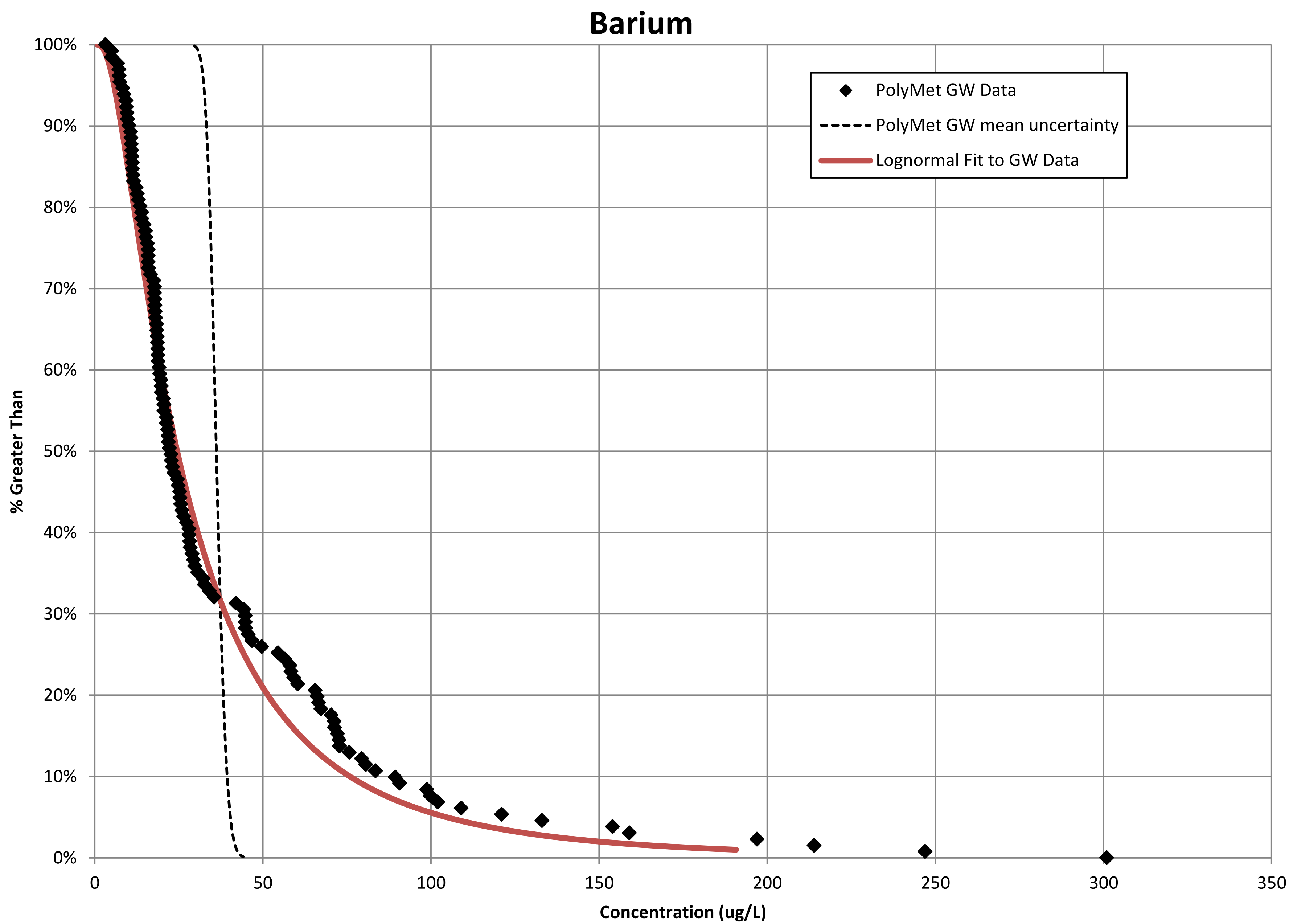


Alkalinity
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
180,000
200,000
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data

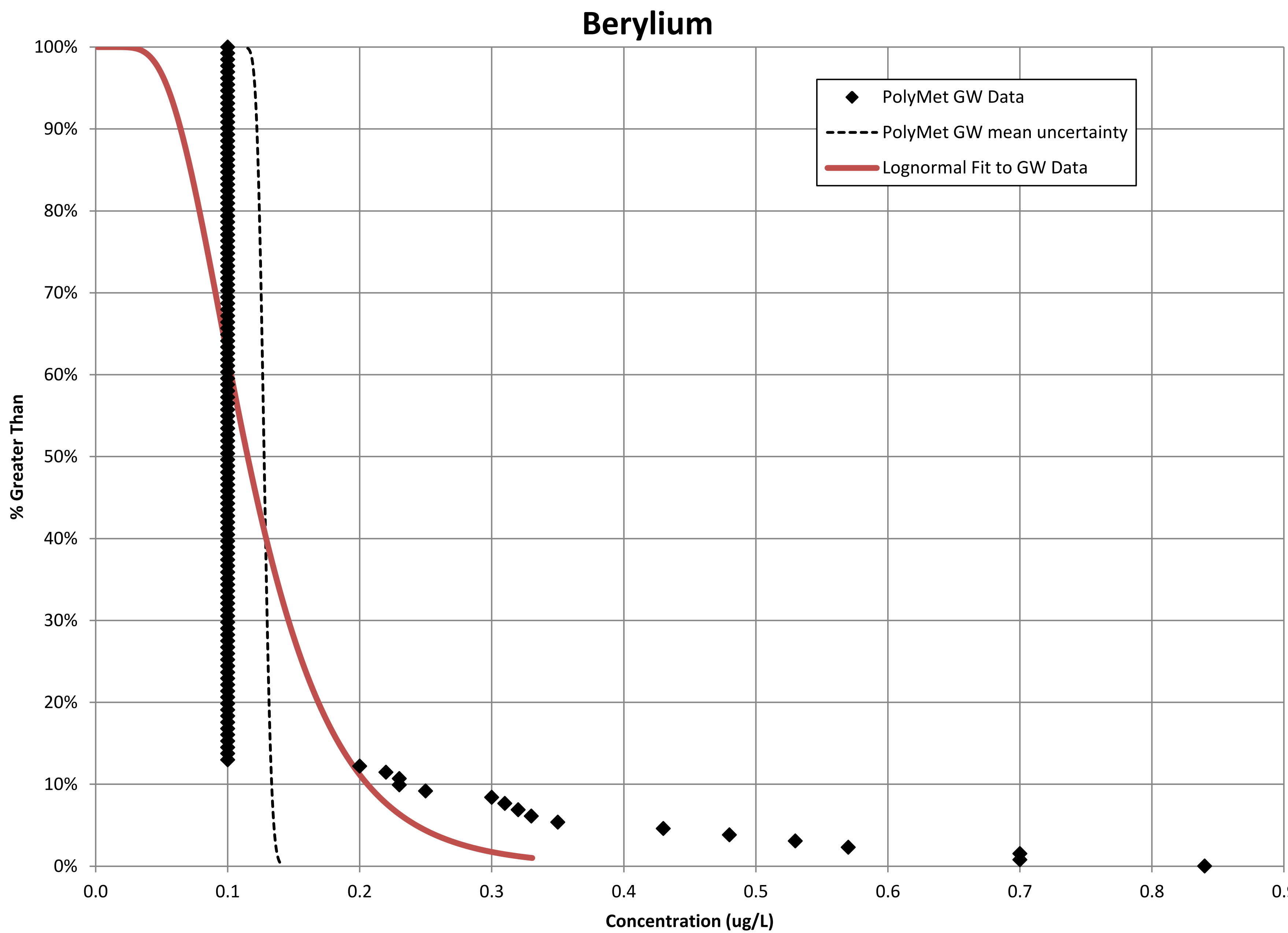


Arsenic
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
1
2
3
4
5
6
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data

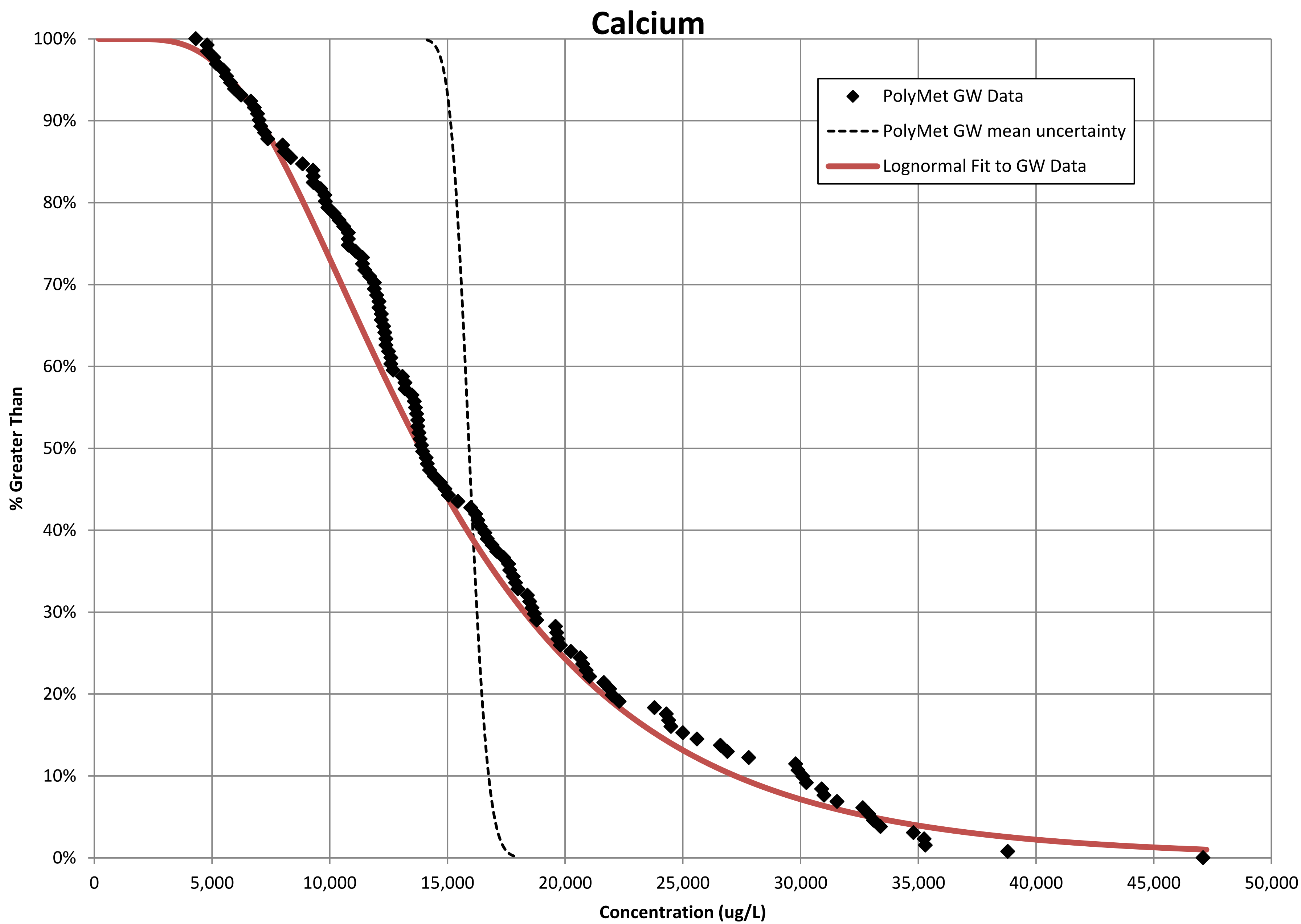

Boron
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
10
20
30
40
50
60
70
80
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data

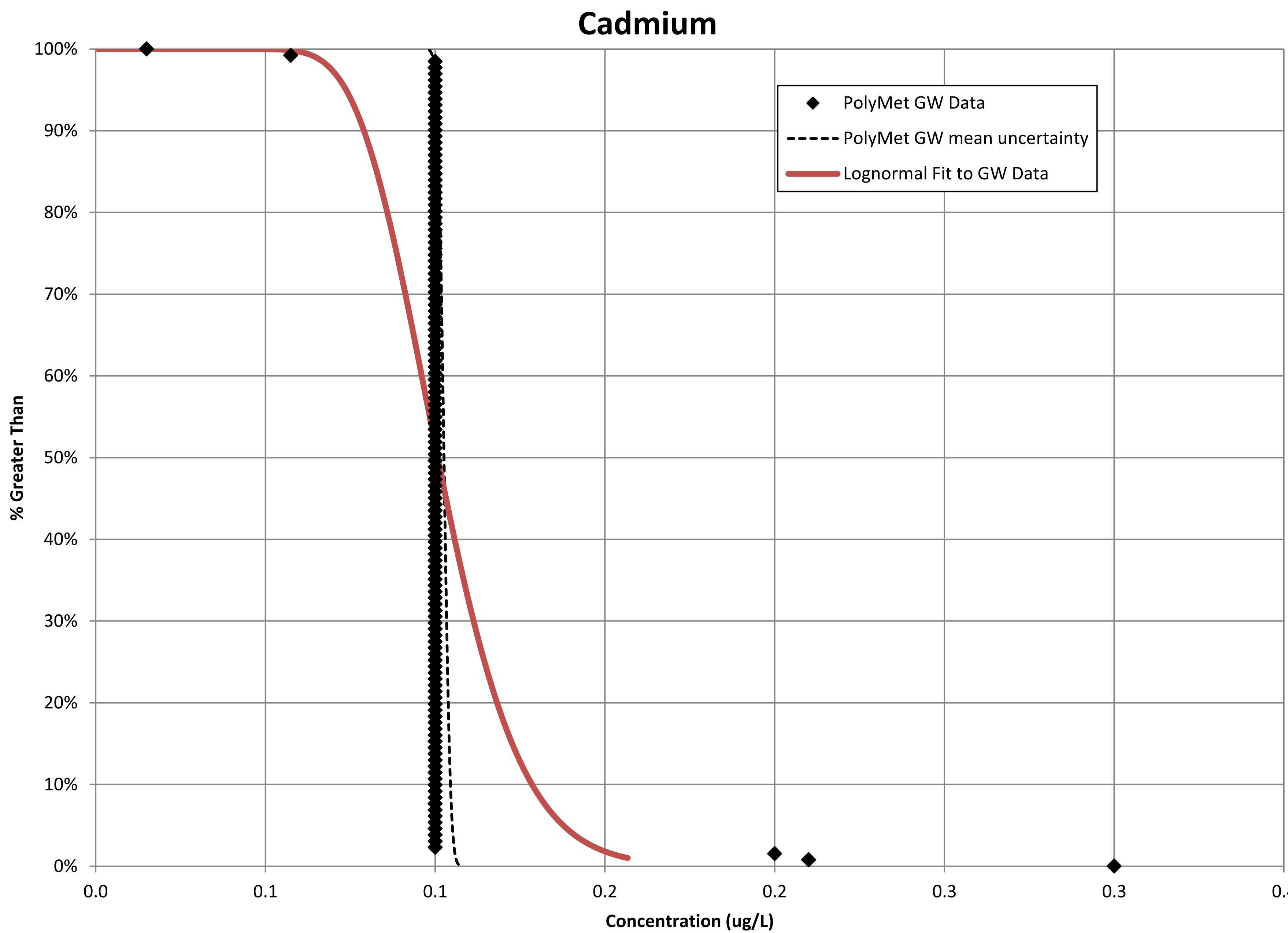


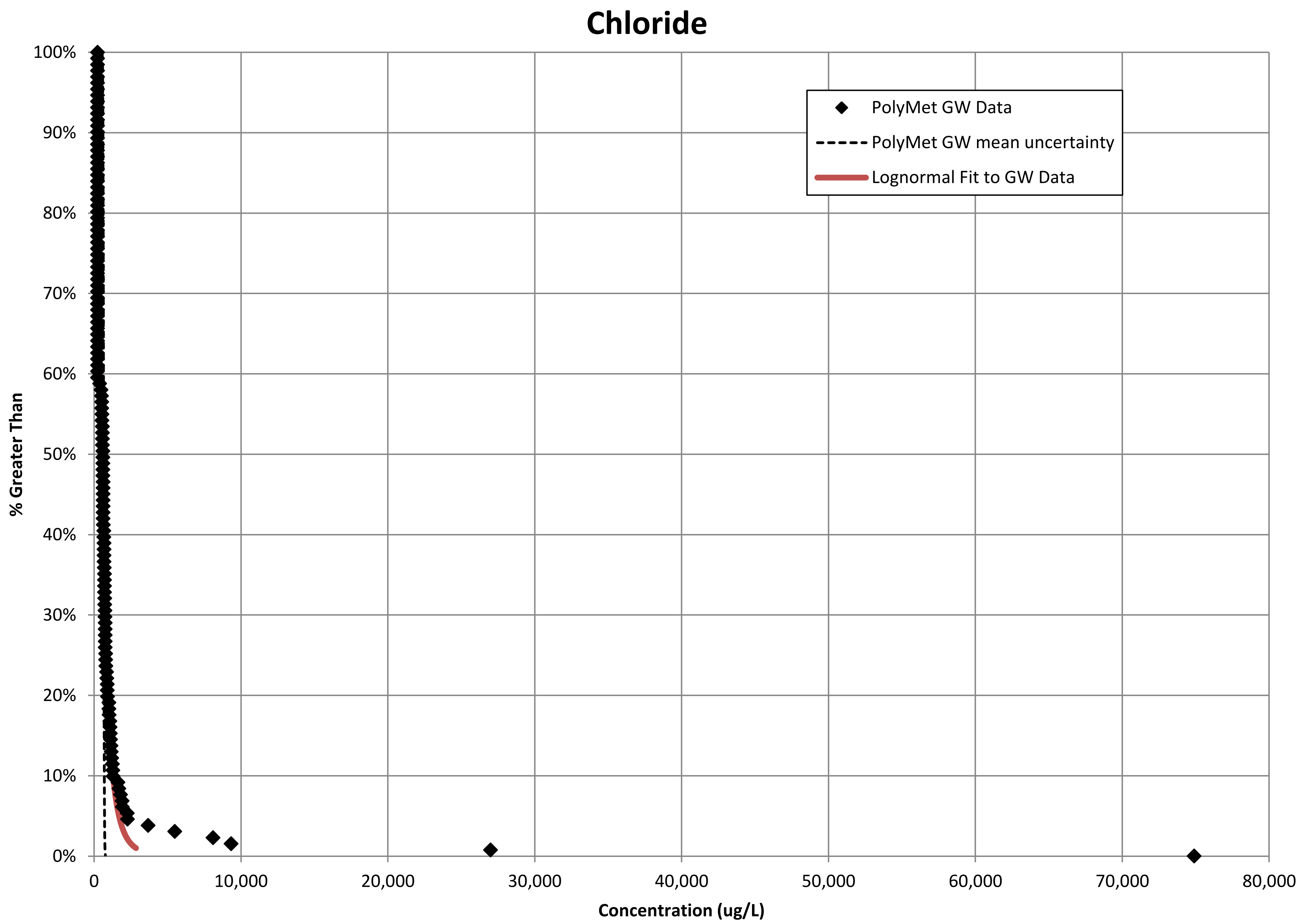
Barium
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
50
100
150
200
250
300
350
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data

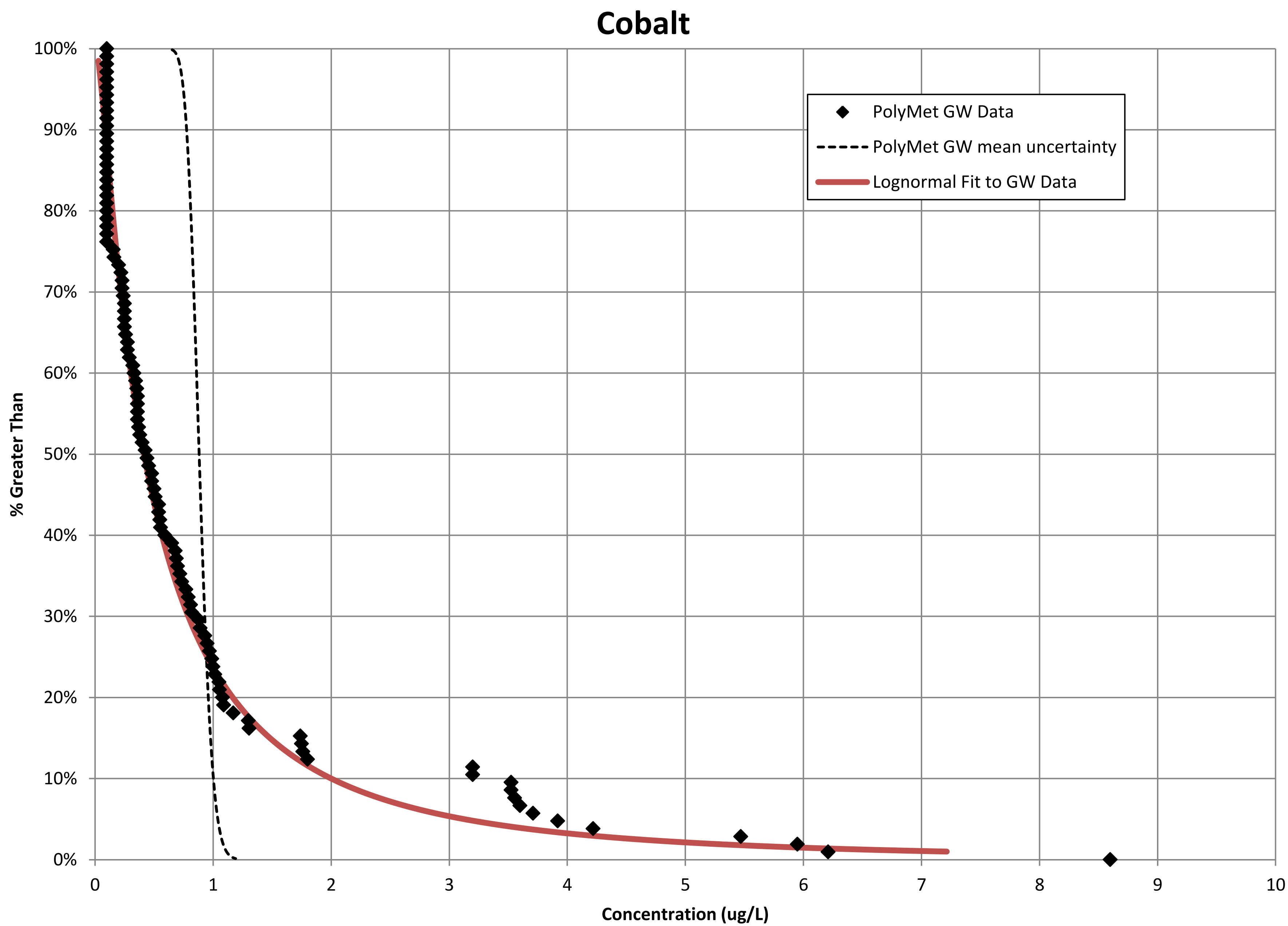


Berylium
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data

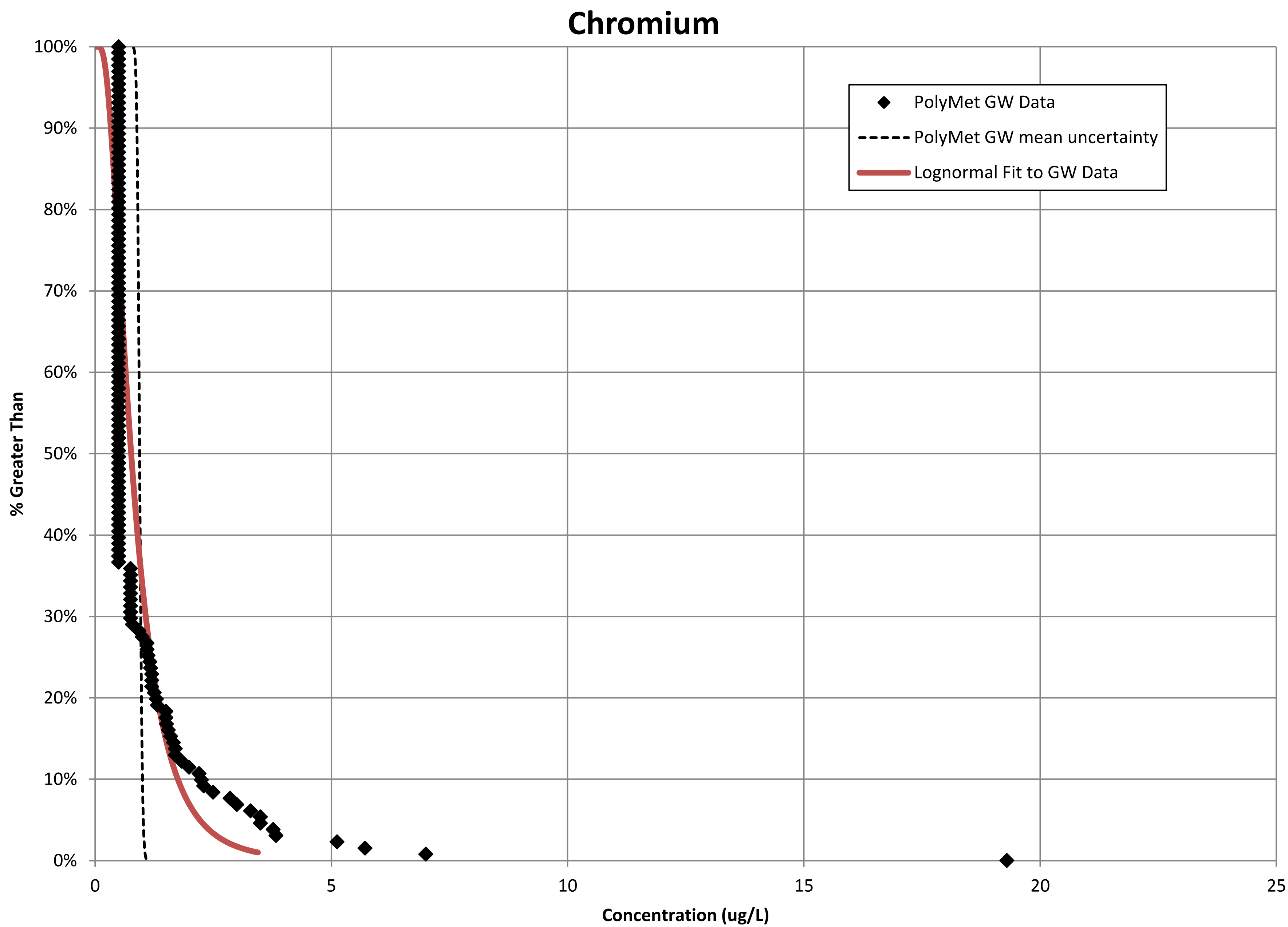

Calcium
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data


Cadmium
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0.0
0.1
0.1
0.2
0.2
0.3
0.3
0.4
Concentration (ug/L)

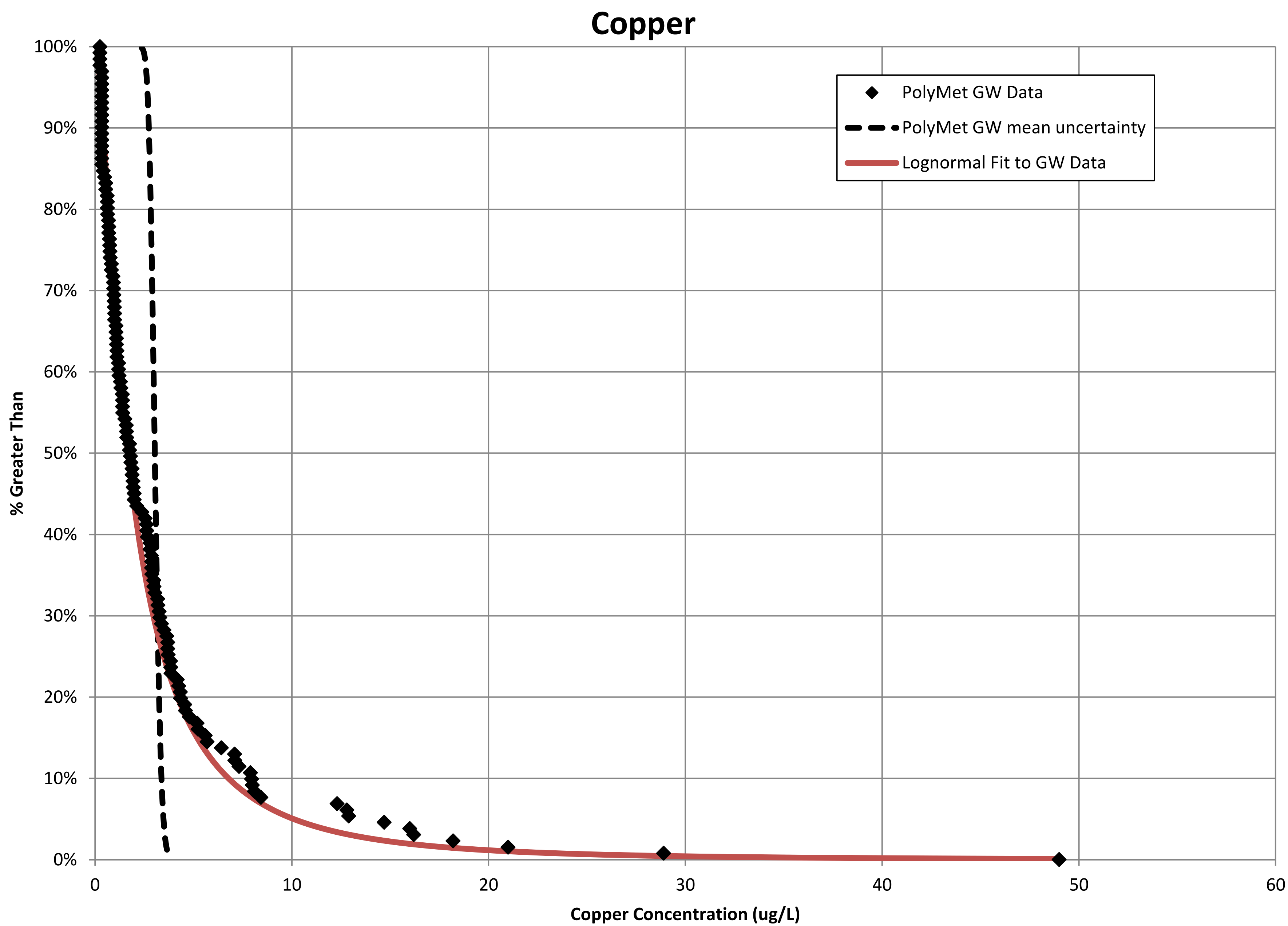

Chloride
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data

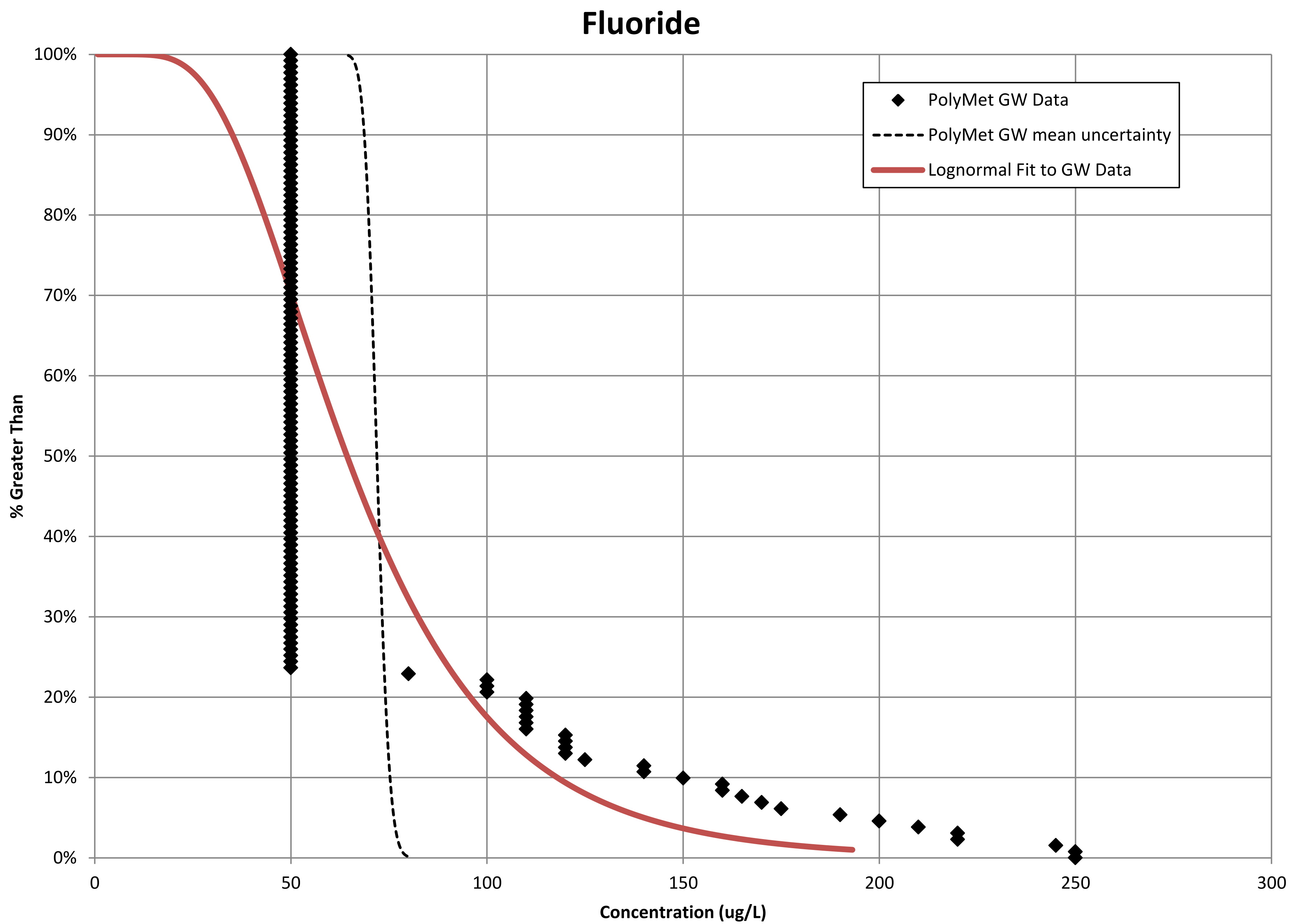


Cobalt
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
1
2
3
4
5
6
7
8
9
10
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data

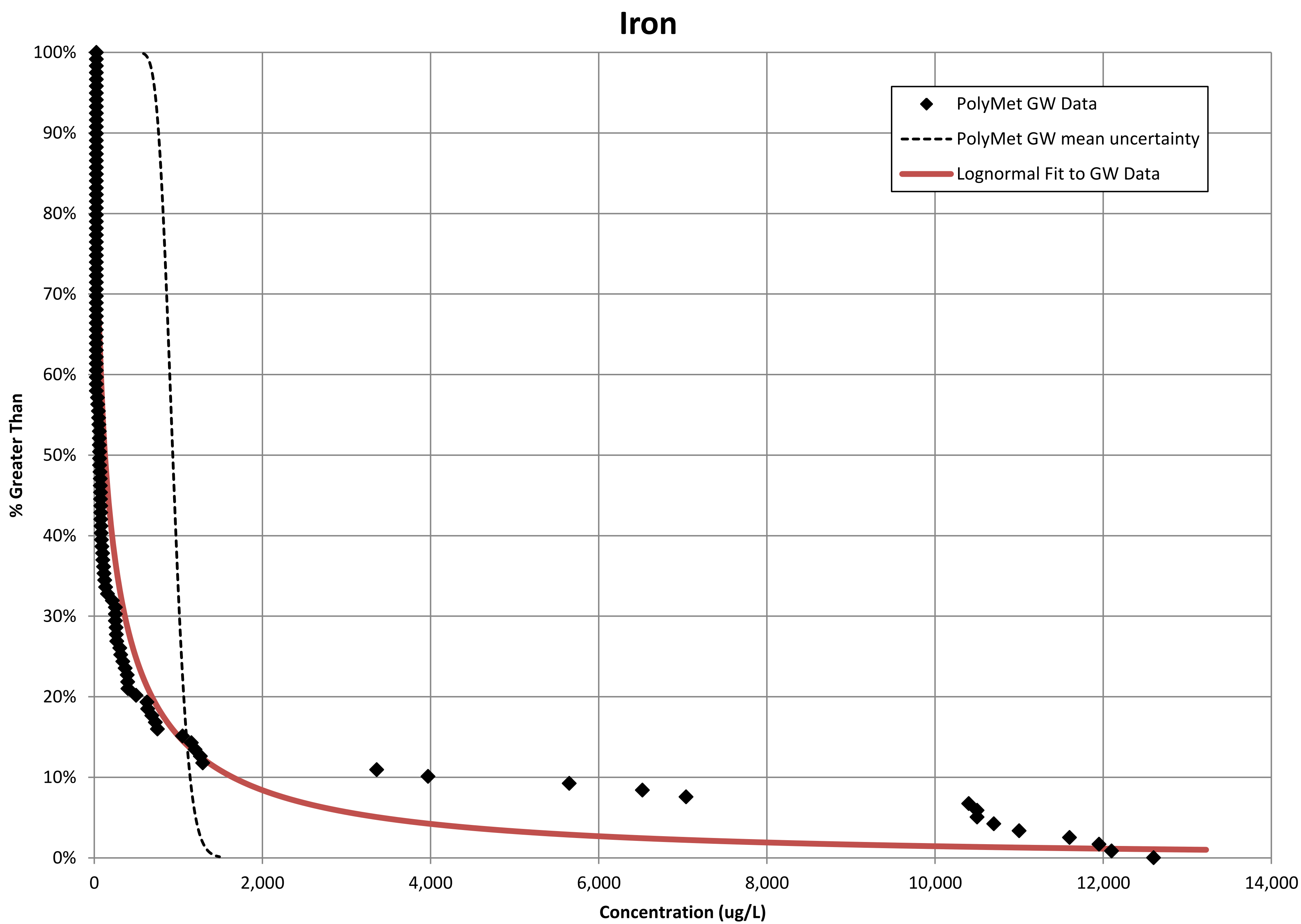


Chromium
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
5
10
15
20
25
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data

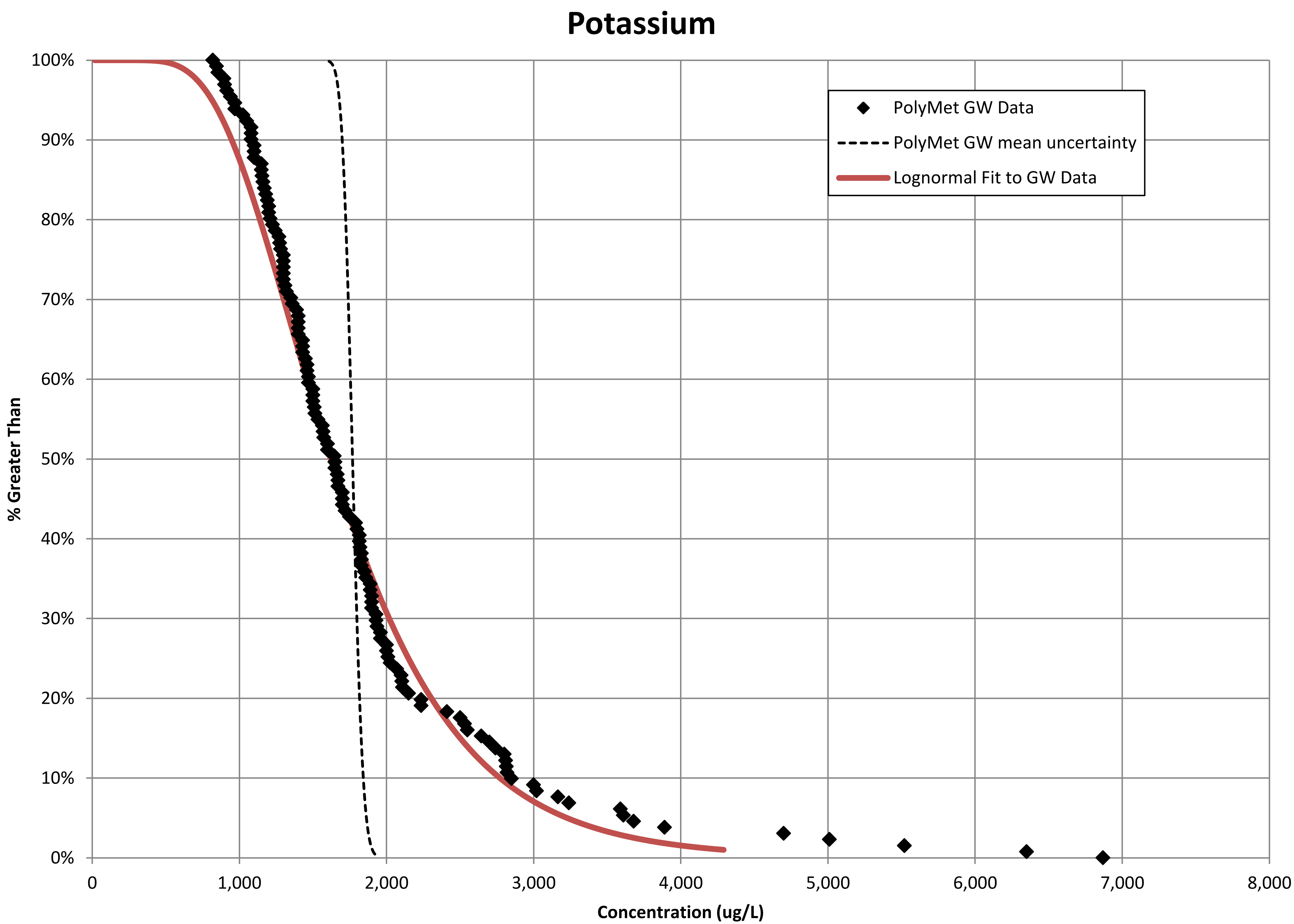

Copper
% Greater Than
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
Copper Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data



