Idaho Department of
Environmental Quality

MIXING ZONE TECHNICAL PROCEDURES MANUAL

DRAFT

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Technical Procedures Manual
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2.0 MIXING ZONE RULES

Federal regulations implementing the CWA and EPA guidance largely defer to the states in establishing the specific requirements of their mixing zone regulations. States have taken advantage of this flexibility by adopting a variety of mixing zone rules and requirements. Idaho water quality standards prohibit any discharges the will injure designated or existing beneficial uses (IDAPA 58.01.02.080) of the receiving water body. In order to protect beneficial uses of the receiving water body, IDAPA 58.01.02.060 provides key considerations that DEQ must take into account when determining whether a mixing zone is appropriate. This section summarizes the key components of Idaho's mixing zone rules. Appendix A includes each provision of IDAPA 58.01.02.060 and other related sections of Idaho's water quality standards, as well as a cross-reference to where they are discussed in this manual.

> *"After a biological, chemical, and physical appraisal of the receiving water and the proposed discharge and after consultation with the person(s) responsible for the wastewater discharge, the Department will determine the applicability of a mixing zone and, if applicable, its size, configuration, and location" (IDAPA 58.01.02.060).*

A key aspect of Idaho's rules (IDAPA 58.01.02.060) is that a biological, chemical, and physical appraisal be conducted of the receiving water body for which a mixing zone is requested. The purpose of this appraisal is to evaluate the potential impact of the mixing zone on the beneficial uses of the receiving water body. Idaho's mixing zone rules specifically provide that a mixing zone should be located so it does not cause unreasonable interference with or danger to existing beneficial uses. DEQ interprets unreasonable interference with beneficial uses to include, but is not limited to, blocking fish migration, causing acute lethality or public swimming beach closures, enticing organisms to spend prolonged periods in the mixing zone, or inhibiting recreation by creating a physical hazard to boaters or swimmers. The evaluation of a mixing zone should include consideration of the types of compounds and substances to be discharged and the potential effects of those pollutants as well as the discharge configuration on the chemical, biological, and physical condition of the receiving water body. Only those mixing zones that are determined to not unreasonably interfere with the beneficial uses of the water body can be allowed. Furthermore, mixing zones should be as small as practical and should only be authorized when meeting water quality criteria at the end of the pipe is technologically or economically infeasible.

To perform a mixing zone analysis, it is important to understand the nature and application of water quality standards and criteria. Section 2.1 of this manual provides background information on water quality standards and criteria. Sections 2.2 and 2.3 specifically discuss how to consider effects of mixing zones on beneficial uses, particularly human health and aquatic life. Section 2.4 summarizes information on chemical analyses. IDAPA 58.01.02.060.01(e) and (f) describe size limitations for mixing zones; information on determining compliance with these provisions is presented in Section 2.5. Section 2.6 briefly describes IDAPA 58.01.02.060.01(a), which indicates that DEQ should consider the use of a submerged pipe, conduit, or diffuser in authorizing mixing zones. Section 2.7 discusses IDAPA 58.01.02.060.02, which addresses mixing zones for Outstanding Resource Waters (ORWs).

Table 1 includes the key questions that should be addressed in mixing zone evaluations.

Table 1. Summary of Key Questions for Mixing Zone Evaluations

Key Mixing Zone Questions	Further Information
Does the receiving water meet criteria for pollutants in the proposed discharge?	If yes, then proceed with mixing zone analysis. If no, then a mixing zone is generally not allowed (e.g., receiving water is impaired for pollutants in the proposed discharge).
What are the existing uses of the water body for which a mixing zone is proposed?	List uses.
What is the existing, designated, or presumed aquatic life use(s) of the water body?	Describe the aquatic life use(s) and list the appropriate aquatic life numeric criteria for all constituents in the effluent for which a mixing zone is proposed.
Is the water body designated as a Domestic Water Supply?	If yes, list the human health-based numeric criteria for consumption of water and organisms for all constituents in the effluent for which a mixing zone is proposed. If no, there is no need to evaluate the mixing zone for human health-based numeric criteria for consumption of water and organisms.
Is contact recreation an existing, designated, or presumed use of the water body?	If yes, describe the public access to the mixing zone area, the extent of the mixing zone, and the seasonality of public use. For discharges from municipal treatment plants, also describe expected *E. coli* concentrations within the mixing zone. If no, there is no need to consider recreational uses.
Will the mixing zone impact critical habitat for Endangered Species Act (ESA)-listed species?	If yes, describe the likely impact, spatial and temporal extent of the impact, and all species and life stages impacted. If no, describe all habitat features that may be altered by the mixing zone, the extent of these impacts, and any associated adverse impacts to other aquatic life in the vicinity of the proposed mixing zone.
What is the extent of the mixing zone and the magnitude, duration, and frequency of pollutant exposure?	Describe the proposed mixing zone's spatial and temporal characteristics.
Will the effluent contain substances known to be toxic to aquatic life?	If yes, describe all potential toxic substances, predicted concentrations within the mixing zone, and sensitivity of the aquatic community in the vicinity of the mixing zone (especially species and/or life stages of special concern). If no, go to the next question.
Will the effluent include chemicals known or predicted to bioaccumulate or bioconcentrate?	If yes, list these compounds and describe their predicted concentration in the mixing zone and the potential impact on the food web. In addition, discuss the assimilative capacity of the receiving system and proposed monitoring efforts for impacts from discharge of such compounds. If no, go to the next question.
Will the effluent contain any known carcinogens, mutagens, or teratogens?	If yes, evaluate the predicted concentrations within the mixing zone, the potential for human contact with the mixing zone, and/or consumption of contaminated fish. If no, go to the next question.
Does the aquatic community in the vicinity of the proposed mixing zone at any time of the year contain ESA-listed species or species of special concern?	If yes, describe the populations of all ESA-listed species or species of special concern within the water body and potential impacts to these species from the proposed mixing zone. If no, go to the next question.

Table 1, continued

Key Mixing Zone Questions	Further Information
Will the mixing zone contain any constituents known to elicit an avoidance behavior?	If yes, list these constituents and the likely species affected and describe the spatial and temporal extent of the mixing zone and extent of the zone of passage. If no, describe the zone of passage for the mixing zone and any potential to interfere with local or migratory fish movements.
Does salmonid spawning occur within the proposed mixing zone area?	If yes, evaluate the potential of the proposed mixing zone to adversely impact salmonid spawning, or relocate the mixing zone. If no, go to the next question.
Are fish likely to be harvested from the water body in the vicinity of the mixing zone area?	If yes, describe all effluent constituents that have the potential to bioaccumulate or cause organoleptic impacts. If no, go to the next question.
Are acute and/or chronic water quality criteria predicted to be exceeded in the mixing zone?	If yes, describe the spatial extent of such exceedances and discuss whether acutely toxic conditions will exist. Concentrations of any substance predicted to exceed 96-hour lethal concentration fifty (LC_{50}) for any biota significant to the receiving water are prohibited. If no, go to the next question.
Is the mixing zone as small as practicable?	If yes, provide documentation supporting such a determination If no, re-evaluate the mixing zone size, effluent limitations, and treatment capabilities of the facility.
Is there a sampling and monitoring protocol set up that will adequately characterize the pre-discharge physical, chemical, and biological condition of the water body, as well as all post-discharge impacts from the proposed mixing zone?	If yes, describe the sample protocol (for pollutants and the biological community) in detail, including all spatial and temporal aspects of the monitoring and quality assurance/quality control (QA/QC) procedures. If no, a sampling and monitoring protocol may be developed for the mixing zone, or sufficient information should be submitted that describes why sampling and monitoring are not needed.

