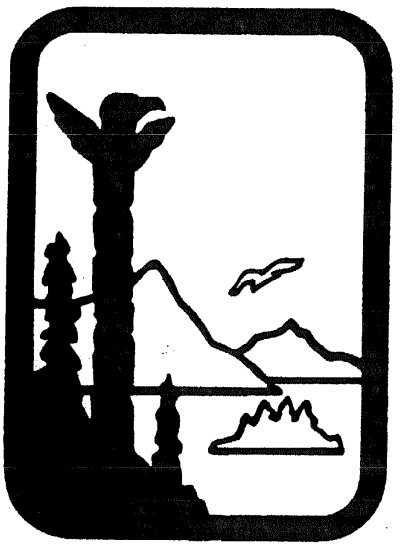
State Of Alaska

DEPARTMENT OF ENVIRONMENTAL CONSERVATION

DIVISION OF WATER



Guidance for Implementation of the Residues Water Quality Criteria

June 12, 2008

TABLE OF CONTENTS

1. INTRODUCTION 1

2. APPLICABLE ELEMENTS OF THE WATER QUALITY STANDARDS 1

3. PROCEDURES 2

3.1. Implementation of the Residues Criteria 2

3.2. Other Water Quality Criteria Associated with Residues Discharges 3

3.3. Guidelines for Nuisance and Objectionable Narrative Residues Criteria 3

3.3.1 Unauthorized Residues and Complaints from Existing Users 4

3.3.2 Land Use and Other Resource Management Plans 4

3.3.3. Existing and Designated Uses 6

Designated uses 6
Existing Uses 6
Protection of Existing and Designated Uses 6

3.4 Assessment of Residues Discharges 7

3.4.1 Potential Effects of Residues 7

Biological Effects 8
Chemical Effects 10
Physical Effects 11

3.4.2 Critical Hydrological, Ecological, and Human Use Characteristics 12

Hydrological Characteristics 12
Ecological and Human Use Characteristics 13

3.5 Methods to Limit and Monitor Residues Discharges 14

3.5.1 Setting Limits, Conditions and Load Allocations 14

Residues on the Water Bottom 14
Residues on the Surface, in the Water Column, and on Adjoining Shorelines 15
Special procedures for Endangered Species and Essential Fish Habitat: 16

3.5.2 Monitoring the Effects of Residues 16

Biological Effects 17
Chemical Effects 18
Physical Effects 20

3.6 Other References for Determining Effects 21

APPENDIX A. WATER QUALITY STANDARDS RELATED TO RESIDUE CRITERIA 23

APPENDIX B. RECOMMENDED CONSERVATION MEASURES FOR LOG TRANSFER FACILITIES/IN-WATER LOG STORAGE AND FISH PROCESSING WASTE-SHORESIDE AND VESSEL OPERATION IMPACTS TO ESSENTIAL FISH HABITAT 27

Department of Environmental Conservation
Guidance for Implementation of the Residues Water Quality Criteria
June 12, 2008

GUIDANCE FOR IMPLEMENTATION OF THE RESIDUES WATER QUALITY CRITERIA

1. INTRODUCTION

Revisions were made to the criteria for residues in the Alaska Water Quality Standards (WQS) on September 1, 2006. The purpose of this implementation guidance is to assist staff of the Department of Environmental Conservation, Division of Water (the Department) in interpreting and applying the residues criteria.

The residues narrative criterion, as revised in 2006, gives discretion to DEC staff to determine what level of residues in a receiving body would constitute an exceedance of the residues narrative standard in 18 AAC 70.020(b)(8) and (20). The Department interprets the residues narrative as requiring protection of designated uses. The State has designated all waters in Alaska for all uses, i.e. water supply, recreation, and growth and propagation of fish, shellfish, other aquatic life and wildlife, except for a few waters reclassified in regulation. Data and analysis may be necessary to determine the amount of residues that may be present and still result in protection of all designated uses. The Department will determine what type and amount of information is necessary, using this guidance document to determine compliance with the residues criterion.

The Department will identify the existing and designated uses of the waterbody including any land use and other resource management plans, evaluate the nature and extent of residues present, their impacts in the receiving water, and consider any complaints regarding residues received. Using this information, the Department will determine whether existing designated uses are affected and whether exceedance of the residues criteria has occurred or is likely to occur and, if so, implement appropriate limits, load allocations and/or monitoring to control any discharge of residues through a permit, certification, total maximum daily load (TMDL), or enforcement action. This guidance provides general direction in each of these areas. The guidance provides a wide range of options to consider; not all considerations will be necessary in every situation. Past evaluations indicate that sensitive environments, large-scale discharges and residues with detrimental characteristics may require extensive evaluations, while simpler evaluations may be sufficient in more routine, better understood situations.

2. APPLICABLE ELEMENTS OF THE WATER QUALITY STANDARDS

Implementation of the residues criteria requires a good understanding of the criteria and other applicable elements of the WQS. In addition to the summary of related water quality criteria and other standards described in this section, the following water quality standards are cited in full in Appendix A:

Residues criteria for fresh waters and marine waters	18 AAC 70.020(b)(8) and (20)
Definition of "residues"	18 AAC 70.900(49)

Definition of "existing uses"	18 AAC 70.900(24)
Designated Uses	18 AAC 70.020(a)

Residues criteria. As with all parameters in the WQS, the residues criteria are stated separately for fresh and marine waters. For both fresh and marine waters, the residues criteria for all designated uses except "Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife" (referred to herein as "aquatic life" criteria) state that residues

> May not, alone or in combination with other substances be present in concentrations or amounts that: form objectionable deposits; constitute a nuisance; produce objectionable odor or taste; or result in undesirable or nuisance species.

For both fresh and marine waters, the residues criterion for aquatic life states that residues

> May not, alone or in combination with other substances be present in concentrations or amounts that form objectionable deposits or result in undesirable or nuisance species.

Also, "objectionable deposits" includes any residue on the surface of the water, within the water column, on the bottom or upon adjoining shorelines that has objectionable properties affecting the uses of the waterbody.

Residues. As defined in the WQS, residues means floating solids, debris, sludge, deposits, foam, scum, or any other material or substance remaining in a waterbody as a result of direct or nearby human activity. This definition is broad, encompassing not only several specific types of residues, but also "any material or substance" that is not dissolved in water.

Designated uses. For residues, as with all parameters under the WQS, there are seven designated uses for fresh waters and seven designated uses for marine waters. Each designated use has an associated water quality criterion. Some designated uses are the same for fresh and marine waters and some are different (see residues criteria in Appendix A). Designated uses are established in 18 AAC 70.020(a). Some designated uses are defined in 18 AAC 70.900.

