



**COLORADO**

**Water Quality  
Control Commission**

Department of Public Health & Environment

**Guidance for Implementation of  
Colorado's Narrative Sediment Standard  
Regulation #31, Section 31.11(1)(a)(i)**

**Policy 98-1**

Adopted: November 10, 2014  
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## **List of Acronyms and Abbreviations**

303(d) List	List of Impaired Waters (pursuant to section 303(d) of the federal Clean Water Act)
AAH	Administrative Action Hearing
BMPs	Best Management Practices
Basic Standards	Basic Standards and Methodologies for Surface Water (5 CCR 1002-31); also known as Regulation #31
CAFO	Confined Animal Feeding Operation
CCR	Colorado Consolidated Regulations
CDPS	Colorado Discharge Permit System
CFR	Code of Federal Regulations
CPW	Colorado Parks and Wildlife
CRS	Colorado Revised Statutes
CWQCA	Colorado Water Quality Control Act
CWA	Clean Water Act
Commission	Colorado Water Quality Control Commission
Division	Colorado Water Quality Control Division
EPA	U.S. Environmental Protection Agency
FAQ	Frequently Asked Questions
M&E List	Monitoring and Evaluation List
MMI	Multi-Metric Index
NA	Not Applicable
Q & A	Questions and Answers
RBP	Rapid Bioassessment Protocol
RMH	Rulemaking Hearing
Regulation #31	Basic Standards and Methodologies for Surface Water
SED	Sediment
SBP	Statement of Basis and Purpose
SOP	Standard Operating Procedures
TAC	Technical Advisory Committee
TIV	Tolerance Indicator Value
TMDL	Total Maximum Daily Load

UAA	Use Attainability Analysis
USFS	U.S. Forest Service
WQCC	Colorado Water Quality Control Commission
WQCD	Colorado Water Quality Control Division
WQS	Water Quality Standards

## Definitions

**“Bedload”**: Bedload is sediment that moves by rolling or sliding along the bed and is essentially in contact with the stream bed in the bed layer.

**“List of Impaired Waters” (303(d) List)**: Colorado’s List of Impaired Waters identifies those waters for which technology-based effluent limitations and other required controls are not stringent enough to implement water-quality standards, pursuant to section 303(d) of the federal Clean Water Act (adopted by the Commission as part of Regulation #93).

**“Monitoring and Evaluation List” (M&E List)**: Colorado’s Monitoring and Evaluation List identifies water bodies where there is reason to suspect water quality problems, but there is also uncertainty regarding one or more factors, such as the representative nature of the data (adopted by the Commission as part of Regulation #93).

**“Multi-Metric Index” (MMI)**: Colorado’s Multi-Metric Index (MMI) bioassessment tool is designed to detect environmental stress that results in alteration of the biological community. It provides biological thresholds for the Aquatic Life Use in streams with a watershed area less than 2700 mi<sup>2</sup>. (see Policy 10-1)

**“redd”**: a hollow in sand or gravel on a river bed, scooped out as a spawning place by salmon, trout, or other fish.

**“Total Maximum Daily Load” (TMDL)**: A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that load among the various sources of that pollutant. Pollutant sources are characterized as either point sources that receive a wasteload allocation, or nonpoint sources that receive a load allocation.

**“Use Attainability Analysis” (UAA)**: A UAA is an assessment of the factors affecting the attainment of aquatic life uses or other beneficial uses, which may include physical, chemical, biological, and economic factors.

**“TIV<sub>SED</sub>”**: The weighted average Tolerance Indicator Value that results in a final unitless score for a benthic macroinvertebrate sample from a given site. Values range from zero to ten. Higher values indicate the macroinvertebrate community is more tolerant of fine-sediment deposits.

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# Guidance for Implementation of Colorado's Narrative Sediment Standard Regulation # 31, Section 31.11(1)(a)(i)

## WQCC Policy 98-1

### I. INTRODUCTION

This policy document is intended to provide guidance to the Water Quality Control Division ("Division") staff and to the public regarding the implementation of the Colorado Water Quality Control Commission's ("Commission") "narrative standards" as they apply to sediments which may form deposits detrimental to the beneficial uses. The Basic Standards and Methodologies for Surface Water, Regulation 31 (5 CCR 1002-31) ("the Basic Standards"), are the basis for establishing this guidance. In particular, section 31.11 of this regulation provides the following language:

All surface waters of the State are subject to the following basic standards; however, discharge of substances regulated by permits which are within those permit limitations shall not be a basis for enforcement proceedings under these basic standards:

- (1) Except where authorized by permits, BMP's, 401 Certifications, or plans of operation approved by the Division or other applicable agencies, state surface waters shall be free from substances attributable to human-caused point source or nonpoint source discharge in amounts, concentrations or combinations which:
  - (a) For all surface waters except wetlands;
    - (i) can settle to form bottom deposits detrimental to the beneficial uses. Depositions are stream bottom buildup of materials which include but are not limited to anaerobic sludges, mine slurry or tailings, silt, or mud;

Policy 98-1 provides guidance in implementing the narrative standard for bottom deposits in all state surface waters (except wetlands). However, different methods and thresholds are appropriate for different geographic settings and different beneficial uses.

The contents of this document have no regulatory effect, serving instead to summarize the Commission's thinking and actions in a single public document. In other words, as opposed to a rule or regulation, this policy statement has no binding effect on the Commission, the Division, or the regulated community. Moreover, this policy is not intended, and should not be interpreted, to limit any options that may be considered or adopted by the Commission in future rulemaking proceedings. Therefore, this policy statement can, and will, be modified over time as warranted by future rulemaking decisions.

Section II of this document records the history of the Commission's actions and sets out the core concepts that are the foundation of the Sediment Guidance. Section III includes a discussion of the applicability of the narrative standard to beneficial uses, the concept of expected condition, and the general framework for attainment decisions. Section IV provides guidance on assessing sediment impacts to the Aquatic Life Use and describes the numerical thresholds for sediment impacts on the Aquatic Life Use (including macroinvertebrates and salmonid spawning), where the thresholds are applicable, and how they were derived. Section V discusses the general method for assessment of sediment impacts where the methods in section IV do not apply. Section VI describes the relationship between the sediment guidance and other related policies. Frequently Asked Questions are included in Appendix A. Protocols for pebble count and benthic macroinvertebrate sampling are included as Appendices B and C,

respectively. Additional information on the development of the methodology and numerical thresholds is provided in Appendices D, E, and F. A literature review pertaining to the relationship between salmonid spawning and percent fines is presented in Appendix G.

## II. HISTORY

Colorado's narrative sediment standard (see (31.11(a)(1)(i))) was included in the Basic Standards adopted by the Commission in 1979. Unfortunately, in the Statement of Basis for that hearing and subsequent hearings there is no direct discussion of why the narrative standards were included or how they were to be interpreted.

All states have adopted similar narrative standards, and EPA considers that the narrative criteria apply to all designated uses, at all flows, and are necessary to meet the statutory requirements of section 303(c)(2)(A) of the CWA <sup>1</sup>

In the mid 1990s, national interest arose in developing quantitative methods for determining the impact caused by sedimentation in the nation's water ways.

### A. Initial Policy Development

In 1996, the Colorado Sediment Task Force was convened with the goal of developing a guidance document for implementing the narrative sediment standard. The product of the Task Force was the *Implementation Guidance for Determining Sediment Deposition Impacts to Aquatic Life in Rivers and Streams* ("Sediment Guidance"). The Sediment Guidance was adopted as "provisional" by the Water Quality Control Commission in 1998 with a review required in 2 years to allow agencies and other stakeholders to gain experience applying the guidance. The expiration date was extended in 2000 and again in 2002.

The initial version of the guidance was specifically intended to apply to the assessment of aquatic life uses in higher gradient, cobble-bed, coarse-grained mountain stream and wadeable river environments. It was not intended to address sediment impacts in sandy-bottom, lower-gradient streams, large unwadeable rivers, or lakes and reservoirs. The Sediment Task Force's intention was to continue to work on approaches for these other environments, but other priorities arose. Much of the momentum from this effort was diverted to the Aquatic Life Use Work Group effort (that culminated in Policy 10-1) and the nutrient criteria development effort.