2.1 Water Quality Standards

Section 101(a) of the CWA states in part that wherever attainable, waters must achieve a level of quality that provides for the protection and propagation of fish, shellfish, and wildlife, and for recreation in and on the water ("fishable/swimmable").

In order to achieve this goal, states are required to adopt water quality standards to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. A water quality standard defines the water quality goals of a water body by designating the beneficial use or uses to be made of the water (e.g., salmonid spawning and/or drinking water supply), by setting criteria necessary to protect the uses, and by preventing degradation of water quality through antidegradation provisions. Critical to the evaluation and authorization of mixing zones are the application of appropriate water quality standards. Idaho has twelve beneficial use designations, which are listed in IDAPA 58.01.02.100. Idaho also has narrative and numeric criteria in Sections 200 through 253 of the water quality standards (IDAPA 58.01.02). Narrative criteria apply to all water bodies, regardless of their beneficial use. Numeric criteria are use-specific and are developed to protect either aquatic life or human health.

2.1.1 Narrative Criteria

There are nine narrative criteria (also known as "general" criteria) in Idaho's water quality standards. Water quality in mixing zones must meet the applicable narrative criteria; therefore, mixing zones must be free from the following materials in concentrations or quantities that impair beneficial uses:

- hazardous materials
- toxic substances
- deleterious materials
- radioactive materials (in concentrations that exceed the values listed in 40 CFR.10.1.20)
- floating, suspended, or submerged matter
- excess nutrients
- oxygen-demanding materials
- sediment

2.1.2 Numeric Criteria

Numeric criteria are use-specific; thus, the beneficial use of the receiving water body must be known in order to appropriately evaluate a mixing zone. The most stringent of all applicable use-specific criteria will drive the mixing zone analysis. Idaho has numeric criteria for a variety of pollutants, including toxics (discussed below), temperature, dissolved oxygen, pH, and *E. coli*. Numeric water quality criteria are listed in IDAPA 58.01.02.210 through 02.252. Additionally, IDAPA 58.01.02.401.01 through 401.03 mandates numeric criteria for temperature, turbidity, and total chlorine residual that apply to point source discharges at the edge of the mixing zone unless they are superseded by other more stringent criteria (e.g., in IDAPA 58.01.02.250).

Idaho water quality rules contain two types of numeric aquatic life water quality criteria for the allowable magnitude of toxic substances: acute criteria to protect against acute or lethal effects, and chronic criteria to protect against chronic effects. For individual chemicals, acute criteria were derived from 48- to 96-hour tests of lethality or immobilization. Chronic criteria were derived from long-term (often greater than 28-day) tests that measure effects on growth and reproduction, and in some cases, bioconcentration. The acute criteria should be met at the edge of the acute mixing zone, otherwise known as the zone of initial dilution (ZID), and the chronic criteria should be met at the edge of the chronic mixing zone (IDAPA 58.01.02.060.01.g). (See Figure 1.)

Human health toxics criteria can be divided into carcinogens and non-carcinogens. For carcinogens, an acceptable risk is based on a lifetime incremental cancer risk level of 1 in 100,000 for exposed individuals. For non-carcinogens, an acceptable risk is based on the reference dose (RfD) obtained from EPA's Integrated Risk Information System (IRIS) or other DEQ-approved toxicological data source. The RfD is an estimate of the daily exposure to the human population that is likely to be without appreciable risk of causing deleterious effects during a lifetime. Not all toxic substances have acute, chronic, and human health criteria. Furthermore, some toxic substances do not have any numeric criteria. This void is filled by the narrative toxic substances criterion.

2.2 Effects on Human Health via Domestic Water Supply, Contact Recreation, and Fish Consumption

In making a determination as to whether or not to allow a mixing zone or the best manner in which to monitor a mixing zone, the impacts of that mixing zone on human health must be considered. Depending on the beneficial use of the water body, various human heath-based water quality criteria may be appropriate for use in evaluating and regulating the mixing zone. Potential impacts can be evaluated through water quality criteria associated with ingestion of water (domestic water supply uses) and consumption of fish (recreational uses). In making a determination as to whether human health-based criteria should be considered, the designated use of the water body in question must be known. Information that may be used in determining the appropriate designated beneficial uses is available at http://www.deq.idaho.gov/water/data_reports/surface_water/monitoring/beneficial_uses.cfm.

The following three subsections address water quality criteria developed to protect domestic water supply, contact recreation, and fish consumption.

2.2.1 Domestic Water Supply

Those water bodies designated as Domestic Water Supply (in IDAPA 58.01.02.100.03.a) should have water quality such that they are appropriate for use as drinking water supplies. Thus, the establishment of any mixing zone must not interfere with this beneficial use.

Water quality criteria designed to protect human health for some compounds are more restrictive (i.e., allowable concentrations are lower) than corresponding water quality criteria designed to protect aquatic life. An example of this is arsenic, for which the current human health-based criterion is 50 micrograms per liter (µg/L), while aquatic life-based criteria are 150 µg/L (Criteria Continuous Concentration [CCC]) and 340 µg/L (Criteria Maximum Concentration [CMC]). Another example is the organochlorine pesticide Aldrin, for which the human health-based criterion is 0.000049 µg/L, while the aquatic life-based CMC is 3 µg/L. More information regarding applicable human health-based (and aquatic life-based) water quality criteria is given in IDAPA 58.01.02.210.

A group of compounds that should be viewed with particular caution when included in a potential or existing mixing zone are carcinogens. Carcinogenic pollutants are those known to cause cancer. Often carcinogens are also mutagens and teratogens. A mutagen is a pollutant that causes changes in genetic material (DNA), and a teratogen is a pollutant that causes birth defects. Examples of such compounds include benzene, creosote, lead, and Lindane. These substances are typically related to human health concerns and usually require that humans be exposed to the substances through ingestion of the water or consumption of fish or shellfish exposed to the pollutant.

EPA maintains a list of carcinogenic chemicals at http://www.epa.gov/tri/chemical/oshacarc.htm. Information on evidence of carcinogenic and mutagenic properties of chemicals can be found on EPA's IRIS database (http://www.epa.gov/iris/). A comprehensive source of information on human teratogens is the *Catalog of Teratogenic Agents* (Shepard 2001).

A mixing zone may not be authorized if there is information that reasonably demonstrates that pollutants discharged could be expected to cause carcinogenic, mutagenic, or teratogenic effects on or present a risk to human health. A site-specific analysis of risk may be required for such compounds and, in the absence of such an analysis, the evaluation of any such mixing zone should be based on the most protective assumptions.

When evaluating any proposed mixing zone, its proximity to existing and/or proposed domestic water intakes should be considered. When a mixing zone is granted for pollutants significant to human health, the mixing zone may not overlap a water supply intake. Idaho rules do not specify a minimum safe distance between the end of the mixing zone and the drinking water intake. Dilution models and conservative flow estimates (e.g., harmonic mean flow or 30Q5 [30-day, 5-year minimum statistical flow value]) should be used to determine the potential proximity of the intake and mixing zone. Using these data, best professional judgment should be used in determining whether the mixing zone has the potential to interfere with the domestic water supply beneficial use.