Existing uses. As defined in the WQS and by EPA regulations, "existing uses" means those uses actually attained in a waterbody on or after November 28, 1975, whether or not they are included in the water quality standards. In most cases, an evaluation of existing uses focus on current local uses of the water.

3. PROCEDURES

3.1. Implementation of the Residues Criteria

Residues in water resulting from human activity that are present on the surface, in the water column, on the bottom, or on adjoining shorelines are subject to the residues criteria; water includes wetlands, and includes ice on waterbodies.

In applying the residues criteria the Department will evaluate existing relevant data and information that is reasonably available for a given situation from within the Department, from a permit applicant or from other sources. In some cases, the collection of new data and information may be required. The Department evaluation will be documented in the record for a permit, TMDL, or other implementation action.

The Department will implement the residues criteria in four primary circumstances:

- evaluating and responding to incidents of unauthorized residues in water;
- setting effluent limits and establishing conditions in wastewater discharge permits and certifications;
- Clean Water Act section 303(d) impaired waters listing and delisting decisions; and
- determining or calculating Total Maximum Daily Load (TMDL) allocations.

The evaluation process to apply the residues criteria in TMDLs is similar to the evaluation process to apply the residues criteria in a discharge permit. The 303(d) listing methodology can be found in *Alaska's Integrated Water Quality Monitoring and Assessment Report.*

3.2. Other Water Quality Criteria Associated with Residues Discharges

The residues criteria are intended to work in conjunction with water quality criteria for other parameters. For example, for seafood and wood waste residues in the water column and on the bottom, the criteria for dissolved oxygen and toxic substances may also be relevant. Discharge of debris or other substances that are not in contact with a waterbody may require a solid waste disposal permit. Criteria for bacteria, petroleum hydrocarbons, oils and grease, color, sediment, turbidity, and other parameters also could be involved. These additional parameters and criteria are found at 18 AAC 70.020(b).

3.3. Guidelines for Nuisance and Objectionable Narrative Residues Criteria

The residues criteria address both aesthetic and functional concerns by using the concepts of "nuisance" and "objectionable." These concepts come from the Environmental Protection Agency (EPA) Water Quality Standards handbook and are common regulatory language in other states.

"Nuisance" and "objectionable" are determinations based on actual or potential degradation of existing or designated waterbody uses as described in Sections 3.4 and 3.5. Residues that are floating, suspended, or settled may constitute a nuisance or objectionable deposit, depending on their characteristics, duration, location relative to waterbody uses, and other factors addressed below.

The Department will evaluate the factors discussed in the following three subsections when determining whether residues would be considered an exceedance. The Department may find an exceedance based on one or more of these factors. Any residues that cause (or could reasonably be expected to cause) a significant degradation of an existing or designated use will constitute an exceedance of the residues criteria. (18 AAC 70.020(b)(8) and (20), note 13)

3.3.1 Unauthorized Residues and Complaints from Existing Users

Complaints regarding effects of residues on the existing or designated uses, or the attraction of nuisance or undesirable species may be an important source of information to support further assessment of residues and their impacts.

The Department will consider the extent to which the presence of residues results in complaints from existing users[1]. An existing user is any person or organization that has current and direct experience with one or more of the waterbody uses protected by the water quality standards.

Historically, complaints received by the Department regarding residues concern unauthorized discharges but can also involve permitted discharges. Complaints typically are received from a small number of sources. A greater number of complaints may indicate a greater degree of public exposure and concern. Aesthetic judgment and values may vary widely between individuals and between neighborhoods or communities. Complaints are an important factor in determining whether the presence of residues constitutes a nuisance or objectionable deposit with respect to existing and designated uses, particularly for those uses that are affected by aesthetic values such as recreational uses.

A complaint concerning residues, insofar as possible, should establish the location and nature of the residues of concern, and the complainant's contact information. The residues must be in contact or have the potential to come in contact with a waterbody or on adjoining shores affecting a waterbody for the residues criteria to apply. If possible, the Department should document the complainant's view of which water uses are affected, and which of the four elements of the residues criteria are at issue, i.e. do the residues in question form objectionable deposits; constitute a nuisance; produce objectionable odor or taste; or result in undesirable or nuisance species.

The Department will consider complaints, along with other factors, to determine whether the aesthetic and environmental effects of residues rise to the level of exceedance of the residues criteria. This evaluation process is discussed further in Section 3.3.3, Evaluating Effects of Residues on Existing or Designated Uses.

3.3.2 Land Use and Other Resource Management Plans

[1] For purposes of complaint investigation, regulatory officials with management or regulatory responsibility concerning a waterbody, including officials of the Department, are also considered to be existing users of all waterbodies.

In evaluating a residues discharge into water, whether actual or proposed, the Department will review and consider applicable land use and other resource management plans adopted by a federal, state, or local government, to help determine whether residues have the potential to constitute a nuisance or objectionable deposit.

Such plans often designate areas for industrial and commercial purposes and areas to be protected for community, recreation, wildlife, and habitat purposes. Review of land use plans that have been through a public review process can provide an indication about a community's expectations for an area. For example, the public may be less tolerant of residues in an area designated for recreational purposes than in an area designated for industrial use. To the extent that the presence of residues is not consistent with land use plans, the Department may determine that residues constitute a nuisance or objectionable deposit in that context.

Note that areas identified for specific purposes in a land use or other resource management plan are not the same as, but may be related to, "designated uses" established in the WQS. Regardless of land use purposes authorized in a land use or other resource management plan, designated uses in the WQS must be protected.

Waters on federal lands are managed by the responsible federal agencies, including the Bureau of Land Management, the U.S. Forest Service, the National Park Service, the U.S. Fish and Wildlife Service, and the military services. These agencies frequently adopt land use and other resource management plans. The U.S. Fish and Wildlife Service designates critical habitat for endangered species. The National Marine Fisheries Service designates essential fish habitat for the protection of fish species covered by the Magnuson-Stevens Fisheries Conservation and Management Act. The Department and EPA prepare and adopt TMDLs or waterbody recovery plans for residues-impaired waterbodies. TMDLs may have specific requirements regarding the amounts and types of residues that may be discharged under permits.