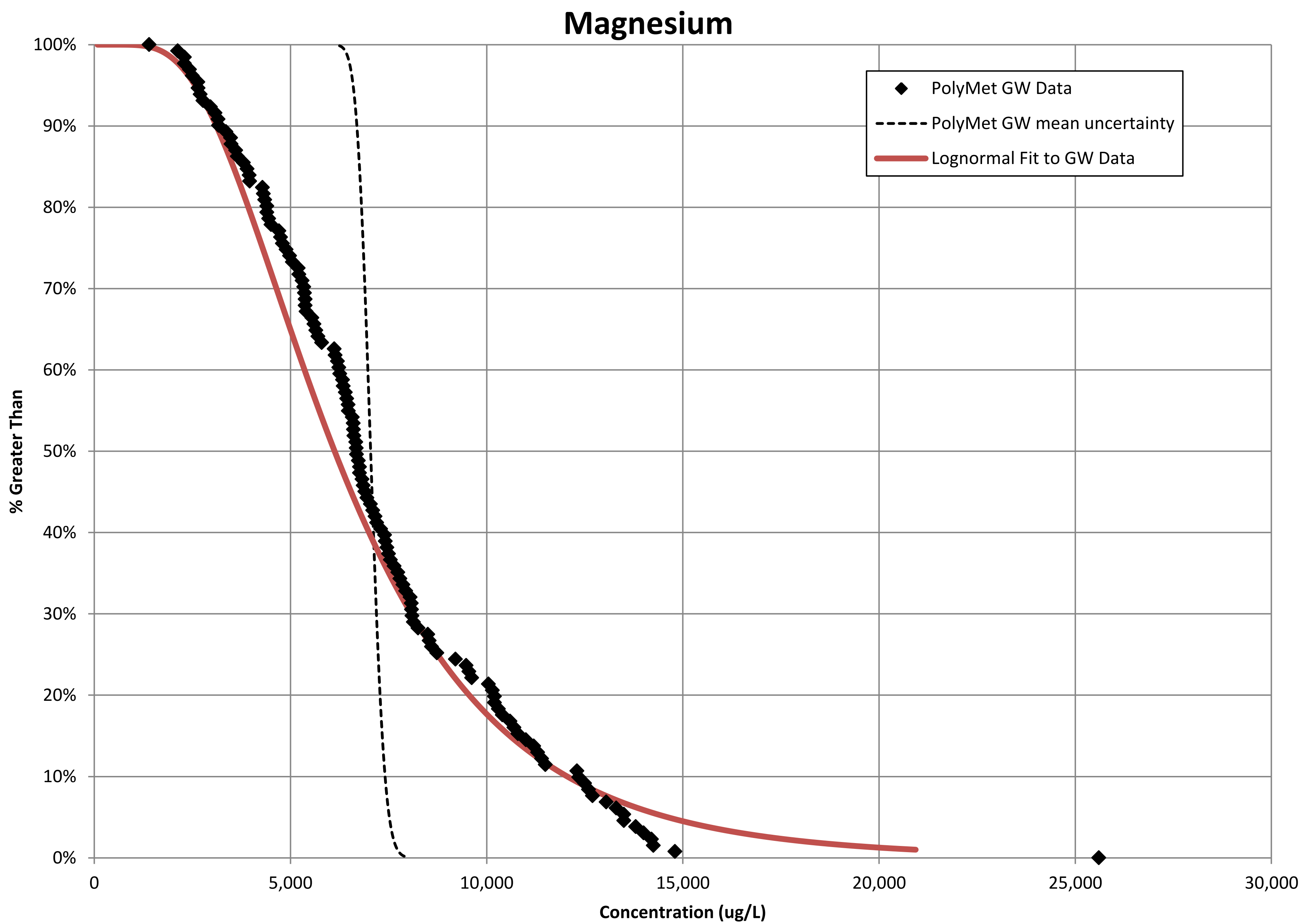
Fluoride
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
50
100
150
200
250
300
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data



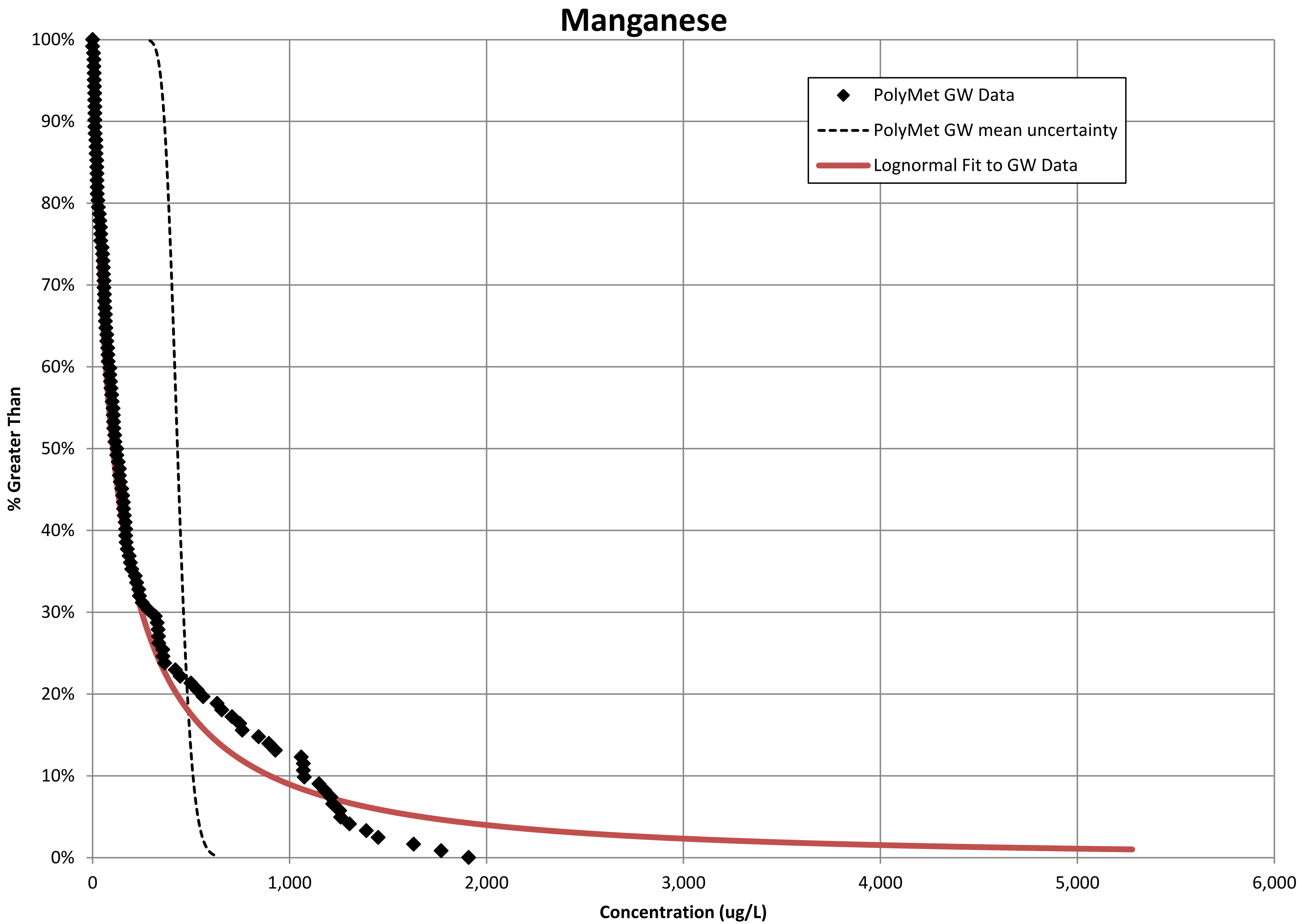
Iron
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data



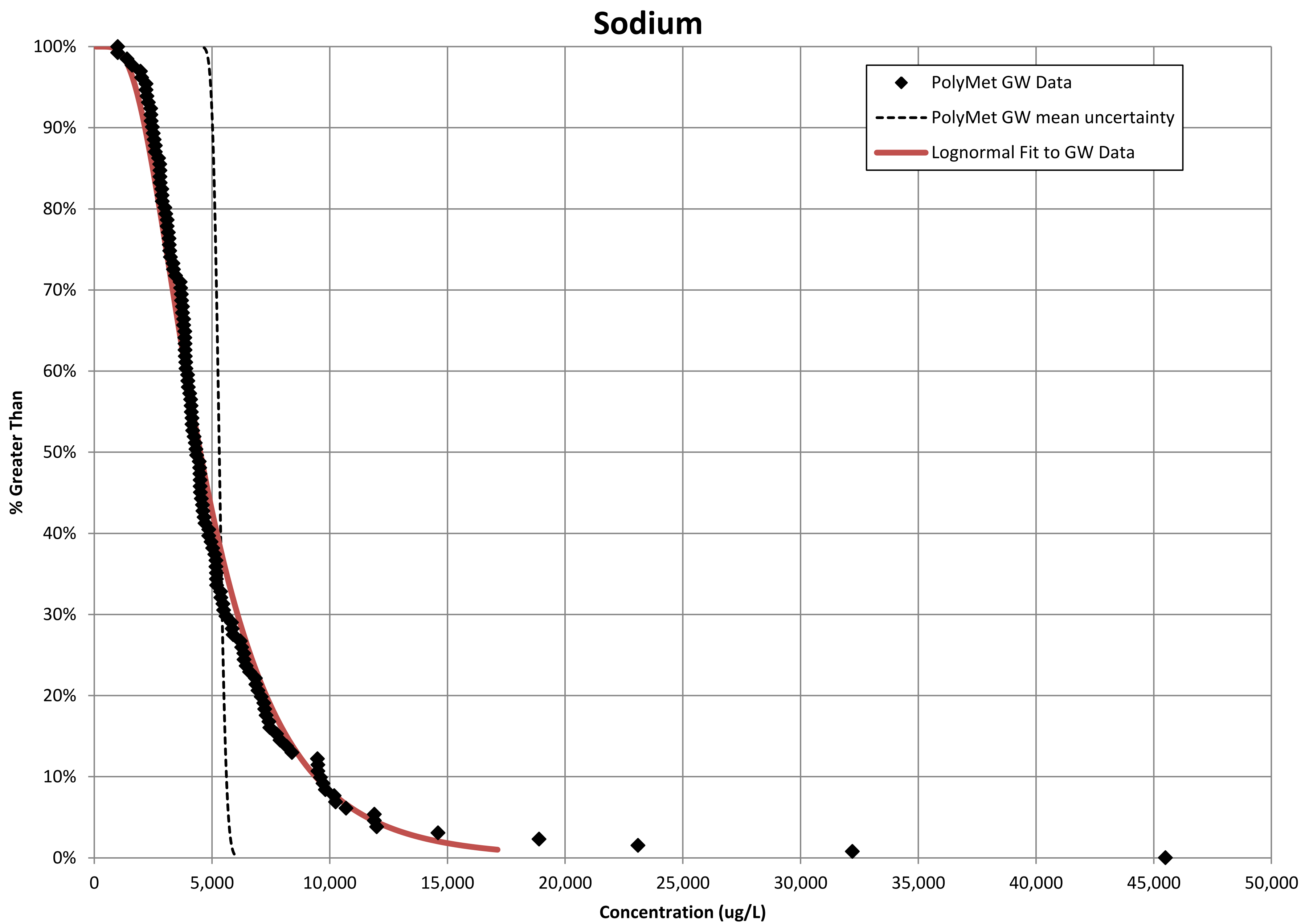
Potassium
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data



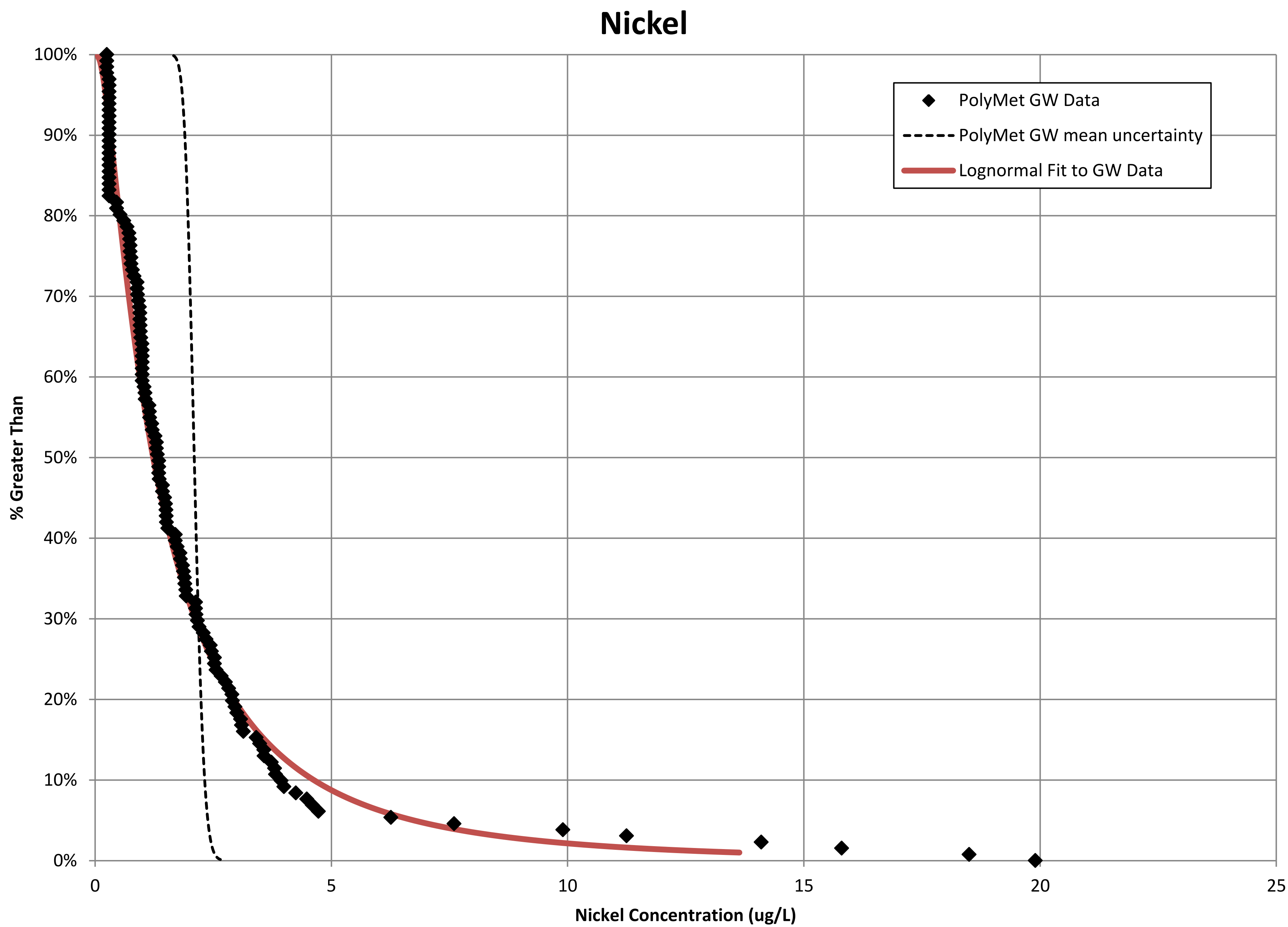
Magnesium
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
5,000
10,000
15,000
20,000
25,000
30,000
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data



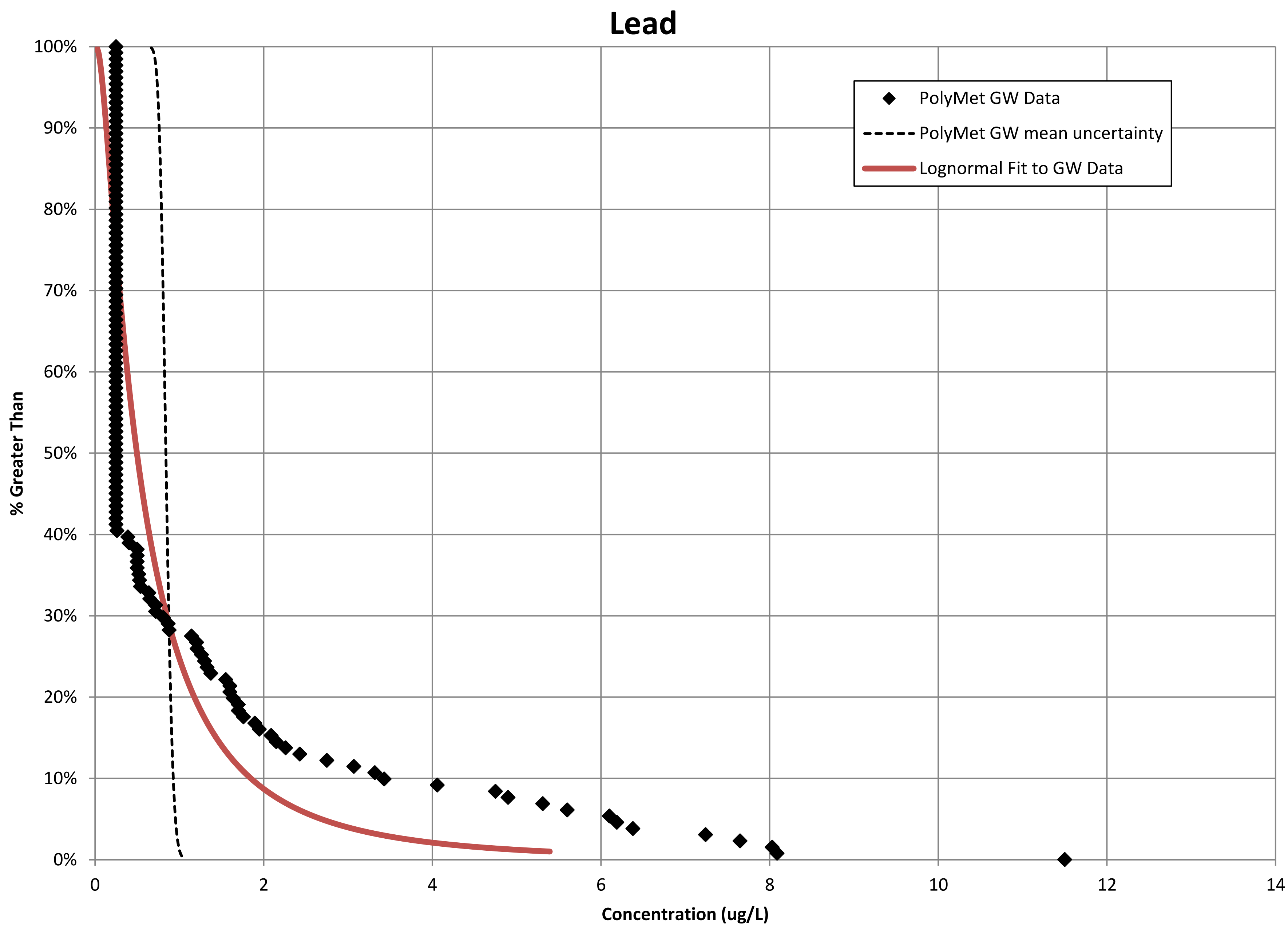
Manganese
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
1,000
2,000
3,000
4,000
5,000
6,000
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data



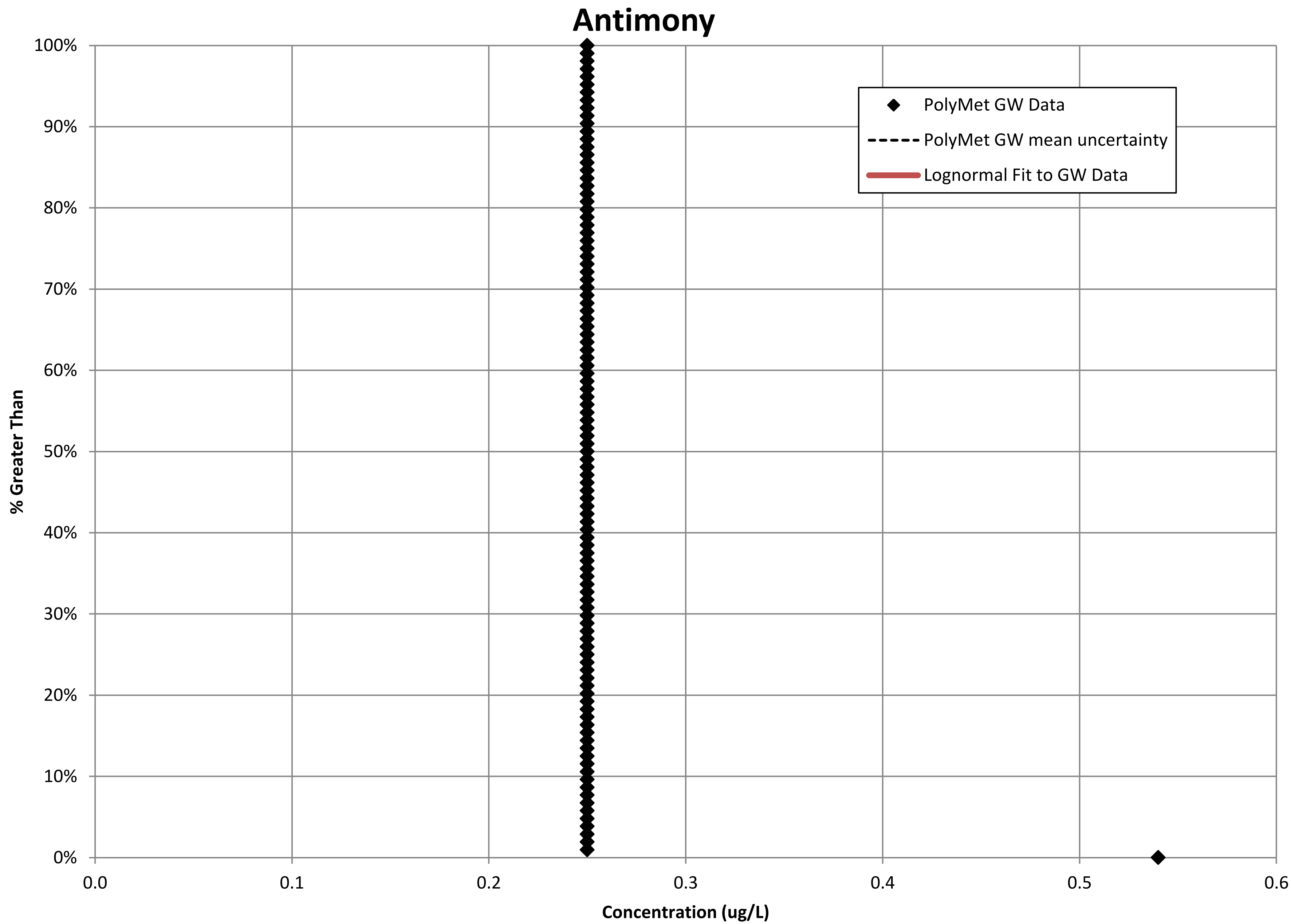
Sodium
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data

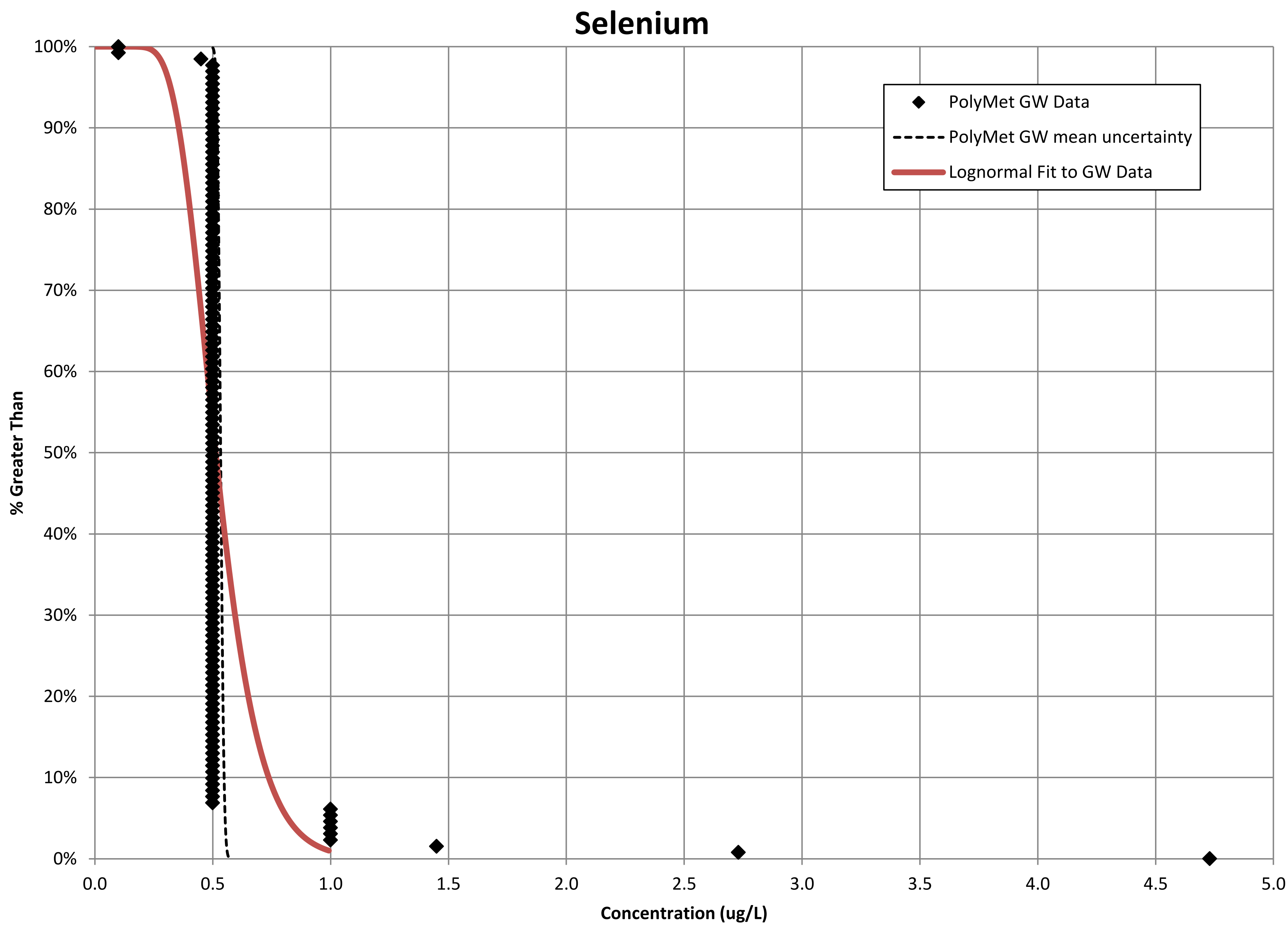


Nickel
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
5
10
15
20
25
Nickel Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data

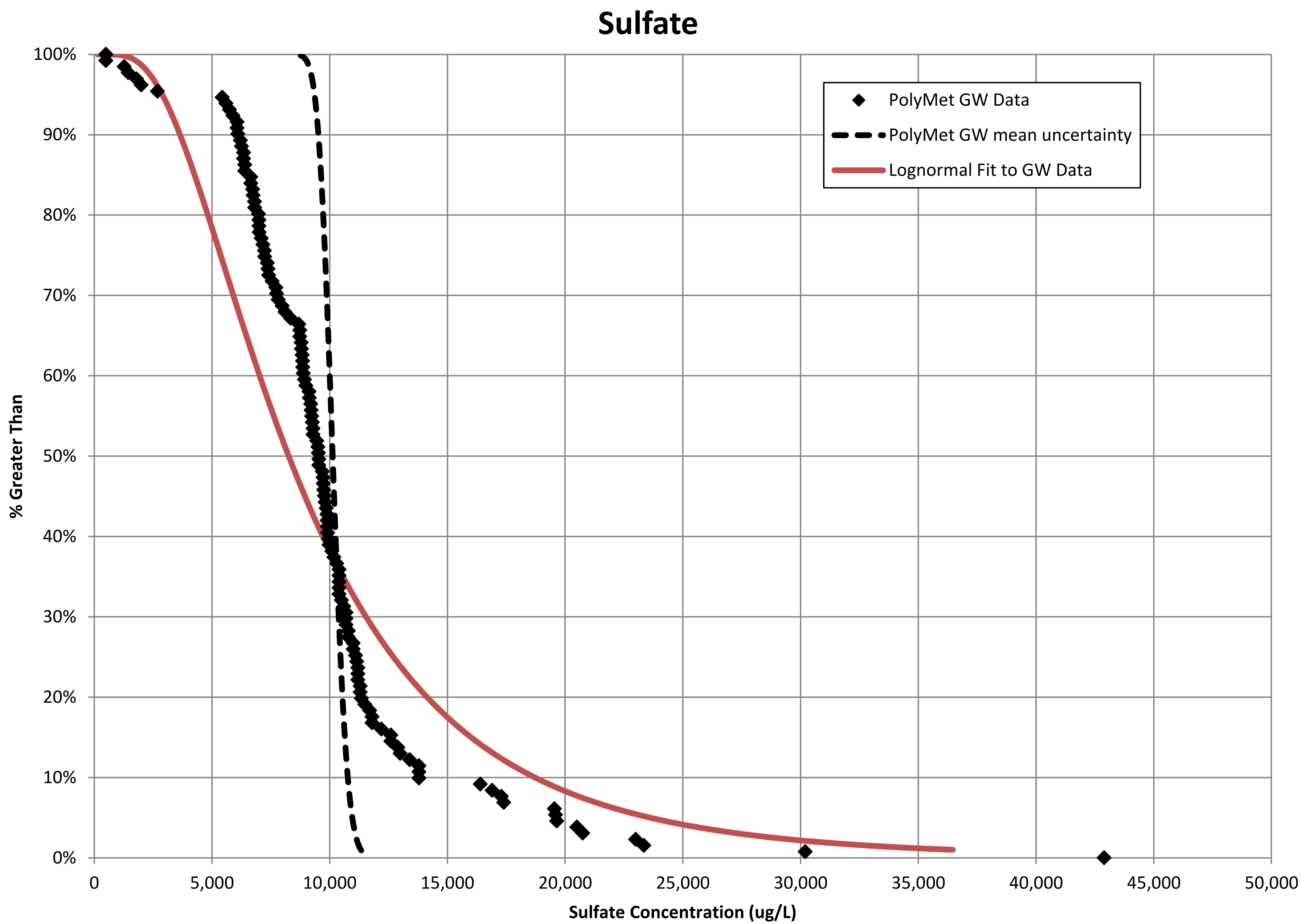


Lead
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
2
4
6
8
10
12
14
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data

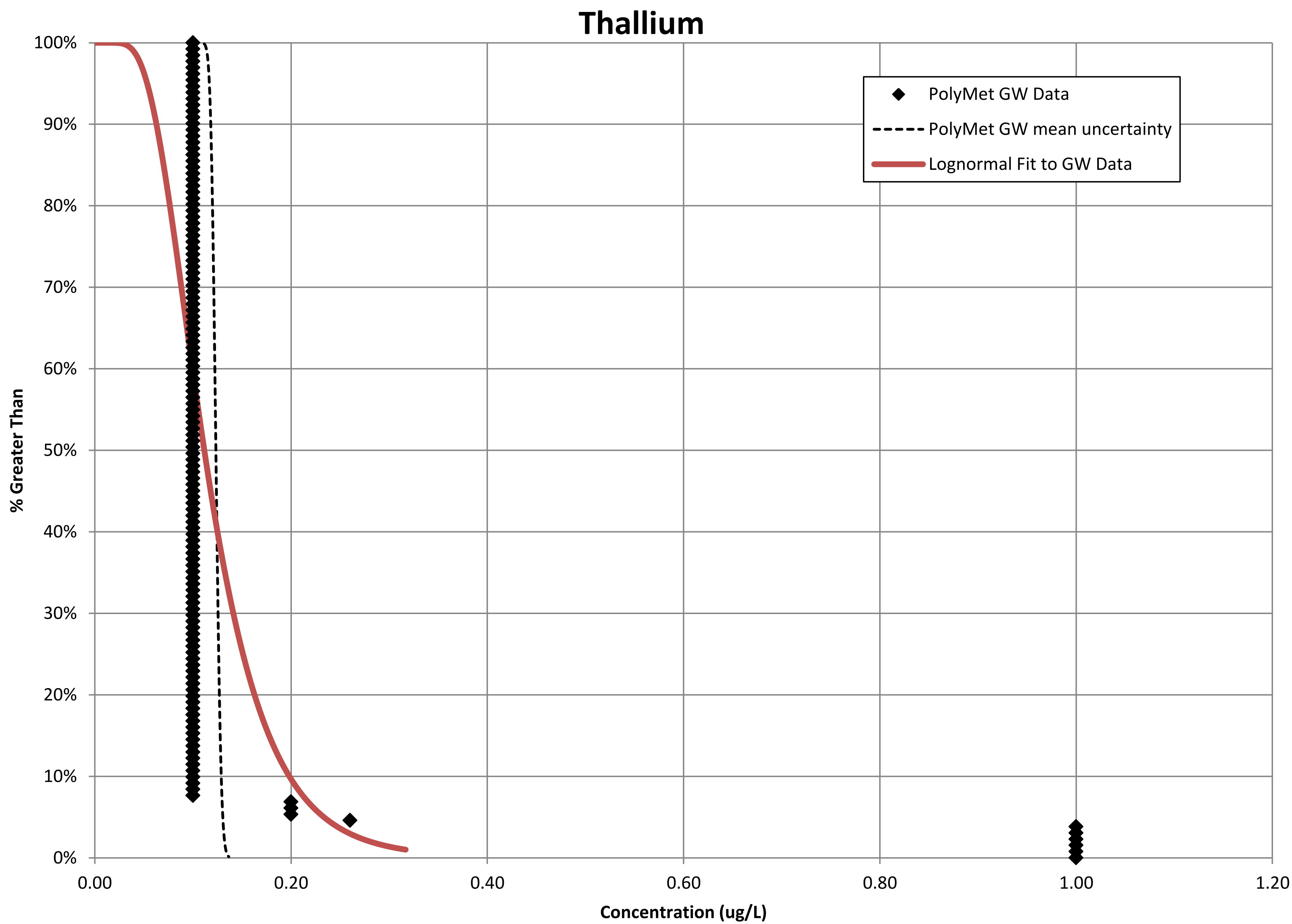

Antimony
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data



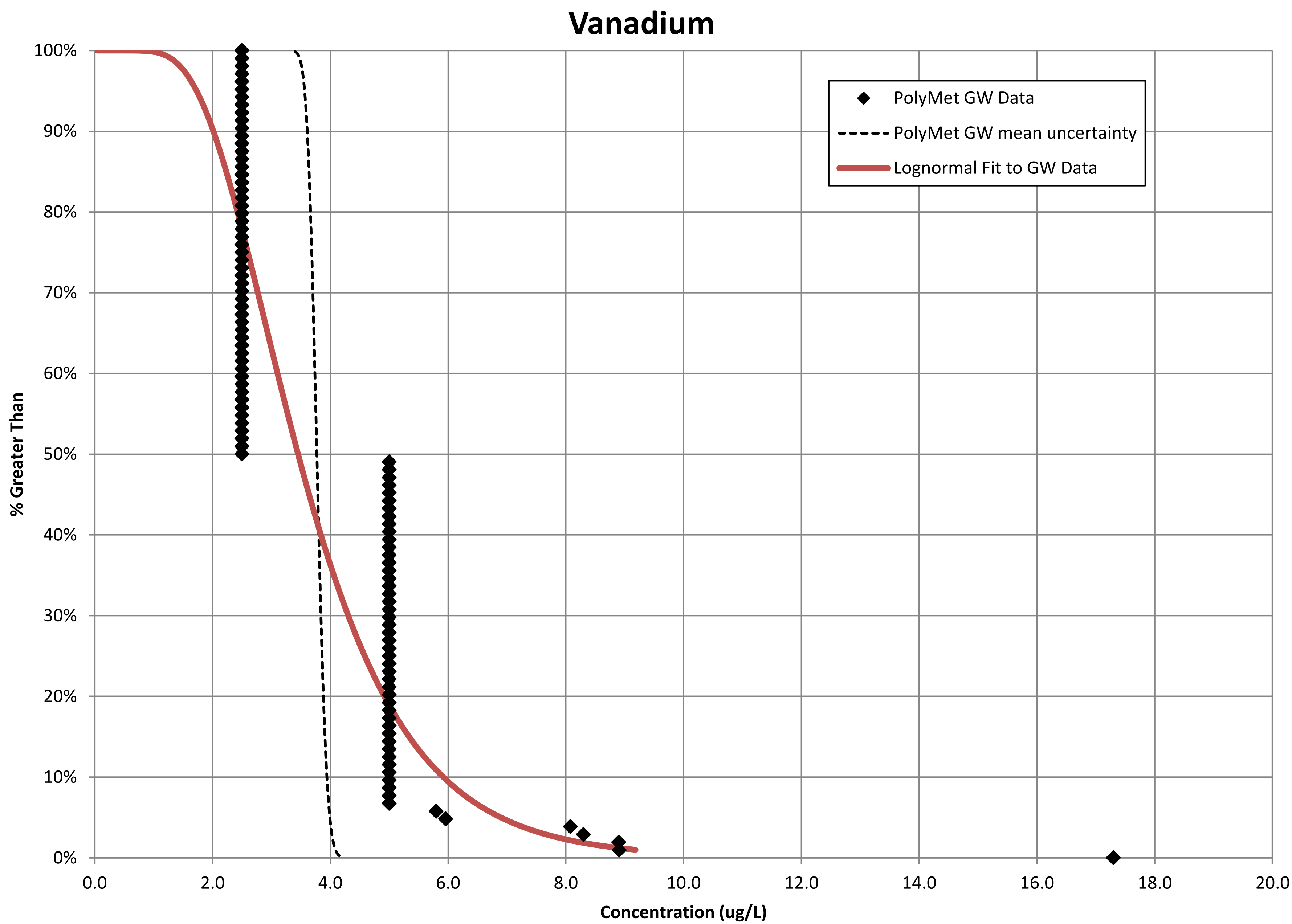
Selenium
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data

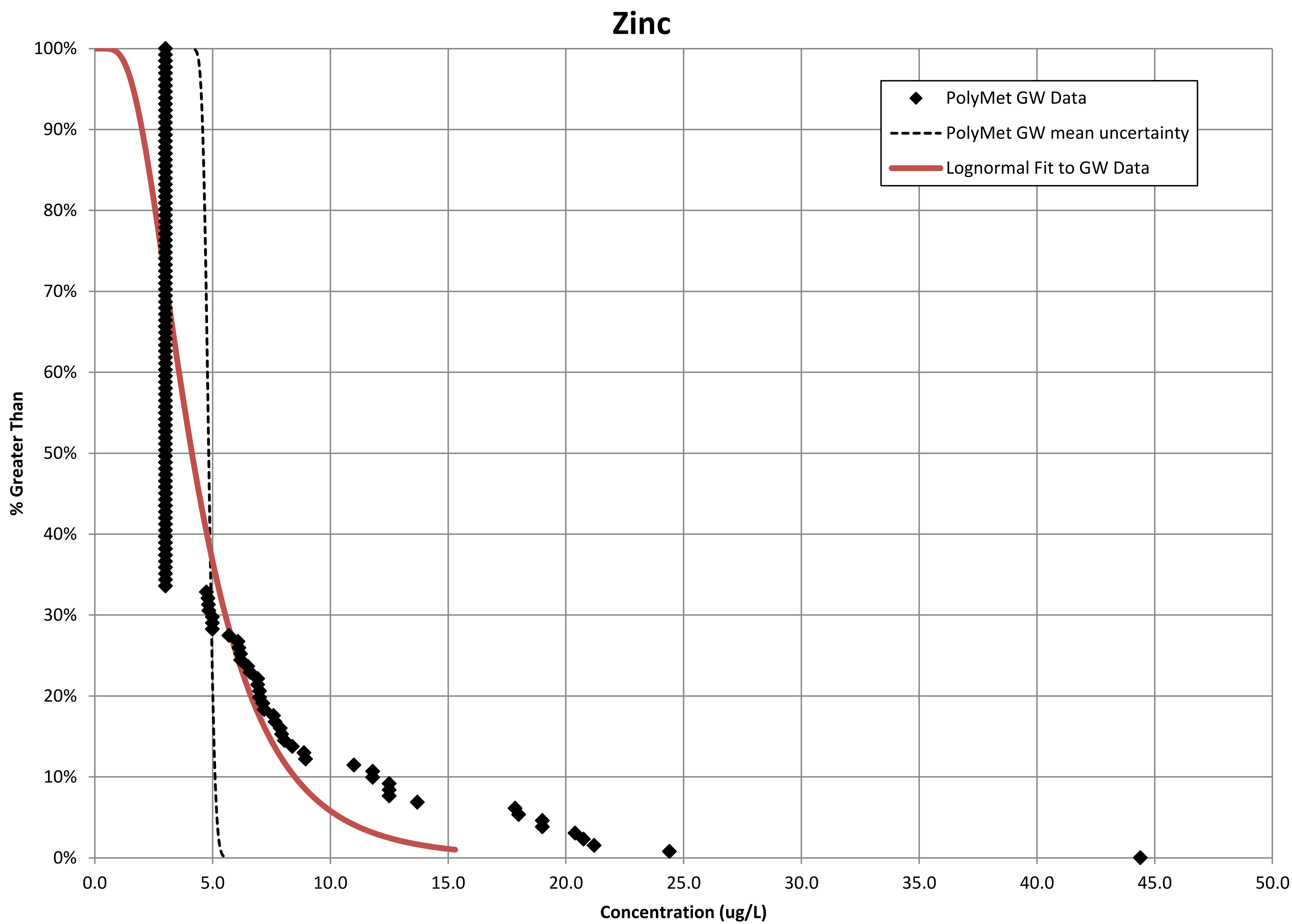


Sulfate
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
Sulfate Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data



