ALASKA LEGISLATURE COMMITTEE FILES 1991-1992 8672
7614 SENATE RESOURCES

Technical Information

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Technical Information

I. Applicant

Ketchikan Pulp Company (Ketchikan Pulp Mill)

Mailing Address:	Facility Location:
P.O. Box 6600	Mile 8.5 North Tongass Highway
Ketchikan, Alaska 99901	Ketchikan, Alaska 99901

Contact: Robert W. Higgins, Environmental Director

NPDES Permit No.: AK-000092-2

II. Activity

Ketchikan Pulp Company (KPC) is engaged in the manufacturing of dissolving or paper grade wood pulp utilizing the magnesium base, acid bisulfate process. Activities include woodchip production from roundwood; pulping of woodchips; capturing of spent cooking liquor for evaporation; incineration with chemical and heat recovery; screening and cleaning of pulp to remove impurities; bleaching using chlorine and caustic; and drying and finishing for customer use.

An average of 31 million gallons per day (mgd) of wastewater generated in the manufacturing process are discharged from three outfalls into Ward Cove. Wastewaters discharged through outfalls 001 and 003 receive no treatment, while most wastewaters at outfall 002 receive secondary treatment from a primary clarifier, activated sludge basin, and secondary clarifier prior to discharge. Part of the 002 discharge receives primary treatment only.

Sludge generated in the primary clarifier (30 - 40 tons/day) is dewatered and mixed with hog fuel. The combination waste sludge and hog fuel is then dried and burned in woodwaste/oil burners. The fly ash is disposed of on mill property. Most of the sludge generated in the secondary clarifier is returned to the activated sludge basin. The company has indicated that excess sludge not returned to the activated sludge basin is discharged through outfall 002. This practice is prohibited in the proposed permit.

III. Background

The current permit for KPC was reissued on December 28, 1984, and expired on January 29, 1990. An application for permit reissuance was received on August 4, 1989. The company is operating under the terms of the expired permit during the reissuance process in accordance with the regulations (40 CFR 122.6).

IV. Receiving Water

Wastewaters from the mill are discharged into Ward Cove, located on the north side of Tongass Narrows, about 5 miles northwest of Ketchikan, Alaska. The cove is approximately 0.3 mile wide at the entrance, 0.5 mile wide at the widest point, and approximately 1 mile long.

Ward Cove has been classified by the Alaska Department of Environmental Conservation (ADEC) as marine water with water use classes 2A through 2D (water supply; water recreation; growth and propagation of fish, shellfish, other aquatic life, and wildlife; and harvesting for consumption of raw mollusks or other raw aquatic life).

A map of the facility location and Ward Cove is included in the draft problem assessment for dissolved oxygen, which accompanies this fact sheet.

Discussions of the impacts of the KPC discharge on water quality within Ward Cove are found in both this fact sheet and the problem assessment document.

V. Discharge Composition

The following pollutants were reported by the Permittee as being present in the discharge, according to KPC's NPDES application. The toxic and conventional pollutant categories are defined in the regulations (40 CFR 401.15 and 401.16). The category of nonconventional pollutants includes all pollutants not included in either of the other categories.

(1) Conventional pollutants - biochemical oxygen demand (BOD_5), total suspended solids (TSS), pH, oil and grease, and fecal coliform.

(2) Toxic pollutants - 2,3,7,8-TCDD, 2,4,6-trichlorophenol, bis (2-ethyl-hexyl) phthalate, cadmium, copper, chromium, zinc, mercury, nickel, chloroform, phenols.

(3) Nonconventional pollutants - temperature, fluoride, color, phosphorus, manganese, iron, adsorbable organic halogens, furans, magnesium, organic nitrogen, chlorine, sulfate, sulfite, sulfide, surfactants, and aluminum.

In developing the proposed permit conditions, EPA has evaluated the concentrations of these pollutants relative to the levels allowed under federal regulations and the state water quality standards.

VI. Compliance Status

At the time the current permit was issued, KPC was unable to comply with the effluent limitations for Biochemical Oxygen Demand (BOD_5) under promulgated guidelines (40 CFR 430) for the Pulp, Paper, and Paperboard Category. An earlier request by KPC for a fundamentally different factors (FDF) variance from the guidelines was denied on September 21, 1984. In response to KPC's inability to comply with the terms of the permit in 1984, EPA issued a consent order following permit reissuance which established interim and final limitations and a schedule for design and construction of treatment systems to bring the facility into compliance. Full compliance with the permit was required no later than December 31, 1987.

As of December 31, 1987, KPC was not in compliance with effluent limitations for BOD_5. As a result of this and other violations, EPA and KPC entered into a consent decree establishing penalties for past and future permit violations on November 13, 1989. The consent decree expired six months later (May 1990).

VII. Permit Conditions

A. General Approach

Sections 101, 301(b), 304, 401, 402, and 405 of the Clean Water Act provide the basis for the effluent limitations and other conditions in the draft permit. EPA evaluates discharges with respect to these sections of the Act and the relevant NPDES regulations in determining which conditions to include in the permit.

In general, EPA first determines which technology-based limits are required, as well as best management practices or other requirements. EPA then evaluates the effluent quality expected to result from these controls, to see if the effluent could result in any exceedances of the water quality standards in the receiving water. If exceedances could occur, EPA must include water quality-based limits in the permit. The permit limits will thus reflect whichever limits (technology-based or water quality-based) are most stringent.

Under section 303 of the Act and 40 CFR 122.44(i), EPA must also include monitoring requirements in the permit to determine compliance with effluent limitations. Effluent and ambient monitoring may also be required to gather data for future effluent limitations or to monitor effluent impacts on receiving water quality.

The basis for each permit condition is described in more detail below.

B. Technology-Based Evaluation

1. Statutory Basis for Technology-Based Limits

The Act requires particular categories of industrial dischargers to meet effluent limitations established by EPA. The Act initially focused on the control of "traditional" pollutants (conventional pollutants and some metals) through the use of BPT. Industries were required by section 301(b)(1)(A) of the Act to meet this level of control by July 1, 1977. Section 301(b)(3) of the Act allowed a deadline of March 31, 1989, under certain circumstances, but that deadline has also passed. Thus, permits issued after March 31, 1989, must include any conditions necessary to ensure that the BPT level of control is achieved.

Section 301(b)(2) of the Act requires further technology-based controls on effluents. After March 31, 1989, all permits are required by sections 301(b)(2) and (3) of the Act to contain effluent limitations for all categories and classes of point sources which: (1) control toxic pollutants and nonconventional pollutants through the use of best available technology economically achievable (BAT), and (2) represent best conventional pollutant control technology (BCT) for conventional pollutants. In no case may BCT or BAT be less stringent than BPT.

In many cases, BPT, BCT, and BAT limitations are based on effluent guidelines developed by EPA for specific industries. Where EPA has not yet developed guidelines for a particular industry or a particular pollutant, permit conditions must be established using Best Professional Judgment (BPJ) procedures (40 CFR 122.43, 122.44, and 125.3).

As required by section 304(b)(2)(B) of the Act, when developing BPJ/BAT permit conditions, the Agency must consider the age of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, the cost of achieving such effluent reduction, non-water quality environmental impact (including energy requirements), and such other factors as EPA deems appropriate.

As required by section 304(b)(4)(B) of the Act, when developing BPJ/BCT permit conditions, the Agency must consider the reasonableness of the relationship between the costs of attaining a reduction in effluent and the effluent reduction benefits derived, the comparison of the cost and level of reduction of such pollutants from the discharge from publicly owned treatment works to the cost and level of reduction of such pollutants from a class or category of industrial sources, the age of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, and non-water quality environmental impact (including energy requirements).

2. Effluent Limitation Guidelines

Effluent Limitations Guidelines, 40 CFR Part 430 (Pulp, Paper, and Paperboard) have been promulgated for BPT (January 6, 1977), BCT (December 16, 1986) and BAT (November 18, 1982 & July 8, 1983). The subparts of these guidelines applicable to KPC are the following: Subpart K - Dissolving Sulfite Pulp Subcategory and Subpart U - Papergrade Sulfite (Drum Wash) Subcategory.

3. Production Bases

The effluent limitations guidelines specify that for the purpose of establishing limitations:

"Production shall be defined as the annual off-the-machine production divided by the number of operating days during the year." and "Production shall be determined for each mill based on past production practices, present trends, or committed growth."

In order to determine past production practices and assess production trends, monthly production by type (i.e. papergrade, nitration, viscose, and cellophane) and operating hours were tabulated for KPC. Characteristics of pulps produced at KPC were compared to those delineated in the BPT Development Document to determine which pulp type was appropriate. This comparison is provided in Attachment A. In addition, 12 month moving averages were calculated to determine annual average values. A review of these data show that production is variable with no apparent trends.