The State of Alaska holds title to submerged lands underlying navigable waters, with the exception of certain submerged land withdrawals for private and federal lands existing at statehood or since conveyed. The Department of Natural Resources (DNR) prepares and adopts area land use plans and management plans for submerged lands and waters under AS 38.04.065 and AS 38.05.300. Adopted plans and those in development can be found on the DNR Land Use Planning Program website at http://www.dnr.state.ak.us/mlw/planning.

Most communities along Alaska's coast have adopted or are in the process of adopting coastal management plans as required under the Alaska Coastal Management Program in AS 46.40. The status of these coastal management plans can be found at http://www.alaskacoast.state.ak.us/District/html/ProgressApproval.htm. Local government comprehensive plans, recreation plans, zoning, and other municipal plans that allow uplands uses that may have an effect on water quality should also be considered..

Any of these plans could be applicable in evaluating residues in Alaskan waters as long as they do not conflict with the protection of the designated uses of the waterbody.

3.3.3. Existing and Designated Uses

Designated uses

Designated uses for water supply, recreation, and aquatic life apply to nearly all waters in Alaska and can be impacted by residues. The designated uses are set by the Alaska Water Quality Standards in 18 AAC 70 and can be found in Appendix A. A few waterbodies listed in 18 AAC 70.230(e) have been reclassified to remove some uses in accordance with applicable regulations. All designated uses that apply to the waterbody must be protected even if they are not currently in practice (e.g., the water may not be currently used as a drinking water source but the water use protection level is for a drinking water source), so that the potential for the designated use will not be lost as a future resource and the designated use determination will be maintained.

Existing Uses

For the purposes of determining compliance with the residues criteria, the focus of the analysis of existing uses will determine current local uses of the waterbody that may be affected by existing or potential residues. These uses can be determined by reviewing relevant and credible information from a permit applicant, the public, and applicable land use and other resource management plans (see Section 3.3.2).

The effort to identify existing uses should correspond to the potential impact of the residue as evaluated in Section 3.4. For residues that are well characterized and the impacts of which have been clearly demonstrated to be of negligible impact on uses, detailed investigation of existing uses may not be necessary. In situations where the residues are not well-characterized or the impacts have not been clearly demonstrated, it may be appropriate to research or consult further to identify and characterize existing uses.

Protection of Existing and Designated Uses

An activity in or near a waterbody involving residues may have the potential to effect designated or existing uses. Evaluation of whether a residue might have an adverse effect on existing or designated uses should be performed in accordance with Section 3.4. Activities with potential to affect existing or designated uses may require a discharge permit to ensure that there is no degradation of the existing or designated uses in the waterbody as a whole.

Incidental activities such as throwing stones, sticks, or other activities which deposit a small amount of natural materials into water is usually presumed to have no affect on existing and designated uses and are not considered to constitute a nuisance or objectionable deposit. However, placement of natural materials, such as log bark and debris, in or near the water in amounts that result in a significant accumulation of residues with potential to affect the uses, will require an authorization or permit.

Similarly, fish and seafood harvesting wastes generated by individuals and households for sport, personal, or subsistence use are generally considered to have negligible effects to existing or designed uses as long as wastes are handled in a manner that does not cause a nuisance to nearby

water users. However, where the activities of individuals are aggregated together to create a significant accumulation of fish wastes at fish cleaning stations in harbors and at boat launch ramps could be considered nuisance and objectionable deposits, depending on the degree of perceived effects. Additional nonpoint source strategies for appropriate waste management and disposal practice may be necessary to control adverse effects to the uses of the waterbody. The control of nonpoint sources of residues may be the responsibility of the property owner, authorized regulatory agencies or other responsible parties. Commercial discharges of fish and seafood residues that accumulate in or near the water in more than trace amounts will need a discharge permit.

Placement of manmade wastes, such as household garbage, household appliances, trash, vehicles, yard wastes, animal wastes, land clearing wastes, construction wastes or other materials in a waterbody or within the high water mark on the shoreline could result in adverse effects to the existing or designated uses unless authorized in a permit.

3.4 Assessment of Residues Discharges

Characterization of the residues and the waterbody are essential in determining how the residues may impact the waterbody and its uses, and to quantify whether there is some specific level of residues that does not degrade the designated uses. An assessment could include the following types of information:

(1) The nature of residues (source, characteristics, amount, placement within the water, duration of discharge, and duration of the residues in the water) and their actual or potential effects on existing and designated uses;
(2) Relevant ecological and hydrological characteristics of the waterbody as they pertain to potential residues effects including the siting considerations for the discharge, waterbody characteristics that affect the duration of residue effects and seasonal variation in waterbody characteristics.

The extent of information required for an assessment will depend on the potential effect of the residue on the receiving waters, sensitive uses, and other factors. The Department can use previously gathered information on the type of residue being discharged. The following sections discuss general categories of information that should be considered. Section 3.5.2 describes the monitoring methods and specific scientific data that may be used for the assessment.

3.4.1 Potential Effects of Residues

The Department will employ the following steps in evaluating a residues discharge for a permit or certification:

(1) Identify designated and existing uses of the waterbody (Section 3.3.3)
(2) Assess the nature, location and duration of the residues discharge (Section 3.4.1)
(3) Assess the characteristics of the waterbody (Section 3.4.2)
(4) Evaluate and document the relationship between level of residues and expected degree of impact on uses given the characteristics of the residues and the waterbody.

(5) Limit and monitor the residue discharge, as specified in a DEC permit, certification, TMDL allocation or other implementation action (Section 3.5).

After identifying the existing and designated uses, the Department will next consider what potential effects the residues might have on these uses. Table 1 lists several biological, chemical, and physical effects that have been reported in the literature for residues.

Table 1. Summary of Potential Effects of Residues

	Designated Use		
Effect Type	**Aquatic Life and Wildlife**	**Recreation**	**Water Supply**
Biological	Algal Blooms	Nuisance species (algal blooms, gulls, aggressive wildlife)	Pathogens - diseases
	Dominance by nuisance, invasive, undesirable species	Attraction of disease vectors (flies, gulls)	
	Loss of native species or habitat		
Chemical	Toxic substances (wood leachate)	Rotten smell (high sulfides, methane), fish oils	Toxics (wood leachate)
	Anoxia (high BOD)		Taste and odor chemicals (surfactants, sulfide)
	Excess nutrients, methane, CO2, sulfide		
Physical	Smothering of substrate, alteration of habitat	Deposits on beaches, other recreation areas	Turbidity
	Turbidity (reduction in light penetration, predator visibility)	Turbidity (reduction in light penetration, cloudy appearance)	Surface accumulation of scum, foam and floating debris
		Surface accumulation of scum, foam, and floating debris	

Biological Effects

Algal Blooms

A potential result of increasing concentrations of nutrients due to organic residues is an increase in phytoplankton biomass. If such an increase in biomass is sufficiently dense, it may be termed an algal bloom. Impacts related to such blooms may include the production of toxins that affect humans and aquatic life, depletion of oxygen levels, and attraction of nuisance species. The occurrence of a bloom is not only related to the input of nutrients, but also to water temperature, mixing and transport. For a given rate of residues discharge, sites with rapid mixing and transport are likely to more rapidly dilute and dissipate nutrients, and are therefore less likely to be impacted by algal blooms than areas with lower dilution or less rapid dissipation of added nutrients. Additionally, the high dissolved oxygen content typical of Alaskan coastal waters near the surface

may make oxygen depletion related to algal blooms less likely. However, dissolved oxygen can be naturally low in the deeper areas of stratified estuaries in summer.