2.2.2 Primary and Secondary Contact Recreation

As discussed previously, most waters in the State of Idaho are presumed to support primary or secondary contact recreation uses. Thus, unless an EPA-approved Use Attainability Analysis removes recreational uses, the establishment of any mixing zone must be protective of these uses.

When considering whether to authorize a mixing zone in an area designated for contact recreational uses, specific information is needed regarding the ability of the public to access the area affected, the spatial extent of the mixing zone, and seasonality of use (e.g., swimming during late summer or whitewater rafting or kayaking during spring high flows). Additional information may be requested from the discharger regarding these uses when evaluating potential impacts of mixing zones.

Of particular concern for discharges from wastewater treatment plants is *E. coli*. Those waters designated for protection of contact recreation are no t to contain *E. coli* in concentrations exceeding a geometric mean of 126 *E. coli* organisms per 100 milliliters (ml) based on a minimum of five samples taken every three to seven days over a 30-day period (IDAPA 58.01.02.251.01.a).

Idaho's water quality standards do not specifically preclude the existence of a mixing zone for *E. coli* in waters designated for primary and secondary contact recreation; however, Idaho rules provide mixing zones should be located so as to not interfere with existing uses. As such, DEQ has not typically authorized mixing zones for bacteria. All available information, including actual recreational use of the receiving water, and best professional judgment should be used in determining whether a mixing zone for *E. coli* is appropriate. For example, if the discharge is adjacent to a public swimming beach, then a mixing zone for *E. coli* is not appropriate. If available data or information with which to make a reasonable decision regarding potential impacts are insufficient, then more information may be required of the discharger.

2.2.3 Fish Consumption

Although fish consumption is not a distinct beneficial use, it is an exposure pathway that is incorporated into the criteria for both domestic water supply and recreational uses. The evaluation of existing or proposed mixing zones to determine potential impacts on harvest and consumption of fish should include a consideration of both the presence in the discharge of substances known to bioaccumulate or otherwise make harvest and consumption of fish less desirable (e.g., organoleptic effects) and the frequency with which fish are harvested in the vicinity of the mixing zone. Thus, the evaluation will include both a consideration of the potential for harm, assuming consumption of fish, and the potential for harvest and consumption of exposed fish.

Although the State of Idaho does not specifically prohibit the allowance of mixing zones for chemicals that bioaccumulate, particular caution should be exercised in allowing such mixing zones, and under some circumstances, they may be denied. The TSD specifically states that:

> *Where fish tissue residues are a concern (either because of measured or predicted residues), mixing zones should not be projected to result in significant health risks to average consumers of fish and shellfish, after considering exposure duration of the affected aquatic organisms in the mixing zone, and the patterns of fisheries use in the area (EPA 1991).*

Restriction or denial of a mixing zone may be considered when the propensity of the contaminant in question has a high potential to bioaccumulate (e.g., a bioconcentration factor [BCF] exceeding 300), the duration of exposure is increased, or the discharge concentration is sufficiently high. The Department will consider "sufficiently high" concentrations to be those that will result in an increase in the downstream water concentration by ten percent or more of either the assimilative capacity or the background concentration, whichever is less. The assimilative capacity is appropriate to use when the background concentration is greater than one-half the criterion. The background concentration is appropriate to use when the background concentration is less than one-half the criterion.

Table 2 presents a list of chemicals that have been identified as significant fish contaminants for human health (EPA 2000c). Generally speaking, lipid soluble (hydrophobic) compounds have a greater potential for bioaccumulation. The chemicals included in Table 2 were selected because of detection in fish monitoring programs, increased persistence in the environment (e.g., half-life exceeding 30 days), high potential for bioaccumulation (e.g., BCF values exceeding 300), and high hazard to human health. The presence of any of these compounds in a mixing zone should be cause for particular concern and scrutiny.

Table 2. Target Analytes Recommended for Fish Sampling Programs[a]

Metals	**Organochlorine Pesticides**
Arsenic (inorganic)	Dicofol
Cadmium	Endosulfan (I and II)
Mercury (methylmercury)	Heptachlor epoxide[c]
Selenium	
Tributyltin (organotin compound)	**Chlorophenoxy Herbicides**
	Oxyfluorfen
PCBs (Polychlorinated biphenyls)	PAHs[d] (Polycyclic aromatic hydrocarbons)
Total PCBs (sum of PCB congeners or Aroclors)[b]	
	Dioxins/Furans[e]

[a] This table has been adapted from the Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Vol. 2: Risk Assessment and Fish Consumption Limits, 3rd ed. (EPA 2000c).
[b] Analysis of total PCBs (as the sum of Aroclors or PCB congeners) is recommended for conducting human health risk assessments for total PCBs (see EPA 2000d, Sections 4.3.6 and 5.3.2.6). Standard methods known as EPA Method 608 and EPA Method 1668 are available for Aroclor and congener analysis, respectively.
[c] Heptachlor epoxide is not a pesticide but a metabolite of the pesticide heptachlor.
[d] It is recommended that tissue samples be analyzed for benzo[a]pyrene and 14 other PAHs and that the order-of-magnitude relative potencies given for these PAHs be used to calculate a potency equivalency concentration (PEC) for each sample (see EPA 2000d, Section 5).
[e] It is recommended that the seventeen 2,3,7,8-substituted tetra- through octa-chlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) and the 12 dioxin-like PCBs be determined and a toxicity-weighted total concentration be calculated for each sample (Van den Berg et al. 1998). (See EPA 2000d, Sections 4.3.7 and 5.3.2.6).

Although EPA recognizes organophosphate pesticides as target analytes, these compounds are not included in Table 2 because they usually break down rapidly in aquatic environments. In addition, any pesticides that have been banned for sale or use were not included in Table 2. In Idaho, herbicide and pesticide compounds are not typically contained in effluent; however, metals commonly are. In addition to the information presented in this section, the discussion of bioaccumulation presented in Section 2.3.5 and the discussion of carcinogenic compounds in Section 2.2.1 should be consulted in evaluating the potential for various effluent constituents to cause harm.

In addition to water column criteria, fish tissue criteria are being considered for protection of human health. Idaho has adopted a maximum methylmercury concentration in fish tissues of 0.3 mg/kg and developed the *Implementation Guidance for the Idaho Mercury Water Quality Criteria* (DEQ 2005). This criterion should also be used when evaluating mixing zones.

Although not a human health concern, organoleptic (taste and odor) impacts have water quality criteria which have been recommended by EPA. These criteria may be consulted in making a determination as to whether or not compounds in any proposed discharge will interfere with the beneficial uses of the receiving water (e.g., harvest and consumption of fish). These criteria are listed among the National Recommended Water Quality Criteria and are available at www.epa.gov/waterscience/criteria/wqcriteria.html.