4. Permit Requirements

a. BPT

Biochemical Oxygen Demand and Total Suspended Solids

BPT effluent limitations were derived using annual average production and the appropriate BPT effluent limitations guidelines. Using the 12 month moving average for total production and the percentages for that same period of various grades, the effluent limitation for each grade was applied and the result totaled. The results of this tabulation were then scanned to determine the 12 month period for which the largest effluent limitation was obtained. This period was April 1988 through March 1989, when the total production was 672 tons/day, of which 1.3 percent was papergrade, 62.5 percent was nitration grade, 20.7 percent was viscose grade, 15.5 percent was cellophane grade. The effluent limitations shown below reflect an allowance for hydraulic debarking of 0.7 pounds BOD_5 per ton (Operating Average), 1.4 pounds BOD_5 per ton (Daily Maximum), 0.2 pounds TSS per ton (Operating Average), 0.3 pounds TSS per ton (Daily Maximum) which needs to be added for 336 tons of production (50%). The resulting limitations are as follows:

	Operating Average	Daily Maximum
BOD_5, pounds/day	30,200	58,100
TSS, pounds/day	51,000	94,600

In the proposed permit, EPA has replaced the term "Daily Average" with "Operating Average" to highlight the method for determining average discharge values. As discussed above, the limitations are based on formulas in the effluent guidelines for pulp mills, historic production volumes, and historic data for the number of days of production, which KPC calculated by summing the hours of production over a calendar month and dividing by 24 to obtain a number of "production days" for the month. EPA has clarified the definition of a "production day" in the permit to provide consistency with the "production days" reported by the KPC for purposes of developing limitations.

The BPT effluent limitations represent a slight decrease over the effluent limitations of the expiring permit due to decreased production. In the proposed permit, the BOD_5 limitations above apply between November and May, while the limitations for the summer months (June through October) are more stringent than those shown above. This is because the water quality-based limitations for BOD_5 in the summer months are more stringent than these technology-based limitations. The water quality-based limitations are described in this fact sheet (under Water Quality-Based Evaluation); the technical support for the limitations is included in the "Draft Problem Assessment: Ward Cove" accompanying this fact sheet.

pH

The BPT guidelines require that effluent pH fall within the range of 5 to 9 standard units. Under the NPDES regulations, the total time during which the pH values are outside the required range shall not exceed 7 hours and 26 minutes (which constitutes 1% of the time) in any calendar month, and no individual excursion shall exceed 60 minutes duration (40 CFR 401.17). This provision does not apply to water quality-based limits. Therefore, the permit contains a technology-based pH range of 5 to 9 that may be exceeded under the above requirement and a water quality-based pH range that may not be exceeded. These latter limitations are further described in the "Water Quality-Based Evaluation" section of this fact sheet.

b. <u>BCT</u>

On December 16, 1986, EPA promulgated BCT effluent limitations guidelines for the pulp, paper, and paperboard industry. These BCT limitations set BCT equal to BPT for the subcategories under which KPC's effluent limitations are derived.

c. <u>BAT</u>

<u>Pentachlorophenol and Trichlorophenol</u>

The promulgated BAT guidelines establish limitations on pentachlorophenol and trichlorophenol, or, as an alternative, require that the Permittee certify that these chlorophenolic-containing biocides are not used at the facility. According to the 2c section of KPC's application, 2,4,6-trichlorophenol has been detected in the effluent at outfalls 001 and 002. Pentachlorophenol is reported as not detected. As discussed in EPA's <u>Final Development Document for Effluent Limitations Guidelines and Standards for the Pulp, Paper and Paperboard Point Source Category</u> (October 1982), these results are expected for this facility. Trichlorophenol is a contaminant that is generated during the bleaching process and would be expected in the effluent even though the Permittee has certified that trichlorophenol is not used as a biocide. The only sources of pentachlorophenol are biocides or wastepaper that may be pulped. Because KPC does not pulp wastepaper and has certified that it does not use pentachlorophenol as a biocide, this compound would not be expected in the effluent.

Because 2,4,6-trichlorophenol is present in the effluent, a technology-based limit for it was calculated as follows:

Subpart U
Daily Max = .0036exp(.017 x 1.00) = .0037 lbs/1000 lbs product
= .0037 lbs/1000 lbs x 1,344,000 lbs production
= 4.97 lbs trichorophenol

Subpart K
Daily Max = .019 lbs/1000 lbs product x 1,344,000 lbs production
= 25.5 lbs trichorophenol

Weighted Average Calculation
(accounting for activity falling under each subpart)

Percentage of production under subpart U = 1.3%
Percentage of production under subpart K = 98.7%

Using the following equation the daily maximum limitation is:

Daily Max = (% U)(U limitation) + (% K)(K limitation)
= (.013)(4.97) + (.987)(25.5)
= 25.2 lbs/day

Because this limit is not sufficient to protect water quality, the limit in the draft permit is more stringent (see "Water Quality-Based Evaluation"). As discussed above, no limit is necessary for pentachlorophenol. As in the existing permit, the draft permit requires that the Permittee certify that pentachlorophenol in not used as a biocide. The draft permit requires that this certification be submitted annually, along with a report of the amounts and types of biocides that have been used. In addition, the permit requires monitoring for pentachlorophenol.

d. Other Technology-Based Requirements

BAT for Adsorbable Organic Halogens (AOX)

At this time, EPA does not have enough information to establish BAT for AOX for the dissolving sulfite subcategory of the pulp and paper point source category. The draft permit requires weekly monitoring for AOX, with a reopener clause that states that the permit may be reopened to establish technology-based limits for AOX when sufficient data are available.

BCT for Sanitary Wastes

Sanitary wastewater is treated by primary settling, biological (secondary) treatment, and disinfection prior to discharge through outfall 001.

The existing permit contains limitations on fecal coliform bacteria and total residual chlorine in treated sanitary wastewater. The proposed permit contains the same limitations for these pollutants; additionally, it contains BOD_5 and TSS limitations indicative of secondary treatment performance. The additional limitations are based on Best Professional Judgement (BPJ) and the Alaska wastewater disposal regulations (18 AAC 72). The state regulations require secondary treatment of domestic wastewater unless a reduced treatment level is established by the Department of Environmental Conservation in response to a request by the applicant. Secondary treatment is defined in both the state regulation and in federal regulations (40 CFR 133) as a monthly average limit of 30 mg/l and a weekly average limit of 45 mg/l for BOD_5 and TSS. These limits apply at the secondary treatment plant effluent before it commingles with the process effluent.

C. Water Quality-Based Evaluation

1. Statutory Basis for Water Quality-Based Limits

Section 301(b)(1) of the Act requires the establishment of limitations in permits necessary to meet water quality standards by July 1, 1977. Discharges to state waters must also comply with limitations imposed by the state as part of its certification of NPDES permits under section 401 of the Act.

The NPDES regulations at 40 CFR 122.44(d)(1) require that permits include limits on all pollutants or parameters which "are or may be discharged at a level which will cause, have the reasonable potential to cause, or contribute to an excursion above any State water quality standard, including State narrative criteria for water quality" (54 Fed. Reg. 23868-23899; June 2, 1989).

The regulations require that this evaluation be made using procedures which account for existing controls on point and nonpoint sources of pollution, the variability of the pollutant in the effluent, species sensitivity (for toxicity), and where appropriate, dilution in the receiving water. The limits must be stringent enough to ensure that water quality standards are met, and must be consistent with any available wasteload allocation.

The regulations also specifically address when the toxicity and chemical-specific limits are required. A toxicity limit is required whenever toxicity is at a level of concern (as discussed above) relative to either a numeric or narrative standard for toxicity. The only exception is where chemical-specific limits will fully achieve the narrative standard. A chemical-specific limit is required whenever an individual pollutant is at a level of concern (as described above) relative to the numeric standard for that pollutant. The regulations also provide three options for developing a chemical-specific limit needed to control a pollutant which does not have a numeric standard, but is contributing to a problem with the narrative standard.

In proposing to reissue the permit, EPA has considered Alaska's antidegradation policy (18 AAC 70.010(c)). The reissuance of this permit will result in decreases in pollutant loading to the receiving water; therefore, this action complies complies with the state's antidegradation policy.

2. Wasteload Allocations and Mixing Zone Boundary

The wasteload allocation is the concentration (or loading) of a pollutant that may be discharged by the Permittee without violating water quality standards in the receiving water. For the KPC facility, three distinct approaches were taken to determine wasteload allocations for BOD_5, aquatic life parameters, and human health parameters. The BOD_5 allocation is based on an assessment of the BOD_5 loading capacity of the entire cove; pollutants toxic to aquatic life are addressed through a spatial dilution analysis, where toxicants cannot exceed the water quality criteria outside a mixing zone within the cove; and pollutants that present a risk to human health cannot exceed the water quality criteria at the end-of-pipe (no mixing zone allowed).

a. BOD_5 - Total Maximum Daily Load

There are times of the year, particularly during the months of July, August, and September, when the dissolved oxygen (DO) standard is violated in Ward Cove. These violations have been documented in several water quality surveys by state and federal agencies as well as by surveys conducted by KPC in compliance with the conditions of the expiring permit. These violations are primarily the result of the discharge of oxygen demanding wastewaters from the KPC facility.

