REVIEW AND EVALUATION OF:

WASHINGTON STATE DEPARTMENT OF ECOLOGY

DRAFT SEDIMENT MANAGEMENT STANDARDS RULE PROPOSED AMENDMENTS

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Confederated Tribes of the Colville Reservation

DRAFT SEDIMENT MANAGEMENT STANDARDS RULE PROPOSED AMENDMENTS

Washington State Department of Ecology
Sediment Management Standards Rule
Review/Comment Form
Reviewer Name: Confederated Tribes of the Colville Reservation
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1.0 Introduction

The Confederated Tribes of the Colville Reservation (CTCR) have reviewed and evaluated the Draft Sediment Management Standards (SMS) Rule Proposed Amendments described in Chapter 173-204 WAC (Review Version Dated August 15, 2012). The results of this evaluation demonstrate that there are many serious technical flaws in the proposed SMS Rule Amendments. Accordingly, the CTCR strongly recommend that the Draft SMS Rule Amendments not be promulgated by Washington State Department of Ecology (Department) at this time. Specific issues that need to be addressed before the Draft SMS Rule Amendments can be adopted include:

- The proposed freshwater benthic criteria are not protective of benthic-invertebrate communities;

- The proposed adjustments to the default scenario for evaluating human health risks will not be protective of Tribal or subsistence resources users;

- The proposed ecological bioaccumulation narrative is not comprehendible and cannot be effectively implemented;

- The draft SMS Rule Amendments ignore Tribal Standards and Regulations;

- The draft SMS Rule Amendments fail to define regional background levels of contaminants and fail to provide a consistent basis for determining natural background levels of contaminants;

- The draft SMS Rule Amendments fail to define required quantitation limits for contaminants and default to potentially inappropriate practical quantitation limits;

- The draft SMS Rule Amendments fail to provide a basis for meaningful consultation with Tribal governments or the public regarding upward adjustment of sediment cleanup levels; and,

- The draft SMS Rule Amendments fail to provide a basis for establishing sediment cleanup levels below the sediment cleanup objectives.

Each of these issues is described in more detail in the following sections of this document. In addition, the recommended steps for resolving each issue are described in the following sections of this document.

2.0 Technical Basis for CTCR Recommendations to Ecology

The following sections of this document describe each of the issues identified by CTCR and provide specific recommendations for resolving the issues in a manner that would support timely promulgation of Draft SMS Rule Amendments.

Issue # 1A: Proposed Freshwater Benthic Criteria Are Not Protective of Benthic Invertebrate Communities and Are Not Consistent with Ecology's Narrative Intent for the Proposed Freshwater Benthic Criteria (Issue 1).

Rationale: Section WAC 173-204-563 of the Proposed SMS Rule Amendments describes two types of sediment cleanup levels based on protection of the benthic community in freshwater sediment, including:

- Sediment cleanup objectives (SCO); and,
- Cleanup screening levels (CSL).

According to Section WAC 173-204-563(2a), the SCOs establish no adverse effect levels, including no acute or chronic effects, on the benthic community. By comparison, the CSLs establish minor adverse effects levels, including minor acute or chronic effects, on the benthic community. The numerical criteria established for the SCOs and CSLs, as presented in Table VII of the Draft SMS Rule Amendments, were developed using a Floating Percentile Model applied to matching sediment chemistry and toxicity data compiled for sites located in Washington and Oregon. While the concept of establishing numerical criteria that define the concentrations of COPCs that represent no and minor adverse effects on the benthic community is reasonable and appropriate, the numerical criteria presented in Table VII of the Draft SMS Rule Amendments are neither reasonable nor appropriate because they do not satisfy the narrative intent of the sediment cleanup levels. That is, the numerical criteria presented in Table VII do not adequately define the concentrations of COPCs that correspond to no or minor adverse effects levels, as required under Section WAC 173-204-563 of the Proposed SMS Rule Amendments.

Proposed Resolution: The freshwater benthic criteria need to be revised to ensure that they represent values that are consistent with the narrative intent of the SQVs (i.e., no adverse effects for the SCOs and minor adverse effects for the CSLs, as stated in WAC 173-204-563). To assist the Department, the CTCR recommend that the numerical sediment quality standards listed in Table 1 be adopted as SCOs and CSLs (see Table 1 Recommended sediment cleanup objectives and cleanup screening levels for sediment quality standards in freshwater ecosystems in Washington State).

Issue # 1B: Methods Used to Designate Sediment Samples as Toxic or Not Toxic Are Not Appropriate.

Rationale: The Floating Percentile Model (FPM) that was used to derive the numerical criteria presented in Table VII of Section WAC 173-204-563 relies on matching sediment chemistry and sediment toxicity data from sites located in Washington and Oregon. The first step in the application of the FPM is determination of whether adverse biological effects are observed in each sample (called a "hit" if toxicity is observed and called "no hit" if toxicity is not observed; WDOE 2011). Table VIII of Section WAC 173-204-563 describes the procedures that were applied by the Department to determine if individual sediment samples used in the FPM were toxic (i.e., hit) or not toxic (i.e., no hit). These procedures are inappropriate for the designation of sediment samples as toxic or not toxic for several reasons, including:

- The procedures described for normalizing the response data for amphipods, *Hyalella azteca*, and midge, *Chironomus dilutus*, are incorrect for the mortality endpoint. Toxicity test results should be control normalized by dividing the response observed for a test sediment sample by the average response for the control treatment(s). In contrast, Ecology has control normalized the toxicity data for the mortality endpoint by subtracting the response for the control treatment from the response for a test sediment sample. This approach to control normalization biases the designation of sediment samples as toxic or not toxic in a way that results in fewer samples being designated as toxic to benthic invertebrates (see Figure 1). Ecology did correctly control normalize the weight data for both species, however.
- The adverse effects levels presented in Table VIII for interpreting the results of sediment toxicity tests are not consistent with the narrative intent of the SCOs (see Table 2). Specifically, no adverse effects are reported (i.e., sediment samples are designated as not toxic) when:

    - Midge survival (10-d toxicity test) <20% decrease compared to control;
    - Midge growth (10-d toxicity test) <20% decrease compared to control;
    - Amphipod survival (10-d toxicity test) <15% decrease compared to control; and,
    - Amphipod growth (28-d toxicity test) <25% decrease compared to control.

    The biological criteria for no adverse effects levels proposed by Ecology in Table VIII are much larger than appropriate for no adverse effects levels (Ingersoll *et al.* 2005). For the uninitiated, it can be difficult to determine if the biological criteria proposed in Table VIII are reasonable. For this reason, CTCR have expressed these criteria in terms that are easier to comprehend. In Washington State, the Department of Social and Health and Services (WDSHS) uses a Body Mass Index (BMI) as one tool for assessing human health. The BMI is a tool that compares height and weight to determine if an individual is underweight, a healthy weight, or over weight, based on the following scale:

    - BMI < 18.5 – Underweight;
    - 18.5 < BMI < 24.9 – Normal weight;
    - 25 < BMI < 29.9 – Overweight; and,
    - BMI > 30 – Obese.

The BMI for a six foot tall human weighing 160 pounds is 21.7. This is the middle of the normal weight range for a six-foot person. In the Proposed SMS Rule Amendment (Table VIII), Ecology has indicated that growth rates of 75% (for amphipods) or 80% (for midge) of the control treatment represent no adverse effect levels. If these same biological criteria were applied to a human scenario, a six foot tall human weighing 120 or 128 pounds would be expected to exhibit no adverse effects. However, WDSHS would classify that individual as underweight based in BMI's of 16.3 or 17.4, respectively. According to WDSHS (2004) individuals with BMIs < 19 are at a high risk of:

- Anemia and nutrient deficiencies;
- Bone loss and osteoporosis;
- Heart irregularities and blood vessel diseases;
- Infertility;
- Increased vulnerability to infection and disease; and,
- Delayed wound healing.

Individuals with the affliction, anorexia nervosa, are often diagnosed based on a BMI of < 17.5. As this example demonstrates, a 20% or 25% reduction in growth would not represent no adverse effects in humans according to the criteria that are being used in Washington State (WSDSH 2004).

Tables 3 and 4 present the results of toxic/not toxic designations for sediment samples from the Upper Columbia River using the reference envelope approach (i.e., the recommended approach) and the approach that was used by Ecology (i.e., identified as the SMS SCO; WDOE 2011). A comparison of the number of samples designated as toxic using the two approaches for four toxicity test endpoints is presented in Table 5. Ecology has not demonstrated that such a magnitude of effect on growth represents no adverse effect in benthic invertebrates. Moreover, the analyses presented in Tables 3, 4, and 5 demonstrate that application of such criteria only rarely identify toxic samples. Therefore, the biological criteria established for the SCOs need to be revised.

- The adverse effects levels presented in Table VIII for interpreting the results of sediment toxicity tests are not consistent with the narrative intent of the CSLs. Specifically minor adverse effects are reported (i.e., sediment samples are designated as not toxic) when:

    - Midge survival (10-d toxicity test) <30% decrease compared to control;
    - Midge growth (10-d toxicity test) <30% decrease compared to control;
    - Amphipod survival (10-d toxicity test) <25% decrease compared to control; and,
    - Amphipod growth (28-d toxicity test) <40% decrease compared to control.

    The biological criteria for minor adverse effects levels proposed by Ecology in Table VIII are much larger than appropriate for minor adverse effects levels (Ingersoll *et al.* 2005). Using the same example for a six foot tall human, a BMI of 13.0 would be calculated for an individual that weighed 40% less than the 160 pound individual (i.e., the individual would weigh 96 pounds). Such a difference between a 160 pound individual and a 96 pound individual would be classified as a "minor adverse effect" using the biological criteria presented in Table VIII for amphipods. However, this example demonstrates that a 30% or 40% reduction in growth would not represent minor adverse effects in humans (i.e., a BMI of 13.0 would be indicative of a grossly underweight human using the biological criteria that are used in Washington State).

- Tables 3 and 4 present the results of toxic/not toxic designations for sediment samples from the Upper Columbia River using the reference envelope approach (i.e., the recommended approach) and the approach that was used by Ecology (i.e., identified as the SMS CSL; WDOE 2011). A comparison of the number of samples designated as toxic using the two approaches for four toxicity test endpoints is presented in Table 5. The case study for the Upper Columbia River demonstrates that application of the biological criteria for CSLs results in designation of even highly contaminated sediment samples as not toxic. The biological criteria presented in Table VIII are also much less protective than those used to develop the National Sediment Inventory (USEPA 2004).

Proposed Resolution: The Department should revise the proposed SMS Rule Amendment to indicate that the acceptability of freshwater toxicity tests will be evaluated using the test acceptability criteria established by ASTM (2012) and USEPA (2000) for control samples. In addition, Table VIII should be revised to describe the correct procedures for control normalizing toxicity test data. Finally, the adverse effect levels presented in Table VIII should be revised to reflect values that correspond to no adverse effects levels and minor adverse effect levels for benthic invertebrate communities. To assist the Department, the CTCR have developed recommended biological criteria that should be included in Table VIII (see Table 6: Recommended methods for designating sediments as toxic or not toxic (i.e., "hit" or "no hit") to benthic invertebrates; Figure 2 provides a visual illustration of the application of the reference envelope approach to designating sediment samples as toxic or not toxic).

Issue # 1C: The Results of Short-Term Toxicity Tests Do Not Provide a Basis for Directly Establishing Numerical Criteria Consistent With the Narrative Intent of the Sediment Cleanup Levels.

Rationale: Section WAC 173-204-563 of the Proposed SMS Rule Amendments indicates that the numerical criteria presented in Table VII (i.e., the sediment cleanup levels) were developed using matching sediment chemistry and sediment toxicity data. The five toxicity test endpoints that were used in the FPM included:

- Amphipod 10-d mortality;
- Amphipod 28-d mortality;
- Amphipod 28-d growth;
- Midge 10-d mortality; and,
- Midge 10-d growth.

The data compiled for these five endpoints were used directly to derive the numerical SCOs and CSLs. While such data (if properly interpreted to identify hits and no hits; see Issue 1B above) are likely to provide some of the information needed to derive numerical criteria for managing contaminated sediments, they do not provide all of the information needed to establish sediment cleanup levels that are protective of the benthic community in freshwater ecosystems. Some of the key limitations of the data used by the Department to establish the numerical SCOs and CSLs include:

- The biomass of benthic invertebrates was not considered in the derivation of numerical criteria. Biomass is calculated as the product of survival and growth (weight; i.e., Biomass = Survival x Weight, where survival and weight are expressed as percentages on a control-normalized basis). Biomass is an important endpoint because one of the ecosystem services that the benthic community provides is food for fish and wildlife species. Therefore, the amount of food available for fish and wildlife is reduced when the biomass of benthic invertebrates decreases. Because biomass integrates the survival and growth endpoints, it frequently provides a more sensitive indicator of effects on the benthic community than does either survival or growth (MacDonald *et al.* 2010; 2011; 2012). To illustrate the relative sensitivities of the biomass and survival endpoints, matching sediment toxicity data for midge and amphipods for the Upper Columbia River site are presented in Figure 3 and 4 (MacDonald *et al.* 2012). Biomass is a more sensitive endpoint than survival for any sample plotted below the line of unity on these figures. Failure to consider the biomass endpoint indicates that the numerical SCOs and CSLs are likely to be underprotective of the benthic community.

- The reproduction of benthic invertebrates was not considered in the derivation of numerical criteria. For both of the species used by the Department in the derivation of freshwater SCOs and CSLs, standard methods are available to evaluate reproduction (See ASTM 2012; USEPA 2000). Reproduction is an important endpoint because the results of studies conducted on many invertebrates indicate that adverse effects on reproduction can occur at concentrations of COPCs substantially lower than those that adversely effect either survival or biomass. Figure 5 shows the relationship between PCB concentration and reproduction of amphipods in 42-day toxicity tests conducted with sediment samples from the Anniston PCB Site, Anniston, AL (Ingersoll *et al.* 2012); toxicity thresholds for survival and biomass are also shown. Failure to consider the reproduction endpoint indicates that the numerical SCOs and CSLs are likely to be underprotective of the benthic community. While it is understood that sufficient data to derive numerical criteria directly for the reproduction endpoint for amphipods or midge are likely not available, an application factor can be used to adjust the SCOs and CSLs in a manner to ensure that they protect against adverse effects on the reproduction of benthic invertebrates.

- The results of toxicity tests conducted on more sensitive benthic invertebrate species were not considered in the derivation of numerical criteria. Data collected at the USGS Columbia Environmental Research Center and elsewhere over the past decade indicate that freshwater molluscs, including mussels and snails, can be more sensitive to sediment-associated COPCs than are midge or amphipods (Besser *et al.* 2009). Similarly, sediments contaminated with metals and PAHs associated with coal mining activities were more toxic to mussels than to either amphipods or midge (Wang *et al.* 2012). Therefore, numerical criteria derived using toxicity data for midge and/or amphipods only may not be sufficiently protective of freshwater molluscs or other invertebrates that exhibit similar sensitivities to contaminants. Failure to consider data on the toxicity of contaminated sediments to freshwater molluscs indicates that the numerical

SCOs and CSLs are likely to be underprotective of the benthic community. Importantly, there is no reason to believe that SCOs and CSLs presented in Table VII are protective of threatened and endangered species of invertebrates or listed species of invertebrates.

Proposed Resolution: The sediment cleanup objectives and cleanup screening levels must be revised to provide numerical criteria that correspond with no adverse effects levels (for the SCOs) and minor adverse effect levels (for the CSLs). Table 1 presents the SCOs and CSLs that are recommended by CTCR that meet the narrative established by the Department.

Issue # 1D: The Proposed Sediment Clean Objectives and Cleanup Screening Levels are Not Comparable to Existing Sediment Quality Guidelines with Similar Narrative Intent.

Rationale: According to Section WAC 173-204-563, the SCOs establish no adverse effect levels, including no adverse acute or chronic effects, on the benthic community. If the numerical SCOs truly represented no adverse effects levels, they should be comparable to other sediment quality guidelines that are intended to represent no adverse effects levels. In 2000, MacDonald *et al.* (2000) conducted a review of the literature to identify sediment quality guidelines that represent threshold effect concentrations (TECs; i.e., no adverse effects levels). The sediment quality guidelines that corresponded with this narrative intent were compiled and used to derive consensus-based TECs (Table 7). Comparison of the consensus-based TECs with the SCOs that are proposed by the Department in Table VII of Section WAC 173-204-563 indicates that many of the SCOs are comparable to the TECs (i.e., within a factor of three). However, the following SCOs are substantially higher than the TECs and, hence, do not represent no adverse effect levels for these contaminants (see Table 7):

- Copper;
- Lead;
- Mercury,
- Zinc;
- Total PAHs;
- Sum DDD;
- Sum DDE;
- Sum DDT; and,
- Endrin.

According to Section WAC 173-204-563, the CSLs establish minor adverse effect levels, including no adverse acute or chronic effects, on the benthic community. If the numerical CSLs truly represent no adverse effects levels, they should be comparable to other sediment quality guidelines that are intended to represent minor adverse effects levels. In 2000, MacDonald *et al.* (2000) conducted a review of the literature to identify sediment quality guidelines that represent probable effect concentrations (PECs; i.e., concentrations of COPCs above which adverse effects are likely to be observed). The sediment quality guidelines that corresponded with this narrative intent were compiled and used to derive consensus-based PECs (Table 8). Comparison of the consensus-based PECs with the SCOs that are proposed by the Department in Table VII of Section WAC 173-204-563 indicates that many of the SCOs are comparable to the PECs (i.e., within a factor of three). However, the following CSLs are substantially higher than the PECs and, hence, do not represent minor adverse effect levels for these contaminants (see Table 8):

- Arsenic;
- Copper;
- Lead;
- Zinc;
- Total PCBs;
- Sum DDD; and,
- Sum DDT.

Importantly, many of the proposed SCOs and CSLs are substantially higher than the sediment quality standards that have been established by the Confederated Tribes of the Colville Reservation and the Spokane Tribe of Indians (Table 9). Therefore, neither the proposed SCOs nor the proposed CSLs would provide an adequate basis for protecting benthic invertebrate communities on lands managed by tribal governments.

Proposed Resolution: The sediment cleanup objectives and cleanup screening levels must be revised to provide numerical criteria that correspond with no adverse effects levels (for the SCOs) and minor adverse effect levels (for the CSLs; see Table 1 for CTCR recommended SCOs and CSLs). In addition, precedence of tribal sediment quality standards and other regulations must be explicitly recognized in the Proposed SMS Rule Amendments.

Issue # 1E: The Proposed Sediment Quality Objectives and Cleanup Screening Levels for Certain Metals Contaminants are Gross Outliers Disproportionately Affected by Slag Influence in Upper Columbia River Sediments.

Rationale: The SCO and CSL chemical criteria for copper, lead, and zinc (and to a lesser extent, arsenic and mercury) derived using the Floating Percentile Method (FPM) are demonstrably high compared to similar chemical criteria derived using other established methods to predict toxicity (See Figure 6). Figure 6 also demonstrates that SCO and CSL chemical criteria for other metals (arsenic, cadmium, chromium, mercury, nickel) derived using FPM do <u>not</u> differ significantly from chemical criteria, such as Threshold Effects Concentrations (TECs) and Probable Effects Concentrations (PECs). Both the CCTR and the Spokane Tribe of Indians (STI) have adopted SQVs based on TECs from MacDonald *et al.* (2000). Comparison of the CTCR and STI sediment quality values with the SQVs proposed by Ecology show reasonable agreement for all metals listed except copper, lead, and zinc (and to a lesser extent, arsenic; Table 9). The degree of difference between Ecology-proposed SCOs/CSLs and sediment quality standards (SQSs) adopted by CTCR and STI is significant. For example, the Ecology SCOs for each of copper, lead, and zinc are at least one full order of magnitude greater than the TEC for each of those same metals, as adopted in the CTCR sediment quality standards. For zinc, the difference between the Ecology SCOs is 26 times greater than the TEC for zinc adopted by the CTCR. This disparity is symptomatic of a contaminant-specific disconnect between FPM generated SCOs/CSLs and the established body of science that associates concentrations of metals in sediment with benthic toxicity.

The same metal-specific disconnect between the proposed FPM-derived freshwater SCOs/CSLs in predicting toxicity in Lake Roosevelt sediments compared to PEC-derived SQVs is apparent in Figure 7, which plots the number of false negatives generated by applying the Ecology-proposed SCOs (designated as SQS in Figure 7) to metals in Lake Roosevelt sediment stations identified by bioassay as being toxic (MacDonald *et al.*, 2012). Figure 7 also plots the number of false negatives generated by applying TEC and PEC values to the same Lake Roosevelt dataset. The graphic clearly demonstrates that CSLs generated by both FPM and PEC methods appear to demonstrate similar predictability to generate false negatives for the majority of metals included in the statistical analysis: arsenic, cadmium, chromium, mercury, and zinc. In significant contrast, the FPM generates SCOs/CSLs with significantly lower reliability/predictability of toxicity from copper, lead, and zinc in Lake Roosevelt than SQVs generated by the PEC method.

