Final Rule Implementation Plan
Chapter 173-201A WAC, Water Quality Standards for Surface Waters of the State of Washington

Salmon Spawning Habitat Protection Rule

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Final Implementation Plan

Chapter 173-201A WAC

Water Quality Standards for Surface Waters of the State of Washington

Water Quality Program

Washington State Department of Ecology

Olympia, Washington

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Purpose

The Washington State Department of Ecology (Ecology) provides the information in this implementation plan to meet agency and Administrative Procedure Act (RCW 34.05.328) requirements related to rule adoptions.

In addition, this document includes further detail on how the narrative fine sediment criteria will be implemented. Appendix A provides draft guidance that is intended to meet requirements of a 2018 U.S. District Court Stipulated Order of Dismissal between Northwest Environmental Advocates, EPA, and Ecology (NWEA vs. USEPA et al. 2018).[1] The stipulated order at 2.b. states: "Washington will propose a criterion for fine sediments to protect salmonid redds. Washington will issue a final rule no later than one year after its proposed rule. If the proposed rule is a narrative criterion, Washington will concurrently issue draft guidance regarding how it will interpret and apply its fine sediment criterion, including, but not limited to, its use in establishing Washington's CWA section 303(d) list and, no later than 18 months following issuance of the final rule, issue final guidance."

[1] NWEA v. USEPA and Northwest Pulp & Paper Association. Stipulated Order of Dismissal. No. C14-196-RSM. Filed 10/18/18.

Introduction

On March 22, 2022 Ecology adopted amendments to chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (AO # 19-05). The purpose of this rule implementation plan is to inform those who must comply with chapter 173-201A WAC about how Ecology intends to:

- Implement and enforce the rule.
- Inform and educate persons affected by the rule.
- Promote and assist voluntary compliance for the rule.
- Evaluate the rule.
- Train and inform Ecology staff about the new or amended rule.

Also included in this plan is information about:

- Supporting documents that may need to be written or revised because of the new rule or amended rule.
- Other resources where more information about the rule is available.
- Contact information for Ecology employees who can answer questions about the rule implementation.

Informing and Educating Persons Affected by the Rule

Rule development phase

During the rule development phase of this rulemaking, we reached out to interested parties through emails, water quality listservs, webpage updates, advisory group meetings, and public informational webinars.

Specifically, during this phase we:

- Held a public informational webinar in October 2020 to introduce the rulemaking for revising freshwater dissolved oxygen and developing new fine sediment criteria.
- Established a Science Advisory Group comprised of members of the public and Ecology with expertise in water quality, fish biology, and biogeochemistry. Between October 2020 and July 2021, held five meetings to discuss the scientific literature and implementation considerations to help inform the rulemaking.
- Held a public informational webinar in September 2021, at the culmination of the advisory group meetings, to provide preliminary rule decisions for feedback, and answer questions prior to starting the formal proposed rulemaking public review.
- Presented at several Northwest Indian Fisheries Commission tribal water quality meetings to provide updates to the rule development in 2020 and 2021.
- Presented at Water Quality Partnership meetings in 2020 and 2021 to provide updates to interested public and private stakeholders.

Rule proposal phase

During the rule proposal phase, we made the proposed rulemaking information available on Ecology's website, provided notification to interested public through email, and held online public hearings on December 8 and 9, 2021. During the public hearings, we presented the rulemaking information and took questions, after which we invited formal testimony on the proposed rule language and associated rule proposal documents. We considered and responded to all comments we received during the CR-102 phase.

Future Outreach

We intend to inform and educate persons affected by the adopted rule by:

- Providing continued opportunities to meet and discuss the implementation of the adopted rule with stakeholders.

- Providing continued opportunities for discussions and government-to-government consultation about the adopted rule with interested tribes.
- Educating Ecology staff on how best to implement the rule in their CWA action work.
- Finalizing guidance on implementing fine sediment criteria, which will build upon draft guidance in Appendix A of this document.

For more information on how we intend to train and inform Ecology staff, see the section "Training and Informing Ecology Staff."

Promoting and Assisting Voluntary Compliance

Entities that currently discharge to state waters will need to continue to meet water quality standards. The adopted changes in the dissolved oxygen (D.O.) criteria provide multiple compliance options to determine if water bodies are protected. The D.O. criteria has multiple elements based on water column D.O. levels, percent oxygen saturation, and intragravel D.O. concentrations that can be used to assess water body protection. This flexibility may assist entities in monitoring and assessing protection of aquatic life. Ecology will assist entities in providing assistance on new monitoring methods for D.O. as requested.

The narrative fine sediment criteria will require a multi-parameter approach to water quality, sediment, and habitat monitoring. In Appendix A, Ecology provides guidance on the methods most useful in evaluating fine sediment pollution. This guidance will help Ecology develop water quality, sediment, and habitat methodologies to determine attainment of the narrative sediment criteria. The guidance in Appendix A will help promote the data collection methods that can be used to better identify where local sources are contributing to impaired spawning habitat.

Evaluating the Rule

The purpose of the surface water quality standards is to restore and maintain the chemical, physical, and biological integrity of Washington's waters. More specifically, the water quality standards are designed to protect public health, public recreation in the water, and the propagation of fish, shellfish, and wildlife. The numeric and narrative criteria in the water quality standards are intended to protect those beneficial uses.

Ecology will consider if the adopted changes have achieved their purpose to protect the beneficial uses.

Objectively measurable outcomes

Outcomes of the rule can be measured if water quality standards are attained. Ecology monitors surface waters across the state to determine whether water quality conditions support the designated uses set in the standards. Monitoring data (meeting requirements of the Data Quality Act; RCW 90-48-570 to 90-48-590) will be used to determine whether designated uses are met.

The adopted D.O criteria, when attained, will demonstrate protection of salmon spawning habitat. The incorporation of D.O. saturation criteria will allow Ecology to better distinguish what pollutants (e.g., nutrients and temperature) are contributing to poor D.O. conditions. Updates to Ecology's Policy 1-11 assessment methodology will include a pathway for separating out exceedances of the new criteria due to excess nutrients or other environmental factors and developing 303(d) listings based on the appropriate pollutant. Identifying the specific pollutant source through the assessment process, rather than the Total Maximum Daily Load (TMDL) process following the assessment, will allow for a more streamlined and cost-effective approach to prioritizing and implementing water quality clean-up.

For the narrative fine sediment criteria, methodologies set in the [Ecology Water Quality Program Policy 1-11 Chapter 1: Washington's Water Quality Assessment Listing Methodology][2] will help to objectively determine waterbody compliance by evaluating water quality, sediment, and habitat data. Ecology currently has protocols available for many of these measures that may be evaluated for potential fine sediment impacts. Forthcoming policy updates will focus on the level of information needed to objectively determine compliance with the adopted criteria. More specifically, Ecology will identify the relevant parameters, the quantity and quality of acceptable data needed, appropriate monitoring protocols, and a statistically-based pathway for determining compliance or impairment. We expect that developing a weight-of-evidence based approach including multiple water quality, sediment, and habitat parameters will result in a holistic methodology that will be protective of aquatic life uses.

[2] https://apps.ecology.wa.gov/publications/documents/1810035.pdf

Implementation and Enforcement

Implementing New Oxygen Saturation Criteria

The addition of an oxygen saturation criterion to the freshwater D.O. criteria is intended to account for environmental factors that preclude meeting concentration based D.O. criteria. When the concentration based D.O. criteria is not met in the water column but the saturation based D.O. criteria is met, it is inferred that temperature, altitude, barometric pressure, or other environmental factors may be limiting the ability of oxygen to dissolve in water. The oxygen saturation criteria adopted in this rule is commensurate with full protection of aquatic life uses and may be most applicable during summer months at higher water temperatures, sites located at higher altitudes, sites limited naturally by groundwater, or during changes in atmospheric conditions that impact barometric pressure readings.

Overview of Implementing Narrative Fine Sediment Criteria

The narrative fine sediment criteria requires the development of a guidance to characterize fine sediment conditions and interpret the narrative criteria. Appendix A contains draft guidance and approaches that serve as the basis for development of an impairment listing methodology. In addition to the guidance on the implementation of the narrative fine sediment criteria herein, the permit writer's[3] manual has some existing guidance on sediment monitoring for permits. We plan to provide additional information in a separate guidance document that will be finalized within 18 months of rule adoption. Future guidance will provide more information on how the final adopted narrative criteria would get used in future NPDES permits and TMDL development. Here, we present draft guidance and considerations for implementing the fine sediment narrative criteria.