Thallium
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Greater Than
0.00
0.20
0.40
0.60
0.80
1.00
1.20
Concentration (ug/L)
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data

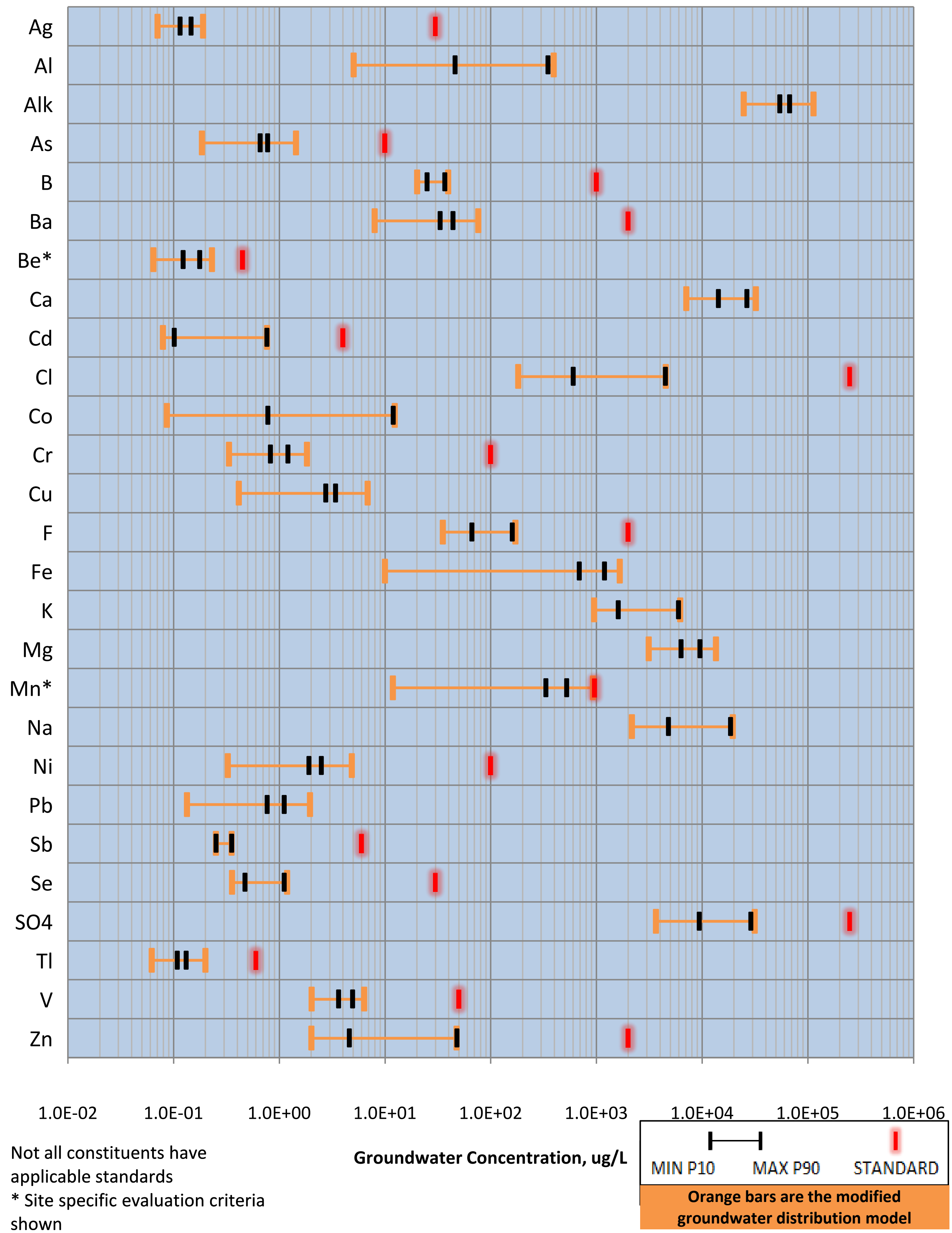

Vanadium
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data
% Greater Than
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
Concentration (ug/L)



Zinc
PolyMet GW Data
PolyMet GW mean uncertainty
Lognormal Fit to GW Data
% Greater Than
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
Concentration (ug/L)

# Appendix D

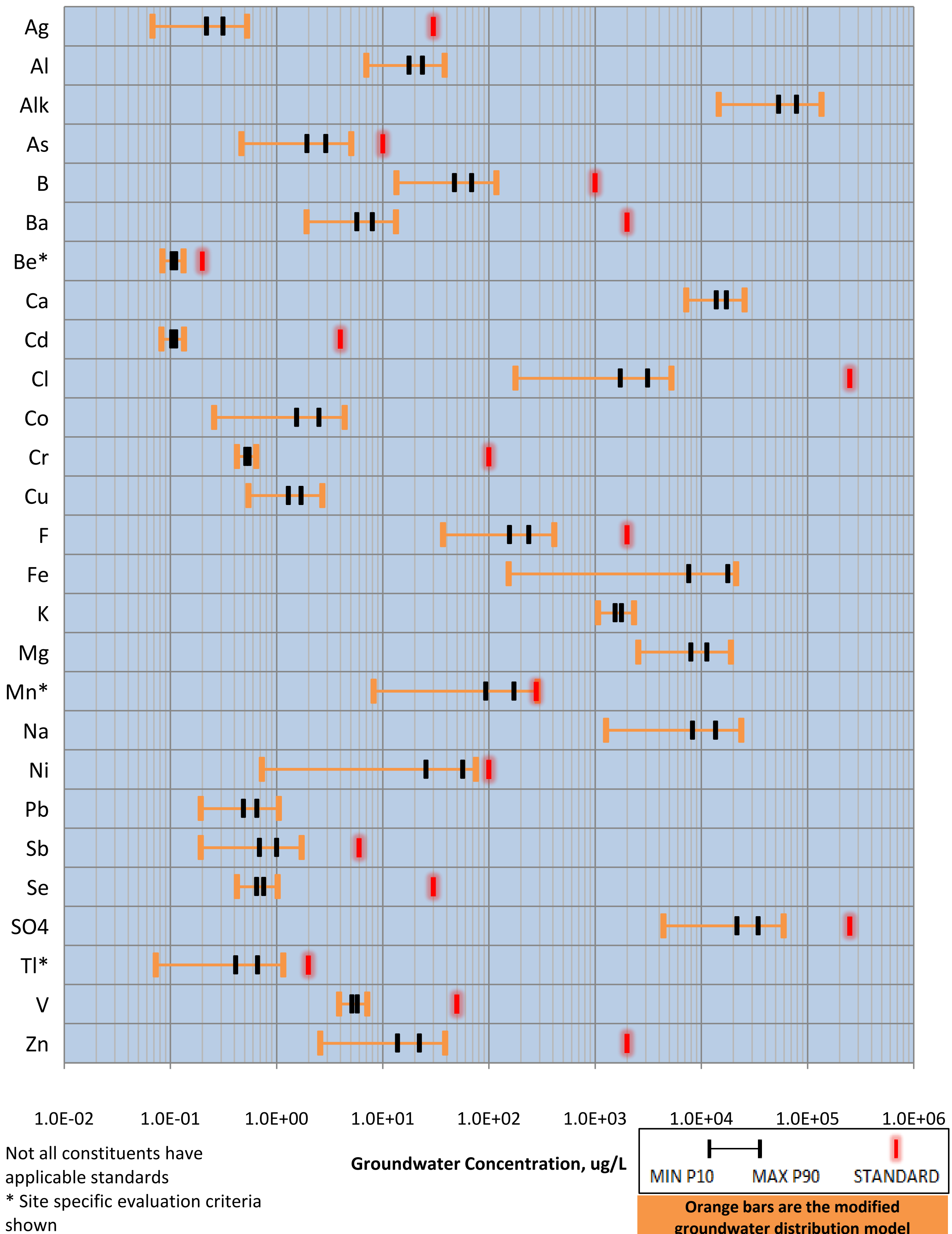
## Groundwater Summary Plots for Mine Site Background Groundwater Quality Analysis




Not all constituents have applicable standards

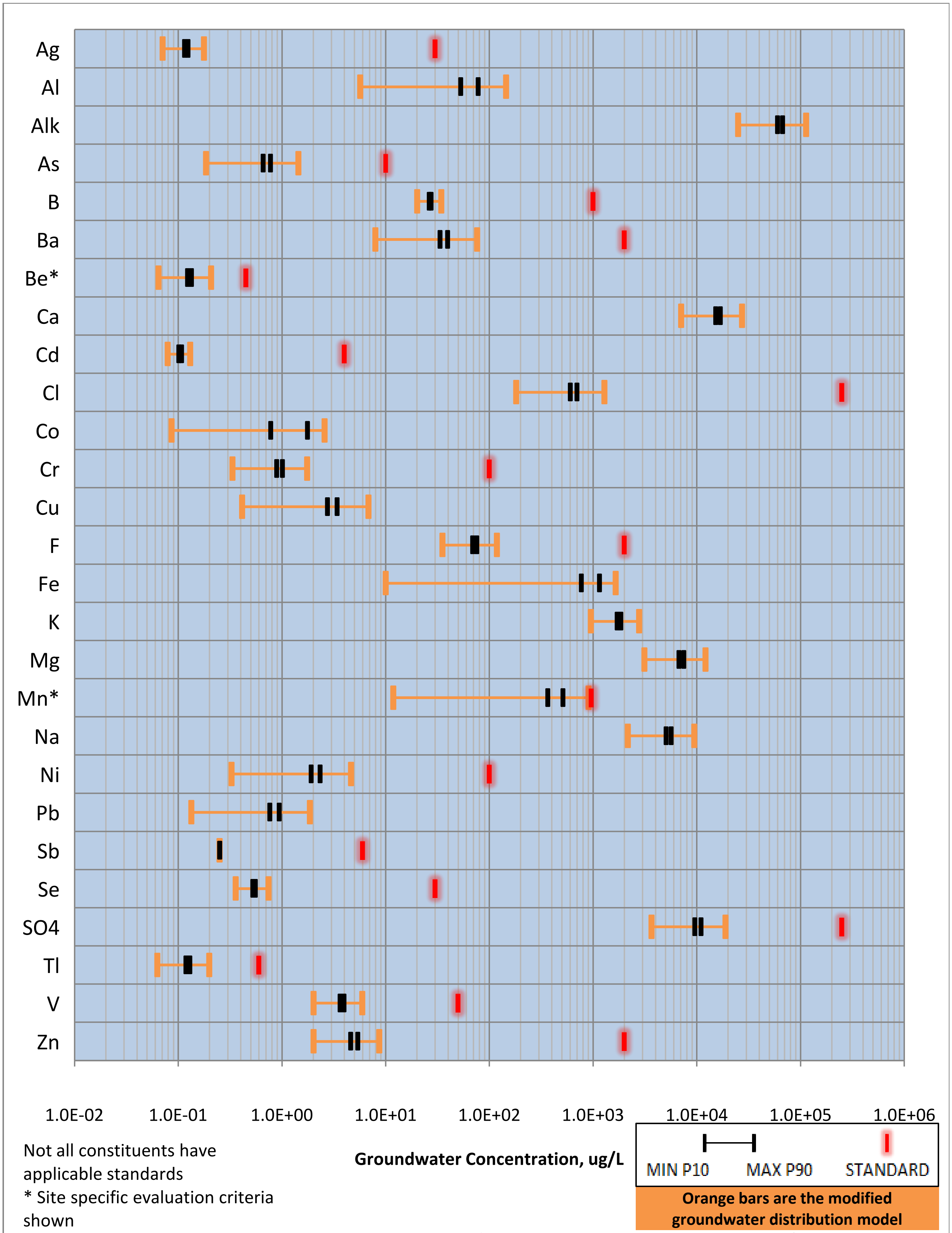
* Site specific evaluation criteria shown

**Large Figure 47 MODIFIED Groundwater Concentration Ranges in the East Pit/Category 2/3 (surficial) Flow Path at the Property Boundary**



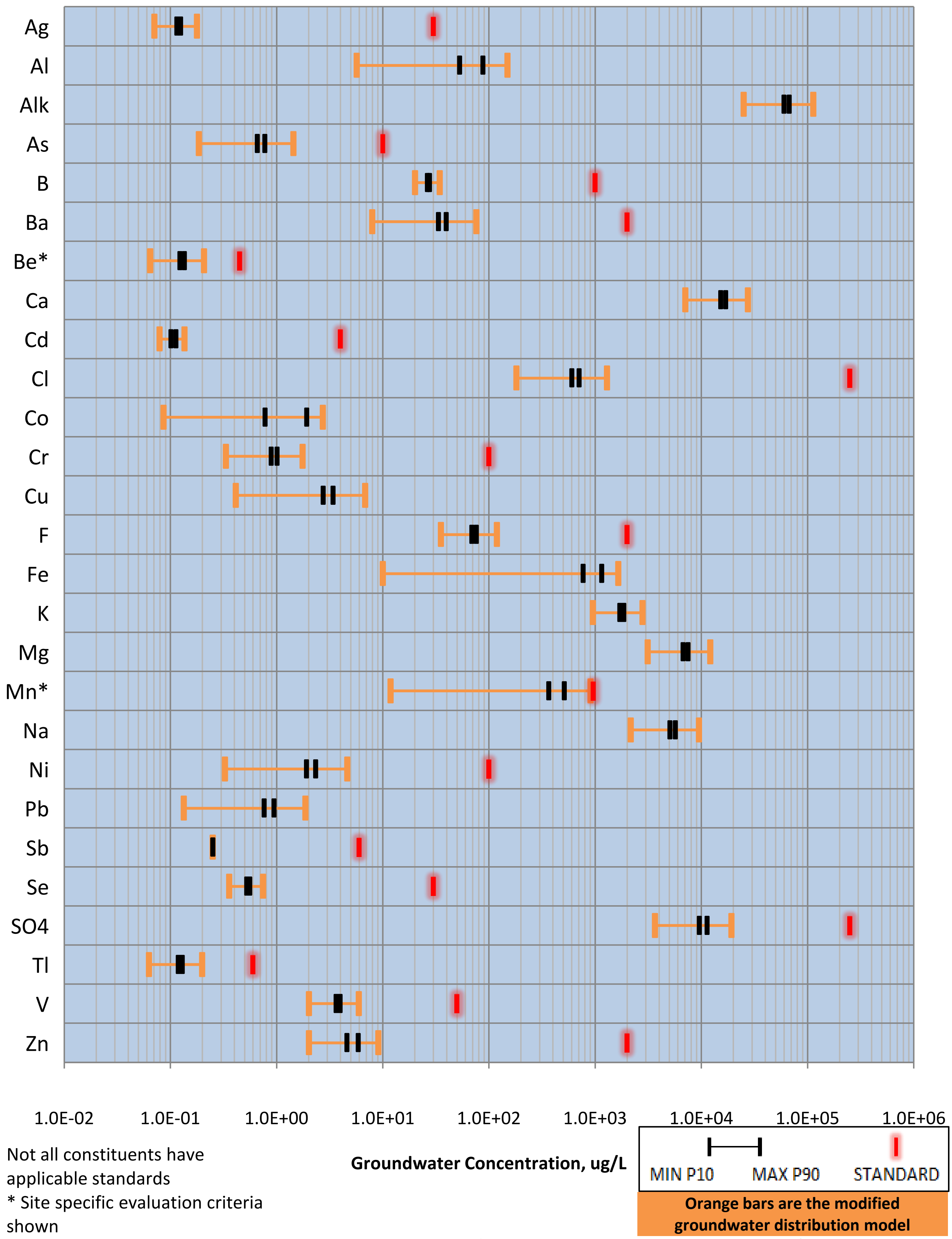

Not all constituents have applicable standards
* Site specific evaluation criteria shown

**Large Figure 48 MODIFIED Groundwater Concentration Ranges in the East Pit (bedrock) Flow Path at the Property Boundary**



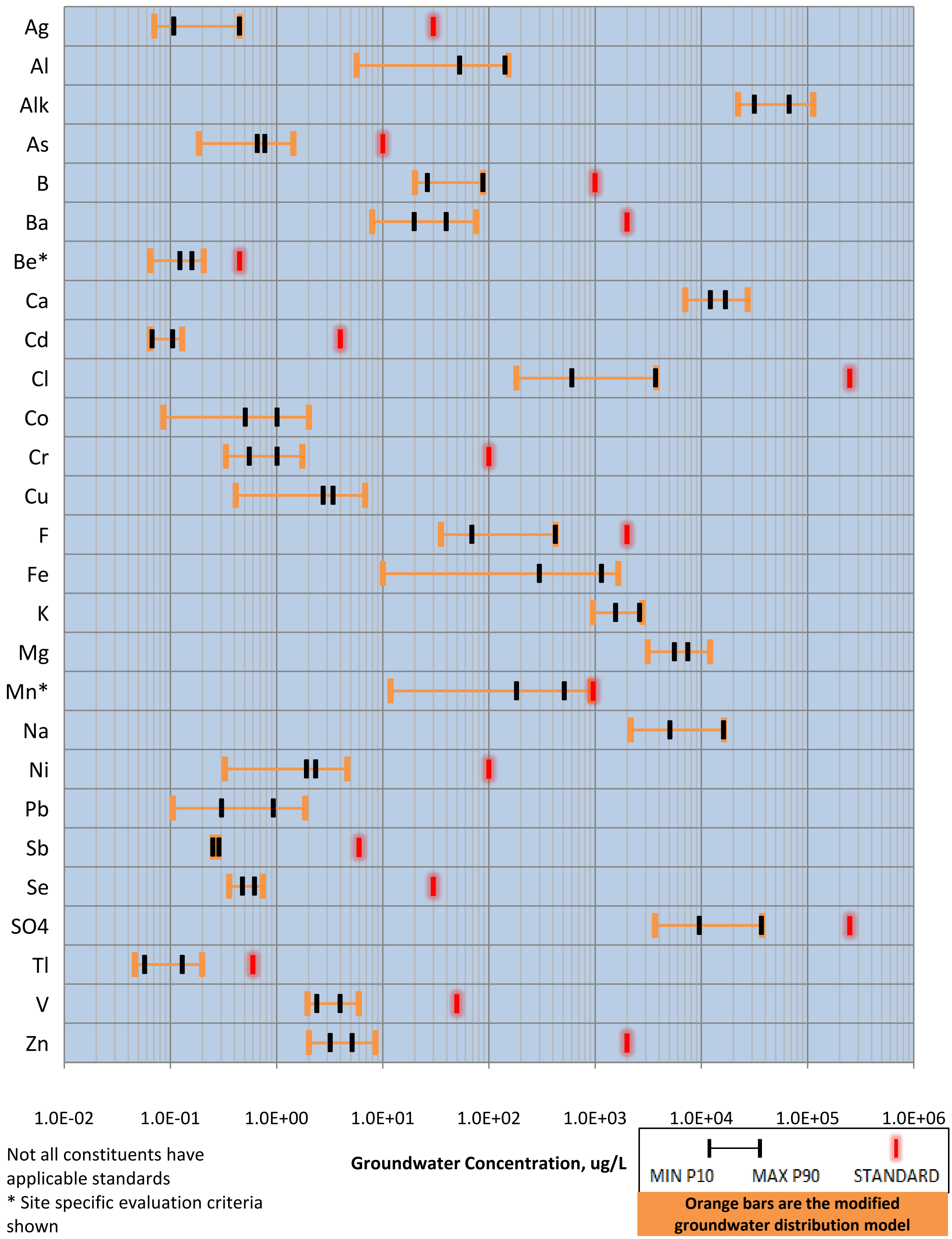

Not all constituents have applicable standards
* Site specific evaluation criteria shown

**Large Figure 49 MODIFIED Groundwater Concentration Ranges in the OSP (surficial) Flow Path at the Partridge River**



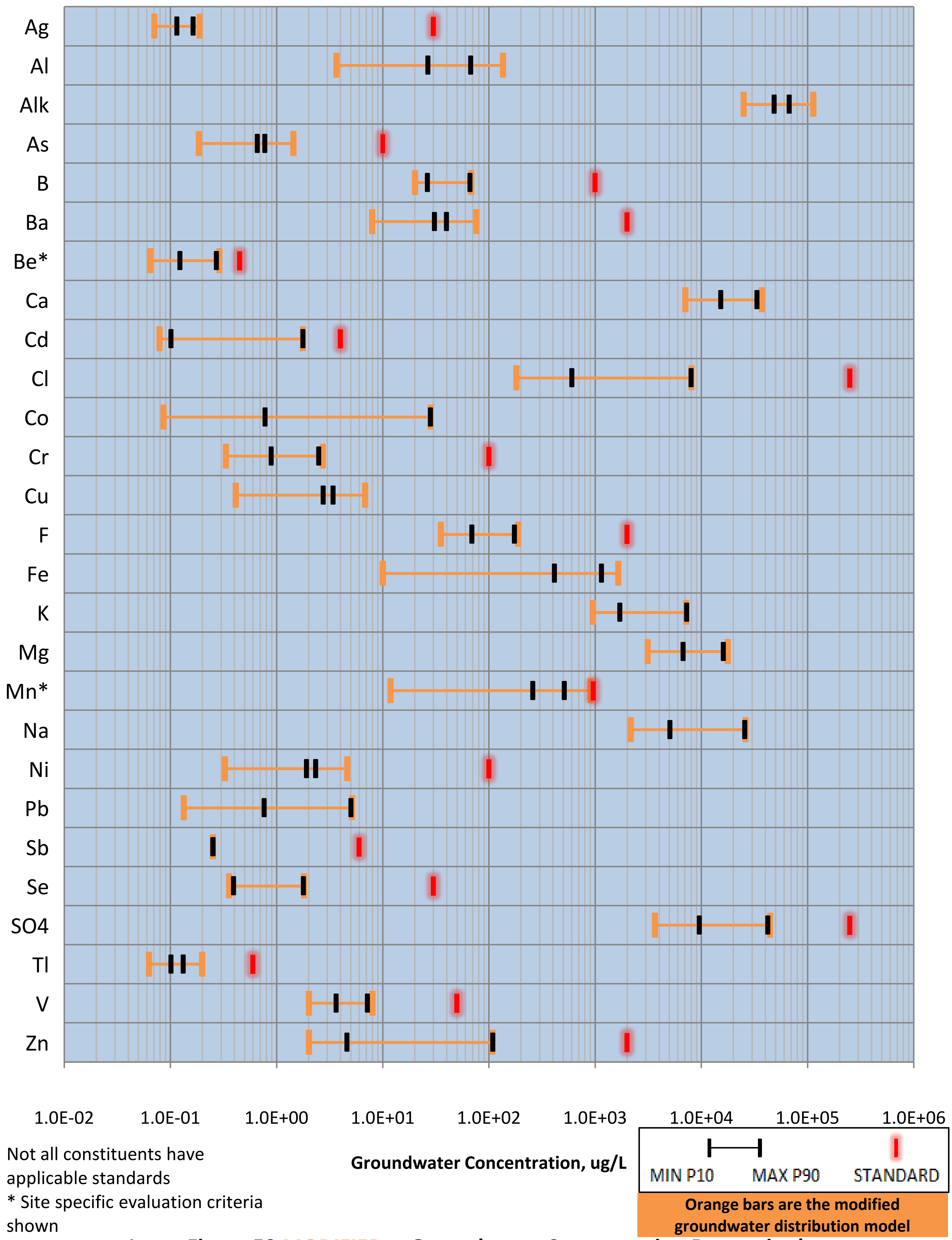

Not all constituents have applicable standards
* Site specific evaluation criteria shown

**Large Figure 50 MODIFIED Groundwater Concentration Ranges in the WWTF (surficial) Flow Path at the Property Boundary**



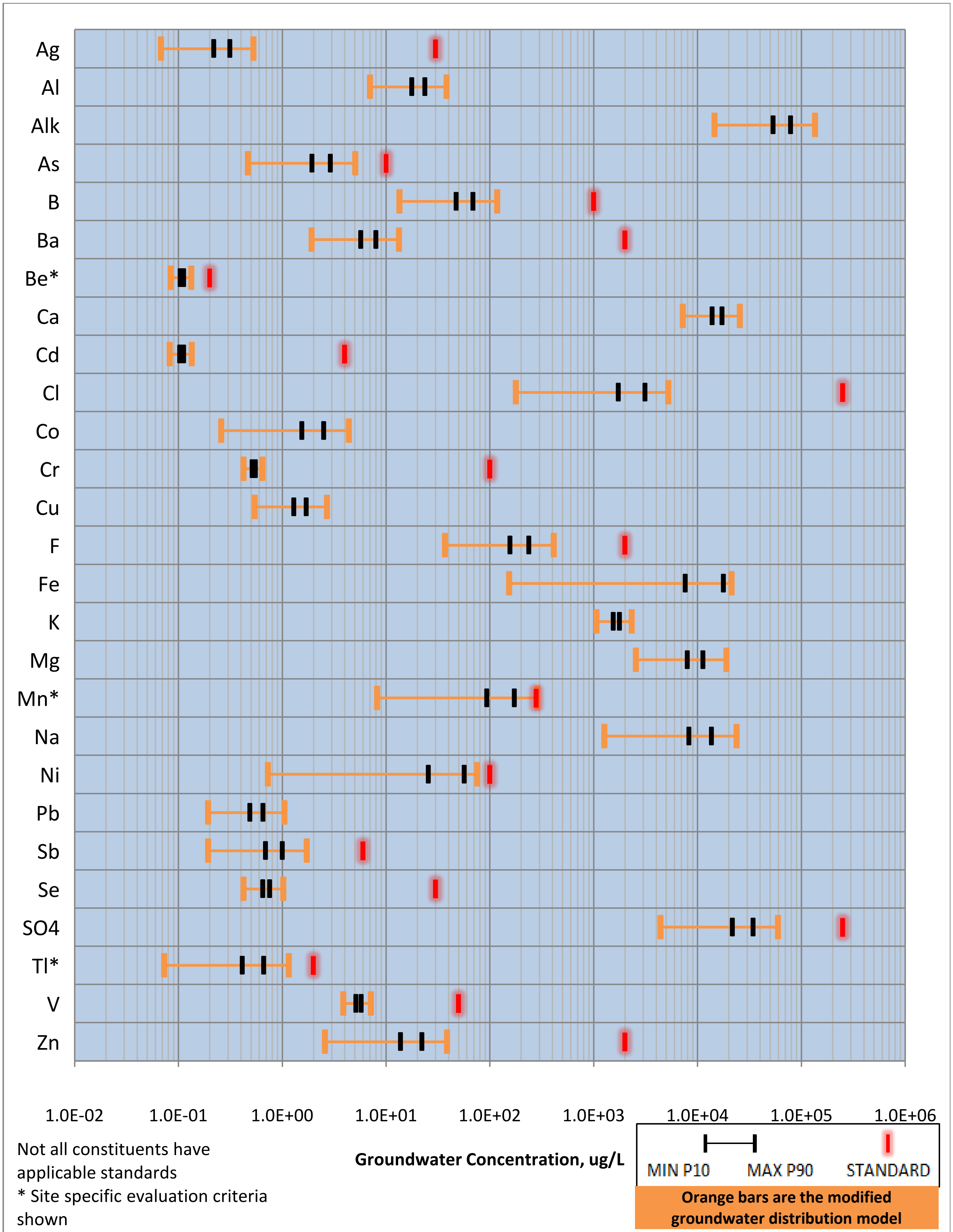

Not all constituents have applicable standards
* Site specific evaluation criteria shown

**Large Figure 51 MODIFIED Groundwater Concentration Ranges in the OSLA (surficial) Flow Path at the Property Boundary**




Not all constituents have applicable standards
* Site specific evaluation criteria shown

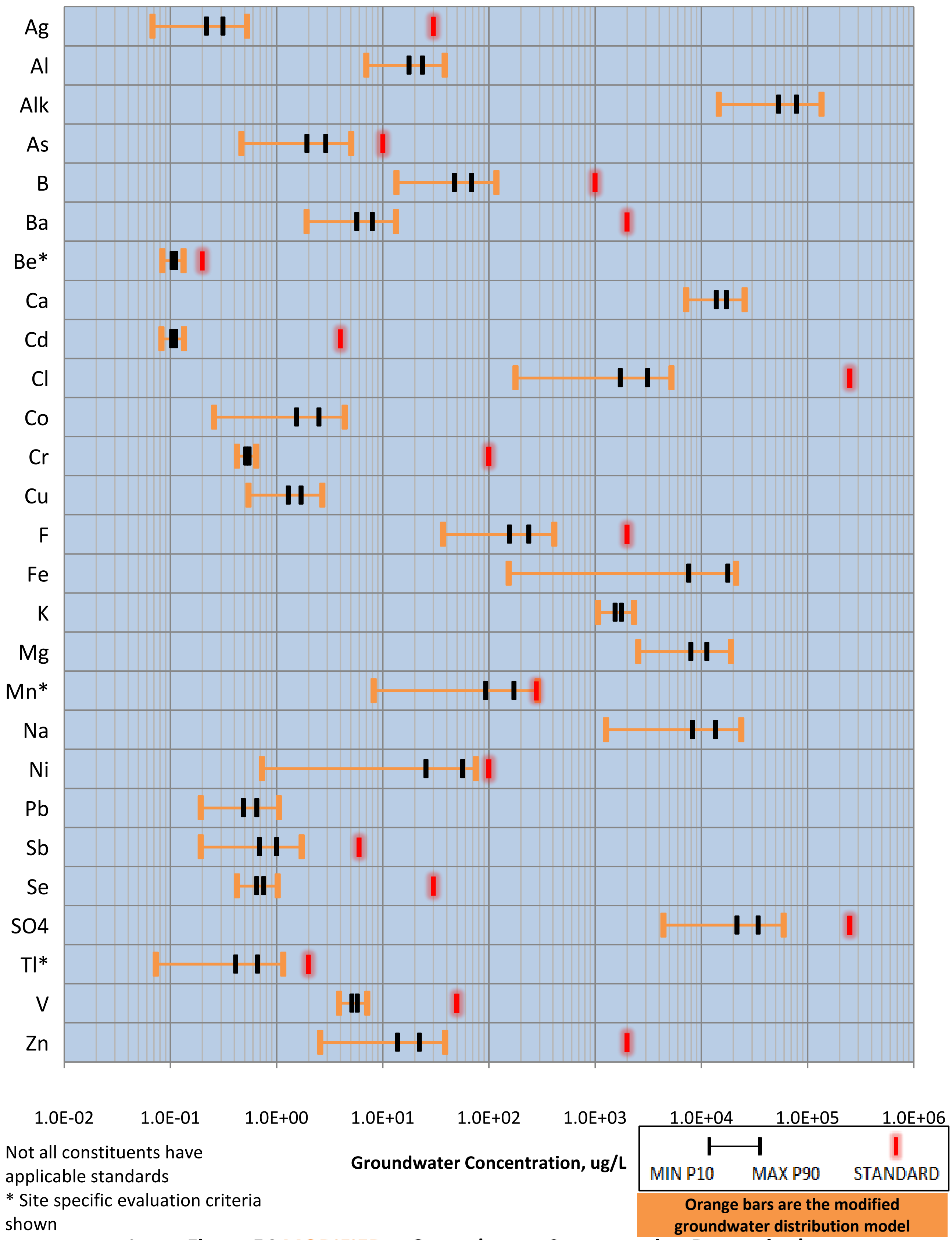
**Large Figure 52 MODIFIED Groundwater Concentration Ranges in the West Pit (surficial) Flow Path at the Property Boundary**




Not all constituents have applicable standards

* Site specific evaluation criteria shown

**Large Figure 53 MODIFIED Groundwater Concentration Ranges in the West Pit (bedrock to SW004) Flow Path at the Property Boundary**

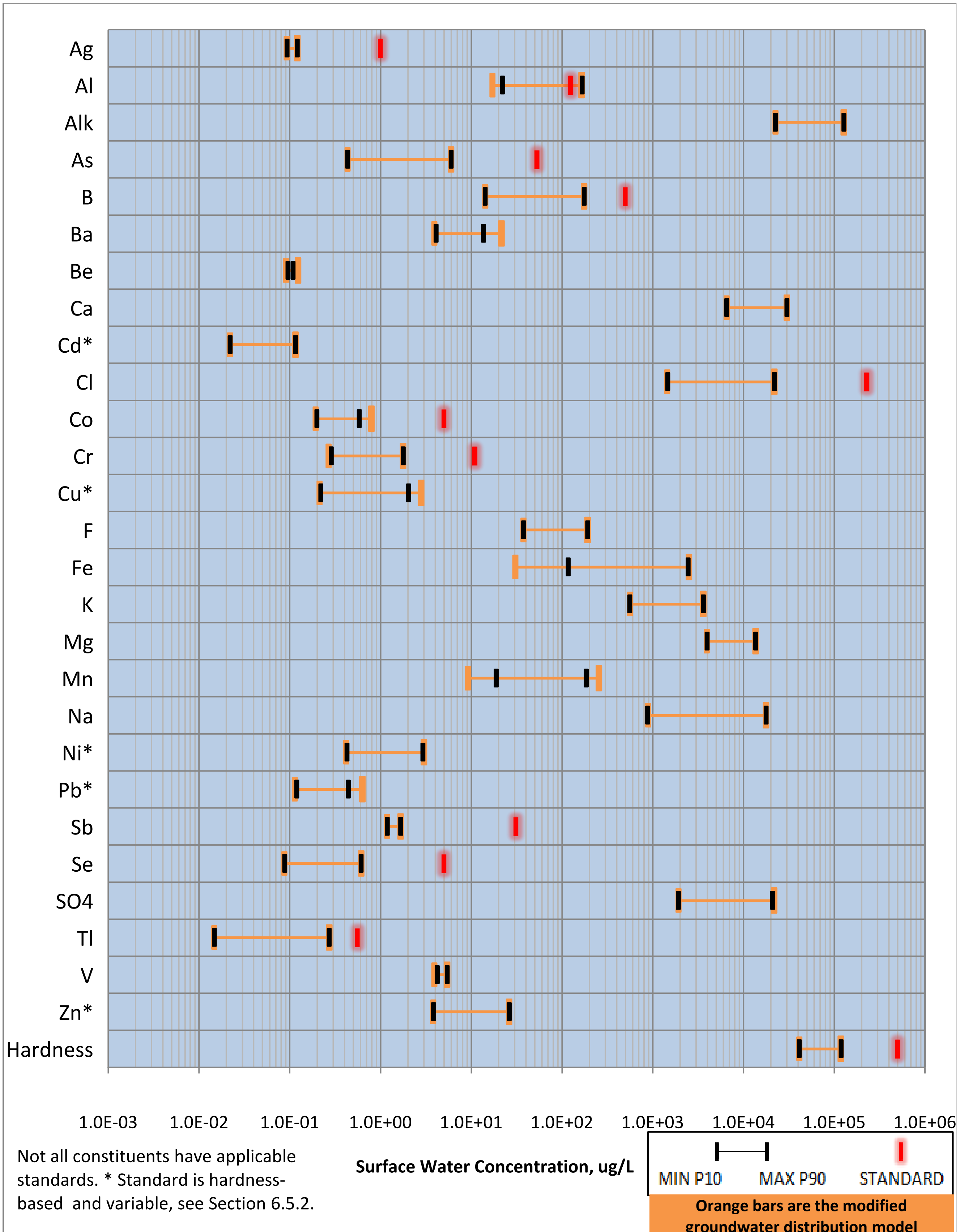



Not all constituents have applicable standards
* Site specific evaluation criteria shown

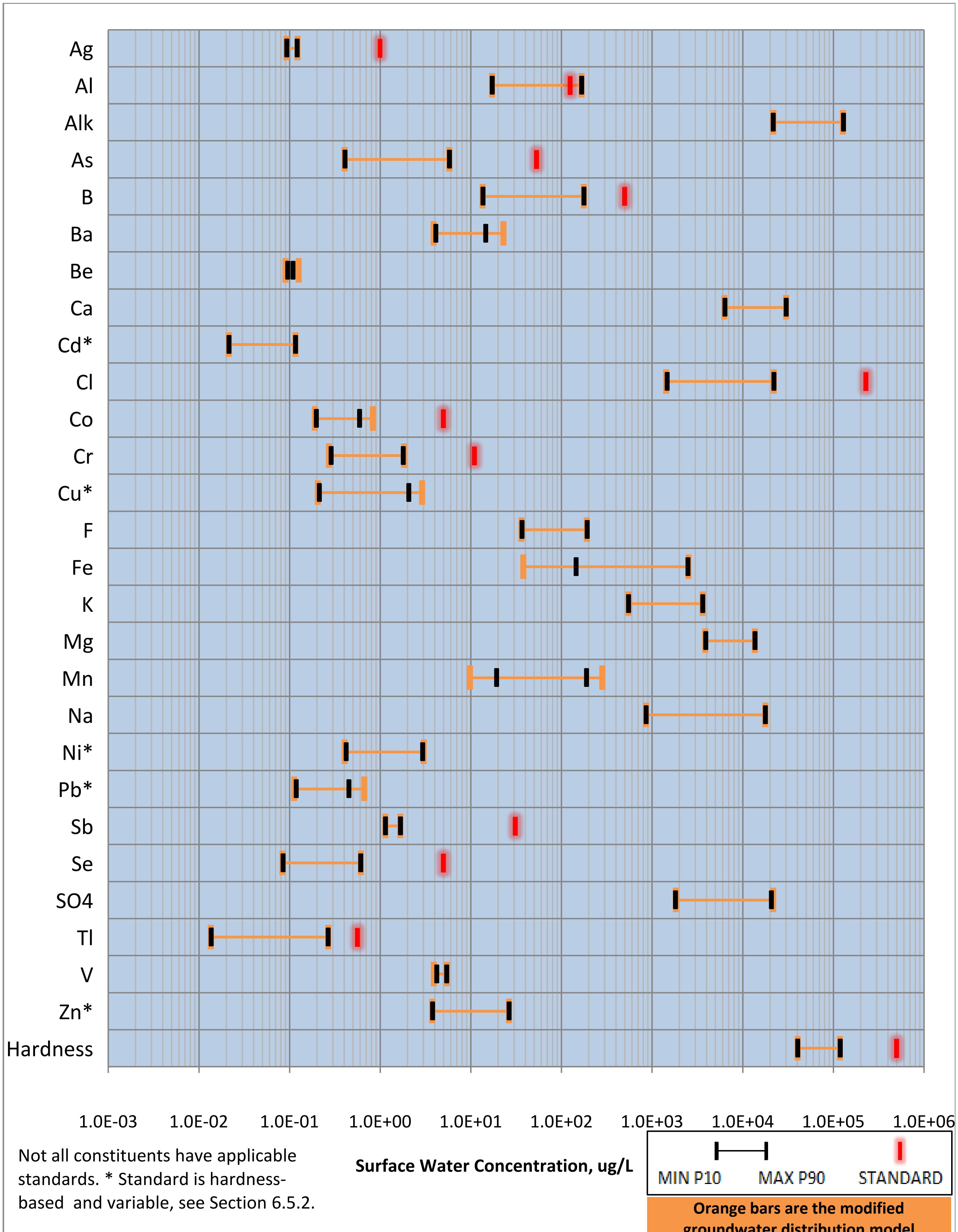
**Large Figure 54 MODIFIED Groundwater Concentration Ranges in the West Pit (bedrock to SW004a) Flow Path at the Property Boundary**

