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A Reproductive and Trophic Transfer Study Associated with Selenium Concentrations in the Upper Mud River Watershed

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A REPRODUCTIVE AND TROPHIC TRANSFER STUDY ASSOCIATED WITH SELENIUM CONCENTRATIONS IN THE UPPER MUD RIVER WATERSHED

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ABSTRACT

Selenium in mining-related discharges has created concern in the Appalachian Region where coal is a significant resource. In West Virginia, evaluation of streams receiving mining discharges focused attention on the Mud River watershed where bioaccumulation of selenium was highest in preliminary surveys. Chronic exposure (mainly dietary) of mature female fish to selenium has the potential to cause developmental abnormalities in developing embryos due to the maternal transfer of selenium into the eggs. Literature suggests that factors affecting the bioaccumulation rate of selenium, and the concentration of selenium associated with the aforementioned effects are site-specific. The purpose of this study was to determine the whole-body selenium tissue concentration which is protective of aquatic life in the watershed as defined by the effective concentration resulting in greater than ten percent deformity (EC_{10}). Further, this study was undertaken to evaluate whether whole-body tissue concentrations in fish in the watershed are within an acceptable range and to test a trophic transfer model which would allow monitoring of selenium whole-body fish tissue concentrations via modeling of the food chain using periphyton (algae) and water column selenium concentrations. By evaluating larval fish deformities within the Mud River watershed, it is demonstrated that a whole-body selenium value of 23.69 mg/kg dry weight (dw) selenium is the concentration shown to be protective of fish communities in this watershed. Whole-body fish tissue concentrations from streams sampled within the watershed generally show compliance with this safe level. Predicting the whole-body concentration using the trophic transfer model was successful for the streams evaluated except for Sites 1 and 2 where variable interactions and site variability reduced the

models predictive ability. This analysis confirms the trophic transfer model as a useful predictive tool in this watershed.

INTRODUCTION

Mining-related discharges containing selenium have created concern in the Appalachian Region where coal is a significant resource. In West Virginia, evaluation of streams receiving mining discharges focused attention on the Mud River watershed where bioaccumulation of selenium was highest in preliminary surveys (WVDEP, 2009). Chronic exposure (mainly dietary) of mature female fish to selenium has the potential to cause developmental abnormalities in developing embryos due to the maternal transfer of selenium into the eggs (GEI Consultants, Golder Associates, Parametrix, & University of Saskatchewan, 2008). Fish population effects can be seen when developmental abnormalities reach levels which impair recruitment to the population. The level at which populations may be affected has been suggested to be abnormality rates of ten percent or greater (EC_{10}) (GEI Consultants et al., 2008). Factors affecting the bioaccumulation rate of selenium, and the concentration of selenium associated with the aforementioned effects are site-specific.

The purpose of this study was:

- to determine the whole-body selenium tissue concentration which is protective of aquatic life in the watershed as defined by the effective concentration resulting in greater than ten percent deformity (EC_{10});
- to evaluate whether whole-body tissue concentrations in fish in the watershed are within an acceptable range based on the calculated EC_{10}; and
- to test a trophic transfer model which would allow monitoring of selenium whole-body fish tissue concentrations by modeling using periphyton and water column selenium concentrations.

Selenium-induced deformities can include spinal curvatures, missing or deformed fins, craniofacial deformities, and edema. Swelling of the yolk sac, or yolk sac edema, is also associated with selenium, but may not result in permanent abnormalities (Chapman, P.M., Adams W.J., Brooks M.L., Delos C.G., Luoma S.N., Maher W.A., Ohlendorf H.M., Presser T.S., & Shaw D.P., 2009), therefore only the teratogenic deformities were used in the EC_{10} evaluation. An EC_{10} value, the value at which 10% of the fish larval population is deformed, is the point which is considered to be protective of the population (GEI Consultants et al., 2008). Hypothesis testing statistics are not appropriate for ecological toxicity due to high variability of outcomes (GEI Consultants et al., 2008). A point estimation approach has more consistency in outcomes which allows for more accurate comparisons between different watersheds and fish species (GEI Consultants et al., 2008). Point estimations of both EC_{10} and EC_{20} have been used in estimating toxicity, however, EC_{10} is more conservative for a broad application use (GEI Consultants et al., 2008). DeForest et al. evaluated 22 studies involving 12 fish species across North America and concluded that an egg/ovary concentration of 20 mg Se/kg satisfied the EC_{10} criteria (DeForest, D. K., Gilron, G., Armstrong, S. A., & Robertson, E. L., 2011).

As selenium uptake is known to occur primarily through the dietary exposure route, biological characterization has included each trophic level from algae (primary producers) through the primary consumers (macroinvertebrates) through the top consumers, generally fish. Reproductive health was evaluated in streams with varying selenium conditions by evaluation of fish larval deformity rates, and selenium accumulation was weighed in each trophic level of the community.

LITERATURE REVIEW

Selenium bioaccumulation is primarily through dietary exposure (Conley, J. M., Funk, D. H., & Buchwalter, D. B., 2009). Conley et al. (2009) also noted that dietary selenium concentrations, rather than dissolved selenium concentrations, were better at predicting the adult body burdens. Selenium is exposed to the parent fish through diet and is subsequently deposited in the eggs, particularly the yolks (Lemly, 1997).

When cells are carrying out protein synthesis, they cannot differentiate between sulfur and selenium due to the similar chemical structure of the two. When there is an excessive amount of selenium and it is substituted for sulfur, the chemical bonds are different and consequently the proteins and enzymes are dysfunctional (Lemly, 1997). A study published in 2001 (Brix, K. V., Volosin, J. S., Adams, W. J., Reash, R. J., Carlton, R. G., & McIntyre, D. O., 2001) indicated that the relationship between ambient sulfate water concentrations and acute selenate toxicity is substantial. Although acute toxicity will vary among species, sulfate is shown to inhibit selenate bioavailability due to the structural similarity of sulfate and selenite (Brix et al., 2001).

Speciation of selenium is important due to variations in toxicity and adsorption of the different selenium species (Goldberg, S., Martens, D.A., Forster, H.S., & Herbel, M.J., 2006). Selenomethionine is the most readily bioaccumulated and toxic organic form of selenium, followed by selenite and selenate, respectively (Lemly, 1997). Regardless of what form, the selenium is processed and included into the yolks as mostly seleno-amino acids, therefore terata can be caused by all forms of selenium (Lemly, 1997).

Both hard and soft fish tissues can be deformed as well as some tissues not being produced at all (Lemly, 1997). Selenium toxicity may be effectively assessed in fish communities by the evaluation of teratogenesis. A study (Holm, J., Palace, V.P., Wautier, K., Evans, R.E., Baron, C.L., Podemski, C., Siwik, P., & Sterling, G., 2003) compared three different methods for evaluating larval deformities. Of the three methods, frequency analysis, a graduated severity index, and morphometric analysis, frequency analysis was found to be the quickest, most cost effective method (Holm et al., 2003). Additionally, data generated by the frequency analysis were more valuable in site-specific toxicity threshold derivation (Holm et al., 2003).

Because larval fish heavily rely on the selenium-laden yolk sac once they are hatched, selenium levels do not affect hatchability, but it does affect survival after hatching (Lemly, 1997). Based on studies of Centrarchidae and Cyprinidae, about 80% of teratogenically deformed larvae die regardless of the selenium levels whereas only 25% of juvenile and adult with these deformities die (Lemly, 1997). For this reason, Lemly recommends that larval fish should be utilized for these assessments more so than the juvenile or adult fish.

Lemly (1997) developed an index to assess the impacts to fish populations by examining the occurrence of teratogenic deformities in the larvae. Lemly suggested that less than 5% terata-induced population mortality was considered a negligible impact, a slight to moderate impact was between 5 and 20%, and greater than 20% was a major impact. Poor reproduction due to selenium-induced impacts, as opposed to varying water levels, predation, food shortage, and poor recruitment, can be verified by utilizing this index (Lemly, 1997).

The biomagnifications step between water and primary producers is larger than that between primary producers to aquatic invertebrates (Conley et al., 2009). Conley et al. (2009) focused a study on selenium bioaccumulation in the mayfly, Centroptilum triangulifer, by allowing the selenium in periphyton which was then fed to the mayfly. The results suggested that, not only is this species a medium for selenium bioaccumulation through the trophic transfer, but it is potentially affected by the selenium exposure itself by growth and/or reproduction changes (Conley et al., 2009). In this study, however, only selenium as selenite was infused into the periphyton (Conley et al., 2009). Selenite is only one form of selenium and it is noted in the text that selenium bioaccumulation varies due to both different species' physiology as well as the geochemical forms of selenium (Conley et al., 2009). Bioaccumulation of metals is site-specific and is influenced by water and sediment compositions, trophic relationships, habitat, stressor, receptor, active regulation of body burdens, and saturable uptake kinetics (Brix, K. V., Toll, J. E., Tear, L. M., DeForest, D. K., Adams, W. J., 2005).

The extent to which selenium adversely affects fish varies (Lohner, T. W., Reash, R. J., Willet, E. V., & Rose, L. A., 2001). These variations may be due to coal ash chemistry, receiving stream characteristics, population exposures, trophic status, habitat preference, and/or mobility (Lohner et al., 2001).

The study by Van Derveer and Canton (1997) indicates that selenium sediment concentration in lotic systems is directly related to sediment organic carbon. Moreover, organically rich streams have the potential to accumulate more selenium in sediments and organically poor streams have the potential to have higher selenium water concentrations (Van Derveer & Canton, 1997). It is also suggested that selenium standards or criteria protecting bioaccumulation in fish and wildlife should be based on modeling with particulate concentrations (Van Derveer & Canton, 1997).

Presser and Luoma (2010) developed a methodology for hypothesizing and measuring selenium concentrations bioaccumulated through the food chain. This model demonstrates safe selenium levels will fluctuate among ecosystems depending on the biogeochemical conditions and ecological pathways (Presser & Luoma, 2010).

RESEARCH METHODS

Site description

An evaluation of the condition of the biological communities and the extent to which elevated selenium levels may be affecting these communities was conducted in the Mud River watershed between 2009 and 2010. The watershed lies in the Cumberland Mountains of the Central Appalachian Plateau in West Virginia. Mining, forestry, and natural gas are the significant economic contributors in the watershed (USEPA, 2004; Woods, A.J., Omernik, J.M., & Brown, D.D., 1999). Coal mining has been ongoing in the basin since the completion of the Norfolk and Western Railroad in the late 1800s. Large scale surface mining (known as mountaintop mining) began in the early 1980s in response to the increased demand for low sulfur coal (USEPA, 2004). In this watershed, there is a strip of land approximately 5 miles wide which lies in the primary mountaintop mining area as described by the West Virginia Geological and Economic Survey. Multiple coal seams are horizontally bedded and most mines extract five or more seams. The primary physiography is unglaciated divided hills and mountains with abrupt slopes and narrow ridges and the primary geology is Pennsylvania sandstone, siltstone, shale and coal of the Pottsville Group and the Allegheny Formation (Woods et al., 1999).

Fish egg collection was conducted in five streams in the Mud River watershed are shown in **Table 1**, **Appendix A**, and periphyton was collected in six streams in the same watershed (**Table 2, Appendix A**).

Reproductive study methods

Eggs were collected in the watershed in spring 2009 and 2010 and each nest was reared in a laboratory with water from each site. After egg hatching in each tank, a subset of larvae was collected every 2 to 3 days until the majority became free swimming. Upon collection, larvae were transferred to labeled plastic jars with a small amount of water and placed in a freezer for 30-60 minutes to anesthetize prior to preserving them in a pre-buffered formalin solution (Formalin 10). After evaluating the larvae for deformities, they were transferred to a 70% ethanol solution for long-term storage.

Preserved larval fish specimens were observed using a dissecting microscope and evaluated for deformities. Each specimen was viewed and the number of the following types of deformities were observed:

- Craniofacial – deformities that are associated with the head region (extension or reduction of jaw structure, malformations, eye diameter, etc.);
- Skeletal – deformities associated with the notochord or spine (severe bends or curvature along the notochord);
- Yolk Sac Edema – deformities associated in the yolk sac during larval development (accumulation of excess body fluid in the yolk sac);
- Finfold – deformities associated among the fins (absence or malformation associated with any developed / developing fins); and

- Teratogenic – the sum of permanent developmental deformities that are not reversible, which are craniofacial, skeletal and finfold deformities.

The larval specimens were identified down to the lowest practical taxon. The following literature was used for the identification and deformity evaluation of larval specimens: Auer, N. A., & Great Lakes Fishery Commission's (1982) "Identification of Larval Fishes of the Great Lakes Basin with Emphasis on the Lake Michigan Drainage," Holm's (2003) "An Assessment of the Development and Survival of Wild Rainbow Trout (*Oncorhynchus mykiss*) and Brook Trout (*Salvelinus fontinalis*) Exposed to Elevated Selenium in an Area of Active Coal Mining", and Lemly's (1997) "A Teratogenic Deformity Index for Evaluating Impacts of Selenium on Fish Populations" along with other noted literature (Holm, J., Palace, V., Siwik, P., Sterling, G., Evans, R., Baron, C., Werner, J., & Wautier, K. 2005; Margulies, 1983).

At the time of egg collections, water samples and representative species of fish were collected in the aforementioned streams by use of an electro-backpack shocker. The water and fish were stored in ice and transported to BioChem Testing Laboratories for selenium and whole-body selenium tissue analysis, respectfully. Half of the detection limit was used for values resulting in non-detect levels of selenium, for both water and fish tissue.