We anticipate that the majority of water bodies listed as impaired for fine sediment will be attributed to nonpoint sources of pollution. To address nonpoint sources of fine sediment and develop load allocations for TMDLs, applicable best management practices (BMPs) that are effective at reducing inputs of sediment, maintaining bank stability, and limiting in-water activities will be essential for controlling sources of nonpoint fine sediment pollution. Nonpoint pollution sources will be addressed by the nonpoint program when the pollution sources are identified. Selection of appropriate BMPs will be made on a site-specific or land use basis and will be dependent on the actions contributing to fine sediment pollution. Other nonpoint related legislative actions and subsequent rule changes that impact long-term sediment input into water bodies, such as riparian buffers and rules that govern logging practices, should contribute to improvements in sediment quality in streams over time and will be key in providing additional tools to address excess fine sediment from human-derived sources that impair designated uses.

[3] https://apps.ecology.wa.gov/publications/documents/92109.pdf

Some water bodies that are listed as impaired may have point sources of fine sediment pollution. The primary method to limit point sources is to regulate discharges via permits. Currently, fine sediment discharges are regulated in permits by administering total suspended solid (TSS) and turbidity effluent limits. Limiting inorganic and organic materials in suspension is likely the best method to restrict point sources that are contributing to a fine sediment impairment in a receiving water body. We anticipate that if a discharger is releasing materials to a water body impaired for fine sediment, then that discharger will need to implement additional removal technology or best management practices to reduce or eliminate discharge of such materials contributing to an impairment. One method to reduce fine sediment input into receiving water bodies is to administer more stringent effluent limits associated with discharge of materials. This action may be implemented by ratcheting down TSS effluent limits. Another approach may be to develop new effluent limits for suspended solids concentrations (SSC). SSC has a stronger correlation to streambed conditions than TSS and is more specific to solid-phase particles than turbidity (Gray et al. 2000). SSC is an optional parameter that can be used to evaluate fine sediment conditions in a receiving water body and is better suited for evaluating particle sizes of >2 mm. Site-specific relationships between SSC and TSS could be developed for a receiving water body and used to develop more stringent TSS limits.

Effectiveness monitoring of a water body impaired for fine sediment will be a measure of success for implementation of nonpoint and point sources controls of fine sediment into the water body. Improvements in fine sediment conditions as determined by parameters (e.g., percent surface substrate, relative bed stability, fine sediment biotic index, suspended solids concentrations, intragravel D.O. levels, and percent subsurface fines) identified to be representative of fine sediment conditions will be a measure of success for implementing controls on point and nonpoint sources of fine sediment.

Implementing changes to permits

Dissolved Oxygen

The majority of permittees do not directly monitor D.O. in their permits. A select number of facilities have biochemical oxygen demand limits and dilution factors to ensure compliance with the D.O. water quality criteria. The Columbia River has a site-specific criterion of 90% oxygen saturation. Some facilities that discharge to the Columbia River already have a 90% oxygen saturation requirement in their permits. Overall, the adopted changes to D.O. criteria should not affect facilities permit limits unless the receiving waterbody is impaired for D.O. The addition of an oxygen saturation criterion to the D.O. criteria may result in requiring the permittee to monitor oxygen saturation to ensure compliance with future TMDL requirements or to address discharges that have a reasonable potential to cause or contribute to an exceedance of the oxygen saturation criterion.

Fine Sediment

Many facilities are currently required to monitor TSS in their permit. We do not anticipate that narrative fine sediment criteria will affect changes to requirements of TSS in permits. If a TMDL is developed in a receiving water, facilities may be required to monitor discharges for fine sediment based parameters. For example, SSC is one of the parameters used to determine a fine sediment based waterbody impairment and may be translated to TSS using site-specific data. If a relationship between SSC and TSS can be established, then more restrictive TSS permit limits could be implemented based on data collected from receiving waters where fine sediment from human sources is causing or contributing to impairment of designated uses. Determining a waterbody impairment will be established through the Water Quality Assessment Policy 1-11[4].

Implementing changes to TMDLs

D.O. TMDLs

Existing D.O. TMDLs that are approved by EPA are not anticipated to change as a result of this rulemaking. This rulemaking provides additional tools to evaluate D.O. in waterbodies. Besides a minimum D.O. level, the addition of oxygen saturation and intragravel D.O. criteria allow additional data to be collected that can be used to determine aquatic life protection and to conduct TMDL effectiveness monitoring. The adopted criteria could result in additional monitoring and new methods to evaluate oxygen levels in waterbodies.

The addition of an oxygen saturation component to the D.O. criteria addresses the relationship between D.O. levels and water temperature. Higher water temperatures are less capable of maintaining D.O. levels in the water. We currently do not account for D.O. limitations influenced by water temperature in the water quality standards. The addition of an oxygen saturation component to the criteria accounts for temperature-related effects on D.O., which allows us to determine if temperature is driving the D.O. level. If high water temperature is causing low D.O. levels, it would not be considered an exceedance since the oxygen saturation represents what the water has the ability to hold.

Furthermore, oxygen saturation addresses the need to account for the influence of altitude on the capacity of oxygen to dissolve in water. The capacity of oxygen to dissolve in water is limited as altitude increases. The development of effluent limits and remedial activities should consider environmental factors that preclude attainment of concentration-based D.O. criteria.

Current waterbodies identified through the Water Quality Assessment process as impaired for D.O. may be a result of nutrient- or temperature-related D.O. reductions. The oxygen saturation component will allow the focus of a TMDL to shift towards addressing temperature issues to resolve D.O. limitations, where needed. The addition of an oxygen saturation component to the

[4] https://apps.ecology.wa.gov/publications/documents/1810035.pdf

D.O. criteria allows for a more accurate list of D.O. impairments for nutrients rather than temperature.

Fine Sediment TMDLs

Existing sediment TMDLs are not anticipated to change as a part of this rulemaking. The parameters used to characterize fine sediment may result in additional monitoring and new methods in evaluating sediment and in effectiveness monitoring.

Implementing the new criteria in the Water Quality Assessment (303d/305b Integrated Report)

Dissolved Oxygen

The addition of new parameters to the D.O. criteria will likely require Ecology to refine the D.O. impairment listing methodology found in Water Quality Program Policy 1-11, Chapter 1: Washington's Water Quality Assessment Listing Methodology to Meet Clean Water Act Requirements[5]. Currently, the water quality standards for D.O. only provide water column-based criteria. With this rulemaking, Ecology seeks to add oxygen saturation and intragravel D.O. criteria. To calculate the oxygen saturation of the water, data on atmospheric pressure[6] and water temperature will be required. The impairment listing methodology will need to include new methodologies for determining impairments using these additional measurements.

Fine Sediment

The addition of narrative fine sediment criteria will require finalizing a methodology to evaluate when the fine sediment standard is met. Appendix A provides draft guidance with sampling recommendations and approaches for making a water body impairment determination for the fine sediment criteria. The listing methodology for assessing a fine sediment-based impairment will be developed by the water quality program through a public process and will result in a revision to Water Quality Program Policy 1-11.

The adopted rule for fine sediment criteria meets a requirement of a stipulated order of dismissal of past litigation against EPA. The subsequent settlement agreement requires that Ecology complete final guidance regarding interpretation of the narrative fine sediment criteria within 18 months of this rule adoption.

[5] https://apps.ecology.wa.gov/publications/SummaryPages/1810035.html
[6] To facilitate the use of historic data, the Water Quality Assessment policy update process will explore the option of using site elevation standardized to 1 atmosphere at sea level as a surrogate for atmospheric pressure at the time of sampling.

Implementing new criteria in Ecology's Nonpoint Program

Dissolved Oxygen

Chapter 90.48 RCW serves as the regulatory authority for the nonpoint program to prevent and eliminate pollution and, if needed, take actions to minimize pollution. This rule is in alignment with chapter 90.48 RCW and does not change our implementation of this law. The adoption of oxygen saturation and intragravel D.O. criteria provides additional tools to characterize D.O. and nutrient-related impairments. If a nonpoint source is discharged or has the high likelihood to pollute a waterbody or impact a downstream beneficial use, then best management practices need to be implemented.

Fine Sediment

This rule is in alignment with chapter 90.48 RCW and does not change our implementation of this law. This rulemaking may provide clarification on specific parameters that can be used to address fine sediment pollution for the nonpoint pollution control program. A review of the available best management practices should be completed to identify best approaches to limit fine sediment pollution.

Intragravel Dissolved Oxygen Sampling

The addition of intragravel criteria to the D.O. criteria requires additional guidance on sampling. Intragravel D.O. can vary based on where the measurement is taken and depends on site-specific and stream characteristics. The intragravel D.O. criteria is aimed at protecting early life stages of salmonids, and thus, sampling locations should target riffles and spawning areas in streams, to the degree possible. Intragravel D.O. measurements should be calculated as a spatial median value within the same habitat area.

A median spatial value is the middle value of multiple ranked intragravel D.O. measurements taken within a sampling area. The spatial median value is aimed at determining a representative value for an aquatic habitat area. The measurements within a given habitat sampling area are sorted in ascending or descending order, and the middle value is representative of the spatial median. The samples collected within a given sampling area should be spatially representative of the sampling area. A minimum of three samples are required to calculate a median spatial value within a specified habitat area (maximum distance of 200 feet between samples), but more may be required depending on the objectives of the study. When an even number of samples are collected, the middle two values are averaged.