### B. First Major Revision: May 2005

The Sediment Task Force was reconvened in January 2003 to address shortcomings that the Task Force members had experienced when using the Provisional Guidance. As a result of the Task Force's work, changes were proposed to:

- Augment the discussion of particle size and the importance of and steps in substrate evaluation;
- Modify the use support categories/percentages for substrate to reflect other sampling/measurement protocols and recent experience;
- Modify the use support percentages for biological assessment to reflect recent experience;

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<sup>1</sup> U.S. EPA. 2012. *Water Quality Standards Handbook: Second Edition*. EPA-823-B-12-002



- Add more information regarding biological metrics that indicate sediment impairment, including tables that identify macroinvertebrate and fish metrics that are sensitive to sedimentation effects; and
- Add example assessments of fictional stream reaches in an appendix.

The Division proposed the document as revised by the Task Force for consideration by the Commission. At the May 2005 AAH, the Commission adopted the revised Sediment Guidance as final (as opposed to “provisional”), with an expiration date of May 2007.

Post-Sediment Task Force Input: After the Sediment Task Force process ended in 2005, the US Forest Service<sup>2</sup> identified serious concerns with the guidance. They noted that in their experience, the guidance was too nebulous, the decision matrix excluded sites that should be considered “impaired,” and the “two part test” should not always be required.

After the adoption of the May 2005 version guidance, the Division and other agencies used the guidance to evaluate streams suspected of sediment impairment. Many streams that had previously been included on the M&E list were re-assessed and over 70 were removed from the list. A few of these were added to the 303(d) list. The Division, along with USFS and EPA, also used the guidance to evaluate streams for post-TMDL project effectiveness.

2007 Review: At this time, the focus of biological assessment work had entirely shifted to development of the Aquatic Life Use Policy 10-1. At the March 2007 review, the Division recommended that the Sediment Guidance be continued as final guidance with an extended expiration date of May 2010.

2010 Review: At the March 2010 review, the Division recommended that the Sediment Guidance be continued as final guidance with an extended expiration date of May 2013. Further, the Division identified two issues that could be addressed in the guidance in the future, when resources were available:

- Because the guidance was specifically written to address high-gradient, cobble-bedded streams, it has limited usefulness in sandy-bottomed xeric or plains streams. Assessment methodologies should be explored to expand the utility in the other portions of the state.
- Once the Division and stakeholders have more experience with the aquatic life assessment methodologies and the macroinvertebrate multi-metric index (MMI) tool, Policy 98-1 should be updated to incorporate use of the MMI tool in assessment of attainment of the narrative sediment standard.

2012 Section 303(d) List (Regulation #93) hearing, December 2011: Sediment Guidance became an issue (see WQCD Rebuttal, 303(d) List RMH, November 30, 2011 pp 46-52). Following the methodology in Policy 98-1 resulted in a determination that the waterbody was impaired. However, following the methodology in Policy 10-1, the waterbody was not impaired. In other cases, it was found that streams met the Aquatic Life Use attainment thresholds in Policy 10-1, but were considered impaired under the methodology in Policy 98-1.

2012 Memo to Commission: In November 2012, the Division discussed the timing of the review of Policy 98-1 (which was set to expire May 31, 2013) with the Commission. It

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<sup>2</sup> USFS letter, April 27, 2005

was the Division's recommendation that the Commission extend the expiration date to December 31, 2014, and schedule an AAH to consider a revised draft at the October 2014 Commission meeting. The Commission followed the Division's recommendation.

### C. Second Major Revision: November 2014

In the fall of 2013, the Division and stakeholders undertook a review of Policy 98-1 with the intent of addressing the shortcomings that have been identified above.

A Technical Advisory Committee ("TAC") was empanelled and given the charge to:  
Develop a scientifically sound tool (s) (or methodology(ies)), that is/are generally based on existing Colorado data, to the extent existing Colorado data are adequate to address the question. The tool(s) should be able to be used to identify or predict the degree of impact to the aquatic community caused by deposits of sediment at a given test site. The procedure must be an improvement (e.g., in terms of accuracy or reduction in ambiguity) over the procedure that is currently included in Policy 98-1.

The remainder of the stakeholder group focused discussion on whether and how the Policy 98-1 document should be revised to address the larger universe of situations where anthropogenic sediment causes problems, such as policy and implementation issues.

Besides format and updating, the major changes that came about from this effort are:

- Removal of redundant material;
- Articulation of the general framework for implementing the narrative sediment standard;
- Development of specific methodologies to evaluate attainment of the narrative sediment standard in terms of effects on the macroinvertebrate and salmonid fish spawning aspects of the Aquatic Life Use; and
- Metrics and thresholds based on Colorado-specific data that are to be used in certain defined Sediment Regions.

The Commission adopted the revised proposal on November 10, 2014 with an expiration date of December 31, 2017.

D. *[Reserved for periodic updates regarding future Commission policy decisions.]*

## III. CENTRAL CONCEPTS

The assessment methodology is a means to determine whether or not a specific waterbody is "free from substances attributable to human-caused point source or nonpoint source discharge in amounts, concentrations or combinations which can settle to form bottom deposits detrimental to the beneficial uses" (Regulation 31.11(1)(a)(i)). This section includes a discussion of the central concepts for identifying sediment impairment, including a description of "beneficial uses" and the concept of the expected condition of a water body.

### A. Beneficial Uses versus Classified Uses

The Colorado Water Quality Control Act and the Basic Standards use both the terms "beneficial use" and "classified use." Although some beneficial uses of the water have

been identified in the classification system for added protection, beneficial use is a broader concept that is also used in the water rights context (see, e.g., 25-8- 105(1)). In the water rights setting, the uses of water are considered beneficial if they are lawfully appropriated and “employ reasonably efficient practices to put the water to use.” The Commission must recognize the beneficial uses of state waters to be protected, and it must do so in a public rulemaking hearing.

The narrative sediment standard in Regulation 31.11 applies to all state surface waters except wetlands, and provides protection to all beneficial uses, even if they have not been classified.

## **B. Expected Condition as a Concept**

The assessment approach described in this guidance is based on the concept of comparing the actual conditions of a specific study stream reach or segment with the expected conditions for the same stream to determine attainment of the narrative standard. This Guidance uses the term “expected condition” rather than the EPA terminology of “reference condition”. Expected condition is used in this guidance in an attempt to avoid the concern that sometimes arises when reference condition is narrowly interpreted to mean pristine streams.

Key to the concept of expected condition is the premise that streams minimally affected by human activity will exhibit biological, chemical and physical conditions that are representative of what is most natural and attainable for streams in the region. Sites that are undisturbed by human activities may be ideal sites; however, land and water use practices and atmospheric pollution have so altered water resources that truly undisturbed sites are rarely available. In practice, most sites will reflect some of these impacts.

Defining the expected condition of a specific stream is a critical step. One approach is to identify an individual expected condition site to use as a direct comparison to the study site. Sometimes that site can be upstream or in a neighboring watershed from the study site. Another approach relies on describing the characteristics of the expected condition from a combination of the attributes of minimally disturbed sites. In this approach, the region of application must be defined and key metrics identified and measured. A third approach relies on a policy statement - for instance, that as a matter of policy, it is the Commission’s expectation that where habitat is suitable for salmonid spawning, deposits of sediment shall not be present in amounts that can harm the survival of salmonid eggs or young.

## **C. General Framework for Attainment Decisions**

In order to protect and maintain Colorado’s beneficial uses of water, wherever possible, defined methods and a consistent approach should be used to determine whether sedimentation has impaired the beneficial or classified uses of a water body. The methods and approaches are based on the following general framework for determining whether the narrative standard is attained.

1. Comparison of Actual Condition with Expected Condition: The Commission supports the use of “expected condition” as the basis for characterizing use support. It is important to note that this concept of use support embraces considerable variation in stream morphology, the biological community, and

geographical setting.

2. Impairment is a Significant Departure from Expected Condition: The Commission affirms the position taken in prior decisions made in the context of the Section 303(d) Listing Methodology – that clear and convincing evidence is needed to show impairment, and the status of non-attainment represents a significant departure from reference or expected condition. Consistent with the CWQCA at section 25-8-204(5), the Commission requires that statistical methodologies be based on assumptions that are compatible with the water quality data. Application of those methodologies should be transparent with respect to uncertainty and risk of mistaken conclusions.
3. Watershed Review: Consistent with the narrative standard, the standard only applies to sediment that is attributable to human causes. A watershed review must be undertaken to inform an impairment decision.