In the most recent report, Jones and Stokes (August 2, 1989) reviewed the results of previous studies and conducted an intensive short-term field study. In the document entitled "Problem Assessment: Ward Cove" that accompanies this fact sheet, EPA has used information from the Jones and Stokes study and KPC's monitoring results to develop a model of the dissolved oxygen budget in Ward Cove. This model supports the establishment of a Total Maximum Daily Load (TMDL) for BOD_5 in Ward Cove, the allowable BOD_5 load to the Cove that is protective of water quality standards. The problem assessment and draft TMDL accompanies this fact sheet. Based on the draft TMDL, the wasteload allocation for KPC is 16,000 lbs/day BOD_5. Seasonal discharge limitations (for the months June through October) are derived using this allocation. During the remaining months (November through May), the facility must meet the technology-based limitations discussed earlier in this fact sheet.

b. Toxicity to Aquatic Life - Mixing Zone

Alaska's water quality standard for toxicity states that substances must not exceed 0.01 times the lowest measured 96-hour LC50 for the most sensitive test organism or EPA Gold Book criteria, whichever is more stringent.

Wasteload allocations for toxic parameters are calculated using available dilution in the mixing zone established in accordance with the Alaska water quality standards. The standards specify that a mixing zone may not exceed 10% of the width of the cove, nor exceed 10% of the total area of the cove, unless the Permittee demonstrates that a larger mixing zone is appropriate. Ward Cove is approximately 2500 feet wide at the discharge point, and its total area is approximately 0.35 square miles. The allowable mixing zone radius using the areal constraint (a semi-circle equal to 0.035 mi^2) is approximately 557 feet. The linear constraint under the standard is more stringent, allowing a mixing zone radius of about 250 feet from the discharge point.

Using a three-dimensional dilution model, EPA estimates that the dilution at a distance of 250 feet from each outfall is as follows:

Outfall	Dilution
001	14:1
002	14:1
003	74:1

As part of the state's certification under section 401 of the Act, these mixing zones will either be approved or modified. If the mixing zones approved by the state are different from the ones used to calculate the limits for the draft permit, the limits in the final permit will reflect these changes.

c. Human Health Concerns (Carcinogenic Pollutants)

The Alaska water quality standard for mixing zones (18 AAC 70.032) states, in part, the following:

> "In applying the water quality criteria set out in this chapter, the department will, upon application and in its discretion, prescribe in its permits or certifications a volume of dilution for an effluent or substance within a receiving water unless pollutants discharged could bioaccumulate; concentrate or persist in the environment; cause carcinogenic, mutagenic, or teratogenic effects; or otherwise present a risk to human health;"

Based on this standard, EPA has not proposed a mixing zone for four pollutants (chloroform, 2,4,6-trichlorophenol, manganese and dioxin) which present a risk to human health due to their bioaccumulative and carcinogenic properties. Wasteload allocations are therefore set equal to the water quality criteria. If the state determines that there are no human health effects due to the discharge of these pollutants, the may designate a mixing zone. If a mixing zone is designated, the permit limits for those compounds will be adjusted accordingly.

The state of Alaska has not yet adopted specific numeric criteria for pollutants which pose a potential risk to human health. The state's standard for raw mollusk harvesting, however, references EPA's Quality Criteria for Water (Gold Book, 1986) as standards for toxic substances. The Gold Book contains concentrations of carcinogens that correspond to specific risks. The risk level chosen in this case is 10^{-6} or one excess cancer case per one million people due to ingestion of contaminated fish and shellfish. EPA has recently proposed the use of the 10^{-6} risk factor in its proposed promulgation of numeric standards for toxic pollutants in the state of Alaska (FR 58420; November 19, 1991). This risk factor is also consistent with EPA's recent decision regarding listing of facilities (including pulp mills) under section 304(l) of the Act.

3. Permit Limit Derivation

Wasteload allocations are compared to reported effluent values to determine if limits are needed for individual parameters. Under 40 CFR 122.4(d)(1), limits must be included if the discharge shows "reasonable potential" to exceed water quality standards. EPA's Technical Support Document for Water Quality-based Toxics Control (TSD, 1991) defines "reasonable potential" as being within a percentage of the wasteload allocation. Based on the comparison of effluent values from the KPC facility and the calculated wasteload allocations, the following parameters are water quality-limited:

BOD_5
Dissolved Oxygen (minimum)
pH
Color
Mercury
Copper
Chloroform
Manganese
Sulfide
Total Hydrocarbons (oil and grease)
2,4,6-trichlorophenol
2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD)
Chronic Whole Effluent Toxicity

In deriving the water quality-based permit limits, Region 10 applied the statistical permit limit derivation approach described in the TSD. This approach takes into account effluent variability in setting limits which are low enough to ensure that the water quality standards are met. The approach also takes into account the difference in time frames and frequency of sampling between the water quality standards and monthly average and daily maximum limits. In addition to the wasteload allocation values below, EPA used the following values in deriving limits using the formulas in the guidance documents:

Coefficient of variation	0.6
Probability value for long-term average calculation	99%
Probability value for monthly average limits	95%
Probability value for daily maximum limits	99%
******* Frequency of monitoring	
2,3,7,8-TCDD	Quarterly
Whole effluent toxicity	Monthly
mercury, chloroform, manganese, copper, nickel, color 2,4,6-trichlorophenol, sulfide, oil and grease	Weekly
BOD_5, Dissolved Oxygen	Daily

These assumptions are used to derive monthly average and daily maximum limits.

The resulting limits which EPA is proposing for each parameter are also discussed below. In some cases, the maximum daily limit may appear to exceed the wasteload allocation value. However, this is due to the difference in time frames between the two values. The proposed limit will ensure that both the acute and chronic WLA and standards are met.

a) Aquatic Criteria

The following sections describe the evaluation of the KPC discharge with regard to water quality criteria for aquatic life.

BOD_5 and Dissolved Oxygen

The following is a comparison of (1) the current effluent limits for BOD_5, (2) BPT limits calculated for the reissued permit, and (3) the water quality-based limits derived from the draft TMDL. The most stringent limits are included in the proposed permit:

	BOD_5 Loading (lbs/day)		
	Operating Ave	Monthly Ave	Daily Max
Current Limits	32,400	-	62,400
New BCT Limits (November through May)	30,200	-	58,100
Water Quality-Based Limits (June through October)	-	10,000	18,000

Based on the technical analysis presented in the TMDL, a minimum dissolved oxygen (DO) limitation (5 mg/l in the combined discharge) is included in the permit. Effluent dissolved oxygen at this concentration affords the maximum BOD_5 loading allocation while maintaining compliance with state standards. A lower minimum DO value is acceptable only if BOD_5 limits are adjusted downward in accordance with the relationships described in the TMDL. Effluent data submitted by KPC in July 1991 indicated that the minimum aggregate DO for outfalls 001, 002, and 003 was 5.3 mg/l and the average over a 10 day sampling period was 6 mg/l.

Metals

In evaluating whether metals in KPC's discharge have reasonable potential to violate standards for aquatic life, the effluent concentrations were compared to the wasteload allocations (calculated by multiplying the Gold Book criteria by the dilution in the mixing zone); a percentage of the wasteload allocation was used in this comparison to allow for effluent variability, as discussed in the TSD.

Based on the applicant's 2c data and data from a recent study of Ward Cove (Jones and Stokes, 1989), mercury, copper, and nickel appear to show reasonable potential to violate state standards. The analysis of metals is complicated by the fact that the 2c application requires reporting of total metals. The metals criteria are written in terms of total recoverable metals. The fraction of the total metal which exists as total recoverable is highly variable and site specific. It is difficult, therefore, to extrapolate from total metal values to determine compliance with the criteria. In determining if limits on a given metal are necessary, EPA has taken the conservative approach of assuming that all of the metal in effluent samples (analyzed for total) was in the total recoverable form.

In order to provide information about the partitioning and bioavailability of the metals in the discharge, both total recoverable and dissolved metals monitoring is required under the proposed permit. Should monitoring indicate that metals values are below levels of concern, the permit contains a provision for reducing the monitoring frequency after one year of monitoring.

The following is a comparison of reported discharge values, wasteload allocations (WLA), and water quality-based limits (all values in ug/l):

Parameter (outfall)	Discharge Level Reported	Wasteload Allocation	Effluent Limitations Daily Max	Month. Ave
Mercury (001)	3.91	0.35	0.6	0.3
Mercury (002)	0.25	0.35	0.6	0.3
Nickel (001)	22	99.4	163	81
Nickel (002)	19	99.4	163	81
Copper (001)	10	41	41	20
Copper (002)	8	41	41	20
Copper (003)	73	215	215	107

Monitoring for these parameters will be weekly for the first year, with provisions to decrease the frequency, if appropriate.