Training and Informing Ecology Staff

A rulemaking requires broad outreach to Ecology staff and management involved with implementing water quality regulations. After this rule is adopted, Ecology will notify all Ecology staff who use the criteria or tools. This will be achieved through outreach meetings with the Permit Writer's Work group and regional permitting staff, email communication to a specific group of permit writers or individual permit writers as requested, providing additional written guidance into the permit Writer's Manual as requested or where specific issues need to be addressed, and one-to-one communication. EPA is required to review and approve new rule language before they can be used for Clean Water Act (CWA) purposes. Ecology will notify all Ecology staff after EPA has taken an approval action on its CWA review of the adopted standards. Training on implementation of the revised water quality standards will be provided to Ecology staff upon request.

Below are examples of staff resources to address training and information sharing related to the adopted rule:

National Pollutant Discharge Elimination System permits

The Water Quality Program will provide training for the Ecology permit writers on changes to the rule and associated changes to the Water Quality Program Permit Writer's Manual (Publication 18-10-042, 15 January 2019). The Permit Writer's Manual will be evaluated to determine if updates are needed to implement the adopted rule. Permit writing tools, templates, and forms will be updated to account for provisions in the new rule, and permit writers will be notified of changes. Typically, changes to the Permit Writer's Manual must get approval from the Water Quality Program management team represented by both regional and headquarters managers. Thus, the permit writing staff will also receive reinforcement from their managers regarding use of the new guidance. The Water Quality Program has a Permit Writer's Workgroup that is made up of permit writers who meet quarterly to discuss emerging permit issues and facilitate communication throughout the regions and across other programs. The workgroup provides ongoing support for implementing the water quality standards in permits. Training permit writers will help inform permittees on how to comply with new requirements.

Water Quality Assessment

The Water Quality Assessment Policy 1-11 update process will help staff identify new and revised methodologies needed to assess Washington waters for compliance with the approved freshwater D.O. and fine sediment criteria.

Total maximum daily loads (TMDL)

Regional TMDL staff will continue to be informed of changes to the standards through TMDL quarterly meetings, workshops, and ongoing interactions. TMDL staff participated in the development of the rule changes, and we will continue to work with staff to get the adopted criteria changes integrated into the TMDL program. The better identification of sediment impaired waters through forthcoming methodologies in the Water Quality Assessment will help prioritize these waters for appropriate cleanup measures. Revised D.O. criteria designed to help distinguish between contributing pollutants will help TMDL analysis planning.

Nonpoint programs

Water quality standards staff are regularly included in nonpoint program staff meetings. Standards staff have discussed this rule and its influence on nonpoint programs and will continue to discuss implementation issues. Additional training on implementation of the revised water quality standards will be provided to Ecology staff upon request.

List of Supporting Documents that May Need to be Written or Revised

We may write or revise the following because of the adopted rule:

- Freshwater monitoring program protocols
- Water Quality Program Policy 1-11, Chapter 1
- Permit Writer's Manual
- Finalizing guidance on interpreting and implementing the new fine sediment criteria, using information from Appendix A.

More Information

Rulemaking Website: WAC173-201A-Salmon spawning habitat - Washington State Department of Ecology[7]

[7] https://ecology.wa.gov/Regulations-Permits/Laws-rules-rulemaking/Rulemaking/WAC173-201A-Salmon-spawning-habitat

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Appendix A. DRAFT Implementation of the Narrative Criteria for Fine Sediment

Background

In February 2014, Northwest Environmental Advocates (NWEA) filed a lawsuit[8] against the U.S. Environmental Protection Agency (EPA), asserting that certain EPA decisions regarding the State of Washington's submissions of specific changes to its water quality standards were inconsistent with federal water quality standards regulations and the Clean Water Act. In March 2015, the Washington State Department of Ecology (Ecology) intervened in this action. NWEA, EPA, and Ecology agreed to a U.S. District Court Stipulated Order of Dismissal on October 18, 2018.

This rulemaking addresses one of those agreed actions, which states under 2.b. of the stipulated order: "Washington will propose a criterion for fine sediments to protect salmonid redds. Washington will issue a final rule no later than one year after its proposed rule. If the proposed rule is a narrative criterion, Washington will concurrently issue draft guidance regarding how it will interpret and apply its fine sediment criterion, including, but not limited to, its use in establishing Washington's CWA section 303(d) list and, no later than 18 months following issuance of the final rule, issue final guidance."

During the rulemaking development process, Ecology determined that a narrative fine sediment criteria would be most appropriate for the state of Washington. Following the agreement in the stipulated order, as part of the rulemaking Ecology concurrently issued draft guidance regarding how it will interpret and apply its narrative fine sediment criteria. Thus, as part of the CR-102 rule proposal, Ecology provided to the public a preliminary Rule Implementation Plan that included an appendix with draft guidance on implementing the narrative criteria for fine sediment. Public comments were received on the preliminary Rule Implementation Plan, including Appendix A.

The Rule Implementation Plan, including Appendix A, represents draft guidance to meet the stipulated order. Following adoption of the rule, Ecology will have final guidance in place by September 2023.

Introduction

Purpose of this guidance

This guidance document provides sampling recommendations and approaches for making a determination of an exceedance of fine sediment criteria. The sampling recommendations are

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[8] NWEA v. USEPA and Northwest Pulp & Paper Association. Stipulated Order of Dismissal. No. C14-196-RSM. Filed 10/18/18.

taken from existing methods in Ecology's Watershed Health Monitoring (WHM) program, standardized protocols, or scientific literature.

Exploring multiple methods

We are exploring multiple methods to assess fine sediment and the impacts of fine sediment to provide flexibility in evaluating the aquatic life and substrates of each unique waterbody. The sediment composition of waterbodies can vary significantly depending on the landscape, geology, and watershed. For example, the assessment of a glacial fed stream will typically be different from a low gradient stream surrounded by grasslands.

Including draft screening levels for methods

Upon review of literature and work that other states are doing, we have developed screening level thresholds that can be used to evaluate if fine sediment is a pollutant of concern in a waterbody and if further analysis is needed. The screening level assessment alone will not be used as the sole method to determine that a waterbody is impaired or not impaired. If a given waterbody does not exceed screening thresholds, but there is reasonable potential that human derived sources of fine sediment are negatively affecting stream health, further analysis should occur through other assessment tools. An exceedance of screening levels is an indication that there may be a concern in the waterbody. This should be followed by a waterbody specific analysis of natural occurring sediment, anthropogenic inputs of sediments, and an analysis of the viability of successful salmonid spawning and rearing. The use of a reference site or an ecoregional reference value for the selected fine sediment based parameters coupled with a weight of evidence approach is one method that will be used in making a determination on the sediment quality of a waterbody.

Some methods rely on reference site information

The reference value approach compares fine sediment parameters between the waterbody of interest and a reference site or ecoregional reference value based on water bodies considered minimally impacted by human derived sources of fine sediment. The reference site or derived reference value should occur in the same watershed or ecoregion and possess many of the same waterbody characteristics (e.g., hydrography, geology, ecology, and habitat) of the waterbody of interest. A statistical comparison of fine sediment parameters between a site of interest and a reference water body or ecoregional reference value should be used to make a determination of significance. If the site of interest is significantly different for fine sediment based parameters compared to reference sites or ecoregional values, then the weight of evidence approach should be used to make an impairment determination.

Supporting a final methodology through a weight of evidence approach

A weight of evidence approach uses fine sediment parameters that have been identified to be most useful in evaluating sediment and habitat quality for aquatic life. This approach evaluates whether there is reasonable potential that a waterbody is impaired due to excess fine sediment from human-derived sources. The weight of evidence approach uses levels of confidence to determine if a water is of concern or if a waterbody is impaired for fine sediment.

Summary of Parameters Used to Characterize Fine Sediment

A summary of the parameters used to characterize fine sediment can be found in Table A-1. Parameters selected are grouped as measures from the water column, streambed, water chemistry, and biomonitoring. The measures include suspended solids, percent substrate (visual), subsurface fines (quantitative), relative bed stability, intragravel D.O. depression, and the fine sediment biotic index (FSBI).

The parameters selected to characterize fine sediment have been identified as primary or optional. Primary parameters are considered the parameters of highest priority and importance to making a fine sediment determination. Optional parameters provide key supplemental information that can be used in the weight of evidence approach when determining a fine sediment exceedance.

Table A-1. Summary of parameters used to characterize fine sediment.