When a mixing zone is in an area commonly used for commercial or recreational fishing, greater caution should be exercised in allowing mixing zones for chemicals known to bioaccumulate or otherwise make harvest and consumption of fish less desirable. Specifically, the TSD (EPA 1991) states that "Mixing zones [for bioaccumulative pollutants] should be restricted such that they do not encroach on areas often used for fish harvesting, particularly of stationary species such as shellfish." The discharger may be required to submit information regarding the frequency of such activities or access points for such activities in the vicinity of the mixing zone. Using this and other information, DEQ staff should use best professional judgment in determining whether to allow a mixing zone for the chemical(s) of concern.

2.3 Effects on Aquatic Life, Including Toxicity, Zone of Passage, Spawning, and Bioaccumulation

Mixing zones have the potential to impact aquatic life (i.e., fish, benthic macroinvertebrates, and algae) by adding toxic concentrations of chemicals to the water (e.g., elevated concentrations of metals or raising or lowering pH beyond physiological thresholds) or through physical impacts such as degraded habitat, decreased dissolved oxygen concentrations, increased temperature, or increased sedimentation and/or turbidity. Both physical and chemical impacts to the receiving water can create a barrier to upstream or downstream movement by fish and aquatic macroinvertebrates. (For further discussion, see Section 2.3.1). As a result, mixing zones should be granted on a case-by-case basis, kept as small as possible, and approved only if acutely toxic conditions and barrier to fish passage are avoided.

Evaluation of any existing or proposed mixing zone must take into consideration the following:

- composition of the aquatic community
- seasonal dynamics of the water body (both physical dynamics such as snowmelt runoff and ecological dynamics such as migrating fish)
- physical impacts the discharge may cause
- concentrations and nature of pollutants that may interfere with the designated aquatic life uses of that water body

In general, the risk of any mixing zone to aquatic life increases with the extent of the mixing zone and the magnitude, duration, and frequency of pollutant exposure. It is critical, therefore, to determine the concentration of toxins in the mixing zone as well as all expected physical and chemical habitat changes that would be associated with it. It is also important to evaluate how frequently the aquatic community will be exposed to the discharge, as the more frequent a discharge, the more likely it is to present a risk to aquatic life and beneficial uses.

For more information on biological communities:

State Fisheries Management Plans
http://fishandgame.idaho.gov/cms/fish/programs/fish_plan.pdf (Note that this is a large file, which may download slowly.)

Critical habitat for salmon and steelhead
http://www.nwr.noaa.gov/Publications/FR-Notices/2005/upload/70FR37160.pdf

Bull trout
http://www.fws.gov/pacific/bulltrout/
http://species.idaho.gov/list/bulltrout.html

Biological communities in certain receiving waters (e.g., those which provide habitat for salmonid spawning and/or species of special concern) may be too sensitive to allow a mixing zone at any time because essential habitat would be affected, or vulnerable life stages and/or listed threatened and endangered species are resident within or near the proposed mixing zone. Alternatively, the seasonal sensitivity of an aquatic community (e.g., during spawning runs) may require that mixing zones be shrunk or prohibited during certain periods of the year. (See Section 2.3.3 for more on seasonal issues). In all cases, the biological community should be thoroughly characterized before a mixing zone is permitted to ensure that the biological condition and support of designated beneficial uses can be quantified and monitored prior to initiation of discharge (if possible) and over the life of the permit. Section 4.0 presents a discussion of monitoring and evaluation methods which may be used for community characterization.

Information regarding the aquatic communities expected to be present in different water bodies of Idaho is available in the Idaho Department of Fish and Game's (IDF&G) State Fisheries Management Plans. These plans, as well as lists of species of special concern (e.g., bull trout) and critical habitat designations (see Section 2.3.4), should be consulted early in the mixing zone review process to determine the potential for occurrence of species of special concern. Critical habitat is identified for salmon and steelhead in the Federal Register (2005). Bull trout recovery plans, critical habitat, and other information are available from the U.S. Fish and Wildlife Service (USFWS). Consultation with USFWS (for threatened species such as bull trout) and the National Marine Fisheries Service (NMFS) (for anadromous fish such as chinook salmon) may be required when there is a reasonable chance that species of special concern may occur in the area of the proposed mixing zone.

The designated use of the water body (e.g., salmonid spawning) may be a significant factor in determining the type of biological community present, as well as the acceptability of, or limits for, a given mixing zone. Although the State water quality criteria for toxics do not vary with the designated aquatic life use, some numeric criteria are dependent upon the use. Those numeric criteria that vary with the designated aquatic life use include dissolved oxygen, temperature, and ammonia. Thus, the designated use of the water body plays a particularly important role for such criteria in mixing zones. The designated use of the water body should be used to evaluate the applicable water quality criteria as well as the potential presence of species of concern during evaluation of a given mixing zone.

The tolerance of different organisms to the effects of the pollutants will vary by species, life stage, and time of year. Prior to authorizing a mixing zone, the tolerances of the aquatic community, particularly species of special concern, to the stressor(s) that will be discharged should be examined. EPA has a regional list of relative tolerance values for aquatic macroinvertebrates and fish (EPA 1999). Additional information regarding the chemical tolerances of many species may be found in EPA Ambient Water Quality Criteria Documents, which form the basis for many state water quality standards. These documents are available at http://www.epa.gov/waterscience/criteria/aqlife.html and contain species-specific chemical toxicity data for many species that occur in Idaho or species that may be used as surrogates to evaluate potential harm. Additionally, evidence may be required that demonstrates that the expected concentrations of pollutants are unlikely to have significant impacts on aquatic life.

2.3.1 Toxicity to Aquatic Organisms

IDAPA 58.01.02.210 includes numeric water quality criteria that address the effects of toxic pollutants on aquatic life. Further toxicity data can be found in EPA's ECOTOX databases, scientific literature in general, and in the DEQ evaluation report of proposed mixing zones for the Thompson Creek Mine, which also includes discussions of potential impacts to species of special concern. Using these resources and information provided by the discharger, it must be determined that acutely toxic conditions will not occur within the mixing zone and that all acute and chronic water quality criteria are met at the edge of the proposed ZID and chronic mixing zone, respectively (see Figure 1).

It is possible to allow ZIDs and at the same time ensure no acutely toxic conditions occur. Acute criteria, which are defined as one-half the final acute value for specific toxicants, describe the concentration at which toxic effects (such as lethality) will not occur when the exposure is less than one hour. Acutely toxic conditions are those conditions that cause lethality after short-term exposure (e.g., one hour or less). Acute lethality is generally not expected when an organism drifting through the mixing zone along the path of maximum exposure would not be exposed to concentrations exceeding the acute criteria when averaged over a one-hour period (EPA 1991). It can be assumed that no lethality to passing organisms will occur if at least one of the following is met:

1. The discharge is of high velocity ($\geq$ 3 m/s) and the ZID is less than fifty times the length scale (defined as the square root of the cross-sectional area of the discharge pipe) in any direction; or

2. The acute criterion will be met within 10% of the distance from the edge of the outfall to the edge of the chronic mixing zone (when the acute to chronic ratio is equal to 10 or more); or

For more information on toxicity:

ECOTOX databases
http://cfpub.epa.gov/ecotox/

Thompson Creek Mine
http://www.deq.idaho.gov/water/data_reports/surface_water/water_bodies/thompson_creek_mixing_zone_report.pdf

3. The acute criterion will be met within a distance of five times the local water depth in any horizontal direction from the outfall; or

4. The discharger provides information showing that a drifting organism, when traveling through the path of maximum exposure, would pass through the acute mixing zone within 15 minutes.