Modeling methods

Periphyton sampling was conducted from summer 2009 through spring 2010, quarterly, in six mine-influenced streams. Unglazed 1-inch x 1-inch tiles were placed in sampling sites and periphyton was allowed to colonize. Four tiles were randomly collected at two week intervals for a total of four samples per season. Periphyton was transported on ice and in dark containers and analyzed for selenium concentration (μg/m^2), ash free dry weight (AFDW) (g/m^2), and chlorophyll-a (mg/m^2) using laboratory methods EPA 6020, SM10300C.5, and SM10200-H, respectively. Any periphyton or water selenium measurements, as well as AFDW, which were below the detection limit were not used in the modeling. The detection limit for water concentration was 0.001 mg/L. The detection limit for periphyton concentration is based on the sample size and variable dilution volumes used in sampling processing. The detection limit for periphyton concentration ranged from 3.3 μg/m^2 to 17.2 μg/m^2. Non-detect values could have resulted from, not only low selenium levels, but also from scouring of the tiles during a high flow. Because the reason the measurements resulted in non-detect values is unknown, it would be inaccurate to include them in the data set. Furthermore, ratios calculated with half of the detection limit would be inaccurate and skew the fit of the model. Due to laboratory malfunction and stolen/washed out tiles various data points for all three parameters were missing throughout summer, winter and spring.

To calculate the particulate selenium concentration (μg/g) for a particular sampling event, the average periphyton selenium concentration (μg/m^2 dw) from the four tiles was divided by the average dry weight (g/m^3) (cf. AFDW) of the four tiles. In order to translate water-column selenium concentration to whole-body fish tissue concentration, several factors in each modeling event had to be selected. Selenium water column concentrations, which were sampled from summer 2009 through spring 2010, were used in the modeling. Both selenium water column and periphyton concentrations are shown in **Table 3, Appendix A**.

Fish species, predator food web, trophic transfer functions for fish and invertebrates, and the operationally defined distribution coefficient (K_d) were all independently selected for each modeling event. Additionally, selenium uptake was presumed to be seasonal due to seasonal periphyton productivity. The equation used for modeling whole-body selenium fish tissue concentration via periphyton selenium concentration is as follows:

$$C_{water} = (C_{fish}) \div (TTF_{fish}) (K_d) (TTF_{invertebrate})$$

K_d was calculated as the ratio of the particulate concentration to the water-column concentration. The trophic transfer functions (TTFs) were selected from a summary of TTFs derived from field averages of multiple matched data sets from sites with similar food webs or regressions for a series of individual sites with similar food webs (Presser & Luoma, 2010). If an invertebrate-to-fish TTF was not available, a TTF_{fish} of 1.1 was used, which is a mean value based on a study of 25 fish species. Most fish species consume a mixed diet, with an inclination towards certain types of food. When selecting TTFs for the food of individual fish species, the preferred foods and the available foods for that particular location and season were taken into account. In order to have the most accurate $TTF_{invertebrate}$, prey fractions for each species' foods were incorporated in the equation. Species designations were found in the USEPA's Rapid Bioassessment Protocols for Streams and Rivers (Barbour, M.T., Gerritsen, J., Snyder, B. D., & Stribling, J. B., 1999). Common foods for each species were found in the Fish and Wildlife Service's Habitat Suitability Index Models (McMahon, 1982; Stuber, R.J., Gebhart, G., & Maughan, O.E., 1982; Trial, J.G., Stanley, J.G., Batcheller, M., Gebhart, G., Maughan, O.E., & Nelson, P.C., 1983). The prey fractions that were chosen take into account, not only the preferred foods for each species, but the available foods in the Mud River watershed, the change in eating habits of each species as they mature, and the time for each species to mature. The United States Geological Survey's Habitat Suitability Index Models were referenced when choosing prey fractions for each of the modeled species. Prey fractions selected are shown in **Table 4, Appendix A**.

RESULTS

Reproductive study results

Average selenium fish tissue concentrations from each sampling site were compared with the percentage of teratogenic deformities found in larvae from the same site (**Table 5, Appendix A**). The highest average selenium fish tissue concentration and percent teratogenic deformities were both found in Sugartree Branch, while the lowest were both found in Upton Branch. Fish were not corrected for age, but all were adults of reproductive age.

From these evaluations the EC_{10} in the Mud River watershed was found to be 23.69 mg/kg dw. The regression coefficient (r^2 =0.7427) generated from this relationship is significant (**Figure 1, Appendix B**). Whole-body tissue concentrations ranged from 3.51 to 25.54 mg/kg dw in fish collected from the five sites in the watershed (**Appendix C**). These concentrations were generally below the projected EC_{10} with the exception of the one creek chub concentration of 25.54 mg/kg dw.

Modeling results

Modeled whole-body fish tissue concentrations of creek chubs, green sunfish, and blacknose dace were compared to measured whole-body fish tissue concentrations of the same species collected contemporaneously with the periphyton collection in 2009

(**Tables 6-8, Appendix A**). In general, modeled and measured values showed good agreement. As **Figures 2-4, Appendix B** illustrate, the majority of the modeled whole-body selenium fish tissue concentrations follow the same trends for each sampling site as the measured data.

To evaluate modeling accuracy, modeled whole-body fish tissue concentrations of creek chubs, green sunfish, and blacknose dace were statistically compared to measured whole-body fish tissue concentrations of the same species. For each fish species and site, the modeled and measured data were ranked and a general linear model (GLM) two-way analysis of variance (ANOVA) was utilized to compare the data.

As shown in **Table 9, Appendix A**, there was no significant difference in the measured and modeled data for all three fish species. As expected, however, there was a significant difference between whole-body selenium fish tissue concentrations and the sampling sites. Although these data demonstrate the accuracy of the modeling, the interaction probability levels for creek chubs and green sunfish conveys that there is an interference between the sampling site and the measured versus modeled data. That is to say, there is a difference in the predictability of the model at the different sites, or some sites are more accurately modeled than others. Raw data for modeling calculations and statistics may be found in **Appendices C** and **D**, respectively.

DISCUSSION

The reproductive health of the streams was evaluated by comparing the percentage of deformed fish larvae to the whole-body selenium concentration (mg/kg dw) in each stream. Despite having sampled in streams substantially influenced by mining, efforts did not generate deformity rates higher than the 10% which is considered to be protective of fish communities (GEI Consultants et al., 2008). As shown in **Table 5, Appendix A**, the deformity rates (teratogenic only - not including edema) were generally lower than the EC_{10} despite tissue concentrations greater than the whole-body screening level of 7.9 mg/kg dw (USEPA, 2004).

An ecosystem-scale model was developed to conceptualize and quantify the process of selenium moving through media in the food web of the Mud River watershed. By employing this type of modeling, dissolved selenium is related to bioaccumulated selenium by systematically quantifying each of the influential processes (Presser & Luoma, 2010). Translating selenium whole-body fish tissue concentrations to a dissolved selenium water column concentration can facilitate site-specific regulation, or show general comparisons among ecosystems (Presser & Luoma, 2010). Additionally, depending on the ecological pathways and biogeochemical conditions in the system, safe levels of dissolved selenium will vary among ecosystems (GEI Consultants et al., 2008). Ecosystem-scale modeling was utilized to predict whole-body selenium fish tissue concentrations from water column and periphyton in lotic systems, as shown in **Tables 6-8**, **Appendix A**.

These results were then statistically compared to actual whole-body fish tissue concentrations. The modeled fish tissues were similar to measured values with no significant differences between in green sunfish, blacknose dace or creek chubs. As expected, due to the differences in selenium exposures, significant differences were noted between the sites. The significant interactions indicate additional evaluations would be beneficial to determine factors not included in the model which may be influencing variability in the model and selenium bioaccumulation.

The trophic-transfer modeling of selenium was found to successfully predict measured concentrations at Sites 4-6, and may be a useful tool in selenium regulation and monitoring. However, inconsistencies in the data were present and it would be beneficial to further evaluate these discrepancies to better understand selenium cycling in the watershed. Similarly, whereas the strong correlation indicates that the EC_{10} for the lotic environment in the Mud River watershed is in the vicinity of 23.69 mg/kg dw, this estimate is based on a low number of data points. More data are necessary and would provide confidence in the relationship between selenium whole-body concentrations and teratogenic deformities.

Additional details from the study described herein can be found in "An Evaluation of the Effects of Selenium on Reproductive Success of Fish in Streams Receiving Coal Mining Discharges – 2010 (POTESTA, 2011a) and "Periphyton Report for the Streams of the Mud River Watershed" (POTESTA, 2011b).

CONCLUSIONS AND RECOMMENDATIONS

Although no deformity rates greater than 10% were measured, a fairly strong regression was generated by the data providing as site-specific screening value. The projected EC_{10} for whole-body fish tissue concentration, 23.69 mg/kg dw, was greater than tissue concentrations measured in most streams in the watershed and population level effects from selenium are not generally expected in lotic systems in the watershed. In one stream individual fish tissue concentrations slightly exceeded this number.

The reproductive study findings are consistent with a recent publication (Deforest et al., 2011) from Canada which summarized available data for developing selenium thresholds based on selenium egg/ovary concentrations. Deforest suggested that sufficient data were available to support a threshold for toxicity and finds a conservative egg/ovary guideline of 20 mg/kg dw. This value is conservative as it represents the 5th percentile of the species sensitivity distribution and no species mean toxicity thresholds lower than this have been identified. When tissue concentrations exceed the threshold, site-specific studies should be conducted to evaluate potential risks (Deforest et al., 2011). Using a site-specific whole-body to egg/ovary selenium concentration conversion factor developed for the Mud River watershed (POTESTA , 2011a), the 23.69 mg/kg dw selenium whole-body concentration converts to a selenium egg/ovary concentration of 26.15 mg/kg dw.

Variation in measured and modeled data could be attributed to non-detect levels of selenium in both the periphyton and the water column. Non-detect values were not used in the calculations to possible erroneous assumptions skewing the data set. If the actual non-detect values were known and utilized in the modeling, there would be additional modeled data points with lower values and the statistical analyses would show more of a similarity between the measured and modeled data. Additional evaluations to determine factors which may be influencing variability in the model, and overall selenium bioaccumulation, are needed to gain better fitness at the range of site conditions.

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APPENDIX A

Location	Latitude (º)	Longitude (º)
Mud River	38.09474 N	81.97635 W
Mud River DS	38.09284 N	81.96379 W
Ballard Branch	38.07332 N	81.94968 W
Sugartree Branch	38.09068 N	81.94989 W
Berry Branch	38.10087 N	81.98917 W
Upton Branch	38.13567 N	82.04774 W

Table 1: Fish Egg Sampling Locations

Site ID	Location	Latitude (º)	Longitude (º)
1	Mud River upstream Ballard Branch	38.07103 N	81.95261 W
2	Ballard Branch	38.07261 N	81.94711 W
3	Stanley Fork	38.08472 N	81.95639 W
4	Sugartree Branch	38.09066 N	81.95040 W
5	Berry Branch	38.10496 N	81.97053 W
6	Mud River downstream Berry Branch	38.09997 N	81.99063 W

Table 2: Periphyton Sampling Locations Mud River Watershed

Summer 2009 - Spring 2010

Se Water Column Concentrations (µg/L)				
Site ID	**Summer 2009**	**Fall 2009**	**Winter 2010**	**Spring 2010**
1	6.2	3.3	nd	nd
2	1.7	nd	nd	nd
3	9.1	8.1	10.3	8.8
4	15.7	14.2	19.7	18.9
5	20.2	5.3	8.0	5.3
6	19.9	14.0	10.5	6.1
Average Se Periphyton (Particulate) Concentration Ranges (µg/g)				
Site ID	**Summer 2009**	**Fall 2009**	**Winter 2010**	**Spring 2010**
1	2.8-25.6	nd-5.3	nd-7.8	nd-1.6
2	4.7-5.8	nd	nd	0.6-0.8
3	3.2	1.2-1.4	0.4-1.6	nd-0.5
4	11.2-11.7	nd-10.3	2.6-3.6	missing tiles
5	1.5-12.1	2.0-4.2	nd	0.8-2.3
6	nd-0.3	2.5-8.8	1.8-2.6	nd-0.8
nd = non-detect value				

Table 3: Model Input

Fish Species	Aquatic Insect	Crayfish	Fish	Zooplankton	Amphipod
Green Sunfish	35	25	25	15	---
Creek Chub (fall, winter, & spring)	25	---	50	---	25
Creek Chub (summer)	---	---	100	---	---
Blacknose Dace	85	---	---	15	---

Table 4: Prey fractions (%) used in the tropic transfer modeling

Collection location and date*	Taxa represented	Average Se fish tissue (mg/kg dw)	Total # of fry	% Yolk sac edema	Total % teratogenic deformities
Sugartree Branch	creek chub	18.24	577	0.17	6.59
Mud River	creek chub & striped shiner	7.61	335	0.60	5.97
Upton Branch	creek chub	7.03	1039	1.35	4.72
Berry Branch	creek chub	4.46	476	2.52	2.73
Berry Branch	white sucker **	1.36	407	0.25	0.25
Upton Branch	white sucker **	1.05	130	0.00	0.00
Berry Branch	creek chub	3.96	295	0.34	1.69

*From 2009 and 2010 reproductive studies (POTESTA a, 2011).

**White suckers were not collected during the fish tissue sample collections but were present when spawning. Tissue concentrations for this species are represented by an average of all species for which data were available.