Environmental Compartment	Measure	Primary or Optional
Water Column	Suspended Solids	Optional
Streambed	Percent Substrate	Primary
Streambed	Subsurface Fines	Optional
Streambed	Relative Bed Stability	Primary
Chemical	Intragravel Dissolved Oxygen Depression	Optional
Biological	Fine Sediment Biotic Index	Primary

Sampling Recommendations

Sampling Overview

We recommend that water quality sampling for fine sediment follow existing methods established by the WHM program for biological monitoring (Adams, 2010). The WHM is primarily focused on wadeable or “narrow” streams and is based on work by EPA (Kaufmann and Robison, 1998). The WHM program has developed stream monitoring protocols for non-wadeable or "wide" streams as well (Wide and Narrow Protocols[9]). EPA guidance for sampling non-wadeable streams is also available (Kaufmann, 2000). The recommended methods use a randomized, systematic spatial sampling design to minimize bias in the placement and positioning of measurements. Measures are taken over defined channel areas, and sampling locations are systematically spaced proportional to channel width. For purposes of fine sediment analyses, a focus on specific waterbody segments may be more appropriate than randomized systematic sampling. Updated sampling protocols have been provided by EPA (US EPA, 2009).

The WHM is aimed at monitoring streams that are perennial and are representative of each of the 5 Strahler-order based size classes. In the WHM program approach, each reach is divided into 11 transects of equal distance per reach (Figure A-1). Since 2009, Ecology's methods for sampling the stream invertebrate community are consistent between its two routine monitoring programs (see SOP EAP073[10]). Both methods randomly select 8 of the 11 habitat transects from across the reach for a reach-wide composite.

Prior to 2009, and prior to WHM's habitat-based routine monitoring, Ecology's Ambient Bioassessment program used a targeted riffle approach, in which all aliquots were collected from riffles. Ecology abandoned this method to improve descriptions for reach-wide biological conditions, the scale upon which WHM habitat metrics are based. Rehn et al. (2007) stated, "Raw data sets and biological indicators derived from targeted riffle and reach wide samples may be generally interchangeable when used in ambient biomonitoring programs." However, many researchers have found that consistently identifying habitat types is difficult because they change with flow. Targeting riffles can introduce sampling error (Poole et al., 1997). For these reasons, investigators use a reach-wide sampling scheme (Hayslip, 2007), as opposed to a targeted "riffle only" sampling scheme (Rehn et al. 2007). In a reach-wide scheme, 11 equidistant transects are established along the stream reach (between 150 m and 2 km in length), and sampling is conducted systematically without consideration for habitat type. A reach-wide assessment of biological indicators and physical measurements provides more data for an assessment of average or baseline conditions to characterize a stream, including sediment conditions and aquatic life. For those reasons, we support the existing protocols used in Ecology's WHM program and their applicability to a fine sediment assessment.

While reach-wide sampling is a useful scheme for long-term monitoring projects, special requests for monitoring may require targeted sampling. Noise in signals of impairment is introduced when habitat-wide data are included in a targeted study (Parsons and Norris, 1996). Data collected from habitat specific samples help reduce noise and allow clear and consistent detection of response to pollutants at an impacted site. For example, the use of riffle habitats for targeted studies such as TMDLs capture the composition of more pollution-sensitive communities. Recently, studies have shown that there is no statistical difference between

[9] https://apps.ecology.wa.gov/publications/UIPages/PublicationList.aspx?IndexTypeName=Topic&NameValue=Standard+Operating+Procedure+(SOP)+%e2%80%94+Watershed+Health+Monitoring&DocumentTypeName=Publication

[10] https://apps.ecology.wa.gov/publications/SummaryPages/1803202.html

samples collected from riffles only and those collected from reach-wide designs (Kerans et al. 1992; Rehn et al. 2007). Therefore, historical Washington State data collected in riffles only are useful for describing past and current stream health in streams currently monitored using habitat-wide methods.

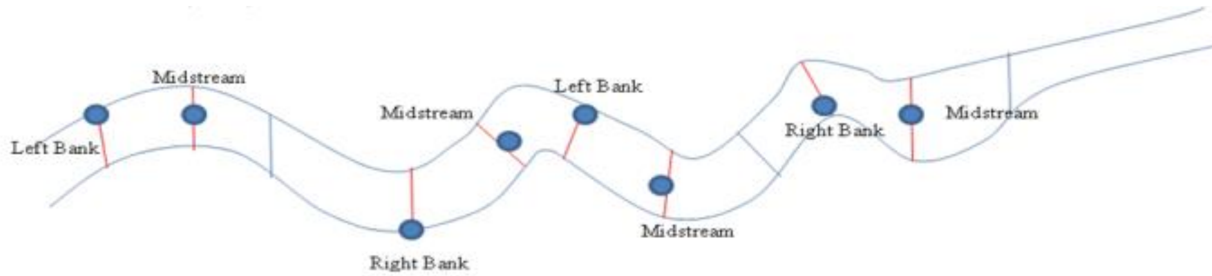

Figure A-1. Reach-wide composite samples from 8 of 11 transects.

Sampling must occur between July 1 and October 15 of each year following WHM program guidelines. This timeframe was chosen for the following reasons:

- Adequate time has passed for the instream environment to stabilize following natural disturbances (such as spring floods).
- Many macroinvertebrates reach body sizes that can be readily identified.
- Representation of benthic macroinvertebrate species reaches a maximum, particularly during periods of pre-emergence, typically from mid-spring to late summer.

This time window is largely consistent with "fish windows" for most streams during which early life stages of salmonids are not present. Therefore, we recommend harmonizing fine sediment analyses with the WHM sampling timeframe.

Human Disturbance Evaluation

Sources of suspended sediment can result from:

- Exposed soil (plowing, livestock grazing, devegetated banks, logging roads and trails, construction, road maintenance, landslides, burned forests, erosional rills and gullies, stored soil or waste).
- In-stream processes (gravel mining, vehicle or boat traffic, dredging and trawling, breached impoundments, incised channels, channel modification, eroding stream banks, shallow root systems, fish activity).
- Altered flows (impoundments, upstream scoured streambeds, impervious surfaces, lack of connectivity with floodplain).

EPA developed a simple conceptual model for impacts of sediment inputs on waterbodies (Figure A-2). Generally, examination of the riparian habitat, riverbanks, and nearby surrounding area will provide information regarding sources of fine sediment. Other useful methods may include any available watershed information, an evaluation of natural features in the stream and headwaters, and GIS analyses of landscape level changes and watershed erosion.

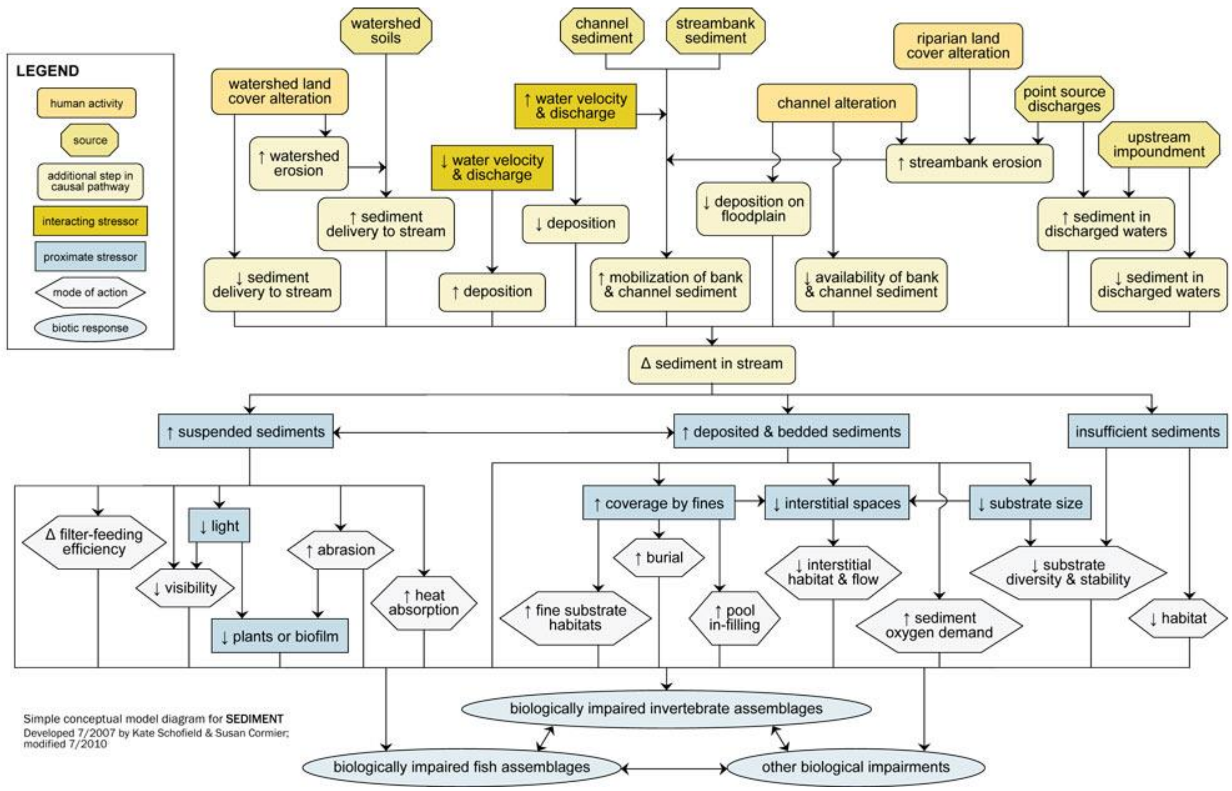

Figure A-2. Simple conceptual diagram depicting human related pathways from sources to sediment impairments (US EPA - Sediments | CADDIS Volume 2 | US EPA[11]).