The reason for the difference in predictability between FPM and TEC/PEC applied to Lake Roosevelt appears to be an artifact of the skewed dataset input to the FPM black box. Organic contaminants are the predominant drivers of toxicity at the vast majority of sediment sites in Washington (Oregon and Idaho) that constitute the final database used to drive the FPM. In contrast, metals are the predominant drivers of toxicity at a comparatively small number of sites, all of which are located east of the Cascades. As is recognized by the authors of the *Development of Benthic SQVs for Freshwater Sediments in Washington, Oregon, and Idaho* (WDOE 2011), only ~ 10% of the stations (65 out of 648) represented in FPM final dataset used to derive SQS and CSL values for metals-influenced freshwater sediments come from sites located east of the Cascades. Of the 65 stations from sites east of the Cascades that met study criteria for inclusion in the final FPM dataset, ~75% (50 out of 65) are from a single site - Lake Roosevelt. When processed through the FPM a relatively small subset of data can cause a relatively large bias, if the subset of data demonstrates a poor relationship between sediment chemistry and benthic toxicity.

Such is the situation regarding copper, lead, and zinc (and to a lesser extent, arsenic) in Lake Roosevelt, as a subset of the total dataset considered in the FPM. Although toxicity is evident in Lake Roosevelt sediments as shown in Figure 8, identification of a consistent dose-response relationship has not been established using the existing data. As concluded in the *Evaluation and Interpretation of the Sediment Chemistry and Sediment Toxicity Data for the Upper Columbia River Site* (MacDonald *et al.* 2012), slag content is an important determinant of sediment toxicity for slag affected sediment samples in Lake Roosevelt sediment. The MESL report also concludes that slag-influenced data from Lake Roosevelt site does <u>not</u> provide a consistently accurate basis to predict the presence and absence of toxicity. Furthermore, the MESL report concludes that sediment chemistry and toxicity data from Lake Roosevelt does <u>not</u> support the development of robust concentration-response relationships applicable throughout the Upper Columbia River region. Much more work is necessary to better understand slag's effect on benthic toxicity, but the existing body of science makes exceedingly clear that slag's influence produces significant variability compared to the same COCs in non-slag bearing sediment, such as sediment data reported from the Spokane River (the only other "metals site" in eastern Washington, Oregon or Idaho input to the FPM).

Lake Roosevelt is the only slag dominated freshwater sediment site in eastern Washington (Oregon or Idaho). Because the number of Lake Roosevelt stations compared to stations at other metals-influenced sites located east of the Cascades is so disparate, the Lake Roosevelt dataset is a profound determinant on statistics generated from the combined dataset from east of the Cascade sites. However, Lake Roosevelt is far from a typical metals site from which to determine SCOs/CSLs based on associations between sediment chemistry and benthic toxicity. Slag is present in depositional environments throughout Lake Roosevelt at concentrations ranging from non-detect to ~90%. Slag grain size demonstrates extreme variability as well, ranging from clay size to coarse sand size fragments. The major COCs in Teck Cominco smelter slag are copper, lead, and zinc (and to a lesser extent, arsenic). The statistical association between copper, lead, and zinc chemistry and benthic toxicity that is well established in other freshwater environments is confounded in Lake Roosevelt due to the influence of slag. While multiple studies (Cox 2002; Paulson 2006; Ryan 2011; MacDonald *et al.* 2012) observe that metals in Lake Roosevelt slag grains leach to pore water, the available data suggests that the bioavailability of copper, lead, and zinc from slag can vary widely from bioavailability of those same metals in more typical fine grained sediment.

In tacit recognition that proposed SCOs/CSLs for metals derived using the FPM are problematic and demonstrate a systematic bias as a function of the final dataset, in Section 173-204-573 (2)(l) of the draft SMS Rule Amendments, the Department states there are freshwater sediment environments where the chemical criteria in Table VII (the SCOs/CSLs) are not predictive of benthic toxicity, such as metals, milling or smelting sites. No criteria is proposed in the Draft SMS Rule Amendments by which Ecology will discern whether a given sediment site is a "metals mining, milling or smelting" site. Indeed, sometimes sediments come to be located at a significant distance from the source of sediment contamination. How Ecology intends to determine provenance from contaminated sediments is not mentioned in the draft SMS Rule Amendments. Presumably, the first indicator would be the mere presence of elevated metals, which would categorically include many, if not most, sediment sites in mining country.

Ironically, it is the Lake Roosevelt site and the "unique" geochemical conditions therein which are largely responsible for Ecology's position that the unreasonably high SCOs/CSLs for copper, lead, and zinc are not applicable to metals-influenced sites. In these situations, the Department proposes that alternative methods be employed for characterizing benthic toxicity (referenced in the Draft SMS Rule Amendments as a "biological over-ride"), unless Ecology determines that they are adequately predictive. Rather than using either circular logic or the results of individual toxicity tests to counter SCOs/CSLs that are shown to be problematic at mining-related sites (i.e., for copper, lead, and zinc), sediment contamination should be assessed using a "weight of evidence" approach that considers empirical sediment quality guidelines/standards, sediment toxicity tests, and other factors exerting potentially significant effects on toxicity, such as grain size and slag content.

Section 173-204-573 (2)(k) states that at sediment sites that demonstrate levels above the CSL (such as mining, milling or smelting sites), bioassays shall be conducted to evaluate benthic toxicity. This position is particularly egregious with regards to lead and zinc, metals at which the FPM-predicted minor adverse effects level are "unknown but above the CSL." Applying the synthetically elevated CSLs for copper, lead, and zinc as screening values to determine which sites warrant bioassays to determine sediment cleanup levels is critically flawed because the FPM CSLs are biased high by the influence of slag unique to Lake Roosevelt. Many (if not most) sites east of the

Cascades with no slag influenced sediments may not meet screening criteria for additional investigation by way of bioassays because concentrations of copper, lead, or zinc are low compared to the underprotective – CSLs which are so heavily influenced by slag dominated sediments from Lake Roosevelt. Using the synthetically-elevated CSLs for copper, lead, and zinc as defacto default values are neither protective of benthic organisms nor is the regulatory philosophy inherent in using them in that manner consistent with a conservative approach to managing the risk to human health and the environment at contaminated sediment sites.

Both the State of Washington and CTCR are members of the Upper Columbia River Natural Resource Trustee Council. Teck American Incorporated (the American proxy for the responsible party at UCR, Teck Cominco Metals Incorporated – Teck), recently submitted public comments on the Draft Injury Assessment Plan for the Upper Columbia River prepared for the UCR Natural Resource Trustee Council. Teck's public comments delineate the disproportional impact on Tribal members of Ecology's policy and technical decisions inherent in slag outlier numerical criteria proposed in the Draft SMS Rule Amendments:

> *"The … Hazardous Substances Control Act for the Spokane Tribe of Indians and the Confederated Tribes of the Colville Reservation that are … incorporated throughout the Plan establish risk and cleanup standards at concentrations that are far lower than the standard of risk established for federal and state assessments and cleanup. Those standards should not be relied upon in assessing injury absent some technical basis establishing the validity and reasonableness of those standards"*

Since the only metals-based SCQs in CTCR and STI regulations are "far lower" than the SCOs/CSLs of copper, lead, and zinc, the Potentially Responsible Party is clearly foretelling that they consider the SCOs/CSLs for copper, lead and zinc to be valid numerical thresholds for delineating natural resource injury in the Upper Columbia River Site. Not only will that set maximum cleanup values for copper, lead and zinc at levels far above those shown by experts in the field to be toxic to benthic organisms, but our preliminary estimates are that applying SCOs/CSLs to the UCR Site will decrease the extent of injured sediments by ~90% compared to CTCR and STI SQSs. Application of SCOs/CSLs for metals, as proposed in the Draft SMS Rule Amendments will have a disproportionate effect upon the membership of the CTCR and the residents of the Colville Indian Reservation.

Proposed Resolution: The sediment cleanup objectives and cleanup screening levels must be revised to provide numerical criteria that correspond with no adverse effects levels (for the SCOs) and minor adverse effect levels (for the CSLs; see Table 1).

Issue #1F: The Proposed Cleanup Screening Levels for Certain Contaminants are higher than Toxicity Thresholds Based on Spiked-Sediment Toxicity Tests.

Rationale: According to Section WAC 173-204-563, the CSLs establish minor adverse effect levels, including no adverse acute or chronic effects, on the benthic community. If the numerical CSLs truly represent minor adverse effects levels, they should be substantially lower than the toxicity thresholds that have been established based on the spiked-sediment toxicity tests (i.e., because the CSLs are intended to be used for assessment field-collected sediments that likely contain mixtures of COPCs and the results of spiked-sediment toxicity tests provide toxicity thresholds for individual COPCs in sediments; the results of laboratory studies have demonstrated that toxicity thresholds derived from spiked-sediment toxicity tests are lower when mixtures of COPCs are tested; Swartz *et al.* 1988).

While a comprehensive review of the literature on spiked sediment toxicity testing was not conducted, the literature that was reviewed for copper demonstrated that the results of spiked-sediment toxicity tests indicate toxicity to benthic invertebrates is frequently observed at concentrations of copper below the CSL (i.e., 1200 mg/kg DW). For example, Malueg *et al.* (1986) reported a 48-h LC_{50} (i.e., median lethal concentration, which is the concentration of copper that killed 50% of test organisms during the toxicity test) of 654 to 688 mg/kg DW for the water flea, *Daphnia magna*. For the midge, *Chironomus dilutus*, a 10-d LC_{50} of 857 mg/kg DW was reported for copper (Cairns *et al.* 1984). By comparison, Cairns *et al.* (1984) reported a 48-h LC_{50} of 937 mg/kg DW for the water flea, *D. Magna*, and a 10-d LC_{50} of 964 mg/kg DW for the amphipod, *Gammarus lacustris*. All of these median lethal concentrations for copper are substantially **below** the levels that the Department expects to cause minor adverse effects on the benthic community. Therefore, the CSL for copper is not protective of the benthic community.

Proposed Resolution: The sediment cleanup objectives and cleanup screening levels must be revised to provide numerical criteria that correspond with no adverse effects levels (for the SCOs) and minor adverse effect levels (for the CSLs; see Table 1).

Issue # 1G: The Sediment Cleanup Objectives and Cleanup Screening Levels Do Not Provide a Reliable Basis for Identifying Sediments Causing No Adverse Effects or Minor Adverse Effects on Benthic Communities.

Rationale: According to Section WAC 173-204-563(2a), the SCOs establish no adverse effect levels, including no acute or chronic effects, on the benthic community. Accordingly, no adverse effects on benthic invertebrates should be observed when the concentrations of COPCs are below the SCOs. To determine if the SCOs provide a reliable basis for classifying sediment samples as not toxic, matching sediment chemistry and toxicity data from the Upper Columbia River and elsewhere in Washington State were compiled. In the resultant database, individual sediment samples were designated as toxic or not toxic using:

- Methods used by the Department (As described in Table VIII of Section WAC 173-204-563); or,
- Methods more commonly applied by sediment quality investigators (i.e., statistical comparison to negative control or reference envelope approach; see Table 10 for an overview of toxicity designation methods by study; Table 11 provides test acceptability criteria based on negative control results – these criteria are typically applied for identifying acceptable reference samples).

In this analysis, the SCOs were considered to provide a reliable basis for designating sediment samples as not toxic if the incidence of toxicity was <20% when the concentrations of all COPCs were below the SCOs (MacDonald *et al.* 2002; 2009; 2012).

In the first analysis, the reliability of the SCOs was evaluated using the toxicity designations assigned by the Department. The results of this analysis showed that the incidence of toxicity was generally low (about 6%) for samples from the Upper Columbia River with the concentrations of all COPCs below the SCOs, when the results of 28-d toxicity tests with amphipods (survival or growth) were considered (Table 12). While the incidence of toxicity was also low when midge growth was considered (i.e., IOT of about 6%), toxicity to midge was frequently observed (i.e., about 29% of samples were toxic) when midge survival was considered for samples from the Upper Columbia River. These results indicate that the SCOs do not represent no adverse effects levels in Upper Columbia River sediments. No data from elsewhere in Washington State were available to evaluate the reliability of the SCOs.

In the second analysis, the reliability of the SCOs was evaluated using the toxicity designations assigned by statistical comparison to negative control or using reference envelope approach. The results of this analysis showed that the incidence of toxicity was generally low (about 5 to 13%) for samples from the Upper Columbia River with the concentrations of all COPCs below the SCOs, when the growth or biomass of amphipods in 28-d toxicity tests were considered (Table 13). However, about 40% of the samples with COPC concentrations below the CSOs were toxic to amphipods when 28-d survival was considered. The incidence of toxicity to midge was also elevated in sediment samples from the Upper Columbia River with the concentrations of all COPCs below the SCOs (i.e., about 23% for midge survival, 40% for midge growth, and 70% for midge biomass). For both 10-d and 28-d toxicity tests conducted with sediment samples from elsewhere in Washington State, the incidence of toxicity to amphipods exceeded 20% when the concentrations of all COPCs were below the SCOs (Table 13). These results demonstrate that the SCOs do not provide a reliable basis for establishing the levels of COPCs that represent no adverse effect levels. These results also emphasize the importance of considering the biomass endpoint in assessments of sediment quality conditions.

According to Section WAC 173-204-563(2a), the CSLs establish minor adverse effects levels, including minor acute or chronic effects, on the benthic community. Using the toxicity designations assigned by the Department, the incidence of toxicity to amphipods or midge was low (i.e., 0 to about 10%) when the concentrations of all COPCs were below the CSLs (Table 14). However, a different picture emerges when sediment samples were designated as toxic or not toxic using statistical comparison to negative control or reference envelope approach. More specifically, the results of this analysis showed that the incidence of toxicity was generally low (about 8 to 19%) for samples from the Upper Columbia River with the concentrations of all COPCs below the CSLs, when the growth or biomass of amphipods in 28-d toxicity tests were considered (Table 15). However, about 42% of the samples with COPC concentrations below the CSLs were toxic to amphipods when 28-d survival was considered. The incidence of toxicity to midge was also elevated in sediment samples from the Upper Columbia River with the concentrations of all COPCs below the CSLs (i.e., about 19% for midge survival, 40% for midge growth, and 66% for midge biomass). For both 28-d toxicity tests conducted with sediment samples from elsewhere in Washington State, the incidence of toxicity to amphipods exceeded 20% when the concentrations of all COPCs were below the CSLs (Table 15). These results demonstrate that the CSLs do not provide a reliable basis for establishing the levels of COPCs that represent no adverse effect levels. These results also emphasize the importance of considering the biomass endpoint in assessments of sediment quality conditions.

It is important to note that the proposed SCOs and CSLs were developed using the results of toxicity tests conducted field-collected sediment samples that typically contain complex mixtures of COPCs. To determine if the resultant numerical criteria would provide a reliable basis for classifying sediment samples from the Upper Columbia River or elsewhere in Washington State as toxic and not toxic, a supplemental data analysis was conducted. In this evaluation, the incidence of toxicity to amphipods and midge was determined when the concentrations of individual COPCs were below the SCO or CSL. This analysis was conducted using the toxicity designations that were established by statistical comparison to negative control or using reference envelope approach. The results of this analysis (Tables 16 to 21) indicate that the SCOs for the individual COPCs evaluated cannot be used to reliably classify sediment samples from the Upper Columbia River or elsewhere in Washington State as not-toxic. That is, the incidence of toxicity below the SCOs for individual COPCs exceeds 20% for one or more of the endpoints considered. Therefore, the SCOs do not define the concentrations of COPCs that represent no adverse effect levels.

Proposed Resolution: The sediment cleanup objectives and CSLs must be revised to provide numerical criteria that correspond with no adverse effects levels (for the SCOs) and minor adverse effect levels (for the CSLs). See Table 1 for a listing of the SCOs/CSLs that are recommended by the CTCR.

Issue # 2: Adjustments to the Default Scenario for Evaluating Human Health Risks Will Not Be Protective of Tribal or Subsistence Resources Users.

Rationale: Section WAC 173-204-561(3b) of the Proposed SMS Rule Amendments describe the process for establishing SCOs based on the protection of human health. In general, the procedures described in that section of the document are reasonable. More specifically, this section of the document indicates that the human health risk-based SCOs shall be calculated using reasonable maximum exposure scenarios for a site and that the reasonable maximum exposure scenario shall be determined using tribal fish and shellfish consumption rates (i.e., Default Scenario). As such tribal fish and shellfish consumption rates are likely to be appropriate for both tribal and non-tribal subsistence users of aquatic resources, SCOs derived using the reasonable maximum exposure scenarios are likely to be protective of virtually all resource users at a site.

While the Default Scenario is likely to be broadly protective of tribal and non-tribal uses for aquatic resources (assuming that the Department selects appropriate tribal fish and shellfish consumption rates, which are yet to be determined), Section WAC 173-204-561(3b) of the Proposed SMS Rule Amendments describe a site-specific override of the Default Scenario. More specifically, this section of the document indicates that the Department ***shall*** consider other information when selecting or approving the exposure parameters used to represent the reasonable maximum exposure scenario including:

- Historic, current, and future tribal use of fish and shellfish from the general vicinity of the site;
- Relevant studies and best available science related to fish consumption rates;

- The portion of an individual's diet that is obtained, or could be obtained from the site;
- The size of the site relative to the fish and shellfish home range; and,
- Other information determined by the Department to be relevant.

Collectively, this additional documentation indicates that the Default Scenario is unlikely to be applied at any given site (i.e., because the Department must consider site-specific exposure information). This is a problem because the Default Scenario provides a basis for providing an acceptable and uniform level of protection to human health at all sediment contaminated sites. Application of this approach will ensure that, over time, individual site cleanups will result in regional reductions in human health risks associated with consumption of fish and shellfish. In contrast, the approach described in WAC 173-204-561(3b) will result in decisions on the management of contaminated sediments that may protect human health at each site (depending on the exposure parameters that are ultimately selected), but will not protect human health on a regional basis. This is because the Department's approach to human health risk assessment assumes that dietary exposure to bioaccumulative contaminants is negligible for all other sources of fish and shellfish. By definition, this assumption is incorrect because both point and non-point sources of bioaccumulative COPCs result in broad contamination of fish and shellfish resources throughout the state (e.g., mercury). Therefore, the total dietary exposure of tribal and other subsistence users to bioaccumulative COPCs in fish and shellfish tissues will almost certainly pose unacceptable risks to human health. This represents a serious environmental justice issue than needs to be resolved before the Proposed SMS Rule Amendments can be promulgated.

Ecology has withdrawn its initial commitment to establish a default Fish Consumption Rate (FCR) within the Draft SMS and instead Ecology proposes that FCRs will be established on a site-by-site basis – a concept in tension with the tenet of a Reasonable Maximum Exposure (RME) default rate scenario. At the same time, several key exposure parameters in the denominator of the equation used to calculate human health risk-based cleanup levels, including Fish Diet Fraction (FDF) and Site Use Factor (SUF), are introduced in the Draft SMS Rule Amendments with default values of 1.0, meaning any site-specific application of these poorly defined variables will have the effect of decreasing the effective FCR and consequently driving human health risk-based cleanup levels towards less protective scenarios.

In general, there is no justification for applying a Fish Diet Fraction (FDF) when most or all of the fish and shellfish in an individual's diet is obtained or has the potential to be obtained in the future from waters affected by a contaminated site - such is the case for tribal fish consumers. While tribes at present obtain most or all of their fish from local sources, it is important to recognize that at the time treaties and executive orders establishing reservations were promulgated, Indian people obtained all of their fish from local waters. Furthermore, tribes' reserved rights under treaties and other legal agreements entitle them to do so in perpetuity. The SMS guidance too narrowly defines the sphere of influence of a contaminated site, referring to fish "from the site or the general vicinity of the site." But clearly, contamination at a site will often have impacts on fish resources beyond the site boundaries. A diet fraction that is selected by reference to Ecology's narrow definition will exclude fish that are adversely affected by contamination at the site, resulting in underprotective sediment cleanup standards.

Similarly, use of the Site Use Factor (SUF) introduced in the SMS may effectively diminish the RME scenario by assigning a value of less than 1.0 to the equation used to derive risk-based cleanup levels as a function of "the percentage of time that a fish/shellfish is in contact with contaminants at the site." Ecology's application of the SUF is generally not supportable where tribes' right and resources are affected. For the case of salmon, Ecology's propensity to assert that the contaminants in a salmon's tissue are due "primarily" to sources other than a contaminated site suggests a predisposition to resolve the science and policy questions at issue in a manner that favors Potentially Liable Parties (PLPs) and disfavors protection of human and ecological health. Additionally, to the extent that scientific uncertainties remain about the source of contaminants in fish tissue at a given site, a conservative predisposition towards a more rather than less protective cleanup level would guide against reducing the FCR.

Proposed Resolution: Eliminate the site-specific override of the default scenario for evaluating human health risk at a site [i.e., as described in WAC 173-204-561(3b)].

Issue # 3: The Ecological Bioaccumulation Narrative is not Comprehendible and Cannot by Effectively Implemented.