Table 5: Lotic deformity statistics from larval fish from the Mud River watershed

Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
Model	**Measure**	**Model**	**Measure**	**Model**	**Measure**	**Model**	**Measure**	**Model**	**Measure**	**Model**	**Measure**
33.79	2.79	7.66	2.77	4.28	13.26	14.84	13.19	15.91	4.99	0.46	3.05
3.72	3.84	6.22	2.74	2.07	10.48	15.48	13.69	1.99	4.41	15.57	3.03
9.45	2.76		2.55	2.41	9.08	18.26	5.52	7.47	3.50	4.37	2.10
	3.46		2.30	2.83	7.22	6.33	14.45	4.07	3.40	4.64	3.81
	3.84		2.28	0.70	11.63	4.62	14.14	3.51	3.76	3.10	3.56
	3.15		2.02	0.87	9.58		15.37	4.11	3.36	1.44	3.85
	3.89		2.74		12.83		15.04	1.38	4.92		3.24
	3.05		1.89		8.40		15.04		3.32		3.18

Table 6: Creek Chub Whole-Body Selenium Tissue Concentrations (mg/kg dw)

Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
Model	**Measure**	**Model**	**Measure**	**Model**	**Measure**	**Model**	**Measure**	**Model**	**Measure**	**Model**	**Measure**
57.75	8.17	13.09	5.60	7.32	25.57	25.37	28.99	27.19	5.15	0.79	6.29
6.36	6.23	10.62	6.86	2.64	16.46	26.45	25.24	3.41	5.52	19.84	4.68
12.04	12.77		3.57	3.08	18.88	23.28	11.10	9.52	4.82	5.57	3.76
	8.20		5.19	3.61	22.21	8.07	9.15	5.19	4.06	5.91	6.20
	9.30		4.87	0.89	22.51	5.89	31.12	4.47	3.64	3.96	5.68
	7.40		17.64	1.11	27.29			5.23	3.88	1.84	6.30
	9.55		15.24		33.38			1.76	2.68		5.48
	6.84		2.52		16.39				12.06		5.92

Table 7: Green Sunfish Whole-Body Selenium Tissue Concentrations (mg/kg dw)

Site 4		Site 5	
Model	Measure	Model	Measure
35.15	38.51	37.67	12.64
36.65	23.90	4.72	10.85
32.25	31.06	13.20	7.85
11.18		7.19	8.48
8.16		6.19	8.20
		7.25	9.70
		2.44	

Table 8: Blacknose Dace Whole-Body Selenium Tissue Concentrations (mg/kg dw)

Fish Species	Creek Chubs		Green Sunfish		Blacknose Dace	
Statistic	**F-Ratio**	**Prob. Level**	**F-Ratio**	**Prob. Level**	**F-Ratio**	**Prob. Level**
Sampling Site	9.52	0.000001*	8.49	0.000004*	10.46	0.004878*
Measured vs. Modeled	1.63	0.206502	1.12	0.293155	1.20	0.288110
Interaction	11.48	0.000000*	8.43	0.000004*	0.00	0.961575

*Term significant at alpha = 0.05

Table 9: Results of statistical comparisons of measured and modeled selenium concentrations in sampling sites in the Mud River watershed

APPENDIX B

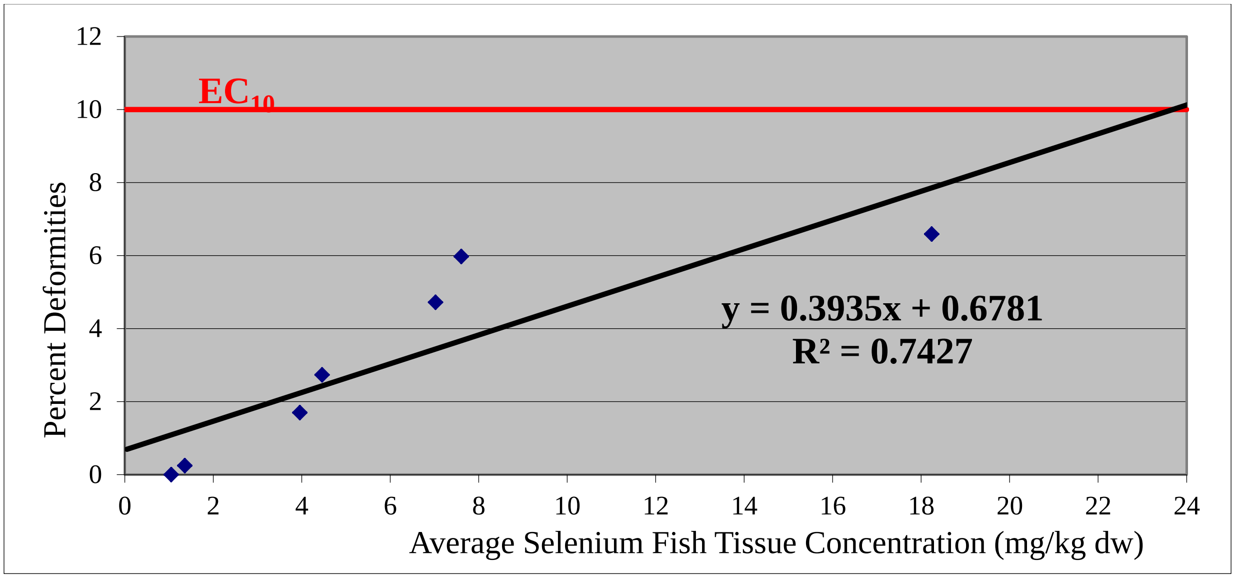

Figure 1: Percent teratogenic deformities of larval fish in relation to selenium whole-body fish tissue concentrations

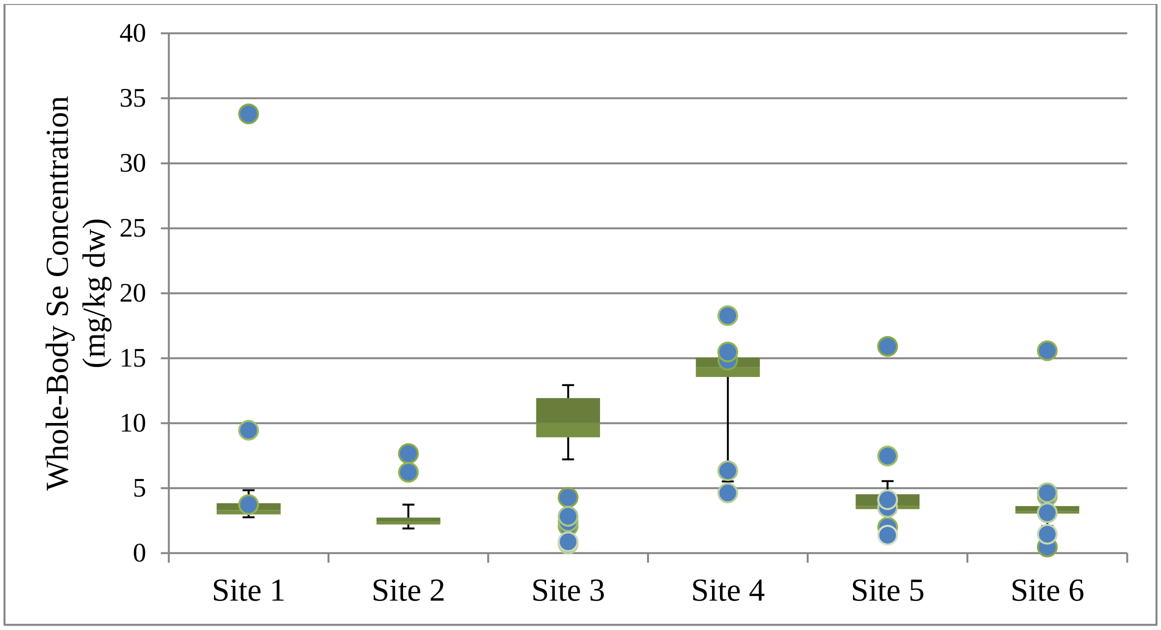

Figure 2: Whole-body creek chub selenium concentrations (green) plotted with modeled concentrations (blue)

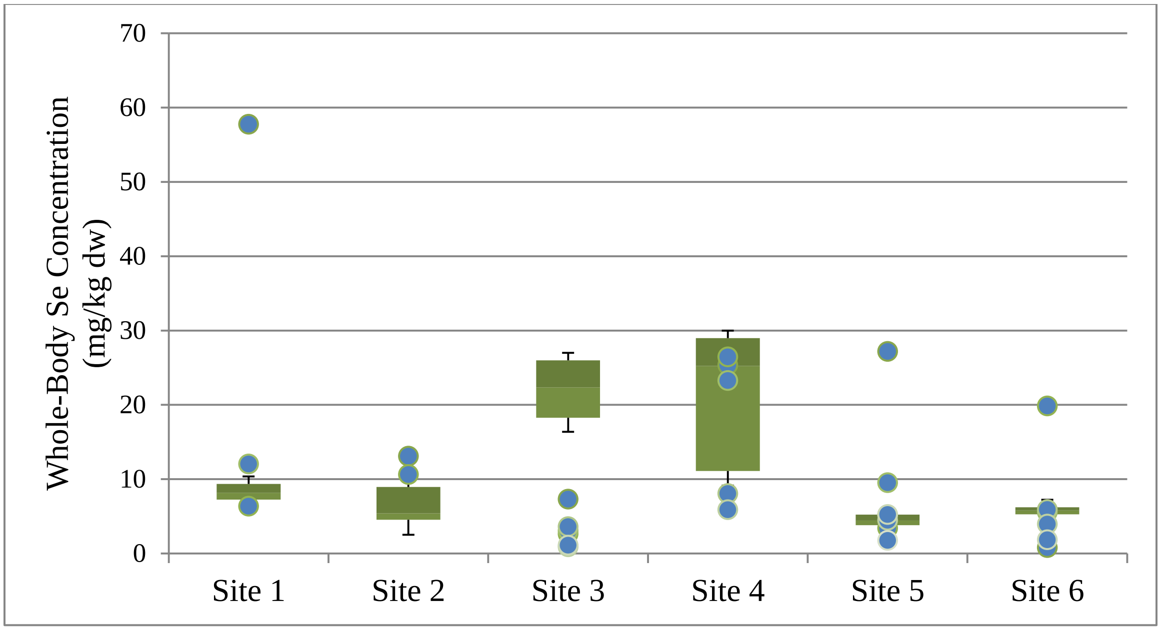

Figure 3: Whole-body green sunfish selenium concentrations (green) plotted with modeled concentrations (blue)

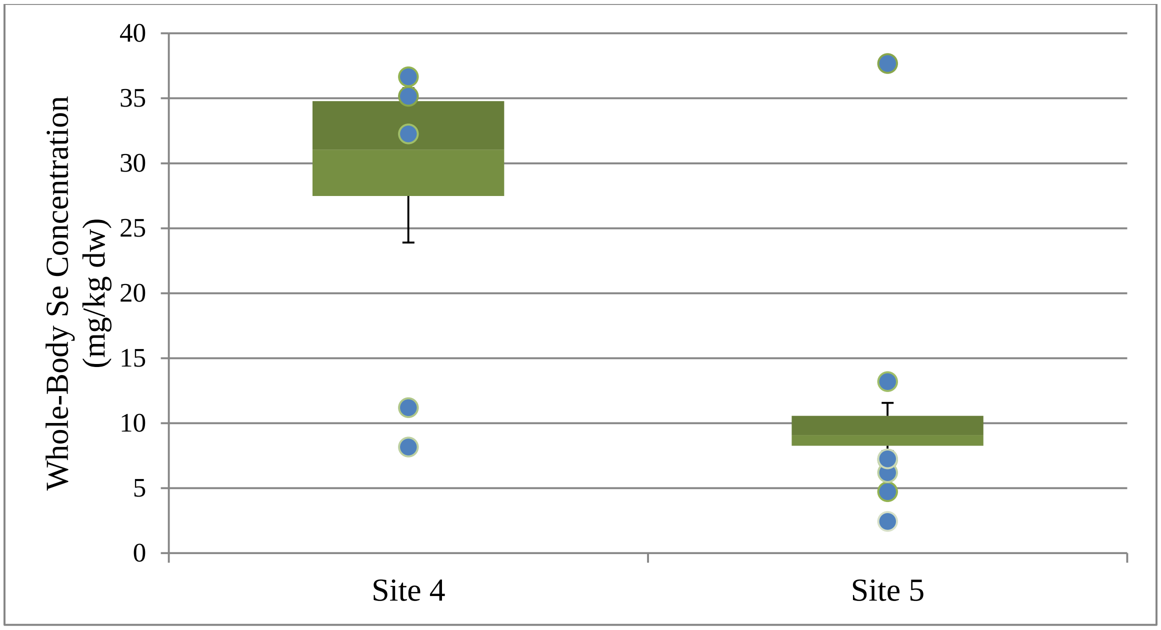

Figure 4: Whole-body blacknose dace selenium concentrations (green) plotted with modeled concentrations (blue)

APPENDIX C

PART 1

Creek Chub Modeling

Summer 2								
							100%	fish diet only
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	$TFF_{Creek\ Chub}$	TFF_{Fish}	$C_{Creek\ Chub}$ (ug/g or mg/kg)
1	254.3	7.609	25.6	6.2	4.129032	1.200	1.1	33.792
	230.2	17.696						
	225.0	4.957						
	n/a	6.696						
2	48.3	11.130	5.80288	1.7	3.413458	1.200	1.1	7.659801
	64.6	11.739						
	58.0	5.826						
	n/a	10.565						
3	204.1	83.087	3.24287	9.1	0.356359	1.200	1.1	4.280585
	212.6	40.261						
	191.1	63.348						
	n/a	63.217						
4	45.7	8.000	11.2441	15.7	0.716184	1.200	1.1	14.8422
	45.0	8.696						
	142.2	5.391						
	n/a	5.522						
5	815.2	50.957	12.0519	20.2	0.59663	1.200	1.1	15.90855
	163.0	27.913						
	111.5	20.304						
	n/a	21.391						
6	31.3	64.870	0.6397	19.9	0.032146	1.200	1.1	0.844404
	86.7	69.130						
	1.7	61.391						
	n/a	54.087						
7	43.0	12.087	4.93333	n/d	#VALUE!	1.200	1.1	#VALUE!
	45.7	7.043						
	32.0	7.087						
	n/a	6.391						