One concern in Alaskan waters is potential increase in biomass of algae in the genus *Alexandrium* that produces a toxin that causes Paralytic Shellfish Poisoning (PSP). Toxin levels in algae, toxicity to humans, and concentrations in shellfish are a function of many factors. The concentration of the toxin is proportional to the number of algal cells present and their growth rate. The development of PSP is dependent in part on salinity and temperature. If the salinity of the system falls below approximately 20 parts per thousand (ppt), generally PSP is unlikely. *Alexandrium* growth, and its occurrence in surface waters (which affects exposure to filter feeding shellfish), is directly related to water temperature. Spring and summer are generally the times during which most PSP outbreaks have been reported.

Nuisance, Invasive, and Undesirable species

Residues can result in the attraction of nuisance and undesirable species. Nuisance and undesirable species include both indigenous and non-indigenous species that impact existing aquatic communities or interfere with other uses of the water. Residues may introduce or attract new species that were not part of the natural communities (e.g., invasive non-indigenous species, predator and scavenger species) by providing a new and abundant food source. Residues may also result in an increase in the abundance of nuisance or undesirable species that were already present (e.g., algal blooms, starfish, and sea cucumber) by changing the physical or chemical conditions of the sediments and/or water column. A shift in the overall structure and productivity of the aquatic ecosystem could displace more desirable shellfish and fish communities. Floating residues, or residues deposited on the shoreline, may attract nuisance and undesirable species that may act as disease vectors (e.g., flies, gulls) or public hazards (e.g., aggressive wildlife) that may interfere with protected water uses such as recreation. Another possible nuisance species effect is the proliferation of bacteria such as *Enterococcus* or other pathogens that can thrive on organic residues deposits. The potential for attraction of nuisance or undesirable species may be evaluated by modeling the fate and transport of residues and conferring with wildlife experts and other appropriate authorities regarding the potential for the simulated residues quantity, nature, and distribution to attract nuisance or undesirable species.

Waste piles and surface accumulations may alter the habitat making it less suitable for native biota and more suitable for nuisance, invasive, and undesirable species. Waste piles may exclude desired species and support high densities of less desirable biota or biota indicative of low dissolved oxygen, such as polychaetes and colonies of the bacteria, *Beggiatoa*. Further, desirable species such as mollusks and demersal fish may be excluded from the areas with the greatest concentration of deposits. The potential for residues to result in presence or dominance of nuisance, invasive, or undesirable species can be evaluated through modeling of residues deposition rates and conferring with appropriate experts regarding the expected benthic response, and by comparison with similar sites where residues deposition has occurred and monitoring has been conducted.

Loss of Native Species and Habitat

Settleable residues, such as seafood processing waste and bark from log transfer facilities (LTFs), may have direct and indirect effects on biota and water quality. Settleable residues from both types of discharges can smother bottom substrate, decreasing available habitat for naturally occurring

benthic fauna and bottom-feeding fish. Loss of aquatic life habitat can ultimately lead to altered ecological structure and function of the system (e.g., loss of desirable or sensitive species; increased abundance of invasive or undesirable species), impairing aquatic life uses.

Some sensitive native species may be reduced or eliminated from the site as the habitat becomes less suitable due to residues smothering of benthic substrate. Marine mammals and birds, including endangered Alaskan species that scavenge on waste piles have been documented to experience such effects as bowel impaction and death as a result of scavenging on the wastes. Marine mammal fur and avian plumage, including those of endangered Alaskan species, may be coated by emulsions or other surface-active substances, leading to loss of insulating properties, hypothermia, and death.

Areas that might be affected by residues will be evaluated by a permittee or the Department to determine whether they contain critical habitat for sensitive species (e.g., fish spawning areas or marine mammal haul-out locations, essential fish habitat, critical habitat for endangered species or species used for subsistence, traditional, sport, or commercial purposes) and whether residues are expected to impact or are impacting such species or uses. Such impacts may be evidenced by declines in population at the site due to avoidance by these species as compared to historic or anecdotal evidence. The Department, after determining the residues characteristics, will consult with relevant authorities regarding sensitive native species and their habitat that potentially could be impacted by the residues.

Objectionable Odors

Decomposition of residues may generate objectionable odors due to sulfides, methane and other decomposition products. As with other potential impacts, the likelihood that such odors will be generated is increased in situations with limited flushing and dissipation of discharged materials. However, in situations where either the discharge itself or deposited residues are transported to depositional areas close to human uses (e.g., boating, fishing, hiking, drinking water source), there is an increased likelihood of aesthetic impacts due to objectionable odors.

Chemical Effects

Toxic substances, nutrients and other chemical contaminants

Accumulations of readily degradable residues can have indirect adverse effects on water quality as the waste decays and microbial decomposition by-products are released as leachates (e.g., polyphenols, terpenoids, monosaccharides, polysaccharides, cyclitols, fatty acid esters, and alkaloids; by-products of wood decomposition such as sulfides, ammonia, and 4-methyl phenol (Dasher et al., 2004, from wood bark waste) that may be toxic to aquatic life, wildlife, or even humans if present in drinking water sources or in contact recreational areas. These by-products could include a surface layer of scum, foam, fine particles, carbon dioxide, methane, nutrients (ammonia, soluble phosphorus), and hydrogen sulfide. These byproducts can directly or indirectly exert a demand on the dissolved oxygen content of the water and within the sediments, reducing or eliminating sensitive species at or near the accumulation. The release of nutrients from decaying organic waste can also result in nutrient enrichment (eutrophication), stimulation of phytoplankton growth, and alteration of the phytoplankton community, as well as the accumulation of buoyant waste solids and oils on the water surface and shorelines. These effects could create taste and odor

problems, degrading drinking water uses, deter avian feeding and visual aquatic predators, degrading aquatic life uses, and create an aesthetically undesirable condition, degrading recreational uses.