#### **IV. AQUATIC LIFE USE IMPACTS - ASSESSMENT METHODOLOGIES**

Excessive deposition of sediment on the bottom of streams and rivers is an important cause of impacts to aquatic life. These impacts usually result from the loss of critical habitat for fish, aquatic invertebrates, and algae. Sediment impacts have been addressed in a detailed review by Waters (1995) and other literature reviews. Impacts to fish can include the smothering of fish spawning gravels and cobble surfaces with fine sediment, resulting in decreased intergravel oxygen and a reduction in survival and growth rates; loss of fish food sources; and loss of pool and other habitat types through changes in stream channel morphology. Impacts to aquatic invertebrates can include the smothering and infilling of the interstitial spaces normally found in clean gravel and cobble. This loss of habitat space can result in changes to the aquatic invertebrate community, including changes in community structure, such as relative abundance, and the loss of sensitive species.

Only human-caused discharges of sediment in amounts, concentrations, or combinations which can settle to form bottom deposits detrimental to beneficial uses are considered in this guidance. Therefore, naturally occurring erosive processes across a variety of geologic conditions must be considered before implementing this guidance.

The following assessment methodology applies to sediment causing stress to aquatic life through the deposition of materials. This method is not intended to provide a complete analysis of Aquatic Life Use attainment. Other analyses (e.g., chemical and toxicity analysis) would be necessary to determine attainment of other standards and to understand the full range of possible stressors which may be impacting aquatic life. It is also not intended to apply to evaluating stress caused by organic or contaminated sediments.

Consistent with policy statements in Policy 10-1, it is the Commission's intent that there should be predictable, transparent, and understandable techniques for evaluating Aquatic Life Use impairment by sediment. It is the Commission's policy to apply, wherever possible, a defined method and a uniform approach to determine whether the Aquatic Life Use is impaired due to sediment for a specific water body.

##### **A. Protection of Benthic Macroinvertebrates**

Aquatic benthic macroinvertebrate communities respond to and therefore may be indicators of a variety of physical and chemical environmental conditions that occur

within stream systems and associated watersheds. The addition of excessive fine sediments, whether in a suspended or deposited state, is expected to have negative impacts on some aquatic life in streams (Waters 1995; Wood and Armitage 1997; Henley et al. 2000). An increase in fine sediment bedload in a stream typically results in a reduction in habitat complexity by filling spaces that exist between cobbles and gravel, and consequently a reduction in macroinvertebrate density and diversity (Wohl 2000). Sediment in transit reduces light transmission and can have abrasive properties, while the deposition of fine sediment reduces benthic habitat and can smother benthic organisms (Culp et al. 1986; Wood and Armitage 1997). It is likely that the percentage of fine sediment in the substrate, the concentration of suspended sediments, and duration of exposure are all important factors when considering the response of benthic macroinvertebrates to sedimentation (Culp et al. 1986; Doeg and Milledge 1991; Newcombe and MacDonald 1991).

Because sedimentation is one of the most common and widespread forms of pollution in the western United States recent research has focused on the development of macroinvertebrate indicator values and community response metrics for the development of biologically-based sediment criteria (Relyea et al. 2000; Carlisle et al. 2007; Bryce et al. 2010; Relyea et al. 2012; Extence et al. 2013). In general, the negative impacts associated with sedimentation on aquatic life are not the result of toxicity, but the result of habitat alteration, displacement, or interference with feeding strategies and/or habits. For these reasons, Waters (1995) suggested that macroinvertebrate density may be one of the most sensitive indicators of sedimentation in streams, and metrics that rely on measures of diversity may only respond to high levels of sedimentation or prolonged exposure. In order to identify and monitor low, medium, and high levels of impact specifically related to sedimentation, recent studies have recommended that individual common taxa be categorized according to sediment tolerance or assigned tolerance values based on the sensitivity of each taxon (Carlisle et al. 2007; Relyea et al. 2012; Extence et al. 2013). This is the approach used to assess protection of macroinvertebrates.

## 1. Summary of the Method

This method applies to sites within one of the defined Sediment Regions and uses three components: a measure of the percent fines, a  $TIV_{SED}$  score, and a review of available watershed information. All three components should be used to inform a listing decision. Figure 1 presents a decision tree that displays the relationship of the steps in the method.

- a. Comparison of Actual Condition with Expected Condition: This method uses the approach that combines attributes from reference sites in a Sediment Region.
  - i. The expected conditions for sediment deposition and the macroinvertebrate community are established from analysis and combination of the attributes of minimally disturbed reference sites in each Sediment Region.
  - ii. The actual conditions of the study site are determined by measuring sediment deposition and the macroinvertebrate community. The percent of the area within the wetted width covered by particles that are less than 2 mm is the sediment deposition metric. The Sediment Tolerance Indicator Value ( $TIV_{SED}$ )

is the biological metric.

- b. Impairment is a Significant Departure from Expected Condition: Study-site metrics for sediment deposition and biological condition are compared to those of the expected condition for the Sediment Region. If the study site's metrics for both indicators exceed the respective thresholds for each indicator the site is significantly different than the expected condition for that Sediment Region.
  
- c. Watershed Review: If both indicators exceed the respective threshold, then the third component in the method is to review available watershed information. This step is intended to identify whether or not the excess sediment is likely due to "human caused point source or nonpoint source discharge(s)." In addition the watershed review should evaluate whether the watershed characteristics for the site are within the range of conditions used to establish the expected condition for the Sediment Region (see Table 1 and Appendix D).

The development and components of this method are further discussed in the following sections.

## Figure 1. Assessment of Macroinvertebrate Protection - Decision Tree

1 - Using Figures 2-4 or Appendix D, determine the Sediment Region for your site.

- A. Region 1 - go to 2
- B. Region 2 - go to 3;
- C. Region 3 - go to 4;
- D. Other - go to 5

2 - **Sediment Region 1:** Compare site information with the thresholds. Does the site exceed both thresholds?

Sediment Region 1	Threshold Values
WA TIV <sub>SED</sub>	6.1
% fines <2 mm	27.5

- A. Yes - site may be impaired for sediment, go to 6
- B. No - site is not impaired for sediment

3 - **Sediment Region 2:** Compare site information with the thresholds. Does the site exceed both thresholds?

Sediment Region 2	Threshold Values
WA TIV <sub>SED</sub>	7.0
% fines <2 mm	29.3

- A. Yes - site may be impaired for sediment, go to 6
- B. No - site is not impaired for sediment

4 - **Sediment Region 3:** Compare site information with the thresholds. Does the site exceed both thresholds?

Sediment Region 3	Threshold Values
WA TIV <sub>SED</sub>	6.3
% fines <2 mm	41.0

- A. Yes - site may be impaired for sediment, go to 6
- B. No - site is not impaired for sediment

5 - **Other Regions:** Conduct individual site assessment to determine macroinvertebrate expected condition and sediment deposition expected condition (see section V)

6 - **Watershed Review:** What does the review of available watershed information tell you?