Rationale**:** Section WAC 173-204-564 of the Proposed SMS Rule Amendments describes the process for establishing sediment cleanup levels based on the protection of higher trophic level species. More specifically, this section of the document indicates that:

> "Sediment cleanup objectives and cleanup screening levels based on protection of higher trophic level species shall not be established at concentrations that do not have the potential for minor adverse effects."

This statement contains a double negative. When the double negative is removed, the statement indicates that SQOs and SCLs levels based on protection of higher trophic level species shall be established at concentrations that have the potential for minor adverse effects. It is unclear why such SQOs and SCLs must be established at levels that result in minor adverse effects on higher trophic level species (i.e., wildlife species). A better approach is to require that the SQOs and SCLs be established at levels that are not associated with adverse effects on wildlife species.

The definitions of minor adverse effects contained in Section WAC 173-204-564 of the Proposed SMS Rule Amendments are also problematic. For threatened and endangered or listed species, minor adverse effects mean "a significant disruption of normal behavior patterns, such as breeding, feeding, or sheltering." It is unclear why SQOs and SCLs must be established at levels that result in a significant disruption of normal behavior patterns, such as breeding, feeding, or sheltering of threatened and endangered or listed species. For other higher trophic level species, minor adverse effects mean "effects that impair the higher trophic level species reproduction, growth, or survival. Again, it is unclear why SQOs and SCLs must be established at levels that result in impairment of the reproduction, growth, or survival of higher trophic level species.

Proposed Resolution: Rewrite the ecological bioaccumulation narrative in clearly understandable language and ensure that the narrative provides a basis for protecting higher trophic level species from adverse effects associated with exposure to bioaccumulative COPCs (i.e., Section WAC 173-204-564).

Issue # 4: Tribal Standards and Regulations Cannot Be Ignored or Marginalized.

Rationale: Section WAC 173-204-560 of the Proposed SMS Rule Amendments describes the process for establishing SCOs and CSLs for a contaminant in sediment. More specifically, these sections of the document indicate that the risk-based concentration of a contaminant is the lowest of:

- The concentration of the contaminant based on protection of human health, as defined in WAC 173-204-561(2)/WAC 173-204-561(3);
- The concentration or level of biological effects of the contaminant based on benthic toxicity, as defined in WAC 173-204-562 to WAC 173-204-563;
- Requirements in other applicable federal, state, and local laws;
- Natural background; and,
- Practical quantitation limit.

While a number of tribal governments within Washington State have established sediment quality standards and/or regulations relative to the management of contaminated sediments, the Proposed SMS Rule Amendments do not provide for utilizing such tribal sediment quality standards or regulations in the establishment of the risk-based concentrations of contaminants in sediment. This is inappropriate and needs to be rectified before the Proposed SMS Rule Amendments are promulgated.

Proposed Resolution: The SMS two-tier framework needs to be revised to explicitly identify the role of tribal standards and regulations in the establishment of risk-based levels of sediment-associated contaminants (i.e., in addition to other applicable federal, state, and local regulations in Section WAC 173-204-560).

Issue # 5: Regional or Natural Background Levels of Contaminants should not be Determined on a Case-by-Case Basis.

Rationale: Section WAC 173-204-560(5) of the Proposed SMS Rule Amendments of the Proposed SMS Rule Amendments describes the process for establishing sediment cleanup objectives and CSLs for a contaminant in sediment, respectively. More specifically, these sections of the document indicate that the SCOs and CSLs is the highest of:

- The risk-based concentration of the contaminant, based on WAC 173-204-561 to WAC 173-204-564;
- Natural background or Regional background; and,
- Practical quantitation limit.

While it is reasonable and appropriate to consider background levels of contaminants in the establishment of SCOs and/or CSLs, the Proposed SMS Rule Amendments do not provide sufficient information to ensure that natural background or regional background concentrations of contaminants are determined using consistent and scientificallydefensible procedures. As establishment of background levels of COPCs is of fundamental importance to the sediment quality assessment and management process, other jurisdictions have either determined background levels on an *a priori* basis and/or established formal procedures for determining background levels (See Protocol 4 for Contaminated Sites, promulgated under the British Columbia Environmental Management Act).

Under certain circumstances, the contaminant-specific values established for "Regional Background" will define the maximum allowable level for cleanup under the two-tiered framework utilized in the proposed SMS Rule Amendments. ***"That portion of an embayment or watershed outside the areas with contamination attributable to one or more specific sources"*** is cited in the proposed SMS Rule Amendments, as indicative of a geographic area appropriate to determine Regional Background. It is essential that the proper relative scale be employed when considering Regional Background. The context of "watershed" implies freshwater by convention whereas regional background in a context delineated by the boundaries of an "embayment" or "baywide" implies a saltwater hydrologic context. While clarification of both saltwater and freshwater terminology is warranted, the need to define freshwater watershed on a regional scale is most pressing and has the greatest potential for misapplication. In the context of the proposed SMS Rule Amendments, "watershed" is synonymous with a hydrologic drainage basin of regional scale. Watersheds in the United States have been delineated by the U.S. Geologic Survey (USGS) using a national standard hierarchical system based on surface hydrologic features into four levels of successively smaller drainage basins (hydrologic units). Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two to twelve digits based on the six levels of classification. All drainages within Washington State are wholly encompassed within the (first level) Pacific Northwest Water Resource Region (2-digit HUC = 17). For purposes of applying SMS regional background within Washington State, the second level (4-digit HUC) or sub-region classification is most appropriate. Please see comments submitted from CTCR to Ecology dated 1/4/2011 and 4/18/2011 for further discussion of Regional Background and its application within the SMS Rule.

Defining contaminant-specific sediment values representative of Regional Background is a responsibility more appropriately borne by Ecology than by Responsible Parties at a given sediment site. Ecology-derived values for Regional Background should be based on the best regional sediment data sets available at the time of the determination, as well as provide for incorporation into the regional calculation of more and better data sets that may be collected in the future. As an underlying principle for determining regional background, Ecology should develop and apply minimum threshold tests for sediment data extent and quality within an ecologically conservative context to be consistent with policy that provides for a cleanup process that tends to being more rather than less protective. SMS Rule guidance should also have provisions for Responsible Parties to propose alternative contaminant-specific values or geographic scale for consideration by the department.

In contrast to the approach that has been used in other jurisdictions, the Proposed SMS Rule Amendments indicate that the Department will determine the appropriate statistical analyses, number and type of samples, and analytical methods to establish a regional background on a case-by-case basis. This is an ill-considered approach that will lead to inconsistent or inappropriate methods being used to establish background and, ultimately, to unfair application of the SMS Rule.

CTCR recommends that Ecology consider samples obtained during the National Uranium Resource Evaluation (NURE) program during 1976-1979 as a reasonable starting point for determining regional background for Upper Columbia Region of Washington. Since the original study, USGS and independent researchers (Church 2007) have applied improved analytical methods to archived subsets of NURE samples that have significantly improved the focus and watershed level applicability of the NURE data set. Assessment of geochemical background from NURE sediment data will provide a strong basis for determining regional background at metals contaminated sediment sites in the Upper Columbia River watershed of northeast Washington.

Particularly relevant to CTCR's concerns for derivation and potential misapplication of Regional Background are several sections of the August, 2012 publication no. 12-09-051, *Preliminary Cost-Benefit and Least Burdensome Alternative Analyses*, a mandatory companion document to the draft SMS, including Section 3.5: *Representative Site (Embayment-Specific Analysis),* Section 3.6: *Freshwater Sediment Standards for Benthic Community Protection,* Section 3.11: *Puget Sound Analysis*, and Appendix A: *Embayment Specific Examples of Cleanup Level Impacts*.

For example, in case studies presented in Appendix A at A.2 and A.3, Ecology calculates Regional Background values for Dioxin at two actual, though unnamed, sites located in the Puget Sound region. Ecology characterizes Site A.2 as an urban marine embayment in Puget Sound, whereas Site A.3 is characterized as rural Puget Sound embayment. Regional Background value for Dioxin calculated by Ecology for the urban marine embayment (14.6 ppt TEQ) is a full order of magnitude higher than Regional Background calculated for the rural embayment (1.17 ppt TEQ), even though both sites are within the same physiographic region. Apparently (the actual calculations are not included in the report), the primary basis for determining different "regional" background values in these two examples is demographics – one site is rural, one is urban – which is reasonable criteria for determining "area background" under Model Toxics Control Act (MTCA), but irrelevant and unacceptable criteria for deriving "regional background" in accordance with the Draft SMS Rule at WAC 173-204-560 (5).

Proposed Resolution: The SMS two-tier framework needs to be revised to include regional background concentrations of listed contaminants and/or detailed guidance for establishing regional or natural background levels of contaminants in sediment. Such procedures for calculating background levels of contaminants in sediment must describe the number and type of samples that need to be collected, the criteria that need to be applied to confirm that a sample qualifies for inclusion in the background calculation, the analytical methods that must be used to generate the required sediment chemistry data, acceptability criteria for use of existing sediment chemistry data, and the statistical analyses that must be conducted to estimate regional or natural background concentrations of contaminants in sediment. These revisions need to be included in Section WAC 173-204-560(5) of the Proposed SMS Rule Amendments.

Issue # 6: Practical Quantitation Limits Should Not Be Considered in the Development of Sediment Cleanup Objectives or Cleanup Screening Levels.

Rationale: Section WAC 173-204-560(5) of the Proposed SMS Rule Amendments of the Proposed SMS Rule Amendments describes the process for establishing SCOs and

CSLs for a contaminant in sediment, respectively. More specifically, these sections of the document indicate that the SCOs and CSLs is the highest of:

- The risk-based concentration of the contaminant, based on WAC 173-204-561 to WAC 173-204-564;
- Natural background or Regional background; and,
- Practical quantitation limit.

While it is reasonable and appropriate to consider the risk-based concentration and background concentration of a contaminant in the establishment of SCOs and CSLs, it is inappropriate and unwise to consider the practical quantitation limit in this process. For all of the contaminants explicitly addressed in the Proposed SMS Rule Amendments, analytical methods have been developed that provide detection limits sufficient to assess risks to human health and the environment. By including a practical quantitation limit override in the Proposed SMS Rule Amendment, the Department is essentially inviting responsible parties to generate sediment chemistry data that do not conform to the requirements for human health risk assessments or ecological risk assessments. Guidance on the detections limits that are required to support sediment quality assessment activities already exists (See MacDonald *et al.* 2008, for example). So, there is no excuse for including practical quantitation limit override in the Proposed SMS Rule Amendment.

Proposed Resolution: The practical quantitation limit override included in the SMS two-tier framework needs to be removed and the Department needs to develop guidance on the detection limits that must be achieved for COPCs that require investigation at sediment contaminated sites within the state.

Issue # 7: Decisions Regarding the Upward Adjustment of Sediment Cleanup Levels should not be made without Meaningful Consultation with Tribal Governments and the Public.

Rationale: Section WAC 173-204-560 of the Proposed SMS Rule Amendments describe the methods for establishing site-specific sediment cleanup levels. In this section, sediment cleanup levels are defined as the concentrations or levels of biological effects on a contaminant in sediment determined by the Department to be protective of human health and the environment. This section also states that the SCO shall be used to establish the sediment cleanup level, unless an upward adjustment from the SCO is necessary because:

- It is not technically possible to achieve the sediment cleanup level at the applicable point of compliance within the site or sediment cleanup unit; or,
- Meeting the sediment cleanup level will have an adverse impact on the aquatic environment, taking into account the long-term positive effects on natural resources and habitat restoration and enhancement and the short-term adverse impacts on natural resources and habitat caused by cleanup actions.

However, the Proposed SMS Rule Amendments do not indicate who would conduct the evaluation of technical feasibility analysis or harm-benefit analysis. This is important because our experience demonstrates that technical infeasibility and/or cleanup impacts have been used to justify inaction at many other contaminated sites throughout the United States. In most cases, the technical and scientific data provided to support such determinations have been weak, but regulatory agencies have been unable or unwilling to require appropriate justification for inaction. However, inaction or incomplete cleanups at sediment contaminated sites have real implications for individuals and organizations that rely on natural resources, particularly tribal members and other subsistence users. Therefore, it is inappropriate to adjust the sediment cleanup level upwards without appropriate and meaningful consultation with tribal governments.

Proposed Resolution: A procedure for reviewing and approving upward adjustment of the sediment cleanup level that includes meaningful consultation with Tribal governments and the public needs to be developed and described in the Proposed SMS Rule Amendments.

Issue # 8: The Department Must be Able to Establish Sediment Cleanup Levels Below the Sediment Cleanup Objective.

Rationale: Section WAC 173-204-560(2b) of the Proposed SMS Rule Amendments indicates that the Department may establish sediment cleanup levels more stringent than those established under Section WAC 173-204-560(2a) when, based on a site-specific evaluation, the Department determines that such levels are necessary to protect human health and the environment. Recall that Section WAC 173-204-560(2a) indicates that:

> "the sediment cleanup objective shall be used to establish the sediment cleanup level," notwithstanding the provisions for upward adjustment.

It is reasonable and appropriate to include provisions for establishing a sediment cleanup level that is lower than the SCO in those situations where the SCO would not provide the required level of protection for human health and/or the environment. However, the last sentence in Section WAC 173-204-560(2b) completely eliminates the Department's flexibility for establishing more stringent sediment cleanup levels by indicating that:

> "The sediment cleanup level may not be established below the sediment cleanup objective."

It is inappropriate to include the last sentence in Section WAC 173-204-560(2b) because it eliminated any possibility that the Department could establish SCOs that are more stringent than the SCOs.

Proposed Resolution: Eliminate the last sentence (i.e., the sediment cleanup level may not be established below the sediment cleanup objective) from Section WAC 173-204-560(2b) of the proposed SMS Rule Amendments.

3.0 Conclusions

A review of the Proposed SMS Rule Amendments and supporting documentation was conducted. While we agree that it is reasonable and appropriate to establish sediment management standards for freshwater sediments, it is our conclusion that the numerical sediment quality values (SQVs) that were developed as part of the Proposed SMS Rule Amendments will not provide an adequate basis for managing contaminated sediments in Washington State or elsewhere in the Pacific Northwest. Therefore, it is strongly recommended that the Department explicitly address the critical flaws in the Proposed SMS Rule Amendments. The results of this review indicated that the key issues that need to be addressed before the Proposed SMS Rule Amendments can be promulgated include:

- The freshwater benthic criteria (i.e., the numerical and the biological criteria) need to be revised to ensure that they represent values that are consistent with the narrative intent of the SCOs/CSLs (i.e., no adverse effects for the SCOs and minor adverse effects for the CSLs, as stated in WAC 173-204-563);
- The site-specific override of the default scenario for evaluating human health risk at a site needs to be eliminated (WAC 173-204-56);
- The ecological bioaccumulation narrative needs to be rewritten in clearly understandable language (WAC 173-204-564);
- The SMS two-tier framework needs to explicitly identify tribal standards and regulations, in addition to other federal, state and local laws (WAC 173-204-560);
- Consistent procedures for establishing regional background levels need to be established as part of the Proposed SMS Rule Amendments [WAC 173-204-560(5)];
- The practical quantitation limit override included in the SMS two-tier framework needs to be removed and the Department needs to develop guidance on the detection limits that must be achieved for COPCs that are investigated at sediment contaminated sites within the state;
- A procedure for reviewing and approving upward adjustment of the sediment cleanup level that includes meaningful consultation with Tribal governments and the public needs to be developed; and,
- Effective provisions for establishing sediment cleanup levels below the SCOs must be included in the Proposed SMS Rule Amendments.

The CTCR has recommended numerical criteria (i.e., SCOs and CSLs) that meet the Department's narrative criteria (Table 1). In additional, the CTCR have recommended biological criteria that are consistent with the Department's narrative criteria (Table 2). As such, the CTCR strongly recommends that these alternate criteria be adopted by the Department in Table VII and VIII of the Draft SMS Rule Amendments.

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Tables

Table 1. Recommended sediment cleanup objectives and cleanup screening levels for sediment quality standards in freshwater ecosystems in Washington State.

Chemical Parameter	Sediment Cleanup Objective[1]	Cleanup Screening Level[2]
Conventional Chemicals (mg/kg DW)		
Ammonia	NCR	NCR
Total sulfides	NCR	NCR
Metals (mg/kg DW)		
Arsenic	9.79	33.0
Cadmium	0.99	4.98
Chromium	43.4	111
Copper	31.6	149
Lead	35.8	128
Mercury	0.18	1.06
Nickel	22.7	48.6
Selenium	NCR	NCR
Silver	NCR	NCR
Zinc	121	459
Organic Chemicals (µg/kg DW)		
4-Methylphenol	NCR	NCR
Benzoic acid	NCR	NCR
Beta-hexachlorocyclohexane	NCR	NCR
Bis(2-ethylhexyl) phthalate	NCR	NCR
Carbazole	NCR	NCR
Dibenzofuran	NCR	NCR
Dibutyltin	NCR	NCR
Dieldrin	1.90	61.8
Di-n-butyl phthalate	NCR	NCR
Di-n-octyl phthalate	NCR	NCR
Endrin ketone[3]	2.22	207
Monobutyltin	NCR	NCR
Pentachlorophenol	NCR	NCR
Phenol	NCR	NCR
Tetrabutyltin	NCR	NCR
Total PCBs (Aroclors)[4]	59.8	676
Total DDDs	4.88	28.0
Total DDEs	3.16	31.3
Total DDTs	4.16	62.9
Total PAHs	1610	22800
Bulk Petroleum Hydrocarbons (mg/kg DW)		
	NCR	NCR
	NCR	NCR

NCR = no criterion recommended; PCB = polychlorinated biphenyl; DDD = dichlorodiphenyldichloroethane; DDE = dichlorodiphenyldichloroethylene; DDT = dichlorodiphenyltrichloroethane; PAH = polycyclic aromatic hydrocarbon

[1] Confederated Tribes of the Colville Reservation / Spokane Tribe of Indians

[2] Probable effect concentration (PEC) values from MacDonald *et al.* (2000).

Table 2. Ecology's quality assurance and adverse effects (toxicity) levels for biological tests, as presented in Table VIII.

Test	QA Control	SCOs	CSLs
Chironomus dilutus 10-day mortality	C ≤ 30% [a]	T - C > 20%	T - C > 30%
Chironomus dilutus 10-day growth	CF ≥ 0.48 mg/ind	T/C < 80%	T/C < 70%
Hyalella azteca 10-day mortality	C ≤ 20% [a]	T - C > 15%	T - C > 25%
Hyalella azteca 28-day mortality	C ≤ 20% [a]	T - C > 10%	T - C > 25%
Hyalella azteca 28-day growth	CF ≥ 0.15 mg/ind	T/C < 75%	T/C < 60%

QA = quality assurance; SCO = sediment cleanup objective; CSL = cleanup screening level; C = control; CF = control final; T = test sample.

[a] These control mortality limits are currently in the process of being reviewed by ASTM and may be lowered in the next few years (Ingersoll *et al* . 2008; as cited in WDOE 2011).

Table 3. Comparison of methods used to designate sediments as toxic or not toxic to the midge (*Chironomus dilutus*) from samples collected from the Upper Columbia River in 2005.

Station	Batch	10-day Percent Survival					10-day Growth (weight)				
		Effect Value (%)	Control-adjusted Value (%)	Reference Envelope	Draft SMS SCO	Draft SMS CSL	Effect Value (mg)	Control-adjusted Value (%)	Reference Envelope	Draft SMS SCO	Draft SMS CSL
Control	1	83.8	100	--	--	--	1.51	100	--	--	--
Control	2	88.8	100	--	--	--	1.97	100	--	--	--
RM727A1(X1)	2	92.5	104	NT	NT	NT	1.74	88.1	T	NT	NT
RM729A1(X1)	2	90	101	NT	NT	NT	2.01	102	NT	NT	NT
RM628A1(X1)	2	87.5	98.5	NT	NT	NT	1.93	97.7	T	NT	NT
RM742A1(X1)	1	82.5	98.4	NT	NT	NT	1.18	78.3	T	NT	NT
RM743A1(X1)	1	82.5	98.4	NT	NT	NT	1.60	106	T	NT	NT
RM641A1(X1)	2	86.3	97.1	NT	NT	NT	1.93	97.8	T	NT	NT
RM743A2(X3)	1	80	95.5	NT	NT	NT	1.43	94.5	T	NT	NT
RM616A1(X3)	2	83.8	94.3	NT	NT	NT	2.22	113	NT	T	NT
RM723A1(X1)	2	83.8	94.3	NT	NT	NT	2.14	109	NT	NT	NT
RM723A2(X3)	2	83.8	94.3	NT	NT	NT	1.96	99.3	NT	NT	NT
RM733A1(X1)	2	83.8	94.3	NT	NT	NT	1.76	89.5	T	NT	NT
RM730A1	2	82.5	92.9	NT	NT	NT	1.96	99.7	NT	NT	NT
RM737A1(X3)	2	82.5	92.9	NT	NT	NT	1.47	74.4	T	T	T
RM605A2(X8)	2	81.3	91.5	NT	NT	NT	1.85	94	T	NT	NT
RM661A1(X1)	2	81.3	91.5	NT	NT	NT	1.84	93.3	T	NT	NT
RM734A1	2	81.3	91.5	NT	NT	NT	1.61	81.8	T	NT	NT
RM736A1(X1)	2	81.3	91.5	NT	NT	NT	1.94	98.5	NT	NT	NT
RM744A2(X3)	1	76.3	91	NT	NT	NT	1.31	86.8	T	NT	NT
RM634A1(X1)	2	80	90.1	NT	NT	NT	1.92	97.3	T	NT	NT
RM658A1(X3)	2	80	90.1	NT	NT	NT	1.78	90.3	T	NT	NT
RM740A1(X1)	1	75	89.5	NT	NT	NT	2.08	137	NT	NT	NT
RM687A1	1	73.8	88	NT	NT	NT	1.62	107	T	NT	NT
RM742A2(X5)	1	73.8	88	NT	NT	NT	1.31	86.5	T	NT	NT
RM605A1(X1)	2	77.5	87.3	NT	NT	NT	1.81	91.9	T	NT	NT
RM622A1(X3)	2	77.5	87.3	NT	NT	NT	1.82	92.4	T	NT	NT
RM637A1(X1)	2	77.5	87.3	NT	NT	NT	1.79	90.9	T	NT	NT

Table 3. Comparison of methods used to designate sediments as toxic or not toxic to the midge (*Chironomus dilutus*) from samples collected from the Upper Columbia River in 2005.