Some components of residues may produce toxins at low concentrations, usually as a result of biological and chemical degradation, such as the leachate from wood associated with LTFs. Given environmental conditions in which there is a low degree of dilution and mixing with the receiving waters, such compounds may reach concentrations that are toxic to invertebrates and fish. The potential for leaching or production of toxins may be evaluated by considering the nature of the residues, the characteristics of the receiving waters as described in the following section, relevant experts, and technical literature (e.g., Dasher et al., 2004).

Anoxia

The decay of seafood processing wastes will draw oxygen from the water column, which may result in hypoxic or anoxic conditions. In addition, algal blooms resulting from increased nutrient availability may also result in decreased dissolved oxygen concentrations. In receiving waters with low flushing and dilution such as relatively enclosed bays or slowly moving rivers, there is potential for waste discharge activities to result in hypoxic or anoxic conditions.

Physical Effects

Smothering

Benthic invertebrates and fish eggs can be impacted and possibly eliminated by residues accumulation due to the physical effects of smothering. The potential degree of smothering and habitat loss may be evaluated through modeling of residues deposition in the receiving environment, conferring with appropriate experts, examination of previous dive survey and other data, or other methods. (Dasher et al., 2004)

Turbidity

Increased turbidity due to floating residues, can impact biota by decreasing light penetration resulting in reduced photosynthesis for phytoplankton and attached algae and macrophytes, by clogging gills and filters of fish and other biota, and by decreasing visibility resulting in decreased predation efficiency for fish and other biota (including marine mammals). Turbidity may also affect aesthetics of receiving water and desirability for recreation.

Nuisance or Objectionable Beach Deposits

Beach deposits of residues may impact recreational or water supply uses. As with other potential impacts, it is necessary to evaluate the site-specific environmental conditions to determine whether beach deposits are likely. The proximity of the discharge site to areas supporting recreational and drinking water uses should be considered. An evaluation of population density around the site, the presence of parks or other waterfront recreational uses, and the presence of docks and cruise ships, would help determine the need for examining whether aesthetic impacts to uses have occurred or could occur. Aesthetic considerations could be identified through user surveys.

Surface Accumulations

Discharge of residues and conditions in the receiving system may result in accumulations of foam, scum, oils, particulates and floating debris on the surface and may interfere with fishing, boating, or other recreational uses. Again user surveys or interviews could be used to establish levels of coverage and duration that are considered objectionable. Similarly, spatial coverage of residues on the water surface or shoreline should be considered relative to the total area generally used for recreation purposes. For example, there may be *de minimus* (trace) amounts of residues on or adjacent to a beach used for hiking or wildlife watching that may not constitute use degradation, However, it would be important to confirm that the amounts of residues discharged do not attract undesirable or nuisance species or cause odor or taste problems, thereby adversely affecting designated uses.

The likelihood of any of the above effects in this section occurring at a given site, and therefore, how the standard should be implemented, depends on several factors including:

- the hydrological and ecological characteristics of the waterbody; and
- the type(s) volume, and duration, of residues in relation to these characteristics.

These factors are discussed in the following section.

3.4.2 Critical Hydrological, Ecological, and Human Use Characteristics

Hydrological Characteristics

The hydrological characteristics of the waterbody, including the anticipated mixing characteristics are important in evaluating the potential for residues to degrade an existing or designated use. Key questions that need to be at least qualitatively considered are:

- Are floating residues, even under critical low flow or low flushing conditions, likely to be rapidly diluted or are they likely to persist?
- Are either settleable or floating residues likely to be transported and encounter sensitive areas such as breeding grounds for an endangered species, a recreational area, or a drinking water supply intake?

Different hydrologic environments will have different susceptibilities to residues effects. If residues, under appropriate assumptions (e.g., maximum discharge, critical low flows) are readily mixed and dispersed in the receiving system due to currents or other factors, there may be less potential to degrade an existing or designated use. An example might include a seafood processing facility on a large bay that has strong flushing. Discharges to partly enclosed waterbodies, that have more limited flushing action and/or poor mixing characteristics, are more likely to experience residues accumulations that might impact aquatic life or other designated uses. Characterization of how the residue mixes with the receiving system is needed to determine the potential for accumulations or other residues effects that could degrade designated uses.

Some sites, especially those for which the fate of residues in the system is uncertain, will need site-specific hydrologic information with which to define and characterize the system. Types of hydrologic information that may be used in evaluating potential residues effects include:

- Location of the residues relative to flow patterns of the receiving water;
- Discharge volume on a daily, monthly, and perhaps yearly basis;
- Waterbody system size (e.g., acres) and approximate volume or flow (dry weather as well as average conditions);
- General bathymetry (depth) and bottom topography of the area;
- Results of CORMIX or another hydraulic model to predict the extent to which the discharge will mix with the receiving system; and
- Average residence time of water in the receiving system (for lakes and bays).

Many of the above measures may be obtained from permit records, aerial photos, and bathymetric maps. Not all of the above measures will always be needed for a given site. Those sites with substantial mixing and currents are likely to quickly dilute residues and therefore may require relatively less site-specific information. Those sites that are more enclosed, and/or have much less hydrological mixing or flushing may have more uncertainty and greater potential risk to uses from residues. These situations may therefore require more site-specific information in order to site a new discharge or evaluate compliance with a permit or the residues criteria.

Ecological and Human Use Characteristics

An understanding of natural ecological and human use characteristics is necessary to evaluate potential interactions between site characteristics and residues effects that could contribute to nuisance or objectionable conditions that exceed the residues criteria. Types of ecological characteristics or processes that may be important to consider are:

- The type of benthic community likely to be present given the salinity, general bottom substrate type, and flow of the system;
- Locations of sensitive or unique ecological areas, such as nursery areas for shellfish or fish, in relation to the known or predicted residue presence, including essential fish habitat protected under the Magnuson-Stevens Act;
- Presence of threatened and endangered species or their critical habitats as defined by U.S. Fish and Wildlife Service (USFWS) or National Marine Fisheries Service (NMFS);

- Presence of subsistence or traditional water and aquatic resource uses by local communities, and presence of water-based recreational or commercial activities;
- Background water quality characteristics of the area, such as temperature and dissolved oxygen regimes; and
- The extent of sensitive or ecologically important aquatic vegetation, wetlands, or marshes near the discharge.