- A. Are the watershed characteristics for the site within the range of conditions used to establish the expected condition for the Sediment Region?
  - Yes - go to part B
  - No - if the expected condition for the Sediment Region is different from the expected condition for the site, then assess the site using the method at Section V.
- B. Does evaluation of available site-specific information identify that the excess sediment is likely a human-caused condition?
  - Yes - site is impaired, the macroinvertebrate use is not protected
  - No - site is not impaired

## 2. Sediment Regions

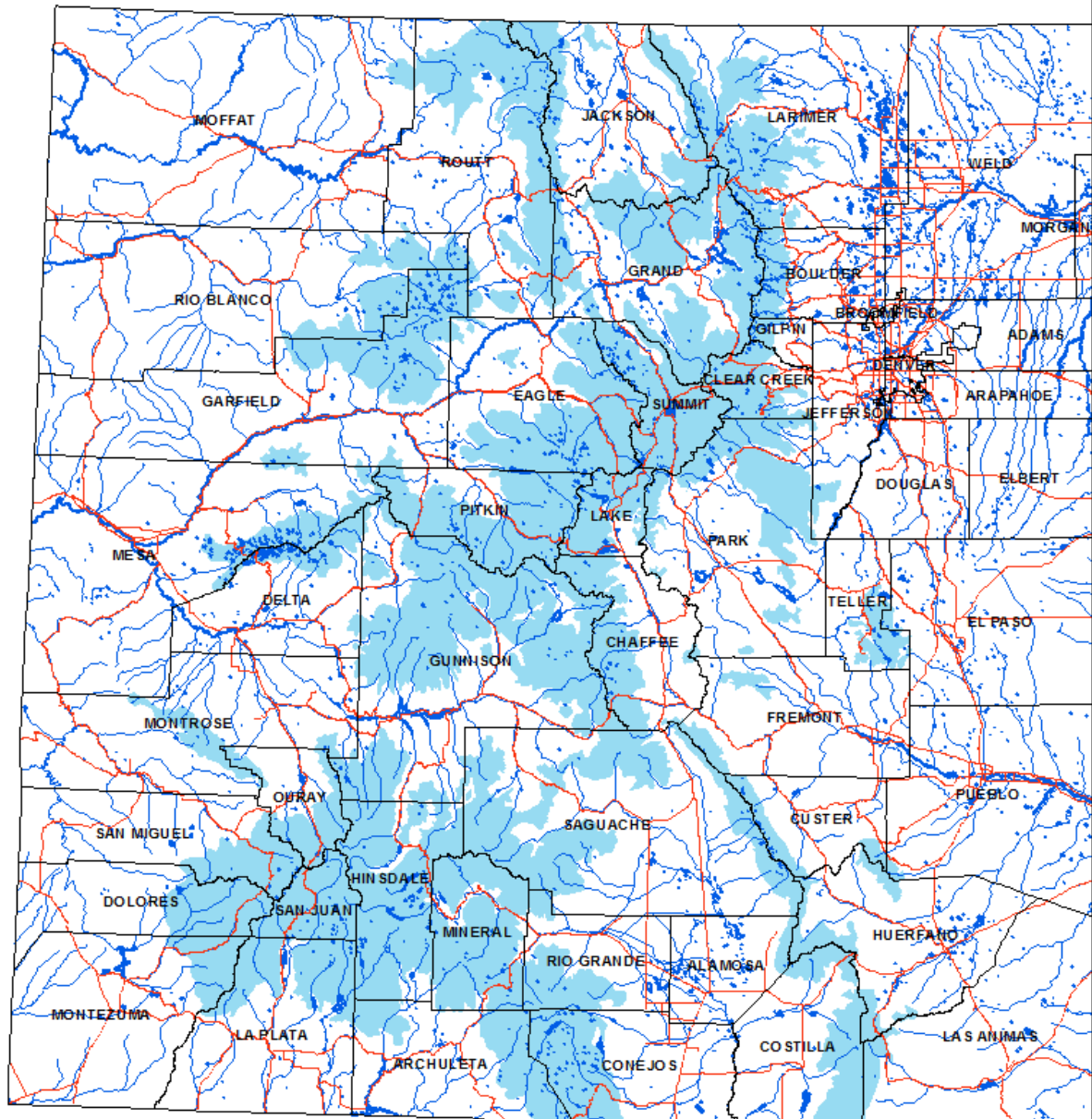
In order to increase the value of the sediment assessment tool, the state was divided or stratified into regions with similar erosion/deposition rates. Approximately half of the state has been included in Sediment Regions 1, 2, and 3. This represents the limits of the existing data and reference sites which formed the basis for assessment tool development. As more data are collected in the rest of the state, it is anticipated that this approach can be extended and more Sediment Regions will be established. Table 1 describes the Sediment Regions, which are also displayed in Figures 2, 3, and 4. Appendix D further describes the development of the Sediment Regions.

**Table 1. Description of Sediment Regions 1, 2, and 3**

Description		Sediment Region 1	Sediment Region 2	Sediment Region 3
		High mountains with steep slopes. Glaciated. Alpine and subalpine forest.	Mid-elevation mountains. Partially glaciated. Mid-Elevation Forests	Low mountains, mid-elevation hills, ridges and foot slopes. Unglaciated. Woodland and shrubland.
Reference Site Conditions	Ecoregion IDs (See Appendix D)	21a, 21b, 21e, and 21g	21c, 21f, and 21h	18d, 20c, 20e, and 21d
	Number of Reference Sites	32	18	16
	Reference Site Range of % Fines <2 mm; median value	1 - 28%; 5%	4 - 52%; 9%	9 - 41%; 18%
	Reference Site Range of Stream Course Slopes (ft/ft); median value	0.008 - 0.235; 0.06	0.01 - 0.1; 0.05	0.004 - 0.1; 0.03
	Reference Site Elevation Range (ft); median value	7400 - 12000, 9600	6600 - 10200, 7800	4900 - 7800, 6200



Figure 2. Map of Sediment Region 1 (Western Colorado).



**Legend**




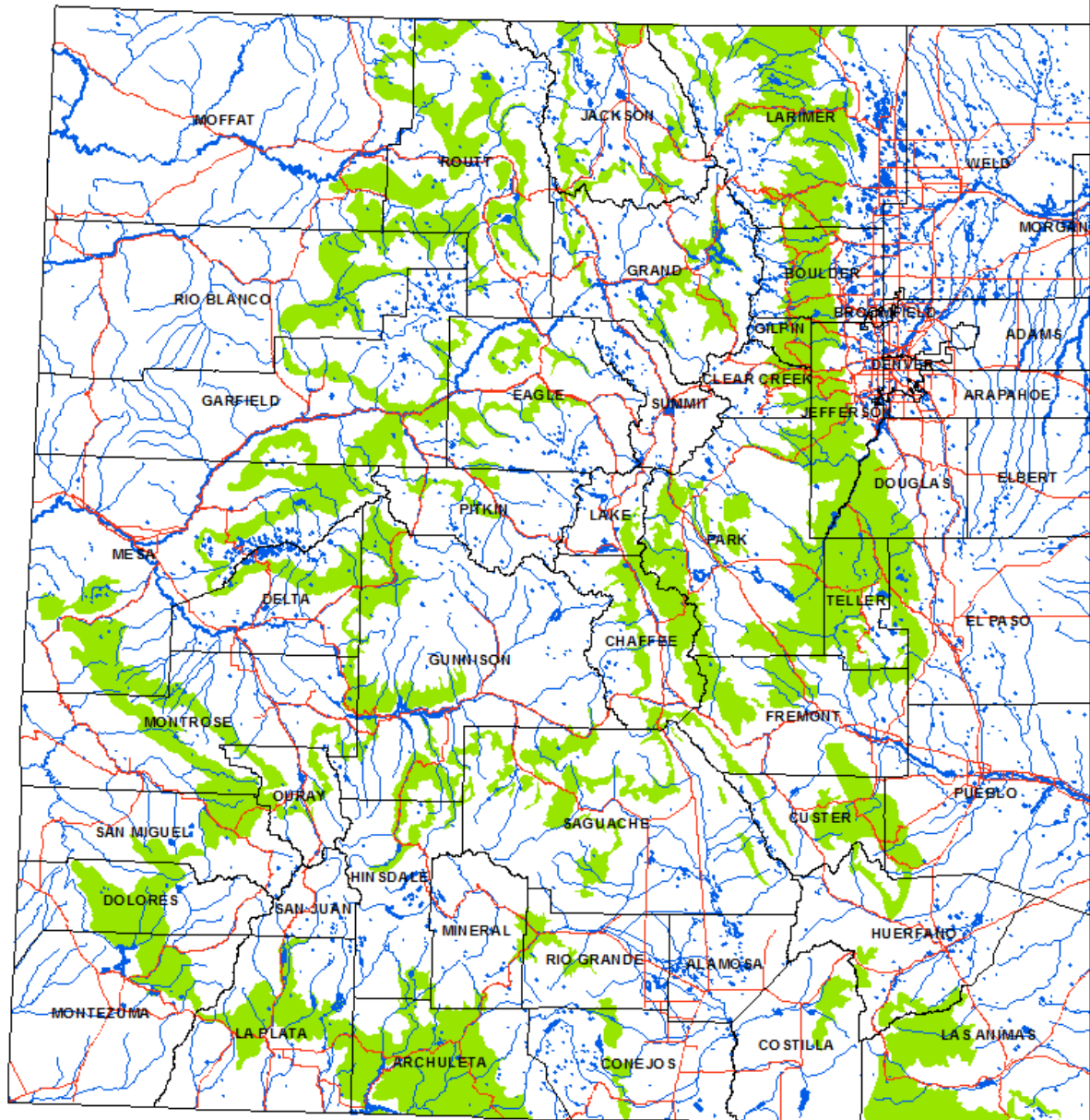
-  County
-  CDOT Highway
-  Major Waterbody

Figure 3. Map of Sediment Region 2 (Western Colorado).