# Appendix E

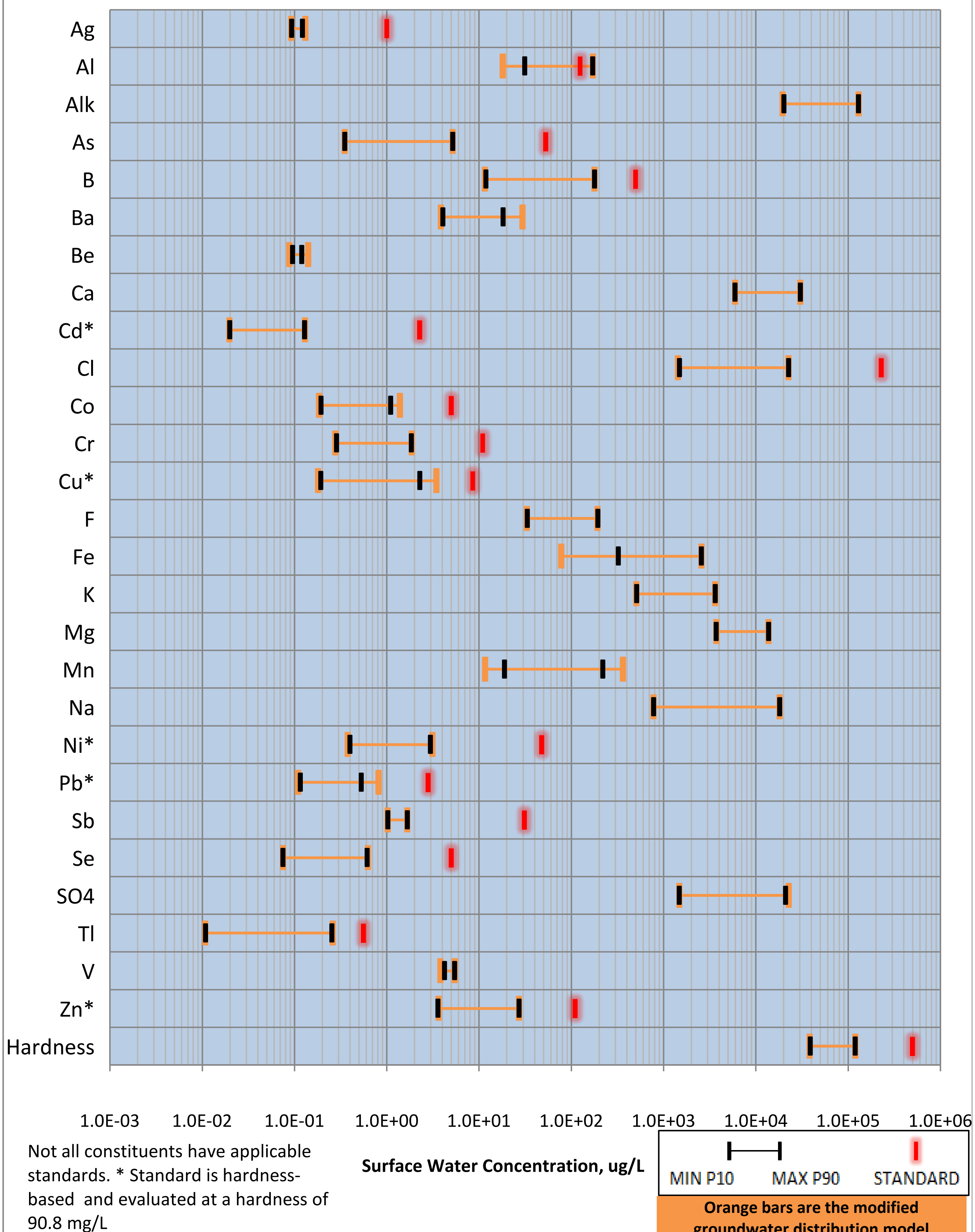
## Surface Water Summary Plots for Mine Site Background Groundwater Quality Analysis




**Large Figure 55 MODIFIED Surface Water Concentration Ranges in the Partridge River at SW002**

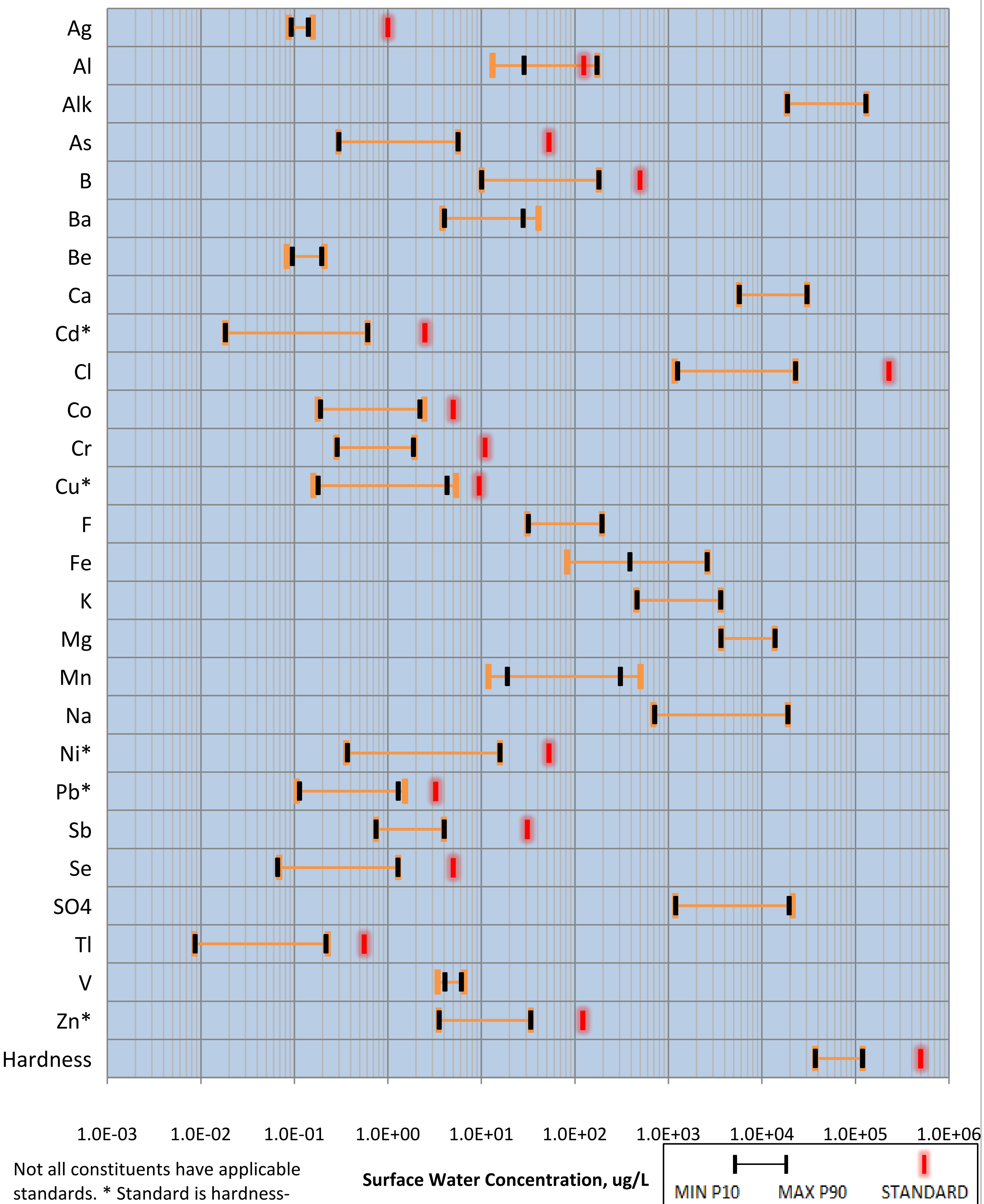



**Large Figure 56 MODIFIED Surface Water Concentration Ranges in the Partridge River at SW003**



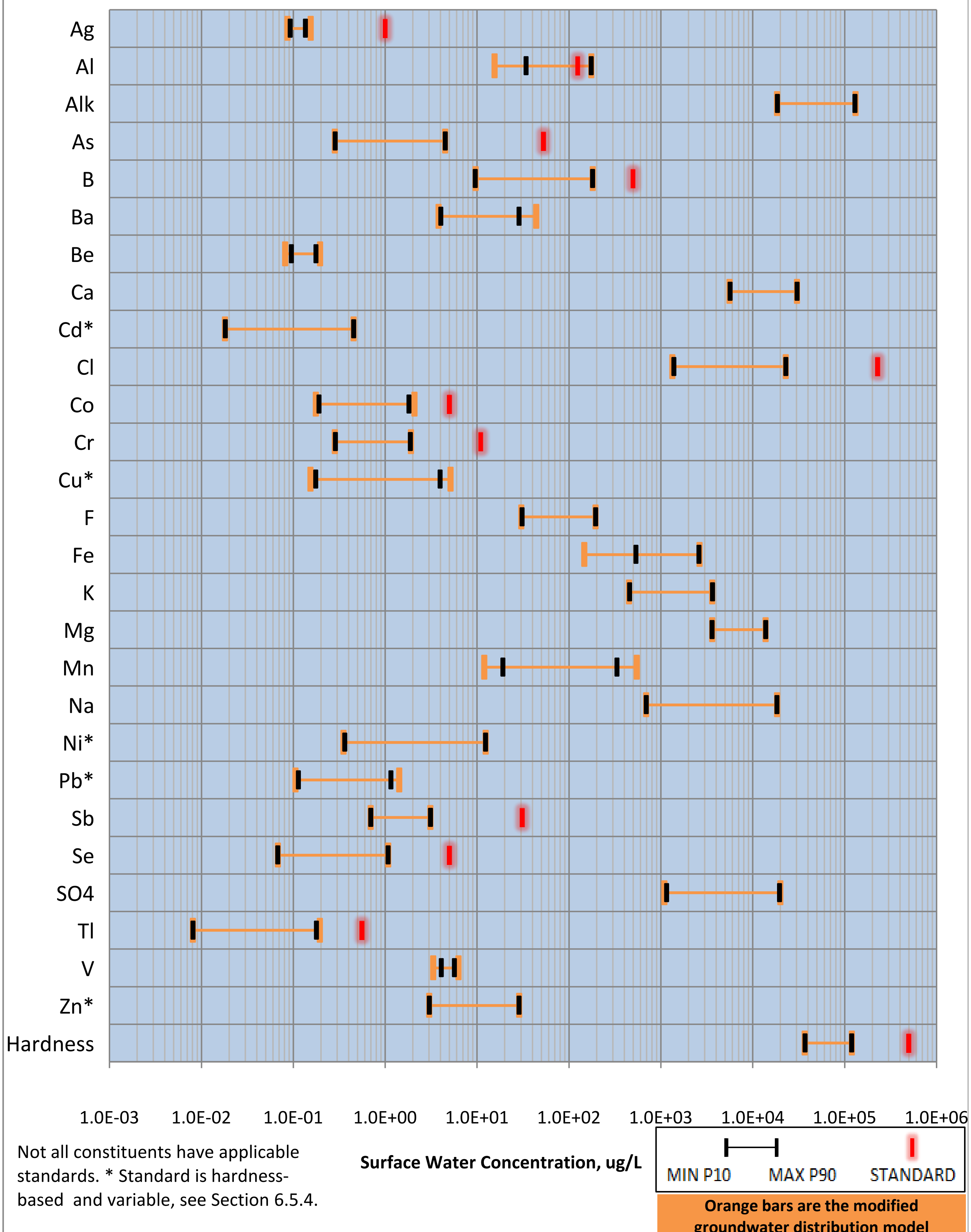

Not all constituents have applicable standards. * Standard is hardness-based and evaluated at a hardness of 90.8 mg/L

**Large Figure 57 MODIFIED Surface Water Concentration Ranges in the Partridge River at SW004**



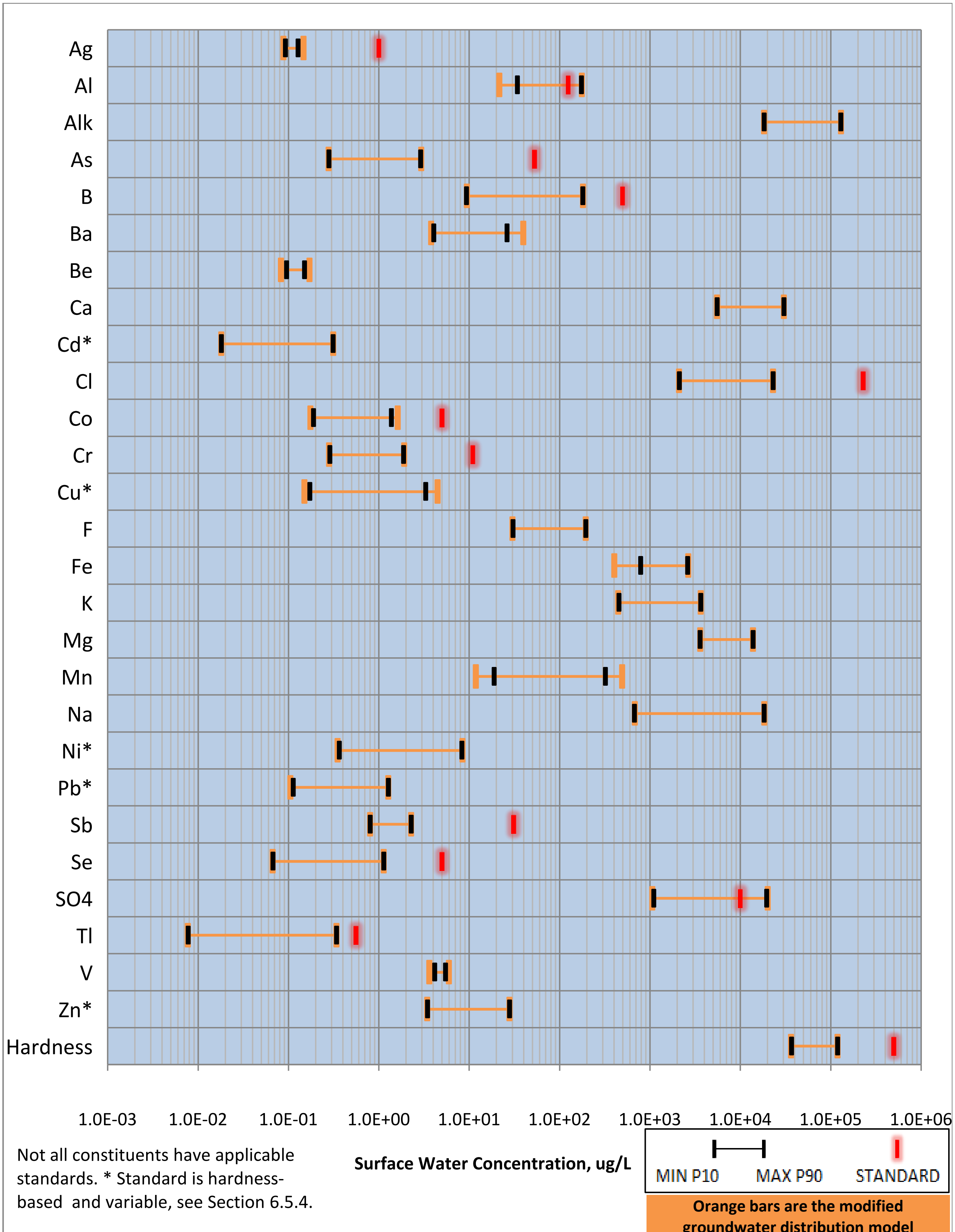

Not all constituents have applicable standards. * Standard is hardness-based and evaluated at a hardness of 102 mg/L

**Large Figure 58 MODIFIED Surface Water Concentration Ranges in the Partridge River at SW004a**



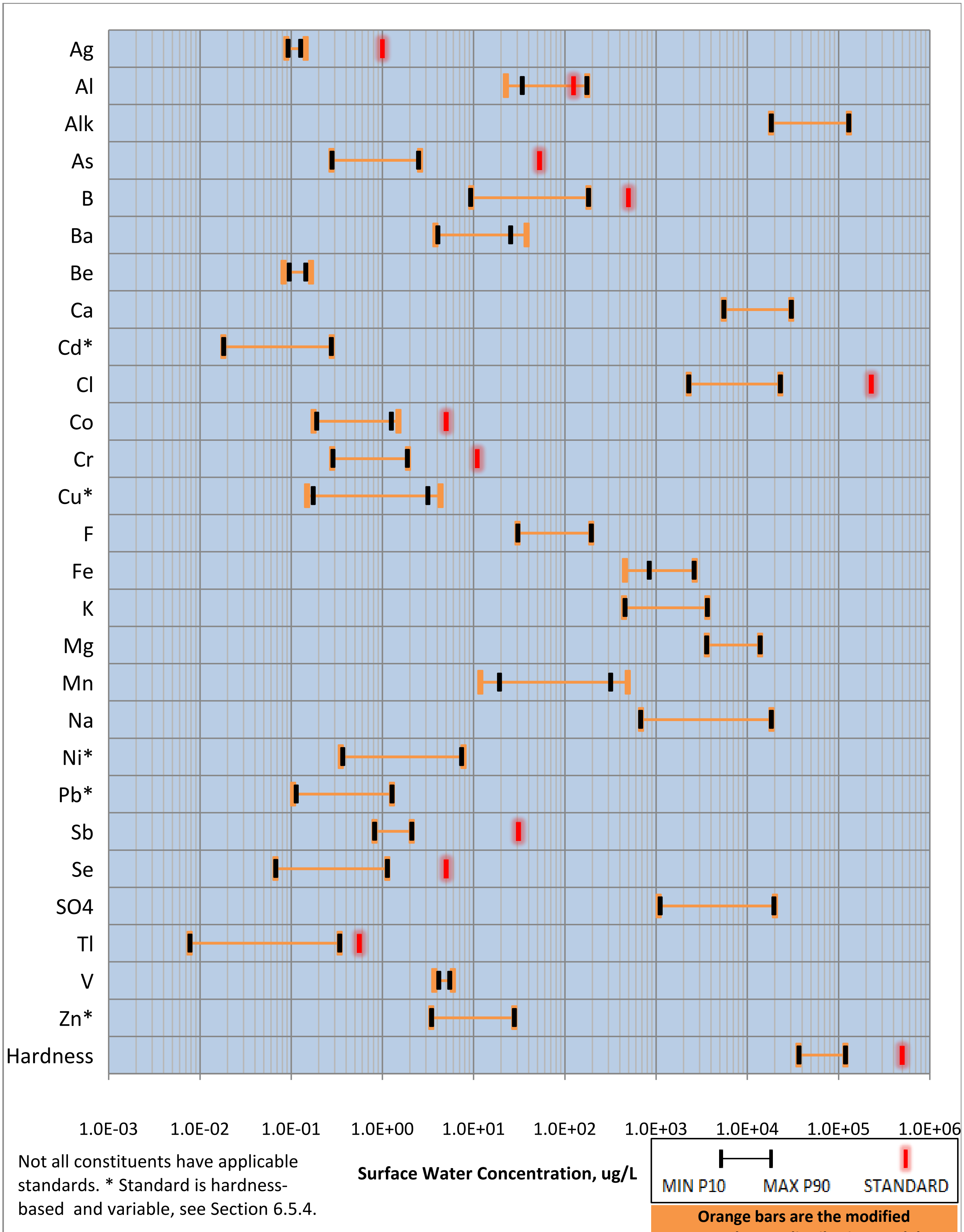

Not all constituents have applicable standards. * Standard is hardness-based and variable, see Section 6.5.4.

**Large Figure 59 MODIFIED Surface Water Concentration Ranges in the Partridge River at SW004b**



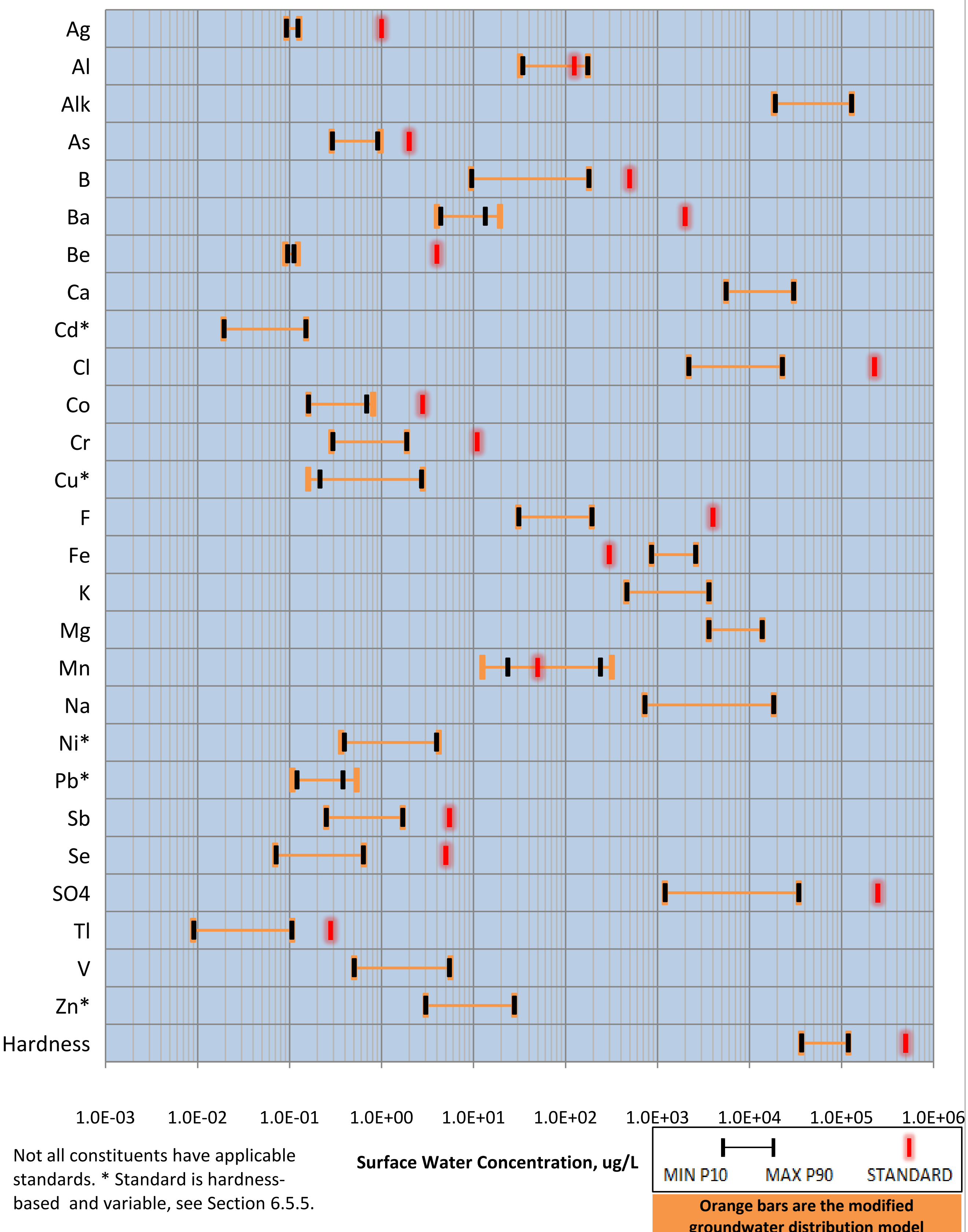

Not all constituents have applicable standards. * Standard is hardness-based and variable, see Section 6.5.4.

**Large Figure 60 MODIFIED Surface Water Concentration Ranges in the Partridge River at SW005**




Not all constituents have applicable standards. * Standard is hardness-based and variable, see Section 6.5.4.

**Large Figure 61 MODIFIED Surface Water Concentration Ranges in the Partridge River at SW006**

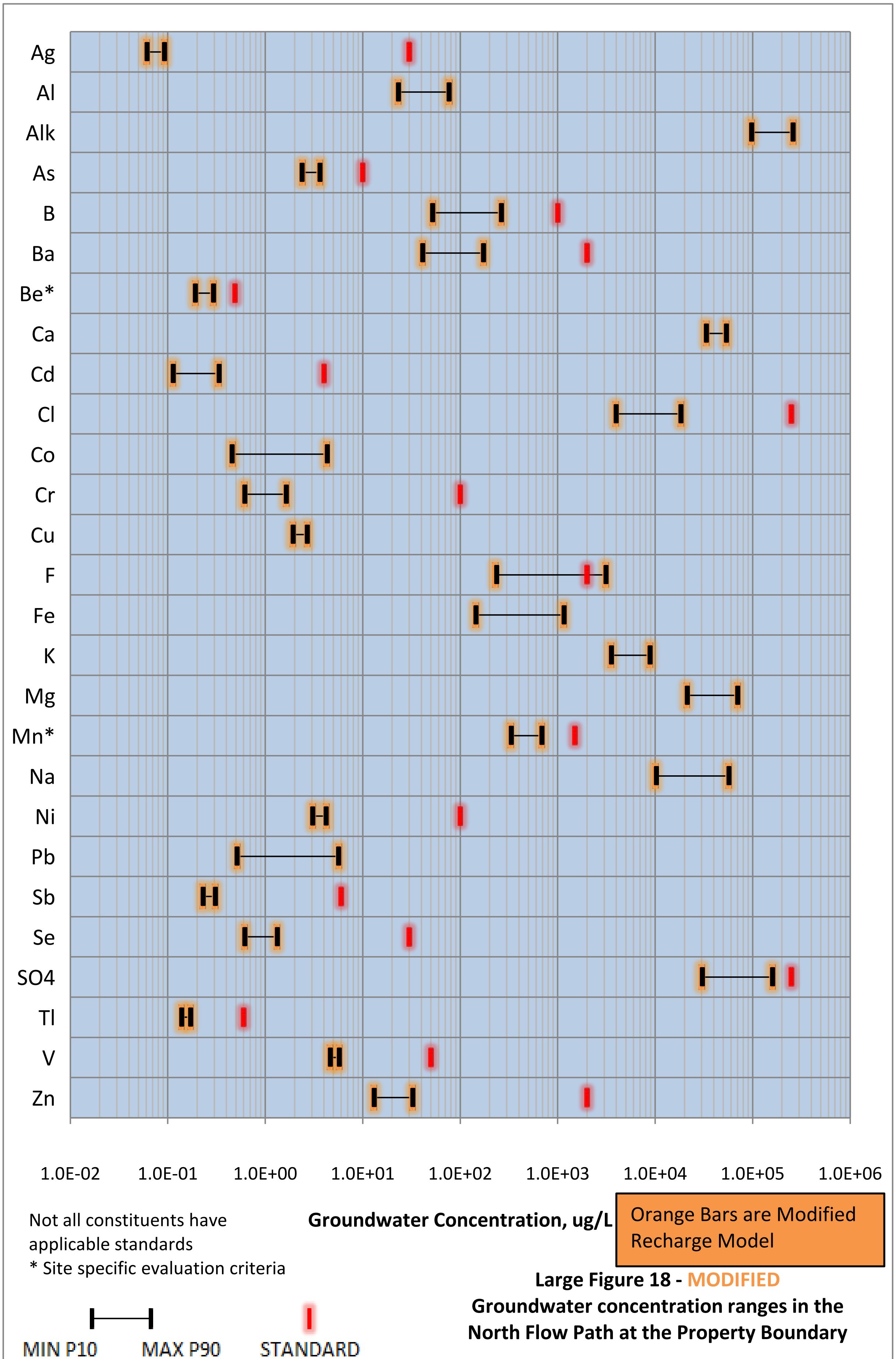



Not all constituents have applicable standards. * Standard is hardness-based and variable, see Section 6.5.5.

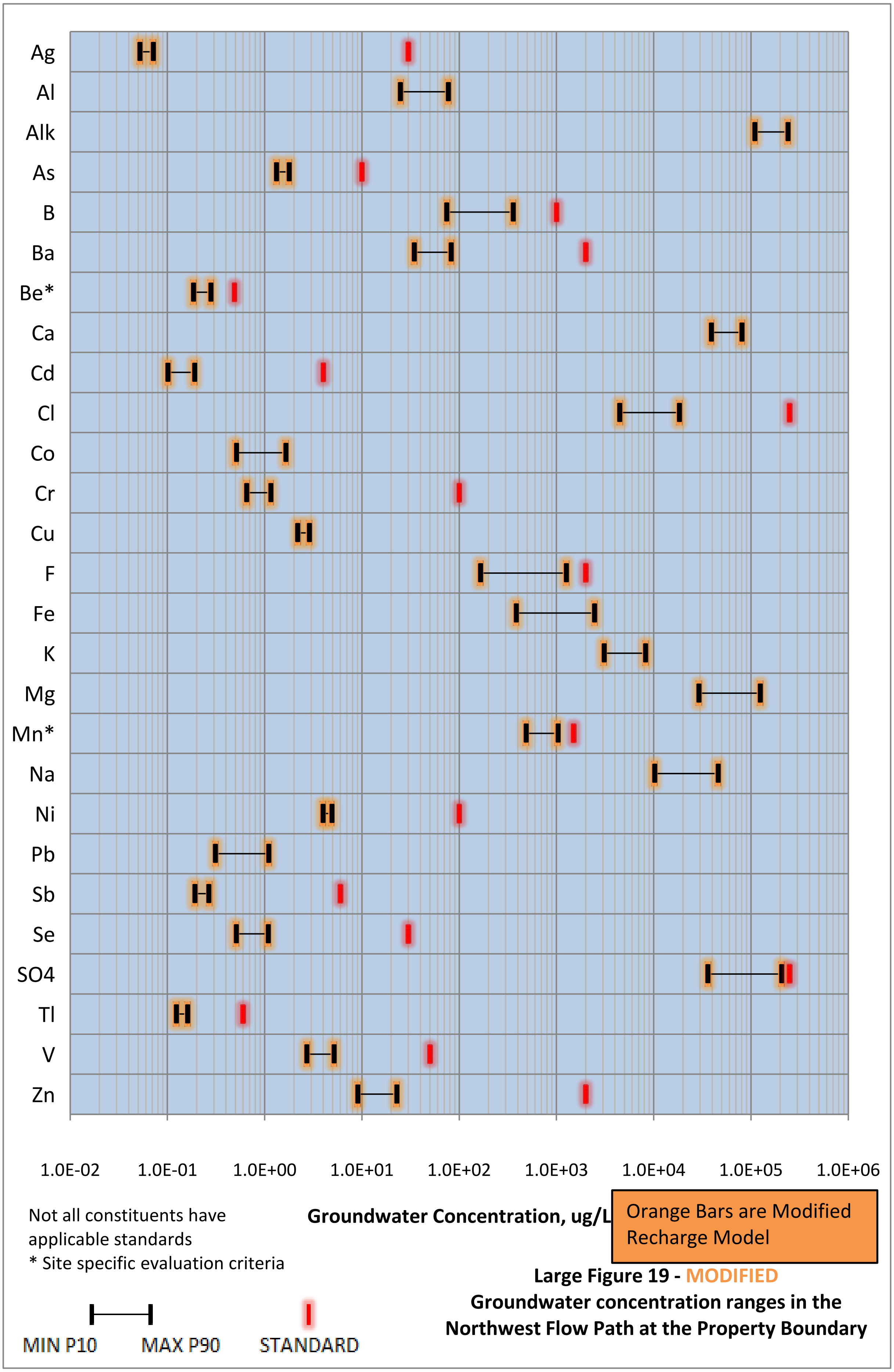
**Large Figure 62 MODIFIED Surface Water Concentration Ranges in Colby Lake**

# Appendix F

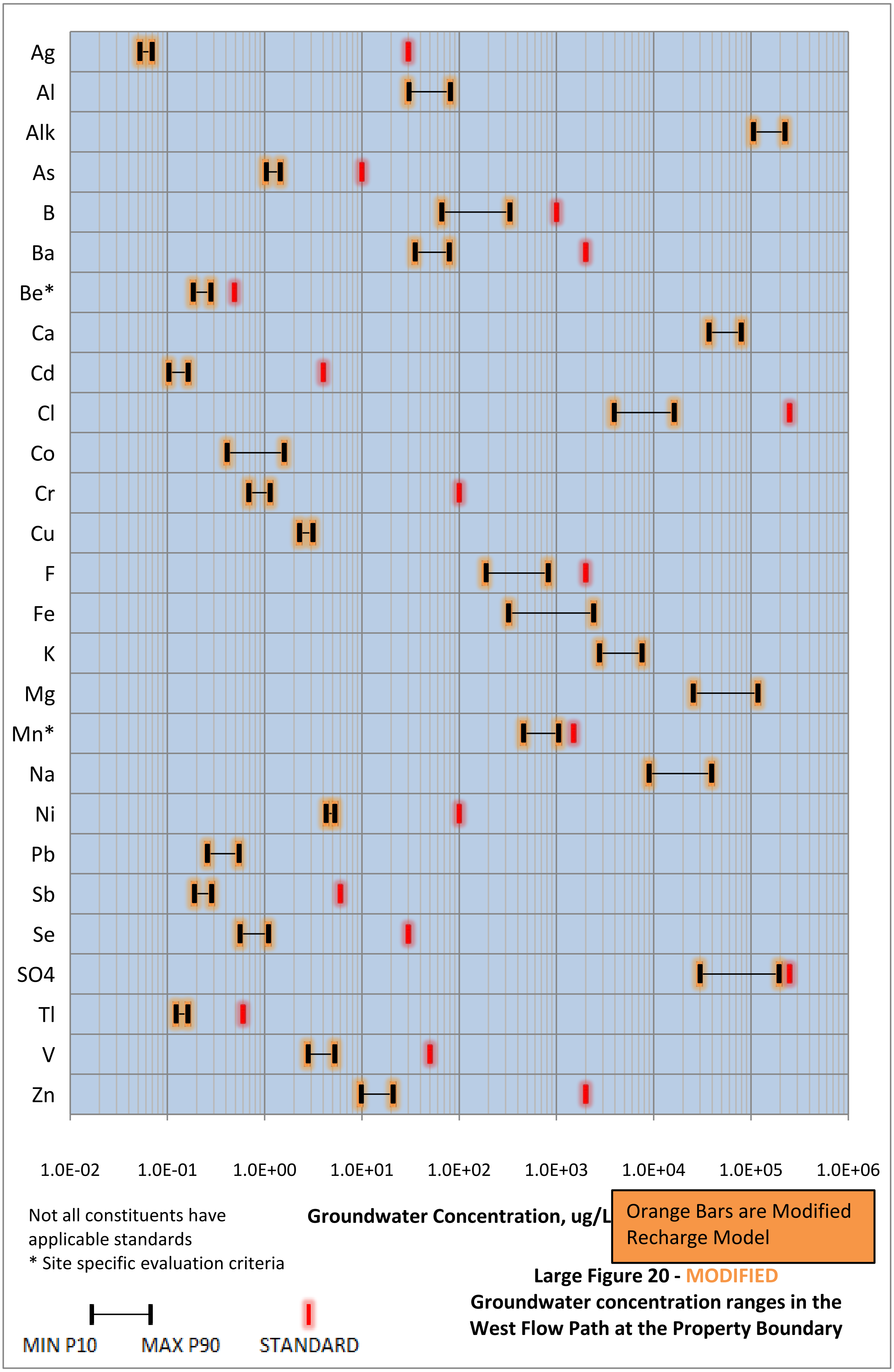
## Groundwater Summary Plots for Plant Site Lognormal Recharge Analysis




**Large Figure 18 - MODIFIED**
**Groundwater concentration ranges in the North Flow Path at the Property Boundary**



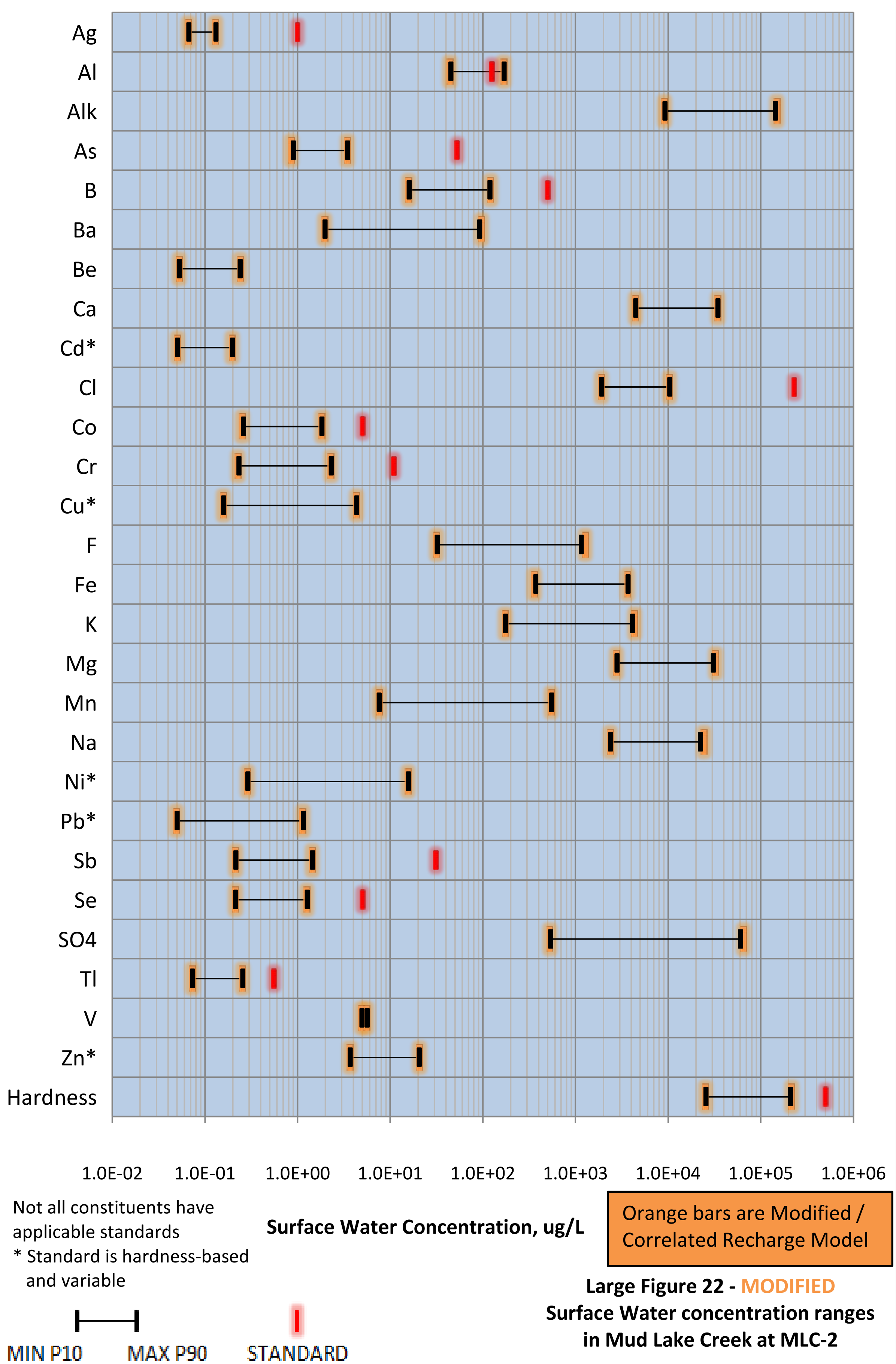

**Large Figure 19 - MODIFIED**
**Groundwater concentration ranges in the Northwest Flow Path at the Property Boundary**



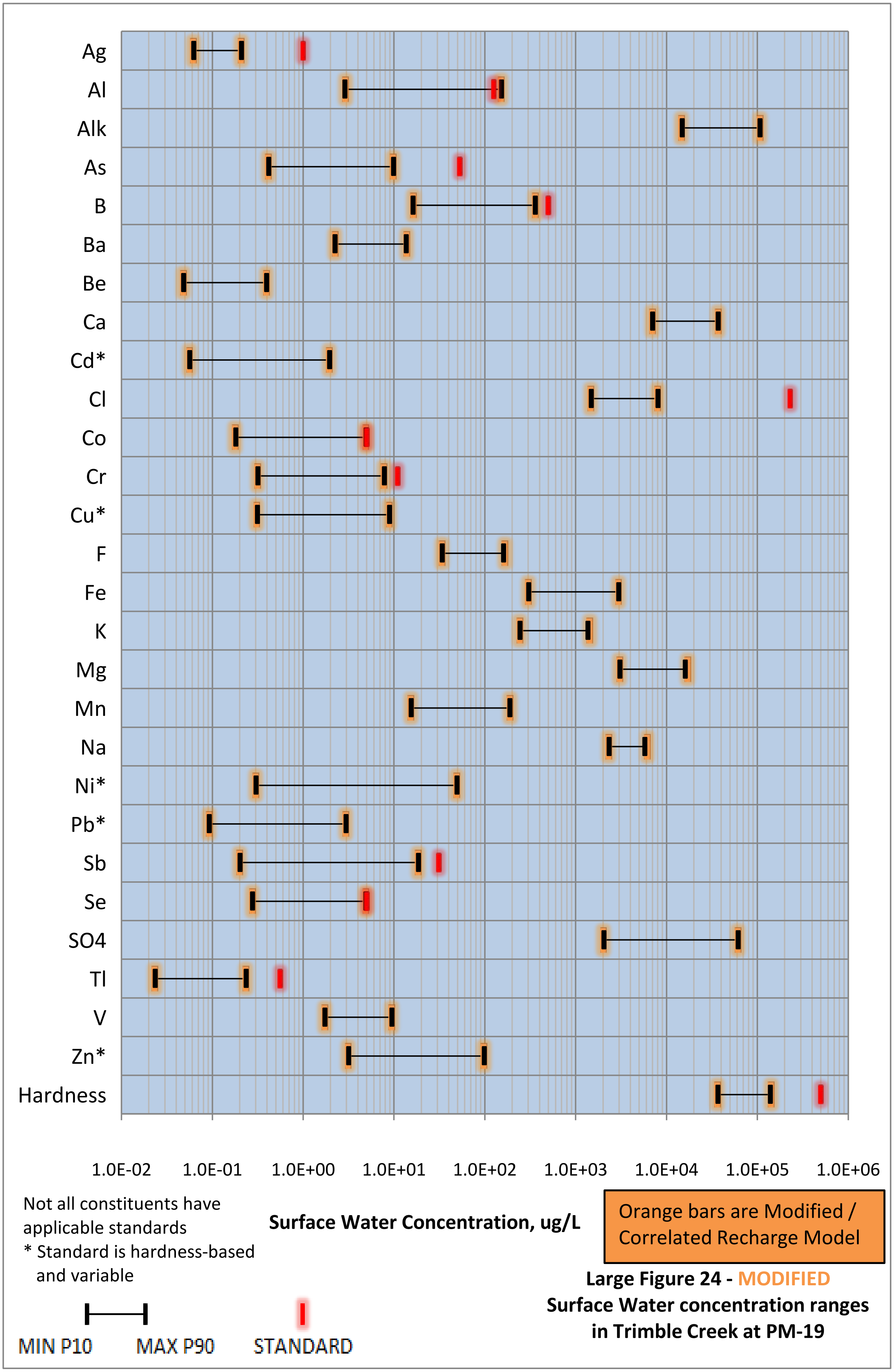

**Large Figure 20 - MODIFIED**
**Groundwater concentration ranges in the West Flow Path at the Property Boundary**

# Appendix G

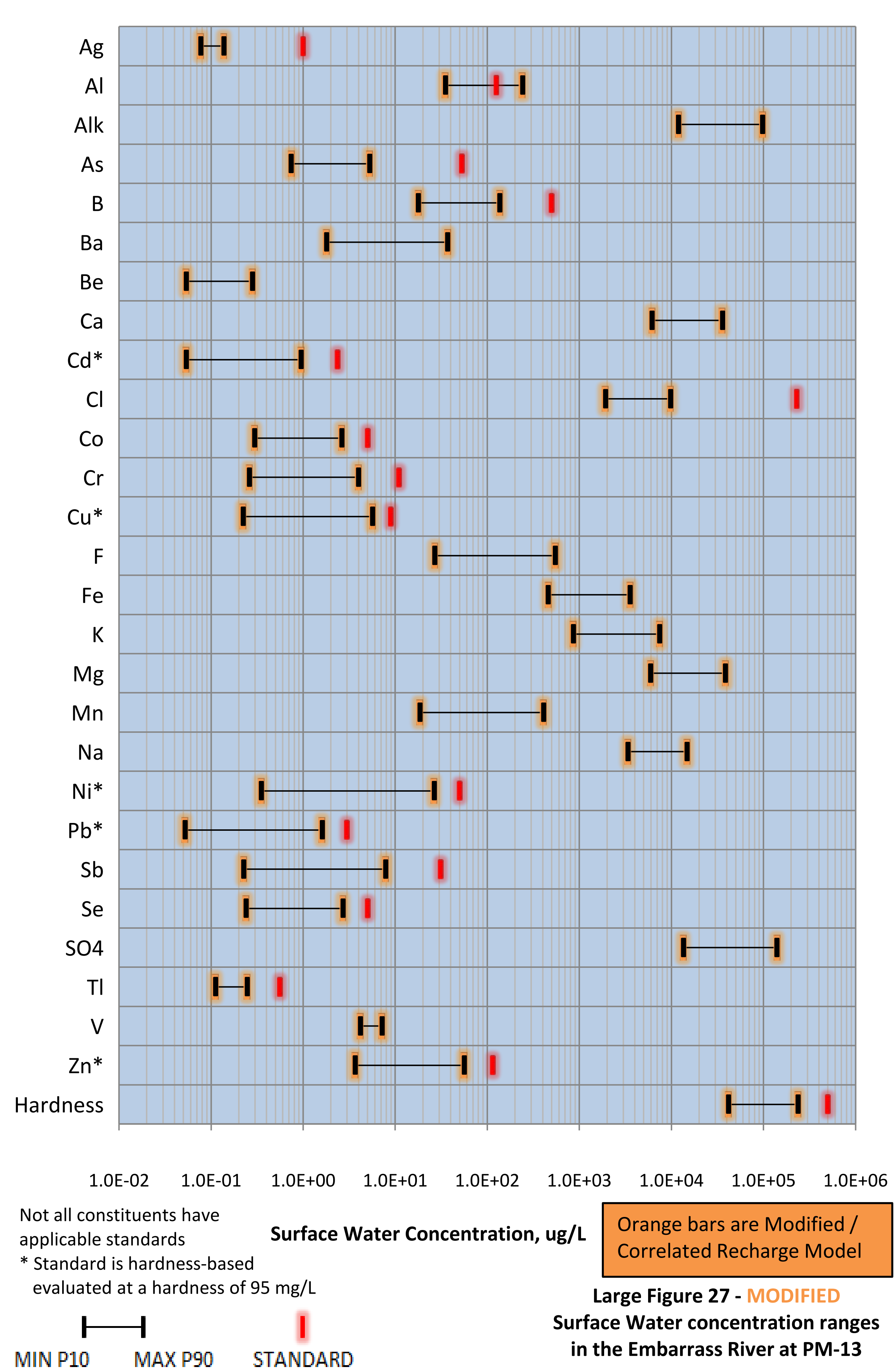
## Surface Water Summary Plots for Plant Site Lognormal Recharge Analysis