Whole Effluent Toxicity

Toxicity was not limited under the expiring permit. Under 40 CFR 122.4(d)(1), whole effluent toxicity limits must be included if the discharge shows "reasonable potential" to exceed water quality standards.

Acute toxicity tests using salmonids have been conducted by KPC in accordance with the expiring permit. The results for the last four years are summarized below:

Outfall	LC50 Range (%)	Number of Tests
Main (001)	6 - 44	6
Primary Effluent (002)	7.5 - 35	6
Secondary Effluent (002)	70 - >100	6
Filter Plant (003)	> 100	1

Results of chronic toxicity tests using Pacific oysters and purple sea urchins were reported in the Jones and Stokes study; chronic tests using Pacific oysters and sand dollars were conducted under the EPA Contract Laboratory Program in 1991. The results are summarized below (note that 4.8% and 6.25% were the lowest effluent concentration tested):

Outfall	Jones & Stokes NOEC (%)	EPA Contract NOEC (%)	Sensitive Species
Main (001)	< 4.8	< 6.25	Oyster/Urchin
Secondary Effluent (002)	< 4.8	< 6.25	Oyster/Urchin
Filter Plant (003)	NA	< 6.25	Oyster

Alaska's water quality standard for toxicity states that substances must not exceed 0.01 times the lowest measured 96-hour LC50 for the most sensitive test organism. This standard protects against chronic effects to aquatic life by applying a translation factor (.01) to an acute toxicity measure (LC50). The state of Alaska has provided guidance to EPA for determining compliance with this standard. The guidance states that the TSD's approach to chronic toxicity, which relies on the use of a No Observable Effects Concentration (NOEC), should be used as a direct measure of compliance with the standard.

To calculate the wasteload allocations, the following relationship is developed using the No Observable Effects Concentration (NOEC) of the effluent:

$$\text{Effluent concentration after mixing} < \text{NOEC}$$

$$100\%/(\text{dilution}) < \text{NOEC}$$

rearranging yields,

NOEC > 100/14 (for outfall 001, 002)
NOEC > 100/74 (for outfall 003)

therefore,

NOEC > 7.1 % effluent (001, 002)
NOEC > 1.3 % effluent (003)

The proposed permit contains numeric effluent limits (expressed in Chronic Toxic Units or TU_c) to insure compliance with the standard outside the mixing zone. The conversion from a minimum allowable NOEC value to a wasteload allocation expressed in chronic toxic units is performed as follows:

Limit in TU_c = 100/(NOEC) (NOEC expressed in percent effluent)

In this case, the denominators are 7.1 (outfall 001, 002) and 1.3 (outfall 003), and the resulting wasteload allocations are 14 TU_c and 77 TU_c respectively. Limitations are developed using the statistical methods outlined in the TSD.

In order to determine compliance with the chronic toxicity limits, the permit requires monthly chronic tests of the effluent. The Permittee shall conduct tests on one of four marine species (sand dollar, sea urchin, oyster, or mussel) based on seasonal availability.

Exceedance of a chronic toxicity limit is considered a violation of the permit. If a limit is exceeded, the Permittee could then be required, through an order, to conduct a toxicity identification/reduction evaluation (TIE/TRE).

Because of concerns about acute toxicity, the permit also requires continued acute toxicity testing on a quarterly basis. The Permittee shall conduct the tests on the inland silverside, which is available throughout the year.

<u>pH</u>

EPA has evaluated the 001, 002 and 003 discharges to determine what pH levels will meet the state standard. The standard stipulates that the ambient pH must fall within the range 6.5 to 8.5 standard units. In addition, any change in ambient pH from natural conditions must be less than 0.1 standard unit. In this case, the latter requirement is more restrictive on the discharge.

Using the method outlined in EPA's "Water Quality Assessment: A Screening Procedure" (EPA/600/6-85/002b), EPA has performed an analysis of pH within the mixing zone that accounts for dilution as well as the buffering capacity of the effluent and receiving water. The range of measured pH range at 001, 002 and 003 along with the new water quality-based limits are as follows:

Parameter	Current Discharge	Water Quality-Based Limits
pH at 001	2.8 - 9.0	5.0 - 11.0
pH at 002	3.4 - 9.0	5.0 - 11.0
pH at 003	3.4 - 9.0	4.5 - 11.8

As described earlier, excursions above or below the existing pH limitation range (5.0 - 9.0 standard units) are allowable for up to 446 minutes per month (40 CFR 401.17). Excursions above or below the water quality-based ranges are not allowed at any time.

The proposed permit requires a change in monitoring methods from the existing permit due to the water quality analysis described above. While samples from the three outfalls are currently composited prior to analysis, the draft permit requires separate analysis of pH at each outfall.

Turbidity

Alaska's standard for turbidity states that turbidity shall not exceed 25 NTU, reduce more than a 10 percent the depth of the compensation point for photosynthetic activity, nor reduce the secchi disk depth by more than 10 percent.

There are not sufficient data to determine current compliance with the compensation point and secchi disk parts of this standard. In addition, an effluent limit cannot be calculated on the basis of these parameters.

Effluent data submitted by the company in July 1991 indicates that turbidity levels are below the 25 NTU standard. The final permit therefore includes a monthly monitoring requirement and no limitation for turbidity.

Color

Alaska's standard for color states that receiving waters shall neither exceed 5 color units nor reduce by more than 10 percent the depth of the compensation point for photosynthetic activity.

There are not sufficient data to determine current compliance with the compensation point part of this standard. In addition, an effluent limit cannot be calculated on the basis of this parameter.

The relationship between effluent color and receiving water color is not certain. Color is not a conservative pollutant (i.e. it may be created or reduced in the receiving water by chemical/physical interactions), so it is difficult to back-calculate an effluent limit for color based on a receiving water standard. However, in 1984, the ninth circuit court ruled that EPA must calculate an effluent limit instead of applying a standard in the receiving water (Trustees for Alaska v. EPA, 749 F 2nd 549). Therefore, the draft permit contains an effluent limit for color at 001 and 002 based on the assumption that it is conservative and that background color is zero.

Wasteload allocations have been established for color by multiplying the dilution in the mixing zones by the color standard (5 color units or 5 mg/l platinum). Limitations in the draft permit are based on this allocation. The following is a comparison of reported color levels in the discharge (from permit application) with the proposed limitations (all values in color units):

Parameter (outfall)	Discharge Level Reported	Wasteload Allocation	Effluent Limitations Daily Max	Effluent Limitations Month. Ave
Color (001)	619	70	70	35
Color (002)	477	70	70	35

Total Hydrocarbons (oil and grease)

The Alaska standard for total hydrocarbons states that concentrations are not to exceed 15 ug/l, using method 503B in Standard Methods for the Examination of Water and Wastewater (16th Edition). Method 503B (partition infrared) is a measure of oil and grease; it detects more compounds than method 503A (partition gravimetric), the corresponding method required for the NPDES application. In the absence of 503B data, EPA has evaluated the need for a total hydrocarbon limit using the oil and grease data in KPC's application. Below is a comparison of this data with the calculated wasteload allocation (all values in mg/l):

Parameter (outfall)	Discharge Level Reported	Wasteload Allocation	Effluent Limitations Daily Max	Effluent Limitations Month. Ave
Total Hydrocarbons (001)	2.1	0.21	0.210	0.105
Total Hydrocarbons (002)	2.4	0.21	0.210	0.105

Sulfide

EPA's Gold Book criterion for sulfide is 2 ug/l undissociated hydrogen sulfide. Data submitted by the Permittee indicates that the effluent contains sulfide concentrations of 12 mg/l (outfall 001) and 8 mg/l (outfall 002), although the form of the sulfide is not specified.

According to the Gold Book, the toxic form of sulfide is undissociated hydrogen sulfide (H_2S), not hydrosulfide (HS^-) or sulfide ($S^=$). The equilibrium between H_2S and HS^- is dependent on pH. At pH 9, approximately 99 percent of the sulfide is in the form of HS^-, at pH 7 the sulfide is about equally divided between H_2S and HS^-, and at pH 5 about 99 percent of the sulfide is in the form of H_2S. Based on the sulfide concentration reported by the Permittee and the pH limitations in the draft permit, the maximum potential undissociated hydrogen sulfide concentrations in the discharges from 001 and 002 are estimated below, and compared with the wasteload allocations:

Parameter (outfall)	Discharge Level Estimated	Wasteload Allocation	Effluent Limitations Daily Max	Month. Ave
Sulfide (001)	1188	28	46	23
Sulfide (001)	792	28	46	23

b) Human Health Criteria

The following sections describe the evaluation of the KPC discharge with respect to criteria for the protection of human health. In evaluating whether specific substances in KPC's discharge have reasonable potential to violate standards for human health, the effluent concentrations were compared to the wasteload allocation (equal to the Gold Book criteria); a percentage of the wasteload allocation was used in this comparison to allow for effluent variability, as discussed in the TSD.