Whole Effluent Toxicity

In addition to evaluating individual toxic constituents, it may be appropriate to examine the aggregate toxicity of an effluent. Because of the complexity of effluents, it is impossible to estimate their final toxicity without directly measuring it through whole effluent toxicity (WET) tests. WET tests account for the toxicity of unknown constituents as well as synergistic or antagonistic effects among the constituents. These laboratory tests involve exposing representative aquatic organisms to various dilutions of effluent under specific conditions. The response of these organisms is used to quantify the toxicity of the aggregate effluent. Various responses, or endpoints, can be used to quantify toxicity, including the lethal concentration in which 50% of the test organisms die (known as lethal concentration fifty, or LC_{50}), the no observed effects concentration (NOEC), and the lowest observed effects concentration (LOEC).

For ease of understanding and use in discharge permits, effluent toxicity is reported in toxic units. A toxic unit (TU) is the reciprocal of the percentage of effluent that causes a specific measured acute or chronic endpoint. Acute toxic units (TU_a) and chronic toxic units (TU_c) can be calculated as follows:

$$TU_a = 100/LC_{50}$$
$$TU_c = 100/NOEC$$

Idaho does not have numeric criteria for WET. Rather, WET tests are used to determine compliance with the narrative criteria for hazardous and toxic substances (IDAPA 58.01.02.200.01 and 200.02, respectively). Typically, EPA interprets Idaho's narrative criterion for toxics to mean a $TU_c = 1$ and $TU_a = 0.3$. This interpretation is consistent with what is recommended in the TSD (EPA 1991). For mixing zones, IDAPA 58.01.02.60.01.h states that concentrations of hazardous materials within the mixing zone should not exceed the 96 hour LC_{50} for biota significant to the receiving water's aquatic community. It is preferable that acute toxicity limits be met at the end of the discharge pipe; however, DEQ may allow acute toxicity limits to be met at the edge of the ZID, so long as lethality does not occur to organisms passing through the ZID. Chronic WET limits should be based on the instream concentration of effluent at the edge of the chronic mixing zone. The most recent EPA WET guidance (EPA 2002b, 2002c) should be followed for all WET testing.

2.3.2 Avoidance Behavior/Zone of Passage

In addition to the physical limitations on the allowable sizes of mixing zones discussed in Section 2.5, the extent of the mixing zone may be restricted in order to ensure sufficient stream area and volume for a zone of passage for fish. Both anadromous (e.g., chinook salmon and steelhead trout) and fluvial species (e.g., bull trout) migrate downstream as juveniles then upstream to spawn as adults. Resident fish may also require adequate zones of passage to maintain the integrity of the water body. Thus, any established mixing zones must provide an adequate zone of passage in order to satisfy the requirement that the mixing zone not interfere with established beneficial uses. The following are of primary concern in evaluating the zone of passage: concentrations of various pollutants that are known to elicit an avoidance behavior, and location of the mixing zone relative to suitable stream velocities and depths for fish passage.

A comprehensive review of the scientific literature on fish avoidance was conducted by DEQ for the Thompson Creek Mine facility. This report, which can be used as a model for evaluation of fish passage issues associated with mixing zones, identified fish avoidance thresholds for cadmium, copper, chromium, nickel, lead, mercury, and zinc (Table 3). Additional pollutants were also discussed in the document, which is available at http://www.deq.idaho.gov/water/data_reports/surface_water/water_bodies/thompson_creek_mixi4ng_zone_report.pdf. Additional avoidance threshold values may be presented by the permit applicant; however, these must be supported by adequate and appropriate scientific literature.

Table 3. Threshold Concentrations (µg/l) Observed to Elicit Avoidance Responses in Salmonids (DEQ 2000)

Selected Avoidance Thresholds	Cadmium	Copper	Chromium	Nickel	Lead	Mercury	Zinc
Lab	8	3	10	24	14	0.2	14
Field	***16***	***3***	***20***	***48***	***28***	***0.4***	***28***

Note: Except for copper, lab avoidance thresholds from the studies reviewed multiplied the lowest lab-to-field response ratio by two in order to obtain field avoidance thresholds. Because of ambiguity with the threshold avoidance response of juvenile chinook salmon to copper, the recommended avoidance threshold is 3 µg/l, without multiplication by the lab-to-field response ratio.

The allowable size of the mixing zone must take into account not only water quality criteria, but also concentrations of various pollutants known to elicit an avoidance response in both the expected resident and migratory fish species. Since fish have been shown to have their upstream passage blocked when encountering elevated concentrations of pollutants, any permitted mixing zone must provide a sufficient zone of fish passage such that the allowable mixing zone does not have the potential to interfere with fish movements.

Idaho mixing zone rules list 25% stream width and 25% stream volume as principles to consider when defining a mixing zone. This example illustrates that there may be times when mixing zone determinations are driven by more limiting factors.

From a physical perspective, the size limitations as described in Section 2.5 on the extent of a mixing zone are expected to provide an adequate zone of passage. However, in order to ensure that the mixing zone “does not cause unreasonable interference with or danger to existing beneficial uses,” (IDAPA 58.01.02.060.a) site-specific considerations of both channel morphology and species of particular concern must be considered. Evaluation of channel morphology could be completed in conjunction with modeling efforts, as these efforts may involve detailed description of the receiving water. Of concern are instances in which a mixing zone is proposed for stream channels which contain a limited percentage of stream width with characteristics capable of supporting fish passage (e.g., depth or flow volume). For example, it is not unusual for limited areas of some streams to contain areas with a well-defined thalweg adjacent to a comparatively large gravel bar over which only shallow, diffuse flow travels. In such situations, a mixing zone could occupy less than 25% of the stream width, or even less than 25% of the stream flow, but close to 100% of the useable area of the stream for fish passage. In such cases, a site-specific determination of the appropriate physical extent of a mixing zone must be made. As indicated, such considerations must take into account requirements of species of concern (e.g., migrating chinook salmon).

2.3.3 Spawning

Of particular concern in Idaho is the protection of the spawning activities of salmonids (trout and salmon). *Oncorhynchus* species spawn by depositing eggs and sperm in a depression cut into the stream bottom of shallow, silt-free riffle/run habitats from large rivers to headwater streams. In general, salmon and trout typically choose to spawn in streams that are shallow, clear, and cold with a strong upwelling of water through the gravel. Discharges containing elevated suspended solids, for example, may clog these critical gravel beds. Sockeye salmon spawning occurs almost exclusively in lakes or streams that connect to lakes. The female sockeye most often selects a redd site in an area of the stream with fine gravels. Detailed descriptions of chinook salmon, steelhead, and bull trout spawning preferences and habitat needs by life stage are provided as part of the Salmon River Idaho restoration project. Information on sockeye habitat requirements can be obtained from the Washington Department of Fish and Wildlife. Any discharge that significantly alters habitat, lowers the dissolved oxygen, or increases the temperature of a water body is likely to impact spawning activities.