Field characterization of the presence and proximity of various types of human activities, disturbances, and land use in the river riparian area is adapted from methods developed by Kaufmann and Robison (1998) for wadeable streams and Lazorchak et al. (2000) for non-wadeable streams (Figure A-3). Ecology currently relies on methodology developed for wadeable (Peck et al. 2006) and boatable (Peck et al. 2005) surveys developed by EPA. This information will be used in combination with riparian and watershed land use information from aerial photos and satellite imagery to assess the potential degree of disturbance of the sample river reaches.

For the left and right banks at each of the 11 detailed channel/riparian cross-sections, the presence/absence and the proximity of 11 categories of human influences are recorded including:

1) walls, dikes, revetments, riprap, dams
2) buildings
3) pavement

[11] https://www.epa.gov/caddis-vol2/caddis-volume-2-sources-stressors-responses-sediments#tab-3

4) roads or railroads
5) inlet or outlet pipes
6) landfills or trash
7) parks or maintained lawns
8) row crops
9) pastures, rangeland, or hay fields
10) logging
11) mining

Observations are confined to the river and riparian area within 5 m upstream and 5 m downstream from the cross-section transect (narrow protocol) or 10 m up and down (wide protocol). Four proximity classes are used: 1) on the riverbank or in channel; 2) 0 - 10 m; 3) 10 - 30 m; and 4) absent. Ecology's disturbance indexes derived from these data are discussed on pages 96 to 103 of the Habitat Metric Dictionary[12] (Janisch 2013).

[12] https://apps.ecology.wa.gov/publications/documents/1303033.pdf

Category	Left Bank				Right Bank			
Buildings	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Clearing or Lot	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Park/Lawn	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Pasture/Range/Hay Field	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Row Crops	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Pipes (Inlet/Outlet)	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Landfill/Trash	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Logging Operations	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Mining Activity	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Human Foot Path	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Unpaved Motor Trail	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
PavedRoad/Railroad	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Wall/Dike/Revetment/Riprap/Dam	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank

Figure A-3. Watershed Health Monitoring Program E-form to record human disturbances by category and proximity.

Percent Surface Substrate (Visual)

Percent substrate field and metric calculation procedures should follow the methods summarized in WHM Standard Operating Procedures[13] and Ecology Publication 13-03-033 (Jansich, 2013). These are derived from EPA methods (Kaufmann et al. 1999; Hillman, 2004; Peck et al. 2005, Peck et al. 2006), but Ecology's methods are from the bankfull channel and involve 11

[13] https://ecology.wa.gov/Research-Data/Monitoring-assessment/River-stream-monitoring/Habitat-monitoring/Habitat-monitoring-methods

observations per transect rather than five (231 stations in a waded stream versus 105). If applicable, water depth is collected alongside each observation of substrate. If data is desired from only the wetted channel width, the investigator may use only data associated with water depth. These methods involve observation of surface particle sizes within a given transect of a stream reach. Generally, substrate can be classified as:

- smooth or rough bedrock (>4 m)
- hardpan (>4 m)
- large boulders (>1 to 4 m)
- small boulders (250 to 1000 mm)
- cobble (64 to 250 mm)
- coarse gravel (16 to 64 mm)
- fine gravel (2 to 16 mm)
- sand (0.06 to 2 mm)
- fines (≤0.06 mm)

A value of 100 indicates that every station in each transect of the site reach was estimated to be of the same particle diameter category. Percent of other, non-lithic particles can also be reported, but those are less informative and do not factor into the bed stability calculation.

Systematic channel pebble counts can be directly reduced to whole-reach substrate characterizations by calculating percentages of observations within stated size classes. Because the data are systematically spaced, these averages and percentiles are interpreted as unbiased representations of the substrate characteristics measured. Reach level substrate compositions are also evaluated based on various combinations of categories:

- Smooth & rough bedrock
- Coarse gravel and larger sizes
- Fine gravel and smaller sizes
- Sand and fines
- Small and large boulder

This rule focuses on fine sediment, and thus, the percent sands and fines is of high interest for determining a fine sediment exceedance. Furthermore, the distribution of substrate is important to determine trend information and evaluate the impact of restoration efforts on impaired waterbodies.

Percent Subsurface Fines

Percent subsurface fines is not measured in Ecology’s WHM, and therefore there are no existing sampling regimes within the Department of Ecology. Subsurface sediment measurements should target riffles and spawning areas in streams with gravel and cobble. Subsurface fines is a mass based measurement that assesses content of surface and subsurface particles. Core sampling methods by Nelson et al. (2002) is recommended by the state of Idaho. Similar methods that entail core sampling may be applicable to subsurface fine collection (Bunt and Abt, 2001). Based on review of literature and research, we recommend a shovel based sampling method that produced comparable results to hollow-core samplers (Grost et al. 1991; Hames et al. 1996; Sutherland et al. 2010). Subsurface samples should be sieved and weighed in the field to determine the mass of the sediment size fractions: >64 mm, >16 mm, and >6.35 mm. Sediment <6.35 mm is typically retained and brought to the lab or be dried, sieved, and weighed. At a minimum, particle size fractions of <0.85 mm and <2 mm should be determined for purposes of a fine sediment analysis.

Relative Bed Stability

Relative bed stability (RBS) involves a series of physical habitat measurements that is expressed as the ratio of the observed substrate median diameter or geometric mean diameter divided by the average critical diameter at bankfull flow (the reach average for the largest particle that is mobile during bankfull flow; Dingman, 1984). RBS values are often expressed as logarithms for comparisons and normalizing variances. As demonstrated in the stepwise equation, the following are required to calculate RBS:

- slope
- mean thalweg depth
- bankfull height
- mean thalweg residual depth
- wood volume per bankfull channel planform area (i.e., wood depth)
- geometric mean bed surface particle diameter measurements

These metrics are collected as part of Ecology's WHM. Ecology has established protocols for collecting the parameters necessary to calculate RBS (Standard Operating Procedures – Watershed Health Monitoring[14]).

Based on review of literature and research, we recommend that RBS and associated parameters used to calculate RBS follow protocols developed in Ecology's WHM (Standard Operating Procedures – Watershed Health Monitoring[15]).

The stepwise methods to calculate RBS and logarithmic RBS (LRBS) are discussed on pages 12 to 21 of Janisch (2013).

[14]https://apps.ecology.wa.gov/publications/UIPages/PublicationList.aspx?IndexTypeName=Topic&NameValue=Standard+Operating+Procedure+(SOP)+%e2%80%94+Watershed+Health+Monitoring&DocumentTypeName=Publication

[15]https://apps.ecology.wa.gov/publications/UIPages/PublicationList.aspx?IndexTypeName=Topic&NameValue=Standard+Operating+Procedure+(SOP)+%e2%80%94+Watershed+Health+Monitoring&DocumentTypeName=Publication

Suspended Solids Concentration

Suspended solids concentration (SSC) can vary depending on flow conditions making it difficult to compare to reference conditions. Based on literature and research, we recommend that SSC be measured under average flow conditions (± 20%) for the waterbody of interest for that time of year and should not be collected following a significant rainfall (defined as 0.5 inch or more within 24 hours).

The United States Geological Survey (USGS) standard method for determining SSC is ASTM D 3977-97, Standard Test Methods for Determining Sediment Concentration in Water Samples. This method is reportedly used by all USGS sediment laboratories and cooperating laboratories certified to provided SSC data to the USGS. Studies on the accuracy of the ASTM D 3977-97 have demonstrated accurate measurements of SSC (Gray et al. 2000). Another optional method is EPA method 180.1.

We recommend following ASTM D 3977-97, EPA method 180.1, or any updated versions of these documents for measuring SSC.

Intragravel Dissolved Oxygen Depression

Intragravel dissolved oxygen (IGDO) depression can vary substantially depending on site-specific locations. To account for spatial variation in a fine sediment assessment, we recommend representative IGDO measurements should occur at each transect within a given reach in the dominant aquatic habitat following the sampling regime of the WHM program. Each sampling location should target riffles and spawning areas in streams to the degree possible. For each reach, the spatial median value should be calculated to determine the representative value for a given reach of a waterbody. A minimum of three samples are required within a specified habitat area (maximum distance of 200 feet between samples). Sampling should follow the reach and transect approach described in the "Sampling Overview" section above.