**Large Figure 22 - MODIFIED**
**Surface Water concentration ranges in Mud Lake Creek at MLC-2**



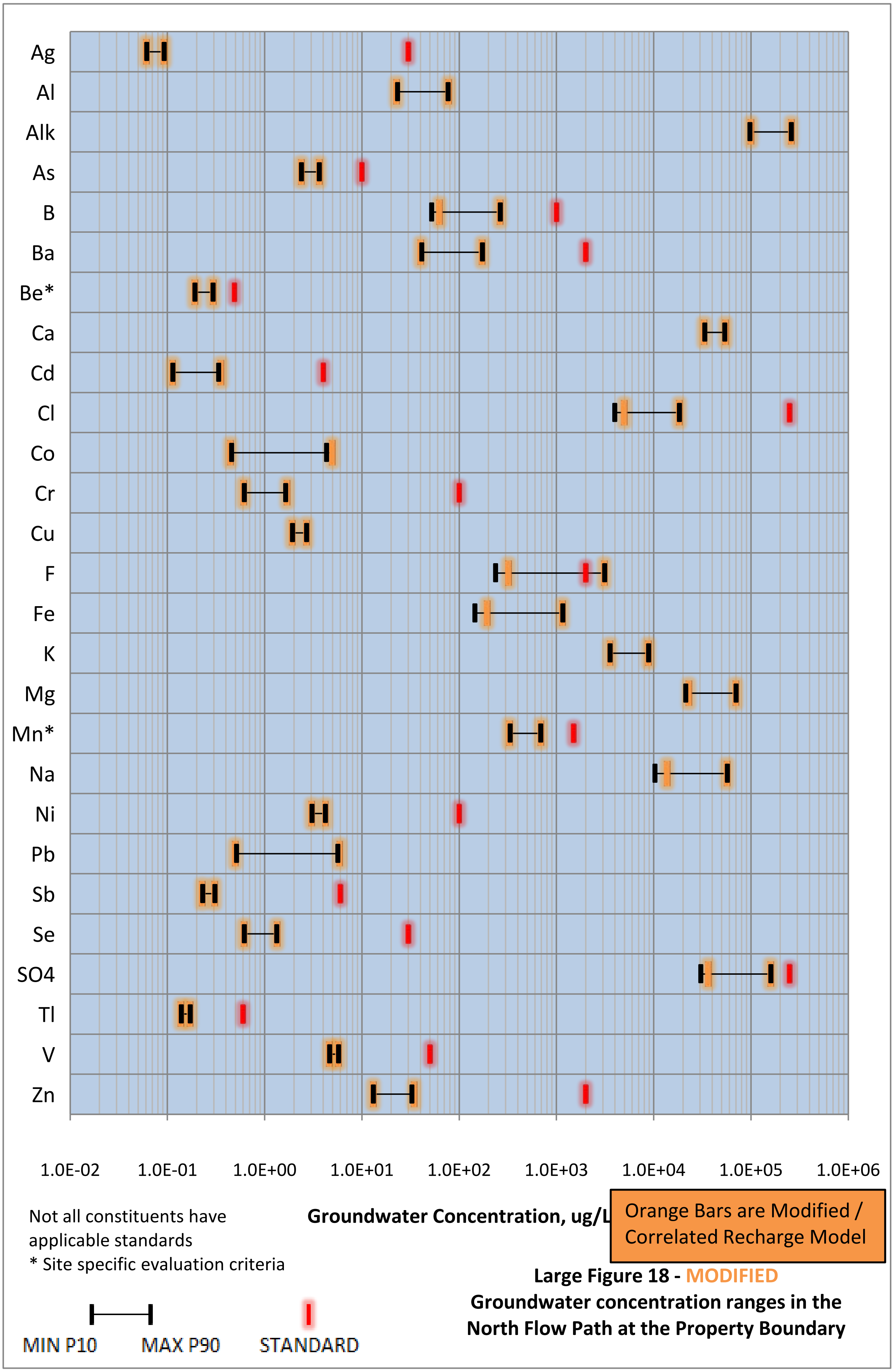

**Large Figure 24 - MODIFIED**
**Surface Water concentration ranges in Trimble Creek at PM-19**



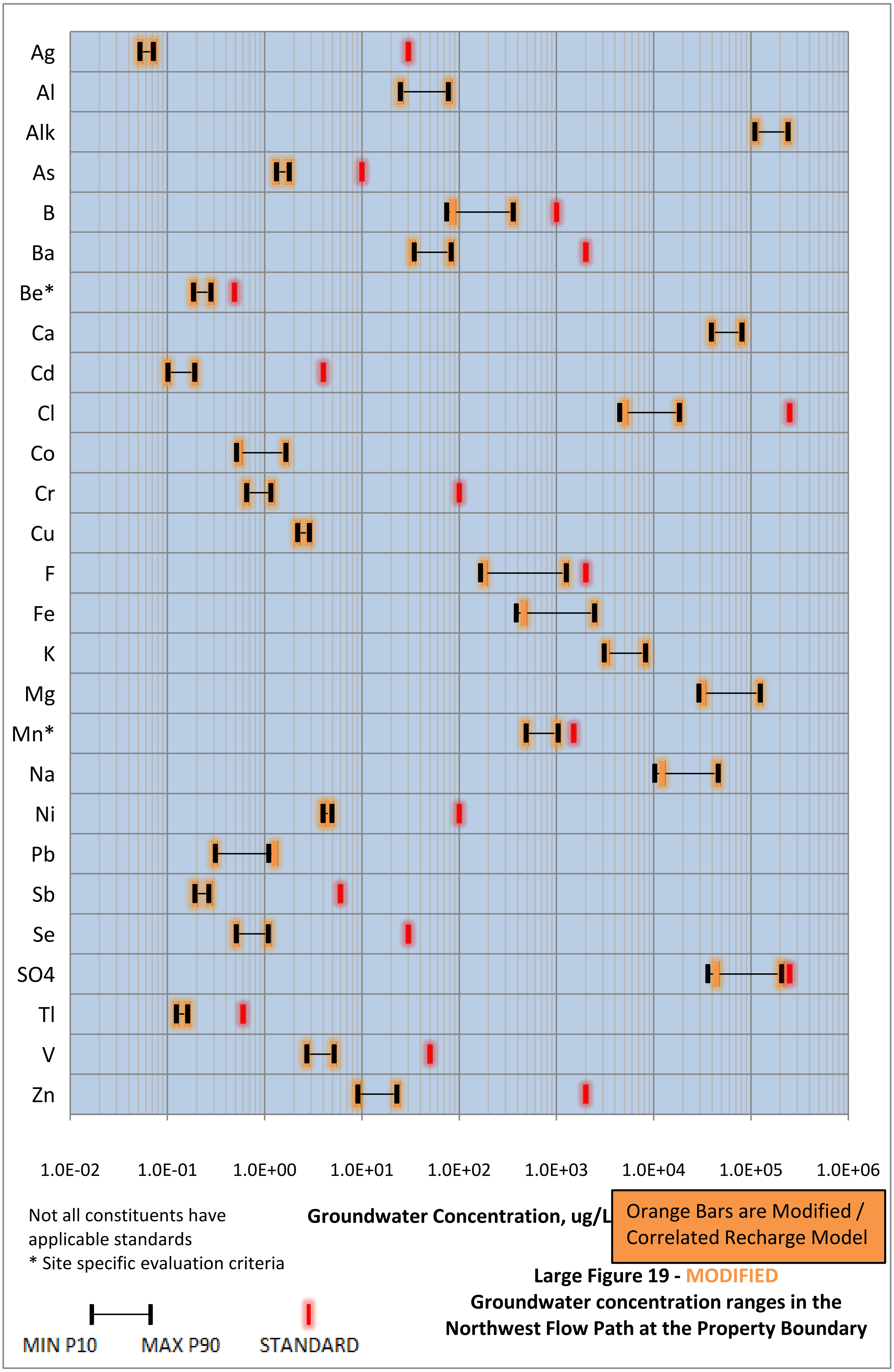

**Large Figure 27 - MODIFIED**
**Surface Water concentration ranges in the Embarrass River at PM-13**

# Appendix H

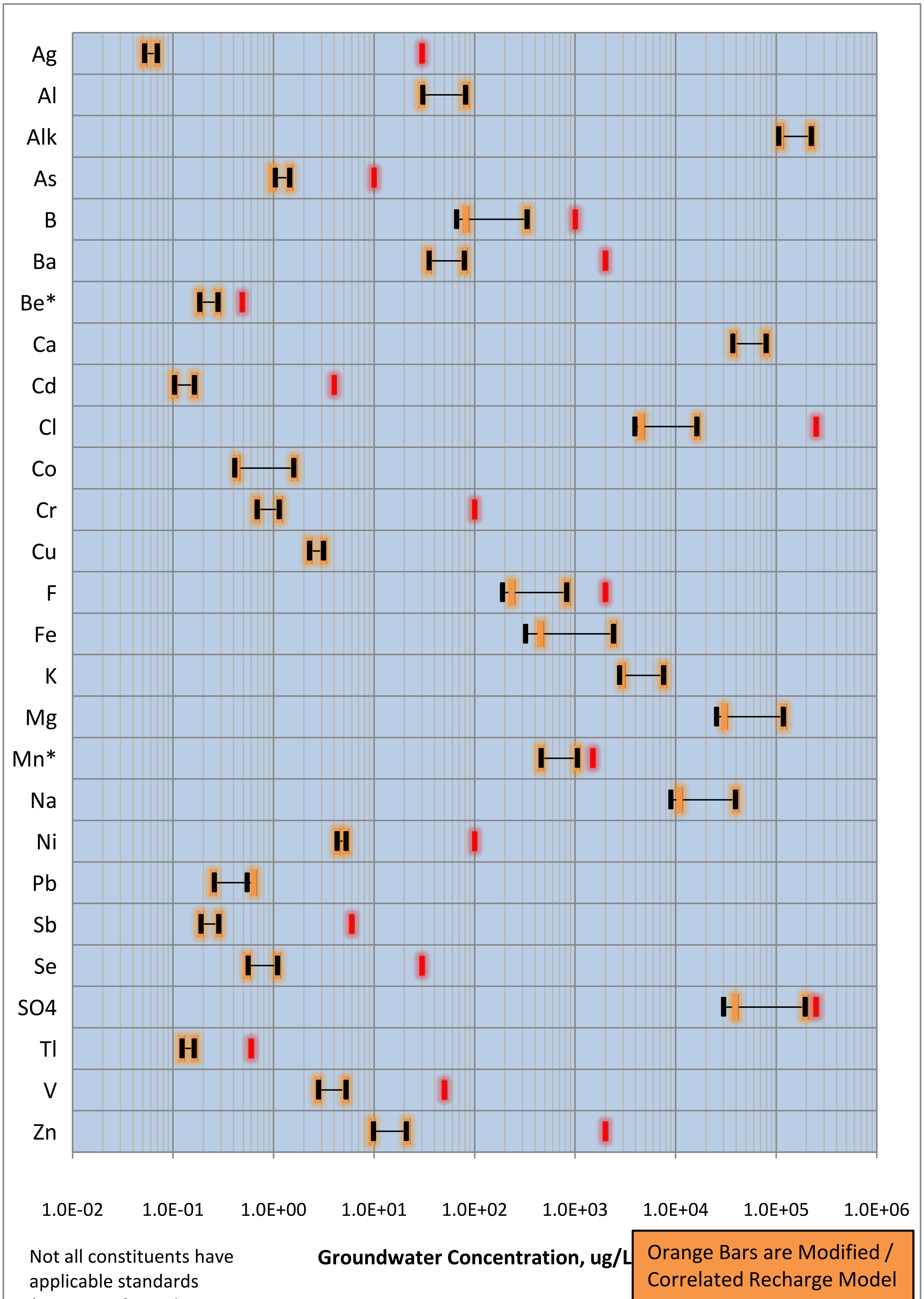
## Groundwater Summary Plots for Plant Site Correlated Recharge Analysis




**Large Figure 18 - MODIFIED**
**Groundwater concentration ranges in the North Flow Path at the Property Boundary**



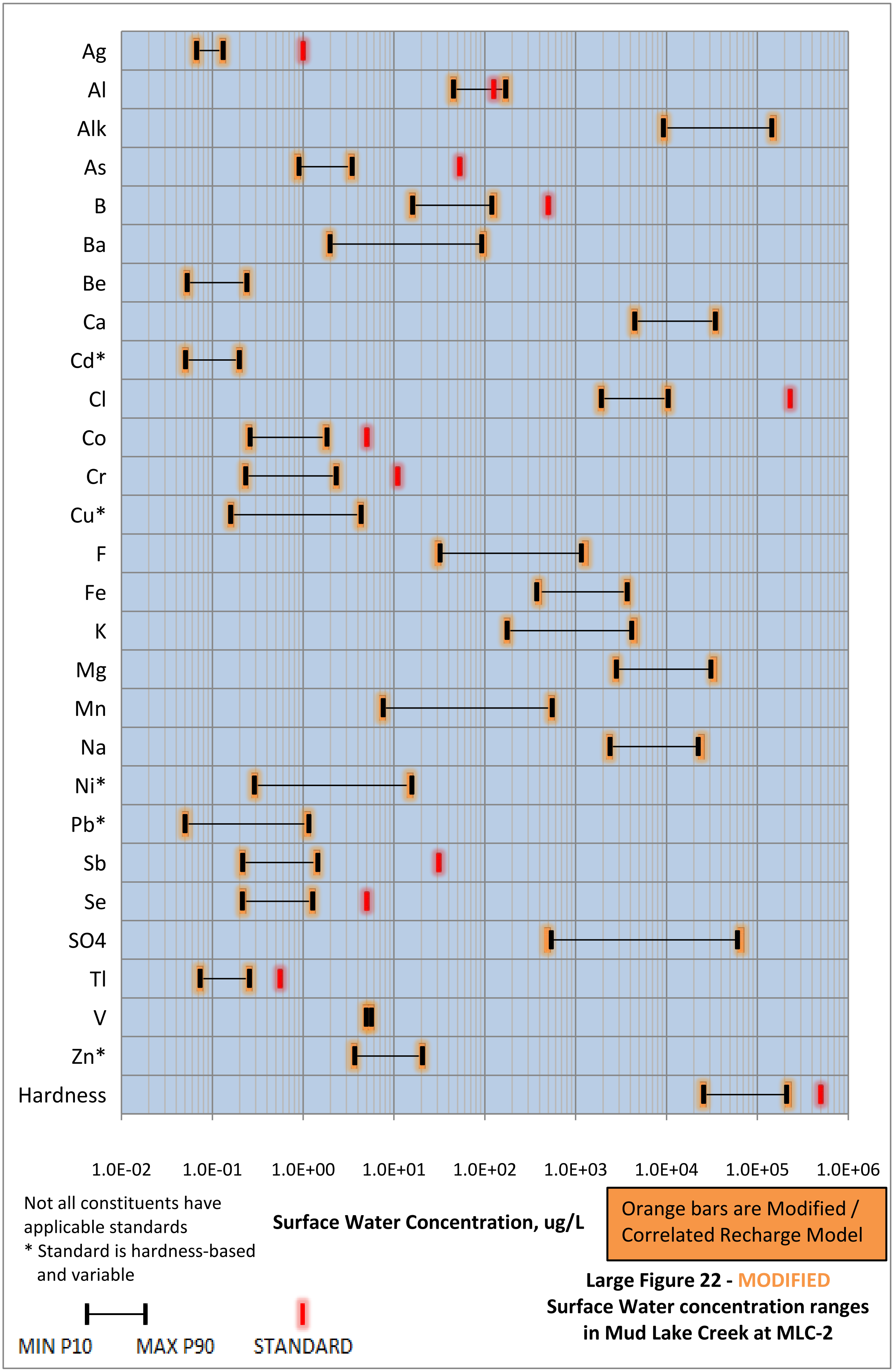

**Large Figure 19 - MODIFIED**
**Groundwater concentration ranges in the Northwest Flow Path at the Property Boundary**



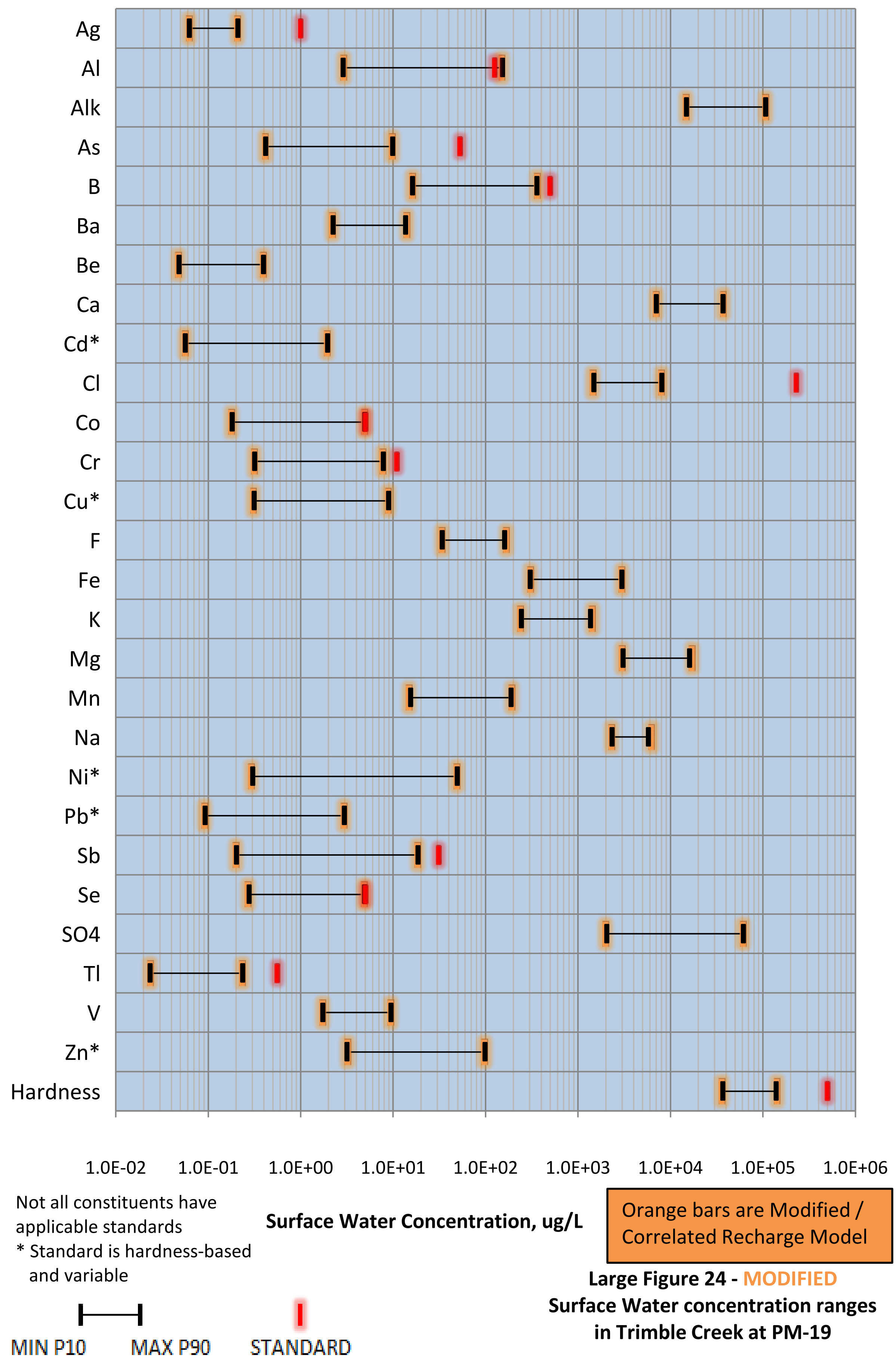

**Large Figure 20 - MODIFIED**
**Groundwater concentration ranges in the West Flow Path at the Property Boundary**

# Appendix I

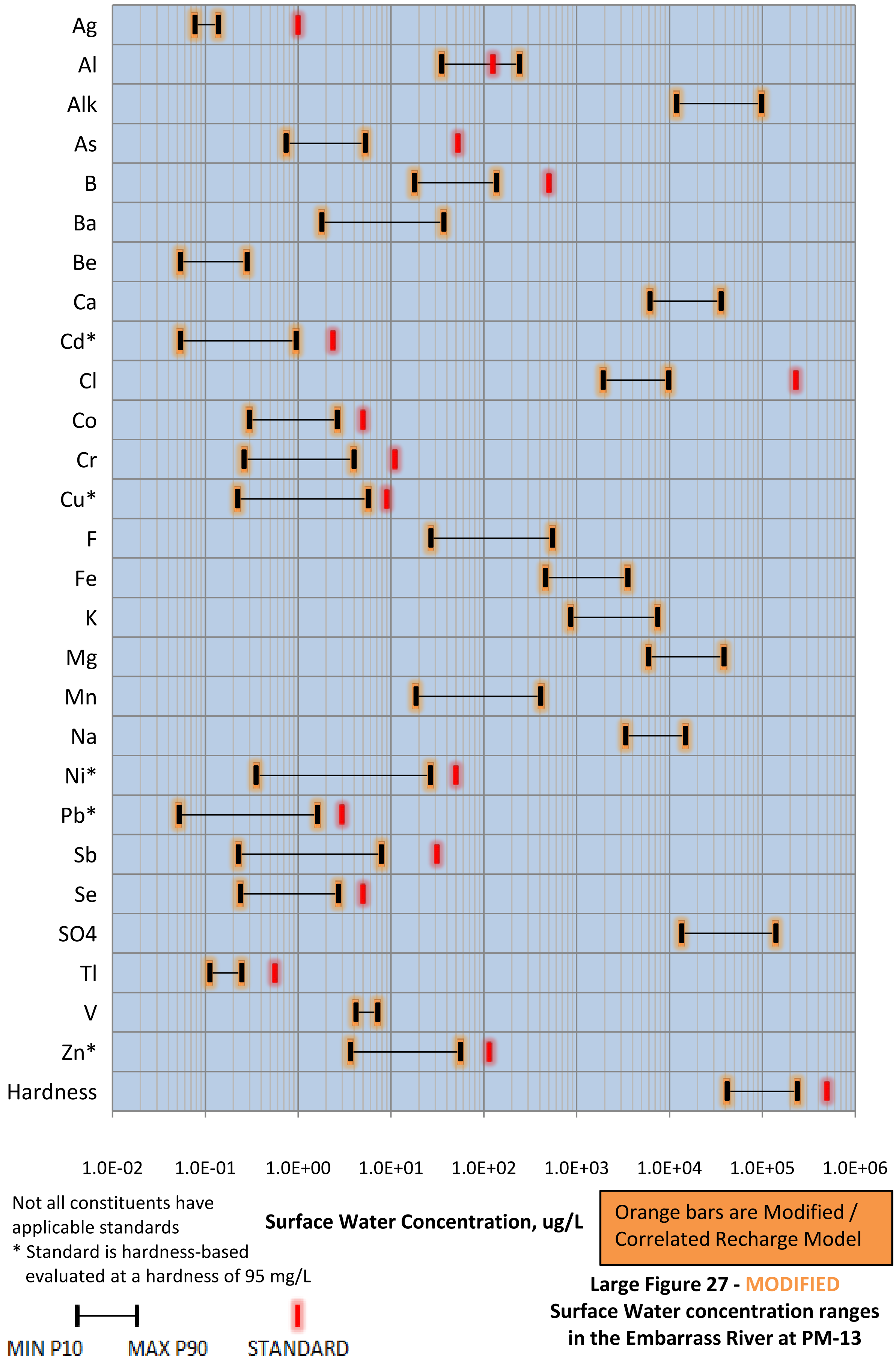
## Surface Water Summary Plots for Plant Site Correlated Recharge Analysis




**Large Figure 22 - MODIFIED**
**Surface Water concentration ranges in Mud Lake Creek at MLC-2**




**Large Figure 24 - MODIFIED**
**Surface Water concentration ranges in Trimble Creek at PM-19**




Not all constituents have applicable standards
* Standard is hardness-based evaluated at a hardness of 95 mg/L

**Large Figure 27 - MODIFIED**
**Surface Water concentration ranges in the Embarrass River at PM-13**

# Appendix J

## Adjusted Input Tables for High Baseflow Sensitivity Analysis

**Table 1-1** Input Variables for the Mine Site Model (High Baseflow Sensitivity Analysis)

| *Variable Name* | *Units* | *Deterministic/ Uncertain* | *Sampling/ Calculation Frequency* | *Distribution* | *Mean or Mode* | *Standard Deviation* | *Minimum* | *Maximum* | *Description* | *Source of Input Data* | *Modeling Package Section* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Grey cells indicate changes from the previously published version FOR THE HIGH BASEFLOW SENSITIVITY ANALYSIS | | | | | | | | | | | |
| ***Background Chemistry*** | | | | | | | | | | | |
| GW_Conc_Surf | [mg/L] | Uncertain | Realization | Transformed Normal | Vector by Constituent. Reference Table 1-12 | | | | Surficial groundwater concentrations in the Partridge River watershed | Analysis of PolyMet background water quality data | Water Section 5.3.1 *Background Groundwater* |
| GW_Conc_Bed | [mg/L] | Uncertain | Realization | Transformed Normal | Vector by Constituent. Reference Table 1-12 | | | | Bedrock groundwater concentrations in the Partridge River watershed | Analysis of PolyMet background water quality data | Water Section 5.3.1 *Background Groundwater* |
| SW_Conc_RO | [mg/L] | Uncertain | Month | Lognormal | Vector by Constituent. Reference Table 1-13 | | | | Calibrated surface runoff concentrations in the Partridge River watershed | Calibration of model to baseline conditions | Water Section 5.3.1 *Background Surface Runoff* |
| SW_Conc_PMP | [mg/L] | Deterministic | N/A | Constant | Vector by Constituent. Reference Table 1-13 | | | | Concentration leaving the Peter Mitchell Pits | 2004-2007 WQ modeling at SW-001 | Water Section 5.5.3.1 *Other (Non-Project) Loads* |
| Flow_PMP | [cfs] | Deterministic | N/A | Constant | 2.6 | N/A | N/A | N/A | Flow from Peter Mitchell Pit dewatering to SW-001 | Calibration of model to baseline conditions | Water Section 5.5.3.1 *Other (Non-Project) Loads* |
| Flow_PMP_end | [yr] | Deterministic | N/A | Constant | 55 | N/A | N/A | N/A | Mine Year when flow from Peter Mitchell Pit ends, equivalent to year 2070 | Northshore Mine Plan | Water Section 5.5.3.1 *Other (Non-Project) Loads* |
| SW_Conc_Partridge | [mg/L] | Deterministic | N/A | Constant | Matrix by Constituent and location. Reference Table 1-14 | | | | Baseline existing chemistry in Partridge River used to evaluate model | 2004-2010 Monitoring Data of Partridge River | Water Section 4.4.4.1 *Water Quality ,Partridge River* |
| Load_Colby | [kg/yr] | Deterministic | N/A | Constant | Vector by Constituent. Reference Table 1-13 | | | | Calibrated additional loading to Colby Lake | Calibration of model to baseline conditions | Water Section 5.5.3.1 *Other (Non-Project) Loads* |

***Groundwater Flowpath Characteristics***

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I_ops | [--] | Uncertain | Realization | Uniform | Vector by flowpath. Reference Table 1-15 | | | | Average hydraulic gradient along aquifer | Mine Site MODFLOW model | Water Section 5.4.1 *Groundwater Flowpath Modeling* |
| I_close | [--] | Uncertain | Realization | Uniform | Vector by flowpath. Reference Table 1-15 | | | | Average hydraulic gradient along aquifer in closure | Mine Site MODFLOW model | Water Section 5.4.1 *Groundwater Flowpath Modeling* |
| Thick | [m] | Deterministic | N/A | Constant | Vector by flowpath. Reference Table 1-15 | | | | Aquifer thickness | Assumed value | Water Section 5.4.1 *Groundwater Flowpath Modeling* |
| EL_Pit | [ft] | Deterministic | N/A | Constant | Vector by flowpath. Reference Table 1-15 | | | | Pit surficial outflow elevation | GIS data/calculations | Water Section 5.4.1 *Groundwater Flowpath Modeling* |
| Width | [m] | Deterministic | N/A | Constant | Vector by flowpath. Reference Table 1-15 | | | | Flowpath width | GIS data/calculations | Water Section 5.4.1 *Groundwater Flowpath Modeling* |
| L_Upstream | [m] | Deterministic | N/A | Constant | Vector by flowpath. Reference Table 1-15 | | | | Length upstream of stockpile | GIS data/calculations | Water Section 5.4.1 *Groundwater Flowpath Modeling* |
| L_Stock | [m] | Deterministic | N/A | Constant | Vector by flowpath. Reference Table 1-15 | | | | Source (stockpile) length | GIS data/calculations | Water Section 5.4.1 *Groundwater Flowpath Modeling* |
| L_Eval_1 | [m] | Deterministic | N/A | Constant | Vector by flowpath. Reference Table 1-15 | | | | Length to Evaluation Point #1 | GIS data/calculations | Water Section 5.4.1 *Groundwater Flowpath Modeling* |
| L_Eval_2 | [m] | Deterministic | N/A | Constant | Vector by flowpath. Reference Table 1-15 | | | | Length to Evaluation Point #2 | GIS data/calculations | Water Section 5.4.1 *Groundwater Flowpath Modeling* |
| L_Eval_3 | [m] | Deterministic | N/A | Constant | Vector by flowpath. Reference Table 1-15 | | | | Length to Evaluation Point #3 | GIS data/calculations | Water Section 5.4.1 *Groundwater Flowpath Modeling* |
| L_Total | [m] | Deterministic | N/A | Constant | Vector by flowpath. Reference Table 1-15 | | | | Total flowpath length | GIS data/calculations | Water Section 5.4.1 *Groundwater Flowpath Modeling* |

**Table 1-1** **Input Variables for the Mine Site Model (High Baseflow Sensitivity Analysis)**

| *Variable Name* | *Units* | *Deterministic/ Uncertain* | *Sampling/ Calculation Frequency* | *Distribution* | *Mean or Mode* | *Standard Deviation* | *Minimum* | *Maximum* | *Description* | *Source of Input Data* | *Modeling Package Section* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Grey cells indicate changes from the previously published version FOR THE HIGH BASEFLOW SENSITIVITY ANALYSIS | | | | | | | | | | | |
| ***Groundwater Flow Variables*** | | | | | | | | | | | |
| Bedrock_Porosity | [--] | Deterministic | N/A | Constant | 0.05 | N/A | N/A | N/A | Porosity of the bedrock flowpaths | Mine Site MODFLOW model (Bedrock units) | Water Section 5.4.1 *Groundwater Flowpath Modeling* |
| Surficial_Porosity | [--] | Deterministic | N/A | Constant | 0.3 | N/A | N/A | N/A | Porosity of the surficial flowpaths | Assumed value, e.g. Fetter, 2001 | Water Section 5.4.1 *Groundwater Flowpath Modeling* |
| K_Flowpath | [m/d] | Uncertain | Realization | Triangular | Vector by flowpath. Reference Table 1-15 | | | | Hydraulic conductivity of the surficial and bedrock material | Mine Site MODFLOW model (Duluth Complex), constraints discussed in Water Section 5.4.1 | Water Section 5.4.4 *Groundwater Transport in GoldSim* |
| Recharge_min | [in/yr] | Deterministic | N/A | Constant | 2.9 | N/A | N/A | N/A | Minimum allowed recharge in surficial aquifer (for checking calculated value) | Mine Site MODFLOW model | Water Section 5.4.1 *Groundwater Flowpath Modeling* |
| Recharge_max | [in/yr] | Deterministic | N/A | Constant | 2.9 | N/A | N/A | N/A | Maximum allowed recharge in surficial aquifer (for checking calculated value) | Mine Site MODFLOW model | Water Section 5.4.1 *Groundwater Flowpath Modeling* |
| Surficial_Density | [kg/m3] | Deterministic | N/A | Constant | 1,500 | N/A | N/A | N/A | Dry (bulk) Density of the surficial deposits | USDA St. Louis County Soil Survey Database | Water Section 5.4.1 *Groundwater Flowpath Modeling* |
| Kd_Surficial | [L/kg] | Deterministic | N/A | Constant | Vector by Constituent. Reference Table 1-16 | | | | Sorption coefficients for the surficial aquifer (As, Sb, Cu, Ni) | EPA screening-level values | Water Section 5.4.3 *Sorption* |
| ***Stream Flow Variables*** | | | | | | | | | | | |
| Streamflow_SW006_(Month) | [cfs] | Uncertain | Timestep | User-defined | Imported from worksheet. Reference Table 1-19 | | | | Randomly sampled daily streamflow at SW-006 for each month | USGS gage data (corrected for PMP dewatering) | Water Section 5.6.5 *Developing Probabilistic Model Inputs* |
| Inc_Flow_Factor_(Month) | [--] | Deterministic | N/A | Time Series | Imported from worksheet. Reference Table 1-20a through 1-20l | | | | Factor to multiply Q at SW006 to get the incremental inflow between nodes for each month | XP-SWMM model results (relative differences) | Water Section 5.6.5 *Developing Probabilistic Model Inputs* |
| GW_Inc_Baseflow | [cfs] | Deterministic | N/A | Time Series | Imported from worksheet. Reference Table 1-21 | | | | Baseflow adding to evaluation points via natural groundwater | XP-SWMM model results scaled to observed baseflow at SW-006 | Water Section 5.6.5 *Developing Probabilistic Model Inputs* |
| ***Pit Hydrology*** | | | | | | | | | | | |
| Wall_RO | [--] | Uncertain | Realization | Uniform | N/A | N/A | 0.4 | 0.6 | Runoff from bare pit walls as a fraction of precipitation | Best professional judgment (watershed avg ~40%) | Water Section 6.1.3.3 *Water Balance, Mine Pits* |
| Natural_RO_Winter | [--] | Uncertain | Annual | Trunc. Normal | 0.63 | 0.275 | 0 | N/A | Runoff (frozen period) from non-stockpile areas as a fraction of precipitation | Calculated from annual fraction and open-water seasonal fraction | Water Section 6.1.3.3 *Water Balance, Mine Pits* |
| Natural_RO_Summer | [--] | Uncertain | Annual | Trunc. Normal | 0.30 | 0.092 | 0 | N/A | Runoff (open water period) from non-stockpile areas as a fraction of precipitation | Average watershed yield from Partridge River (USGS gage) | Water Section 6.1.3.3 *Water Balance, Mine Pits* |
| Pit_GW_Uncertainty_unshift | [--] | Uncertain | Realization | Log-Normal | 0.3 | 0.31 | N/A | N/A | Uncertainty multiplier for the groundwater flow into the pits (un-shifted) | Best professional judgment | Water Section 6.1.3.3 *Water Balance, Mine Pits* |
| Pit_GW_Uncertainty_shift | [--] | Deterministic | N/A | Constant | 0.7 | N/A | N/A | N/A | Upward shift for uncertainty multiplier for the groundwater flow into the pits (shifted mean = 1.0) | Best professional judgment | Water Section 6.1.3.3 *Water Balance, Mine Pits* |
| WP_GW_Inflow | [gpm] | Deterministic | Timestep | Time Series/ Lookup | Imported from worksheet. Reference Table 1-22a and 1-22b | | | | Groundwater inflow to the pit as a function of time or elevation | MODFLOW modeling | Water Section 5.4.5 *Groundwater Modeling, MODFLOW* |
| WP_GW_Surf | [%] | Deterministic | Timestep | Time Series/ Lookup | Imported from worksheet. Reference Table 1-22a and 1-22b | | | | Surficial fraction of inflow to the pit as a function of elevation | MODFLOW modeling | Water Section 5.4.5 *Groundwater Modeling, MODFLOW* |
| EP_GW_Inflow | [gpm] | Deterministic | Timestep | Time Series/ Lookup | Imported from worksheet. Reference Table 1-22a and 1-22b | | | | Groundwater inflow to the pit as a function of time or elevation | MODFLOW modeling | Water Section 5.4.5 *Groundwater Modeling, MODFLOW* |
| EP_GW_Surf | [%] | Deterministic | Timestep | Time Series/ Lookup | Imported from worksheet. Reference Table 1-22a and 1-22b | | | | Surficial fraction of inflow to the pit as a function of elevation | MODFLOW modeling | Water Section 5.4.5 *Groundwater Modeling, MODFLOW* |
| CP_GW_Inflow | [gpm] | Deterministic | Timestep | Time Series/ Lookup | Imported from worksheet. Reference Table 1-22a and 1-22b | | | | Groundwater inflow to the pit as a function of time or elevation | MODFLOW modeling | Water Section 5.4.5 *Groundwater Modeling, MODFLOW* |
| CP_GW_Surf | [%] | Deterministic | Timestep | Time Series/ Lookup | Imported from worksheet. Reference Table 1-22a and 1-22b | | | | Surficial fraction of inflow to the pit as a function of elevation | MODFLOW modeling | Water Section 5.4.5 *Groundwater Modeling, MODFLOW* |
| CP_to_WP | [gpm] | Deterministic | N/A | Constant | 0.1 | N/A | N/A | N/A | Flow through bedrock from East Pit porewater to West Pit during pit filling (0 after West Pit is full) | MODFLOW modeling | Water Section 5.4.5 *Groundwater Modeling, MODFLOW* |

## Table 1-13 Existing Surface Water Concentrations (High Baseflow Sensitivity Analysis)

| Constituent | [SW_Conc.RO] RO Concentration Mean (mg/L) | St. Dev. (mg/L) | [SW_Conc.PMP] Northshore Discharge (mg/L) | [SW_Conc.Load_Colby] Colby Lake add'l Loading (kg/yr) |
|---|---|---|---|---|
| Ag | 9.30E-05 | 9.30E-07 | 1.09E-04 | 9.70E-02 |
| Al | 2.30E-01 | 2.00E-01 | 2.74E-02 | 0 |
| Alk* | 7.80E+01 | 1.38E+02 | 9.90E+01 | 0 |
| As | 1.17E-03 | 2.10E-03 | 1.33E-03 | 1.19E+00 |
| B | 1.07E-01 | 1.70E-01 | 1.41E-01 | 0 |
| Ba | 1.00E-06 | 1.00E-08 | 1.43E-02 | 0 |
| Be | 8.00E-05 | 8.00E-07 | 1.00E-04 | 4.24E-01 |
| Ca | 1.79E+01 | 2.50E+01 | 2.86E+01 | 1.54E+05 |
| Cd | 4.90E-05 | 9.30E-04 | 1.00E-04 | 1.26E+00 |
| Cl* | 1.04E+01 | 1.50E+01 | 1.63E+01 | 0 |
| Co | 7.80E-05 | 2.15E-03 | 3.39E-04 | 0 |
| Cr | 4.40E-04 | 5.60E-04 | 5.47E-04 | 0 |
| Cu | 5.00E-04 | 9.50E-04 | 9.75E-04 | 1.50E+02 |
| F | 9.40E-02 | 1.01E-01 | 1.28E-01 | 0 |
| Fe* | 2.90E+00 | 4.60E+00 | 2.31E+00 | 0 |
| K | 1.75E+00 | 3.80E+00 | 3.00E+00 | 0 |
| Mg | 7.90E+00 | 7.50E+00 | 1.52E+01 | 6.21E+04 |
| Mn | 1.00E-06 | 1.00E-08 | 1.91E-01 | 0 |
| Na | 4.45E+00 | 2.10E+01 | 1.20E+01 | 3.90E+04 |
| Ni | 1.04E-03 | 3.70E-03 | 8.73E-04 | 3.93E+01 |
| Pb | 2.40E-04 | 3.00E-03 | 2.94E-04 | 1.01E+01 |
| Sb | 2.40E-04 | 2.60E-06 | 2.50E-04 | 4.02E-01 |
| Se | 7.30E-04 | 6.50E-04 | 8.72E-04 | 0 |
| $SO_4$* | 5.90E+00 | 8.10E+00 | 2.80E+01 | 1.05E+06 |
| Tl | 1.00E-06 | 1.00E-08 | 3.61E-05 | 0 |
| V | 1.00E-06 | 1.00E-08 | 1.50E-03 | 6.90E+00 |
| Zn | 1.45E-02 | 2.90E-02 | 6.21E-03 | 0 |

Notes

Cells highlighted grey indicate a change from previously published values (FOR THE HIGH BASEFLOW SENSITIVITY ANALYSIS)

Values have been updated using the methodology in "Calibration of the Existing Natural Watershed at the Mine Site", Version 4 (June 2012) to reflect updated surficial groundwater distributions in Table 1-12 and PolyMet surface water quality data through December 2013. The calibration target has been changed to include only locations SW003 through SW005 (excluding SW002).