Specific types of ecological information needed to evaluate whether residues cause or have the potential to cause a nuisance or objectionable deposit will depend on the site geomorphic and hydrological characteristics and on the types and amount of residues under consideration. Some knowledge of baseline ecological conditions, including the types of fauna and flora that should naturally occur in the system, may be available through various State monitoring program reports, as well as the Department's EMAP Program and NMFS and USFWS reports. Alternatively, benthic bioassessment sampling and dive surveys can be used to characterize and monitor the invertebrate and fish fauna present, as discussed in Sections 3.4.1 and 3.5.2.

3.5 Methods to Limit and Monitor Residues Discharges

3.5.1 Setting Limits, Conditions and Load Allocations

After characterizing the type of residues and the uses in the waterbody, the Department will determine whether the residues have potential to affect existing and designated uses. If the Department determines, based upon its analysis, that there is potential for residues to cause nuisance or objectionable conditions, the Department will set appropriate limits in wastewater discharge permits or certifications, or waste load allocations in TMDLs based upon its analysis such that existing and designated uses will be maintained and protected.

Routine discharges that include well-understood residues may be permitted using general permits, which may include standard practices, effluent limits, and monitoring requirements to ensure protection of uses. If a site specific evaluation indicates that the situation includes sensitive environments, large scale residues or impairments, multiple residues discharges in a single waterbody, or residues with detrimental characteristics, then a more extensive evaluation and an individual permit with more stringent permit limits and/or additional monitoring to measure effects may be necessary. Determinations will be made based on a case-by-case analysis of the residues and waterbody-specific conditions, considering the factors described in Sections 3.4.1 and 3.4.2.

Residues on the Water Bottom

The residues standard has been used historically to address deposition of residues on the water bottom from two industries: LTFs and seafood processing facilities. LTFs occur only in marine waters; seafood processors occur in both marine and fresh waters. Residues deposition in the future could be caused by other types of facilities, as well. One concern associated with deposition from these industries is potential degradation of the designated use for aquatic life. In authorizing discharges in permits, the Department will assess effects to to the waterbody as a whole based on

information provided by the applicant and any other available evidence, considering the overall health of the waterbody rather than evaluating only those effects occurring within the footprint of accumulated residues or within the limited local area of the discharge.

There are exceptions to this waterbody guideline when considering adverse effects to threatened and endangered species under the Endangered Species Act or to essential fish habitat protected under the Magnuson-Stevens Act. In these cases, the Department will consider adverse effects to localized habitats, individuals, or small numbers of organisms as necessary to meet the requirements of these laws. See Section 3.3.3.

The Department anticipates that LTFs and seafood processing discharges generally will be considered as having the potential to cause a nuisance or an objectionable residue if not authorized through discharge permits. To implement the residues criteria in permits, the Department may use the zone of deposit (ZOD) provision under 18 AAC 70.210 to establish an area in a permit or certification where residues deposition is allowed.

The ZOD provisions require the State to consider several factors prior to authorizing a ZOD, including alternatives that would eliminate or reduce adverse effects of the deposit and potential impacts on aquatic life and other uses of the waterbody. ZODs are authorized only when the Department determines through an antidegradation determination that designated uses are protected in the waterbody as a whole.

For the seafood processing industry, the Department has in the past authorized one-acre ZODs based on the Department's determinations under 18 AAC 70.210 and the protection of designated uses. The Department has also in the past authorized certain "project-area" ZODs for LTFs and a one-acre threshold for continuous cover bark and wood debris. The Department retains the discretion under 18 AAC 70.210 to evaluate site specific information that may result in different sized ZODs. This guidance does not cover the water quality standards for ZODs or their implementation in permits and certifications, although siting considerations and effects assessment for residues may also pertain to ZODs.

The residues criteria are also used for developing and implementing TMDLs for deposited residues associated with seafood processors, LTFs and former pulp mill sites. Further information regarding potential effects evaluation and monitoring methods for residues is provided in Sections 3.4 and 3.5.2 of this document.

Residues on the Surface, in the Water Column, and on Adjoining Shorelines

Residues, both permitted and unauthorized, can occur on the surface, in the water column, and on adjoining shorelines. Seafood processing facilities have historically been the primary source of residues that are suspended in the water column, deposited on the bottom, float on the surface, and deposited on adjoining shorelines. These discharges may affect recreational or other water supply uses. Aquatic life and wildlife impacts can involve solids as well as nutrients.

There are currently, seafood processing discharge permits that authorize floating and suspended residues within a mixing zone. The mixing zone regulations in 18 AAC 70.240, under which these

discharges were authorized, have since been revised to prohibit floating residues that form nuisances, and to prohibit residues that form objectionable deposits (except within a ZOD). In addition mixing zones must protect and maintain existing and designated uses, and may not result in undesirable or nuisance aquatic life, or produce objectionable color, taste, or odor in aquatic resources harvested for human consumption. In future seafood processing discharge permits the residues criteria would apply to floating or suspended residues at any point in the water. The Department may allow a limited amount of floating or suspended residues that comply with the criteria, as determined in a permit or certification. These residues limits and conditions may also apply to other types of municipal and industrial discharges that could cause residues to be present on the surface, in the water column, or on adjoining shorelines, in both fresh and marine waters.

Special procedures for Endangered Species and Essential Fish Habitat:

A residues discharge in critical habitat designated under the Endangered Species Act or essential fish habitat designated under the Magnuson Stevenson Act will use the following guidelines:

- If a residue could affect any candidate, proposed, or listed species, or their designated critical habitat as defined in the Endangered Species Act (ESA), the Department will interpret "objectionable" to mean any amount greater than trace amounts.
- The Department may determine that greater than trace amounts of residues are not "objectionable" if, after conferring with the relevant Services, an acceptable level of residues discharge is identified.
- Discharge of a residue that causes undesirable or nuisance species populations to grow in a manner that could have an adverse effect on any candidate, proposed, or listed species, or their designated critical habitat as defined in the ESA will be interpreted as "objectionable."
- If residues discharged could encounter essential fish habitat protected under the Magnuson-Stevens Act, the Department will interpret "objectionable" to mean amounts of residues discharged after recommended conservation measures (see Appendix B) have been applied to the maximum extent practicable.