2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD)

Bleached pulp, effluent, and sludge from KPC were analyzed for 2,3,7,8-TCDD as part of the EPA/Paper Industry Cooperative Dioxin Study in 1989. The compound was detected in an effluent sample at a level of 15 pg/l (picograms per liter or parts per quadrillion); it was also detected in the sludge sample at a level of 3500 pg/l.

EPA and ADEC collected and analyzed salmon, rockfish, and crab tissues collected in Ward Cove for dioxins and furans in 1991. While dioxins and furans were found in the tissues, the levels of contamination appear to be similar to background concentrations reported for urban areas in the United States and other countries.

The 2,3,7,8-TCDD effluent limitations for the KPC mill were calculated based on the EPA Gold Book criterion of .014 pg/l. Due to the inability of current analytical techniques to detect this compound near the criterion level, loading limitations (in micrograms per day or μg/day) were developed using the maximum flow from outfalls 001 (29.0 mgd) and 002 (21.7 mgd); this enables the Permittee and agencies to conduct compliance monitoring on individual waste streams in the bleach plant, where 2,3,7,8-TCDD originates. The effluent sampling will be used in conjunction with flow measurements to determine the loading of 2,3,7,8-TCDD in the facility's final effluent. The following formula is used to convert from an effluent concentration and flow to a loading:

Loading (ug/day) = (conc. in pg/l) x (flow in mgd) x (3.785)

Based on the above concentration and flows, daily maximum limits of 1.5 pg/day (outfall 001) and 1.1 pg/day (outfall 002) were established. Because monitoring is quarterly, it is not feasible to express the limitation in terms of a monthly average. Using current analytical techniques, the Permittee will not be able to measure the effluent concentration that corresponds with this loading. Therefore, the permit specifies that compliance can be determined by monitoring the bleach plant effluent or individual bleach plant filtrate streams, which is where 2,3,7,8-TCDD is generated. Furthermore, the permit states that if the concentration of 2,3,7,8-TCDD in all filtrate streams is below the "minimum level" set by EPA (10 pg/l), the Permittee will be considered to be in compliance with the effluent limit. The minimum level is the lowest point at which the calibration curve is calculated and is set by EPA based on a level that can reasonably be quantified.

The draft permit requires the Permittee to conduct quarterly monitoring for 2,3,7,8-TCDD, beginning the first calendar quarter after the effective date of the permit. The Permittee must collect twenty-four-hour composite samples of the final effluent, bleach plant waste streams, and sludge.

EPA's Office of Research and Development is currently conducting a reassessment of the risks of dioxin. The proposed permit includes a reopener clause to allow for a modification of the 2,3,7,8-TCDD limitations, if the reassessment results in a revision of the Gold Book criterion.

Chloroform, Trichlorophenol and Manganese

Based on KPC's application, chloroform, 2,4,6-trichlorophenol and manganese appear to show reasonable potential to violate state standards. The following is a comparison of reported discharge values, wasteload allocations, and effluent limitations (all values in ug/l):

Parameter (outfall)	Discharge Level Reported	Wasteload Allocation	Effluent Limitations Daily Max	Effluent Limitations Month. Ave
Manganese (001)	1140	100	200	100
Manganese (002)	430	100	200	100
Chloroform (001)	268	15.7	31	16
Chloroform (002)	720	15.7	31	16
Chloroform (003)	22	15.7	31	16
Trichlorophenol(001)	13	3.6	7.2	3.6
Trichlorophenol(002)	9	3.6	7.2	3.6

D. Monitoring Requirements

Under Section 308 of the Act and 40 CFR 122.44(i), EPA must require a discharger to conduct monitoring whenever necessary to determine compliance with effluent limitations, assist in the development of effluent limitations, and assess the quality of receiving waters. The proposed permit contains both effluent monitoring and ambient monitoring requirements.

Facility Monitoring

In the proposed permit, each limited pollutant is monitored in the effluent at a specified frequency. Selected monitoring frequencies are based on the nature and effect of the pollutant as well as a determination of the minimum sampling necessary to adequately monitor the facility's performance. The monitoring frequency for those pollutants previously limited under the expired permit remain unchanged.

The permit also requires quarterly monitoring of the effluent, sludge, and bleached pulp for AOX (EOX, in sludge), 2,3,7,8-TCDD, and 2,3,7,8-TCDF. This chlorinated organics monitoring will be used to gather information on the levels of chlorinated organics in the effluent for possible future establishment of technology-based and/or water quality-based effluent limitations.

Ambient Monitoring

The draft permit requires the Permittee to conduct ambient monitoring in Ward Cove to assess dissolved oxygen levels in the water column, the extent of sediment contamination, and the extent to which TCDD and TCDF are bioaccumulating in resident organisms. Except for the addition of turbidity (secchi disk) and color monitoring, the conditions of the water column monitoring program are unchanged from the previous permit. The sediment and bioaccumulation monitoring programs are new requirements; each will be conducted on an annual basis.

Stormwater Monitoring

A stormwater monitoring program is included in the proposed permit in order to identify and characterize any significant sources of pollutant loadings to Ward Cove. Monitoring data is also needed for determining compliance with the limitations on BOD_5 and Dissolved Oxygen in the aggregate discharge from the facility.

If a significant source(s) is identified, EPA may reopen the permit to include specific effluent limitations, additional monitoring requirements, and/or specific additions to the BMP plan to reduce the pollutant discharge(s).

E. <u>Best Management Practices Plan</u>

The draft permit requires that the Permittee develop a best management practices (BMP) plan to prevent the accidental discharge of toxic chemicals to waters of the United States. The plan shall address plant site runoff, spillage, leaks, sludge and waste disposal, and drainage from materials storage areas. Specific BMPs identified within the plan become enforceable conditions of the permit. In addition, the plan must be amended whenever there is a significant change in facility operations. The plan will incorporate elements of pollution prevention as set forth in the Pollution Prevention Act of 1990 (42 U.S.C. 13101).

F. Unauthorized Discharges

Based on concerns about the potential discharge of pollutants and/or wastestreams not listed in the permit application, the permit does not authorize discharges of waste streams that are not part of the normal operation of the facility as disclosed in the permit application.

G. Changes to Standard Conditions

EPA has made several changes to the standard conditions of the permit. Some of the changes are intended to clarify or reorganize the conditions; others are substantive changes. These substantive changes are described below:

Representative Sampling

This language has been expanded and specifically requires sampling whenever a bypass, spill, or non-routine discharge of pollutants occurs, if the discharge may reasonably be expected to cause or contribute to a violation of an effluent limit under the permit. This change is in response to concerns that permit violations and/or water quality standards violations could result from bypasses, spills, or non-routine discharges during times when the effluent is not routinely monitored. This requirement directs the Permittee to conduct additional, targeted monitoring to quantify the effects of these occurrences on the final effluent discharge.

Changes in Discharge of Pollutants

Under the expired permit, the Permittee must notify EPA that an activity will occur or has occurred that may result in elevated discharges of toxic pollutants not limited in the permit. EPA has broadened this requirement in two ways. First, the requirement now applies to all pollutants; previously, this requirement only applied to the toxic pollutants listed under Section 307(a) of the Clean Water Act. Secondly, notification is now required when any of four notification levels is exceeded; previously, notification was required only if the highest of four notification levels was exceeded.

This broadening of the requirement will help insure that EPA is apprised of elevated discharges that may cause or contribute to violations of state water quality standards. Depending on the pollutants involved, elevated discharges of this kind may prompt EPA to reopen the permit to include appropriate limitations.

VI. Other Legal Requirements

A. Endangered Species Act

EPA has concluded that the discharges authorized by this permit will have no effect on any endangered or threatened species or its critical habitat. EPA is requesting concurrence from the U.S. Fish and Wildlife Service on the draft permit, and will consider their comments in the final permit decision. EPA will initiate consultation should new information reveal impacts not previously considered, should the activities be modified in a manner beyond the scope of the original opinion, or should the activities affect a newly listed species.

B. State Water Quality Standards and State Certification

Since state waters are involved in this permitting action, the provisions of Section 401 of the Act apply. In accordance with 40 CFR 124.10(c)(1), public notice of the draft permit has been provided to the state of Alaska agencies having jurisdiction over fish, shellfish, and wildlife resources.

C. Coastal Zone Management Act (CZMA)

The state of Alaska will be reviewing this permit to determine consistency with the Coastal Zone Management Act.

D. Permit Term

This permit shall expire five years from the effective date.

REFERENCES

USEPA, Development Document for Effluent Limitations Guidelines (BPCTCA) for the Bleached Kraft, Groundwood, Sulfite, Soda, Deink and Non-integrated Paper Mills Segment of the Pulp, Paper, and Paperboard Point Source Category, EPA 440/1-76/047-b, December, 1976.