Source for NorthShore Discharge: PolyMet surface water monitoring at SW001 and SW002, combined mean values. Constituents marked with * include monitoring data from NorthShore NPDES discharge location SD009 from November 2008 through March 2014 in the calculation of average concentrations. NorthShore reported bicarbonate alkalinity as $HCO_3$ was assumed to be equivalent to total alkalinity and converted to units of $CaCO_3$.

**Table 1-15 Groundwater Flowpath Characteristics (High Baseflow Sensitivity Analysis)**

| Variable Name | Units | Description | *Groundwater Flowpath* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | *East Pit (Bedrock)* | *East Pit & Cat 2/3 Stockpile (Surficial Aquifer)* | *Ore Surge Pile* | *Waste Water Treatment Facility* | *Overburden Storage Area* | *West Pit (Surficial Aquifer)* | *West Pit (Bedrock to SW-004)* | *West Pit (Bedrock to SW-004a)* |
| I_ops | [--] | Minimum flowpath gradient (uniform distribution) | 0 | 4.10E-03 | 9.96E-03 | 8.90E-03 | 8.88E-03 | 4.32E-03 | 0 | 0 |
| | | Maximum flowpath gradient (uniform distribution) | 0 | 4.10E-03 | 9.96E-03 | 8.90E-03 | 8.88E-03 | 4.32E-03 | 0 | 0 |
| I_close | [--] | Minimum flowpath gradient (uniform distribution) | 8.05E-03 | 6.23E-03 | 0 | 0 | 0 | 9.30E-03 | 8.70E-03 | 9.07E-03 |
| | | Maximum flowpath gradient (uniform distribution) | 8.59E-03 | 6.23E-03 | 0 | 0 | 0 | 9.30E-03 | 9.37E-03 | 9.73E-03 |
| Thick | [m] | Aquifer thickness | 15 | 5 | 5 | 5 | 5 | 5 | 15 | 15 |
| EL_Pit | [ft] | Pit surficial outflow elevation | 0 | 1577 | 0 | 0 | 0 | 1550 | 0 | 0 |
| Width | [m] | Flowpath width | 1735 | 1440 | 430 | 240 | 550 | 665 | 535 | 810 |
| L_Upstream | [m] | Length upstream of stockpile | 0 | 775 | 0 | 0 | 0 | 0 | 0 | 0 |
| L_Stock | [m] | Source (stockpile) length | 0 | 395 | 230 | 420 | 375 | 0 | 0 | 0 |
| L_Eval_1 | [m] | Length to Evaluation Point #1 (Dunka Rd.) | 0 | 30 | 40 | 60 | 5 | 175 | 0 | 0 |
| L_Eval_2 | [m] | Length to Evaluation Point #2 (Prop. or river) | 1435 | 140 | 1085 | 910 | 235 | 680 | 505 | 340 |
| L_Eval_3 | [m] | Length to Evaluation Point #3 (Average river) | 440 | 780 | 60 | 340 | 985 | 650 | 1115 | 1160 |
| L_Total | [m] | Total flowpath length | 1875 | 2120 | 1415 | 1730 | 1600 | 1505 | 1620 | 1500 |
| K_Flowpaths | [m/d] | Minimum hydraulic conductivity | 0.001 | 7.59 | 2.01 | 2.53 | 5.26 | 5.15 | 0.001 | 0.001 |
| | | Most likely hydraulic conductivity (mode) | 0.003 | 7.59 | 2.01 | 2.53 | 5.26 | 5.15 | 0.003 | 0.003 |
| | | Maximum hydraulic conductivity | 0.010 | 7.59 | 2.01 | 2.53 | 5.26 | 5.15 | 0.010 | 0.010 |

Grey indicates a change in value since the previous publication FOR THE HIGH BASEFLOW SENSITIVITY ANALYSIS

## Table 1-21 Partridge River Baseflow (High Baseflow Sensitivity Analysis)

| Year | [GW_Inc_Baseflow] Incremental Flow from Groundwater into each Evaluation Point (cfs) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***SW-001*** | ***SW-002*** | ***SW-003*** | ***SW-004*** | ***SW-004a*** | ***SW-004b*** | ***SW-005*** | ***SW-006*** | ***Colby Lake*** |
| 0 | 0.260 | 1.364 | 0.416 | 1.620 | 6.112 | 5.476 | 4.388 | 1.460 | 1.055 |
| 1 | 0.260 | 1.288 | 0.400 | 1.504 | 6.060 | 5.468 | 4.412 | 1.452 | 1.055 |
| 2 | 0.260 | 1.288 | 0.404 | 1.504 | 6.000 | 5.476 | 4.236 | 1.632 | 1.055 |
| 11 | 0.260 | 1.272 | 0.400 | 1.484 | 5.764 | 5.476 | 4.432 | 1.452 | 1.055 |
| 20 | 0.260 | 1.352 | 0.400 | 1.480 | 5.836 | 5.480 | 4.420 | 1.460 | 1.055 |
| 21 | 0.260 | 1.344 | 0.404 | 1.572 | 5.680 | 5.480 | 4.424 | 1.456 | 1.055 |
| 50 | 0.260 | 1.344 | 0.404 | 1.572 | 5.876 | 5.484 | 4.408 | 1.464 | 1.055 |
| 2000 | 0.260 | 1.344 | 0.404 | 1.572 | 5.876 | 5.484 | 4.408 | 1.464 | 1.055 |

Notes

Source: 2012 XP-SWMM modeling (and area relationship for Colby Lake), scaled from USGS data, see Water Modeling Data Package Vol 1 - Mine Site, Section 4.4.1.3
Incremental flows reflect updated XP-SWMM modeling.
Cells highlighted grey indicate 4x the FEIS model baseflow for baseflow sensitivity analysis

## Table 1-22a Groundwater Inflows to the Pits During Operations (High Baseflow Sensitivity Analysis)

| | East Pit | | Central Pit | | West Pit | |
|---|---|---|---|---|---|---|
| *Year* | *[EP_GW_Inflow_Ops] Flow Rate (gpm)* | *[EP_GW_Surf_Ops] Surficial Percent* | *[CP_GW_Inflow_Ops] Flow Rate (gpm)* | *[CP_GW_Surf_Ops] Surficial Percent* | *[WP_GW_Inflow_Ops] Flow Rate (gpm)* | *[WP_GW_Surf_Ops] Surficial Percent* |
| 0 | 0 | 100 | 0 | 100 | 0 | 100 |
| 1 | 290 | 36.6 | 0 | 100 | 0 | 100 |
| 2 | 250 | 30.9 | 0 | 100 | 120 | 99.1 |
| 3 | 280 | 24 | 0 | 100 | 90 | 98.1 |
| 4 | 310 | 18.6 | 0 | 100 | 70 | 97 |
| 5 | 520 | 9.5 | 0 | 100 | 60 | 95.7 |
| 6 | 500 | 8.9 | 0 | 100 | 80 | 97.4 |
| 7 | 500 | 8.5 | 0 | 100 | 70 | 94.9 |
| 8 | 550 | 7.5 | 0 | 100 | 70 | 92.1 |
| 9 | 790 | 5.1 | 0 | 100 | 60 | 90.1 |
| 10 | 810 | 4.8 | 0 | 100 | 60 | 86.5 |
| 10.75 | 860 | 2.2 | 60 | 99.6 | 140 | 91.0 |
| 11 | 860 | 2.2 | 60 | 99.8 | 140 | 94.7 |
| 12 | 850 | 2.1 | 40 | 98.6 | 100 | 92.9 |
| 13 | 800 | 2.1 | 30 | 97 | 90 | 91.5 |
| 14 | 800 | 2 | 30 | 94.9 | 80 | 90.5 |
| 15 | 800 | 2.0 | 30 | 89.9 | 80 | 88.6 |
| *16* | *660* | *2.4* | *30* | *90* | 80 | 87.3 |
| *17* | *470* | *3.3* | *20* | *92.7* | 80 | 85.7 |
| *18* | *350* | *4.3* | *20* | *93.6* | 70 | 84.8 |
| *19* | *240* | *6.3* | *20* | *94.9* | 80 | 82.9 |
| *20* | *110* | *18.1* | *20* | *99.6* | 80 | 80.9 |
| *2000* | *150* | *19.7* | *20* | *100* | *80* | *81.4* |

Note: Time series not used beyond year 15 for East/Central pit and year 20 for West Pit, values shown are necessary for input but not used in model. See Table 1-22b for inflow lookup in closure.

Cells highlighted grey indicate a change from previously published values (FOR THE HIGH BASEFLOW SENSITIVITY ANALYSIS)

## Table 1-22b Groundwater Inflows to the Pits During Backfilling and Closure (High Baseflow Sensitivity Analysis)

| West Pit | | |
|---|---|---|
| ***WS Elevation (ft)*** | ***Flow Rate (gpm)*** | ***Surficial Percent*** |
| 940 | 110 | 90.8 |
| 1000 | 110 | 90.8 |
| 1100 | 110 | 91 |
| 1200 | 110 | 91.4 |
| 1320 | 110 | 92.4 |
| 1450 | 100 | 95.1 |
| 1579 | 80 | 99.3 |
| 1585 | 60 | 99.5 |

| East Pit | | |
|---|---|---|
| ***WS Elevation (ft)*** | ***Flow Rate (gpm)*** | ***Surficial Percent*** |
| 1260 | 820 | 2.1 |
| 1360 | 800 | 2.0 |
| 1435 | 800 | 2.0 |
| 1485 | 660 | 2.4 |
| 1530 | 400 | 3.9 |
| 1565 | 270 | 5.8 |
| 1592 | 60 | 56.7 |
| 1595 | 50 | 69.4 |

| Central Pit | | |
|---|---|---|
| ***WS Elevation (ft)*** | ***Flow Rate (gpm)*** | ***Surficial Percent*** |
| 1260 | 30 | 89.9 |
| 1360 | 30 | 90.0 |
| 1435 | 20 | 93.8 |
| 1485 | 20 | 95.2 |
| 1530 | 20 | 98.0 |
| 1565 | 20 | 99.6 |
| 1592 | 10 | 99.8 |
| 1595 | 10 | 100.0 |

Cells highlighted grey indicate a change from previously published values (FOR THE HIGH BASEFLOW SENSITIVITY ANALYSIS)

# Appendix K

## Mine Site MODFLOW Model Baseflow Sensitivity

# Technical Memorandum

**To:** Project File
**From:** Katy Lindstrom, Katrina Marini
**Subject:** Mine Site MODFLOW Model Baseflow Sensitivity
**Date:** January 23, 2015
**Project:** 23690862

## 1.0 Introduction

Groundwater flow modeling was completed for the Poly Met Mining Inc. (PolyMet) NorthMet Project (Project) Mine Site to support probabilistic (i.e., GoldSim) modeling used to estimate Project water balances and water quality impacts as part of the Final Environmental Impact Statement (FEIS) effort (Attachment B of Reference (1)); Reference (1)). The sensitivity of the model output to Partridge River baseflow values was assessed by conducting a sensitivity run using a Partridge River baseflow value four times higher than the value used in the FEIS modeling effort, in accordance with the *Partridge River Baseflow Sensitivity Analysis – Work Plan (Version 2)* (Reference (2)). Because the GoldSim model used outputs from the groundwater flow model, the groundwater flow model developed for the Project Mine Site (baseline model) was recalibrated to the "high baseflow" condition. Predictive simulations of the high baseflow condition were then conducted to estimate the amount of groundwater expected to flow into the mine pits during operations and pit flooding and to evaluate the groundwater flow conditions following pit closure.

This memorandum describes modifications made to the baseline model for the sensitivity run and discusses the model results. Only changes related to the sensitivity run are described herein; all other aspects of the model remained as described in Attachment B of Reference (1).

## 2.0 Modifications to the Baseline Model

Baseflow information was supplied to the baseline model in two ways:

- **As recharge** – Conceptually, baseflow in the Partridge River at any point is expected to be directly related to the recharge that occurs over the surface watershed tributary to that point (Reference (1); therefore, the baseline recharge rate was set such that the total recharge applied to the SW004 surface watershed was consistent with the estimate of baseflow at SW004.

- **As a calibration observation** – The model was calibrated to estimates of baseflow in the Partridge River at monitoring stations SW002, SW003, and SW004 (Section 4.4.1.3 of Reference (1)). For this purpose, baseflow is defined as the groundwater contribution to streamflow.

For the purpose of the sensitivity run, the baseline recharge value and the calibration observations at stations SW002, SW003, and SW004 were increased by a factor of 4. Table 2-1 and Table 2-2 show the recharge rates and calibration observations used for both the baseline model and sensitivity run.

**Table 2-1 Recharge Parameter Values**

| Parameter | Baseline Recharge Rate (inches/year) | Sensitivity Run Recharge Rate (inches/year) |
|---|---|---|
| Recharge – Upland Deposits | 1.8 | 7.2 |
| Recharge – Wetland Deposits | 0.36 | 1.4 |

**Table 2-2 Baseflow Calibration Observations**

| Location | Baseline Calibration Observation (cfs)(1) | Sensitivity Calibration Observation (cfs)(1) |
|---|---|---|
| SW002 | 0.41 | 1.6 |
| SW003 | 0.51 | 2.0 |
| SW004 | 0.92 | 3.7 |

(1) cfs – cubic feet per second

# 3.0 Model Recalibration

Applying the baseflow values for the sensitivity run shown in Table 2-1 and Table 2-2, the model was recalibrated to steady-state conditions using the automated calibration software PEST (Reference (3), Reference (4)). Through systematic adjustment of model parameters within a user-specified range, PEST attempts to minimize the difference between observed and modeled values (i.e., residuals) for a variety of different types of calibration observations. When using PEST, the difference between observed and modeled values is quantified as the sum of squared weighted residuals and is termed the objective function or "phi." Therefore, the goal of the calibration was to minimize the objective function.

In addition to minimizing the objective function, the model calibration was considered acceptable if the following criteria were met:

- the absolute residual mean was less than 15% of the observed range in heads
- simulated flows at SW002, SW003, and SW004 were within 5% of the baseflow calibration observation
- widespread areas of simulated heads significantly above the ground surface did not result

This section presents the results of the model recalibration for the sensitivity run. Other aspects of the model recalibration (i.e., calibration parameters, calibration datasets, prior information, regularization) were not changed from the baseline model calibration and were documented in Attachment B of Reference (1).

## 3.1 Recalibration Results

Optimized hydraulic conductivity values are summarized in Table 3-1, and Large Figure 1 shows the calibrated hydraulic conductivity distribution in Layer 1 for the area of interest, including the average hydraulic conductivity for each of the GoldSim groundwater flow path areas. Because the horizontal hydraulic conductivity of the unconsolidated deposits varies by cell, the range of values and mean value in each zone (one zone for upland deposits and one zone for wetland deposits) resulting from the calibration are shown in Table 3-1. The mean horizontal hydraulic conductivity values in the upland and wetland deposits were higher in the sensitivity run than the baseline calibration, and the range of hydraulic conductivity values was generally higher. Because the calibration heads remained the same as for the baseline calibration, whereas recharge and river flux were increased, it was expected that hydraulic conductivity values would increase. Consistent with the increase in hydraulic conductivity of the unconsolidated deposits, the vertical hydraulic conductivity terms for the Partridge River were generally higher in the sensitivity run, particularly in downstream reaches. Observed heads in the bedrock were located in Layer 2 of the model and were, therefore, less affected by the increase in recharge to the uppermost model layer. As a result, hydraulic conductivity of the bedrock was very similar to the baseline calibration.

As described in Attachment B of Reference (1), estimates of hydraulic conductivity for the unconsolidated deposits were used as prior information in model calibration. Table 3-2 provides a comparison between the estimated and calibrated hydraulic conductivity values at locations where prior information was included in the calibration. Calibrated hydraulic conductivity values generally compare well with the estimated values, though at a majority of the locations with hydraulic conductivity estimates, the optimized hydraulic conductivity was somewhat higher than the estimated value, consistent with the general increase in hydraulic conductivity described above.

**Table 3-1 Optimized Hydraulic Conductivity Values**

| Model Parameter | Baseline Calibration Value (feet/day) | Sensitivity Run Calibration Value (feet/day) |
|---|---|---|
| Horizontal hydraulic conductivity – Upland Deposits | Range: 0.056 – 167<br>Mean: 19.2 | Range: 0.071 – 193<br>Mean: 35.3 |
| Horizontal hydraulic conductivity - Wetland deposits | Range: 0.003 – 224<br>Mean: 23.7 | Range: 0.013 – 296<br>Mean: 58.9 |
| Vertical hydraulic conductivity – Upland and wetland deposits (1) | 0.0028 | 0.0028 |
| Hydraulic conductivity – Giants Range granite | Kx = Ky = 0.029<br>Kz = 0.0029 | Kx = Ky = 0.029<br>Kz = 0.0029 |
| Hydraulic conductivity – Biwabik Iron Formation | Kx = Ky = 0.87<br>Kz = 0.087 | Kx = Ky = 0.97<br>Kz = 0.097 |
| Hydraulic conductivity – Virginia Formation, Upper Portion | Kx = Ky = 0.31<br>Kz = 0.031 | Kx = Ky = 0.32<br>Kz = 0.032 |
| Hydraulic conductivity – Duluth Complex | Kx = Ky = 4.4x10-4<br>Kz = 4.4x10-5 | Kx = Ky = 4.6x10-4<br>Kz = 4.6x10-5 |
| Hydraulic conductivity – Virginia Formation, Lower Portion | Kx = Ky = 0.079<br>Kz = 0.0079 | Kx = Ky = 0.082<br>Kz = 0.0082 |
| Vertical hydraulic conductivity term of Partridge River Reach 1 | 41.0 | 49.6 |
| Vertical hydraulic conductivity term of Partridge River Reach 2 | 32.8 | 35.0 |
| Vertical hydraulic conductivity term of Partridge River Reach 3 | 25.6 | 66.0 |
| Vertical hydraulic conductivity term of Partridge River Reach 4 | 18.5 | 82.6 |
| Vertical hydraulic conductivity term of Partridge River Reach 5 | 13.2 | 58.6 |
| Vertical hydraulic conductivity term of Partridge River Reach 6 | 10.4 | 69.0 |
| Vertical hydraulic conductivity term of Partridge River Reach 7 | 8.8 | 82.7 |
| Vertical hydraulic conductivity term of Partridge River Reach 8 | 10.0 | 99.6 |

(1) Parameter not allowed to vary during calibration

### Table 3-2 Estimated and Calibrated Hydraulic Conductivity Values

| | Horizontal Hydraulic Conductivity | |
|---|---|---|
| **Location** | **Estimated Value (feet/day)** | **Sensitivity Run Calibration Value (feet/day)** |
| **Unconsolidated Deposits:** | | |
| MW-05-02 | 31 | 150 |
| MW-05-08 | 0.062 | 4.9 |
| MW-05-09 | 0.027 | 0.032 |
| SB-05-01 | 26 | 35 |
| SB-05-03 | 0.014 | 0.91 |
| SB-05-04 | 0.033 | 0.11 |
| SB-05-06 | 0.012 | 0.011 |
| SB-05-07 | 3.6 | 1.9 |
| SB-05-10 | 0.11 | 0.19 |
| RS-01B | 10 | 15 |
| RS-03 | 3.6 | 2.2 |
| RS-04 | 17 | 28 |
| RS-05A | 18 | 36 |
| RS-06 | 5.9 | 14 |
| RS-07 | 72 | 30 |
| RS-08A | 12 | 5.9 |
| RS-09 | 21 | 26 |
| RS-10 | 7.9 | 4.3 |
| RS-11 | 66 | 87 |
| RS-12 | 52 | 65 |
| RS-13 | 27 | 20 |
| RS-14 | 92 | 81 |
| RS-15 | 5.6 | 7.7 |
| RS-16 | 32 | 38 |
| RS-17B | 56 | 54 |
| RS-18 | 6.9 | 5.7 |
| RS-19 | 10 | 29 |
| RS-20 | 9.2 | 18 |

| | Horizontal Hydraulic Conductivity | |
|---|---|---|
| **Location** | **Estimated Value (feet/day)** | **Sensitivity Run Calibration Value (feet/day)** |
| **Bedrock:** | | |
| Duluth Complex | $4.5x10^{-4}$ | $4.6x10^{-4}$ |
| Biwabik Iron Formation | 0.98 | 0.97 |
| Upper Virginia Formation | 0.33 | 0.32 |
| Lower Virginia Formation | 0.085 | 0.082 |
| Giants Range granite | 0.029 | 0.029 |

Simulated groundwater contours from the sensitivity run for Layers 1 and 2 are shown on Large Figure 2 and Large Figure 3, respectively. Consistent with the baseline model, modeled heads from the sensitivity run show general agreement between the expected and simulated flow directions in both the unconsolidated deposits and bedrock.

Head residuals for Layers 1 and 2 are also shown on Large Figure 2 and Large Figure 3, respectively. A scatter plot of simulated and observed head values is presented on Large Figure 4. The mean residual was 0.46 feet, and the absolute residual mean was 2.9 feet. The range of observed heads (maximum head measured minus minimum head measured) was 85 feet. The absolute residual mean was 3.4% of the observed range in heads, satisfying one of the calibration objectives indicated above.

As described above, minimizing the occurrence of simulated heads above the ground surface was one objective of the calibration. Large Figure 5 presents a comparison of modeled heads and the ground surface (based on a digital elevation model (DEM) of the Mine Site created from a combination of 2010 LiDAR data in the immediate project area (plus a 500-feet buffer), Minnesota Department of Natural Resources data, and United States Geological Survey DEM data). Consistent with the baseline model, estimated heads within the area of interest were above the ground surface only in limited areas and did not exceed 10 feet above the ground surface.

Simulated values of baseflow to the Partridge River and the corresponding calibration observations are summarized in Table 3-3. Baseflow estimates at all three locations satisfy the calibration objective of having the MODFLOW-simulated flow within 5% of the baseflow calibration observation.

**Table 3-3 Comparison between Estimated and Modeled Baseflow**

| Location | Sensitivity Run Baseflow Calibration Observation (cfs)(1) | Sensitivity Run MODFLOW Modeled Baseflow (cfs)(1) |
|---|---|---|
| SW002 | 1.6 | 1.6 |
| SW003 | 2.0 | 2.0 |
| SW004 | 3.7 | 3.8 |

(1) cfs – cubic feet per second

The overall mass balance error of the calibration simulation was 0.01%. This falls well below the guidance provided in Reference (5), which state that "Ideally the error in the water balance is less than 0.1%" and "error of around 1%, however, is usually considered acceptable."

# 4.0 Predictive Simulations and Results

As with the baseline model, the sensitivity run was used to simulate groundwater flow during and after mining operations for the purpose of estimating groundwater inflow rates to the mine pits. The model-estimated groundwater inflow rates are an input to the GoldSim model (Reference (1)), and the results of the sensitivity run were used as part of the sensitivity assessment of Partridge River baseflow in the GoldSim model (Reference (6)).

Predictive simulations included:

- a set of transient simulations to represent the 20-year period of mine operations
- a series of steady-state model simulations to estimate groundwater inflow rates into the West Pit at various stages of flooding
- two model simulations to evaluate groundwater conditions during long-term closure (i.e., once the system has reached equilibrium)

Additional predictive simulation details were unchanged from the baseline model and are documented in Attachment B of Reference (1). This section describes the results of predictive simulations for the sensitivity run.

## 4.1 Pit Inflow Rates

Zone-based analysis was used to calculate the net groundwater inflow rates to the mine pits during operations, West Pit flooding, and long-term closure. Specific zones were defined for the pits, unconsolidated deposits, and bedrock units by layer, and the mass balance for each zone was then calculated from the MODFLOW cell-by-cell flow file. The net flow of groundwater into the pits was calculated by taking the difference between the flow from the rest of the model to the pit zone minus the flow leaving the pit zone and entering the rest of the model. Table 4-1 shows the estimated groundwater inflow rates for operations from the sensitivity run, and Figure 4-1 shows a comparison of the baseline model and sensitivity run results.

**Table 4-1 Estimated Pit Inflow Rates – Operations**

| Mine Year | Sensitivity Run East Pit Groundwater Inflow (gpm)(1) | Sensitivity Run Central Pit Groundwater Inflow (gpm)(1) | Sensitivity Run West Pit Groundwater Inflow (gpm)(1) |
|---|---|---|---|
| 1 | 290 | 0 | 0 |
| 2 | 250 | 0 | 120 |
| 3 | 280 | 0 | 90 |
| 4 | 310 | 0 | 70 |
| 5 | 520 | 0 | 60 |
| 6 | 500 | 0 | 80 |
| 7 | 500 | 0 | 70 |
| 8 | 550 | 0 | 70 |
| 9 | 790 | 0 | 60 |
| 10 | 810 | 0 | 60 |
| 11 | 860 | 60 | 140 |
| 12 | 850 | 40 | 100 |
| 13 | 800 | 30 | 90 |
| 14 | 800 | 30 | 80 |
| 15 | 800 | 30 | 80 |
| 16 | 660 | 30 | 80 |
| 17 | 470 | 20 | 80 |
| 18 | 350 | 20 | 70 |
| 19 | 240 | 20 | 80 |
| 20 | 110 | 20 | 80 |

(1) gpm – gallons per minute

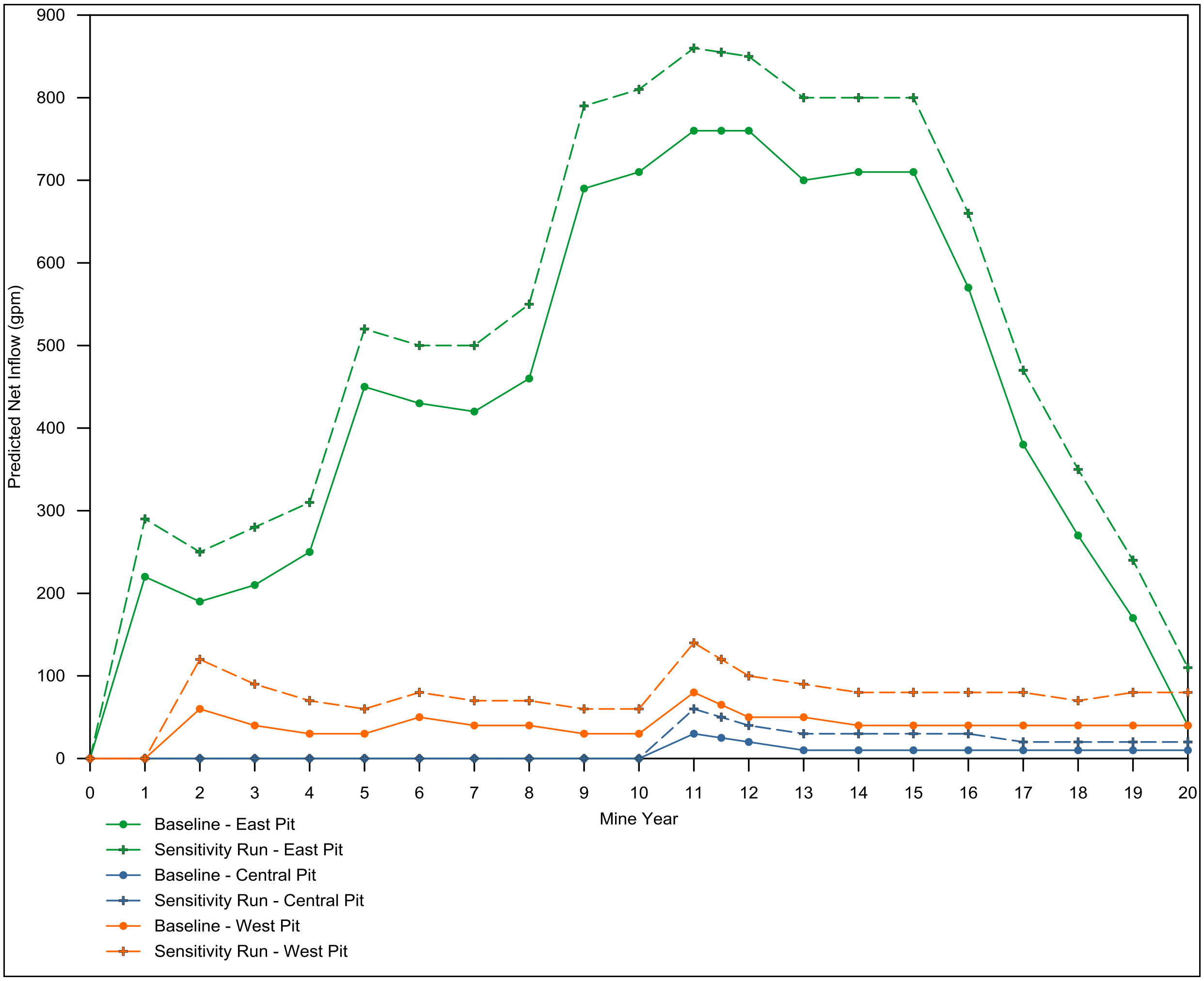



**Figure 4-1 Comparison of Estimated Pit Inflows – Baseline Model and Sensitivity Run**

In general, pit inflows estimated from the sensitivity run follow the same general patterns as the baseline model results; however, pit inflows are higher for the sensitivity run which is consistent with the general increase in hydraulic conductivity of the unconsolidated deposits.

The model mass balance error for all simulations of operations was less than 0.01%.

## 4.2 West Pit Flooding

Simulated groundwater inflow rates into the West Pit during flooding, as a function of groundwater elevation, are shown in Table 4-2. Inflow rates during West Pit flooding (calculated using the method described in Section 4.1) were relatively insensitive to the pit stage because the majority of groundwater inflow to the West Pit comes from the unconsolidated deposits and the pit stages evaluated are generally below the top of bedrock elevation. Consistent with pit inflows during operations (described in

Section 4.1), the estimated pit inflow rates are higher for the sensitivity run due to the generally higher hydraulic conductivity values compared to the baseline model. The model mass balance error for all simulations of West Pit flooding was less than 0.01%.

**Table 4-2 Estimated Groundwater Inflow Rates - West Pit Flooding**

| West Pit Water Elevation (feet MSL) | Baseline Groundwater Inflow Rate (gpm)(1) | Sensitivity Run Groundwater Inflow Rate (gpm)(1) |
|---|---|---|
| 940 | 50 | 110 |
| 1000 | 50 | 110 |
| 1100 | 50 | 110 |
| 1200 | 50 | 110 |
| 1320 | 50 | 110 |
| 1450 | 50 | 100 |

(1) gpm – gallons per minute

## 4.3 Long-Term Closure Conditions

The rate of groundwater flow into and out of the pits during long-term closure was calculated using the method described in Section 4.1. Simulated groundwater flow rates for the long-term closure simulations are shown in Table 4-3 and Table 4-4 for the sensitivity run and baseline model, respectively. With the exception of the West Pit flow rates, results from the sensitivity run estimate the same net direction of flow (i.e., net inflow or net outflow), but at higher flow rates. For the West Pit under the second long-term closure condition (i.e., East and Central Pits at 1595 feet above mean sea level (MSL) and West Pit at 1585 feet MSL) the sensitivity run estimated a net outflow of water from the pit instead of a net inflow. The model mass balance error for all long-term closure simulations was less than 0.01%.

**Table 4-3 Estimated Groundwater Inflow and Outflow Rates – Long-term Closure Conditions, Sensitivity Run**

| | | | East Pit | | Central Pit | | West Pit | |
|---|---|---|---|---|---|---|---|---|
| East Pit Elevation (feet MSL) | Central Pit Elevation (feet MSL) | West Pit Elevation (feet MSL) | Inflow (gpm) | Outflow (gpm) | Inflow (gpm) | Outflow (gpm) | Inflow (gpm) | Outflow (gpm) |
| 1592 | 1592 | 1579 | 60 | <10 | 10 | 30 | 80 | 60 |
| 1595 | 1595 | 1585 | 50 | 10 | 10 | 50 | 60 | 80 |

**Table 4-4 Estimated Groundwater Inflow and Outflow Rates – Long-term Closure Conditions, Baseline Model**

| | | | East Pit | | Central Pit | | West Pit | |
|---|---|---|---|---|---|---|---|---|
| East Pit Elevation (feet MSL) | Central Pit Elevation (feet MSL) | West Pit Elevation (feet MSL) | Inflow (gpm) | Outflow (gpm) | Inflow (gpm) | Outflow (gpm) | Inflow (gpm) | Outflow (gpm) |
| 1592 | 1592 | 1579 | 30 | <10 | <10 | 20 | 40 | 10 |
| 1595 | 1595 | 1585 | 20 | 10 | 10 | 40 | 30 | 20 |

# 5.0 Summary and Conclusions

Modifications to the groundwater flow model developed for the Project Mine Site as part of the FEIS modeling effort were made to assess the sensitivity of the modeling outcomes on Partridge River baseflow values. The groundwater flow model was recalibrated using a Partridge River baseflow estimate 4 times higher than the value used in the baseline model. Predictive simulations were completed with the recalibrated model to estimate the amount of groundwater expected to flow into the mine pits during operations and pit flooding and to evaluate the groundwater flow conditions during long-term closure.

All four calibration objectives were met: the objective function was minimized; the absolute residual mean was less than 15% of the observed range in heads; simulated flow at three locations (SW002, SW003 and SW004) were within 5% of the calibration observation; and widespread areas of simulated heads significantly above the ground surface did not result.

The following conclusions can be drawn from the modeling described in this memorandum:

- Calibrated hydraulic conductivity values for the unconsolidated deposits and the vertical hydraulic conductivity term of the Partridge River generally increased as a result of the higher baseflow value used in the sensitivity run.
- In general, pit inflows estimated from the sensitivity run follow the same general patterns as the baseline model results; however, pit inflows are higher for the sensitivity run, consistent with the general increase in hydraulic conductivity of the unconsolidated deposits.
- During long-term closure, the East Pit is estimated to have net flow of groundwater into the pit at a higher rate than estimated by the baseline model. The West Pit is estimated to have a net flow of groundwater into the pit with an elevation of 1579 feet MSL; however, net outflow from the pit is estimated from the sensitivity run with an elevation of 1585 feet MSL. This is consistent with the trend from the baseline model where the pits were estimated to lose more water under a scenario

where the pit water levels rise above their anticipated surface outflow elevations (as might occur temporarily during spring snowmelt or very wet conditions).

# 6.0 References

1. **Poly Met Mining Inc.** NorthMet Project Water Modeling Data Package Volume 1 - Mine Site (v14). January 2015.

2. **Barr Engineering Co.** Partridge River Baseflow Sensitivity Analysis – Work Plan (Version 2) Memorandum to Jennifer Saran, Poly Met Mining Inc. November 19, 2014.

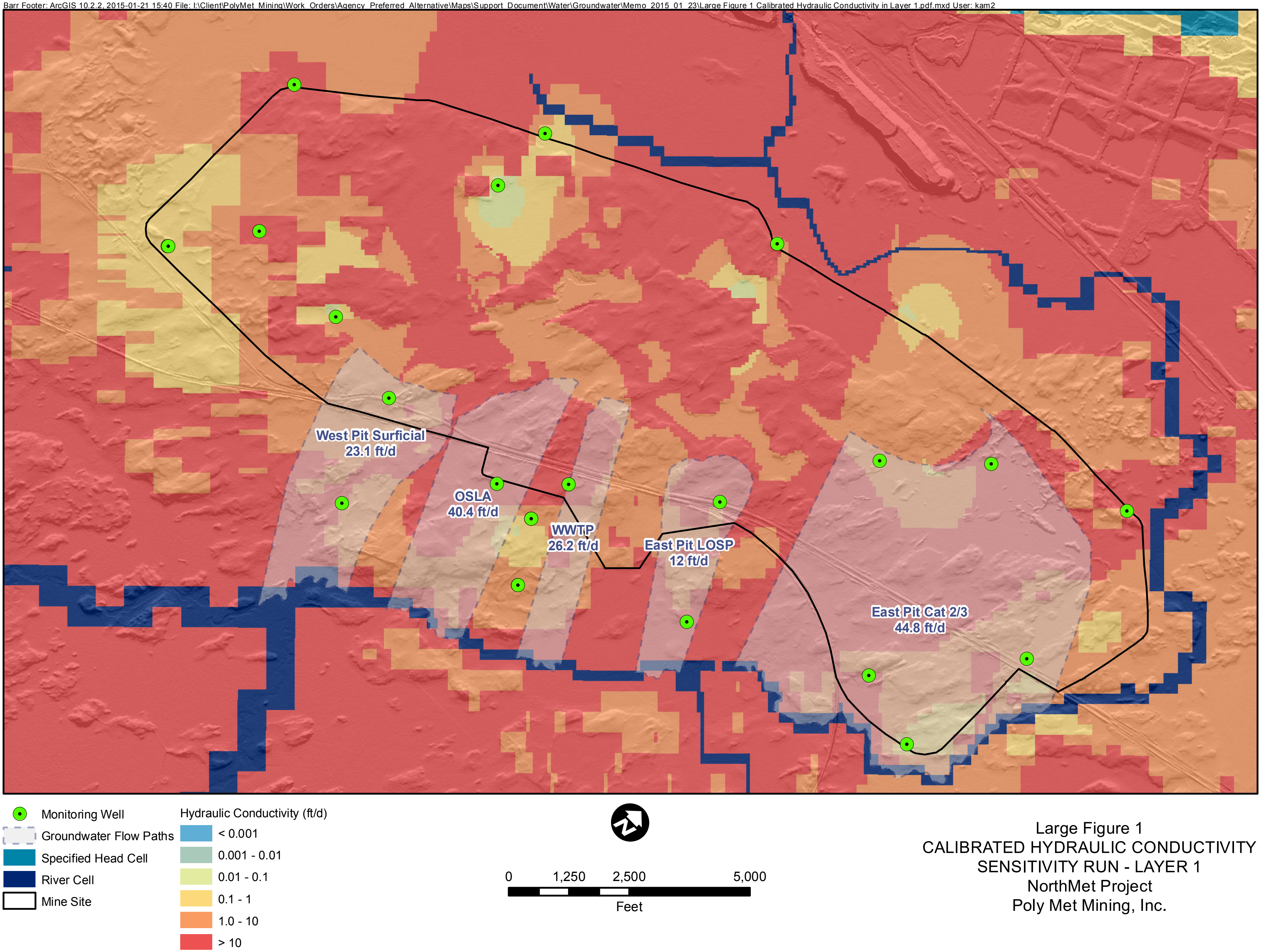
3. **Watermark Numerical Computing.** PEST: Model-Independent Parameter Estimation. User Manual, 5th Edition. 2005.