3.5.2 Monitoring the Effects of Residues

The following sections address methods and indicators that can be used to measure the types of impacts as outlined in 3.4.1 and described in section 3.4.2. In addition, the Department will consider historical complaints or reports of residues from existing users and other factors described in Section 3.3 to evaluate the potential for the residue to cause nuisance or objectionable conditions. If there is a potential to cause nuisance or objectionable conditions, the department may require monitoring to ensure that impacts remain within acceptable limits set in a permit, certification or other department action.

As noted in Section 3.2 and described in Section 3.4, residues can have characteristics and effects that involve other water quality criteria in addition to the residues criteria. The following section describes a range of monitoring options for a residue discharge which may relate to determining

compliance with both the residues criteria and any other criteria which may apply to a residue discharge.

Biological Effects

Several kinds of biological effects can be caused by residues. These include effects on algal communities, benthos, fish, and shellfish. Given the broad applicability of these uses, deleterious effects on any compartment or community of the ecosystem could degrade the overall uses. The following describes monitoring methods that Department may use to identify whether impacts to aquatic life or raw consumption uses could occur, or have occurred, at a given site.

Algal Blooms

The potential for residues to lead to increased nutrient concentrations and changes to phytoplankton biomass and other effects noted in Section 3.4.1 above can be evaluated through aquatic ecosystem modeling under appropriate critical conditions. If simulated biomass endpoints exceed scientifically defensible thresholds, then the Department may conclude that the residue has the potential to cause a nuisance or objectionable condition. Algal biomass is typically monitored by measuring the concentration of chlorophyll *a* (Chl *a*) in the water. For an existing facility, if the nature of the discharge and the receiving system are such that blooms are a potential concern, algal biomass can be monitored during summer periods, when algal biomass is likely to be greatest. For marine systems, NOAA has identified a threshold Chl *a* concentration of 60 µg/L to define a hypereutrophic system and a Chl *a* concentration > 20 µg/L is considered moderately eutrophic. EMAP has used the same thresholds in their assessments of Alaskan coastal waters.

Constituent	Concentration	Condition
Ch *a*	60 µg/L	Hyper-eutrophic
Ch *a*	20 µg/L	Moderately eutrophic
Light Transmission/ Turbidity	>10%	Impairment

Because algal blooms reduce light transmission in the water column, turbidity and light transmission measures can also be used to identify whether aquatic life use impairment has occurred. As indicated in 18 AAC 70, a decrease in light transmission depth > 10 percent or an increase in turbidity by 10 percent over natural conditions, could be considered an impairment.

The Department's Division of Environmental Health has a Food Safety & Sanitation Program that samples harvested shellfish for Paralytic Shellfish Poison (PSP), which is related to a specific type of algal bloom. If there is concern regarding the potential for a bloom to occur, the Department will assess past blooms in the vicinity of residues and determine whether monitoring of harvested shellfish for PSP and other toxins may be appropriate.

Dominance of Nuisance, Invasive, and Undesirable species

The Department may require benthic monitoring by divers or by boat using grab samples of the bottom substrate, to determine whether the diversity of species is typical of the use or if dominance of a particular undesirable or pollution-tolerant species is present, in which case a remediation plan may be required.

Monitoring may include biological indicators to determine whether degradation has occurred and whether remediation is needed when monitoring effects to sensitive species and habitat. EMAP and NOAA both have developed biological indicators of benthic community integrity for estuarine and marine areas of Alaska that may also be used evaluating residues impacts. The Department and DNR have established sampling methods and biological indicators for freshwater streams and rivers. All of these methods and measures rely on some knowledge of baseline or reference conditions as a basis for comparison to determine whether aquatic life uses are degraded. EMAP coastal data, along with Department biological data collected for select coves (e.g., Cook Inlet) can provide a representative baseline in many cases. Significant departures of specific metrics or indicators from baseline (e.g., lower than normal abundance and diversity of mollusks in samples, higher densities of worms than normal) may indicate aquatic life use degradation. In systems that have been previously impacted by human activities, baseline ecological conditions may not be determined via sampling. In these cases, the Department may find it more useful to evaluate current ecological conditions on the basis of the presence and extent of nuisance growths/species and other aquatic life use indicators of residues exceedances.

Monitoring of shoreline areas for residues and increased densities of potential nuisance species may be required by or conducted by the Department if pre-discharge predictions or post-discharge observations indicate that such accumulations occur to an extent to attract such species. Monitoring could include visual inspections under environmental conditions expected to result in such beach deposition or surface accumulation, based on the site characterization and/or knowledge of currents at the site.

Other possible biological monitoring requirements include water column measurements of enterococci bacteria, using EPA methods. Monitoring of coliform bacteria or other microbiological levels also may be appropriate, as wildlife may be a source of water-borne pathogens. Examinations of non-migratory fish collected at the site for lesions or infections (using methods developed by EMAP) could help indicate whether pathogen-impairment of human consumption use may have occurred.

Finally, qualitative surveys of gull abundance, flies, or other nuisance species if environmental conditions in the receiving system encourage potential surface or shoreline accumulations of residues. Aggressive wildlife (e.g., bears) reports could also serve as documentation that recreational uses may be impaired due to nuisance species. Such monitoring could include visual inspections timed to coincide with times when human recreational uses are greatest (e.g., summer).

Loss of Native Species

If sensitive species and habitats are identified during the permitting process, the Department may require periodic monitoring (which may include pre-discharge monitoring) during the life of a permit to ensure that impacts of residues on identified species are prevented or minimized.

Chemical Effects

Toxic Substances

Monitoring could include grab samples of benthic substrate which could be used to characterize the benthic community composition. The results of such sampling could be compared to site specific baseline reference data or regional monitoring data in order to determine whether or not the community was impacted, but would not necessarily indicate the cause of the impairment (e.g., pollutants, natural habitat deficiencies, chemical or physical effects of residues). Sediments and whole effluent toxicity (WET) testing may be useful to determine whether chemical effects of residues could impact or are impacting aquatic life uses. In situations in which there has been determined to be a potential for release of toxic concentrations of such compounds, periodic ecological monitoring may be an appropriate permit requirement.

Alaska's water quality criteria for toxic and other deleterious substances can be found in 18 AAC 70.020(b)(11) for fresh water and 18 AAC 70.0020(b)(23) for marine water and the *Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Substances*. Narrative criteria for toxics substances for the aquatic life uses are as follows:

> "There may no concentrations of toxic substances in water or in any shoreline or bottom substances that singly or in combination cause, or can be expected to cause, adverse effects on aquatic life or produce undesirable or nuisance aquatic life, except as authorized in this chapter. Substances may not be present in concentrations that individually or in combination impart undesirable odor or taste to fish or other aquatic organisms, as determined by either bioassay or organoleptic tests."