USEPA, Final Development Document for Effluent Limitations Guidelines and Standards for the Pulp, Paper, and Paperboard Point Source Category, EPA 440/1-82/025, October 1982.

USEPA, Permit Writer's Guide to Water Quality-Based Permitting for Toxic Pollutants, EPA 440/4-87-005, July, 1987.

USEPA, Technical Support Document for Water Quality-Based Toxics Control, EPA 505/2-90-001, March, 1991.

USEPA, Quality Criteria for Water, EPA 440/5-86-001, May 1986.

USEPA, Water Quality Assessment: A Screening Procedure, EPA/600/6-85/002b, 1985.

Jones and Stokes Associates, Inc., Ward Cove: Water Quality Assessment, August, 1989.

ATTACHMENT A

KPC PULP GRADE DATA SUMMARY

Grade Name	Pulp End Use	Shrinkage-Hot Caustic Extraction, %	Total Yield%	Caustic Consumed, lbs/ton	S-10/ S-18%	Alpha Cellulose Content, %
K-118-N	Cellophane/Viscose	8.0	37.3	160	10.2/6.4	91.0
K-120-N	Cellophane/Viscose	8.0	38.3	160	10.2/6.4	91.0
K-316-N	Cellophane/Viscose	8.5	35.5	190	9.0/4.5	92.5
K-317-N	Cellophane/Viscose	8.5	35.5	190	9.0/4.5	92.5
K-320-N	Viscose	9.0	35.6	190	8.3/4.5	93.0
K-324-N	Viscose	9.0	35.8	190	7.9/4.5	93.0
K-340-M	Cellulose Spec.	9.0	35.0	190	7.0/3.3	94.0
KKW	Cellulose Spec.	9.0	35.8	190	7.9/4.5	93.0
K-NH	Nitration	9.0	36.1	190	7.0/3.3	94.0
Paper	Paper	5.0	41.0	60	14.0/10.9	87.0

CHARACTERISTICS OF DISSOLVING SULFITE PULP

Grade	Shrinkage Hot Caustic Extraction, %	Total Yield, %	Caustic Consumed, lbs/ton	S-18, %
Nitration	8-12	37	288	5.3-6.5
Viscose	13-17	36	250	4.5-5.3
Cellophane	17-20	34	300	2.9-4.5
Acetate	24 and above	31	350	<2.9

KPC PULP CLASSIFICATION

KPC Grade Name	Shrinkage-Hot Caustic Extraction	Total Yield, %	Caustic Consumed lbs/ton	S-18, %	Guideline Grade
K-118-N	Nitration	Nitration	Paper	Nitration	Nitration
K-120-N	Nitration	Paper	Paper	Nitration	Nitration
K-316-N	Nitration	Viscose	Paper	Vis/Cell	Viscose
K-317-N	Nitration	Viscose	Paper	Vis/Cell	Viscose
K-320-N	Nitration	Viscose	Paper	Vis/Cell	Viscose
K-324-N	Nitration	Viscose	Paper	Vis/Cell	Viscose
K-340-M	Nitration	Viscose	Paper	Cellophane	Cellophane
KKW	Nitration	Viscose	Paper	Vis/Call	Viscose
K-NH	Nitration	Viscose	Paper	Cellophane	Cellophane
Paper	Paper	Paper	Paper	Paper	Paper

Ward Cove

PROBLEM AT A GLANCE:

Water Quality-limited?	*Yes*
Segment Identifier:	*10102-601*
Parameter of Concern:	*Dissolved Oxygen (DO)*
Uses Affected:	*Aquatic Life*
Known Sources:	*Point Sources: Pulp Mill Fish Processor*

Background Information

Ward Cove, located near Ketchikan in southeastern Alaska, is the site of a pulp mill operated by the Ketchikan Pulp Company (KPC) as well as a fish processing plant operated by Ward Cove Packing Company. The cove is located on the north side of Tongass Narrows about 5 miles northwest of the City of Ketchikan (Figure 1). It is 0.3 mile wide at the entrance, 0.5 mile wide at the widest point, and approximately 1 mile long. Centerline depths range from 9 meters at the head to over 50 meters at the mouth of the cove.

The physical setting and oceanography of Ward Cove characterize it as an estuary. There is no sill between Ward Cove and Tongass Narrows; therefore, water column stratification is expected to be similar to that in Tongass Narrows, apart from the effects of surface runoff and industrial discharges. Tongass Narrows is connected to the Gulf of Alaska through a series of larger channels leading to the waters of Dixon Entrance.

Ward Creek drops steeply from the mountains to the head of the cove. Three small lakes provide brief stretches of calm in its otherwise rapid descent. Stream discharge is subject to wide variation, as the stream collects water from steep mountain slopes in the area. The cove is located in an area of heavy rainfall, receiving an average of 150 inches annually.

Ward Cove is protected under the Alaska Water Quality Standards for the following beneficial uses:

Water supply for aquaculture, seafood processing, and industrial uses.
Contact and secondary recreation.
Growth and propagation of fish, shellfish, other aquatic life, and wildlife.
Harvesting for consumption of raw mollusks or other raw aquatic life.

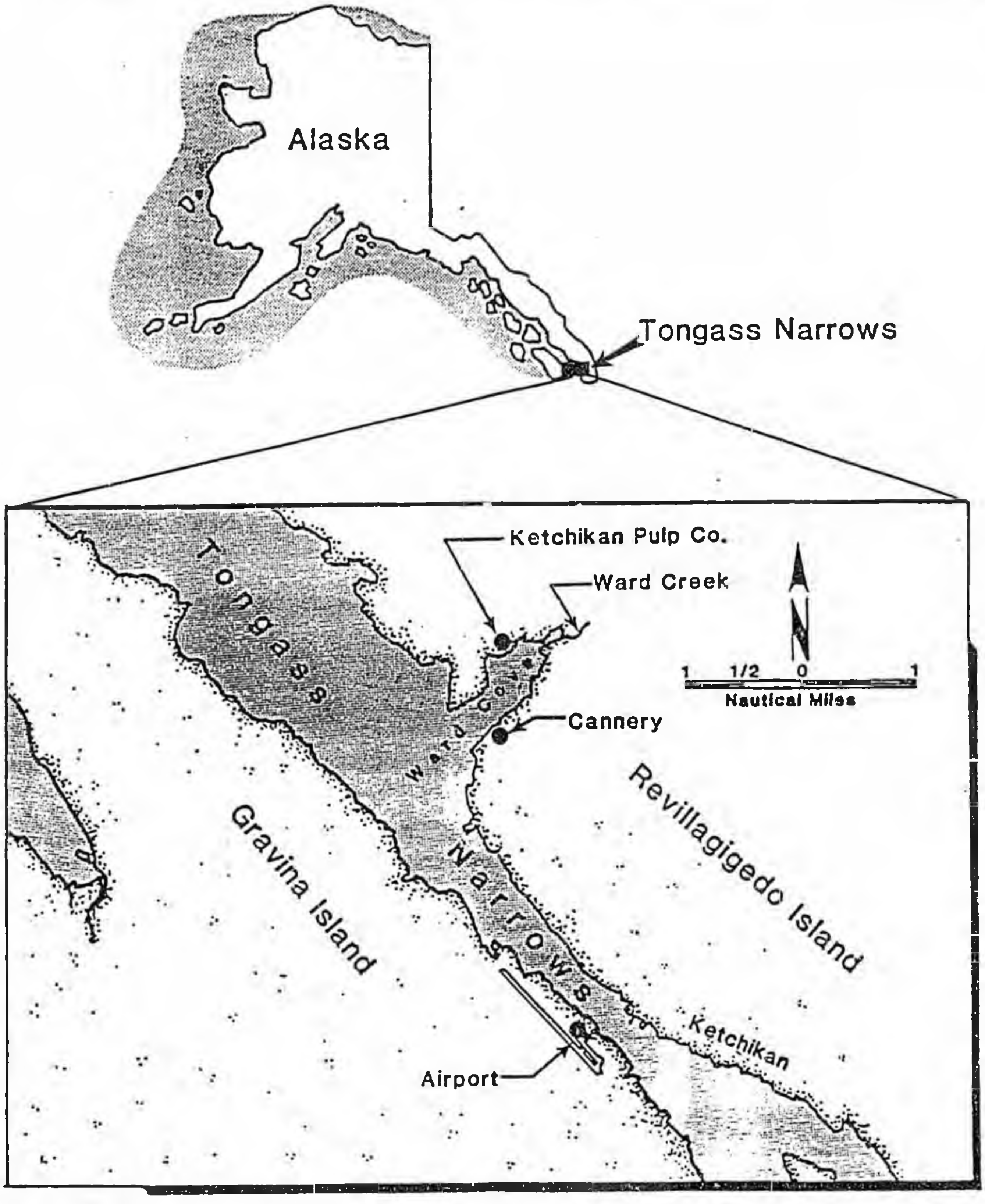

Figure 1: Tongass Narrows and Ward Cove

A great deal of data has been collected in Ward Cove by state and federal resource agencies and by the major industrial facility in the area, KPC, as part of the requirements of its National Pollutant Discharge Elimination System (NPDES) permit. The principal analyses of water quality conditions in Ward Cove are contained in the following reports:

Alaska Water Pollution Control Board (1953,1957)
Federal Water Pollution Control Administration (1965)
Federal Water Quality Administration (1970)
Environmental Protection Agency (1975)
KPC Discharge Monitoring Reports (1980-Present)
Jones and Stokes Associates (1989)

A brief synopsis of each report is included in Appendix A of this document.