Station	Batch	10-day Percent Survival					10-day Growth (weight)				
		Effect Value (%)	Control-adjusted Value (%)	Reference Envelope	Draft SMS SCO	Draft SMS CSL	Effect Value (mg)	Control-adjusted Value (%)	Reference Envelope	Draft SMS SCO	Draft SMS CSL
RM686A1(X3)	1	72.5	86.5	NT	NT	NT	1.83	121	T	NT	NT
RM692A1(X1)	1	72.5	86.5	NT	NT	NT	1.80	119	T	NT	NT
RM739A1(X3)	1	72.5	86.5	NT	NT	NT	2.04	135	NT	NT	NT
RM678A1(X1)	1	71.3	85	NT	NT	NT	1.93	128	T	NT	NT
RM713A1(X3)	2	75	84.5	NT	NT	NT	2.23	113	NT	NT	NT
RM708A1(X3)	1	70	83.5	NT	NT	NT	1.65	109	T	NT	NT
RM706A1(X1)	1	68.8	82	NT	NT	NT	1.69	112	T	NT	NT
RM606A1(X3)	2	72.5	81.6	NT	NT	NT	2.04	104	NT	T	T
RM698A1(X1)	1	67.5	80.5	NT	NT	NT	1.75	116	T	NT	NT
RM738A1(X3)	1	67.5	80.5	NT	NT	NT	1.14	75.7	T	NT	NT
RM741A1(X3)	1	67.5	80.5	NT	NT	NT	2.18	144	NT	NT	NT
RM603A1(X1)	2	71.3	80.2	NT	NT	NT	1.90	96.6	T	NT	NT
RM644A1(X3)	2	70	78.8	T	NT	NT	1.82	92.4	T	NT	NT
RM724A2(X3)	1	65	77.6	NT	NT	NT	2.44	162	NT	NT	NT
RM704A1(X1)	1	62.5	74.6	NT	T	NT	2.02	134	NT	NT	NT
RM642A1(X1)	2	66.3	74.6	T	NT	NT	1.97	100	NT	NT	NT
RM744A1(X1)	1	61.3	73.1	T	T	NT	1.98	131	NT	NT	NT
RM640A1(X3)	2	60	67.6	T	T	NT	2.52	128	NT	NT	NT
RM724A1(X1)	1	56.3	67.1	T	T	NT	2.13	141	NT	NT	NT
RM706A2(X7)	1	55	65.6	T	T	NT	2.05	135	NT	NT	NT
RM689A1(X3)	1	50	59.7	T	T	T	2.37	157	NT	NT	NT
RM676A1(X3)	1	46.3	55.2	T	T	T	2.10	139	NT	NT	NT
RM677A1(X3)	1	42.5	50.7	T	T	T	1.99	132	NT	NT	NT
RM680A1(X1)	1	38.8	46.2	T	T	T	2.17	143	NT	NT	NT

SMS = sediment management standards; SCO = sediment cleanup objective; CSL = cleanup screening level; T = toxic; NT = not toxic

Table 4. Comparison of methods used to designate sediments as toxic or not toxic to the amphipod (*Hyalella azteca*) from samples collected from the Upper Columbia River in 2005.

Station	Batch	28-day Percent Survival					28-day Growth (weight)				
		Effect Value (%)	Control-adjusted Value (%)	Reference Envelope	Draft SMS SCO	Draft SMS CSL	Effect Value (mg)	Control-adjusted Value (%)	Reference Envelope	Draft SMS SCO	Draft SMS CSL
Control	1	96.3	100	--	--	--	0.41	100	--	--	--
Control	2	97.5	100	--	--	--	0.38	100	--	--	--
RM724A1(X1)	1	98.8	103	NT	NT	NT	0.371	90.5	NT	NT	NT
RM713A1(X3)	2	100	103	NT	NT	NT	0.334	87.9	NT	NT	NT
RM678A1(X1)	1	97.5	101	NT	NT	NT	0.334	81.5	NT	T	NT
RM740A1(X1)	1	97.5	101	NT	NT	NT	0.515	126	NT	NT	NT
RM658A1(X3)	2	98.8	101	NT	NT	NT	0.412	108	NT	NT	NT
RM661A1(X1)	2	97.5	100	NT	NT	NT	0.345	90.8	NT	NT	NT
RM727A1(X1)	2	97.5	100	NT	NT	NT	0.412	108	NT	NT	NT
RM680A1(X1)	1	96.3	99.9	NT	NT	NT	0.326	79.5	NT	NT	NT
RM698A1(X1)	1	96.3	99.9	NT	NT	NT	0.285	69.5	T	T	NT
RM704A1(X1)	1	96.3	99.9	NT	NT	NT	0.383	93.4	NT	NT	NT
RM692A1(X1)	1	95	98.7	NT	NT	NT	0.412	100	NT	NT	NT
RM706A1(X1)	1	95	98.7	NT	NT	NT	0.312	76.1	NT	NT	NT
RM706A2(X7)	1	95	98.7	NT	NT	NT	0.335	81.7	NT	NT	NT
RM724A2(X3)	1	95	98.7	NT	NT	NT	0.642	157	NT	NT	NT
RM742A2(X5)	1	95	98.7	NT	NT	NT	0.32	78	NT	NT	NT
RM603A1(X1)	2	96.3	98.7	NT	NT	NT	0.324	85.3	NT	NT	NT
RM616A1(X3)	2	96.3	98.7	NT	NT	NT	0.484	127	NT	NT	NT
RM637A1(X1)	2	96.3	98.7	NT	NT	NT	0.451	119	NT	NT	NT
RM640A1(X3)	2	96.3	98.7	NT	NT	NT	0.401	106	NT	NT	NT
RM642A1(X1)	2	96.3	98.7	NT	NT	NT	0.301	79.2	NT	NT	NT
RM723A1(X1)	2	96.3	98.7	NT	NT	NT	0.652	172	NT	NT	NT
RM686A1(X3)	1	93.8	97.4	T	NT	NT	0.592	144	NT	NT	NT
RM687A1	1	93.8	97.4	T	NT	NT	0.268	65.4	T	NT	NT
RM689A1(X3)	1	93.8	97.4	T	NT	NT	0.368	89.8	NT	NT	NT
RM622A1(X3)	2	95	97.4	NT	NT	NT	0.516	136	NT	NT	NT
RM641A1(X1)	2	95	97.4	NT	NT	NT	0.348	91.6	NT	NT	NT

Table 4. Comparison of methods used to designate sediments as toxic or not toxic to the amphipod (*Hyalella azteca*) from samples collected from the Upper Columbia River in 2005.

Station	Batch	28-day Percent Survival					28-day Growth (weight)				
		Effect Value (%)	Control-adjusted Value (%)	Reference Envelope	Draft SMS SCO	Draft SMS CSL	Effect Value (mg)	Control-adjusted Value (%)	Reference Envelope	Draft SMS SCO	Draft SMS CSL
RM723A2(X3)	2	95	97.4	NT	NT	NT	0.423	111	NT	NT	NT
RM605A2(X8)	2	93.8	96.2	T	NT	NT	0.334	87.9	NT	NT	NT
RM606A1(X3)	2	93.8	96.2	T	NT	NT	0.421	111	NT	NT	NT
RM676A1(X3)	1	92.5	96.1	T	NT	NT	0.347	84.6	NT	NT	NT
RM708A1(X3)	1	92.5	96.1	T	NT	NT	0.339	82.7	NT	NT	NT
RM605A1(X1)	2	92.5	94.9	T	NT	NT	0.486	128	NT	NT	NT
RM644A1(X3)	2	92.5	94.9	T	NT	NT	0.341	89.7	NT	NT	NT
RM729A1(X1)	2	92.5	94.9	T	NT	NT	0.449	118	NT	NT	NT
RM739A1(X3)	1	91.3	94.8	T	NT	NT	0.461	112	NT	NT	NT
RM743A1(X1)	1	91.3	94.8	T	NT	NT	0.486	119	NT	NT	NT
RM634A1(X1)	2	91.3	93.6	T	NT	NT	0.371	97.7	NT	NT	NT
RM733A1(X1)	2	91.3	93.6	T	NT	NT	0.499	131	NT	NT	NT
RM677A1(X3)	1	90	93.5	T	NT	NT	0.276	67.3	T	T	NT
RM737A1(X3)	2	90	92.3	T	NT	NT	0.194	51.1	T	T	T
RM742A1(X1)	1	88.8	92.2	T	NT	NT	0.273	66.6	T	T	NT
RM736A1(X1)	2	88.8	91.0	T	NT	NT	0.336	88.4	NT	NT	NT
RM738A1(X3)	1	86.3	89.6	T	NT	NT	0.178	43.4	T	T	T
RM730A1	2	86.3	88.5	T	T	NT	0.336	88.4	NT	NT	NT
RM734A1	2	86.3	88.5	T	T	NT	0.227	59.7	T	T	T
RM744A1(X1)	1	83.8	87	T	T	NT	0.349	85.1	NT	NT	NT
RM628A1(X1)	2	83.8	85.9	T	NT	NT	0.524	138	NT	NT	NT
RM743A2(X3)	1	81.3	84.4	T	T	NT	0.321	78.3	NT	NT	NT
RM741A1(X3)	1	80	83.1	T	T	NT	0.46	112	NT	NT	NT
RM744A2(X3)	1	75	77.9	T	T	NT	0.166	40.5	T	T	T

SMS = sediment management standards; SCO = sediment cleanup objective; CSL = cleanup screening level; T = toxic; NT = not toxic

Table 5. Comparison showing the number of stations designated toxic from the Upper Columbia River 2005 study according to each method.

Test	Reference Envelope	Draft SMS SCO	Draft SMS CSL
Chironomus dilutus 10-day Percent survival	10 of 56 (18%)	9 of 50 (18%)	4 of 50 (8%)
Chironomus dilutus 10-day Growth (weight)	28 of 56 (50%)	3 of 50 (6%)	2 of 50 (4%)
Hyalella azteca 28-day Percent survival	26 of 56 (46%)	6 of 50 (12%)	0 of 50 (0%)
Hyalella azteca 28-day Growth (weight)	8 of 56 (14%)	8 of 50 (16%)	4 of 50 (8%)

SMS = sediment management standards; SCO = sediment cleanup objective; CSL = cleanup screening level.

Table 6. Recommended methods for designating sediments as toxic or not toxic (i.e., "hit" or "no hit") to benthic invertebrates.

Species / Endpoint	Draft SMS Rule Amendments: Sediment Cleanup Objective[1]	Draft SMS Rule Amendments: Cleanup Screening Level[1]	Recommended Biological Criteria (Based on Reference Envelope): No Effect	Recommended Biological Criteria (Based on Reference Envelope): Minor Effect
Chironomus dilutus				
10-day mortality	$M_T - M_C > 20\%$	$M_T - M_C > 30\%$	Control-adjusted response[2] within the reference envelope[3]	Control-adjusted response within 10% of the reference envelope[3]
10-day growth	$\left(\frac{MIG_T}{MIG_C}\right) < 0.8$	$\left(\frac{MIG_T}{MIG_C}\right) < 0.7$	Control-adjusted response[2] within the reference envelope[3]	Control-adjusted response within 10% of the reference envelope[3]
20-day mortality	$M_T - M_C > 15\%$	$M_T - M_C > 25\%$	Control-adjusted response[2] within the reference envelope[3]	Control-adjusted response within 10% of the reference envelope[3]
20-day growth	$\left(\frac{MIG_T}{MIG_C}\right) < 0.75$	$\left(\frac{MIG_T}{MIG_C}\right) < 0.6$	Control-adjusted response[2] within the reference envelope[3]	Control-adjusted response within 10% of the reference envelope[3]
Hyalella azteca				
10-day mortality	$M_T - M_C > 15\%$	$M_T - M_C > 25\%$	Control-adjusted response[2] within the reference envelope[3]	Control-adjusted response within 10% of the reference envelope[3]
28-day mortality	$M_T - M_C > 10\%$	$M_T - M_C > 25\%$	Control-adjusted response[2] within the reference envelope[3]	Control-adjusted response within 10% of the reference envelope[3]
28-day growth	$\left(\frac{MIG_T}{MIG_C}\right) < 0.75$	$\left(\frac{MIG_T}{MIG_C}\right) < 0.6$	Control-adjusted response[2] within the reference envelope[3]	Control-adjusted response within 10% of the reference envelope[3]

M = mortality; MIG = mean individual growth at time final; R = response; C = control sediment; T = test sediment; F = final

[1] An exceednce of the sediment cleanup objective and cleanup screening level requires statistical significance at $\rho = 0.05$ in addition to these thresholds.

[2] Control-adjusted response = $\left(\frac{R_T}{R_C}\right)$

[3] Reference envelope is developed using geographic and internal sediments that meet the biological and chemical criteria outlined in MacDonald *et al.* 2012. It is defined as the minimum and maximum response observed in the reference sediments for each endpoint.

Table 7. Comparison of sediment cleanup objectives (SCOs) to sediment quality guidelines in freshwater ecosystems that reflect TECs (i.e., below which harmful effects are unlikely to be observed).

Substance	*Threshold Effect Concentrations*							
	TEL	**LEL**	**MET**	**ERL**	**TEL-HA28**	**SQAL**	**Consensus-Based TEC**	**SCO**
Metals (mg/kg DW)								
Arsenic	5.9	6	7	33	11	NG	9.79	14
Cadmium	0.596	0.6	0.9	5	0.58	NG	0.99	2.1
Chromium	37.3	26	55	80	36	NG	43.4	72
Copper	35.7	16	28	70	28	NG	31.6	400
Lead	35	31	42	35	37	NG	35.8	360
Mercury	0.174	0.2	0.2	0.15	NG	NG	0.18	0.66
Nickel	18	16	35	30	20	NG	22.7	26
Zinc	123	120	150	120	98	NG	121	3200
Polycyclic Aromatic Hydrocarbons (PAH; µg/kg DW)								
Anthracene	NG	220	NG	85	10	NG	57.2	NG
Fluorene	NG	190	NG	35	10	540	77.4	NG
Naphthalene	NG	NG	400	340	15	470	176	NG
Phenanthrene	41.9	560	400	225	19	1800	204	NG
Benz[a]anthracene	31.7	320	400	230	16	NG	108	NG
Benzo(a)pyrene	31.9	370	500	400	32	NG	150	NG
Chrysene	57.1	340	600	400	27	NG	166	NG
Dibenz[a,h]anthracene	NG	60	NG	60	10	NG	33.0	NG
Fluoranthene	111	750	600	600	31	6200	423	NG
Pyrene	53	490	700	350	44	NG	195	NG
Total PAHs	NG	4000	NG	4000	260	NG	1610	17000
Polychlorinated Biphenyls (PCB; µg/kg DW)								
Total PCBs	34.1	70	200	50	32	NG	59.8	110
Organochlorine Pesticides (µg/kg DW)								
Chlordane	4.5	7	7	0.5	NG	NG	3.24	NG
Dieldrin	2.85	2	2	0.02	NG	110	1.90	4.9

Table 7. Comparison of sediment cleanup objectives (SCOs) to sediment quality guidelines in freshwater ecosystems that reflect TECs (i.e., below which harmful effects are unlikely to be observed).

Substance	*Threshold Effect Concentrations*							
	TEL	**LEL**	**MET**	**ERL**	**TEL-HA28**	**SQAL**	**Consensus-Based TEC**	**SCO**
Organochlorine Pesticides (µg/kg DW; cont.)								
Sum DDD	3.54	8	10	2	NG	NG	4.88	310
Sum DDE	1.42	5	7	2	NG	NG	3.16	21
Sum DDT	NG	8	9	1	NG	NG	4.16	100
Total DDTs	7	7	NG	3	NG	NG	5.28	NG
Endrin	2.67	3	8	0.02	NG	42	2.22	8.5 [1]
Heptachlor epoxide	0.6	5	5	NG	NG	NG	2.47	NG
Lindane (gamma-BHC)	0.94	3	3	NG	NG	3.7	2.37	NG

TEL = threshold effect level, dry weight (Smith *et al*. 1996); LEL = lowest effect level, dry weight (Persaud *et al*. 1993); MET = minimal effect threshold, dry weight (EC & MENVIQ 1992); ERL = effects range low, dry weight (Long and Morgan 1991); TEL-HA28 = threshold effect level for *Hyalella azteca,* 28-day test, dry weight (USEPA 1996); SQAL = sediment quality advisory levels, dry weight at 1% OC (USEPA 1997); TEC = threshold effect concentration (MacDonald *et al*. 2000); SCO = sediment cleanup objective, dry weight; NG = no guideline; OC = organic carbon; DDD = dichlorodiphenyldichloroethane; DDE = dichlorodiphenyldichloroethylene; DDT = dichlorodiphenyltrichloroethane

[1] Guideline for endrin ketone

Table 8. Comparison of cleanup screening levels to sediment quality guidelines in freshwater ecosystems that reflect PECs (i.e., above which harmful effects are likely to be observed).

Substance	*Probable Effect Concentrations*						
	PEL	**SEL**	**TET**	**ERM**	**PEL-HA28**	**Consensus-Based PEC**	**CSL**
Metals (mg/kg DW)							
Arsenic	17	33	17	85	48	33.0	120
Cadmium	3.53	10	3	9	3.2	4.98	5.4
Chromium	90	110	100	145	120	111	88
Copper	197	110	86	390	100	149	1200
Lead	91.3	250	170	110	82	128	> 1300
Mercury	0.486	2	1	1.3	NG	1.06	0.8
Nickel	36	75	61	50	33	48.6	110
Zinc	315	820	540	270	540	459	> 4200
Polycyclic Aromatic Hydrocarbons (PAH; µg/kg DW)							
Anthracene	NG	3700	NG	960	170	845	NG
Fluorene	NG	1600	NG	640	150	536	NG
Naphthalene	NG	NG	600	2100	140	561	NG
Phenanthrene	515	9500	800	1380	410	1170	NG
Benz[a]anthracene	385	14800	500	1600	280	1050	NG
Benzo(a)pyrene	782	14400	700	2500	320	1450	NG
Chrysene	862	4600	800	2800	410	1290	NG
Fluoranthene	2355	10200	2000	3600	320	2230	NG
Pyrene	875	8500	1000	2200	490	1520	NG
Total PAHs	NG	100000	NG	35000	3400	22800	30000
Polychlorinated Biphenyls (PCB; µg/kg DW)							
Total PCBs	277	5300	1000	400	240	676	2500
Organochlorine Pesticides (µg/kg DW)							
Chlordane	8.9	60	30	6	NG	17.6	NG
Dieldrin	6.67	910	300	8	NG	61.8	9.3

Table 8. Comparison of cleanup screening levels to sediment quality guidelines in freshwater ecosystems that reflect PECs (i.e., above which harmful effects are likely to be observed).

Substance	*Probable Effect Concentrations*						
	PEL	SEL	TET	ERM	PEL-HA28	Consensus-Based PEC	CSL
Organochlorine Pesticides (µg/kg DW; cont.)							
Sum DDD	8.51	60	60	20	NG	28.0	860
Sum DDE	6.75	190	50	15	NG	31.3	33
Sum DDT	NG	710	50	7	NG	62.9	8100
Total DDTs	4450	120	NG	350	NG	572	NG
Endrin	62.4	1300	500	45	NG	207	NG
Heptachlor Epoxide	2.74	50	30	NG	NG	16.0	NG
Lindane (gamma-BHC)	1.38	10	9	NG	NG	4.99	NG

PEL = probable effect level, dry weight (Smith *et al.* 1996); SEL = severe effect level, dry weight (Persaud *et al* . 1993); TET = toxic effect threshold, dry weight (EC & MENVIQ 1992);
ERM = effects range median, dry weight (Long and Morgan 1991); PEL-HA28 = probable effect level for *Hyalella azteca* ; 28 day test; dry weight (USEPA 1996);
PEC = probable effect concentration (MacDonald *et al.* 2000); CSL = cleanup screening level, dry weight; NG = no guideline; OC = organic carbon; NG = no guideline; OC = organic carbon;
DDD = dichlorodiphenyldichloroethane; DDE = dichlorodiphenyldichloroethylene; DDT = dichlorodiphenyltrichloroethane

Table 9. Comparison of sediment cleanup objectives and cleanup screening levels to sediment quality standards in freshwater ecosystems in Washington State.