Anoxia

Alaska water quality standards for dissolved oxygen can be found in 18 AAC 70.020(b)(3) and (15).

The Department may require monitoring of ambient oxygen concentrations in receiving waters with limited mixing and dissolution of discharged and deposited materials resulting in residue formation. Dissolved oxygen concentrations immediately above seafood waste piles or large accumulations of LTF debris may be significantly lower than ambient levels and may be hypoxic or anoxic. Rapid mixing with ambient waters and flushing into a larger receiving waterbody may offset such areas with depressed oxygen levels. The Department could use benthic monitoring (described earlier), as well as sediment biological oxygen demand (BOD) analyses and dive surveys of the size and depth of residue piles to supplement direct DO monitoring to determine whether residues are causing low oxygen levels. It is important to note, however, that monitoring data indicates that low DO levels may occur naturally in some estuaries, and may not necessarily indicate impairment.

Objectionable Odors

If residues have the potential to cause objectionable odors, the Department will set appropriate permit limits to ensure that nuisance or objectionable conditions do not occur. The Department may require direct measurements of sulfides or methane in sediments or the water column to determine levels at which these chemicals are present.

The Department may identify user groups in the area that may be impacted by aesthetic effects and use either informal surveys or interviews to determine whether a given condition would be considered a nuisance or objectionable. The responses to such queries will generally be interpreted on a site-specific basis, as the level of residues impact tolerated by recreational and commercial

users of a given resource are likely to vary based upon the actual uses of the receiving water (e.g., shoreline bird-watching and clamming versus recreational boat fishing and upland hiking near to, but not on the water). The types of user groups that might be identified could include local or seasonal residents, commercial fishermen, professional fishing guides and outfitters, cruise ship tourists, tour operators, shoreline business owners, and hiking and outdoor recreation groups that may use the area. The need to examine aesthetic impacts on odor should consider the duration over which residues-caused odors occur and the amount of time spent by people using the site for aesthetic or recreational purposes.

Physical Effects

Smothering

Bark deposits of up to 40% coverage seem to exhibit increased species diversity and abundance. The bark may provide attachment surfaces and carbon sources to support new species without completely displacing existing species. A mix of adverse effect and beneficial effects may be expected above 50%, although the evidence of where adverse effects dominate is unclear. (Dasher et al., 2004)

Monitoring of residue accumulations that may result in smothering include dive surveys as required by the Department. Alternatively, benthic samplers, deployed outside a permitted ZOD, could be used to determine the benthic community composition in such areas and whether or not areas beyond the ZOD have been impacted by waste deposition. Key indicators of smothering in this case would be high sediment biochemical oxygen demand (BOD), presence of sulfide, methane or other chemical products of anaerobic metabolism in the sediments, and discoloration of the sediment, indicating the presence of reduced metals (i.e., low oxygen – see Anoxia section).

Additional methods of monitoring residues accumulation in sediments may include the following:.

- Sediment vertical profile imaging (SVPI). A camera is lowered to the bottom on a frame and penetrates vertically into the sediment. This approach takes a cross-section of the top 20 cm of sediment, and is used to determine the depth of the bark layer, the depth at which oxygen penetrates into the sediment, and any benthic organisms present.
- Using cameras to observe fixed areas for residues accumulation using vertical camera images.
- Deployment of residues traps that could be set for a period of time, retrieved and the residues measured to determine the amount of residues being generated.
- Sampling using coring techniques to differentiate the historic deposits from new deposits. This could also be used to estimate percent bark cover.

Turbidity

Alaska's water quality criteria for turbidity are found at 18 AAC.70.020(b)(12) for fresh water) and 18 AAC 70.020(b)(24) for marine water.

The Department may require monitoring of turbidity if conditions in the receiving system are such that increases in turbidity may result from discharge of residues. These conditions would include

sites with little mixing or flushing for prolonged periods, and sites in which the volume of floating residues discharged exceeds the assimilative capacity of the water.

The Department may also evaluate the potential for these residues effects by reviewing monitoring results from discharge of residues in similar receiving environments, modeling residues discharges and the receiving water response, or other methods.

Nuisance or Objectionable Beach Deposits

If environmental conditions are such that beach deposits have occurred or have the potential to occur at or near beaches frequented by people, the Department may set appropriate permit limits for residues to ensure that nuisance or objectionable deposits do not occur. In addition, the Department may require a visual monitoring program to detect the occurrence of beach deposits that may impact recreational uses.

Surface Accumulations of Foam, scum and floating debris

The Department will set appropriate permit limits for residues to ensure that objectionable residues do not occur. A monitoring program to evaluate the extent of these accumulations may be necessary. The scope and extent of such a monitoring program would be influenced by the proximity of the discharge and receiving water to areas utilized for recreation (e.g., boating) and water supply. Depending on the extent of the observed or predicted accumulations, a monitoring program consisting of visual observations from shore or from a boat in the receiving system could be used to qualitatively determine the approximate spatial coverage of the residues on the water surface or shorelines. The timing of such monitoring efforts could also be arranged to coincide with likely periods of maximum human recreation or other aesthetic uses.

3.6 Other References for Determining Effects

Numerous scientific studies have documented various effects of residues on established aquatic communities and species. The following studies and reports may assist with evaluating thresholds for compliance and impairment decisions.

- *Environmental Impacts of Residues on the Aquatic Environment*, May 2004, Dasher, et al., Alaska Department of Environmental Conservation.
- *Marine Environmental Assessment Report: The Effects of Seafood Waste Discharges on the Benthic Environment at Ketchikan, Alaska*, June 2004, Germano & Associates. Prepared for Tetra Tech, Inc., Mountlake Terrace, Washington.
- *Final Decision: Department of Environmental Conservation Adjudication in the Matter of EPA General Permits AK-G70-1000 and AK-G70-000*, May 2002.
- *Log Transfer Facility Siting, Construction, Operation and Monitoring/Reporting Guidelines, October 1985, Alaska Timber Taskforce, Alaska Department of Environmental Conservation.*

- *Final Draft Report: Ocean Discharge Criteria Evaluation of The NPDES General Permit for Alaskan Log Transfer Facilities. for Log Transfer Facility General Permits. April 1996. Prepared by Tetra Tech. EPA Region X Seattle Washington. TC B216-1.*
- *Final Report: Department of Environmental Conservation Cottonwood Creek TMDL Development – Residues*, June 30, 2005. Prepared by The Aquatic and Restoration Research Institute, Talkeetna, AK.