Several methods are available to measure IGDO depression, with most techniques involving a piezometer or standpipe. The state of Alaska recommends using the technique found in "Variations in the Dissolved Oxygen Content of Intragravel Water in Four Spawning Streams of Southeastern Alaska" (McNeil, 1962). Hoffman (1986) developed the horizontal intragravel pipe that sought to allow significantly more water to be withdrawn for analysis, given that the McNeil method limited samples to about 30 mL. Terhune (1958) developed a standpipe method that measured substrate permeability and IGDO but could not extract a core sample for particle size analysis. Barnard and McBain (1994) developed a standpipe method that requires extracting a freeze core to determine permeability, D.O., and vertical particle size distribution in gravels. Jeric et al. (1995) developed a method that draws water through a syringe from an intragravel pipe. All of these methods and variations thereof may be applicable to measuring IGDO concentration.

The D.O. in the water column should be collected from a standard hydroprobe or Winkler titration. To calculate the IGDO depression value, the differential between the water column and

IGDO concentration should be evaluated at each sampling location. A median value should be determined from multiple samples within a transect.

Biomonitoring

Benthic macroinvertebrate community data should be collected and reported in accordance with the "Standard Operating Procedures and Minimum Requirements for the Collection of Freshwater Benthic Macroinvertebrate Data in Streams and Rivers" (Larson, 2019) or using protocols that are at least as rigorous as Ecology standard operating procedures and that produce data to which the Benthic Index of Biological Integrity (B-IBI) and FSBI model can be applied. Ecology currently has a quality assurance monitoring plan for collecting benthic macroinvertebrates as part of the WHM program (Adams, 2010). We recommend these methods continue to be used for the purposes of evaluating benthic macroinvertebrate health alongside fine sediment based parameters. Once samples are collected, we recommend that the FSBI be used to compare the health of the benthic macroinvertebrate community to reference values within the same ecoregion as the waterbody of interest.

Approaches to Fine Sediment Assessments

Selection of the appropriate approach for fine sediment assessments may be dependent on stream size and classification. Some approaches outlined below are dependent on data from specific stream sizes (e.g., wadeable streams of Strahler order ≤ 5), while other approaches may be more applicable to non-wadeable streams or those streams of lower gradient.

Threshold Approach

A threshold approach is intended to be used as a screening level tool to determine if additional fine sediment data should be collected in a water body. In some circumstances, substantially high exceedances of single parameter thresholds should be used to prioritize a water body for further fine sediment assessment. Relationships between fine sediment based parameters and biological responses are generally poorly understood, and thus, these thresholds are only intended to evaluate prioritization of fine sediment assessments for waterbodies with incomplete data sets.

Composite samples for a stream reach or waterbody segment may be appropriate to evaluate sediment quality. Composite samples may be presented as a mean or median value for each metric (i.e., percent substrate, LRBS, subsurface fines, IGDO depression, SSC, FSBI) for a given waterbody or waterbody segment. Where applicable, the variability around the statistic should be reported. Fine sediment quality may be of concern when a particular parameter exceeds screening level thresholds developed based on literature or reference site information gathered within Washington State (Table A-2).

Table A-2. Thresholds for fine sediment based parameters.

Parameter	Threshold
Percent Substrate	If >20% fines (<2 mm), then do full characterization of fine sediment and proceed to a comparison with reference values.
Subsurface Fines	If >20% fines (< 2 mm), then do full characterization of fine sediment and proceed to a comparison with reference values If >10% fines (< 0.06 mm), then characterize fine sediment and proceed to a comparison with reference values.
Logarithmic Relative Bed Stability (LRBS)	In the absence of ecoregional reference values, LRBS should be greater than -1. If LRBS is -1 or lower, then do full characterization of fine sediment and proceed to a comparison with reference values. Lower 25th percentile within given ecoregion: Coast Range: To be determined Puget Lowlands: To be determined North Cascades: To be determined Cascades: To be determined Columbia Plateau: To be determined Northern Rockies: To be determined Willamette Valley: To be determined Blue Mountains: To be determined
Fine Sediment Biotic Index	If the 10th percentile of ecoregional reference values (shown below) are exceeded, then do a full characterization of fine sediment. Coast Range: 89 Puget Lowlands: 89 North Cascades: 89 Cascades: 89 Columbia Plateau: 8

Parameter	Threshold
	Northern Rockies: 79 Willamette Valley: 89 Blue Mountains: 79
Intragravel Dissolved Oxygen Depression	If the differential between dissolved oxygen concentrations in the water column and gravels is greater than 3.0 mg/L, then proceed to a full characterization of fine sediment and a comparison with reference values.
Suspended Solids Concentration	If >20% percent increase in SSC over natural or instream background conditions, then proceed to a full characterization of fine sediment and a comparison with reference values.

Percent Substrate and Subsurface Fines

The threshold approach for percent substrate and subsurface fines is set at 20% sand/fines at particle sizes less than 2 mm. Additionally, subsurface fines threshold for particle sizes less than 0.85 mm is 10% fines. This threshold is based on multiple peer-reviewed articles that indicate at percent fine levels greater than the thresholds recommended results in adverse effects to early life stages of salmonids (see Table A-3, Table A-4; Bryce et al. 2010; CDPHE, 2002).

Table A-3. Optimum sediment tolerance values and medians for areal percentage fines (≤0.06 mm) and areal % sand and fines (≤2 mm) for selected sediment-sensitive species. Percent fines for salmonids were first presented in Bryce et al. (2008). This table was adapted from Bryce et al. 2010.

Taxon	% Fines (≤0.06 mm)	% Sand / Fines (<2 mm)
Sediment-sensitive salmonids		
Chinook salmon	4	11
Bull trout	6	11
Rainbow trout	7	16
Cutthroat trout	8	19
Sediment-sensitive amphibians		
Foothill yellow-legged frog	2	11
Tailed frog	3	7
Pacific giant salamander	9	14
Rough-skinned newt	9	14
Red-legged frog	10	17
Cascades frog	11	15
Sediment-sensitive macroinvertebrates		

Taxon	% Fines (≤0.06 mm)	% Sand / Fines (<2 mm)
Trichioptera (*Ecclisomyia sp.*)	1.6	7.3
Ephemeroptera (*Epeorus grandis*)	1.7	9.1
Ephemeroptera (*Caudatella hystrix*)	2.5	12.3
Plecoptera (*Pteronarcys sp.*)	2.6	8.2
Trichoptera (*Oligophlebodes sp.*)	3.0	8.8
Trichoptera (*Arctopysche grandis*)	3.6	10.2
Ephemeroptera (*Epeorus longimanus*)	3.9	11.4
Plecoptera (*Megarcys sp.*)	4.3	11.4

Table A-4. Summary of the effects of particle size on salmonid spawning and rearing (adapted from CDPHE, 2002).

Reference	Species	Endpoint	Particle Size (mm)	% Fines Threshold
Bennett et al. 1993	Chinook salmon	Emergence success	<6.4	24
Bjornn (1969)	Steelhead trout and Chinook salmon	Embryo survival	<6.03	20
Canadian Council of Ministers of the Environment (2002)	Salmonids	80% embryo survival	<2 3 6.3	10 19 25
Chapman (1988)	Coho salmon, Chinook salmon, steelhead trout, and rainbow trout	Embryo survival	0.85 6 6-12	20 20 10
Hausle and Coble (1976)	Brook trout	Embryo survival and emergence success	1-3	20
Jensen et al. (2009)	Pacific salmon	Embryo survival	0.85 6.4	10 20
Kondolf (2000)	Bull, brook, cutthroat, steelhead, and rainbow trout	50% emergence	2 3.35 6.35 9.5	10 30 30 28
McHenry et al. (1994)	Coho salmon and steelhead trout	Embryo survival	0.85	10
Phillips et al. (1975)	Coho salmon and steelhead trout	Emergence success	1-3	20
Sowden and Power (1985)	Rainbow trout	Embryo survival	2	25
Tappel and Bjornn (1983)	Steelhead trout and Chinook salmon	Embryo survival	0.85 9.5	<12 <35
Weaver and Fraley (1993)	Westslope cutthroat trout	Emergence success	6.35	20

Reference	Species	Endpoint	Particle Size (mm)	% Fines Threshold
Witzel and MacCrommon (1983)	Brook and brown trout	Survival and emergence	3	<20
US FWS Habitat Suitability Index Models (1982, 1984, 1986)	Brook, brown, cutthroat, and rainbow trout	Survival and emergence	3	5-30%

In other studies, Hall (1986) found survival of egg to emergence of coho, chinook, and chum salmon to be 7-10% when fines composed 10% of the substrate at particle sizes of <0.85 mm compared to 50-75% survival with no fines <0.85 mm. Reiser and White (1988) found little survival of steelhead and Chinook salmon eggs beyond 10-20% fines <0.84 mm. In artificial redds, Bjornn et al. (1998) reported a significant reduction in fry survival when fines <0.25 mm comprised 5% of the substrate in the egg pocket. Three tiers of subsurface sediment conditions were developed for the Clearwater River drainage that included good conditions for embryos at <20% subsurface fines (<6.3 mm), marginal conditions from 20 to 27% fines, and improbable survival above 27% fines (Rowe et al. 2003). The Forest Service and the Bureau of Land Management developed guidelines based on the Clearwater and Nez Perce National Forests and Cottonwood (Idaho) area that indicated high levels of habitat conditions when fines were less than 20% (<6 mm) at depth, while >25% fines was considered poor habitat conditions (USDA-FS et al. 1998).