> *For more information on salmon habitat:*
>
> *Salmon River Restoration Project*
> *www.nww.usace.army.mil/salmonriver/default.htm*
>
> *Washington Department of Fish and Wildlife – Sockeye Information*
> *www.wdfw.wa.gov/fish/sockeye/ecosystem.htm*

In order to be adequately protective of vulnerable fish communities, mixing zones for Idaho's streams and rivers may be prohibited within all areas during all times of the year that the area provides salmonid fish spawning habitat. The spawning periods for salmonids occur in seasonal blocks. During late winter and spring, cutthroat trout, rainbow trout, and steelhead move into spawning habitats. Anadromous and landlocked salmon (coho, chinook, sockeye, and kokanee) spawn during late summer and fall. Brown trout, brook trout, and bull trout will typically spawn in the fall and early winter. In order for a mixing zone to be allowed in any spawning area, the applicant must demonstrate that (1) there will be no adverse impact to spawning salmonids, salmonid eggs, or alevins within the mixing zone when the discharge will occur, and (2) that the discharge will not adversely affect the capability of the area to support ongoing and future spawning, incubation, and rearing activities. Whether or not the mixing zone is to be authorized during fish spawning seasons should be carefully investigated.

The applicant for a mixing zone may be required to provide documentation that the pollutants discharged do not have the potential to interfere with present or future salmonid spawning, incubation, or rearing activities in the vicinity of the proposed mixing zone. Further consultation with NMFS, USFWS, and IDF&G may be necessary to determine potential impacts on spawning areas.

2.3.4 Species of Special Concern

Of particular concern in evaluating potential and existing mixing zones are a small group of fish species designated by the State as "species of special concern" because of their limited range in Idaho, low populations, or threats to their existence. These species of special concern for Idaho's fisheries include rainbow trout, cutthroat trout, bull trout, steelhead trout, chinook salmon, kokanee salmon, sockeye salmon, whitefish, and white sturgeon (all native fish). These fish are all of particular ecological, social, and economic importance.

A mixing zone will not be granted if it is likely to jeopardize the existence of any endangered or threatened species or result in the destruction or detrimental modification of such species' critical habitat (Federal Register 2001). All mixing zone evaluations, therefore, should include an analysis of the potential for impacts to habitat used for spawning by endangered or threatened species or species of special concern. Further, in order to be adequately protective of vulnerable fish communities, mixing zones for Idaho's streams and rivers may not be allowed within all areas during any time of the year that the area provides critical habitat for any life stage of sockeye salmon, chinook salmon, steelhead trout, Kootenai River population of white sturgeon, or bull trout.

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) (which was amended by the Sustainable Fisheries Act of 1996), established procedures designed to identify, conserve, and enhance Essential Fish Habitat (EFH) for those species regulated under a Federal fisheries management plan. MSA procedures are also very useful for identifying essential salmon spawning habitat in order to determine the appropriateness of a mixing zone. EFH for the Pacific coast salmon fishery has been defined as those waters and substrates necessary for salmon production, which are needed to support a long-term sustainable salmon fishery while maintaining the contributions of salmon to a healthy ecosystem. Salmon habitat is also protected under the Endangered Species Act (ESA), which requires the federal government to designate "critical habitat" for any species it lists under the ESA. Salmon and steelhead "critical habitat" is defined as: (1) specific areas within the geographical area occupied by the species at the time of listing, if those areas contain physical or biological features essential to conservation, and those features may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation. For more information on identifying EFH and critical habitat for Pacific salmon and steelhead, see the National Oceanic and Atmospheric Administration's northwest region website at www.nwr.noaa.gov/Salmon-Habitat.

2.3.5 Bioaccumulation

Bioaccumulation is the concentration of substances in an organism or part of an organism from its diet or environment. The process involves sequestration of the substances, which leads to the organism having a higher internal concentration of the substance than its surrounding environment. Though similar to bioaccumulation, bioconcentration involves uptake from water only. In general, substances that have properties that make them more lipid soluble and less soluble in water are more likely to bioaccumulate. A general discussion of these properties is available through the U.S. Geologic Survey (USGS) website (see the first link in the text box below). Well-known bioaccumulative substances include mercury, poly-chlorinated biphenyls (PCBs), and chlorinated pesticides. More information on and examples of such chemicals can be found at the EPA Persistent, Bioaccumulative, and Toxic (PBT) Chemical Program website, which maintains a list of priority PBT chemicals. Additionally, EPA's Great Lakes Initiative has identified 22 bioaccumulative chemicals of concern (see Table 4) for which mixing zones are not allowed in the Great Lakes.

For more information on bioaccumulation:

Bioaccumulative properties
http://toxics.usgs.gov/definitions/bioaccumulation.html

EPA PBT Chemical Program
http://www.epa.gov/pbt/

Great Lakes
http://www.epa.gov/waterscience/gli/mixingzones/

Table 4. List of 22 Bioaccumulative Chemicals for which Mixing Zones are Prohibited in the Great Lakes

Compound	
Lindane	Mirex
Hexachlorocyclohexane (BHC)	Hexachlorobenezene
alpha-Hexachlorocyclohexane	Chlordane
beta-Hexachlorocyclohexane	DDD[a]
delta-Hexachlorocyclohexane	DDT[b]
Hexachlorobutadiene	DDE[c]
Photomirex	Octachlorostyrene
1,2,4,5-Tetrachlorobenzene	PCBs[d]
Toxaphene	2,3,7,8-TCDD[e]
Pentachlorobenzene	Mercury
1,2,3,4-Tetrachlorobenzene	Dieldrin

Notes: [a]DDD: dichlorodiphenyldichloroethane, [b]DDE: dichlorodiphenyldichloroethylene, [c]DDT: dichlorodiphenyltrichloroethane, [d]PCB: poly-chlorinated biphenyl, [e]2,3,7,8-TCDD: tetrachlorodibenzo-p-dioxin

Idaho does not specifically prohibit mixing zones for compounds that have the potential to bioaccumulate. However, permitting of mixing zones for bioaccumulative compounds should only be done when there is a high degree of certainty that such compounds will not interfere with the beneficial uses in that water body. Thus, mixing zones for bioaccumulative compounds should be restricted or denied unless there is sufficient evidence that allowing a mixing zone for the compound(s) in question will not:

- Exceed the assimilative capacity of the receiving system
- Lead to elevated tissue concentrations in fish and benthic macroinvertebrates or other organisms

- Violate the Idaho water quality standards that require mixing zones to be free from toxic chemicals in toxic amounts, which includes toxicity caused through food-chain transfer

In applying for a mixing zone for bioaccumulative compounds, the discharger may be required to provide information regarding the potential for that compound to bioaccumulate or bioconcentrate in the system in question. In general, the residence time of the compound will increase the propensity to bioaccumulate (e.g., fish occupying a fast-flowing stream are likely less subject to bioaccumulation than those occupying a lake); however, bioaccumulation can occur in all systems, given the right conditions. Information the discharger may be required to provide could include the expected fate and transport of the compound in the system; potential impacts on all species, including species of special concern; and a plan to monitor tissue and sediment or water samples (if determined to be appropriate), both before and after establishment of the mixing zone. It is critical that monitoring of tissue concentrations (and possibly other matrices, such as sediment) be initiated prior to permitting of the mixing zone and be continued through the life of the permit. A final consideration should be for the potential impacts on human health (Section 2.2).