Substance	*Threshold Effect Concentrations*			*Probable Effect Concentrations*	
	Confederated Tribes of the Colville Reservation	**Spokane Tribe of Indians**	**SCO**	**Confederated Tribes of the Colville Reservation**	**CSL**
Metals (mg/kg DW)					
Arsenic	9.79	9.79	14	33.0	120
Cadmium	0.99	0.99	2.1	4.98	5.4
Chromium	43.4	43.4	72	111	88
Copper	31.6	31.6	400	149	1200
Lead	35.8	35.8	360	128	> 1300
Mercury	0.18	0.18	0.66	1.06	0.8
Nickel	22.7	22.7	26	48.6	110
Zinc	121	121	3200	459	> 4200
Polycyclic Aromatic Hydrocarbons (PAH; µg/kg DW)					
Anthracene	57.2	57.2	NG	845	NG
Fluorene	77.4	77.4	NG	536	NG
Naphthalene	176	176	NG	561	NG
Phenanthrene	204	204	NG	1170	NG
Benz[a]anthracene	108	108	NG	1050	NG
Benzo(a)pyrene	150	150	NG	1450	NG
Chrysene	166	166	NG	1290	NG
Dibenz[a,h]anthracene	33.0	33.0	NG	NG	NG
Fluoranthene	423	423	NG	2230	NG
Pyrene	195	195	NG	1520	NG
Total PAHs	1610	1610	17000	22800	30000
Polychlorinated Biphenyls (PCB; µg/kg DW)					
Total PCBs	59.8	59.8	110	676	2500
Organochlorine Pesticides (µg/kg DW)					
Chlordane	3.24	3.24	NG	17.6	NG
Dieldrin	1.90	1.90	4.9	61.8	9.3
Sum DDD	4.88	4.88	310	28.0	860
Sum DDE	3.16	3.16	21	31.3	33
Sum DDT	4.16	4.16	100	62.9	8100
Total DDTs	5.28	5.28	NG	572	NG
Endrin	2.22	2.22	8.5 [1]	207	NG
Heptachlor epoxide	2.47	2.47	NG	16.0	NG
Lindane (gamma-BHC)	2.37	2.37	NG	4.99	NG

NG = no guideline; SCO = sediment cleanup objective, dry weight; CSL = cleanup screening level, dry weight;
DDD = dichlorodiphenyldichloroethane; DDE = dichlorodiphenyldichloroethylene; DDT = dichlorodiphenyltrichloroethane
[1] Guideline for endrin ketone.

Table 10. Summary of methods used to designate sediments collected in Washington State as toxic or not toxic.

Study	Toxicity Test	Number of Stations	Comparison Method Used for Designating Toxicity	Reference
Upper Columbia River				
Schut and Stefanoff (2007)	10-d *Chironomus dilutus* WST (S, G, B)	56	Reference Envelope	MacDonald *et al.* (2012)
	28-d *Hyalella azteca* WST (S, G, B)	56	Reference Envelope	MacDonald *et al.* (2012)
Besser *et al.* (2008)	12-d *Chironomus dilutus* WST (S, G, B)	8	Reference Envelope	MacDonald *et al.* (2012)
	28-d *Hyalella azteca* WST (S, G, B)	8	Reference Envelope	MacDonald *et al.* (2012)
Bortleson *et al.* (1994)	7-d *Hyalella azteca* WST (S)	19	Negative Control (α = 0.05)	Bortleson *et al.* (1994)
Era and Serdar (2001)	20-d *Chironomus dilutus* WST (S, G)	9	Negative Control (α = 0.05)	Era and Serdar (2001)
	10-d *Hyalella azteca* WST (S)	9	Negative Control (α = 0.05)	Era and Serdar (2001)
Johnson (1991)	10-d *Hyalella azteca* WST (S)	6	Negative Control (α = 0.05)	Unpublished analysis by MESL
Washington State				
Johnson and Norton (2001)	20-d *Chironomus dilutus* WST (S, G)	8	Negative Control (α = 0.05)	Johnson and Norton (2001)
	28-d *Hyalella azteca* WST (S, G, B)	8	Negative Control (α = 0.05)	Johnson and Norton (2001)
Johnson and Plotnkioff (2000)	10-d *Hyalella azteca* WST (S)	4	Negative Control (α = 0.05)	Johnson and Plotnikoff (2000)
Bennett and Cubbage (1992; Phase I)	14-d *Hyalella azteca* WST (S)	11	Negative Control (α = 0.05)	Bennett and Cubbage (1992)
Bennett and Cubbage (1992; Phase II)	10-d *Chironomus dilutus* WST (S, G)	4	Negative Control (α = 0.05)	Bennett and Cubbage (1992)
	14-d *Hyalella azteca* WST (S)	4	Negative Control (α = 0.05)	Bennett and Cubbage (1992)
Landau Associates, Inc. (1993)	> 20-d *Chironomus dilutus* WST (S)	19	Negative Control (α = 0.05)	Landau Associates, Inc. (1993)
	10-d *Hyalella azteca* WST (S)	19	Negative Control (α = 0.05)	Landau Associates, Inc. (1993)
Cubbage (1992)	10-d *Hyalella azteca* WST (S)	9	Negative Control (α = 0.05)	Cubbage (1992)
Tetra Tech (1993)	10-d *Hyalella azteca* WST (S)	15	Negative Control (α = 0.05)	Unpublished analysis by MESL

Table 10. Summary of methods used to designate sediments collected in Washington State as toxic or not toxic.

Study	Toxicity Test	Number of Stations	Comparison Method Used for Designating Toxicity	Reference
Brady (1994)	10-d *Hyalella azteca* WST (S)	6	Negative Control (α = 0.05)	Brady (1994)
ENSR Consulting (1994)	14-d *Hyalella azteca* WST (S)	4	Negative Control (α = 0.05)	ENSR Consulting (1994)
FishPro Eng. and Env. (1991)	28-d *Hyalella azteca* WST (S)	9	Negative Control (α = 0.05)	FishPro Eng. and Env. (1991)

d = day; WST = whole-sediment toxicity; PWT = pore-water toxicity; S = survival; G = growth; B = biomass.

Table 11. Test acceptability recommendations for measuring the toxicity of sediment-associated contaminants with freshwater invertebrates and biological criteria used for establishing the reference envelope.

Species / Endpoint	**ASTM (E 1706)**	**Reference Envelope**
Chironomus dilutus		
Survival	Average survival in control sediment at day 10 should be ≥ 70%.	Average survival in control sediment at day 10 should be ≥ 70%.
Growth	Minimum mean weight at day 10 of 0.48 mg/surviving organism (AFDW).	Minimum mean weight at day 10 of 0.48 mg/surviving organism (AFDW).
Hyalella azteca		
Survival	Average survival in control sediments at day 28 should be > 80%.	Average survival in control sediments at day 28 should be > 80%.
Growth	Not specified.	Not specified.

mg = milligrams; DW = dry weight; AFDW = ash-free dry weight

Table 12. Summary of the evaluation of sediment cleanup objectives using toxicity designations in Table VIII of the Proposed SMS Rule Amendment.

Species / Endpoint / Region	Incidence of Toxicity[1]			
	7- to 14-day Toxicity Tests[2]		20- to 28-day Toxicity Tests[3]	
	No Exceedances of SCO[4]	One or More Exceedances of SCO[4]	No Exceedances of SCO[4]	One or More Exceedances of SCO[4]
Chironomus dilutus				
Survival				
UCR[5]	9 of 31 (29%)	0 of 19 (0%)	ND	ND
Washington State	ND	ND	ND	ND
Overall	**9 of 31 (29%)**	**0 of 19 (0%)**	**ND**	**ND**
Growth				
UCR[5]	2 of 31 (6.45%)	1 of 19 (5.26%)	ND	ND
Washington State	ND	ND	ND	ND
Overall	**2 of 31 (6.45%)**	**1 of 19 (5.26%)**	**ND**	**ND**
Biomass				
UCR[5]	ND	ND	ND	ND
Washington State	ND	ND	ND	ND
Overall	**ND**	**ND**	**ND**	**ND**
Hyalella azteca				
Survival				
UCR[5]	ND	ND	2 of 31 (6.45%)	4 of 19 (21.1%)
Washington State	ND	ND	ND	ND
Overall	**ND**	**ND**	**2 of 31 (6.45%)**	**4 of 19 (21.1%)**
Growth				
UCR[5]	ND	ND	2 of 31 (6.45%)	6 of 19 (31.6%)
Washington State	ND	ND	ND	ND
Overall	**ND**	**ND**	**2 of 31 (6.45%)**	**6 of 19 (31.6%)**
Biomass				
UCR[5]	ND	ND	ND	ND
Washington State	ND	ND	ND	ND
Overall	**ND**	**ND**	**ND**	**ND**

ND = no data; SCO = sediment cleanup objective; SMS = sediment management standards; UCR = Upper Columbia River.

[1] Toxicity was designated using criteria outlined in WDOE (2011).

[2] 7- to 14-d toxicity tests are defined as 10-d to 12-d tests for *Chironomus dilutus* or 7-d to 14-d tests for *Hyalella azteca*.

[3] 20- to 28-d toxicity tests are defined as 20-d tests for *Chironomus dilutus* or 28-d tests for *Hyalella azteca*.

[4] Analytes used in the analysis include metals (arsenic, cadmium, copper, lead, and zinc), total PAHs (polycyclic aromatic hydrocarbons), total PCBs (polychlorinated biphenyls), total DDTs (dichlorodiphenyltrichloroethane), bis(2-ethylhexyl) phthalate, and pentachlorophenol.

[5] Portion of the Columbia River between the international border and the Grand Coulee dam.

Table 13. Summary of the evaluation of sediment cleanup objectives using toxicity designation methods described in Table 11.

Species / Endpoint / Region	Incidence of Toxicity[1]			
	7- to 14-day Toxicity Tests[2]		20- to 28-day Toxicity Tests[3]	
	No Exceedances of SCO[4]	One or More Exceedances of SCO[4]	No Exceedances of SCO[4]	One or More Exceedances of SCO[4]
Chironomus dilutus				
Survival				
UCR[5]	9 of 40 (22.5%)	1 of 24 (4.17%)	0 of 3 (0%)	2 of 6 (33.3%)
Washington State	0 of 1 (0%)	0 of 3 (0%)	0 of 5 (0%)	8 of 22 (36.4%)
Overall	**9 of 41 (22%)**	**1 of 27 (3.7%)**	**0 of 8 (0%)**	**10 of 28 (35.7%)**
Growth				
UCR[5]	16 of 40 (40%)	16 of 24 (66.7%)	1 of 3 (33.3%)	4 of 6 (66.7%)
Washington State	0 of 1 (0%)	0 of 3 (0%)	1 of 3 (33.3%)	2 of 5 (40%)
Overall	**16 of 41 (39%)**	**16 of 27 (59.3%)**	**2 of 6 (33.3%)**	**6 of 11 (54.5%)**
Biomass				
UCR[5]	28 of 40 (70%)	18 of 24 (75%)	ND	ND
Washington State	ND	ND	ND	ND
Overall	**28 of 40 (70%)**	**18 of 24 (75%)**	**ND**	**ND**
Hyalella azteca				
Survival				
UCR[5]	3 of 6 (50%)	11 of 28 (39.3%)	16 of 40 (40%)	14 of 24 (58.3%)
Washington State	9 of 32 (28.1%)	6 of 41 (14.6%)	3 of 4 (75%)	12 of 13 (92.3%)
Overall	**12 of 38 (31.6%)**	**17 of 69 (24.6%)**	**19 of 44 (43.2%)**	**26 of 37 (70.3%)**
Growth				
UCR[5]	ND	ND	2 of 40 (5%)	6 of 24 (25%)
Washington State	ND	ND	3 of 3 (100%)	4 of 5 (80%)
Overall	**ND**	**ND**	**5 of 43 (11.6%)**	**10 of 29 (34.5%)**
Biomass				
UCR[5]	ND	ND	5 of 40 (12.5%)	11 of 24 (45.8%)
Washington State	ND	ND	3 of 3 (100%)	5 of 5 (100%)
Overall	**ND**	**ND**	**8 of 43 (18.6%)**	**16 of 29 (55.2%)**

ND = no data; SCO = sediment cleanup objective; UCR = Upper Columbia River.

[1] Toxicity was desgnated using either the reference envelope approach or by statistical comparisons to negative control.

[2] 7- to 14-d toxicity tests are defined as 10-d to 12-d tests for *Chironomus dilutus* or 7-d to 14-d tests for *Hyalella azteca* .

[3] 20- to 28-d toxicity tests are defined as 20-d tests for *Chironomus dilutus* or 28-d tests for *Hyalella azteca* .

[4] Analytes used in the analysis include metals (arsenic, cadmium, copper, lead, and zinc), total PAHs (polycyclic aromatic hydrocarbons), total PCBs (polychlorinated biphenyls), total DDTs (dichlorodiphenyltrichloroethane), bis(2-ethylhexyl) phthalate, and pentachlorophenol.

[5] Portion of the Columbia River between the international border and the Grand Coulee dam.

Table 14. Summary of the evaluation of cleanup screening levels using toxicity designations in Table VIII of the Proposed SMS Rule Amendment.

Species / Endpoint / Region	Incidence of Toxicity[1]			
	7- to 14-day Toxicity Tests[2]		20- to 28-day Toxicity Tests[3]	
	No Exceedances of CSL[4]	One or More Exceedances of CSL[4]	No Exceedances of CSL[4]	One or More Exceedances of CSL[4]
Chironomus dilutus				
Survival				
UCR[5]	4 of 42 (9.52%)	0 of 8 (0%)	ND	ND
Washington State	ND	ND	ND	ND
Overall	**4 of 42 (9.52%)**	**0 of 8 (0%)**	**ND**	**ND**
Growth				
UCR[5]	1 of 42 (2.38%)	1 of 8 (12.5%)	ND	ND
Washington State	ND	ND	ND	ND
Overall	**1 of 42 (2.38%)**	**1 of 8 (12.5%)**	**ND**	**ND**
Biomass				
UCR[5]	ND	ND	ND	ND
Washington State	ND	ND	ND	ND
Overall	**ND**	**ND**	**ND**	**ND**
Hyalella azteca				
Survival				
UCR[5]	ND	ND	0 of 42 (0%)	0 of 8 (0%)
Washington State	ND	ND	ND	ND
Overall	**ND**	**ND**	**0 of 42 (0%)**	**0 of 8 (0%)**
Growth				
UCR[5]	ND	ND	0 of 42 (0%)	4 of 8 (50%)
Washington State	ND	ND	ND	ND
Overall	**ND**	**ND**	**0 of 42 (0%)**	**4 of 8 (50%)**
Biomass				
UCR[5]	ND	ND	ND	ND
Washington State	ND	ND	ND	ND
Overall	**ND**	**ND**	**ND**	**ND**

ND = no data; CSL = cleanup screening level; SMS = sediment management standards; UCR = Upper Columbia River.

[1] Toxicity was designated using criteria outlined in WDOE (2011).

[2] 7- to 14-d toxicity tests are defined as 10-d to 12-d tests for *Chironomus dilutus* or 7-d to 14-d tests for *Hyalella azteca* .

[3] 20- to 28-d toxicity tests are defined as 20-d tests for *Chironomus dilutus* or 28-d tests for *Hyalella azteca* .

[4] Analytes used in the analysis include metals (arsenic, cadmium, copper, lead, and zinc), total PAHs (polycyclic aromatic hydrocarbons), total PCBs (polychlorinated biphenyls), total DDTs (dichlorodiphenyltrichloroethane), bis(2-ethylhexyl) phthalate, and pentachlorophenol.

[5] Portion of the Columbia River between the international border and the Grand Coulee dam.

Table 15. Summary of the evaluation of cleanup screening levels using toxicity designation methods described in Table 11.

Species / Endpoint / Region	Incidence of Toxicity[1]			
	7- to 14-day Toxicity Tests[2]		20- to 28-day Toxicity Tests[3]	
	No Exceedances of CSL[4]	One or More Exceedances of CSL[4]	No Exceedances of CSL[4]	One or More Exceedances of CSL[4]
Chironomus dilutus				
Survival				
UCR[5]	10 of 53 (18.9%)	0 of 11 (0%)	0 of 3 (0%)	2 of 6 (33.3%)
Washington State	0 of 4 (0%)	ND	2 of 11 (18.2%)	6 of 16 (37.5%)
Overall	**10 of 57 (17.5%)**	**0 of 11 (0%)**	**2 of 14 (14.3%)**	**8 of 22 (36.4%)**
Growth				
UCR[5]	23 of 53 (43.4%)	9 of 11 (81.8%)	1 of 3 (33.3%)	4 of 6 (66.7%)
Washington State	0 of 4 (0%)	ND	1 of 4 (25%)	2 of 4 (50%)
Overall	**23 of 57 (40.4%)**	**9 of 11 (81.8%)**	**2 of 7 (28.6%)**	**6 of 10 (60%)**
Biomass				
UCR[5]	35 of 53 (66%)	11 of 11 (100%)	ND	ND
Washington State	ND	ND	ND	ND
Overall	**35 of 53 (66%)**	**11 of 11 (100%)**	**ND**	**ND**
Hyalella azteca				
Survival				
UCR[5]	4 of 11 (36.4%)	10 of 23 (43.5%)	22 of 53 (41.5%)	8 of 11 (72.7%)
Washington State	10 of 56 (17.9%)	5 of 17 (29.4%)	4 of 5 (80%)	11 of 12 (91.7%)
Overall	**14 of 67 (20.9%)**	**15 of 40 (37.5%)**	**26 of 58 (44.8%)**	**19 of 23 (82.6%)**
Growth				
UCR[5]	ND	ND	4 of 53 (7.55%)	4 of 11 (36.4%)
Washington State	ND	ND	4 of 4 (100%)	3 of 4 (75%)
Overall	**ND**	**ND**	**8 of 57 (14%)**	**7 of 15 (46.7%)**
Biomass				
UCR[5]	ND	ND	10 of 53 (18.9%)	6 of 11 (54.5%)
Washington State	ND	ND	4 of 4 (100%)	4 of 4 (100%)
Overall	**ND**	**ND**	**14 of 57 (24.6%)**	**10 of 15 (66.7%)**

ND = no data; CSL = cleanup screening level; UCR = Upper Columbia River.

[1] Toxicity was desgnated using either the reference envelope approach or by statistical comparisons to negative control.

[2] 7- to 14-d toxicity tests are defined as 10-d to 12-d tests for *Chironomus dilutus* or 7-d to 14-d tests for *Hyalella azteca* .

[3] 20- to 28-d toxicity tests are defined as 20-d tests for *Chironomus dilutus* or 28-d tests for *Hyalella azteca* .

[4] Analytes used in the analysis include metals (arsenic, cadmium, copper, lead, and zinc), total PAHs (polycyclic aromatic hydrocarbons), total PCBs (polychlorinated biphenyls), total DDTs (dichlorodiphenyltrichloroethane), bis(2-ethylhexyl) phthalate, and pentachlorophenol.

[5] Portion of the Columbia River between the international border and the Grand Coulee dam.

Table 16. Evaluation of sediment cleanup objectives and sediment screening levels based on incidence of toxicity to *Chironomus dilutus* (endpoint: percent survival).