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Summer 3								
							100%	fish diet only
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	$TFF_{Creek\ Chub}$	TFF_{Fish}	$C_{Creek\ Chub}$ (ug/g or mg/kg)
1	41.7	22.130	2.82087	6.2	0.45498	1.200	1.1	3.723554
	39.8	13.783						
	48.9	12.565						
	n/a	13.174						
2	152.0	30.913	4.70914	1.7	2.770083	1.200	1.1	6.216066
	37.2	10.435						
	32.6	12.652						
	n/a	8.783						
3	161.1	**0.022**	2.6314	9.1	0.289165	1.200	1.1	3.473449
	196.3	71.348						
	268.7	112.174						
	n/a	133.696						
4	182.0	23.739	11.7255	15.7	0.74685	1.200	1.1	15.47772
	202.8	11.348						
	178.0	15.652						
	n/a	13.261						
5	56.7	24.913	1.51054	20.2	0.074779	1.200	1.1	1.993919
	73.0	51.043						
	71.1	41.304						
	n/a	60.043						
6	74.3	168.652	0.3492	19.9	0.017548	1.200	1.1	0.46095
	72.4	411.652						
	80.2	101.087						
	n/a	185.174						
7	33.3	16.609	2.26316	n/d	#VALUE!	1.200	1.1	#VALUE!
	29.3	11.783						
	21.5	11.652						
	n/a	9.522						

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Fall 1

Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water\text{-}column}$ (ug/L)	K_d (L/g)	$TFF_{Creek\ Chub}$	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Amphipod}$	$C_{Creek\ Chub}$ (ug/g or mg/kg)
							50%	25%	25%	
1	**1.7**	3.652	0.32786	3.3	0.099352	1.200	1.1	2.8	0.9	**0.5803153**
	1.7	4.565								
	1.7	7.261								
	1.7	4.652								
2	**1.7**	4.391	0.47438	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	1.7	3.348								
	1.7	3.087								
	1.7	3.087								
3	**1.7**	2.957	0.33289	8.1	0.041098	1.200	1.1	2.8	0.9	**0.5892237**
	1.7	5.652								
	1.7	1.522								
	1.7	9.696								
4	21.5	4.522	1.13167	14.2	0.079695	1.200	1.1	2.8	0.9	**2.00305**
	37.2	8.000								
	1.7	34.826								
	1.7	7.435								
5	54.8	16.957	4.22147	5.3	0.796504	1.200	1.1	2.8	0.9	7.4720019
	32.6	8.783								
	25.4	9.522								
	77.0	9.696								
6	**1.7**	3.174	6.83212	14	0.488009	1.200	1.1	2.8	0.9	**12.092858**
	71.1	5.652								
	32.0	2.739								
	1.7	4.000								
7	**1.7**	8.000	1.20836	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	28.0	6.174								
	1.7	8.043								
	1.7	5.087								

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Fall 2										
							50%	25%	25%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	$TFF_{Creek\ Chub}$	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Amphipod}$	$C_{Creek\ Chub}$ (ug/g or mg/kg)
1	**1.7**	7.640	0.24738	3.3	0.074963	1.200	1.1	2.8	0.9	**0.4378561**
	1.7	5.640								
	1.7	5.320								
	1.7	8.080								
2	**1.7**	6.760	0.12168	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	1.7	1.600								
	1.7	40.160								
	1.7	5.720								
3	**1.7**	12.640	1.21088	8.1	0.149491	1.200	1.1	2.8	0.9	**2.1432534**
	1.7	5.720								
	22.2	10.080								
	26.7	14.680								
4	39.8	9.760	4.6548	14.2	0.327803	1.200	1.1	2.8	0.9	**8.2390028**
	1.7	8.800								
	71.7	5.920								
	43.0	9.080								
5	**1.7**	14.800	1.18158	5.3	0.222939	1.200	1.1	2.8	0.9	**2.0913888**
	73.7	16.520								
	1.7	59.000								
	48.9	16.240								
6	44.3	26.000	0.55754	14	0.039824	1.200	1.1	2.8	0.9	**0.9868447**
	1.7	28.240								
	3.4	39.080								
	24.8	39.640								
7	**1.7**	7.160	0.40146	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	1.7	2.520								
	1.7	2.880								
	1.7	3.880								

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Fall 3										
							50%	25%	25%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	$TFF_{Creek Chub}$	TFF_{Fish}	$TFF_{Aquatic Insect}$	$TFF_{Amphipod}$	$C_{Creek Chub}$ (ug/g or mg/kg)
1	88.0	6.208	5.33789	3.3	1.617541	1.200	1.1	2.8	0.9	9.448057
	35.2	42.750								
	34.6	1.292								
	131.1	3.875								
2	40.4	6.750	6.98196	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	38.5	6.125								
	53.5	4.500								
	26.7	5.417								
3	127.8	16.708	1.17034	8.1	0.144486	1.200	1.1	2.8	0.9	2.0714944
	37.2	22.875								
	110.2	36.667								
	82.2	229.125								
4	100.4	7.083	10.3183	14.2	0.726641	1.200	1.1	2.8	0.9	18.263383
	108.3	7.167								
	48.3	6.708								
	108.9	14.500								
5	134.3	27.125	2.29897	5.3	0.433768	1.200	1.1	2.8	0.9	4.0691756
	112.8	33.208								
	103.0	142.958								
	150.0	14.292								
6	574.6	21.000	8.79619	14	0.628299	1.200	1.1	2.8	0.9	15.569254
	111.5	38.500								
	395.2	13.333								
	193.0	72.042								
7	**1.7**	2.583	2.16836	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	26.7	3.792								
	1.7	8.375								
	25.4	10.833								

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Fall 4										
							50%	25%	25%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	$TFF_{Creek\ Chub}$	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Amphipod}$	$C_{Creek\ Chub}$ (ug/g or mg/kg)
1	31.3	51.292	0.73776	3.3	0.223564	1.200	1.1	2.8	0.9	**1.3058389**
	45.7	33.792								
	35.9	46.583								
	1.7	23.500								
2	37.2	15.042	1.78854	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	30.0	17.375								
	30.0	13.042								
	23.5	22.000								
3	366.5	143.250	1.36308	8.1	0.168281	1.200	1.1	2.8	0.9	2.4126456
	101.7	241.708								
	90.7	209.083								
	379.6	94.458								
4	55.4	77.750	1.99611	14.2	0.140571	1.200	1.1	2.8	0.9	**3.5331218**
	185.2	54.917								
	120.7	**0.022**								
	129.8	113.333								
5	81.5	94.375	1.98065	5.3	0.373708	1.200	1.1	2.8	0.9	3.505758
	88.0	51.500								
	62.0	19.750								
	129.8	16.792								
6	154.6	92.375	2.46948	14	0.176392	1.200	1.1	2.8	0.9	4.3709876
	122.6	18.250								
	45.0	27.833								
	121.3	41.125								
7	**1.7**	26.125	0.38704	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	1.7	10.083								
	1.7	69.375								
	43.0	18.417								

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Winter 1

Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water\text{-}column}$ (ug/L)	K_d (L/g)	$TFF_{Creek\ Chub}$	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Amphipod}$	$C_{Creek\ Chub}$ (ug/g or mg/kg)
							50%	25%	25%	
1	**5.5**	0.826	5.73036	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.5	1.000								
	5.5	1.217								
	5.5	0.826								
2	**5.5**	0.870	4.4737	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.5	1.391								
	5.5	1.130								
	5.5	1.565								
3	**5.5**	1.739	4.14636	10.3	0.402559	1.200	1.1	2.8	0.9	**7.339053**
	5.5	1.304								
	5.5	1.217								
	5.5	1.087								
4	13.0	5.565	3.57708	19.7	0.181578	1.200	1.1	2.8	0.9	6.331438
	18.9	3.739								
	24.1	6.565								
	11.1	2.913								
5	n/a	n/a	n/a	8	n/a	1.200	1.1	2.8	0.9	**#VALUE!**
	n/a	n/a								
	n/a	n/a								
	n/a	n/a								
6	**5.5**	1.087	3.42283	10.5	0.325984	1.200	1.1	2.8	0.9	**6.058413**
	5.5	1.130								
	5.5	1.522								
	5.5	2.739								
7	**5.5**	0.435	11.087	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.5	0.348								
	5.5	0.348								
	5.5	0.870								

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Winter 2										
							50%	25%	25%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	$TFF_{Creek Chub}$	TFF_{Fish}	$TFF_{Aquatic Insect}$	$TFF_{Amphipod}$	$C_{Creek Chub}$ (ug/g or mg/kg)
1	17.0	3.217	7.78626	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	21.5	2.739								
	29.3	1.652								
	20.9	3.783								
2	**5.5**	6.130	1.96155	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.5	2.087								
	5.5	2.087								
	5.5	1.000								
3	22.2	67.609	1.60027	10.3	0.155366	1.200	1.1	2.8	0.9	2.83247
	30.0	4.652								
	56.1	8.565								
	48.9	17.391								
4	81.5	33.043	2.61157	19.7	0.132567	1.200	1.1	2.8	0.9	4.622475
	80.9	21.826								
	125.2	70.913								
	99.1	22.304								
5	**5.5**	2.522	2.77672	8	0.34709	1.200	1.1	2.8	0.9	**4.9148**
	15.0	1.609								
	5.5	4.957								
	5.5	2.304								
6	22.2	6.174	2.61905	10.5	0.249433	1.200	1.1	2.8	0.9	4.635714
	13.0	6.217								
	17.6	7.174								
	18.9	7.826								
7	**5.5**	2.783	1.81495	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.5	2.304								
	5.5	4.087								
	5.5	3.043								

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Winter 3										
							50%	25%	25%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	$TFF_{Creek Chub}$	TFF_{Fish}	$TFF_{Aquatic Insect}$	$TFF_{Amphipod}$	$C_{Creek Chub}$ (ug/g or mg/kg)
1	25.435	14.261	1.39699	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.544	18.565								
	28.043	3.609								
	5.544	9.783								
2	**5.544**	10.174	0.7612	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.544	6.043								
	5.544	2.565								
	5.544	10.348								
3	39.783	23.696	0.39639	10.3	0.038485	1.200	1.1	2.8	0.9	0.701617
	33.913	150.870								
	11.739	37.870								
	25.435	67.261								
4	n/a	n/a	n/a	19.7	n/a	1.200	1.1	2.8	0.9	**#VALUE!**
	n/a	n/a								
	n/a	n/a								
	n/a	n/a								
5	n/a	n/a	n/a	8	n/a	1.200	1.1	2.8	0.9	**#VALUE!**
	n/a	n/a								
	n/a	n/a								
	n/a	n/a								
6	**5.544**	10.087	1.81905	10.5	0.173243	1.200	1.1	2.8	0.9	**3.219721**
	43.696	8.174								
	30.000	9.348								
	24.130	29.217								
7	**5.544**	7.609	0.95675	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.544	4.652								
	5.544	10.739								
	11.739	6.652								

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Winter 4										
							50%	25%	25%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	$TFF_{Creek\ Chub}$	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Amphipod}$	$C_{Creek\ Chub}$ (ug/g or mg/kg)
1	**5.5**	6.696	0.85397	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	20.2	29.522								
	44.3	44.000								
	37.8	46.174								
2	24.1	42.826	0.47444	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.5	7.609								
	5.5	11.000								
	5.5	24.478								
3	40.4	14.000	0.57367	10.3	0.055697	1.200	1.1	2.8	0.9	**1.015405**
	5.5	16.043								
	67.2	244.174								
	68.5	42.391								
4	n/a	n/a	n/a	19.7	n/a	1.200	1.1	2.8	0.9	**#VALUE!**
	n/a	n/a								
	n/a	n/a								
	n/a	n/a								
5	n/a	n/a	n/a	8	n/a	1.200	1.1	2.8	0.9	**#VALUE!**
	n/a	n/a								
	n/a	n/a								
	n/a	n/a								
6	26.7	26.130	1.75392	10.5	0.16704	1.200	1.1	2.8	0.9	3.104433
	80.9	20.696								
	26.7	45.043								
	65.2	21.913								
7	34.6	29.870	1.28144	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	34.6	7.391								
	33.3	39.522								
	37.2	32.130								

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Spring 1										
							50%	25%	25%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	$TFF_{Creek Chub}$	TFF_{Fish}	$TFF_{Aquatic Insect}$	$TFF_{Amphipod}$	$C_{Creek Chub}$ (ug/g or mg/kg)
1	50.2	23.167	1.56288	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.5	12.083								
	42.4	21.125								
	32.6	27.292								
2	26.1	15.583	0.57416	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	33.9	101.792								
	33.3	28.083								
	11.7	37.417								
3	22.2	6.542	1.29561	8.8	0.147229	1.200	1.1	2.8	0.9	**2.293232**
	17.0	8.250								
	11.7	13.750								
	5.5	15.000								
4	n/a	n/a	n/a	18.9	n/a	1.200	1.1	2.8	0.9	**#VALUE!**
	n/a	n/a								
	n/a	n/a								
	n/a	n/a								
5	18.3	7.625	2.31983	5.3	0.437703	1.200	1.1	2.8	0.9	4.106096
	12.4	5.708								
	13.7	5.250								
	12.4	5.875								
6	**5.5**	6.042	0.95372	6.1	0.156348	1.200	1.1	2.8	0.9	**1.688085**
	5.5	9.208								
	5.5	4.542								
	5.5	3.458								
7	11.7	20.792	0.87118	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.5	3.625								
	5.5	11.833								
	16.3	8.667								

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*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Spring 2										
							50%	25%	25%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	$TFF_{Creek Chub}$	TFF_{Fish}	$TFF_{Aquatic Insect}$	$TFF_{Amphipod}$	$C_{Creek Chub}$ (ug/g or mg/kg)
1	37.2	26.348	1.56771	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.5	6.522								
	50.2	6.696								
	33.9	41.348								
2	35.2	57.913	0.7696	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	26.1	41.217								
	40.4	39.870								
	39.1	44.043								
3	30.0	91.087	0.49028	8.8	0.055713	1.200	1.1	2.8	0.9	0.867789
	24.8	94.174								
	33.3	24.957								
	42.4	55.826								
4	n/a	n/a	n/a	18.9	n/a	1.200	1.1	2.8	0.9	**#VALUE!**
	n/a	n/a								
	n/a	n/a								
	n/a	n/a								
5	58.7	38.609	0.779	5.3	0.146981	1.200	1.1	2.8	0.9	1.378829
	52.2	94.957								
	84.1	162.957								
	73.0	47.565								
6	67.8	130.478	0.81578	6.1	0.133735	1.200	1.1	2.8	0.9	1.443936
	91.3	102.609								
	32.6	28.391								
	94.6	89.478								
7	**5.5**	3.087	1.00791	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.5	2.652								
	5.5	11.174								
	5.5	5.087								