4. —. Addendum to the PEST Manual. 2010.

5. **Anderson, M. P. and Woessner, W. W.** *Applied Groundwater Modeling: Simulation of Flow and Advective Transport.* San Diego : Academic Press, Inc., 1992.

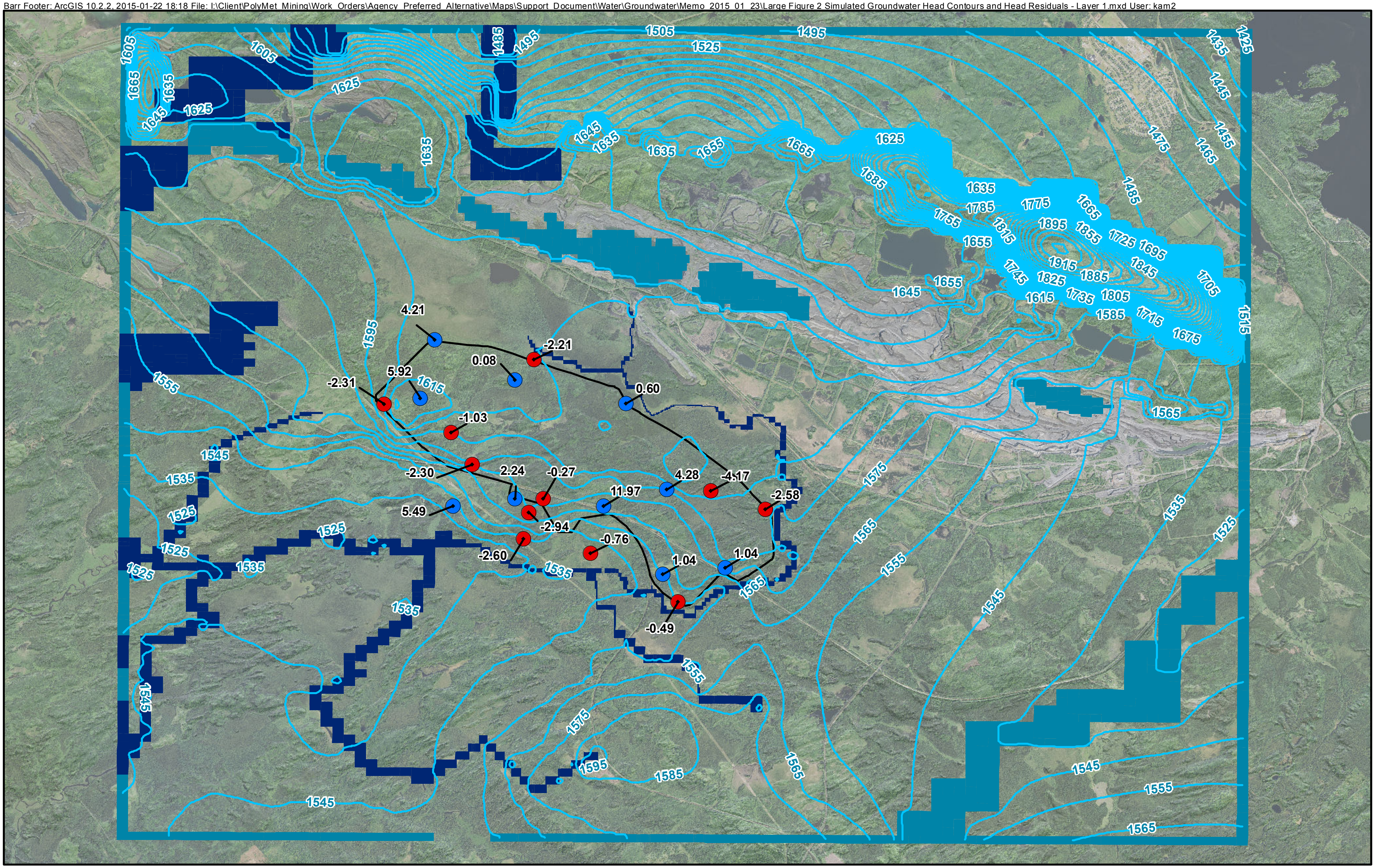
6. **Barr Engineering Co.** Sensitivity Analysis of the NorthMet Water Quality Models (v2). January 2015.

Barr Footer: ArcGIS 10.2.2, 2015-01-21 15:40 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Water\Groundwater\Memo_2015_01_23\Large Figure 1 Calibrated Hydraulic Conductivity in Layer 1.pdf.mxd User: kam2




Large Figure 1
CALIBRATED HYDRAULIC CONDUCTIVITY
SENSITIVITY RUN - LAYER 1
NorthMet Project
Poly Met Mining, Inc.

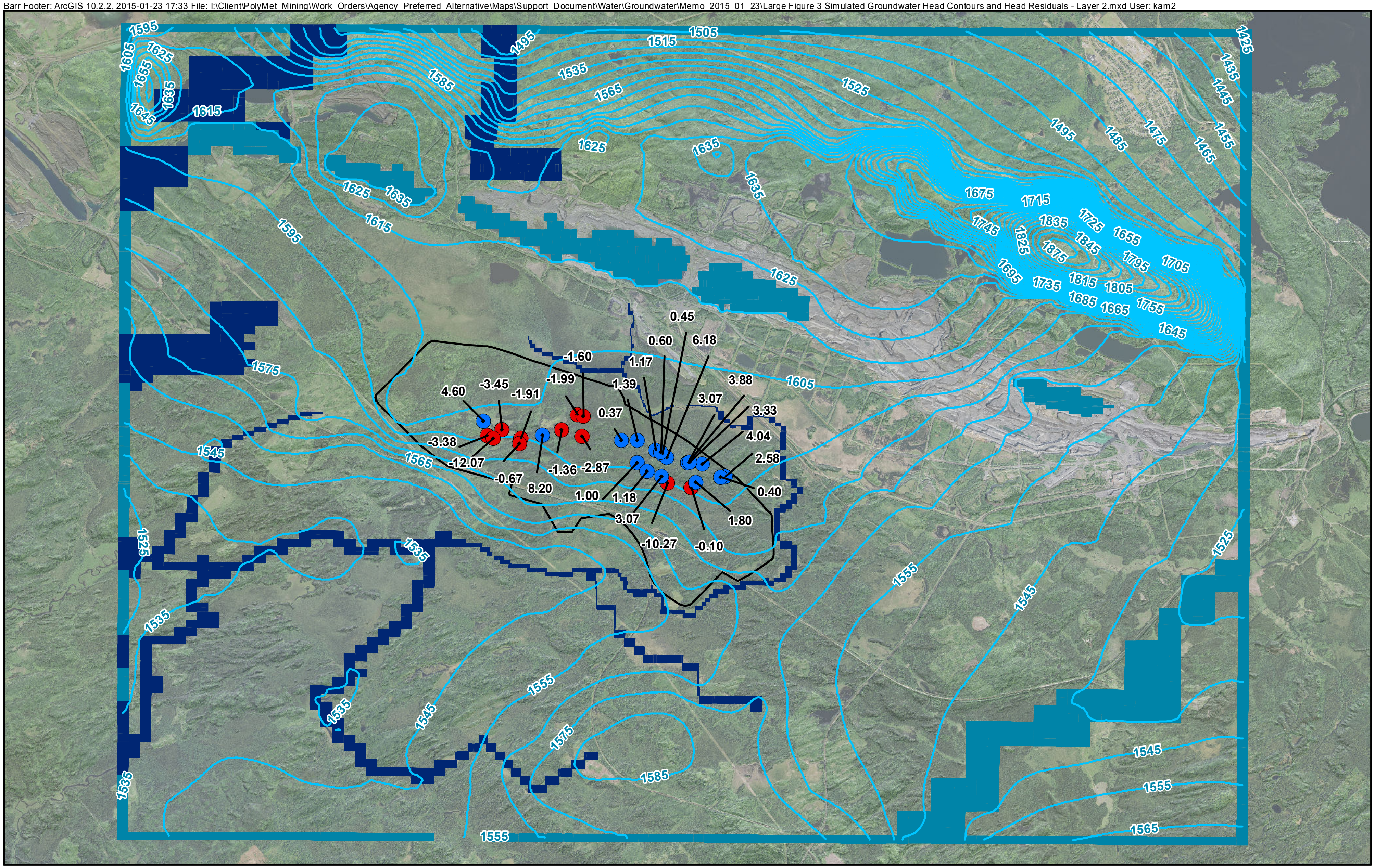
Barr Footer: ArcGIS 10.2.2, 2015-01-22 18:18 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Water\Groundwater\Memo_2015_01_23\Large Figure 2 Simulated Groundwater Head Contours and Head Residuals - Layer 1.mxd User: kam2




- Unconsolidated Monitoring Well with Negative Residual in Feet
- Unconsolidated Monitoring Well with Positive Residual in Feet
- Simulated Groundwater Head Contours (Ft)
- River Cell
- Specified Head Cell
- Mine Site

0 0.65 1.3 2.6
Miles

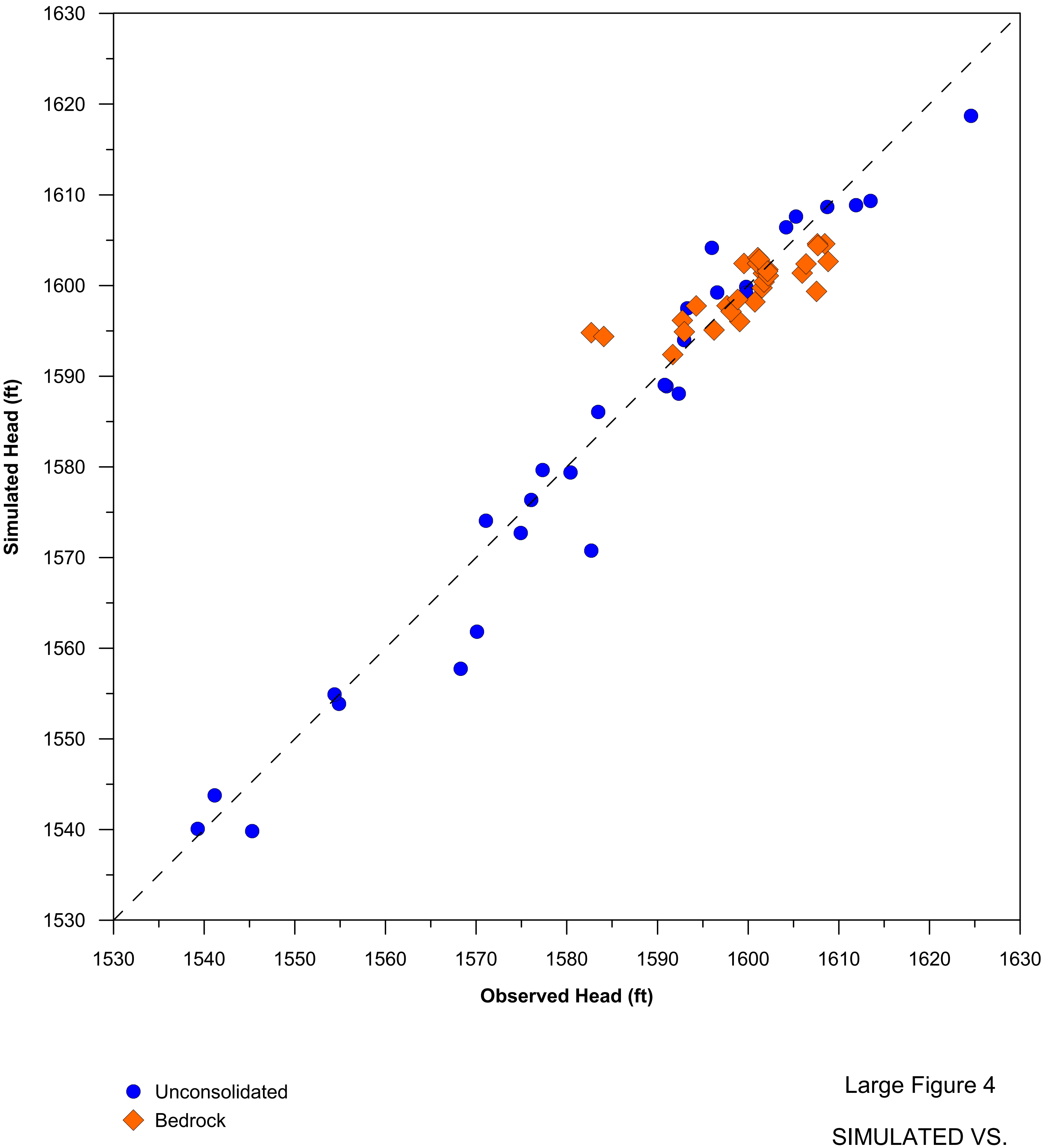
Large Figure 2
SIMULATED GROUNDWATER HEAD CONTOURS AND HEAD RESIDUALS - LAYER 1
NorthMet Project
Poly Met Mining, Inc.




- Bedrock Monitoring Well with Negative Head Residual in Feet
- Bedrock Monitoring Well with Positive Head Residual in Feet
- Simulated Groundwater Head Contours (Ft)
- River Cell
- Specified Head Cell
- Mine Site

0 0.65 1.3 2.6
Miles

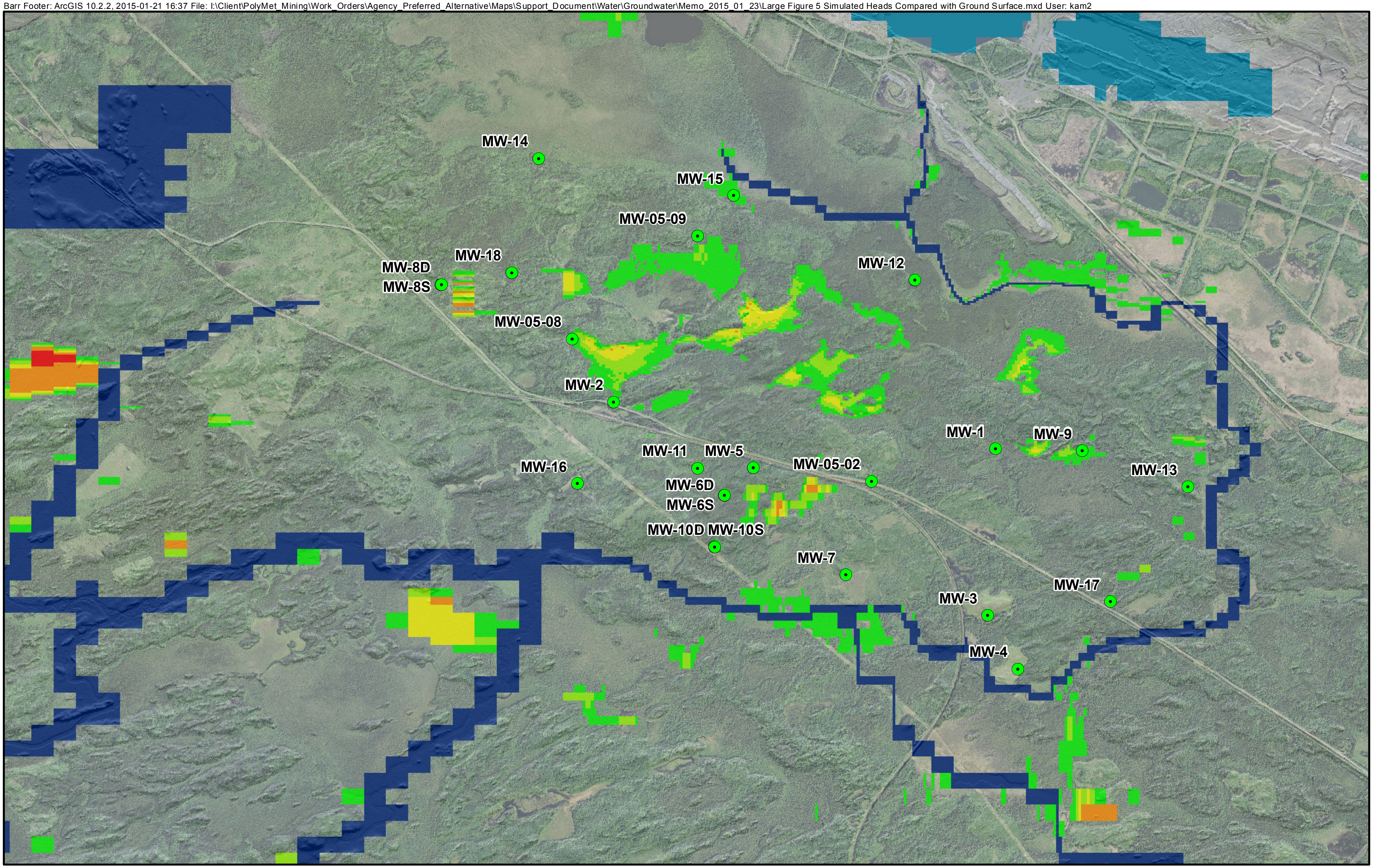
Large Figure 3
SIMULATED GROUNDWATER HEAD CONTOURS AND HEAD RESIDUALS - LAYER 2
NorthMet Project
Poly Met Mining, Inc.




Large Figure 4

SIMULATED VS.
OBSERVED HEADS
SENSITIVITY RUN
NorthMet Project
Poly Met Mining, Inc.

Barr Footer: ArcGIS 10.2.2, 2015-01-21 16:37 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Water\Groundwater\Memo_2015_01_23\Large Figure 5 Simulated Heads Compared with Ground Surface.mxd User: kam2




Unconsolidated Monitoring Well

River Cell

Specified Head Cell

Simulated Head - Ft Above Ground

- >10
- 6-10
- 4-6
- 2-4
- 0-2

0 1,750 3,500 7,000

Feet

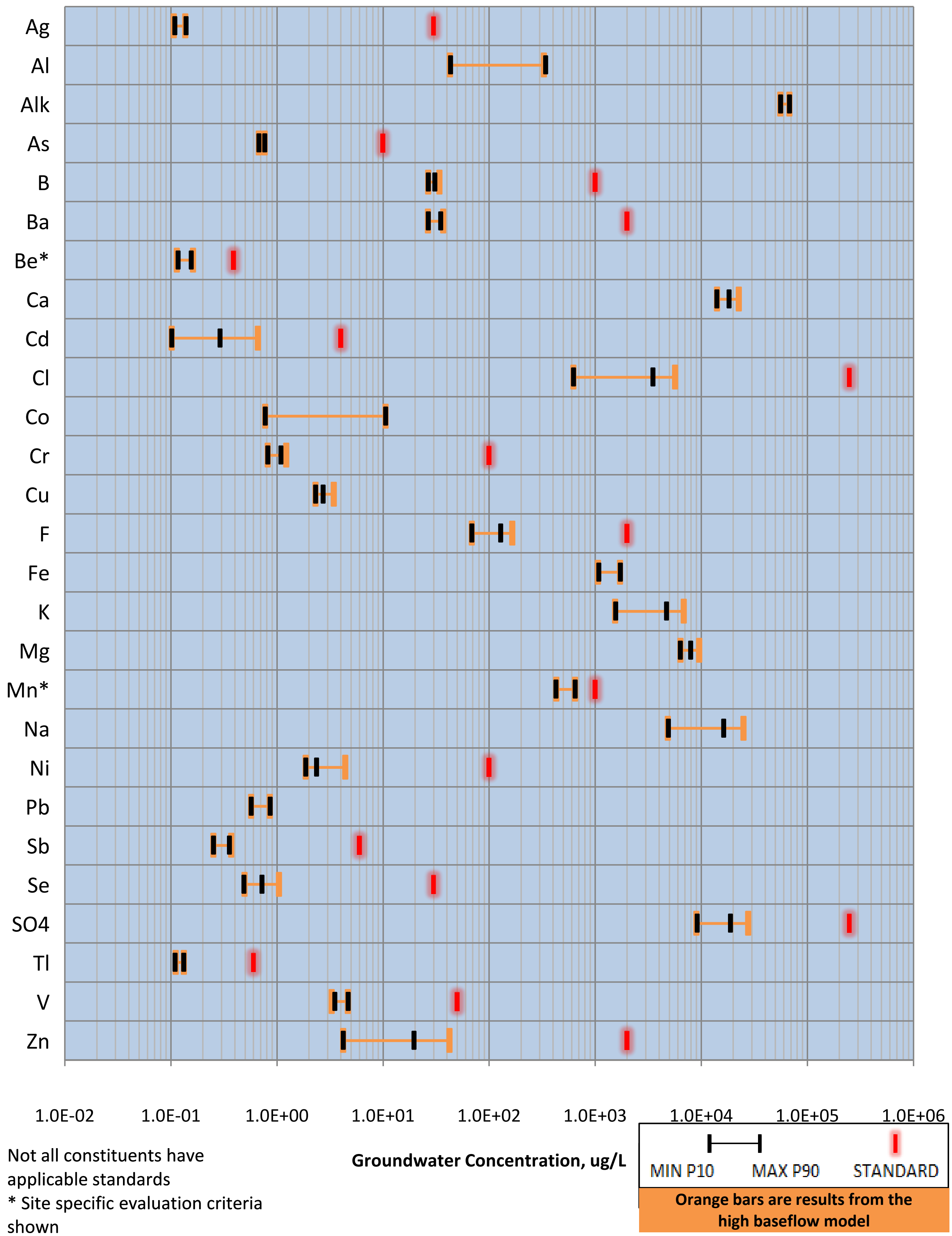
Large Figure 5
SIMULATED HEADS COMPARED WITH GROUND SURFACE
NorthMet Project
Poly Met Mining, Inc.

# Appendix L

## Groundwater Summary Plots for Mine Site High Baseflow Analysis

The plots in this appendix are reproduced with modifications from Large Figures 47-54 in Reference (1) and show:

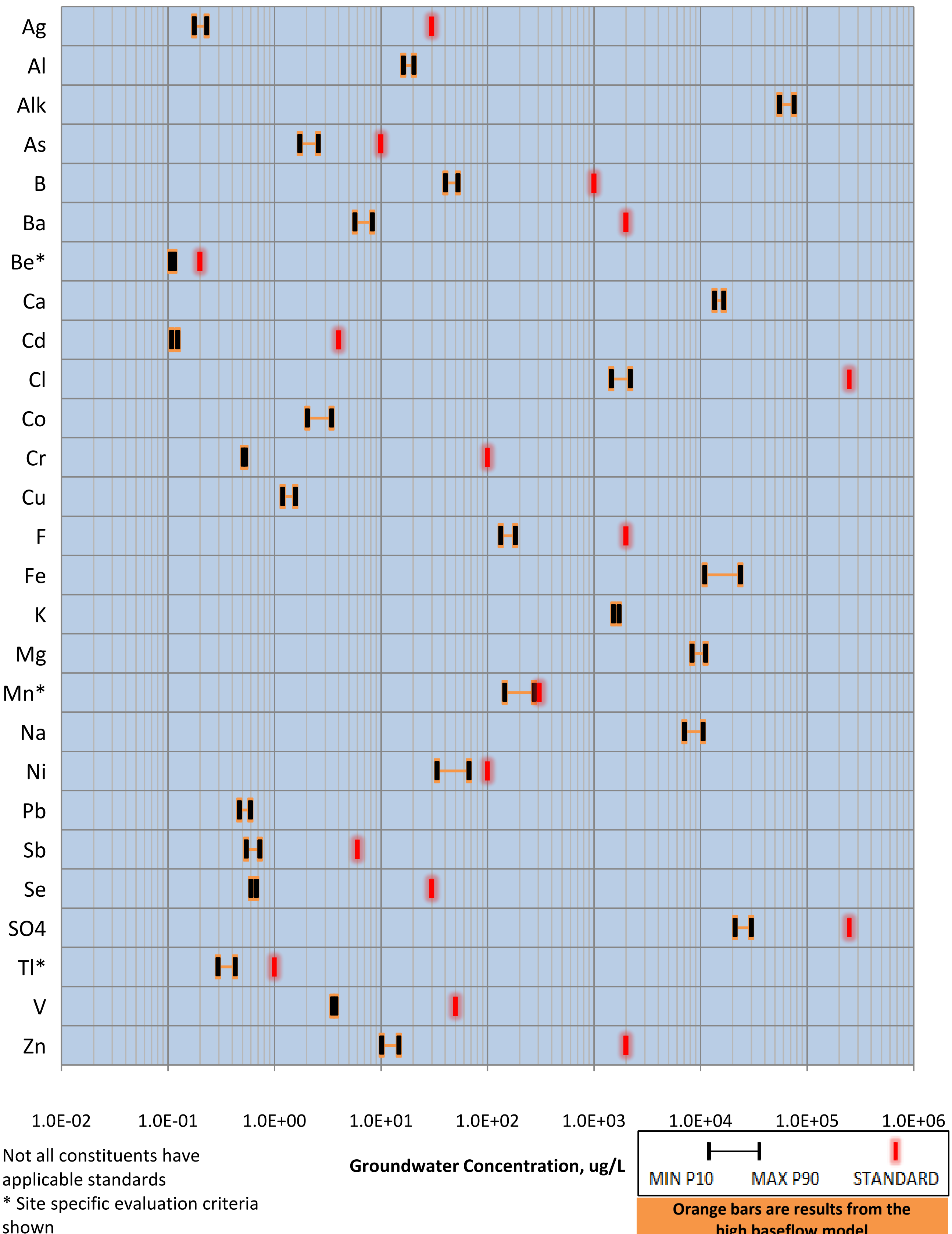
- Range from the maximum of the 90th percentile to the minimum of the 10th percentile for the Version 6.0 Mine Site model (black bars)
- Range from the maximum of the 90th percentile to the minimum of the 10th percentile for the high baseflow sensitivity model with the full range of background concentrations (orange bars)
- Applicable water quality standard (red bars)




Not all constituents have applicable standards

* Site specific evaluation criteria shown

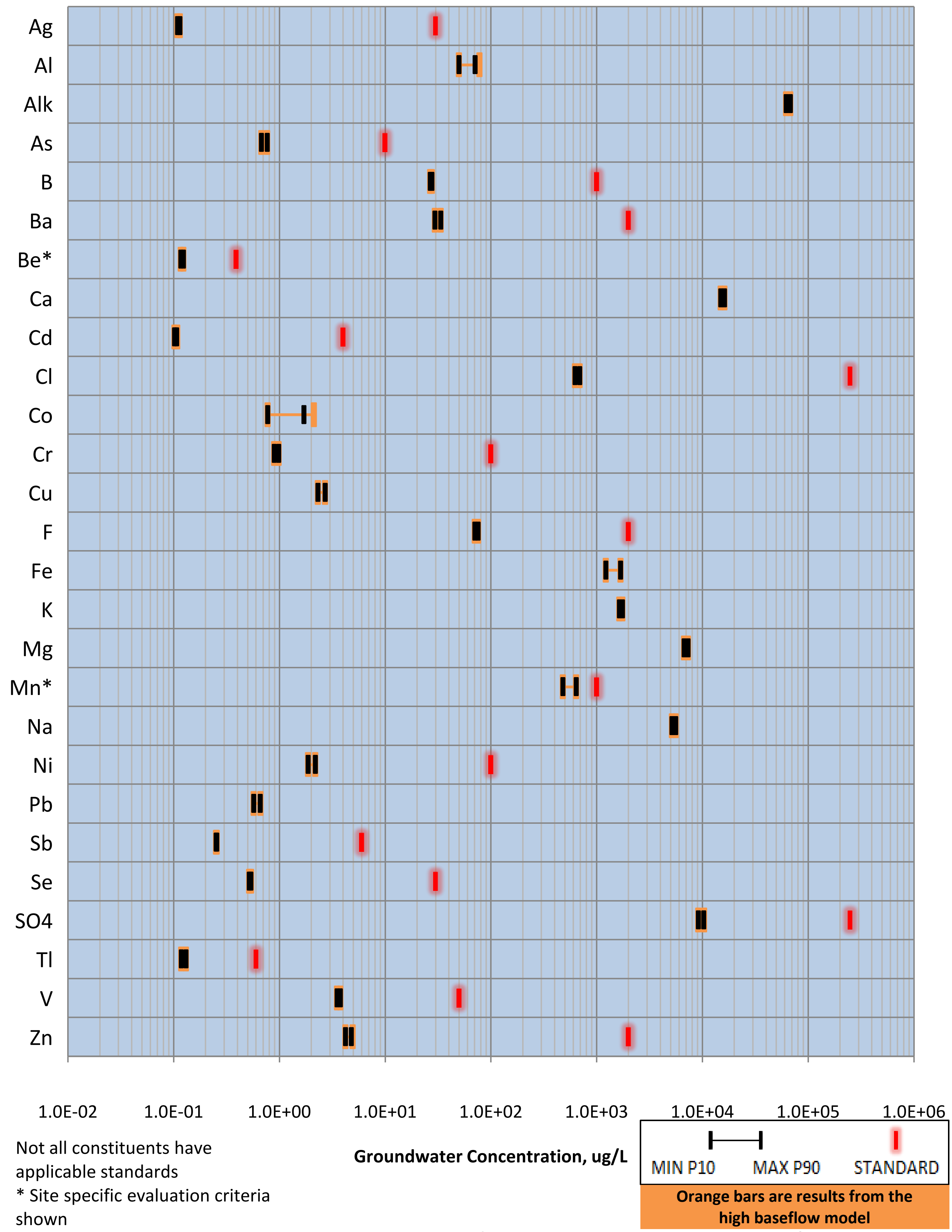
**Large Figure 47 MODIFIED Groundwater Concentration Ranges in the East Pit/Category 2/3 (surficial) Flow Path at the Property Boundary**




Not all constituents have applicable standards

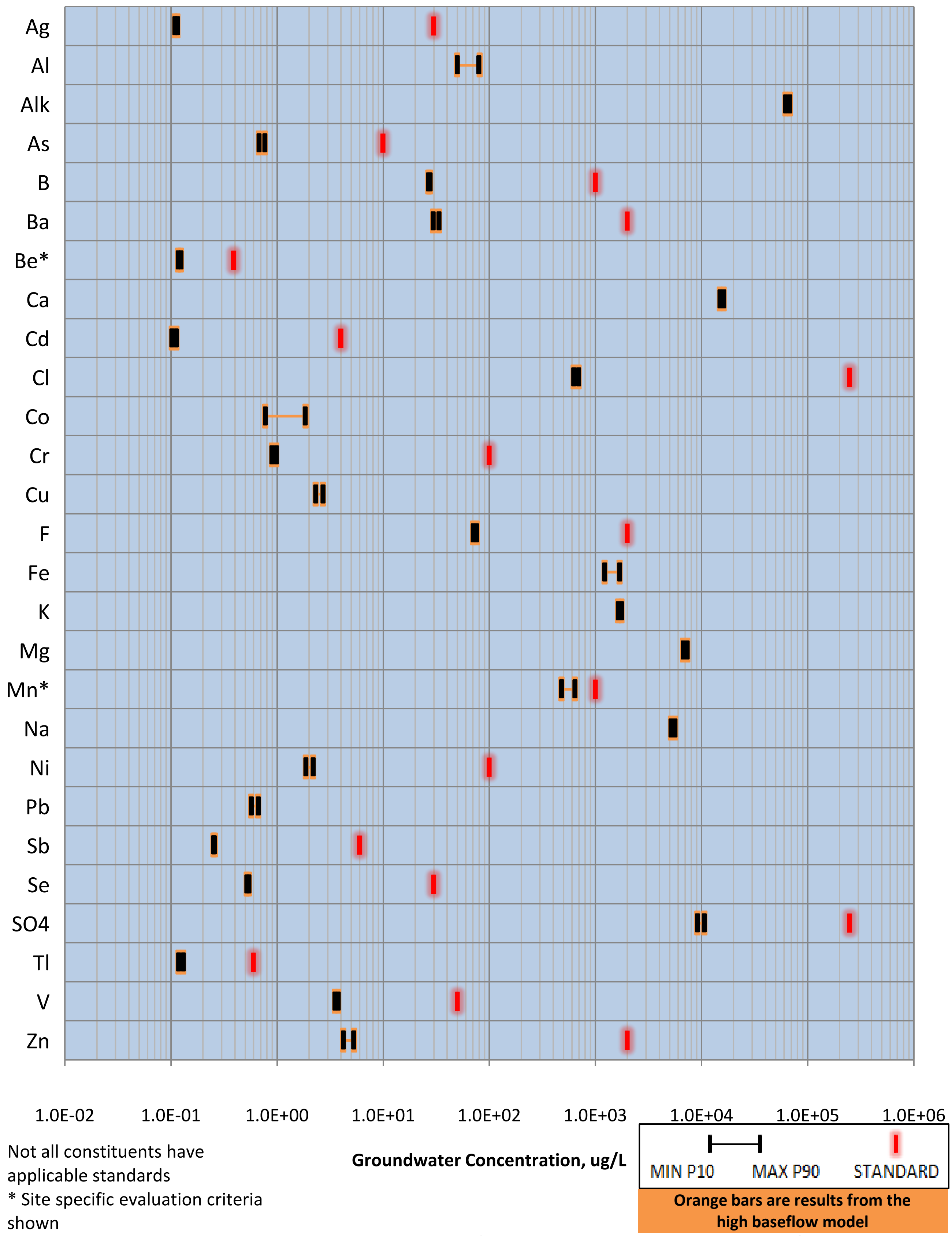
* Site specific evaluation criteria shown

**Large Figure 48 MODIFIED Groundwater Concentration Ranges in the East Pit (bedrock) Flow Path at the Property Boundary**



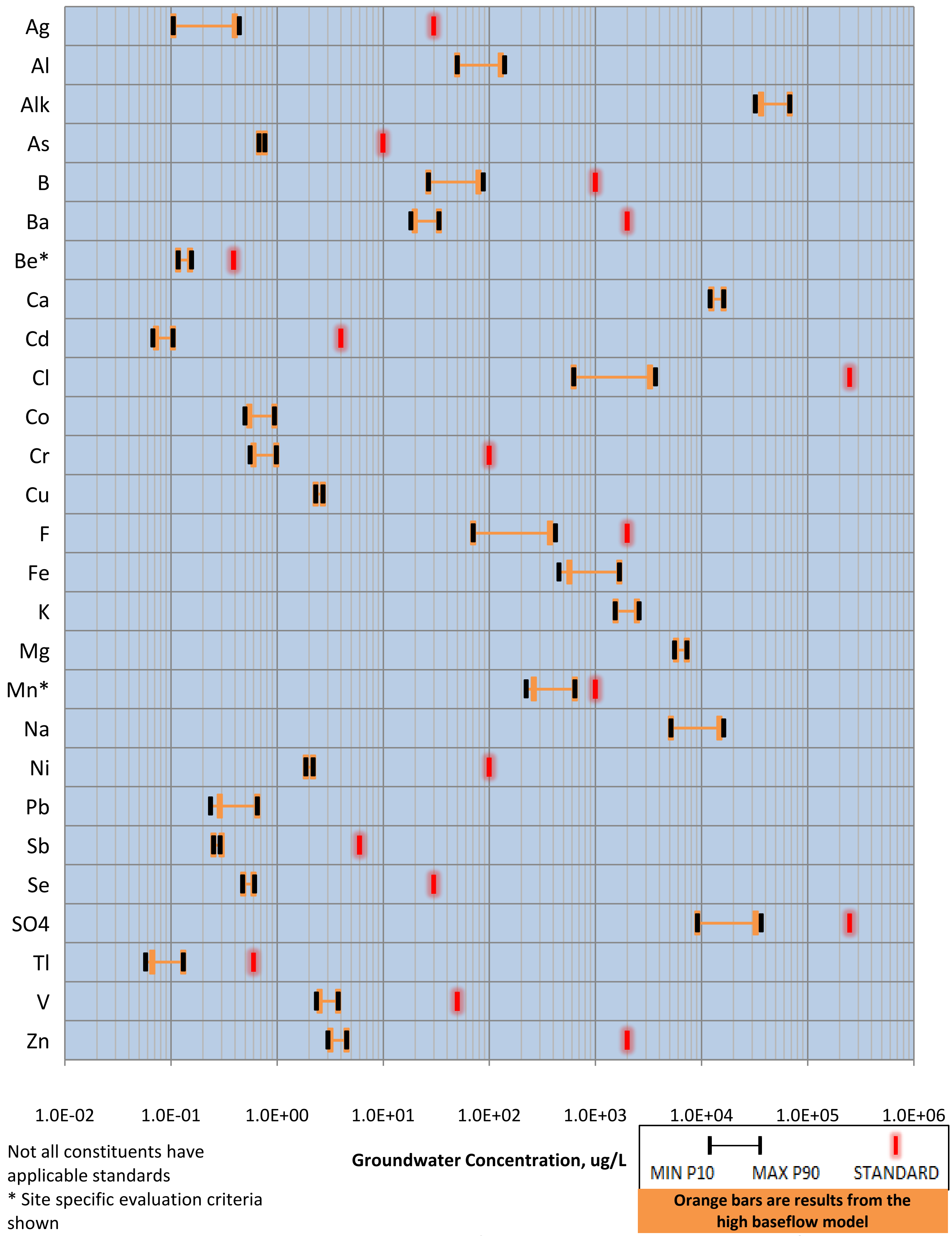

Not all constituents have applicable standards
* Site specific evaluation criteria shown

**Large Figure 49 MODIFIED Groundwater Concentration Ranges in the OSP (surficial) Flow Path at the Partridge River**



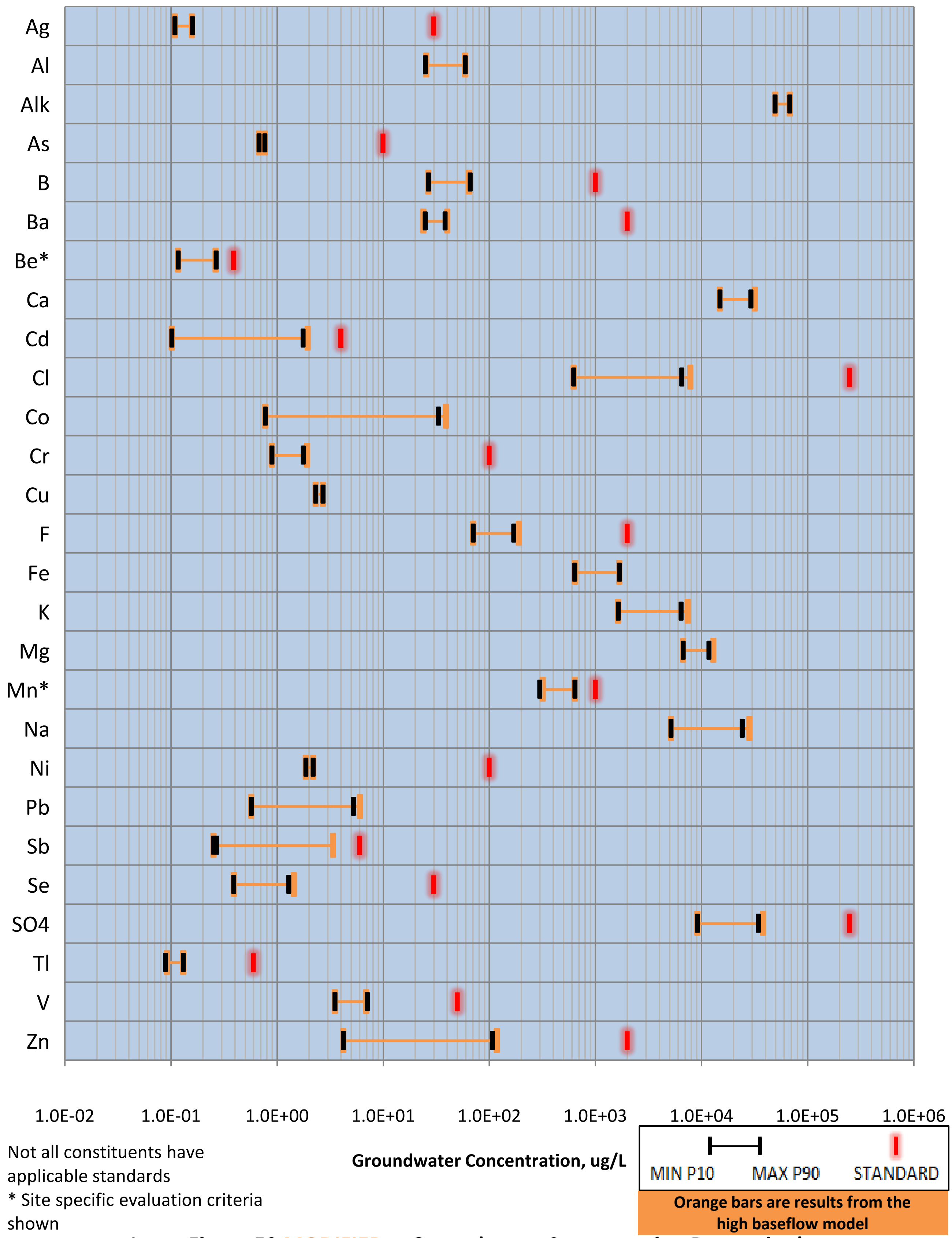

Not all constituents have applicable standards
* Site specific evaluation criteria shown