Substance / Region	Incidence of Toxicity based on *Chironomus dilutus* Percent Survival[1]							
	10- to 12-day Toxicity Tests				20-day Toxicity Tests			
	≤ SCO	SCO - CSL	≤ CSL	> CSL	≤ SCO	SQS - CSL	≤ CSL	> CSL
Arsenic								
UCR[2]	9 of 61 (14.8%)	1 of 3 (33.3%)	10 of 64 (15.6%)	ND	1 of 8 (12.5%)	1 of 1 (100%)	2 of 9 (22.2%)	ND
Washington	0 of 2 (0%)	0 of 2 (0%)	0 of 4 (0%)	ND	6 of 23 (26.1%)	2 of 4 (50%)	8 of 27 (29.6%)	ND
Overall	**9 of 63 (14.3%)**	**1 of 5 (20%)**	**10 of 68 (14.7%)**	**ND**	**7 of 31 (22.6%)**	**3 of 5 (60%)**	**10 of 36 (27.8%)**	**ND**
Cadmium								
UCR[2]	10 of 47 (21.3%)	0 of 15 (0%)	10 of 62 (16.1%)	0 of 2 (0%)	0 of 3 (0%)	ND	0 of 3 (0%)	2 of 6 (33.3%)
Washington	0 of 3 (0%)	0 of 1 (0%)	0 of 4 (0%)	ND	2 of 7 (28.6%)	1 of 5 (20%)	3 of 12 (25.0%)	5 of 14 (35.7%)
Overall	**10 of 50 (20%)**	**0 of 16 (0%)**	**10 of 66 (15.2%)**	**0 of 2 (0%)**	**2 of 10 (20%)**	**1 of 5 (20%)**	**3 of 15 (20%)**	**7 of 20 (35%)**
Copper								
UCR[2]	10 of 56 (17.9%)	0 of 3 (0%)	10 of 59 (16.9%)	0 of 5 (0%)	0 of 6 (0%)	0 of 1 (0%)	0 of 7 (0%)	2 of 2 (100%)
Washington	0 of 2 (0%)	0 of 2 (0%)	0 of 4 (0%)	ND	8 of 27 (29.6%)	ND	8 of 27 (29.6%)	ND
Overall	**10 of 58 (17.2%)**	**0 of 5 (0%)**	**10 of 63 (15.9%)**	**0 of 5 (0%)**	**8 of 33 (24.2%)**	**0 of 1 (0%)**	**8 of 34 (23.5%)**	**2 of 2 (100%)**
Lead								
UCR[2]	10 of 61 (16.4%)	0 of 2 (0%)	10 of 63 (15.9%)	0 of 1 (0%)	2 of 9 (22.2%)	ND	2 of 9 (22.2%)	ND
Washington	0 of 3 (0%)	ND	0 of 3 (0%)	ND	7 of 26 (26.9%)	1 of 1 (100%)	8 of 27 (29.6%)	ND
Overall	**10 of 64 (15.6%)**	**0 of 2 (0%)**	**10 of 66 (15.2%)**	**0 of 1 (0%)**	**9 of 35 (25.7%)**	**1 of 1 (100%)**	**10 of 36 (27.8%)**	**ND**
Zinc								
UCR[2]	10 of 55 (18.2%)	ND	10 of 55 (18.2%)	0 of 9 (0%)	0 of 6 (0%)	0 of 1 (0%)	0 of 7 (0%)	2 of 2 (100%)
Washington	0 of 4 (0%)	ND	0 of 4 (0%)	ND	5 of 24 (20.8%)	ND	5 of 24 (20.8%)	3 of 3 (100%)
Overall	**10 of 59 (16.9%)**	**ND**	**10 of 59 (16.9%)**	**0 of 9 (0%)**	**5 of 30 (16.7%)**	**0 of 1 (0%)**	**5 of 31 (16.1%)**	**5 of 5 (100%)**
Total PAHs[3]								
UCR[2]	10 of 56 (17.9%)	ND	10 of 56 (17.9%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	7 of 25 (28%)	0 of 1 (0%)	7 of 26 (26.9%)	1 of 1 (100%)
Overall	**10 of 56 (17.9%)**	**ND**	**10 of 56 (17.9%)**	**ND**	**7 of 25 (28%)**	**0 of 1 (0%)**	**7 of 26 (26.9%)**	**1 of 1 (100%)**

Table 16. Evaluation of sediment cleanup objectives and sediment screening levels based on incidence of toxicity to *Chironomus dilutus* (endpoint: percent survival).

Substance / Region	Incidence of Toxicity based on *Chironomus dilutus* Percent Survival[1]							
	10- to 12-day Toxicity Tests				20-day Toxicity Tests			
	≤ SCO	SCO - CSL	≤ CSL	> CSL	≤ SCO	SQS - CSL	≤ CSL	> CSL
Total PCBs								
UCR[2]	10 of 56 (17.9%)	ND	10 of 56 (17.9%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	0 of 5 (0%)	1 of 3 (33.3%)	1 of 8 (12.5%)	ND
Overall	**10 of 56 (17.9%)**	**ND**	**10 of 56 (17.9%)**	**ND**	**0 of 5 (0%)**	**1 of 3 (33.3%)**	**1 of 8 (12.5%)**	**ND**
Sum DDTs (*o, p′ + p, p′*)								
UCR[2]	10 of 56 (17.9%)	ND	10 of 56 (17.9%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	6 of 20 (30%)	ND	6 of 20 (30%)	ND
Overall	**10 of 56 (17.9%)**	**ND**	**10 of 56 (17.9%)**	**ND**	**6 of 20 (30%)**	**ND**	**6 of 20 (30%)**	**ND**
Bis(2-ethylhexyl) phthalate								
UCR[2]	10 of 56 (17.9%)	ND	10 of 56 (17.9%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	1 of 8 (12.5%)	1 of 1 (100%)	2 of 9 (22.2%)	1 of 2 (50%)
Overall	**10 of 56 (17.9%)**	**ND**	**10 of 56 (17.9%)**	**ND**	**1 of 8 (12.5%)**	**1 of 1 (100%)**	**2 of 9 (22.2%)**	**1 of 2 (50%)**
Pentachlorophenol								
UCR[2]	10 of 56 (17.9%)	ND	10 of 56 (17.9%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	1 of 8 (12.5%)	ND	1 of 8 (12.5%)	ND
Overall	**10 of 56 (17.9%)**	**ND**	**10 of 56 (17.9%)**	**ND**	**1 of 8 (12.5%)**	**ND**	**1 of 8 (12.5%)**	**ND**

ND = no data; SCO = sediment cleanup objective; CSL = cleanup screening level; PAH = polycyclic aromatic hydrocarbon; PCB = polychlorinated biphenyl; DDT = dichlorodiphenyltrichloroethane
UCR = Upper Columbia River.

[1] Toxicity was desgnated using either the reference envelope approach or by statistical comparisons to negative control.

[2] Portion of the Columbia River between the international border and the Grand Coulee dam.

[3] Total PAHs were calculated as the sum of 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene.

Table 17. Evaluation of sediment cleanup objectives and sediment screening levels based on incidence of toxicity to *Chironomus dilutus* (endpoint: weight).

Substance / Region	Incidence of Toxicity based on *Chironomus dilutus* Growth (weight)[1]							
	10- to 12-day Toxicity Tests				20-day Toxicity Tests			
	≤ SCO	SCO - CSL	≤ CSL	> CSL	≤ SCO	SCO - CSL	≤ CSL	> CSL
Arsenic								
UCR[2]	29 of 61 (47.5%)	3 of 3 (100%)	32 of 64 (50%)	ND	4 of 8 (50%)	1 of 1 (100%)	5 of 9 (55.6%)	ND
Washington	0 of 2 (0%)	0 of 2 (0%)	0 of 4 (0%)	ND	2 of 7 (28.6%)	1 of 1 (100%)	3 of 8 (37.5%)	ND
Overall	**29 of 63 (46%)**	**3 of 5 (60%)**	**32 of 68 (47.1%)**	**ND**	**6 of 15 (40%)**	**2 of 2 (100%)**	**8 of 17 (47.1%)**	**ND**
Cadmium								
UCR[2]	22 of 47 (46.8%)	8 of 15 (53.3%)	30 of 62 (48.4%)	2 of 2 (100%)	1 of 3 (33.3%)	ND	1 of 3 (33.3%)	4 of 6 (66.7%)
Washington	0 of 3 (0%)	0 of 1 (0%)	0 of 4 (0%)	ND	1 of 3 (33.3%)	0 of 1 (0%)	1 of 4 (25.0%)	2 of 4 (50%)
Overall	**22 of 50 (44%)**	**8 of 16 (50%)**	**30 of 66 (45.4%)**	**2 of 2 (100%)**	**2 of 6 (33.3%)**	**0 of 1 (0%)**	**2 of 7 (28.6%)**	**6 of 10 (60%)**
Copper								
UCR[2]	26 of 56 (46.4%)	1 of 3 (33.3%)	27 of 59 (45.8%)	5 of 5 (100%)	2 of 6 (33.3%)	1 of 1 (100%)	3 of 7 (42.9%)	2 of 2 (100%)
Washington	0 of 2 (0%)	0 of 2 (0%)	0 of 4 (0%)	ND	3 of 8 (37.5%)	ND	3 of 8 (37.5%)	ND
Overall	**26 of 58 (44.8%)**	**1 of 5 (20%)**	**27 of 63 (42.9%)**	**5 of 5 (100%)**	**5 of 14 (35.7%)**	**1 of 1 (100%)**	**6 of 15 (40%)**	**2 of 2 (100%)**
Lead								
UCR[2]	29 of 61 (47.5%)	2 of 2 (100%)	31 of 63 (49.2%)	1 of 1 (100%)	5 of 9 (55.6%)	ND	5 of 9 (55.6%)	ND
Washington	0 of 3 (0%)	ND	0 of 3 (0%)	ND	2 of 7 (28.6%)	1 of 1 (100%)	3 of 8 (37.5%)	ND
Overall	**29 of 64 (45.3%)**	**2 of 2 (100%)**	**31 of 66 (47.0%)**	**1 of 1 (100%)**	**7 of 16 (43.8%)**	**1 of 1 (100%)**	**8 of 17 (47.1%)**	**ND**
Zinc								
UCR[2]	25 of 55 (45.5%)	ND	25 of 55 (45.5%)	7 of 9 (77.8%)	2 of 6 (33.3%)	1 of 1 (100%)	3 of 7 (42.9%)	2 of 2 (100%)
Washington	0 of 4 (0%)	ND	0 of 4 (0%)	ND	3 of 8 (37.5%)	ND	3 of 8 (37.5%)	ND
Overall	**25 of 59 (42.4%)**	**ND**	**25 of 59 (42.4%)**	**7 of 9 (77.8%)**	**5 of 14 (35.7%)**	**1 of 1 (100%)**	**6 of 15 (40%)**	**2 of 2 (100%)**
Total PAHs[3]								
UCR[2]	28 of 56 (50%)	ND	28 of 56 (50%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	3 of 8 (37.5%)	ND	3 of 8 (37.5%)	ND
Overall	**28 of 56 (50%)**	**ND**	**28 of 56 (50%)**	**ND**	**3 of 8 (37.5%)**	**ND**	**3 of 8 (37.5%)**	**ND**

Table 17. Evaluation of sediment cleanup objectives and sediment screening levels based on incidence of toxicity to *Chironomus dilutus* (endpoint: weight).

Substance / Region	Incidence of Toxicity based on *Chironomus dilutus* Growth (weight)[1]							
	10- to 12-day Toxicity Tests				20-day Toxicity Tests			
	≤ SCO	SCO - CSL	≤ CSL	> CSL	≤ SCO	SCO - CSL	≤ CSL	> CSL
Total PCBs								
UCR[2]	28 of 56 (50%)	ND	28 of 56 (50%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	1 of 5 (20%)	2 of 3 (66.7%)	3 of 8 (37.5%)	ND
Overall	**28 of 56 (50%)**	**ND**	**28 of 56 (50%)**	**ND**	**1 of 5 (20%)**	**2 of 3 (66.7%)**	**3 of 8 (37.5%)**	**ND**
Sum DDTs (*o, p'* + *p, p'*)								
UCR[2]	28 of 56 (50%)	ND	28 of 56 (50%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	1 of 3 (33.3%)	ND	1 of 3 (33.3%)	ND
Overall	**28 of 56 (50%)**	**ND**	**28 of 56 (50%)**	**ND**	**1 of 3 (33.3%)**	**ND**	**1 of 3 (33.3%)**	**ND**
Bis(2-ethylhexyl) phthalate								
UCR[2]	28 of 56 (50%)	ND	28 of 56 (50%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	3 of 8 (37.5%)	ND	3 of 8 (37.5%)	ND
Overall	**28 of 56 (50%)**	**ND**	**28 of 56 (50%)**	**ND**	**3 of 8 (37.5%)**	**ND**	**3 of 8 (37.5%)**	**ND**
Pentachlorophenol								
UCR[2]	28 of 56 (50%)	ND	28 of 56 (50%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	3 of 8 (37.5%)	ND	3 of 8 (37.5%)	ND
Overall	**28 of 56 (50%)**	**ND**	**28 of 56 (50%)**	**ND**	**3 of 8 (37.5%)**	**ND**	**3 of 8 (37.5%)**	**ND**

ND = no data; SCO = sediment cleanup objective; CSL = cleanup screening level; PAH = polycyclic aromatic hydrocarbon; PCB = polychlorinated biphenyl; DDT = dichlorodiphenyltrichloroethane
UCR = Upper Columbia River.

[1] Toxicity was desgnated using either the reference envelope approach or by statistical comparisons to negative control.

[2] Portion of the Columbia River between the international border and the Grand Coulee dam.

[3] Total PAHs were calculated as the sum of 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene.

Table 18. Evaluation of sediment cleanup objectives and sediment screening levels based on incidence of toxicity to *Chironomus dilutus* (endpoint: biomass).

Substance / Region	Incidence of Toxicity based on *Chironomus dilutus* Biomass[1]							
	10- to 12-d Toxicity Tests				20-d Toxicity Tests			
	≤ SCO	SCO - CSL	≤ CSL	> CSL	≤ SCO	SCO - CSL	≤ CSL	> CSL
Arsenic								
UCR[2]	43 of 61 (70.5%)	3 of 3 (100%)	46 of 64 (71.9%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	ND	ND	ND	ND
Overall	**43 of 61 (70.5%)**	**3 of 3 (100%)**	**46 of 64 (71.9%)**	**ND**	**ND**	**ND**	**ND**	**ND**
Cadmium								
UCR[2]	35 of 47 (74.5%)	9 of 15 (60%)	44 of 62 (80%)	2 of 2 (100%)	ND	ND	ND	ND
Washington	ND	ND	ND	ND	ND	ND	ND	ND
Overall	**35 of 47 (74.5%)**	**9 of 15 (60%)**	**44 of 62 (80%)**	**2 of 2 (100%)**	**ND**	**ND**	**ND**	**ND**
Copper								
UCR[2]	38 of 56 (67.9%)	3 of 3 (100%)	41 of 59 (69.5%)	5 of 5 (100%)	ND	ND	ND	ND
Washington	ND	ND	ND	ND	ND	ND	ND	ND
Overall	**38 of 56 (67.9%)**	**3 of 3 (100%)**	**41 of 59 (69.5%)**	**5 of 5 (100%)**	**ND**	**ND**	**ND**	**ND**
Lead								
UCR[2]	43 of 61 (70.5%)	2 of 2 (100%)	45 of 63 (71.4%)	1 of 1 (100%)	ND	ND	ND	ND
Washington	ND	ND	ND	ND	ND	ND	ND	ND
Overall	**43 of 61 (70.5%)**	**2 of 2 (100%)**	**45 of 63 (71.4%)**	**1 of 1 (100%)**	**ND**	**ND**	**ND**	**ND**
Zinc								
UCR[2]	37 of 55 (67.3%)	ND	37 of 55 (67.3%)	9 of 9 (100%)	ND	ND	ND	ND
Washington	ND	ND	ND	ND	ND	ND	ND	ND
Overall	**37 of 55 (67.3%)**	**ND**	**37 of 55 (67.3%)**	**9 of 9 (100%)**	**ND**	**ND**	**ND**	**ND**
Total PAHs[3]								
UCR[2]	42 of 56 (75%)	ND	42 of 56 (75%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	ND	ND	ND	ND
Overall	**42 of 56 (75%)**	**ND**	**42 of 56 (75%)**	**ND**	**ND**	**ND**	**ND**	**ND**

Table 18. Evaluation of sediment cleanup objectives and sediment screening levels based on incidence of toxicity to *Chironomus dilutus* (endpoint: biomass).

Substance / Region	Incidence of Toxicity based on *Chironomus dilutus* Biomass[1]							
	10- to 12-d Toxicity Tests				20-d Toxicity Tests			
	≤ SCO	SCO - CSL	≤ CSL	> CSL	≤ SCO	SCO - CSL	≤ CSL	> CSL
Total PCBs								
UCR[2]	42 of 56 (75%)	ND	42 of 56 (75%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	ND	ND	ND	ND
Overall	**42 of 56 (75%)**	**ND**	**42 of 56 (75%)**	**ND**	**ND**	**ND**	**ND**	**ND**
Sum DDTs (*o, p'* + *p, p'*)								
UCR[2]	42 of 56 (75%)	ND	42 of 56 (75%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	ND	ND	ND	ND
Overall	**42 of 56 (75%)**	**ND**	**42 of 56 (75%)**	**ND**	**ND**	**ND**	**ND**	**ND**
Bis(2-ethylhexyl) phthalate								
UCR[2]	42 of 56 (75%)	ND	42 of 56 (75%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	ND	ND	ND	ND
Overall	**42 of 56 (75%)**	**ND**	**42 of 56 (75%)**	**ND**	**ND**	**ND**	**ND**	**ND**
Pentachlorophenol								
UCR[2]	42 of 56 (75%)	ND	42 of 56 (75%)	ND	ND	ND	ND	ND
Washington	ND	ND	ND	ND	ND	ND	ND	ND
Overall	**42 of 56 (75%)**	**ND**	**42 of 56 (75%)**	**ND**	**ND**	**ND**	**ND**	**ND**

ND = no data; SCO = sediment cleanup objective; CSL = cleanup screening level; PAH = polycyclic aromatic hydrocarbon; PCB = polychlorinated biphenyl; DDT = dichlorodiphenyltrichloroethane
UCR = Upper Columbia River.

[1] Toxicity was desgnated using either the reference envelope approach or by statistical comparisons to negative control.

[2] Portion of the Columbia River between the international border and the Grand Coulee dam.

[3] Total PAHs were calculated as the sum of 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene.

Table 19. Evaluation of the sediment cleanup objectives and cleanup screening levels, based on incidence of toxicity to *Hyalella azteca* (endpoint: percent survival).

Substance / Region	Incidence of Toxicity based on *Hyalella azteca* Percent Survival[1]							
	7- to 14-day Toxicity Tests				28-day Toxicity Tests			
	≤ SCO	SQS - CSL	≤ CSL	> CSL	≤ SCO	SQS - CSL	≤ CSL	> CSL
Arsenic								
UCR[2]	9 of 17 (52.9%)	5 of 15 (33.3%)	14 of 32 (43.8%)	ND	28 of 61 (45.9%)	2 of 3 (66.7%)	30 of 64 (46.9%)	ND
Washington	10 of 46 (21.7%)	3 of 10 (30%)	13 of 56 (23.2%)	1 of 2 (50%)	6 of 8 (75%)	3 of 3 (100%)	9 of 11 (81.8%)	6 of 6 (100%)
Overall	**19 of 63 (30.2%)**	**8 of 25 (32%)**	**27 of 88 (30.7%)**	**1 of 2 (50%)**	**34 of 69 (49.3%)**	**5 of 6 (83.3%)**	**39 of 75 (52%)**	**6 of 6 (100%)**
Cadmium								
UCR[2]	7 of 10 (70%)	0 of 5 (0%)	7 of 15 (46.7%)	7 of 19 (36.8%)	22 of 47 (46.8%)	7 of 15 (46.7%)	29 of 62 (46.8%)	1 of 2 (50%)
Washington	11 of 43 (25.6%)	1 of 8 (12.5%)	12 of 51 (23.5%)	3 of 12 (25%)	3 of 4 (75%)	3 of 3 (100%)	6 of 7 (85.7%)	9 of 10 (90%)
Overall	**18 of 53 (34%)**	**1 of 13 (7.69%)**	**19 of 66 (28.9%)**	**10 of 31 (32.3%)**	**25 of 51 (49%)**	**10 of 18 (55.6%)**	**35 of 69 (50.7%)**	**10 of 12 (83.3%)**
Copper								
UCR[2]	8 of 25 (32%)	1 of 4 (25%)	9 of 29 (31%)	5 of 5 (100%)	24 of 56 (42.9%)	2 of 3 (66.7%)	26 of 59 (44.1%)	4 of 5 (80%)
Washington	14 of 60 (23.3%)	1 of 13 (7.69%)	15 of 73 (20.5%)	ND	10 of 12 (83.3%)	2 of 2 (100%)	12 of 14 (85.7%)	3 of 3 (100%)
Overall	**22 of 85 (25.9%)**	**2 of 17 (11.8%)**	**24 of 102 (23.5%)**	**5 of 5 (100%)**	**34 of 68 (50%)**	**4 of 5 (80%)**	**38 of 73 (52.1%)**	**7 of 8 (87.5%)**
Lead								
UCR[2]	14 of 29 (48.3%)	0 of 5 (0%)	14 of 34 (41.2%)	ND	27 of 61 (44.3%)	2 of 2 (100%)	29 of 63 (46%)	1 of 1 (100%)
Washington	13 of 59 (22%)	1 of 4 (25%)	14 of 63 (22.2%)	ND	9 of 11 (81.8%)	3 of 3 (100%)	12 of 14 (85.7%)	3 of 3 (100%)
Overall	**27 of 88 (30.7%)**	**1 of 9 (11.1%)**	**28 of 97 (28.9%)**	**ND**	**36 of 72 (50%)**	**5 of 5 (100%)**	**41 of 77 (53.2%)**	**4 of 4 (100%)**
Zinc								
UCR[2]	8 of 26 (30.8%)	1 of 2 (50%)	9 of 28 (32.1%)	5 of 6 (83.3%)	23 of 55 (41.8%)	ND	23 of 55 (41.8%)	7 of 9 (77.8%)
Washington	12 of 61 (19.7%)	ND	12 of 61 (19.7%)	3 of 3 (100%)	12 of 14 (85.7%)	ND	12 of 14 (85.7%)	3 of 3 (100%)
Overall	**20 of 87 (23%)**	**1 of 2 (50%)**	**21 of 89 (23.6%)**	**8 of 9 (88.9%)**	**35 of 69 (50.7%)**	**ND**	**35 of 69 (50.7%)**	**10 of 12 (83.3%)**
Total PAHs[3]								
UCR[2]	1 of 7 (14.3%)	ND	1 of 7 (14.3%)	ND	26 of 56 (46.4%)	ND	26 of 56 (46.4%)	ND
Washington	6 of 48 (12.5%)	0 of 1 (0%)	6 of 49 (12.2%)	3 of 4 (75%)	7 of 9 (77.8%)	1 of 1 (100%)	8 of 10 (80%)	6 of 6 (100%)
Overall	**7 of 55 (12.7%)**	**0 of 1 (0%)**	**7 of 56 (12.5%)**	**3 of 4 (75%)**	**33 of 65 (50.8%)**	**1 of 1 (100%)**	**34 of 66 (51.5%)**	**6 of 6 (100%)**

Table 19. Evaluation of the sediment cleanup objectives and cleanup screening levels, based on incidence of toxicity to *Hyalella azteca* (endpoint: percent survival).