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*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Spring 3										
							50%	25%	25%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	$TFF_{Creek\ Chub}$	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Amphipod}$	$C_{Creek\ Chub}$ (ug/g or mg/kg)
1	**5.5**	1.783	2.81769	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.5	2.522								
	5.5	2.130								
	5.5	1.435								
2	n/a	n/a	n/a	n/d	n/a	1.200	1.1	2.8	0.9	**#VALUE!**
	n/a	n/a								
	n/a	n/a								
	n/a	n/a								
3	n/a	n/a	n/a	8.8	n/a	1.200	1.1	2.8	0.9	**#VALUE!**
	n/a	n/a								
	n/a	n/a								
	n/a	n/a								
4	n/a	n/a	n/a	18.9	n/a	1.200	1.1	2.8	0.9	**#VALUE!**
	n/a	n/a								
	n/a	n/a								
	n/a	n/a								
5	**5.5**	6.000	2.21503	5.3	0.41793	1.200	1.1	2.8	0.9	**3.9206**
	5.5	2.435								
	12.4	3.739								
	13.7	4.609								
6	n/a	n/a	n/a	6.1	n/a	1.200	1.1	2.8	0.9	**#VALUE!**
	n/a	n/a								
	n/a	n/a								
	n/a	n/a								
7	44.3	1.565	6.37501	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.5	2.870								
	5.5	2.957								
	5.5	2.174								

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*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Spring 4										
							50%	25%	25%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water\text{-}column}$ (ug/L)	K_d (L/g)	$TFF_{Creek\ Chub}$	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Amphipod}$	$C_{Creek\ Chub}$ (ug/g or mg/kg)
1	16.3	17.217	1.60436	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	15.7	10.522								
	20.2	6.565								
	15.0	7.565								
2	n/a	n/a	n/a	n/d	n/a	1.200	1.1	2.8	0.9	**#VALUE!**
	n/a	n/a								
	n/a	n/a								
	n/a	n/a								
3	n/a	n/a	n/a	8.8	n/a	1.200	1.1	2.8	0.9	**#VALUE!**
	n/a	n/a								
	n/a	n/a								
	n/a	n/a								
4	n/a	n/a	n/a	18.9	n/a	1.200	1.1	2.8	0.9	**#VALUE!**
	n/a	n/a								
	n/a	n/a								
	n/a	n/a								
5	33.9	10.696	0.99317	5.3	0.18739	1.200	1.1	2.8	0.9	**1.757906**
	5.5	37.522								
	35.9	22.391								
	16.3	21.652								
6	n/a	n/a	n/a	6.1	n/a	1.200	1.1	2.8	0.9	**#VALUE!**
	n/a	n/a								
	n/a	n/a								
	n/a	n/a								
7	12.4	7.130	1.23841	n/d	#VALUE!	1.200	1.1	2.8	0.9	**#VALUE!**
	5.5	5.087								
	5.5	6.261								
	5.5	4.957								

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

PART 2

Green Sunfish Modeling

Summer 2											
							35%	25%	25%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Crayfish}$	TFF_{Fish}	$TFF_{Zooplankton}$	C_{GS} (ug/g or mg/kg)
1	254.3	7.609	25.6	6.2	4.129032	1.200	2.8	1.6	1.1	1.5	57.7536
	230.2	17.696									
	225.0	4.957									
	n/a	6.696									
2	48.3	11.130	5.80288	1.7	3.413458	1.200	2.8	1.6	1.1	1.5	13.0913
	64.6	11.739									
	58.0	5.826									
	n/a	10.565									
3	204.1	83.087	3.24287	9.1	0.356359	1.200	2.8	1.6	1.1	1.5	7.315908
	212.6	40.261									
	191.1	63.348									
	n/a	63.217									
4	45.7	8.000	11.2441	15.7	0.716184	1.200	2.8	1.6	1.1	1.5	25.36668
	45.0	8.696									
	142.2	5.391									
	n/a	5.522									
5	815.2	50.957	12.0519	20.2	0.59663	1.200	2.8	1.6	1.1	1.5	27.18915
	163.0	27.913									
	111.5	20.304									
	n/a	21.391									
6	31.3	64.870	0.6397	19.9	0.032146	1.200	2.8	1.6	1.1	1.5	1.443164
	86.7	69.130									
	1.7	61.391									
	n/a	54.087									
7	43.0	12.087	4.93333	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	#VALUE!
	45.7	7.043									
	32.0	7.087									
	n/a	6.391									

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Summer 3

Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic Insect}$	$TFF_{Crayfish}$	TFF_{Fish}	$TFF_{Zooplankton}$	C_{GS} (ug/g or mg/kg)
							35%	25%	25%	15%	
1	41.7	22.130	2.82087	6.2	0.45498	1.200	2.8	1.6	1.1	1.5	6.363893
	39.8	13.783									
	48.9	12.565									
	n/a	13.174									
2	152.0	30.913	4.70914	1.7	2.770083	1.200	2.8	1.6	1.1	1.5	10.62382
	37.2	10.435									
	32.6	12.652									
	n/a	8.783									
3	161.1	**0.022**	2.6314	9.1	0.289165	1.200	2.8	1.6	1.1	1.5	5.93644
	196.3	71.348									
	268.7	112.174									
	n/a	133.696									
4	182.0	23.739	11.7255	15.7	0.74685	1.200	2.8	1.6	1.1	1.5	26.45283
	202.8	11.348									
	178.0	15.652									
	n/a	13.261									
5	56.7	24.913	1.51054	20.2	0.074779	1.200	2.8	1.6	1.1	1.5	3.407788
	73.0	51.043									
	71.1	41.304									
	n/a	60.043									
6	74.3	168.652	0.3492	19.9	0.017548	1.200	2.8	1.6	1.1	1.5	0.787806
	72.4	411.652									
	80.2	101.087									
	n/a	185.174									
7	33.3	16.609	2.26316	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	#VALUE!
	29.3	11.783									
	21.5	11.652									
	n/a	9.522									

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Fall 1

Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Crayfish}$	TFF_{Fish}	$TFF_{Zooplankton}$	C_{GS} (ug/g or mg/kg)
							35%	25%	25%	15%	
1	**1.7**	3.652	0.32786	3.3	0.0993521	1.200	2.8	1.6	1.1	1.5	0.7396562
	1.7	4.565									
	1.7	7.261									
	1.7	4.652									
2	**1.7**	4.391	0.47438	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	#VALUE!
	1.7	3.348									
	1.7	3.087									
	1.7	3.087									
3	**1.7**	2.957	0.33289	8.1	0.0410981	1.200	2.8	1.6	1.1	1.5	0.7510105
	1.7	5.652									
	1.7	1.522									
	1.7	9.696									
4	21.5	4.522	1.13167	14.2	0.0796948	1.200	2.8	1.6	1.1	1.5	2.55304
	37.2	8.000									
	1.7	34.826									
	1.7	7.435									
5	54.8	16.957	4.22147	5.3	0.7965038	1.200	2.8	1.6	1.1	1.5	9.5236364
	32.6	8.783									
	25.4	9.522									
	77.0	9.696									
6	**1.7**	3.174	6.83212	14	0.4880088	1.200	2.8	1.6	1.1	1.5	15.413269
	71.1	5.652									
	32.0	2.739									
	1.7	4.000									
7	**1.7**	8.000	1.20836	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	#VALUE!
	28.0	6.174									
	1.7	8.043									
	1.7	5.087									

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Fall 2											
							35%	25%	25%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Crayfish}$	TFF_{Fish}	$TFF_{Zooplankton}$	C_{GS} (ug/g or mg/kg)
1	**1.7**	7.640	0.24738	3.3	0.0749625	1.200	2.8	1.6	1.1	1.5	0.558081
	1.7	5.640									
	1.7	5.320									
	1.7	8.080									
2	**1.7**	6.760	0.12168	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	#VALUE!
	1.7	1.600									
	1.7	40.160									
	1.7	5.720									
3	**1.7**	12.640	1.21088	8.1	0.1494911	1.200	2.8	1.6	1.1	1.5	2.7317399
	1.7	5.720									
	22.2	10.080									
	26.7	14.680									
4	39.8	9.760	4.6548	14.2	0.3278031	1.200	2.8	1.6	1.1	1.5	10.501237
	1.7	8.800									
	71.7	5.920									
	43.0	9.080									
5	**1.7**	14.800	1.18158	5.3	0.2229388	1.200	2.8	1.6	1.1	1.5	2.6656345
	73.7	16.520									
	1.7	59.000									
	48.9	16.240									
6	44.3	26.000	0.55754	14	0.0398242	1.200	2.8	1.6	1.1	1.5	1.2578088
	1.7	28.240									
	3.4	39.080									
	24.8	39.640									
7	**1.7**	7.160	0.40146	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	#VALUE!
	1.7	2.520									
	1.7	2.880									
	1.7	3.880									

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Fall 3											
							35%	25%	25%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Crayfish}$	TFF_{Fish}	$TFF_{Zooplankton}$	C_{GS} (ug/g or mg/kg)
1	88.0	6.208	5.33789	3.3	1.617541	1.200	2.8	1.6	1.1	1.5	12.042269
	35.2	42.750									
	34.6	1.292									
	131.1	3.875									
2	40.4	6.750	6.98196	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	#VALUE!
	38.5	6.125									
	53.5	4.500									
	26.7	5.417									
3	127.8	16.708	1.17034	8.1	0.1444859	1.200	2.8	1.6	1.1	1.5	2.6402776
	37.2	22.875									
	110.2	36.667									
	82.2	229.125									
4	100.4	7.083	10.3183	14.2	0.7266405	1.200	2.8	1.6	1.1	1.5	23.278075
	108.3	7.167									
	48.3	6.708									
	108.9	14.500									
5	134.3	27.125	2.29897	5.3	0.4337678	1.200	2.8	1.6	1.1	1.5	5.1864746
	112.8	33.208									
	103.0	142.958									
	150.0	14.292									
6	574.6	21.000	8.79619	14	0.6282992	1.200	2.8	1.6	1.1	1.5	19.844202
	111.5	38.500									
	395.2	13.333									
	193.0	72.042									
7	**1.7**	2.583	2.16836	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	#VALUE!
	26.7	3.792									
	1.7	8.375									
	25.4	10.833									

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Fall 4											
							35%	25%	25%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Crayfish}$	TFF_{Fish}	$TFF_{Zooplankton}$	C_{GS} (ug/g or mg/kg)
1	31.3	51.292	0.73776	3.3	0.2235643	1.200	2.8	1.6	1.1	1.5	1.6643913
	45.7	33.792									
	35.9	46.583									
	1.7	23.500									
2	37.2	15.042	1.78854	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	#VALUE!
	30.0	17.375									
	30.0	13.042									
	23.5	22.000									
3	366.5	143.250	1.36308	8.1	0.1682811	1.200	2.8	1.6	1.1	1.5	3.0751009
	101.7	241.708									
	90.7	209.083									
	379.6	94.458									
4	55.4	77.750	1.99611	14.2	0.1405714	1.200	2.8	1.6	1.1	1.5	4.5032331
	185.2	54.917									
	120.7	**0.022**									
	129.8	113.333									
5	81.5	94.375	1.98065	5.3	0.3737084	1.200	2.8	1.6	1.1	1.5	4.468356
	88.0	51.500									
	62.0	19.750									
	129.8	16.792									
6	154.6	92.375	2.46948	14	0.1763918	1.200	2.8	1.6	1.1	1.5	5.5711571
	122.6	18.250									
	45.0	27.833									
	121.3	41.125									
7	**1.7**	26.125	0.38704	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	#VALUE!
	1.7	10.083									
	1.7	69.375									
	43.0	18.417									

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Winter 1											
							35%	25%	25%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Crayfish}$	TFF_{Fish}	$TFF_{Zooplankton}$	C_{GS} (ug/g or mg/kg)
1	**5.5**	0.826	5.73036	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.5	1.000									
	5.5	1.217									
	5.5	0.826									
2	**5.5**	0.870	4.4737	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.5	1.391									
	5.5	1.130									
	5.5	1.565									
3	**5.5**	1.739	4.14636	10.3	0.402559	1.200	2.8	1.6	1.1	1.5	**9.354183**
	5.5	1.304									
	5.5	1.217									
	5.5	1.087									
4	13.0	5.565	3.57708	19.7	0.181578	1.200	2.8	1.6	1.1	1.5	8.0699
	18.9	3.739									
	24.1	6.565									
	11.1	2.913									
5	n/a	n/a	n/a	8	n/a	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	n/a	n/a									
	n/a	n/a									
	n/a	n/a									
6	**5.5**	1.087	3.42283	10.5	0.325984	1.200	2.8	1.6	1.1	1.5	**7.7219095**
	5.5	1.130									
	5.5	1.522									
	5.5	2.739									
7	**5.5**	0.435	11.087	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.5	0.348									
	5.5	0.348									
	5.5	0.870									