**Large Figure 50 MODIFIED Groundwater Concentration Ranges in the WWTF (surficial) Flow Path at the Property Boundary**



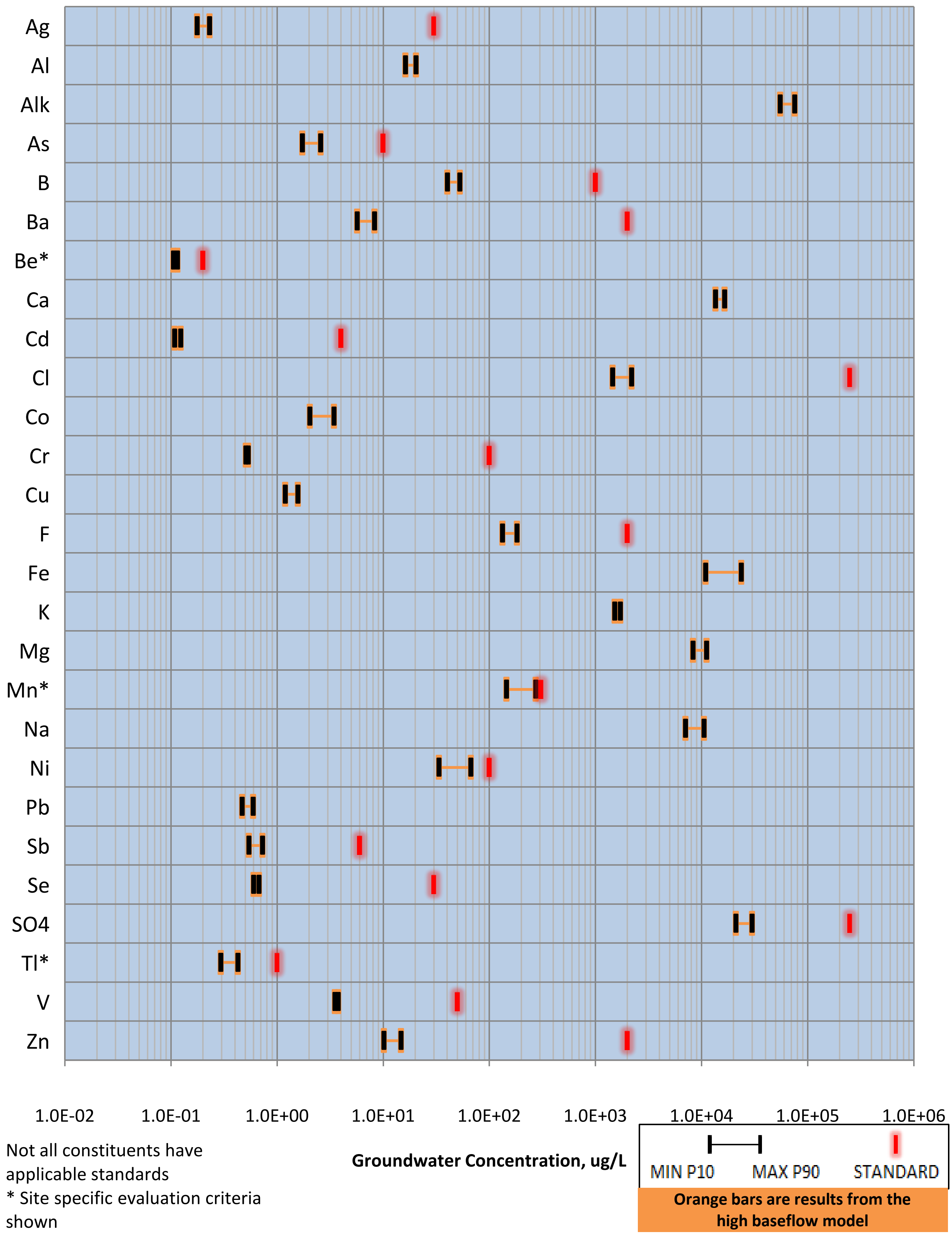

Not all constituents have applicable standards
* Site specific evaluation criteria shown

**Large Figure 51 MODIFIED Groundwater Concentration Ranges in the OSLA (surficial) Flow Path at the Property Boundary**




Not all constituents have applicable standards
* Site specific evaluation criteria shown

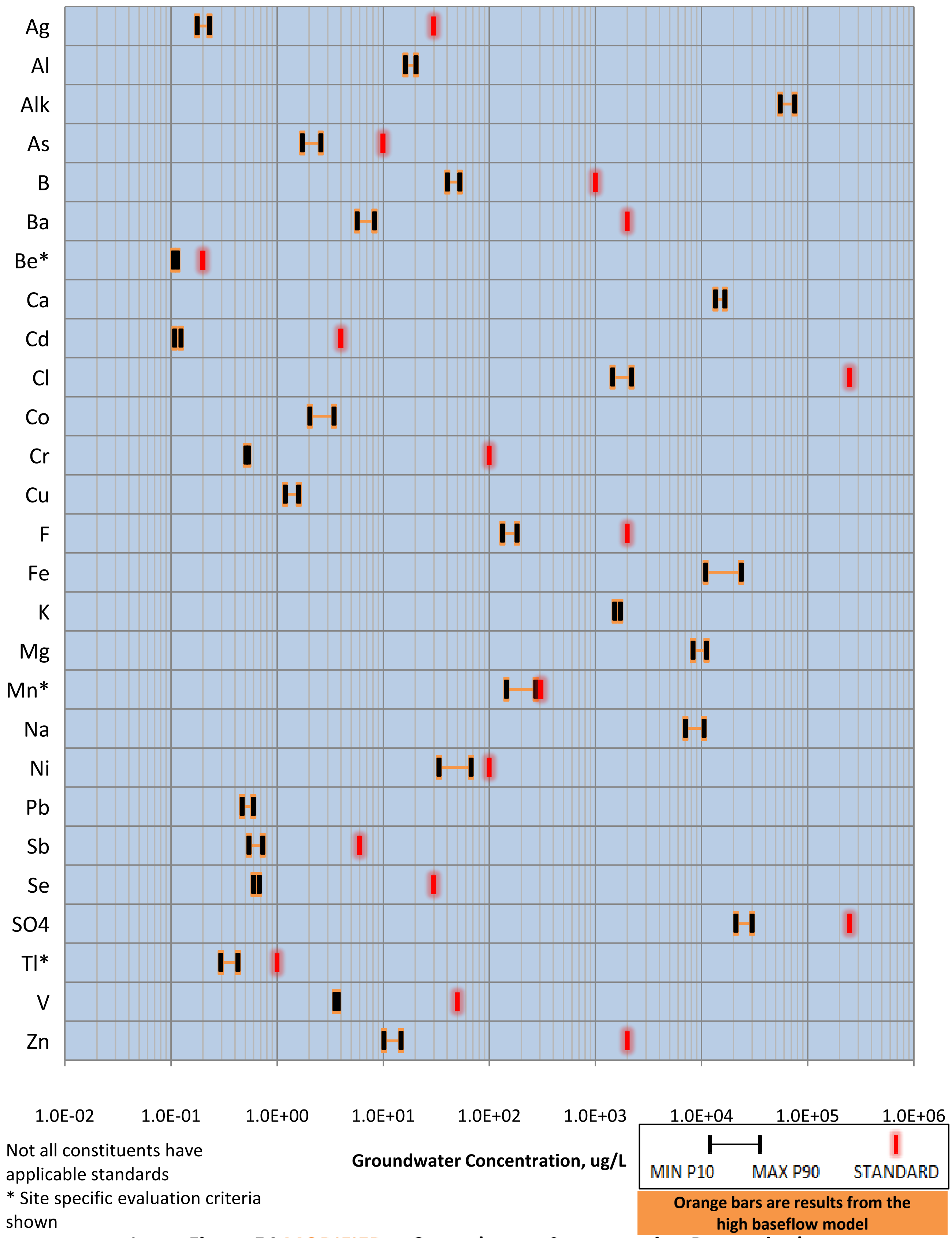
**Large Figure 52 MODIFIED Groundwater Concentration Ranges in the West Pit (surficial) Flow Path at the Property Boundary**




Not all constituents have applicable standards

* Site specific evaluation criteria shown

**Large Figure 53 MODIFIED Groundwater Concentration Ranges in the West Pit (bedrock to SW004) Flow Path at the Property Boundary**




Not all constituents have applicable standards
* Site specific evaluation criteria shown

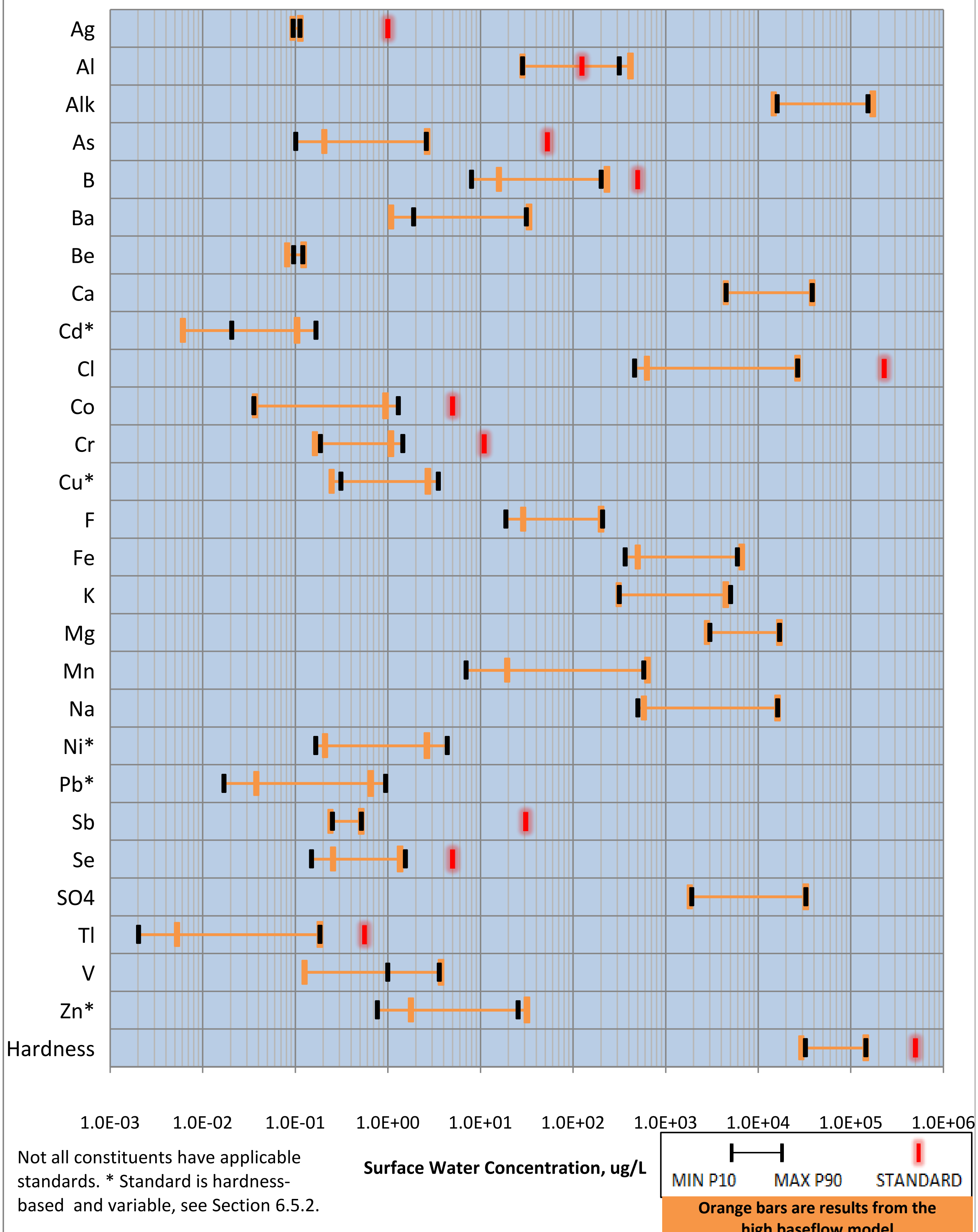
**Large Figure 54 MODIFIED Groundwater Concentration Ranges in the West Pit (bedrock to SW004a) Flow Path at the Property Boundary**

# Appendix M

## Surface Water Summary Plots for Mine Site High Baseflow Analysis

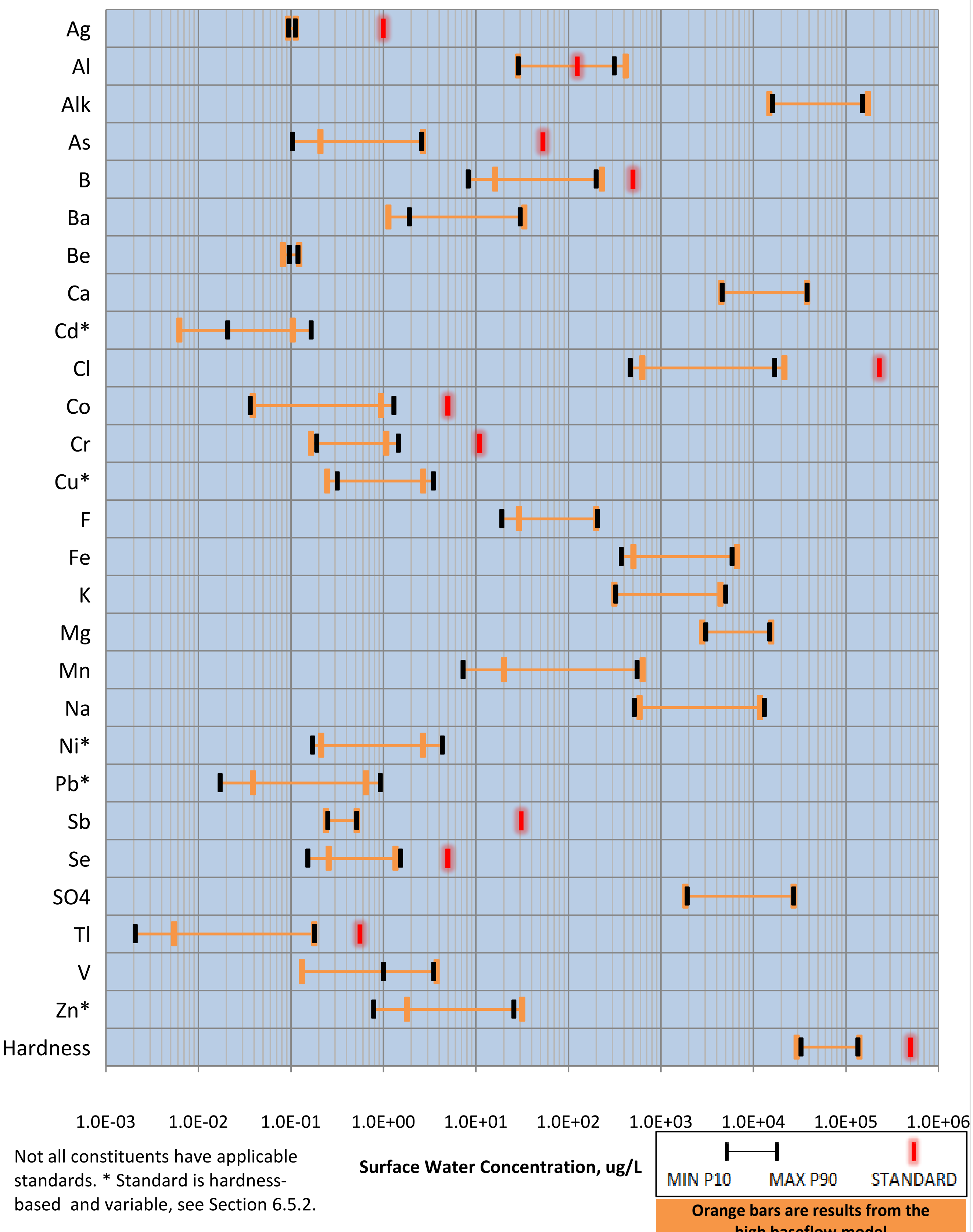
The plots in this appendix are reproduced with modifications from Large Figures 55-62 in Reference (1) and show:

- Range from the maximum of the 90th percentile to the minimum of the 10th percentile for the Version 6.0 Mine Site model (black bars)
- Range from the maximum of the 90th percentile to the minimum of the 10th percentile for the high baseflow sensitivity model with the full range of background concentrations (orange bars)
- Applicable water quality standard (red bars)



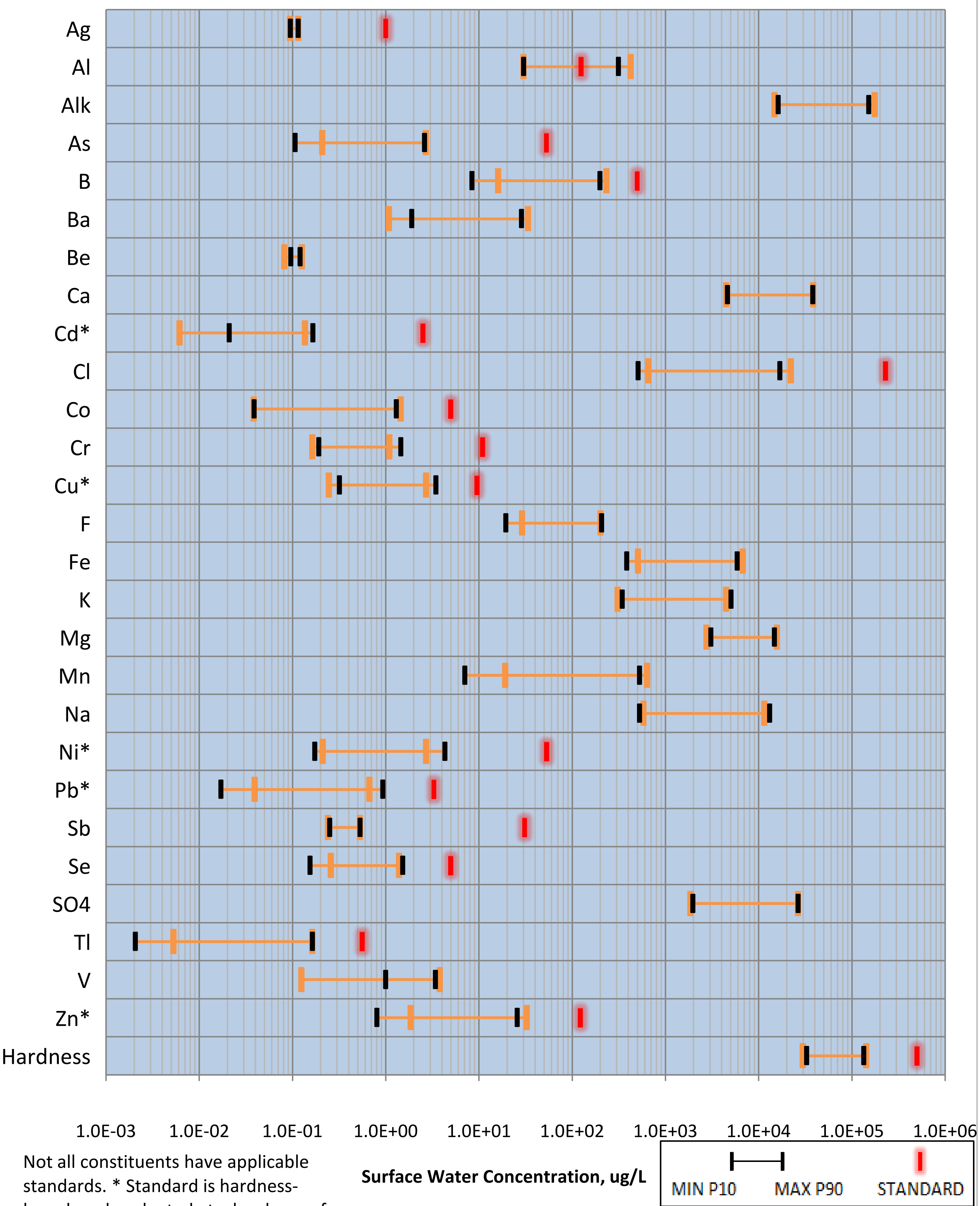

Not all constituents have applicable standards. * Standard is hardness-based and variable, see Section 6.5.2.

**Large Figure 55 MODIFIED Surface Water Concentration Ranges in the Partridge River at SW002**



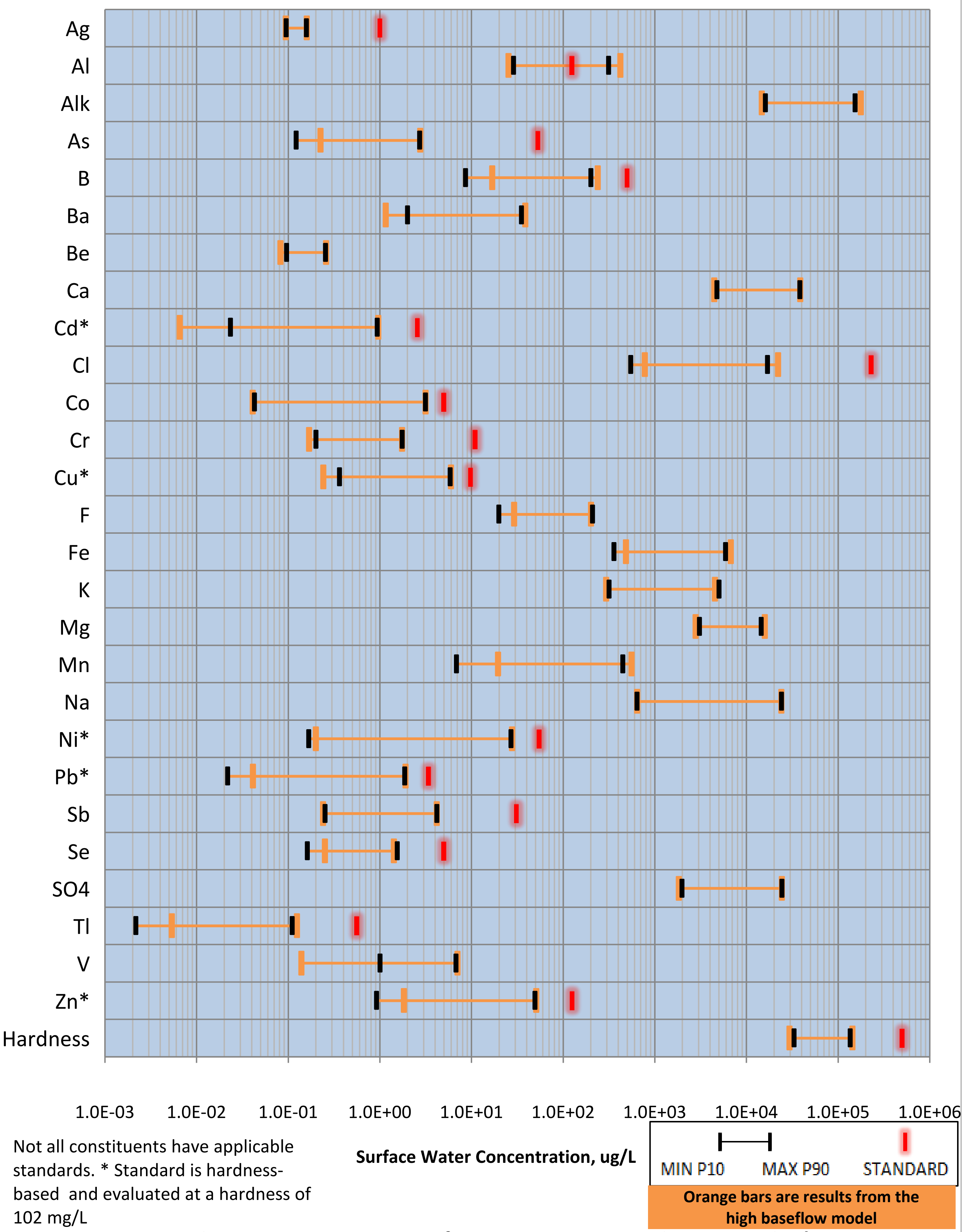

Not all constituents have applicable standards. * Standard is hardness-based and variable, see Section 6.5.2.

**Large Figure 56 MODIFIED Surface Water Concentration Ranges in the Partridge River at SW003**



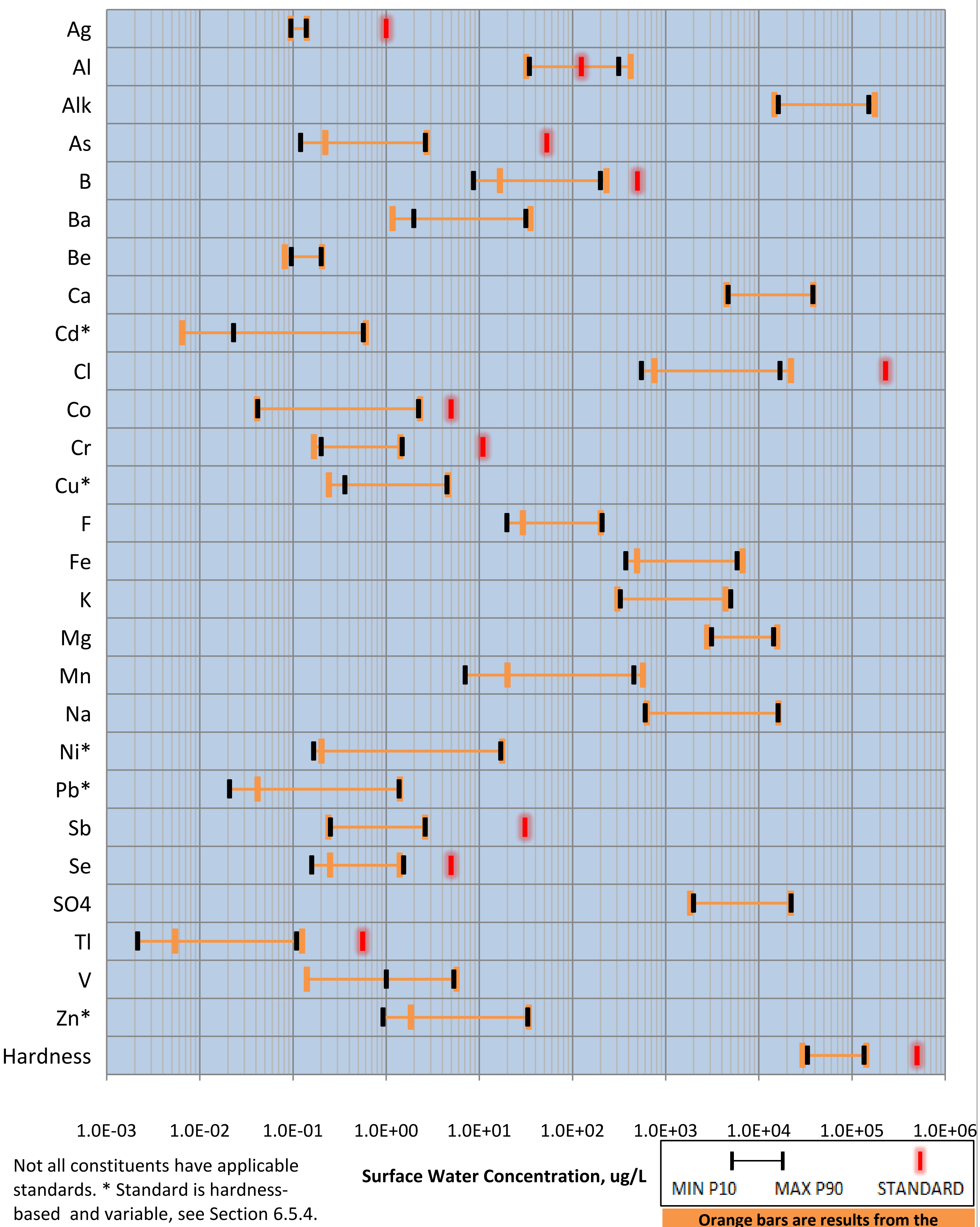

Not all constituents have applicable standards. * Standard is hardness-based and evaluated at a hardness of 90.8 mg/L

**Large Figure 57 MODIFIED Surface Water Concentration Ranges in the Partridge River at SW004**



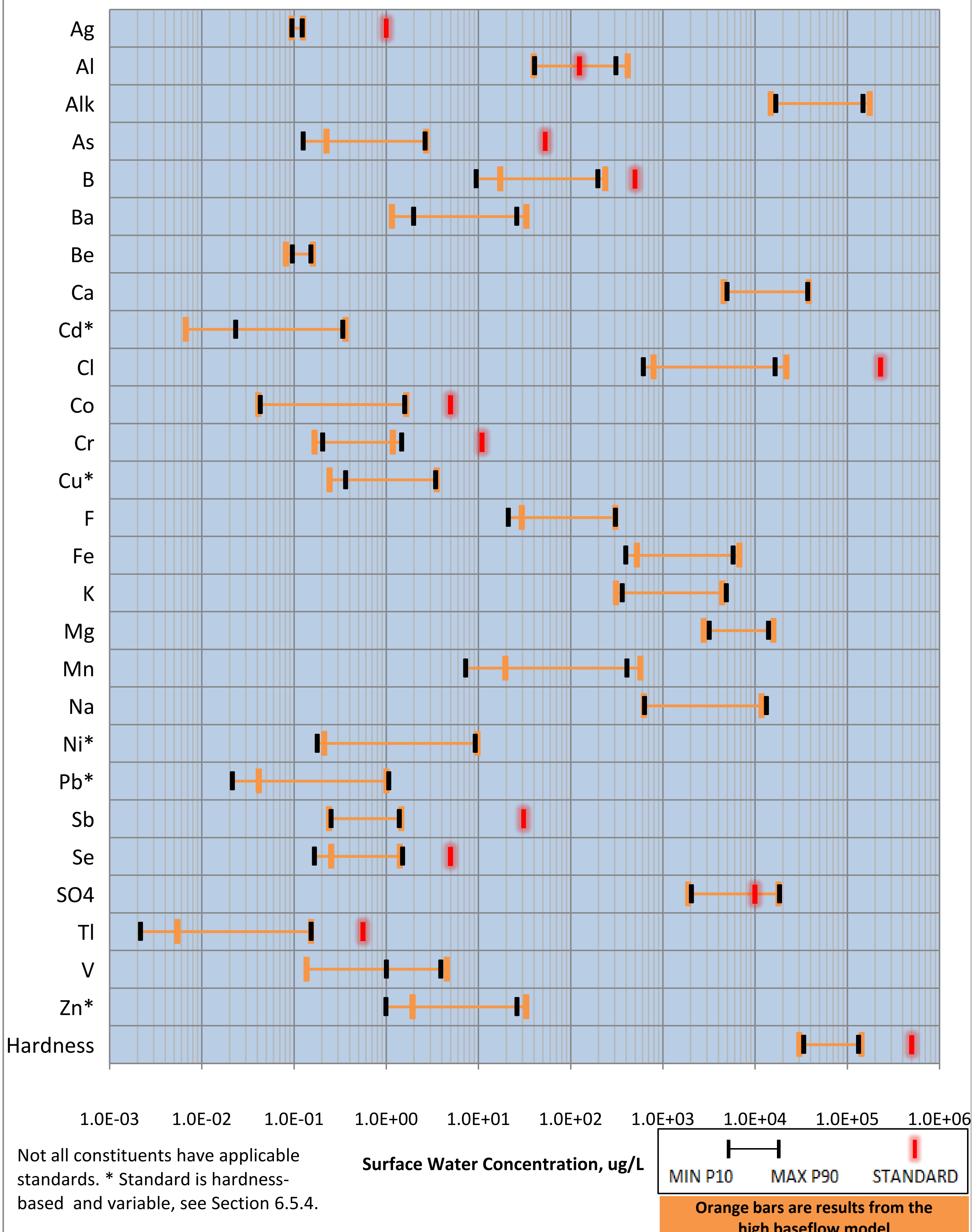

Not all constituents have applicable standards. * Standard is hardness-based and evaluated at a hardness of 102 mg/L

**Large Figure 58 MODIFIED Surface Water Concentration Ranges in the Partridge River at SW004a**



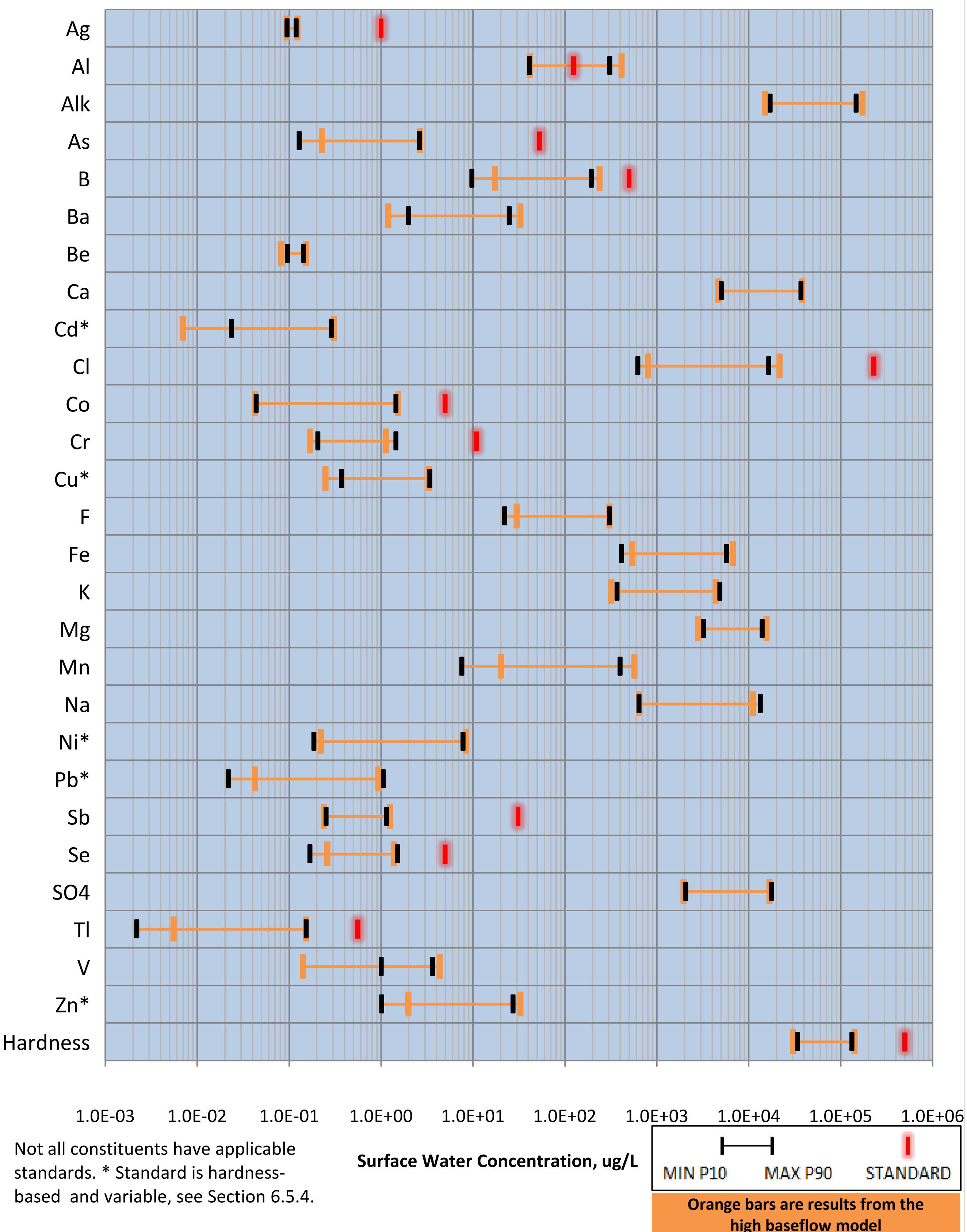

Not all constituents have applicable standards. * Standard is hardness-based and variable, see Section 6.5.4.

**Large Figure 59 MODIFIED Surface Water Concentration Ranges in the Partridge River at SW004b**



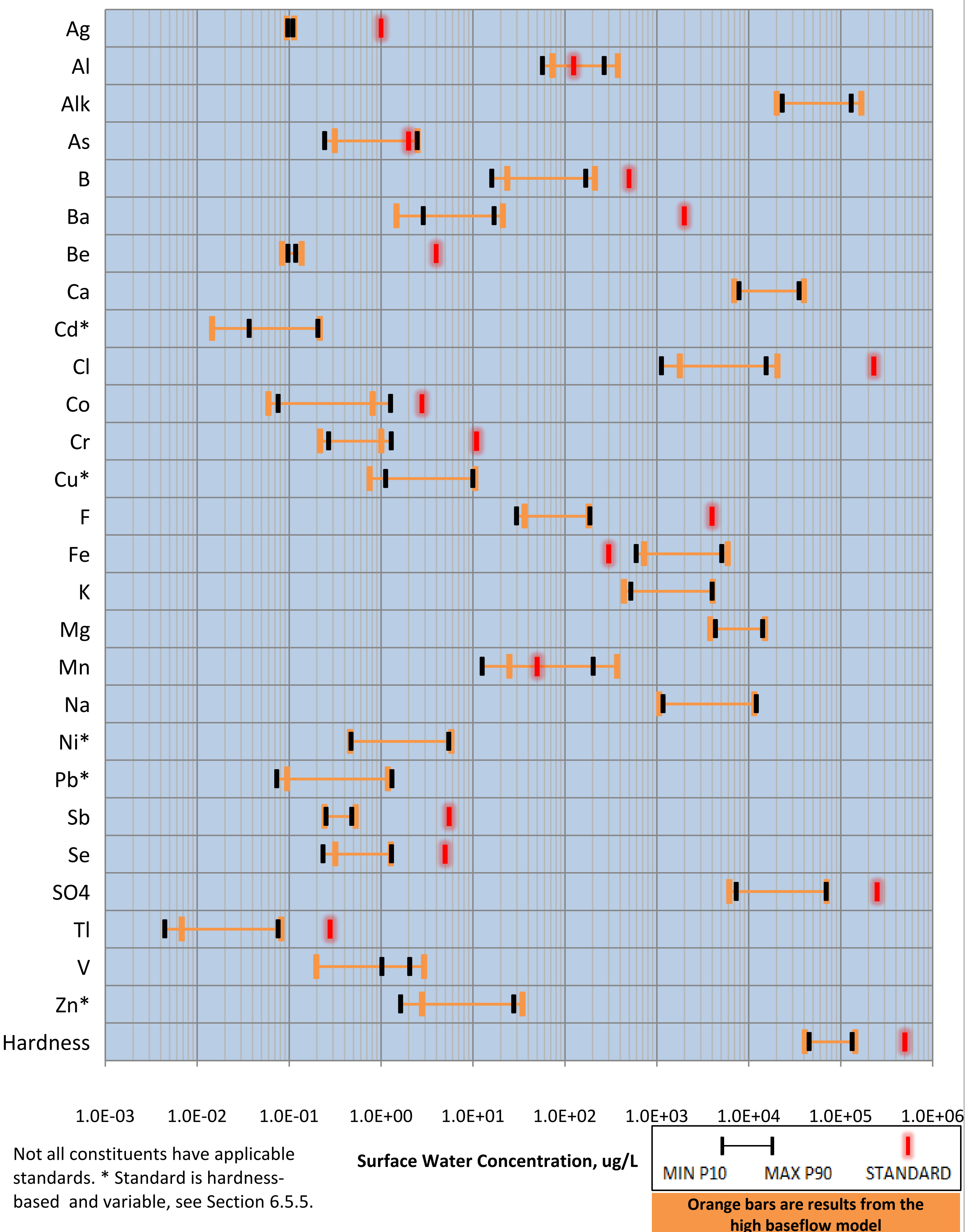

Not all constituents have applicable standards. * Standard is hardness-based and variable, see Section 6.5.4.

**Large Figure 60 MODIFIED Surface Water Concentration Ranges in the Partridge River at SW005**




Not all constituents have applicable standards. * Standard is hardness-based and variable, see Section 6.5.4.

**Large Figure 61 MODIFIED Surface Water Concentration Ranges in the Partridge River at SW006**




Not all constituents have applicable standards. * Standard is hardness-based and variable, see Section 6.5.5.

**Large Figure 62 MODIFIED Surface Water Concentration Ranges in Colby Lake**