2.4 Required Chemical Analyses

Where possible, all analytical methods used to measure pollutants in the effluent and receiving water body should be approved by EPA. Further, the detection limits and reporting limits should be sufficiently low to ensure that concentrations of concern can actually be reliably measured. Of particular concern are chemicals with very low water quality criteria values such as cadmium. EPA's Office of Science and Technology is a good source for information regarding required methods and their detection limits (http://www.epa.gov/ost/methods/).

2.5 General Size and Location Principles to Consider

Mixing zones should be kept as small as practicable to ensure they do not impact the integrity of the water body as a whole. DEQ's mixing zone policy lists specific principles that should be considered when evaluating the size and location of a mixing zone. However, it is important to note that these principles are not regulatory requirements, and DEQ has discretion to depart from these principles. The following subsections discuss each of the size and location principles in detail.

2.5.1 Flowing Waters

Flow Principle

As described in IDAPA 58.01.02.060.01(e)(iv), a mixing zone should not include more than 25% of the volume of the critical stream flow. Efforts must be made to keep the mixing zone as small as possible. In order to accomplish this, 10% of the critical low flow may be initially considered for dilution; however, additional volume (in 5% increments) can be used if needed (e.g. it is determined the WQBEL can not be practically achieved). When determining whether a WQBEL can be practically achieved, issues such as technological feasibility and cost feasibility may be considered. The rationale for this approach is to ensure that any applicable mixing zone be as small as possible. DEQ may authorize a mixing zone that includes more than 25% of the volume of the critical stream flow provided the discharger demonstrates such dilution is needed and submits sufficient information illustrating that the increased mixing zone size will not unreasonably interfere with the beneficial uses of the receiving water body. Table 5 lists the critical flow values that apply to mixing zones, as described in IDAPA 58.01.02.210.03.

Table 5. Critical Flows to Use in Mixing Zone Evaluations

Criteria	Critical Flow
Aquatic Life – Toxics[1]	
Acute toxic criteria (CMC)[2]	1Q10 or 1B3
Chronic toxic criteria (CCC)[3]	7Q10 or 4B3
Aquatic Life – Non conventionals[4]	
Temperature	7Q10
Ammonia	7Q10
Phosphorus	Seasonal average (May to September)
Human Health – Toxics[1]	
Non-carcinogens	30Q5
Carcinogens	Harmonic mean flow

1Q10: lowest one-day flow with an average recurrence frequency of 10 years
1B3: biologically based low flow which indicates an allowable exceedance of once every 3 years
7Q10: lowest 7-day average flow with an average recurrence frequency of 10 years
4B3: biologically based low flow which indicates an allowable exceedance for 4 consecutive days once every 3 years
30Q5: lowest 30-day average flow with an average recurrence frequency of 5 years
Harmonic mean flow: long-term mean flow value calculated by dividing the number of daily flows by the sum of the reciprocals of those daily flows.

1 These critical flows are specified in IDAPA 58.01.02.210.03.b, and thus are non-negotiable.
2 CMC: Criterion Maximum Concentration.
3 CCC: Criterion Continuous Concentration.
4 These critical flows are not specified in Idaho water quality standards; thus, alternative flows may be used with DEQ approval.

To determine critical flow values where there is an extended record of flow data at or near the discharge point, EPA recommends using the EPA Office of Research and Development's DFLOW program, which can be downloaded free of charge. Alternatively, the USGS SWSTAT can be used. Other statistical methods can be proposed by dischargers, although they should consult with DEQ staff prior to using alternative methods.

Both DFLOW and SWSTAT rely upon the availability of long-term flow data. These models require at least three years, and preferably 10 years, of flow data to provide reliable statistical results. Such data may be independently collected by the discharger or another party within the watershed. Alternatively (as well as to verify discharger data), long-term flow data may be available if there is a nearby USGS stream gage. If there is no suitable USGS flow gage, the approximate size of a river using topozone or other maps can help verify the applicant's flow data/estimates.

In many cases, long-term flow data are not available for a specific receiving water. In that case, one option is to identify comparable watersheds in the area that have long-term data. A simple approach is to then calculate the critical low flows for the comparable watershed and estimate the low flows for the receiving water based on the ratio of upstream drainage areas. Further, long-term flow data can be compiled for multiple, comparable watersheds in the area. These data can be used to develop a correlation between drainage area size and flow, which can then be used to estimate the low flow in the receiving water. Care must be taken in using this approach because of the difficulties in "comparing" watersheds due to potential differences in local precipitation, elevation, topography, soils, aspect, etc.

For more information on critical flows:

DFLOW
http://epa.gov/waterscience/dflow/index.htm

SWSTAT Instructions
http://water.usgs.gov/software/swstat.html

USGS Gage Information
http://waterdata.usgs.gov/nwis/sw

Topozone
http://www.topozone.com

DEQ will consider other stream flow estimates (of which a proportion can be allocated to the mixing zone) where requested by dischargers. Such requests, however, must be accompanied by supporting information to demonstrate that the mixing zones will not affect the designated uses of the water body. For example, mixing zones could be based on tiered stream flows. Appropriate ranges (tiers) of stream flows can be established that range from very low minimum stream flows such as the 7Q10 (the 7-day, 10-year minimum statistical flow value) to very high normal spring runoff levels. The allowable mixing volume would be based on the lowest level of the range. For example, if DEQ establishes a tier between 100 and 150 cubic feet per second (cfs), then the allowable mixing volume would be based on a proportion of 100 cfs. This approach was used by DEQ, EPA, and the Forest Service in establishing a mixing zone for discharges from the Hecla Mining Company Grouse Creek Mine (http://yosemite.epa.gov/r10/water.nsf/NPDES+Permits/Current+ID1319).

Width Principle

The concentration of the constituent(s) being discharged to a mixing zone should meet or be less than the applicable chronic criteria before the width of the effluent plume becomes wider than 25% of the total width of the stream (IDAPA 58.01.02.060.01.e.ii). In addition, the cumulative width of adjacent mixing zones should not exceed 50% of the total width of the receiving water (IDAPA 58.01.02.060.01.e.i). The relevant width of the stream is the wetted width of the water flowing in the channel. Wetted width is a dynamic parameter that varies with flow. Additionally, at any given stream flow, channel widths and wetted widths also naturally change as one goes upstream or downstream. As channel gradients become steeper, flow often becomes more constricted and velocities increase. Likewise, channels tend to spread out and widen with decreasing gradients and lower flow velocities.

It is important, therefore, to define the flow regime (i.e., the level of water) and the channel cross-section downstream where constituent concentrations meet the chronic criteria. Mixing zone models, such as CORMIX, can be used as tools to compare different levels of flow, the width and length of the effluent plume, and the appropriate cross-section where the critical wetted width would be established as a compliance point. Since aquatic life toxics criteria are typically considered during analyses, DEQ generally uses the 7Q10 to define the critical wetted-width and the location of the compliance cross-section. This use of the 7Q10 is also consistent with the flow volume approach discussed above. In most cases, determining the mixing zone width at the 7Q10 would ensure that the mixing of effluent plumes would result in meeting chronic criteria prior to becoming wider than 25% of the stream width at all flow conditions. However, there may be instances where as stream flow and velocity increase, effluent plumes travel greater distances before becoming sufficiently mixed to meet criteria. In addition, wider plumes could be observed at higher flows in some instances. Where the required mixing zone to meet chronic criteria approaches 25% of the stream, additional studies and modeling may be necessary to predict the length, width, and amount of mixing at higher flow conditions.