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Winter 2											
							35%	25%	25%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water\text{-}column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Crayfish}$	TFF_{Fish}	$TFF_{Zooplankton}$	C_{GS} (ug/g or mg/kg)
1	17.0	3.217	7.78626	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	21.5	2.739									
	29.3	1.652									
	20.9	3.783									
2	**5.5**	6.130	1.96155	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.5	2.087									
	5.5	2.087									
	5.5	1.000									
3	22.2	67.609	1.60027	10.3	0.155366	1.200	2.8	1.6	1.1	1.5	3.6101992
	30.0	4.652									
	56.1	8.565									
	48.9	17.391									
4	81.5	33.043	2.61157	19.7	0.132567	1.200	2.8	1.6	1.1	1.5	5.891697
	80.9	21.826									
	125.2	70.913									
	99.1	22.304									
5	**5.5**	2.522	2.77672	8	0.34709	1.200	2.8	1.6	1.1	1.5	**6.2642877**
	15.0	1.609									
	5.5	4.957									
	5.5	2.304									
6	22.2	6.174	2.61905	10.5	0.249433	1.200	2.8	1.6	1.1	1.5	5.9085714
	13.0	6.217									
	17.6	7.174									
	18.9	7.826									
7	**5.5**	2.783	1.81495	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.5	2.304									
	5.5	4.087									
	5.5	3.043									

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Winter 3											
							35%	25%	25%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic Insect}$	$TFF_{Crayfish}$	TFF_{Fish}	$TFF_{Zooplankton}$	C_{GS} (ug/g or mg/kg)
1	25.435	14.261	1.39699	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.544	18.565									
	28.043	3.609									
	5.544	9.783									
2	**5.544**	10.174	0.7612	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.544	6.043									
	5.544	2.565									
	5.544	10.348									
3	39.783	23.696	0.39639	10.3	0.038485	1.200	2.8	1.6	1.1	1.5	0.894264
	33.913	150.870									
	11.739	37.870									
	25.435	67.261									
4	n/a	n/a	n/a	19.7	n/a	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	n/a	n/a									
	n/a	n/a									
	n/a	n/a									
5	n/a	n/a	n/a	8	n/a	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	n/a	n/a									
	n/a	n/a									
	n/a	n/a									
6	**5.544**	10.087	1.81905	10.5	0.173243	1.200	2.8	1.6	1.1	1.5	**4.1037805**
	43.696	8.174									
	30.000	9.348									
	24.130	29.217									
7	**5.544**	7.609	0.95675	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.544	4.652									
	5.544	10.739									
	11.739	6.652									

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Winter 4											
							35%	25%	25%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic Insect}$	$TFF_{Crayfish}$	TFF_{Fish}	$TFF_{Zooplankton}$	C_{GS} (ug/g or mg/kg)
1	**5.5**	6.696	0.85397	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	20.2	29.522									
	44.3	44.000									
	37.8	46.174									
2	24.1	42.826	0.47444	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.5	7.609									
	5.5	11.000									
	5.5	24.478									
3	40.4	14.000	0.57367	10.3	0.055697	1.200	2.8	1.6	1.1	1.5	**1.2942105**
	5.5	16.043									
	67.2	244.174									
	68.5	42.391									
4	n/a	n/a	n/a	19.7	n/a	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	n/a	n/a									
	n/a	n/a									
	n/a	n/a									
5	n/a	n/a	n/a	8	n/a	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	n/a	n/a									
	n/a	n/a									
	n/a	n/a									
6	26.7	26.130	1.75392	10.5	0.16704	1.200	2.8	1.6	1.1	1.5	3.9568361
	80.9	20.696									
	26.7	45.043									
	65.2	21.913									
7	34.6	29.870	1.28144	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	34.6	7.391									
	33.3	39.522									
	37.2	32.130									

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Spring 1											
							35%	25%	25%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water\text{-}column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Crayfish}$	TFF_{Fish}	$TFF_{Zooplankton}$	C_{GS} (ug/g or mg/kg)
1	50.2	23.167	1.56288	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.5	12.083									
	42.4	21.125									
	32.6	27.292									
2	26.1	15.583	0.57416	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	33.9	101.792									
	33.3	28.083									
	11.7	37.417									
3	22.2	6.542	1.29561	8.8	0.1472285	1.200	2.8	1.6	1.1	1.5	**2.9228986**
	17.0	8.250									
	11.7	13.750									
	5.5	15.000									
4	n/a	n/a	n/a	18.9	n/a	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	n/a	n/a									
	n/a	n/a									
	n/a	n/a									
5	18.3	7.625	2.31983	5.3	0.4377034	1.200	2.8	1.6	1.1	1.5	5.2335323
	12.4	5.708									
	13.7	5.250									
	12.4	5.875									
6	**5.5**	6.042	0.95372	6.1	0.1563476	1.200	2.8	1.6	1.1	1.5	**2.1515933**
	5.5	9.208									
	5.5	4.542									
	5.5	3.458									
7	11.7	20.792	0.87118	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.5	3.625									
	5.5	11.833									
	16.3	8.667									

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Spring 2											
							35%	25%	25%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic Insect}$	$TFF_{Crayfish}$	TFF_{Fish}	$TFF_{Zooplankton}$	C_{GS} (ug/g or mg/kg)
1	37.2	26.348	1.56771	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.5	6.522									
	50.2	6.696									
	33.9	41.348									
2	35.2	57.913	0.7696	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	26.1	41.217									
	40.4	39.870									
	39.1	44.043									
3	30.0	91.087	0.49028	8.8	0.0557132	1.200	2.8	1.6	1.1	1.5	1.1060631
	24.8	94.174									
	33.3	24.957									
	42.4	55.826									
4	n/a	n/a	n/a	18.9	n/a	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	n/a	n/a									
	n/a	n/a									
	n/a	n/a									
5	58.7	38.609	0.779	5.3	0.146981	1.200	2.8	1.6	1.1	1.5	1.7574223
	52.2	94.957									
	84.1	162.957									
	73.0	47.565									
6	67.8	130.478	0.81578	6.1	0.1337349	1.200	2.8	1.6	1.1	1.5	1.8404063
	91.3	102.609									
	32.6	28.391									
	94.6	89.478									
7	**5.5**	3.087	1.00791	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.5	2.652									
	5.5	11.174									
	5.5	5.087									

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Spring 3											
							35%	25%	25%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Crayfish}$	TFF_{Fish}	$TFF_{Zooplankton}$	C_{GS} (ug/g or mg/kg)
1	**5.5**	1.783	2.81769	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.5	2.522									
	5.5	2.130									
	5.5	1.435									
2	n/a	n/a	n/a	n/d	n/a	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	n/a	n/a									
	n/a	n/a									
	n/a	n/a									
3	n/a	n/a	n/a	8.8	n/a	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	n/a	n/a									
	n/a	n/a									
	n/a	n/a									
4	n/a	n/a	n/a	18.9	n/a	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	n/a	n/a									
	n/a	n/a									
	n/a	n/a									
5	**5.5**	6.000	2.21503	5.3	0.4179299	1.200	2.8	1.6	1.1	1.5	**4.9971043**
	5.5	2.435									
	12.4	3.739									
	13.7	4.609									
6	n/a	n/a	n/a	6.1	n/a	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	n/a	n/a									
	n/a	n/a									
	n/a	n/a									
7	44.3	1.565	6.37501	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.5	2.870									
	5.5	2.957									
	5.5	2.174									

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Spring 4											
							35%	25%	25%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Crayfish}$	TFF_{Fish}	$TFF_{Zooplankton}$	C_{GS} (ug/g or mg/kg)
1	16.3	17.217	1.60436	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	15.7	10.522									
	20.2	6.565									
	15.0	7.565									
2	n/a	n/a	n/a	n/d	n/a	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	n/a	n/a									
	n/a	n/a									
	n/a	n/a									
3	n/a	n/a	n/a	8.8	n/a	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	n/a	n/a									
	n/a	n/a									
	n/a	n/a									
4	n/a	n/a	n/a	18.9	n/a	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	n/a	n/a									
	n/a	n/a									
	n/a	n/a									
5	33.9	10.696	0.99317	5.3	0.18739	1.200	2.8	1.6	1.1	1.5	**2.2405849**
	5.5	37.522									
	35.9	22.391									
	16.3	21.652									
6	n/a	n/a	n/a	6.1	n/a	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	n/a	n/a									
	n/a	n/a									
	n/a	n/a									
7	12.4	7.130	1.23841	n/d	#VALUE!	1.200	2.8	1.6	1.1	1.5	**#VALUE!**
	5.5	5.087									
	5.5	6.261									
	5.5	4.957									

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

PART 3

Blacknose Dace Modeling

Summer 2									
							85%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic Insect}$	$TFF_{Zooplankton}$	C_{BDace} (ug/g or mg/kg)
1	254.3	7.609	25.6	6.2	4.129032	1.200	2.8	1.5	80.0256
	230.2	17.696							
	225.0	4.957							
	n/a	6.696							
2	48.3	11.130	5.80288	1.7	3.413458	1.200	2.8	1.5	18.1398
	64.6	11.739							
	58.0	5.826							
	n/a	10.565							
3	204.1	83.087	3.24287	9.1	0.356359	1.200	2.8	1.5	10.1372
	212.6	40.261							
	191.1	63.348							
	n/a	63.217							
4	45.7	8.000	11.2441	15.7	0.716184	1.200	2.8	1.5	35.14904
	45.0	8.696							
	142.2	5.391							
	n/a	5.522							
5	815.2	50.957	12.0519	20.2	0.59663	1.200	2.8	1.5	37.67433
	163.0	27.913							
	111.5	20.304							
	n/a	21.391							
6	31.3	64.870	0.6397	19.9	0.032146	1.200	2.8	1.5	1.999703
	86.7	69.130							
	1.7	61.391							
	n/a	54.087							
7	43.0	12.087	4.93333	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	45.7	7.043							
	32.0	7.087							
	n/a	6.391							

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Summer 3									
							85%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$FF_{Aquatic\ Ins}$	$TFF_{Zooplankton}$	C_{BDace} (ug/g or mg/kg)
1	41.7	22.130	2.82087	6.2	0.45498	1.200	2.8	1.5	8.818054
	39.8	13.783							
	48.9	12.565							
	n/a	13.174							
2	152.0	30.913	4.70914	1.7	2.770083	1.200	2.8	1.5	14.72078
	37.2	10.435							
	32.6	12.652							
	n/a	8.783							
3	161.1	**0.022**	2.6314	9.1	0.289165	1.200	2.8	1.5	8.225758
	196.3	71.348							
	268.7	112.174							
	n/a	133.696							
4	182.0	23.739	11.7255	15.7	0.74685	1.200	2.8	1.5	36.65405
	202.8	11.348							
	178.0	15.652							
	n/a	13.261							
5	56.7	24.913	1.51054	20.2	0.074779	1.200	2.8	1.5	4.721962
	73.0	51.043							
	71.1	41.304							
	n/a	60.043							
6	74.3	168.652	0.3492	19.9	0.017548	1.200	2.8	1.5	1.091614
	72.4	411.652							
	80.2	101.087							
	n/a	185.174							
7	33.3	16.609	2.26316	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	29.3	11.783							
	21.5	11.652							
	n/a	9.522							

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Fall 1

Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Zooplankton}$	C_{BDace} (ug/g or mg/kg)
							85%	15%	
1	**1.7**	3.652	0.32786	3.3	0.099352	1.200	2.8	1.5	1.024896
	1.7	4.565							
	1.7	7.261							
	1.7	4.652							
2	**1.7**	4.391	0.47438	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	1.7	3.348							
	1.7	3.087							
	1.7	3.087							
3	**1.7**	2.957	0.33289	8.1	0.041098	1.200	2.8	1.5	1.040629
	1.7	5.652							
	1.7	1.522							
	1.7	9.696							
4	21.5	4.522	1.13167	14.2	0.079695	1.200	2.8	1.5	3.53759
	37.2	8.000							
	1.7	34.826							
	1.7	7.435							
5	54.8	16.957	4.22147	5.3	0.796504	1.200	2.8	1.5	13.19632
	32.6	8.783							
	25.4	9.522							
	77.0	9.696							
6	**1.7**	3.174	6.83212	14	0.488009	1.200	2.8	1.5	21.35722
	71.1	5.652							
	32.0	2.739							
	1.7	4.000							
7	**1.7**	8.000	1.20836	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	28.0	6.174							
	1.7	8.043							
	1.7	5.087							

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Fall 2									
							85%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water\text{-}column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Zooplankton}$	C_{BDace} (ug/g or mg/kg)
1	**1.7**	7.640	0.24738	3.3	0.074963	1.200	2.8	1.5	0.773298
	1.7	5.640							
	1.7	5.320							
	1.7	8.080							
2	**1.7**	6.760	0.12168	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	1.7	1.600							
	1.7	40.160							
	1.7	5.720							
3	**1.7**	12.640	1.21088	8.1	0.149491	1.200	2.8	1.5	3.785203
	1.7	5.720							
	22.2	10.080							
	26.7	14.680							
4	39.8	9.760	4.6548	14.2	0.327803	1.200	2.8	1.5	14.55092
	1.7	8.800							
	71.7	5.920							
	43.0	9.080							
5	**1.7**	14.800	1.18158	5.3	0.222939	1.200	2.8	1.5	3.693605
	73.7	16.520							
	1.7	59.000							
	48.9	16.240							
6	44.3	26.000	0.55754	14	0.039824	1.200	2.8	1.5	1.742868
	1.7	28.240							
	3.4	39.080							
	24.8	39.640							
7	**1.7**	7.160	0.40146	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	1.7	2.520							
	1.7	2.880							
	1.7	3.880							

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Fall 3									
							85%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water\text{-}column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Zooplankton}$	C_{BDace} (ug/g or mg/kg)
1	88.0	6.208	5.33789	3.3	1.617541	1.200	2.8	1.5	16.68623
	35.2	42.750							
	34.6	1.292							
	131.1	3.875							
2	40.4	6.750	6.98196	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	38.5	6.125							
	53.5	4.500							
	26.7	5.417							
3	127.8	16.708	1.17034	8.1	0.144486	1.200	2.8	1.5	3.65847
	37.2	22.875							
	110.2	36.667							
	82.2	229.125							
4	100.4	7.083	10.3183	14.2	0.726641	1.200	2.8	1.5	32.25499
	108.3	7.167							
	48.3	6.708							
	108.9	14.500							
5	134.3	27.125	2.29897	5.3	0.433768	1.200	2.8	1.5	7.186578
	112.8	33.208							
	103.0	142.958							
	150.0	14.292							
6	574.6	21.000	8.79619	14	0.628299	1.200	2.8	1.5	27.49689
	111.5	38.500							
	395.2	13.333							
	193.0	72.042							
7	**1.7**	2.583	2.16836	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	26.7	3.792							
	1.7	8.375							
	25.4	10.833							