**Legend**




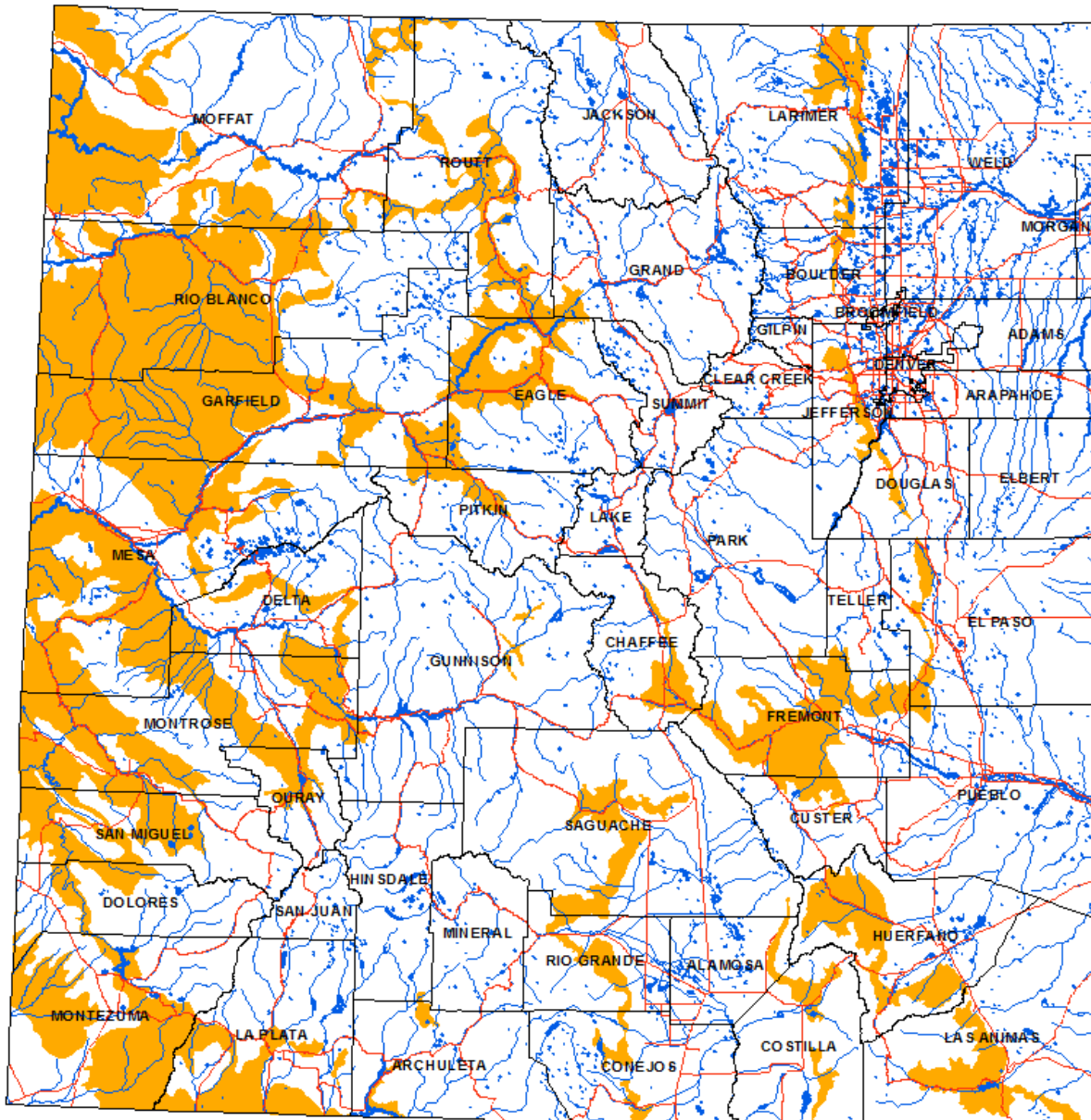



-  County
-  CDOT Highway
-  Major Waterbody

Figure 4. Map of Sediment Region 3 (Western Colorado).



**Legend**

-  County
-  CDOT Highway
-  Major Waterbody

### 3. Measure of Sediment Deposition (Percent Fines)

The exposure indicator for bedded sediments is the percent of particles with a grain size <2 mm, or “percent fines.” The grain size of <2 mm was selected because the body of literature on sediment impacts to macroinvertebrates indicates that the small fines (<2 mm) have the most significant impact (Bryce et al. 2010). The method that the WQCD uses to measure percent fines is the Modified Wolman Pebble Count Method, while USEPA and the USFS used other methods developed for their own specific projects. For measuring percent fines, the WQCD will employ its Pebble Count Standard Operating Procedure (see Appendix B) or use sediment data collected using a comparable method to determine the percent fines that are <2 mm that are within the wetted width of the stream.

Measured percent fines from the site should be compared to the Threshold for Percentage of Bedded Fines (<2 mm) for the Sediment Region. If the measured percent fines are below the threshold, the site is attaining the narrative standard. If the measured percent fines are above the threshold, then the next step is to evaluate macroinvertebrate data (i.e., biological sediment indicator) from the site.

Threshold for Percent Fines (<2 mm)	
Sediment Region 1	27.5%
Sediment Region 2	29.3%
Sediment Region 3	41.0%

### 4. Measurement of the Biological Indicator (TIV<sub>SED</sub>)

Sediment Tolerance Indicator Values (TIV<sub>SED</sub>) for macroinvertebrates were developed as the biological indicator of impacts by excess fine sediments. The TIV<sub>SED</sub> reflects both the reduction in relative abundance of sediment-sensitive taxa and the increase in relative abundance of sediment-tolerant taxa. The method for calculating TIV<sub>SED</sub> was developed using recommended methods from the National Water Quality Assessment Program (Carlisle et al. 2007). A complete description of the method for developing the TIV<sub>SED</sub> and the steps for calculating a TIV<sub>SED</sub> is included in Appendix E.

The calculated TIV<sub>SED</sub> score from the site should be compared to the threshold for the Sediment Region. If the TIV<sub>SED</sub> score from the site is below the threshold, the site is attaining the narrative standard (even if the sediment threshold is exceeded). If both the measured percent fines and the TIV<sub>SED</sub> score for a site are above the thresholds, then the next step is to complete a watershed review.

Threshold for TIV <sub>SED</sub>	
Sediment Region 1	6.1
Sediment Region 2	7.0
Sediment Region 3	6.3

## 5. Watershed Review

The purpose of the watershed review is to answer these questions:

- 1) Are the watershed characteristics for the site within the range of conditions used to establish the expected condition for the Sediment Region? (This step is only appropriate for the macroinvertebrate method at section IV.A.)
- 2) Is the excess sediment attributable to human-caused point source or nonpoint source discharge(s)?
- 3) If a site is determined to be impaired, which portion of the stream segment is not in attainment (i.e., should the entire segment or only a portion of the segment be listed)?

Because different types of data may be useful on a site-specific basis, this method should remain flexible about the types of data and information that can be used to inform the watershed review. The watershed assessment could include qualitative or quantitative information. The following options are suggestions, and should not be interpreted as requirements or limitations.