Distance to Shoreline Principle

The concentration of the constituent(s) being discharged to a mixing zone should meet or be less than the applicable chronic criteria before the edge of the effluent plume is closer to the 7Q10 shoreline than 15% of that stream width (IDAPA 58.01.02.060.01.e.iii). For these purposes, 15% of the stream width is defined as 15% of the wetted width of the water flowing in the channel when the stream flow is at the 7Q10 level.

To provide an example, assume that the wetted width of the 7Q10 low-flow is 40 feet. Fifteen percent of 40 feet is 6 feet. In this case, the concentration of the constituent(s) being discharged to a mixing zone must meet or be less than the applicable chronic criteria before the edge of the effluent plume comes closer than 6 feet to the location of the 7Q10 low-flow shoreline. The 6 foot criterion would apply for all flow levels.

As discussed for the 25% width criterion, at any given stream flow, channel widths and wetted widths also naturally change as one goes upstream or downstream. Open channel hydraulics models such as the Hydrologic Engineering Centers River Analysis System (HEC-RAS) could be used to define the wetted width and shoreline of the 7Q10 low-flow. Mixing zone models such as CORMIX can be used to compare different levels of flow and the width and length of the effluent plume; they can also define the appropriate cross-section where the critical wetted width would be established as a compliance point.

The distance to shoreline principle can be interpreted as prohibiting shore-hugging plumes, which supports EPA's position (1994) that shore-hugging plumes should be avoided. However, although DEQ believes that these principles should be followed to the maximum extent practicable, these principles are not binding. Outfalls constructed at the bank generally result in shore-hugging plumes. Currently, most dischargers in Idaho have outfall structures located on the bank, perpendicular to stream flow. DEQ encourages, but does not require, diffusers. While DEQ recognizes there may be instances where installation of a diffuser results in more harm than good, or does not result in any added environmental benefits, diffusers generally result in more rapid mixing, decrease the area containing elevated concentrations, and thus minimize biological effects.

2.5.2 Lakes and Reservoirs

IDAPA 58.01.02.060.01.f.i limits the size of mixing zones to 10% of the lake's surface area. Wherever practicable, the discharger should provide an estimate of the maximum area of the lake's surface. The size of the lake may be estimated based on USGS topographic maps and/or other maps that delineate the lake boundaries. IDAPA 58.01.02.060.01.f.ii provides that adjacent mixing zones (from different discharge points) should be no closer than the greatest horizontal dimension of any of the individual zones. This is demonstrated by overlaying the modeled mixing zone dimensions with the overall lake area.

2.5.3 Multiple Mixing Zones

IDAPA 58.01.02.060.01(d) provides that multiple mixing zones can be established for a single discharge, each being specific for one or more pollutants. In addition, a single discharger may be allowed two or more discharge points; however, the sum of the mixing zones from those discharge points should not exceed the area and volume that would be allowed for a single mixing zone (IDAPA 58.01.02.060.01(c)). The mixing zone area and volume are generally determined through modeling, as discussed in Section 6.

2.6 Requirements for Submerged Discharges

IDAPA 58.01.02.060.01(a) indicates that mixing zones may receive discharges from a submerged conduit, pipe, or diffuser. Although not required in Idaho rules, a submerged discharge point is preferable because it enhances hydrodynamic mixing. A description of the discharge location and depth should be provided by the mixing zone applicant.

2.7 Special Resource Waters and Outstanding Resource Waters

Idaho's water quality standards define Outstanding Resource Waters (ORWs) as high quality waters which have been designated by the legislature, such as waters of national and state parks and wildlife refuges and waters of exceptional recreational or ecological significance. An ORW constitutes an outstanding national or state resource that requires protection from point and nonpoint source activities that may lower water quality. A Special Resource Water (SRW) is a segment or water body which is recognized as needing special protection to preserve outstanding or unique characteristics or to maintain current beneficial use.

Mixing zones are not prohibited in SRWs or ORWs, and the same considerations given to proposed mixing zones in other bodies of water should be given to SRWs as well as ORWs. However, the expectations of conditions at the edge of the mixing zone boundary as well as the level of scrutiny given to discharges to either type of waters (ORW or SRW) may be much greater in order to meet the requirements set forth in Idaho's antidegradation policies (IDAPA 58.01.02.051) and rules governing point source discharges to special resource waters (IDAPA 58.01.02.400). Implementation of these provisions is beyond the scope and intent of this manual. However, DEQ's evaluation report of proposed mixing zones for the Thompson Creek Mine (DEQ 2000) provides an excellent example of the type of analysis that may be required for new or increased discharges to SRWs.

2.8 Other Considerations

2.8.1 Assimilative Capacity

Mixing zones can only be granted when there is assimilative capacity in the receiving water body. Generally, mixing zones cannot be granted for parameters for which a water body is considered “impaired;” however, exceptions may be granted for parameters that are non-conservative in nature or when the discharge is considered de minimis.

De minimis discharges are those that will have insignificant (e.g., immeasurable) impacts on the receiving water based on concentration or loading. For example, a wastewater treatment plant discharging heated effluent which does not raise background stream temperatures by more than 0.3ºC at the edge of the applicable mixing zone may be considered a de minimis discharge. De minimis determinations will require a case-by-case evaluation by DEQ and EPA, and in all instances, efforts must be made to ensure the mixing zone is as small as possible and does not unreasonably interfere with the beneficial uses of the water body.

2.8.2 Temperature

When evaluating thermal plumes, DEQ will consider the limitations EPA expressed in *EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards* (2003). Thermal plumes should not cause instantaneous lethality; thermal shock; migration blockage; adverse impacts to spawning, egg incubation, and fry emergence areas; or the loss of cold water refugia. In order to minimize or avoid these types of impacts, the following considerations (EPA 2003) will be taken into account when conducting a mixing zone analysis:

- Within two seconds of plume travel from the point of discharge, maximum temperatures should not exceed 32ºC; and
- The cross-sectional area of the receiving water body exceeding 25ºC should be limited to less than 5%; and
- The cross-sectional area of the receiving water body exceeding 21ºC should be limited to less than 25%, or if upstream temperatures exceed 21ºC, then at least 75% of the receiving water body should not have temperature increases of more than 0.3ºC; and
- In spawning and egg incubation areas, the stream temperatures should not exceed 13ºC, or the temperatures should not be increased by more than 0.3ºC above ambient stream temperatures.

2.8.3 Nonpoint Sources

Mixing zones for nonpoint source activities are not specifically mentioned in Idaho’s water quality standards. However, there are instances where mixing allowances are appropriate for nonpoint source activities (such as large soil absorption systems, underground injection, or septic systems). Determining the allowable area for mixing between discharges from these activities and ambient waters is beyond the scope of this document, as the models presented in Section 6 are designed for point source discharges (such as a pipe or channel).

2.8.4 Effluent-dominated waters

In some cases, the volume of discharge may provide a benefit (e.g. flow augmentation) to the beneficial uses of the receiving water body, and this benefit would be lost if the discharge were to cease. In these instances, DEQ may authorize mixing zones which utilize more than 25% of the stream volume at critical flow as long as the mixing zone does not unreasonably interfere with the beneficial uses of the receiving water body.