Substance / Region	Incidence of Toxicity based on *Hyalella azteca* Percent Survival[1]							
	7- to 14-day Toxicity Tests				28-day Toxicity Tests			
	≤ SCO	SQS - CSL	≤ CSL	> CSL	≤ SCO	SQS - CSL	≤ CSL	> CSL
Total PCBs								
UCR[2]	ND	ND	ND	ND	26 of 56 (46.4%)	ND	26 of 56 (46.4%)	ND
Washington	0 of 15 (0%)	2 of 5 (40%)	2 of 20 (10%)	ND	4 of 5 (80%)	4 of 4 (100%)	8 of 9 (88.9%)	ND
Overall	**0 of 15 (0%)**	**2 of 5 (40%)**	**2 of 20 (10%)**	**ND**	**30 of 61 (49.2%)**	**4 of 4 (100%)**	**34 of 65 (52.3%)**	**ND**
Sum DDTs (*o, p′* + *p, p′*)								
UCR[2]	ND	ND	ND	ND	26 of 56 (46.4%)	ND	26 of 56 (46.4%)	ND
Washington	3 of 34 (8.82%)	0 of 1 (0%)	3 of 35 (8.6%)	ND	3 of 3 (100%)	ND	3 of 3 (100%)	ND
Overall	**3 of 34 (8.82%)**	**0 of 1 (0%)**	**3 of 35 (8.6%)**	**ND**	**29 of 59 (49.2%)**	**ND**	**29 of 59 (49.2%)**	**ND**
Bis(2-ethylhexyl) phthalate								
UCR[2]	0 of 1 (0%)	1 of 1 (100%)	1 of 2 (50%)	ND	26 of 56 (46.4%)	ND	26 of 56 (46.4%)	ND
Washington	0 of 16 (0%)	2 of 9 (22.2%)	2 of 25 (8%)	0 of 2 (0%)	7 of 8 (87.5%)	4 of 4 (100%)	11 of 12 (91.7%)	ND
Overall	**0 of 17 (0%)**	**3 of 10 (30%)**	**3 of 27 (11.1%)**	**0 of 2 (0%)**	**33 of 64 (51.6%)**	**4 of 4 (100%)**	**37 of 68 (54.4%)**	**ND**
Pentachlorophenol								
UCR[2]	1 of 3 (33.3%)	ND	1 of 3 (33.3%)	ND	26 of 56 (46.4%)	ND	26 of 56 (46.4%)	ND
Washington	0 of 15 (0%)	ND	0 of 15 (0%)	ND	7 of 8 (87.5%)	ND	7 of 8 (87.5%)	ND
Overall	**1 of 18 (5.56%)**	**ND**	**1 of 18 (5.56%)**	**ND**	**33 of 64 (51.6%)**	**ND**	**33 of 64 (51.6%)**	**ND**

ND = no data; SCO = sediment cleanup objective; CSL = cleanup screening level; PAH = polycyclic aromatic hydrocarbon; PCB = polychlorinated biphenyl; DDT = dichlorodiphenyltrichloroethane
UCR = Upper Columbia River.

[1] Toxicity was desgnated using either the reference envelope approach or by statistical comparisons to negative control.

[2] Portion of the Columbia River between the international border and the Grand Coulee dam.

[3] Total PAHs were calculated as the sum of 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene.

Table 20. Evaluation of the sediment cleanup objectives and cleanup screening levels, based on incidence of toxicity to *Hyalella azteca* (endpoint: weight).

Substance / Region	Incidence of Toxicity based on *Hyalella azteca* Growth (weight)[1]							
	7- to 14-day Toxicity Tests				28-day Toxicity Tests			
	≤ SCO	SCO - CSL	≤ CSL	> CSL	≤ SCO	SCO - CSL	≤ CSL	> CSL
Arsenic								
UCR[2]	ND	ND	ND	ND	8 of 61 (13.1%)	0 of 3 (0%)	8 of 64 (12.5%)	ND
Washington	ND	ND	ND	ND	6 of 7 (85.7%)	1 of 1 (100%)	7 of 8 (87.5%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**14 of 68 (20.6%)**	**1 of 4 (25%)**	**15 of 72 (20.8%)**	**ND**
Cadmium								
UCR[2]	ND	ND	ND	ND	6 of 47 (12.8%)	2 of 15 (13.3%)	8 of 62 (12.9%)	0 of 2 (0%)
Washington	ND	ND	ND	ND	3 of 3 (100%)	1 of 1 (100%)	4 of 4 (100%)	3 of 4 (75%)
Overall	**ND**	**ND**	**ND**	**ND**	**9 of 50 (18%)**	**3 of 16 (18.8%)**	**12 of 66 (18.2%)**	**3 of 6 (50%)**
Copper								
UCR[2]	ND	ND	ND	ND	5 of 56 (8.93%)	0 of 3 (0%)	5 of 59 (8.5%)	3 of 5 (60%)
Washington	ND	ND	ND	ND	7 of 8 (87.5%)	ND	7 of 8 (87.5%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**12 of 64 (18.8%)**	**0 of 3 (0%)**	**12 of 67 (17.9%)**	**3 of 5 (60%)**
Lead								
UCR[2]	ND	ND	ND	ND	8 of 61 (13.1%)	0 of 2 (0%)	8 of 63 (12.7%)	0 of 1 (0%)
Washington	ND	ND	ND	ND	6 of 7 (85.7%)	1 of 1 (100%)	7 of 8 (87.5%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**14 of 68 (20.6%)**	**1 of 3 (33.3%)**	**15 of 71 (21.1%)**	**0 of 1 (0%)**
Zinc								
UCR[2]	ND	ND	ND	ND	4 of 55 (7.27%)	ND	4 of 55 (7.27%)	4 of 9 (44.4%)
Washington	ND	ND	ND	ND	7 of 8 (87.5%)	ND	7 of 8 (87.5%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**11 of 63 (17.5%)**	**ND**	**11 of 63 (17.5%)**	**4 of 9 (44.4%)**
Total PAHs[3]								
UCR[2]	ND	ND	ND	ND	8 of 56 (14.3%)	ND	8 of 56 (14.3%)	ND
Washington	ND	ND	ND	ND	7 of 8 (87.5%)	ND	7 of 8 (87.5%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**15 of 64 (23.4%)**	**ND**	**15 of 64 (23.4%)**	**ND**

Table 20. Evaluation of the sediment cleanup objectives and cleanup screening levels, based on incidence of toxicity to *Hyalella azteca* (endpoint: weight).

Substance / Region	Incidence of Toxicity based on *Hyalella azteca* Growth (weight)[1]							
	7- to 14-day Toxicity Tests				28-day Toxicity Tests			
	≤ SCO	SCO - CSL	≤ CSL	> CSL	≤ SCO	SCO - CSL	≤ CSL	> CSL
Total PCBs								
UCR[2]	ND	ND	ND	ND	8 of 56 (14.3%)	ND	8 of 56 (14.3%)	ND
Washington	ND	ND	ND	ND	5 of 5 (100%)	2 of 3 (66.7%)	7 of 8 (87.5%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**13 of 61 (21.3%)**	**2 of 3 (66.7%)**	**15 of 64 (23.4%)**	**ND**
Sum DDTs (*o, p′* + *p, p′*)								
UCR[2]	ND	ND	ND	ND	8 of 56 (14.3%)	ND	8 of 56 (14.3%)	ND
Washington	ND	ND	ND	ND	3 of 3 (100%)	ND	3 of 3 (100%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**11 of 59 (18.6%)**	**ND**	**11 of 59 (18.6%)**	**ND**
Bis(2-ethylhexyl) phthalate								
UCR[2]	ND	ND	ND	ND	8 of 56 (14.3%)	ND	8 of 56 (14.3%)	ND
Washington	ND	ND	ND	ND	7 of 8 (87.5%)	ND	7 of 8 (87.5%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**15 of 64 (23.4%)**	**ND**	**15 of 64 (23.4%)**	**ND**
Pentachlorophenol								
UCR[2]	ND	ND	ND	ND	8 of 56 (14.3%)	ND	8 of 56 (14.3%)	ND
Washington	ND	ND	ND	ND	7 of 8 (87.5%)	ND	7 of 8 (87.5%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**15 of 64 (23.4%)**	**ND**	**15 of 64 (23.4%)**	**ND**

ND = no data; SCO = sediment cleanup objective; CSL = cleanup screening level; PAH = polycyclic aromatic hydrocarbon; PCB = polychlorinated biphenyl; DDT = dichlorodiphenyltrichloroethane
UCR = Upper Columbia River.

[1] Toxicity was desgnated using either the reference envelope approach or by statistical comparisons to negative control.

[2] Portion of the Columbia River between the international border and the Grand Coulee dam.

[3] Total PAHs were calculated as the sum of 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene.

Table 21. Evaluation of the sediment cleanup objectives and sediment screening levels, based on incidence of toxicity to *Hyalella azteca* (endpoint: biomass).

Substance / Region	Incidence of Toxicity based on *Hyalella azteca* Biomass[1]							
	7- to 14-day Toxicity Tests				28-day Toxicity Tests			
	≤ SCO	SCO - CSL	≤ CSL	> CSL	≤ SCO	SCO - CSL	≤ CSL	> CSL
Arsenic								
UCR[2]	ND	ND	ND	ND	15 of 61 (24.6%)	1 of 3 (33.3%)	16 of 64 (25%)	ND
Washington	ND	ND	ND	ND	7 of 7 (100%)	1 of 1 (100%)	8 of 8 (100%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**22 of 68 (32.4%)**	**2 of 4 (50%)**	**24 of 72 (33.3%)**	**ND**
Cadmium								
UCR[2]	ND	ND	ND	ND	10 of 47 (21.3%)	6 of 15 (40%)	16 of 62 (25.8%)	0 of 2 (0%)
Washington	ND	ND	ND	ND	3 of 3 (100%)	1 of 1 (100%)	4 of 4 (100%)	4 of 4 (100%)
Overall	**ND**	**ND**	**ND**	**ND**	**13 of 50 (26%)**	**7 of 16 (43.8%)**	**20 of 66 (30.3%)**	**4 of 6 (66.7%)**
Copper								
UCR[2]	ND	ND	ND	ND	11 of 56 (19.6%)	0 of 3 (0%)	11 of 59 (18.6%)	5 of 5 (100%)
Washington	ND	ND	ND	ND	8 of 8 (100%)	ND	8 of 8 (100%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**19 of 64 (29.7%)**	**0 of 3 (0%)**	**19 of 67 (28.4%)**	**5 of 5 (100%)**
Lead								
UCR[2]	ND	ND	ND	ND	15 of 61 (24.6%)	1 of 2 (50%)	16 of 63 (25.4%)	0 of 1 (0%)
Washington	ND	ND	ND	ND	7 of 7 (100%)	1 of 1 (100%)	8 of 8 (100%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**22 of 68 (32.4%)**	**2 of 3 (66.7%)**	**24 of 71 (33.8%)**	**0 of 1 (0%)**
Zinc								
UCR[2]	ND	ND	ND	ND	10 of 55 (18.2%)	ND	10 of 55 (18.2%)	6 of 9 (66.7%)
Washington	ND	ND	ND	ND	8 of 8 (100%)	ND	8 of 8 (100%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**18 of 63 (28.6%)**	**ND**	**18 of 63 (28.6%)**	**6 of 9 (66.7%)**
Total PAHs[3]								
UCR[2]	ND	ND	ND	ND	14 of 56 (25%)	ND	14 of 56 (25%)	ND
Washington	ND	ND	ND	ND	8 of 8 (100%)	ND	8 of 8 (100%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**22 of 64 (34.4%)**	**ND**	**22 of 64 (34.4%)**	**ND**

Table 21. Evaluation of the sediment cleanup objectives and sediment screening levels, based on incidence of toxicity to *Hyalella azteca* (endpoint: biomass).

Substance / Region	Incidence of Toxicity based on *Hyalella azteca* Biomass[1]							
	7- to 14-day Toxicity Tests				28-day Toxicity Tests			
	≤ SCO	SCO - CSL	≤ CSL	> CSL	≤ SCO	SCO - CSL	≤ CSL	> CSL
Total PCBs								
UCR[2]	ND	ND	ND	ND	14 of 56 (25%)	ND	14 of 56 (25%)	ND
Washington	ND	ND	ND	ND	5 of 5 (100%)	3 of 3 (100%)	8 of 8 (100%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**19 of 61 (31.1%)**	**3 of 3 (100%)**	**22 of 64 (34.4%)**	**ND**
Sum DDTs (*o, p′* + *p, p′*)								
UCR[2]	ND	ND	ND	ND	14 of 56 (25%)	ND	14 of 56 (25%)	ND
Washington	ND	ND	ND	ND	3 of 3 (100%)	ND	3 of 3 (100%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**17 of 59 (28.8%)**	**ND**	**17 of 59 (28.8%)**	**ND**
Bis(2-ethylhexyl) phthalate								
UCR[2]	ND	ND	ND	ND	14 of 56 (25%)	ND	14 of 56 (25%)	ND
Washington	ND	ND	ND	ND	8 of 8 (100%)	ND	8 of 8 (100%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**22 of 64 (34.4%)**	**ND**	**22 of 64 (34.4%)**	**ND**
Pentachlorophenol								
UCR[2]	ND	ND	ND	ND	14 of 56 (25%)	ND	14 of 56 (25%)	ND
Washington	ND	ND	ND	ND	8 of 8 (100%)	ND	8 of 8 (100%)	ND
Overall	**ND**	**ND**	**ND**	**ND**	**22 of 64 (34.4%)**	**ND**	**22 of 64 (34.4%)**	**ND**

ND = no data; SCO = sediment cleanup objective; CSL = cleanup screening level; PAH = polycyclic aromatic hydrocarbon; PCB = polychlorinated biphenyl; DDT = dichlorodiphenyltrichloroethane
UCR = Upper Columbia River.

[1] Toxicity was desgnated using either the reference envelope approach or by statistical comparisons to negative control.

[2] Portion of the Columbia River between the international border and the Grand Coulee dam.

[3] Total PAHs were calculated as the sum of 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene.

Figures

Figure 1. Comparison of methods for classifying sediments as toxic or not toxic based on a function of control response (i.e., use of incorrect control−normalization procedure results in a larger effect required to result in designation of a sediment samples as toxic).

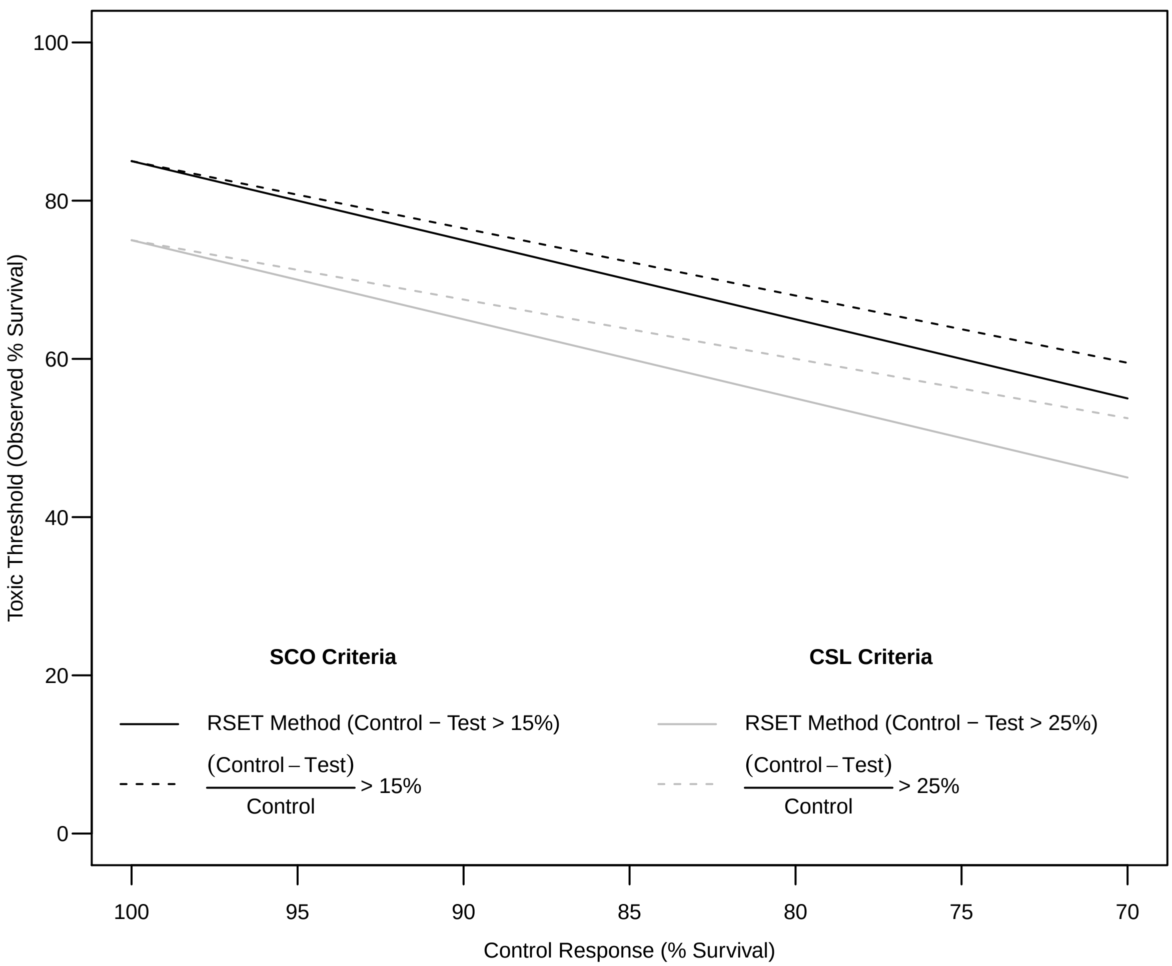
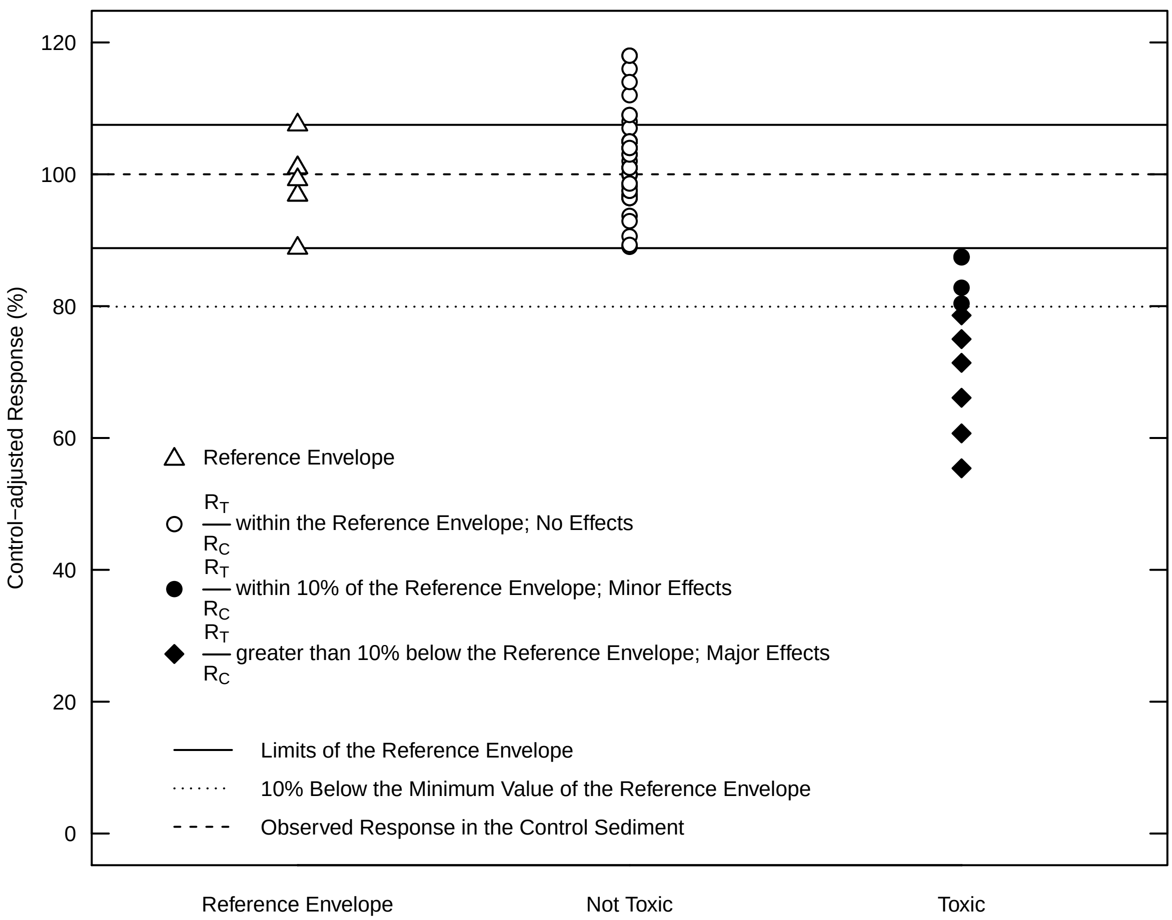


Figure 2. Designation of sediments as toxic or not toxic using the reference envelope approach.