Benthic Macroinvertebrates

Ecology has developed B-IBI thresholds for indicating degraded biological integrity and diagnostic metric thresholds for the FSBI by ecoregion (Table A-5). The B-IBI thresholds are derived from 10,000 bootstrap replications for reference site scores within the various ecoregions of Washington using data through 2016.

Table A-5. B-IBI and fine sediment biotic index thresholds for different ecoregions in Washington State using data through 2016.

EPA Level III Ecoregion	B-IBI (0-100 scale) 10th Percentile	Fine Sediment Biotic Index[2]
North Cascades	63	89
Cascades	72	89
Coast Range	62	89
Puget Lowland	65	89
Willamette Valley[1]	65	89
Eastern Cascades Slopes & Foothills	54	79

EPA Level III Ecoregion	B-IBI (0-100 scale) 10th Percentile	Fine Sediment Biotic Index[2]
Northern Rockies	60	79
Blue Mountains	68	79
Columbia Plateau	39	8

[1]The threshold for the Puget Lowland ecoregion also applies to the small portion of the Willamette Valley Ecoregion in Washington for Water Quality Assessment purposes.

[2]Scores less than these values indicate sediment pollution. These numbers are based on the 10th percentile of Fine Sediment Biotic Index values at reference sites in western Washington, eastern Washington, and the Columbia Plateau.

Relative Bed Stability

Currently, Ecology does not have LRBS reference values for ecoregions within Washington State. However, data exists within the Environmental Information Management database to develop thresholds or reference values. EPA outlines methods for developing reference values for LRBS (US EPA, 2020). The development of LRBS reference values may be completed in the future. In the absence of LRBS waterbody specific or ecoregional reference values, literature may be used to develop screen level thresholds. A study conducted by Kaufmann et al. (2008) in the Pacific Northwest found that sites in the upper quartile of human disturbance and riparian area had LRBS values ranging from -1.1 to -4.2. We have used this information to determine a threshold of less than -1 for LRBS.

Intragravel Dissolved Oxygen Depression

As previously discussed, IGDO levels can vary temporally and spatially. Research has suggested that early life stages of salmonids require IGDO levels of 8.0 mg/L (Hicks, 2002; US EPA, 1986). However, early life stages of salmonids are not present in all water bodies year-round. Therefore, an evaluation of IGDO concentration is less relevant than D.O. depression during the summer field sampling season. In our analysis of moderate to high quality spawning gravels, the IGDO depression is limited to a maximum of 2 mg/L. In higher sediment load streams, IGDO depression values can reach as high as 7.3 mg/L (Bowen and Nelson, 2003). Groundwater can also have a significant impact on IGDO concentrations, with reported depressions as high as 9.4 mg/L at upwelling sites (Geist et al. 2002). We selected a D.O. depression threshold of greater than 3 mg/L due to the number of environmental factors that can contribute to D.O. depression. Selecting a value 1 mg/L higher than the D.O. depression value observed in moderate to high quality spawning gravels provides a degree of confidence that the water body should be prioritized for a complete fine sediment assessment. At a spatial median IGDO depression value of greater than 3.0 mg/L, there is reasonable certainty that the water quality may be limited due to fine sediment.

Suspended Solids Concentration

SSC thresholds are based on an increase in the suspension of particles relative to background conditions under average flow conditions. An increase in 20% of SSC over background concentrations provides reasonable assurance that inputs of fine sediment are contributing to a reduction in sediment quality in the streambed. The 20% increase in SSC is based on a similar criterion that Washington has for turbidity. SSC has a stronger correlation to streambed conditions and is more specific to solid-phase particles than turbidity (Gray et al. 2000).

Background and Trend Approach

Another approach to evaluate excess fine sediment from human derived sources is to use background information from historical monitoring of a waterbody. Historical or long-term monitoring data sets can be used to determine if significant sediment related changes have occurred within the waterbody. When background conditions are used, site conditions should not reflect temporary fine sediment increases associated with infrequent natural events (e.g., landslides and wildlifes), or sustained elevation of fine sediment from past human disturbances. Significant changes in sediment conditions are to be determined by statistical analyses between historical and current conditions or by setting an allowable percent change in sediment conditions over time (e.g., 20% decrease in RBS). Guidance on statistical comparisons between background conditions and reference conditions are outlined in the weight of evidence approach for impairment determination section shown below. Adequate historical information will likely not be available for all metrics on all water bodies, and therefore, alternative approaches, such as reference values, are needed to make a determination on sediment conditions.

Reference Value Approach

To determine if a waterbody contains excessive fine sediment, the metrics used to characterize fine sediment may be compared to upstream reference sites that are minimally impacted by human disturbance, reference sites within the same watershed, or ecoregional reference data compiled from multiple streams with similar characteristics such as hydrography, geology, ecology, and habitat. Consideration should be made to streams of similar classification or size when developing ecoregional reference values.

If anthropogenic inputs of sediment are identified at specific locations or segments of a waterbody, then undisturbed upstream sites may be used for comparison. Upstream sites should not be used if there is evidence of anthropogenic inputs of fine sediment or significant alteration in the landscape that may affect the metrics being measured in the evaluation of fine sediment. Upstream sites should be minimally impacted to serve as a reference condition. Given that many of Washington’s waterbodies have been impacted in upper watersheds from historical logging practices, other options may need to be used for a reference condition.

In the absence of in-stream background conditions identified from historical monitoring data or at upstream-undisturbed sites for a waterbody, we suggest that a reference site or ecoregional reference value be used. Reference sites should be within the same watershed or ecoregion. If reference sites are unavailable within the same watershed or other waterbodies do not share similar geomorphological characteristics, then reference sites should be selected according to ecoregion. Since inception, Ecology's routine stream habitat-based monitoring programs (Watershed Health Monitoring and Biological Monitoring Programs) have sampled 117 reference sites across eight Level 3 ecoregions of the state (Table A-6). Ecoregional reference values have been developed for some parameters (e.g., FSBI) used for sediment characterization and may be used in a reference comparison. Reference values are typically derived from several water bodies considered relatively undisturbed by humans and representative of an ecoregion based on hydrography, ecology, geology, stream classification, and habitat.

Some reference sites are sampled annually and are considered sentinel sites. Other reference sites are based on limited human disturbance and are sampled occassionally. The sentinel site studies aim to investigate long-term patterns in stream health at 'least-disturbed' sites to determine the impacts of natural shifts in climate, environment, and habitat without the influence of human interference. Some reference sites have been monitored for over a decade and represent a baseline for fine sediment at relatively undisturbed sites. These least disturbed sites may be used for reference sites on a site-specific or ecoregion level.

The "reference condition" is the physical, chemical, and biological condition of a class of streams with little or no human-induced degradation. High road densities and the presence of other human activities in Washington State require the definition of minimally disturbed conditions or least disturbed for reference. Minimally disturbed conditions reflect sites that have experienced very little human activity. Least disturbed conditions are based on measurements from best available streams given today's state of the landscape (Stoddard et al. 2006).

In 2003 to 2006, prior to habitat-based monitoring, Ecology staff collected annual invertebrate samples from riffles (fast flowing water) of 12 wadeable reference streams among five of the 1986 edition level III ecoregions in Washington: Coast Range, Puget Lowlands, Cascades, Columbia Plateau, and Northern Rockies (Figure A-4; Omernik and Gallant, 1986). The number of ecoregions has expanded to eight with several additional locations within ecoregions (Table A-6).