Problem Description

According to the Alaska Department of Environmental Conservation (ADEC), Ward Cove is water quality-limited due to the depletion of dissolved oxygen (DO). Adequate DO in the water column is a fundamental measure of the ability of the waterbody to support aquatic life.

Applicable Water Quality Standards

Appendix B describes applicable portions of Alaska's water quality standards related to DO. The following sections further summarize this information.

Beneficial Uses Affected

Ward Cove's most impaired beneficial use is the ability to support growth and propagation of fish, shellfish, other aquatic life, and wildlife. Recent and historic studies provide a picture of a biologically declining marine environment in the cove. There is historical evidence that Ward Cove had a diverse and healthy benthic community and had relatively good water quality prior to the beginning of operations of KPC in 1953. Ward Cove was studied in 1953, 1957, 1965, 1970, 1975, and 1989. KPC's discharge monitoring reports (DMRs), which are required as a part of their NPDES permit, provide additional evidence of conditions within the cove between 1980 and 1989. The studies document a gradual decline in biological activity and in water quality, in particular with respect to DO. State of Alaska officials have observed a number of fish kills in the summer months, further indicating that the decline in water quality threatens the cove's ability to support fish, shellfish, and other aquatic life.

Water Quality Criteria

The State of Alaska water quality standards establish the following criteria for minimum concentrations of DO in marine waters:

> "Surface dissolved oxygen (D.O.) concentrations in coastal water shall not be less than 6.0 mg/l for a depth of one meter except when natural conditions cause this value to be depressed. D.O. shall not be reduced

below 4 mg/l at any point beneath the surface. D.O. concentrations in estuaries and tilal tributaries shall not be less than 5.0 mg/l except when natural conditions cause this value to be depressed."

Because Ward Cove is considered both coastal and estuarine, the more stringent coastal criterion (6 mg/l) is applied at the surface, while the estuarine criterion (5 mg/l) is applied at depth. The focus of this assessment is the level of DO in the surface waters of Ward Cove.

Available Monitoring Data

Field data collected by KPC as a requirement for their NPDES permit shows persistent, severe water quality impacts upon DO in the surface waters (depth < 1 meter) of Ward Cove (Figures 2 and 3). ADEC found that, for the months of July through September, the percentage of times measurements were less than the water quality standard ranged from 55% to 100% (Appendix B). Earlier studies (FWQA, 1970) in Ward Cove showed similar results, although the magnitude and extent of the water quality impacts were greater; this was also a period when organic loadings from KPC were higher. More recent data, including the results of water quality studies by KPC from 1987 through 1989, showed continued violations of the State of Alaska's DO standards.

Pollutant Sources

Since the early 1950s, Ketchikan Pulp Company (KPC) has been engaged in the manufacturing of dissolving or paper grade wood pulp utilizing the magnesium base, acid bisulfate process. An average of 31 million gallons per day of wastewater generated in the manufacturing process are discharged from three outfalls into Ward Cove. A description of the current discharge conditions at KPC is included in Appendix D. The current National Pollutant Discharge Elimination System (NPDES) permit for the facility limits the discharge of biochemical oxygen demand (BOD_5) to an average of 32,400 pounds per day. As described in Appendix E, the available information indicates that KPC's discharge is the primary cause of depressed DO in the surface waters of Ward Cove.

Stormwater on the mill site is collected and discharged at several locations in Ward Cove. The volume and pollutant concentrations, including BOD_5, of these discharges are unknown. Potential sources of oxygen demanding materials in stormwater include runoff from the dredge disposal site, material storage areas, and vehicle maintenance yards. The draft NPDES permit for KPC includes a stormwater monitoring program to provide quantitative data about these discharges.

As described in the water quality studies listed earlier, the bottom of Ward Cove in the vicinity of the mill is covered by both large and small wood debris as well as fiber mats. Sediments are generally characterized as high in organic content and high in hydrogen sulfide, indicating anoxic conditions. The settled matter and sediments exert demand on the DO of the bottom waters of the cove. Dredging operations in the cove may result in localized impacts on DO due to sediment resuspension. While sediments affect DO in the deep waters of the cove, the data indicate that the impact of the sediments on surface waters is not significant (see Appendix E).