R_T = Response in the test sediments; R_C = Response in the control sediments.

Figure 3. Relative endpoint sensitivity of *Chironomus dilutus* survival and biomass in sediments collected from the Upper Columbia River (dashed lines represent ± 20% difference from unity).

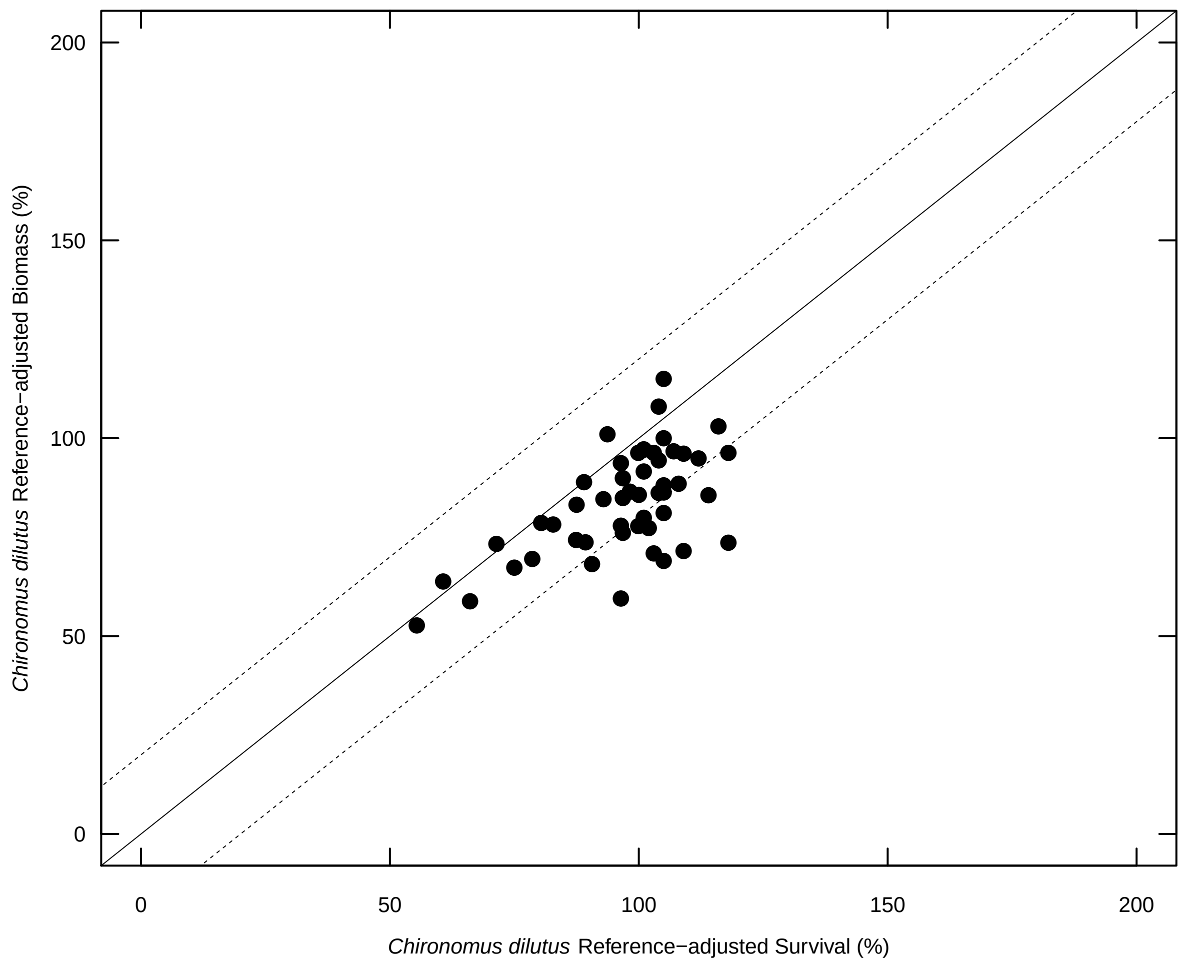


Figure 4. Relative endpoint sensitivity of *Hyalella azteca* survival and biomass in sediments collected from the Upper Columbia River (dashed lines represent ± 20% difference from unity).

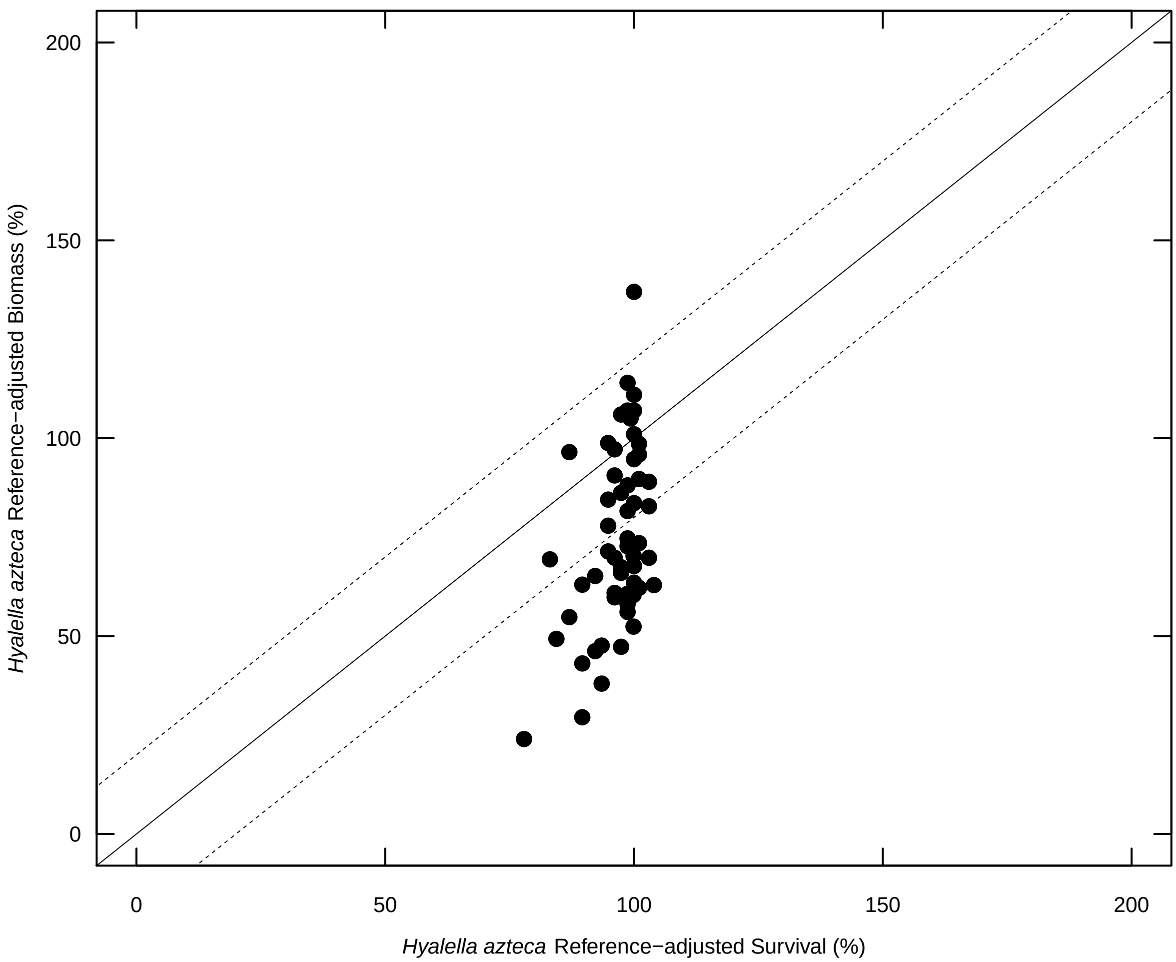


Figure 5. Concentration−response model for total polychlorinated biphenyls (PCBs; µg/kg DW) and *Hyalella azteca* reproduction (young per female normalized to percent survival) based on samples collected from the Anniston PCB site.

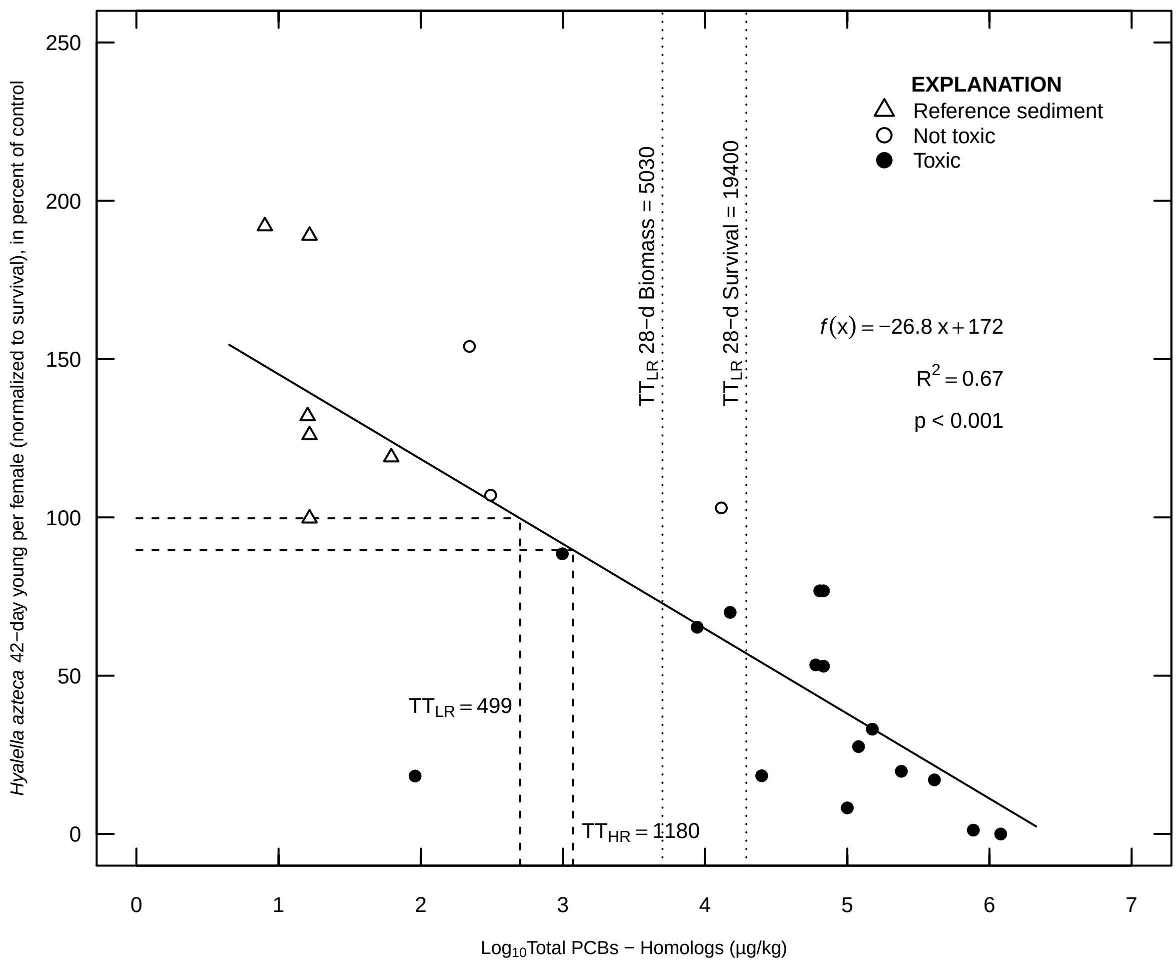


Figure 6. Comparison of Washington Department of Ecology recommended benthic SQVs (SQS, CSL) with consensus-based SQVs (TEC, PEC) for freshwater ecosystems.

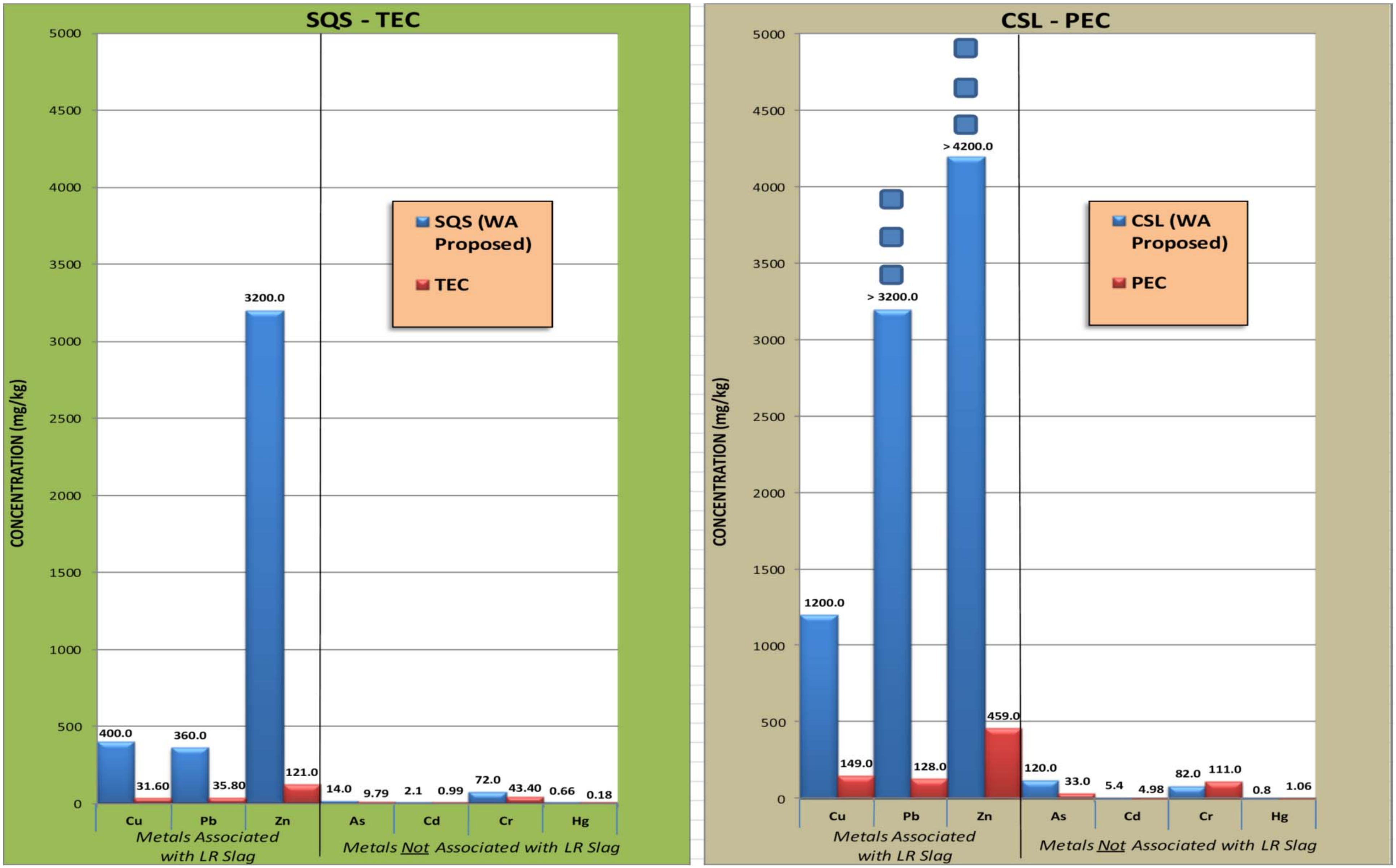


Figure 7. Comparison of false negative frequencies applying Floating Percentile method SQVs (SQS & CSL) and Apparent Effects Threshold (TEL & PEC) SQVs to Lake Roosevelt stations identified as toxic in MESL (2011) report.

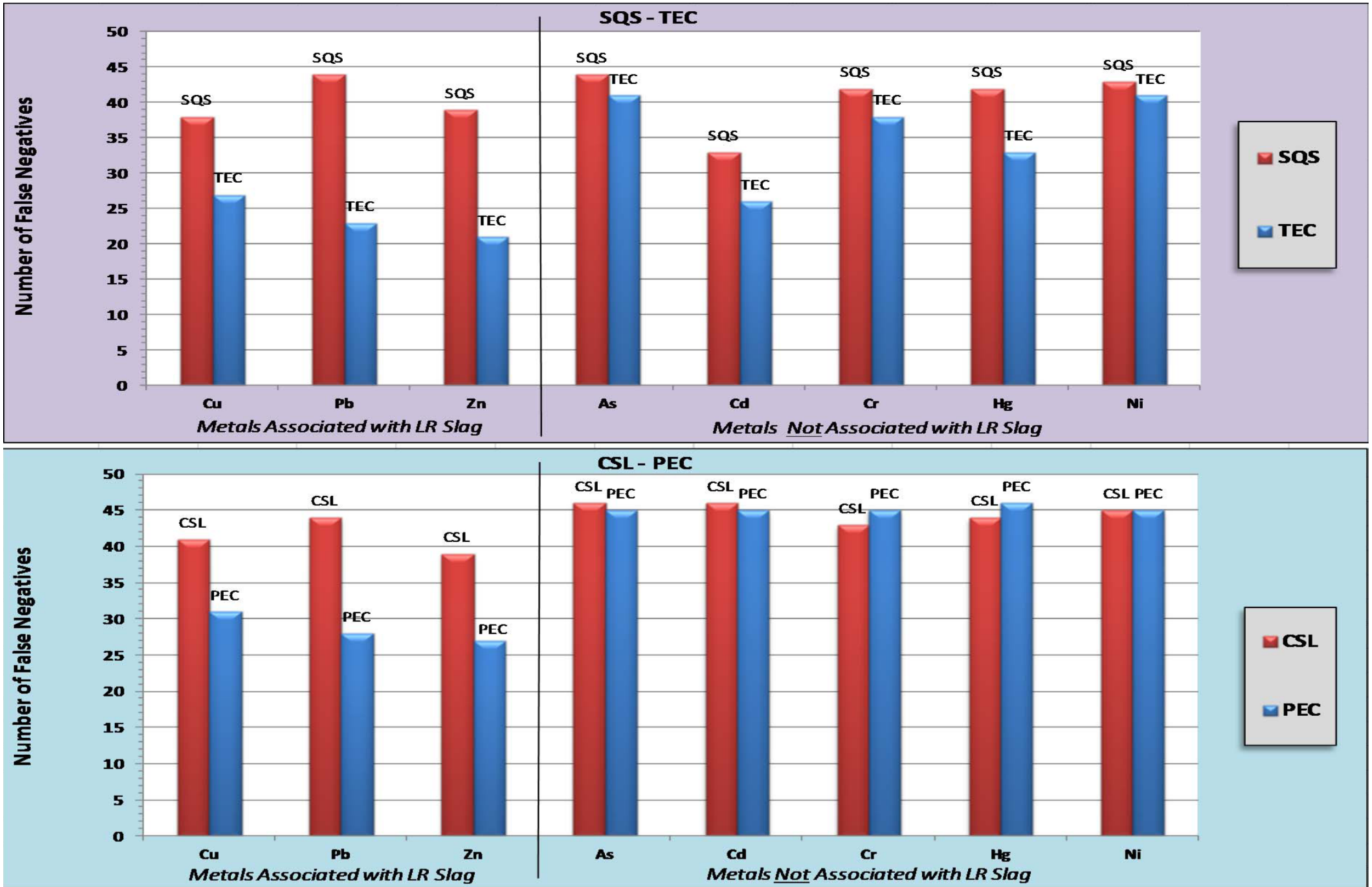


Figure 8. Map of the Upper Columbia River showing toxic and not toxic stations for toxicity of all species, inclusive of all endpoints.