A) Information which may be useful for determining whether the watershed characteristics for the site are within the range of conditions used to establish the expected condition for the Sediment Region:

- Relative location of the site within the watershed
- Comparison of local site characteristics (e.g., slope, elevation, geology, etc) to the range of conditions within the Sediment Region (See Appendix D)

B) Information which may be useful for determining whether excess sediment is attributable to a natural cause or human sources:

- Types and density of vegetation in the riparian zone and any observed damage to vegetation or areas of bare soil
- Bank stability (e.g., observations of slumping banks or streambank erosion)
- Evidence of channelization
- Flow sequences (depth/velocity regimes)
- Ratio of Pool/Riffle/Run habitats within the stream reach
- River geomorphology
- Information regarding the timing and potential effect of recent precipitation events
- Description of surrounding land uses
- Observations of erosion in the surrounding watershed
- Photographs of the site and surrounding watershed
- Review of aerial photographs

For the assessment method at Section IV.A, if the characteristics of a particular site support a conclusion that the deposition of fines is expected to be higher than the range of percent fines observed at reference sites in the region, then it

can be determined that the thresholds developed for the Sediment Region are not representative or applicable. In such a case, an alternative expected condition for percent fines and/or the macroinvertebrate community should be developed and used as site-specific threshold(s) to assess attainment following the general method in Section V.

For assessment using any of the methods, available information that points to a natural cause (e.g., beaver dams) as the best explanation for excess sediment can be used to inform the listing decision. In this example, a decision could be made that the excess sediment is not the result of human-caused point source or nonpoint source discharges.

If available information indicates that there are point or nonpoint sources of sediment (e.g., evidence of anthropogenic erosion), then it can be determined that the site is impaired. The watershed review may be qualitative and should identify potential source(s) of excess sediment. It is not necessary to quantify all potential sources of sediment loading before listing the water body (this would be analogous to developing a TMDL before making a listing decision).

Finally, for assessment using any of the methods, if it is determined that a site is impaired for sediment, the information regarding potential sources of sediment should also be used to identify the extent of impairment, if possible. Aerial photographs, land use coverage maps, information regarding potential sources and observations made at the site could also be useful for identifying the extent of impairment. If only a portion of the segment is not in attainment with the narrative standard, then it is only necessary to list the impaired portion.

## **B. Protection of Fish Spawning Habitat - Site Specific**

In some circumstances, this guidance can be used to evaluate attainment of the narrative sediment standard in terms of protection of fish spawning habitat. Excessive amounts of fine sediments can affect salmonid spawning in various ways, such as smothering eggs and restricting intragravel flow during incubation and blocking fry emergence from gravel.

For streams with aquatic life that includes salmonids (i.e., trout), measurements of particles smaller than 6.35 mm are commonly used to describe spawning gravel quality (Chapman 1988). Chapman (1988) presented results from several studies showing effects on embryo survival when the percentage of fine sediment ranging from <0.83 mm to <6-12 mm exceeds 10-20%. Weaver and Fraley (1991) observed a significant inverse relationship between the percentage of fine sediments smaller than 6.35 mm and the emergence success of trout species (Figure 5). Reviews by Kondolf (2000) and Jensen et al. (2009) presented data from several salmonid spawning studies that also reported impacts of fine sediments (e.g., particles smaller than 6.35 mm) on embryo survival and fry emergence. Kondolf (2000) reported 50% fry emergence (which the authors considered a productive amount of emergence success) for several salmonid species when there is a maximum of 10-30% fines ranging from <2 to <9.5 mm. Jensen et al. (2009) reported decreases in salmonid eyed egg survival when percent fines <6.4 mm exceeded 20-25%. U.S. Fish and Wildlife Service Habitat Suitability Index models (Hickman and Raleigh 1982; Raleigh 1982; Raleigh et al. 1984; Raleigh et al. 1986) for brook, brown, cutthroat, and rainbow trout recommend <5% fines <3 mm for optimal spawning, with 30% fines <3 mm expected to cause low embryo survival and fry



emergence. Similar results were reported in several earlier studies (Koski 1966; Bjornn 1969; Phillips et al. 1975; Hausle and Coble 1976; Tappel and Bjornn 1983; Witzel and MacCrimmon 1983; Burton et al. 1990; Bennett et al. 1993; McHenry et al. 1994). Appendix G provides additional information regarding the basis of the salmonid spawning guideline, including summaries of the literature reviewed and a summary table of literature-reported thresholds.

Considering the studies presented above and in Appendix G, the provisional guideline for protection of salmonid spawning is that less than 20% of the spawning area may be covered by particles that are less than 8 mm for a site to be considered attaining the narrative standard.

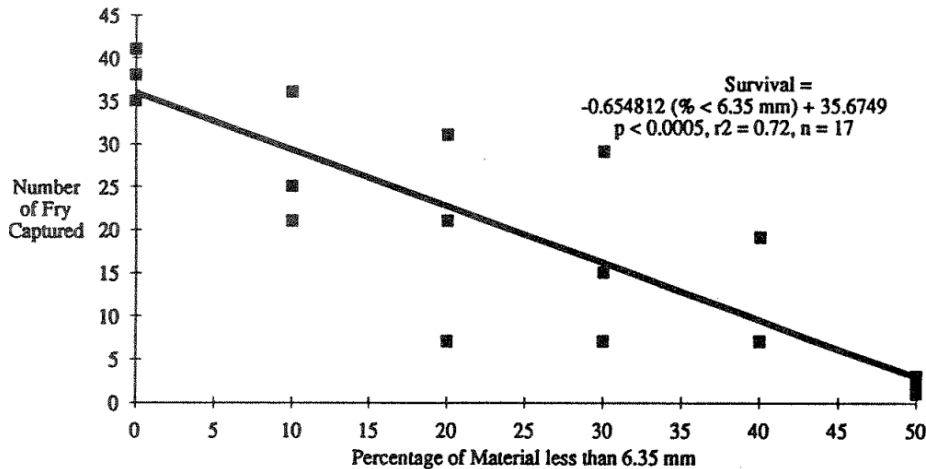


Figure 5. Relationship between numbers of westslope cutthroat trout fry successfully emerging from replicates of six gravel mixtures and the percentage of material smaller than 6.35 mm in each mixture (from Weaver and Fraley 1991).

## 1. Summary of the Method

This method applies to sites where salmonid fish are expected to spawn. Section 3 below addresses identification of those sites. Figure 6 presents a decision tree that displays the relationship of the steps in the method.

a. Comparison of Actual Condition with Expected Condition: This method uses the approach that establishes an expected condition through a policy statement.

i. It is the Commission's expectation that where habitat is suitable for salmonid spawning, deposits of sediment shall not be present in amounts that can harm the survival of salmonid eggs.

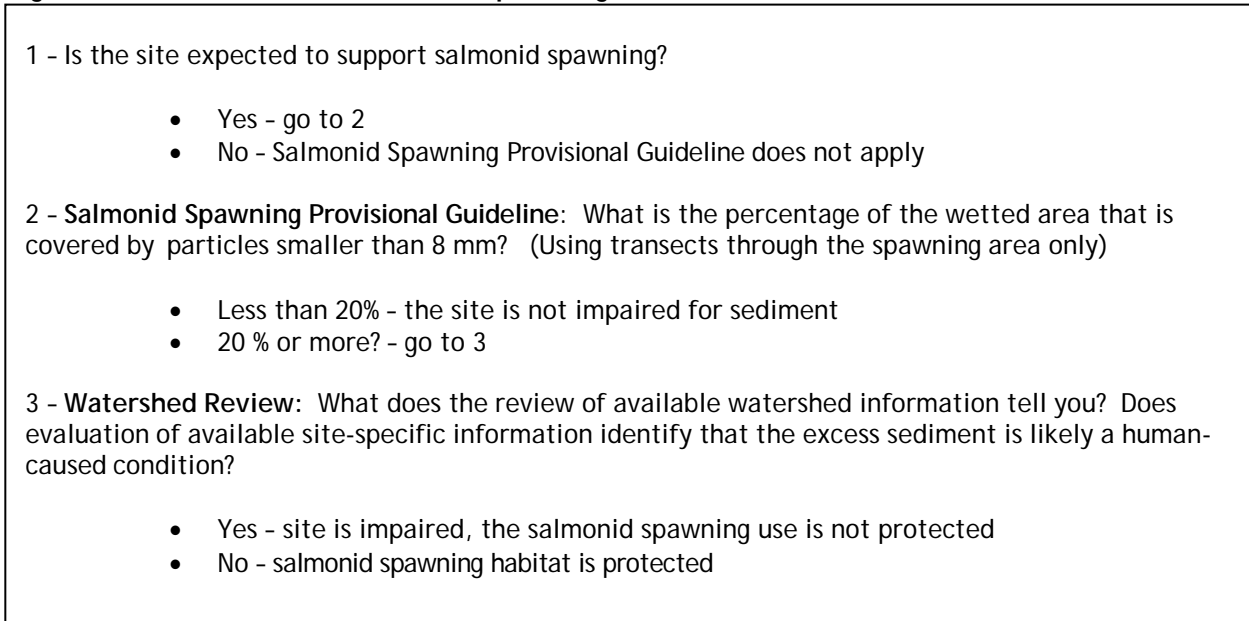
ii. The actual condition of the study site is determined by measuring sediment deposition. The percent of the area within the location suitable for spawning that is covered by particles less than 8 mm is the sediment deposition metric.