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Fall 4									
							85%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Zooplankton}$	C_{BDace} (ug/g or mg/kg)
1	31.3	51.292	0.73776	3.3	0.223564	1.200	2.8	1.5	2.306244
	45.7	33.792							
	35.9	46.583							
	1.7	23.500							
2	37.2	15.042	1.78854	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	30.0	17.375							
	30.0	13.042							
	23.5	22.000							
3	366.5	143.250	1.36308	8.1	0.168281	1.200	2.8	1.5	4.260978
	101.7	241.708							
	90.7	209.083							
	379.6	94.458							
4	55.4	77.750	1.99611	14.2	0.140571	1.200	2.8	1.5	6.239852
	185.2	54.917							
	120.7	**0.022**							
	129.8	113.333							
5	81.5	94.375	1.98065	5.3	0.373708	1.200	2.8	1.5	6.191525
	88.0	51.500							
	62.0	19.750							
	129.8	16.792							
6	154.6	92.375	2.46948	14	0.176392	1.200	2.8	1.5	7.719609
	122.6	18.250							
	45.0	27.833							
	121.3	41.125							
7	**1.7**	26.125	0.38704	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	1.7	10.083							
	1.7	69.375							
	43.0	18.417							

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Winter 1									
							85%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Zooplankton}$	C_{BDace} (ug/g or mg/kg)
1	**5.5**	0.826	5.73036	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.5	1.000							
	5.5	1.217							
	5.5	0.826							
2	**5.5**	0.870	4.4737	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.5	1.391							
	5.5	1.130							
	5.5	1.565							
3	**5.5**	1.739	4.14636	10.3	0.402559	1.200	2.8	1.5	12.961514
	5.5	1.304							
	5.5	1.217							
	5.5	1.087							
4	13.0	5.565	3.57708	19.7	0.1815778	1.200	2.8	1.5	11.181963
	18.9	3.739							
	24.1	6.565							
	11.1	2.913							
5	n/a	n/a	n/a	8	n/a	1.200	2.8	1.5	#VALUE!
	n/a	n/a							
	n/a	n/a							
	n/a	n/a							
6	**5.5**	1.087	3.42283	10.5	0.325984	1.200	2.8	1.5	10.699774
	5.5	1.130							
	5.5	1.522							
	5.5	2.739							
7	**5.5**	0.435	11.087	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.5	0.348							
	5.5	0.348							
	5.5	0.870							

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*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Winter 2									
							85%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Zooplankton}$	C_{BDace} (ug/g or mg/kg)
1	17.0	3.217	7.78626	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	21.5	2.739							
	29.3	1.652							
	20.9	3.783							
2	**5.5**	6.130	1.96155	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.5	2.087							
	5.5	2.087							
	5.5	1.000							
3	22.2	67.609	1.60027	10.3	0.1553656	1.200	2.8	1.5	5.0024303
	30.0	4.652							
	56.1	8.565							
	48.9	17.391							
4	81.5	33.043	2.61157	19.7	0.1325669	1.200	2.8	1.5	8.163761
	80.9	21.826							
	125.2	70.913							
	99.1	22.304							
5	**5.5**	2.522	2.77672	8	0.3470904	1.200	2.8	1.5	8.680037
	15.0	1.609							
	5.5	4.957							
	5.5	2.304							
6	22.2	6.174	2.61905	10.5	0.2494331	1.200	2.8	1.5	8.1871429
	13.0	6.217							
	17.6	7.174							
	18.9	7.826							
7	**5.5**	2.783	1.81495	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.5	2.304							
	5.5	4.087							
	5.5	3.043							

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*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Winter 3

							85%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Zooplankton}$	C_{BDace} (ug/g or mg/kg)
1	25.435	14.261	1.39699	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.544	18.565							
	28.043	3.609							
	5.544	9.783							
2	**5.544**	10.174	0.7612	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.544	6.043							
	5.544	2.565							
	5.544	10.348							
3	39.783	23.696	0.39639	10.3	0.0384848	1.200	2.8	1.5	1.2391264
	33.913	150.870							
	11.739	37.870							
	25.435	67.261							
4	n/a	n/a	n/a	19.7	n/a	1.200	2.8	1.5	#VALUE!
	n/a	n/a							
	n/a	n/a							
	n/a	n/a							
5	n/a	n/a	n/a	8	n/a	1.200	2.8	1.5	#VALUE!
	n/a	n/a							
	n/a	n/a							
	n/a	n/a							
6	**5.544**	10.087	1.81905	10.5	0.173243	1.200	2.8	1.5	5.6863554
	43.696	8.174							
	30.000	9.348							
	24.130	29.217							
7	**5.544**	7.609	0.95675	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.544	4.652							
	5.544	10.739							
	11.739	6.652							

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Winter 4									
							85%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Zooplankton}$	C_{BDace} (ug/g or mg/kg)
1	**5.5**	6.696	0.85397	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	20.2	29.522							
	44.3	44.000							
	37.8	46.174							
2	24.1	42.826	0.47444	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.5	7.609							
	5.5	11.000							
	5.5	24.478							
3	40.4	14.000	0.57367	10.3	0.0556966	1.200	2.8	1.5	1.7933077
	5.5	16.043							
	67.2	244.174							
	68.5	42.391							
4	n/a	n/a	n/a	19.7	n/a	1.200	2.8	1.5	#VALUE!
	n/a	n/a							
	n/a	n/a							
	n/a	n/a							
5	n/a	n/a	n/a	8	n/a	1.200	2.8	1.5	#VALUE!
	n/a	n/a							
	n/a	n/a							
	n/a	n/a							
6	26.7	26.130	1.75392	10.5	0.1670397	1.200	2.8	1.5	5.4827436
	80.9	20.696							
	26.7	45.043							
	65.2	21.913							
7	34.6	29.870	1.28144	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	34.6	7.391							
	33.3	39.522							
	37.2	32.130							

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Spring 1									
							85%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Zooplankton}$	C_{BDace} (ug/g or mg/kg)
1	50.2	23.167	1.56288	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.5	12.083							
	42.4	21.125							
	32.6	27.292							
2	26.1	15.583	0.57416	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	33.9	101.792							
	33.3	28.083							
	11.7	37.417							
3	22.2	6.542	1.29561	8.8	0.1472285	1.200	2.8	1.5	4.0500802
	17.0	8.250							
	11.7	13.750							
	5.5	15.000							
4	n/a	n/a	n/a	18.9	n/a	1.200	2.8	1.5	#VALUE!
	n/a	n/a							
	n/a	n/a							
	n/a	n/a							
5	18.3	7.625	2.31983	5.3	0.4377034	1.200	2.8	1.5	7.2517828
	12.4	5.708							
	13.7	5.250							
	12.4	5.875							
6	**5.5**	6.042	0.95372	6.1	0.1563476	1.200	2.8	1.5	2.9813301
	5.5	9.208							
	5.5	4.542							
	5.5	3.458							
7	11.7	20.792	0.87118	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.5	3.625							
	5.5	11.833							
	16.3	8.667							

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Spring 2									
							85%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Zooplankton}$	C_{BDace} (ug/g or mg/kg)
1	37.2	26.348	1.56771	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.5	6.522							
	50.2	6.696							
	33.9	41.348							
2	35.2	57.913	0.7696	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	26.1	41.217							
	40.4	39.870							
	39.1	44.043							
3	30.0	91.087	0.49028	8.8	0.0557132	1.200	2.8	1.5	1.5326034
	24.8	94.174							
	33.3	24.957							
	42.4	55.826							
4	n/a	n/a	n/a	18.9	n/a	1.200	2.8	1.5	#VALUE!
	n/a	n/a							
	n/a	n/a							
	n/a	n/a							
5	58.7	38.609	0.779	5.3	0.146981	1.200	2.8	1.5	2.4351516
	52.2	94.957							
	84.1	162.957							
	73.0	47.565							
6	67.8	130.478	0.81578	6.1	0.1337349	1.200	2.8	1.5	2.5501375
	91.3	102.609							
	32.6	28.391							
	94.6	89.478							
7	**5.5**	3.087	1.00791	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.5	2.652							
	5.5	11.174							
	5.5	5.087							

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Spring 3									
							85%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Zooplankton}$	C_{BDace} (ug/g or mg/kg)
1	**5.5**	1.783	2.81769	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.5	2.522							
	5.5	2.130							
	5.5	1.435							
2	n/a	n/a	n/a	n/d	n/a	1.200	2.8	1.5	#VALUE!
	n/a	n/a							
	n/a	n/a							
	n/a	n/a							
3	n/a	n/a	n/a	8.8	n/a	1.200	2.8	1.5	#VALUE!
	n/a	n/a							
	n/a	n/a							
	n/a	n/a							
4	n/a	n/a	n/a	18.9	n/a	1.200	2.8	1.5	#VALUE!
	n/a	n/a							
	n/a	n/a							
	n/a	n/a							
5	**5.5**	6.000	2.21503	5.3	0.4179299	1.200	2.8	1.5	6.9241791
	5.5	2.435							
	12.4	3.739							
	13.7	4.609							
6	n/a	n/a	n/a	6.1	n/a	1.200	2.8	1.5	#VALUE!
	n/a	n/a							
	n/a	n/a							
	n/a	n/a							
7	44.3	1.565	6.37501	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.5	2.870							
	5.5	2.957							
	5.5	2.174							

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

Spring 4									
							85%	15%	
Site	Se (ug/m2)	Dry Weight (g/m2)	$C_{particulate}$ (ug/g)	$C_{water-column}$ (ug/L)	K_d (L/g)	TFF_{Fish}	$TFF_{Aquatic\ Insect}$	$TFF_{Zooplankton}$	C_{BDace} (ug/g or mg/kg)
1	16.3	17.217	1.60436	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	15.7	10.522							
	20.2	6.565							
	15.0	7.565							
2	n/a	n/a	n/a	n/d	n/a	1.200	2.8	1.5	#VALUE!
	n/a	n/a							
	n/a	n/a							
	n/a	n/a							
3	n/a	n/a	n/a	8.8	n/a	1.200	2.8	1.5	#VALUE!
	n/a	n/a							
	n/a	n/a							
	n/a	n/a							
4	n/a	n/a	n/a	18.9	n/a	1.200	2.8	1.5	#VALUE!
	n/a	n/a							
	n/a	n/a							
	n/a	n/a							
5	33.9	10.696	0.99317	5.3	0.18739	1.200	2.8	1.5	3.1046402
	5.5	37.522							
	35.9	22.391							
	16.3	21.652							
6	n/a	n/a	n/a	6.1	n/a	1.200	2.8	1.5	#VALUE!
	n/a	n/a							
	n/a	n/a							
	n/a	n/a							
7	12.4	7.130	1.23841	n/d	#VALUE!	1.200	2.8	1.5	#VALUE!
	5.5	5.087							
	5.5	6.261							
	5.5	4.957							

*Non-detect values are bolded and black.

*Calculations which are based non-detect values are bolded and grey.

*Valid modeled tissue concentrations are highlighted in green.

APPENDIX D

PART 1

Creek Chub Statistics

Site	Treatment	Se (mg/kg dw)	Rank
1	Modeled	33.792	1
1	Modeled	3.723554	43
1	Modeled	9.448057	19
2	Modeled	7.659801	22
2	Modeled	6.216066	26
3	Modeled	4.280585	34
3	Modeled	2.071494	69
3	Modeled	2.412646	65
3	Modeled	2.83247	58
3	Modeled	0.701617	76
3	Modeled	0.867789	75
4	Modeled	14.8422	9
4	Modeled	15.47772	5
4	Modeled	18.26338	2
4	Modeled	6.331438	25
4	Modeled	4.622475	31
5	Modeled	15.90855	3
5	Modeled	1.993919	71
5	Modeled	7.472002	23
5	Modeled	4.069176	36
5	Modeled	3.505758	45
5	Modeled	4.106096	35
5	Modeled	1.378829	74
6	Modeled	0.46095	77
6	Modeled	15.56925	4
6	Modeled	4.370988	33
6	Modeled	4.635714	30
6	Modeled	3.104433	54
6	Modeled	1.443936	73
1	Measured	2.791045	59
1	Measured	3.836538	40
1	Measured	2.755556	61
1	Measured	3.461538	47
1	Measured	3.839806	39
1	Measured	3.150754	53
1	Measured	3.893939	37
1	Measured	3.052632	55
2	Measured	2.768473	60
2	Measured	2.736607	63
2	Measured	2.552511	64
2	Measured	2.296117	66
2	Measured	2.275701	67
2	Measured	2.018018	70
2	Measured	2.743590	62
2	Measured	1.894273	72

Site	Treatment	Se (mg/kg dw)	Rank
3	Measured	13.258621	13
3	Measured	10.483471	17
3	Measured	9.082353	20
3	Measured	7.219626	24
3	Measured	11.634361	16
3	Measured	9.583710	18
3	Measured	12.834146	15
3	Measured	8.395455	21
4	Measured	13.192913	14
4	Measured	13.685185	12
4	Measured	5.515021	27
4	Measured	14.452206	10
4	Measured	14.140496	11
4	Measured	15.365462	6
4	Measured	15.043478	7
4	Measured	15.043478	7
5	Measured	4.985577	28
5	Measured	4.412371	32
5	Measured	3.495798	46
5	Measured	3.403846	48
5	Measured	3.763736	42
5	Measured	3.364162	49
5	Measured	4.917476	29
5	Measured	3.319249	50
6	Measured	3.051020	56
6	Measured	3.029046	57
6	Measured	2.097166	68
6	Measured	3.805263	41
6	Measured	3.556757	44
6	Measured	3.846154	38
6	Measured	3.239437	51
6	Measured	3.184783	52

Analysis of Variance Report – Creek Chub

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Response	Rank	

Expected Mean Squares Section

Source Term	DF	Term Fixed?	Denominator Term	Expected Mean Square
A: Site	5	Yes	S(AB)	S+bsA
B: Treatment	1	Yes	S(AB)	S+asB
AB	5	Yes	S(AB)	S+sAB
S(AB)	65	No		S

Note: Expected Mean Squares are for the balanced cell-frequency case.