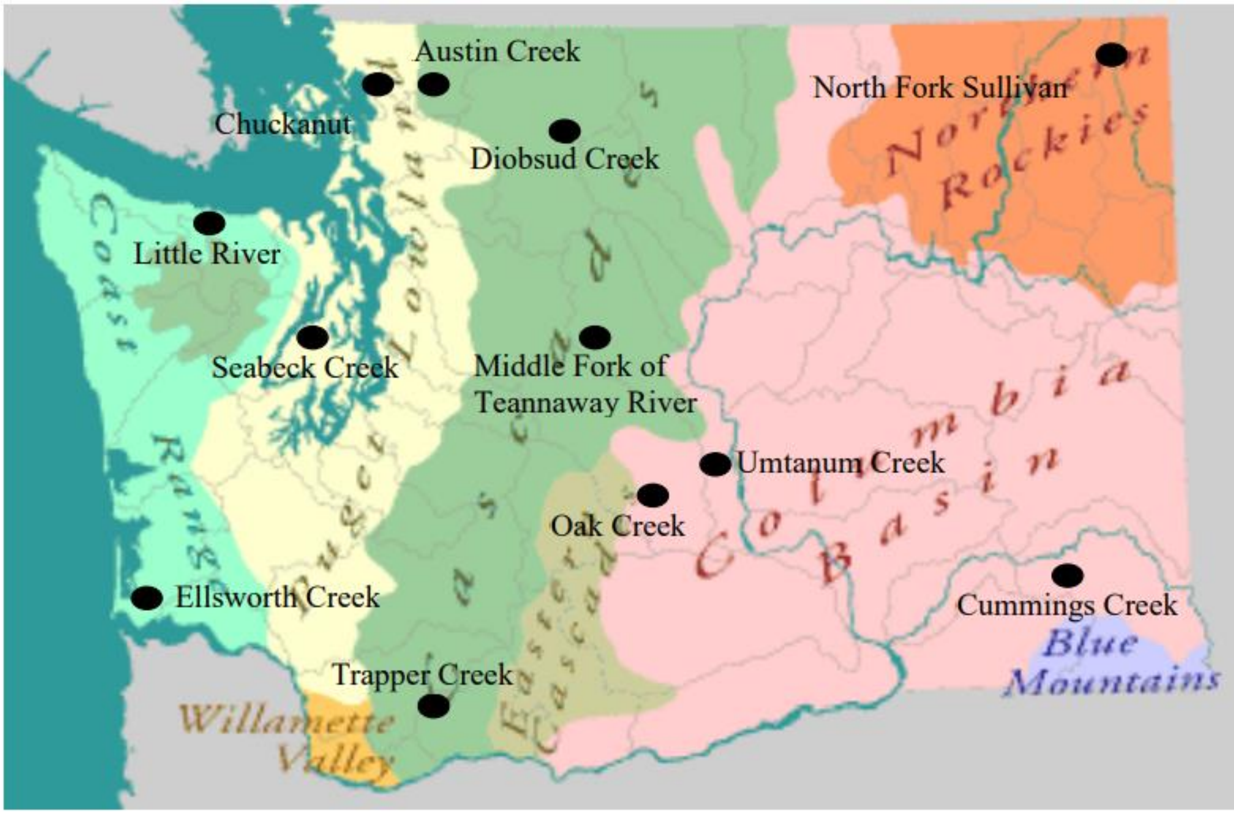

Figure A-4. Washington State Ambient Biological Field Sites (1993-2006) and Ecoregions as defined by Omernik and Gallant (1986).

Table A-6. Number of reference sites sampled by Ecology's routine habitat-based monitoring programs through 2020, by latest Level 3 Ecoregion[16]

Level 3 Ecoregion	Reference Sites
North Cascades	20
Cascades	14
Coast Range	16
Puget Lowland	15
Willamette Valley	0
Eastern Cascades Slopes & Foothills	13

[16] https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states

Level 3 Ecoregion	Reference Sites
Northern Rockies	16
Blue Mountains	8
Columbia Plateau	15

When reference sites are used, natural habitat and sediment conditions shall be determined by reference to measured conditions at sites and within watersheds that represent least disturbed conditions. Reference site conditions should not reflect temporary fine sediment increases associated with infrequent natural events or sustained elevation of fine sediment from past human disturbances.

Weight of Evidence Approach for Impairment Determination

The methods used to determine a fine sediment impairment for purposes of the Clean Water Act Section 303(d) will be finalized in Ecology's Water Quality Policy 1-11, Chapter 1. However, the following recommendations should be considered in developing an approach to determining a fine sediment exceedance. We recommend a weight of evidence approach be established for an impairment determination that is not dependent on a single metric or threshold, but rather multiple metrics that provide support that anthropogenic inputs of fine sediment are excessive.

First, a statistical (i.e., mean or median) value should be calculated for each metric (i.e., percent substrate, LRBS, subsurface fines, IGDO depression, SSC, FSBI) for the reach, segment, or entire waterbody of interest. Data may be compiled for several reaches within a waterbody segment or for an entire waterbody, or both. Where applicable, the variability (e.g., standard error) around the parameter measured should be reported. We recommend a statistical approach be used, similar to the state of Montana, to compare if metrics for the assessed waterbody differs significantly from the same metrics for the reference condition (e.g., background conditions, reference site, ecoregional reference value). In these situations, the statistical value (mean or median) for a given metric in an assessed stream is compared to reference conditions and a determination of significance or non-significance is made. Non-parametric statistical tests are recommended to compare waterbodies to reference conditions for fine sediment based parameters due to the distribution of data. Statistical methods recommended for comparisons include the 1-Sample Wilcoxon Signed Rank Test (less than 4 sampling events) and the Mann-Whitney U Test (≥ 4 sampling events). If statistical testing indicates statistically significant differences between the assessed site and the reference condition, then that metric is considered one line of evidence towards determining a fine sediment exceedance. The statistical tests should be conducted for each required metric.

Once statistical comparison tests have been conducted, a determination of exceedance may be determined through the weight of evidence approach. We recommend a minimum of the three primary parameters (percent substrate, LRBS, FSBI) for a fine sediment determination. We recommend that a weight of evidence of ≥75% be used to determine if anthropogenic inputs of fine sediment are in excess. The 75% thresholds assumes reasonable assurance that the site is impaired for fine sediment and that fine sediment presence is not naturally occurring. For example, after evaluating the four required parameters, if one or two parameters out of four are significantly different from reference conditions, the waterbody is not considered impaired (Table A-7). However, if three or four out of four parameters are significantly different from reference conditions, then the waterbody may be considered impaired for fine sediment (Table A-7). If additional fine sediment measures are used, then the ≥75% weight still applies, but the number of parameters used would be a total of five or six (Table A-7). If the line of evidence is between ≥50% and <75%, the water may be of concern, and sampling should be monitored. The thresholds for the weight of evidence approach will be further reviewed by the water quality assessment program and are subject to change.

Table A-7. Example of a weight of evidence approach for determining a fine sediment exceedance.

Statistically Significant Impairment	Exceedance Determination
1 out of 3 parameters	No exceedance
2 out of 3 parameters	Water of concern
3 out of 3 parameters	Exceedance
1 out of 4 parameters	No exceedance
2 out of 4 parameters	No exceedance
3 out of 4 parameters	Exceedance
4 out of 4 parameters	Exceedance
3 out of 5 parameters	Water of concern
4 out of 5 parameters	Exceedance
5 out of 5 parameters	Exceedance
3 out of 6 parameters	No exceedance
4 out of 6 parameters	Water of concern
5 out of 6 parameters	Exceedance
6 out of 6 parameters	Exceedance

We have pursued another method that weighs fine sediment based parameters used to make a fine sediment impairment determination. In this approach, primary parameters carry more weight or influence in a fine sediment determination than optional parameters. However, there are inherent difficulties in weighted parameters based on best judgement. Making a decision on the relative importance of each parameter is an inexact comparison. This is because relationships between fine sediment based parameters and biological responses and/or impairment of water uses are not fully developed for individual parameters. However, the relationship between fine sediment based metrics and stream conditions can be evaluated based on the literature (Larson et al. 2019). When considering weighing the selected fine sediment based parameters, we suggest that relatively equal weight be given to the three primary parameters, while a lesser weight be given for the optional parameters. For example, percent substrate, RBS, and FSBI metrics may be given a weight of 1, IGDO depression and percent subsurface fines a weight of 0.75, and SSC a weight of 0.5. These suggestions are based partially on Washington based data demonstrating relationships between these metrics and stream health (Larson et al. 2019; Sutherland et al. 2010) as well as the uncertainty in the relationship between the parameter and streambed condition.

Table A-8. Example of weight of evidence approach using weighed parameters.

Statistically Significant Impairment Weighted Score	Exceedance Determination
1 out of 3 points	No exceedance
2 out of 3 points	Water of concern
3 out of 3 points	Exceedance
………..	
0.5 out of 5 points	No exceedance
0.75 out of 5 points	No exceedance
1 out of 5 points	No exceedance
1.25 out of 5 points	No exceedance
1.5 out of 5 points	No exceedance
1.75 out of 5 points	No exceedance
2 out of 5 points	No exceedance
2.25 out of 5 points	No exceedance
2.5 out of 5 points	No exceedance
2.75 out of 5 points	Water of concern
3 out of 5 points	Water of concern

Statistically Significant Impairment Weighted Score	Exceedance Determination
3.25 out of 5 points	Water of concern
3.5 out of 5 points	Water of concern
3.75 out of 5 points	Exceedance
4 out of 5 points	Exceedance
4.25 out of 5 points	Exceedance
4.5 out of 5 points	Exceedance
4.75 out of 5 points	Exceedance
5 out of 5 points	Exceedance

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