b. Impairment is a Significant Departure from Expected Condition: The study site metric for sediment deposition of <8 mm particles is compared to the provisional guideline of 20%. If a site's metric exceeds

the provisional guideline, the site is significantly different than the expected condition.

c. Watershed Review: The watershed review step is intended to identify whether or not the excess sediment is likely due to “human caused point source or nonpoint source discharge(s).”

**Figure 6. Assessment of Salmonid Spawning Habitat Protection - Decision Tree**



## 2. Applicability – Identification of Appropriate Locations

This methodology is applicable at sites where salmonid fish spawning is expected. Therefore, the first step is to determine whether salmonid fish spawning is expected to occur at the site. A determination that salmonid fish spawning is expected to occur at the site may be based on a determination by knowledgeable persons who have the training and/or experience in performing such evaluations and using the salmonid spawning habitat information provided below. Assessment reports should include a statement of the qualifications of the person determining that salmonid fish spawning is expected to occur at the site, and should also include the basis for such determination. Such persons may include knowledgeable local fishing experts, biologists, technicians, or Colorado Parks and Wildlife biologists. Figure 6 presents the decision tree.

The four most important factors that determine where salmonids spawn, in order of importance, are substrate size, water depth, water velocity, and stream width (Knapp and Preisler 1999). Salmonids generally construct redds in gravel areas near the downstream end of a pool or at the head of a riffle (Hickman and Raleigh 1982; Raleigh 1982; Raleigh et al. 1984). Salmonids often prefer areas with groundwater inflow (Raleigh 1982). Colorado Parks and Wildlife (CPW) recommends using a set of habitat characteristics as guidelines for identifying ideal spawning habitat for brook, brown, cutthroat, and rainbow trout (Table 2).

**Table 2. Guidelines for identifying stream conditions suitable for salmonid redds (Hickman and Raleigh 1982; Raleigh 1982; Raleigh et al. 1984; Raleigh et al. 1986;**



Knapp and Preisler 1999).

Water Column Velocity	Substrate Size	Water Depth	Stream Width
1 – 92 cm/sec	0.3 cm – 10 cm diameter	6.4 cm – 91.4 cm	200 cm – 800 cm

Because salmonids may use less than ideal spawning habitat if more suitable habitat is unavailable, the values in Table 2 should be used only as general guidelines. For instance, salmonids may spawn in areas with higher amounts of fine sediment, but as described in the literature (see discussion above and Appendix G), expected survival would be low.

The most reliable way to identify spawning habitat is to directly observe spawning activity, but this may be infeasible and can cause disturbance to the spawning fish. Redds and egg pockets constructed during spawning are sometimes visible and can be identified as a series of depressions followed by a downstream mound of sediment, called the tailspill. Because female salmonids create redds by clearing the upper layer of sediment from an area, there are often distinct patches of disturbed substrate that are a different color than undisturbed sites which remain coated in sediment and algae (Figure 7).

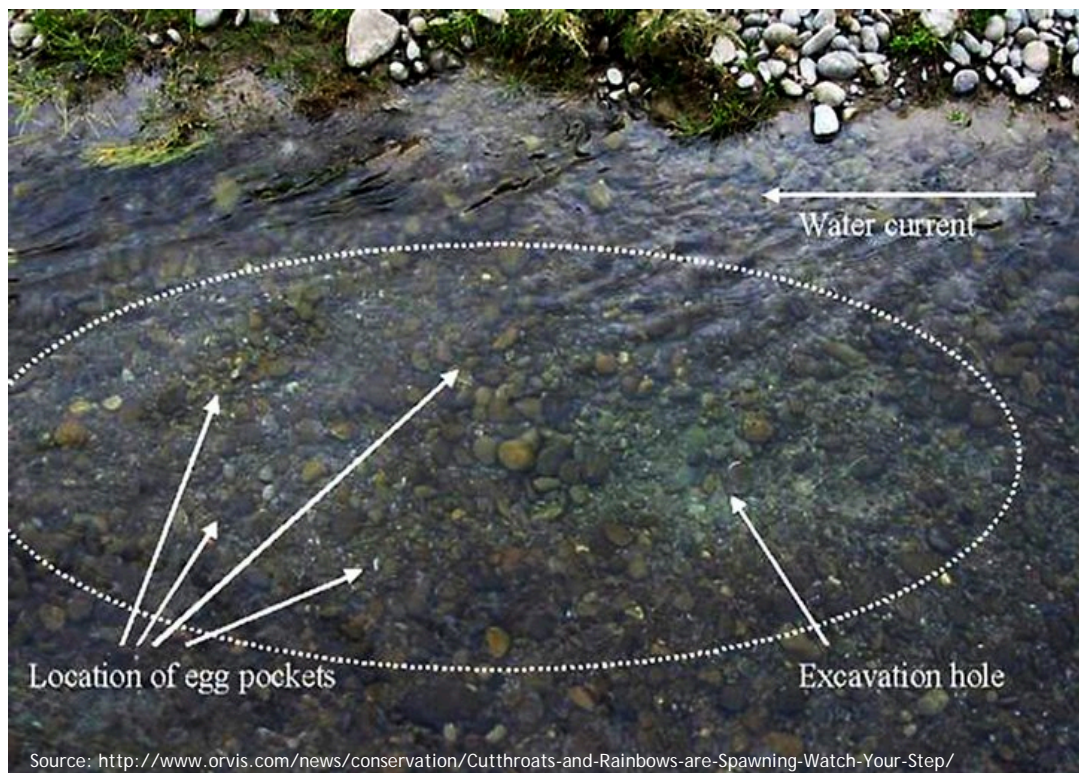


Figure 7. Example of a salmonid redd.

The time from spawning to emergence can be several months, resulting in the likelihood that salmonid embryos, alevins, or fry are present in the gravel year-round (Table 3). Cutthroat trout and rainbow trout spawn in the spring, while brook trout, brown trout, and mountain whitefish spawn in the fall. Spring spawners' eggs incubate throughout the summer and emerge from the gravel just before the fall spawners lay their eggs. The fall spawners' eggs incubate in the

winter and emerge just before the spring spawners lay their eggs (Table 3).

While conducting sediment assessments during salmonid spawning periods would help ensure that sediments were being measured when relevant to the fish, such an approach has complications. As mentioned above, different salmonid species spawn at different times of the year, including spring, summer, and fall, making it difficult to identify when a given site may be in use by salmonids. In addition, narrowing the sampling period to a known time when salmonids are actively spawning could result in disturbance and flushing of spawning adults, crushing of redds, or disturbance of sediment resulting in burial of redds. Finally, natural variability in the timing of spawning could make it difficult to determine exactly when sampling should occur in a given year. For these reasons, salmonid spawning habitat assessments cannot be restricted to a specific time of year.