Analysis of Variance Table

Source Term	DF	Sum of Squares	Mean Square	F-Ratio	Prob Level	Power (Alpha=0.05)
A: Site	5	9501.208	1900.242	9.52	0.000001*	0.999893
B: Treatment	1	325.0287	325.0287	1.63	0.206502	0.241740
AB	5	11460.24	2292.047	11.48	0.000000*	0.999992
S	65	12976.12	199.6326			
Total (Adjusted)	76	38100.99				
Total	77					

* Term significant at alpha = 0.05

Means and Standard Error Section

Term	Count	Mean	Standard Error
All	77	36.99166	
A: Site			
1	11	34.9375	4.260096
2	10	44.75	4.468026
3	14	40.41667	3.776171
4	13	13.075	3.918718
5	15	40.75	3.648128
6	14	48.02083	3.776171
B: Treatment			
Measured	48	39.25	2.039366
Modeled	29	34.73333	2.623715
AB: Site,Treatment			
1,Measured	8	48.875	4.995405
1,Modeled	3	21	8.157462
2,Measured	8	65.5	4.995405
2,Modeled	2	24	9.990809
3,Measured	8	18	4.995405
3,Modeled	6	62.83333	5.768197
4,Measured	8	11.75	4.995405
4,Modeled	5	14.4	6.318743
5,Measured	8	40.5	4.995405
5,Modeled	7	41	5.340312
6,Measured	8	50.875	4.995405
6,Modeled	6	45.16667	5.768197

Analysis of Variance Report

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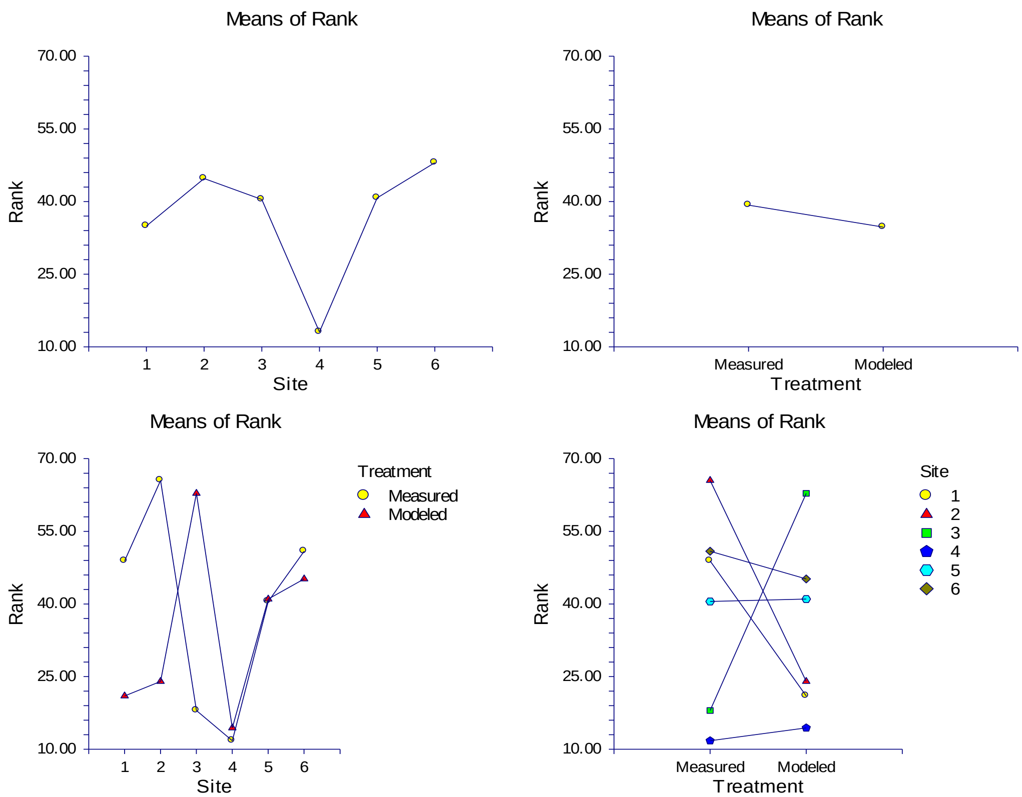
Response Rank

Plots Section



PART 2

Green Sunfish Statistics

Site	Treatment	Se (mg/kg dw)	Rank
1	Modeled	57.7536	1
1	Modeled	6.363893	37
1	Modeled	12.04227	23
2	Modeled	13.0913	20
2	Modeled	10.62382	25
3	Modeled	7.315908	34
3	Modeled	2.640278	68
3	Modeled	3.075101	66
3	Modeled	3.610199	63
3	Modeled	0.894264	73
3	Modeled	1.106063	72
4	Modeled	25.36668	9
4	Modeled	26.45283	7
4	Modeled	23.27807	11
4	Modeled	8.0699	32
4	Modeled	5.891697	44
5	Modeled	27.18915	6
5	Modeled	3.407788	65
5	Modeled	9.523636	27
5	Modeled	5.186475	51
5	Modeled	4.468356	57
5	Modeled	5.233532	50
5	Modeled	1.757422	71
6	Modeled	0.787806	74
6	Modeled	19.8442	14
6	Modeled	5.571157	47
6	Modeled	5.908571	43
6	Modeled	3.956836	59
6	Modeled	1.840406	70
1	Measured	8.174468	31
1	Measured	6.232673	40
1	Measured	12.769231	21
1	Measured	8.195238	30
1	Measured	9.299145	28
1	Measured	7.398230	33
1	Measured	9.551220	26
1	Measured	6.836538	36
2	Measured	5.602740	46
2	Measured	6.857820	35
2	Measured	3.574257	64
2	Measured	5.186275	52
2	Measured	4.872549	54
2	Measured	17.636905	16
2	Measured	15.238342	19
2	Measured	2.515625	69

Site	Treatment	Se (mg/kg dw)	Rank
3	Measured	25.570281	8
3	Measured	16.460967	17
3	Measured	18.881890	15
3	Measured	22.209402	13
3	Measured	22.514423	12
3	Measured	27.287554	5
3	Measured	33.375610	2
3	Measured	16.385714	18
4	Measured	28.986111	4
4	Measured	25.237354	10
4	Measured	11.095833	24
4	Measured	9.150000	29
4	Measured	31.122449	3
5	Measured	5.145455	53
5	Measured	5.524378	48
5	Measured	4.820259	55
5	Measured	4.061404	58
5	Measured	3.639269	62
5	Measured	3.875556	60
5	Measured	2.682464	67
5	Measured	12.058559	22
6	Measured	6.291667	39
6	Measured	4.681102	56
6	Measured	3.756098	61
6	Measured	6.201754	41
6	Measured	5.679487	45
6	Measured	6.299107	38
6	Measured	5.481818	49
6	Measured	5.921488	42

Analysis of Variance Report – Green Sunfish

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Expected Mean Squares Section

Source Term	DF	Term Fixed?	Denominator Term	Expected Mean Square
A: Site	5	Yes	S(AB)	S+bsA
B: Treatment	1	Yes	S(AB)	S+asB
AB	5	Yes	S(AB)	S+sAB
S(AB)	62	No		S

Note: Expected Mean Squares are for the balanced cell-frequency case.

Analysis of Variance Table

Source Term	DF	Sum of Squares	Mean Square	F-Ratio	Prob Level	Power (Alpha=0.05)
A: Site	5	9496.721	1899.344	8.49	0.000004*	0.999576
B: Treatment	1	251.5027	251.5027	1.12	0.293155	0.181138
AB	5	9433.366	1886.673	8.43	0.000004*	0.999545
S	62	13871.96	223.7413			
Total (Adjusted)	73	33762.5				
Total	74					

* Term significant at alpha = 0.05

Means and Standard Error Section

Term	Count	Mean	Standard Error
All	74	35.31091	
A: Site			
1	11	25.47917	4.510002
2	10	33.4375	4.73013
3	14	36.95833	3.99769
4	10	17.3	4.73013
5	15	49.91964	3.862135
6	14	48.77083	3.99769
B: Treatment			
Measured	45	33.29167	2.229805
Modeled	29	37.33016	2.777628
AB: Site,Treatment			
1,Measured	8	30.625	5.288446
1,Modeled	3	20.33333	8.635997
2,Measured	8	44.375	5.288446
2,Modeled	2	22.5	10.57689
3,Measured	8	11.25	5.288446
3,Modeled	6	62.66667	6.106572
4,Measured	5	14	6.689415
4,Modeled	5	20.6	6.689415
5,Measured	8	53.125	5.288446
5,Modeled	7	46.71429	5.653587
6,Measured	8	46.375	5.288446
6,Modeled	6	51.16667	6.106572

Analysis of Variance Report

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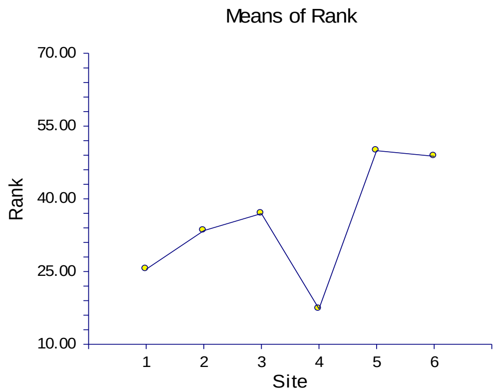
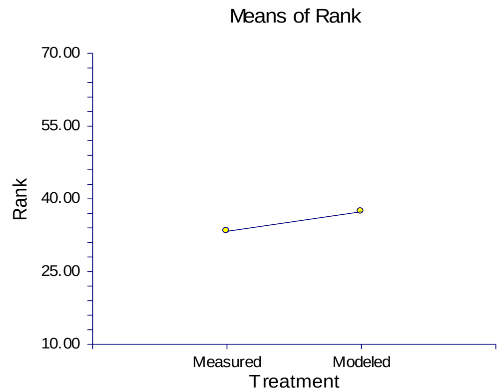
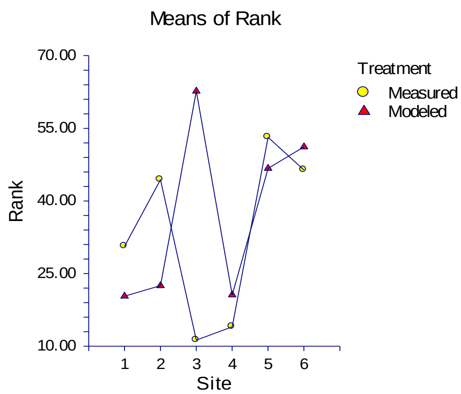
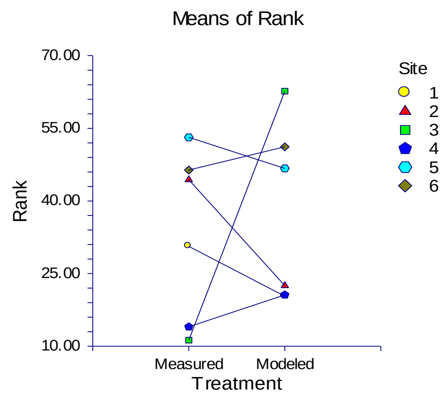
Response Rank

Plots Section









PART 3

Blacknose Dace Statistics

Site	Treatment	Se (mg/kg dw)	Rank
4	Modeled	35.14904	4
4	Modeled	36.65405	3
4	Modeled	32.25499	5
4	Modeled	11.18196	10
4	Modeled	8.163761	15
5	Modeled	37.67433	2
5	Modeled	4.721962	20
5	Modeled	13.19632	8
5	Modeled	7.186578	18
5	Modeled	6.191525	19
5	Modeled	7.251783	17
5	Modeled	2.435152	21
4	Measured	38.506276	1
4	Measured	23.901709	7
4	Measured	31.058608	6
5	Measured	12.638655	9
5	Measured	10.849206	11
5	Measured	7.852941	16
5	Measured	8.477032	13
5	Measured	8.197080	14
5	Measured	9.698565	12

Analysis of Variance Report – Blacknose Dace

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Database		
Response	Rank	

Expected Mean Squares Section

Source Term	DF	Term Fixed?	Denominator Term	Expected Mean Square
A: Site	1	Yes	S(AB)	S+bsA
B: Treatment	1	Yes	S(AB)	S+asB
AB	1	Yes	S(AB)	S+sAB
S(AB)	17	No		S

Note: Expected Mean Squares are for the balanced cell-frequency case.

Analysis of Variance Table

Source Term	DF	Sum of Squares	Mean Square	F-Ratio	Prob Level	Power (Alpha=0.05)
A: Site	1	282.5957	282.5957	10.46	0.004878*	0.861418
B: Treatment	1	32.49397	32.49397	1.20	0.288110	0.178981
AB	1	0.0645951	0.0645951	0.00	0.961575	0.050244
S	17	459.3667	27.02157			
Total (Adjusted)	20	770				
Total	21					

* Term significant at alpha = 0.05

Means and Standard Error Section

Term	Count	Mean	Standard Error
All	21	9.891666	
A: Site			
4	8	6.033333	1.837851
5	13	13.75	1.441729
B: Treatment			
Measured	9	8.583333	1.732742
Modeled	12	11.2	1.500599
AB: Site,Treatment			
4,Measured	3	4.666667	3.001198
4,Modeled	5	7.4	2.324718
5,Measured	6	12.5	2.122168
5,Modeled	7	15	1.964745

Analysis of Variance Report

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Plots Section