**Table 3. Timing of spawning, incubation, and emergence for salmonids in Colorado. Information from Colorado Temperature Criteria Methodology Policy Statement 06-1.**

Colorado Fishes, Early Life Stage Expectation and Temperature Criteria Tiers Shaded cells indicate ELS default assumption.													
Species	Temp. Tier	J	F	M	A	M	J	J	A	S	O	N	D
Cutthroat Trout	CS-I				S	S	S	S,I	I,E				
Brook Trout	CS-I	I	I	E	E	E				S	S	I	I
Mountain Whitefish	CS-II	I	I	I						S	S	S	I
Brown Trout	CS-II	S,I	I	I	I,E					S	S	S	S
Golden Trout	CS-II						S	S	I,E				
Rainbow Trout	CS-II			S	S	S	S	I	E				
Lake Trout	CL	I	I	I	I						S	S	S,I
Kokanee	CL	I	I	I						S	S	S	I
A. Grayling	CL				S	S	S	S,I					

Notes: S = Spawning period, I = Incubation period for eggs, E = Emergence/Time period when sac-fry are in gravels Source: [https://www.colorado.gov/pacific/sites/default/files/T1\\_WQCC\\_Policy06-1.pdf](https://www.colorado.gov/pacific/sites/default/files/T1_WQCC_Policy06-1.pdf)

### 3. Measure of Sediment Deposition

This method is based on assessment of the percent of sediment that is less than 8 mm and its potential impacts on fish spawning habitat. This method was developed based on an assessment of the literature documenting scientific studies of sediment impacts on salmonid fish spawning. The grain size of <8 mm was selected because the body of literature on sediment impacts to salmonid spawning success indicates that particles <10 mm have the most significant impact on salmonid embryo survival and fry emergence (Koski 1966; Phillips et al. 1975; Hausle and Coble 1976; Tappel and Bjornn 1983; Chapman 1988; Weaver and Fraley 1991 and 1993; McHenry et al. 1994; Kondolf 2000; Jensen et al. 2009). While the particle size of 6.35 mm is often used to describe spawning gravel quality (e.g., Chapman et al. 1988), the gravelometer used by WQCD and other parties does not include a 6.35 mm size class. The tool provides data regarding the <5.6 mm and <8 mm size classes. Therefore, the salmonid spawning guideline is based on sediment particles <8 mm. A guideline of 20% was chosen because it is the percent of small sediment particles (<8 mm) frequently associated with negative effects to salmonid spawning, as reported in the literature (see discussion above and Appendix G).

Using a modified approach to the WQCD's Pebble Count Standard Operating Procedure (see Appendix B), determine the percent of sediment particles that are < 8 mm within the wetted width of the stream. Because fish can be selective of microhabitat, it is important to measure sediment deposition at the location where spawning is expected. Therefore, it is necessary to modify the WQCD's Pebble Count Standard Operating Procedure (Appendix B) so that sediment is sampled from locations along each transect only within the portion of the stream where spawning habitat may be present. Alternatively, other methods for assessing sediment deposition in salmonid spawning habitat can be used. For instance, Montana Department of Environmental Quality (2013) assesses fines in spawning habitat using the grid toss method or "percent fines by grid."

#### 4. Provisional Guideline

The Provisional Guideline of 20% <8 mm was selected to protect salmonid spawning habitat. This value is supported by the literature (see Appendix G). Using the information in Figure 5, 20% fines would result in a reduction of approximately 30%, which is a significant reduction. However, based on evidence presented in a rulemaking hearing, the Commission can and should make a case-by-case determination, using the information contained in this Policy document as perspective, not rule.

If the measured percent of sediment materials <8 mm is above 20% at a site, then the next step is to complete a watershed review (see Figure 6).

## V. GENERAL METHOD FOR DETERMINATION OF IMPAIRMENT BY SEDIMENT

This method can be used to assess sites for impacts to any beneficial use by excess sediment, where the methods at Section IV are not applicable. It is the Commission's intent that the beneficial uses of water shall be protected from impairment by sedimentation. Because of the wide range of uses and the variety of settings, at this time the Commission is relying on the following narrative statements:

- Clear and convincing evidence is needed to show impairment; and
- Impairment represents a significant departure from the expected condition.

The Commission expects that the proponents of an impairment decision will provide the Commission and hearing participants with clear and convincing evidence that:

- Establishes what the representative expected condition is (in terms of sediment deposition) for the specific water body in question;
- Demonstrates that the actual observed sedimentation condition for that specific water body is significantly different than the expected condition;
- Demonstrates that the sediment is attributable to an anthropogenic source; and
- Documents that there is a beneficial use and that the excess sediment could be a detriment to a beneficial use.

## VI. IMPLEMENTATION AND ASSOCIATION WITH OTHER

## **POLICIES**

This policy document is intended to provide guidance regarding the implementation of the narrative sediment standard as it applies to sediments which may form deposits that can be detrimental to beneficial uses. As such, it has no regulatory effect, serving instead to summarize the Commission's thinking and actions in a single public document and has no binding effect on the Commission, the Division, or the regulated community. It is not intended to limit any options that may be considered or adopted by the Commission in future rulemaking proceedings.

Only the Commission can make decisions about uses and impairment through noticed public rulemaking hearings. Determinations of whether water bodies are impaired by sediment are made by the Commission in the context of Regulation #93, Colorado's List of Impaired Waters (also known as the 303(d) List). The process for developing the Listing Methodology is described more below in section B.

The Commission has other policies and policy-like documents that have some overlap with this Sediment Guidance, namely Policy 10-1 (Aquatic Life Use Attainment: Methodology to Determine Use Attainment for Rivers and Streams) and the Section 303(d) Listing Methodology, which is prepared for each Impaired Waters Listing cycle. Each is described below.

### **A. Aquatic Life Use Attainment Policy**

Policy 10-1 (Aquatic Life Use Attainment: Methodology to Determine Use Attainment for Rivers and Streams) provides the Commission's methodology for determining whether the Aquatic Life Use is attained in rivers and streams. The procedures detailed in the guidance rely upon direct measurement of the Aquatic Life Use rather than on comparing existing water quality to numeric standards for individual pollutants. Policy 10-1 provides Colorado's Multi-Metric Index (MMI) bioassessment tool which is designed to detect environmental stressors that result in alteration of the biological community. No specific stressors are identified because the intent of the MMI is to have a generalized tool that responds to a wide range of potential stressors. The MMI tool cannot determine if the stressor is a specific pollutant, pollution or habitat limitation (including flow). The other important part of Policy 10-1 is that it provides biological thresholds for the Aquatic Life Use in streams with a watershed area less than 2700 mi<sup>2</sup>. These thresholds establish the minimum expectations for MMI scores for waters to be deemed to be in attainment of the Aquatic Life Use.

Both policies 98-1 and 10-1 use the approach of assessing impairment by comparing an actual condition of a test site with the expected condition for that site. Both policies provide at least one tool (which uses biological metrics) for determining attainment of the respective policy's topic in portions of the state. However, each policy has a specific, distinct focus. Policy 10-1 addresses attainment of the aquatic life use, regardless of the stressor. Policy 98-1 addresses attainment of the narrative sediment standard. There will be cases where the MMI tool in Policy 10-1 results in a decision that a site is attaining its aquatic life use, yet the TIV<sub>sed</sub> /% fines tool results in a decision that the same site is not attaining the narrative sediment standard. That is not unlike what occurs when a numeric chemical standard is exceeded yet the bulk of the aquatic community is not affected. In both cases, the site is included on the 303(d) List as impaired by those constituents.

### **B. Section 303(d) Listing Methodology**

The Listing Methodology provides a framework for the determination of attainment of non-attainment of assigned water quality standards and uses. The Listing Methodology is reviewed and revised by the Commission (in a noticed public hearing) in preparation for the biennial development of the List of Impaired Waters as required by Section 303(d) of the Clean Water Act.

The Listing Methodology generally relies on previous policy decisions made by the Commission, and acts as a useful repository for all the guidance about attainment/non-attainment decisions. Where guidance resides in other documents, the Listing Methodology references those documents rather than repeating the guidance. For instance, for assessment of the Aquatic Life Use, the Listing Methodology refers to the protocols establish in Policy 10-1<sup>3,4</sup>. For assessment of numeric standards, the methods are detailed in the Listing Methodology itself<sup>4</sup>. The methods in Policy 98-1 are referred to at Section III.D.7.d. as the assessment methods to be used for listing decisions.

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<sup>3</sup> In the 2012 Listing Methodology at section III.D.7.a

<sup>4</sup> In the 2012 Listing Methodology at section III D.4

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