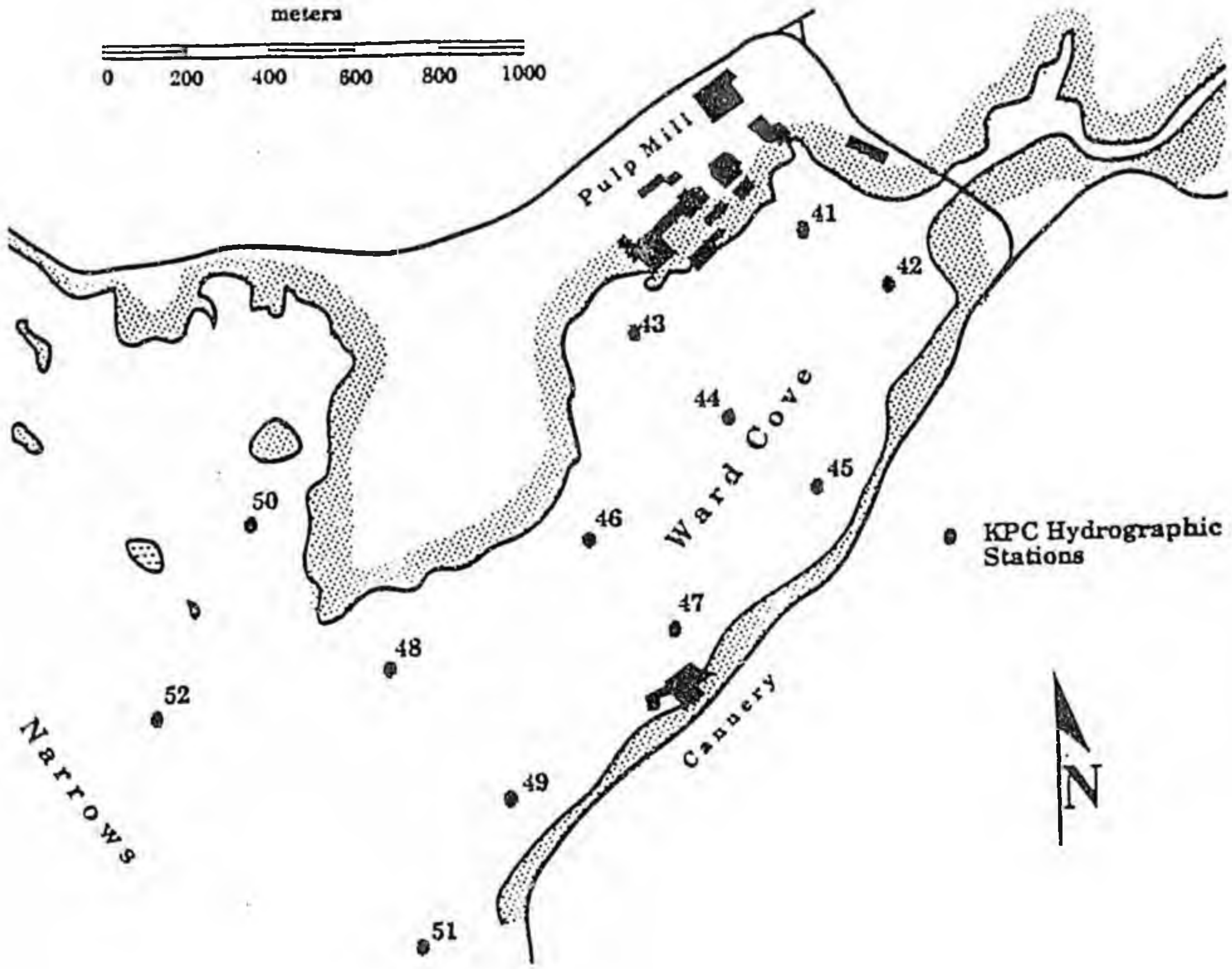

Figure 2: Map of Ward Cove showing KPC monitoring stations

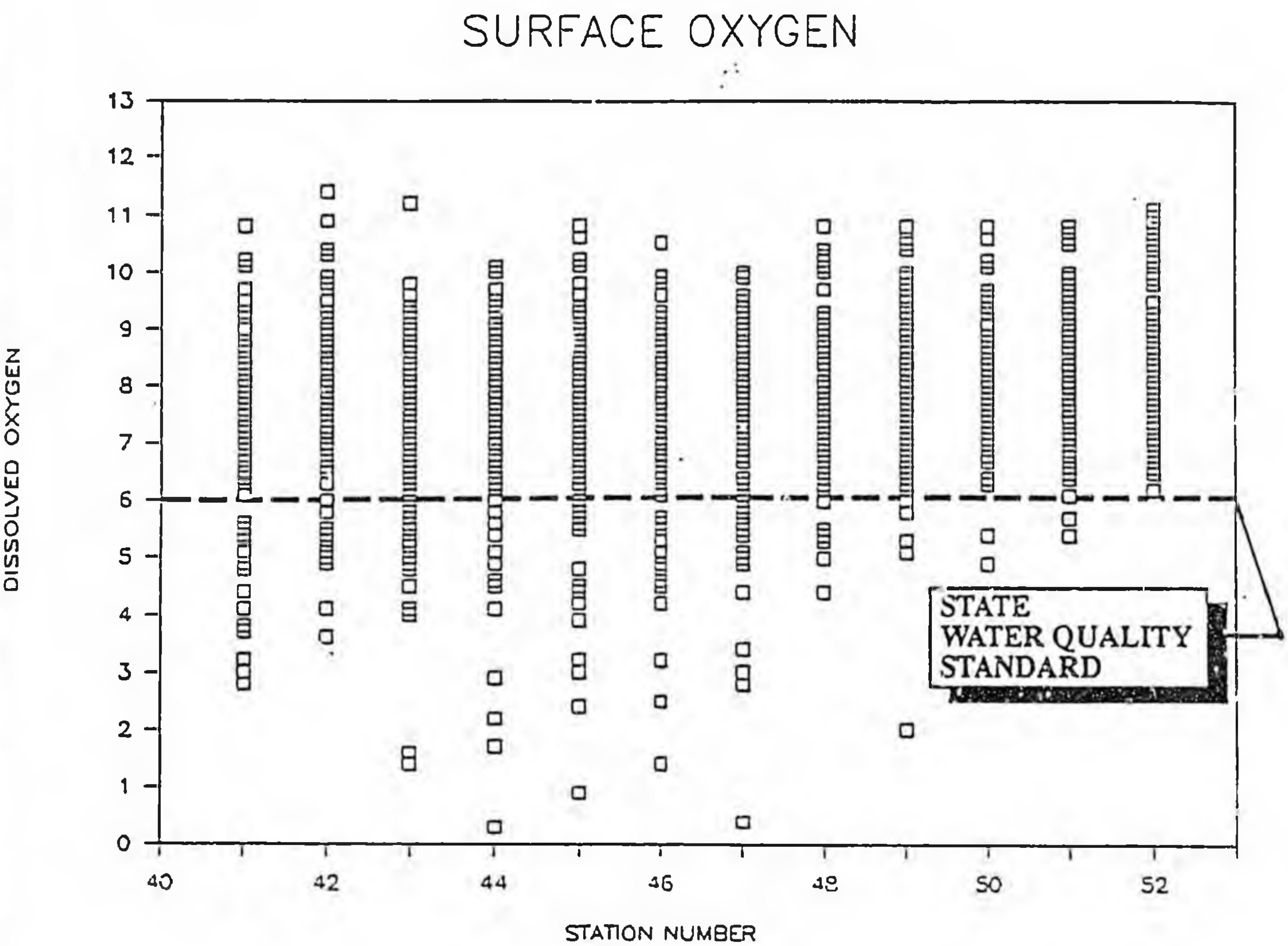

Figure 3: Dissolved Oxygen Values from KPC Monitoring (1980-1987)

Ward Cove Packing Company operates a seafood processing facility near the mouth of Ward Cove. Seafood wastes are ground to 0.5 inch and discharged to Ward Cove at a depth of approximately 58 feet at Mean Lower Low Water (MLLW). The magnitude of their discharge with respect to organic loading is significant. In 1988, for example, Ward Cove Packing Company reported that 3,847,117 pounds of waste were processed during a 35-day processing period. According to EPA (1975) guidelines, on the average, 45.5 pounds of BOD_5 are generated by every 1000 pounds of salmon processed. For the 1988 season, this corresponds to a daily average BOD_5 discharge from Ward Cove Packing Co. of approximately 5000 pounds. The discharge generally occurs during the critical months of July, August, and September. Due to the depth of this discharge (58 feet at Mean Lower Low Water), its significance in relation to surface water DO is believed to be minor (see Appendix E).

Non-point source pollution typically results from agricultural, silvicultural, and land use development activities. Land use adjacent to Ward Cove is dominated by the pulp mill complex, and most runoff from these areas is collected and discharged as point source stormwater (see above). Upstream activities may lead to non-point contributions to Ward Creek. These impacts are not documented; limited data from the 1989 study indicate DO concentrations between 7.7 and 8.7 mg/l at the mouth of Ward Creek.

Actions to Date

KPC's allowable discharge of BOD_5 and TSS has been reduced over the years due to changes in production. For example, in 1980, KPC's permitted BOD_5 limit was set at an average of 120,000 lbs BOD_5/day. For the period 1981-1984, the average BOD_5 level was reduced to 52,500 lbs/day. In 1986 the limit was reduced to an average of 46,100 lbs/day. The 1987 allowable effluent limit was further reduced to an average of 40,600 lbs/day. Effective January 1988, effluent limits of an average 32,400 lbs BOD_5/day (62,400 lbs BOD_5/day maximum) and an average 52,900 lbs TSS/day (98,000 lbs TSS/day maximum) were placed on the mill to bring it into compliance with federal Clean Water Act mandates. KPC installed a primary wastewater treatment facility in 1972 and a secondary biological wastewater treatment facility for selected waste streams in 1979. Since 1984, KPC has implemented modifications to the mill to reduce the quantity and mass loading of the discharge.

Pollution Control Strategy

Assessment Model

As described earlier, EPA has determined that the discharge of BOD_5 from the KPC mill is the primarily cause of DO depletion in the surface waters of Ward Cove. In order to establish adequate discharge controls, a three-dimensional, steady-state model of DO and BOD_5 in Ward Cove has been developed (see Appendix E); the model satisfies criteria for the difference between observed and simulated values of DO. Based on data from August and September of 1986, the model predicts that the state standard for DO will be violated for a discharge of 20,000 pounds/day when effluent DO is at least 5.0 mg/l.

Total Maximum Daily Load (TMDL)

A Total Maximum Daily Load (TMDL) is an implementation plan which identifies levels of pollution control to achieve water quality standards. The components used to address water quality problems through the TMDL process include:

- Effluent Limits
- Monitoring Requirements
- Compliance Schedules
- Special Conditions

A TMDL includes a determination of the amount of a pollutant (from point, nonpoint, and background sources), that may be discharged to a water-quality limited waterbody. Any loading above this capacity, which includes a margin of safety, risks violating state water quality standards.

Based on the available data and the model of the DO bugdet in Ward Cove, a TMDL is recommended for Ward Cove that establishes a maximum load of 20,000 pounds per day of BOD_5, to be allocated among the pollutant sources affecting the surface layer. Consistent with this problem assessment, this TMDL should focus on the DO problems in the surface waters of Ward Cove. As information about other potential water quality problems in the cove is collected and studied, additional TMDL's may be needed for other pollutants of concern.

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APPENDICES

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APPENDIX A

HISTORICAL CHANGES IN THE ECOLOGY OF WARD COVE

The physical setting and oceanography of Ward Cove characterize it as an estuary. An estuary is defined as a

> "semi-enclosed body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage." (Pritchard, 1967)

Estuary settings range from coastal plain to steep-sided fjords, but all have the common feature of being a mixing region for fresh and salt water. Density differences between fresh and salt water can drive circulation and, hence, influence mixing and flushing in estuaries. The net circulation in an estuary depends on the amount and timing of fresh and salt water input as well as other influences such as winds, tides, topography, relation to continental shelf regions, and latitude. These influences can combine in various ways so that distinctly different circulations develop in otherwise similar estuaries.

A great deal of data has been collected in Ward Cove by state and federal resource agencies and by the major industrial facility in the area, KPC, as part of the requirements of their National Pollutant Discharge Elimination System (NPDES) permit. The principal analyses of water quality conditions in Ward Cove are contained in the following reports:

Alaska Water Pollution Control Board (1953,1957)
Federal Water Pollution Control Administration (1965)
Federal Water Quality Administration (1970)
Environmental Protection Agency (1975)
KPC Discharge Monitoring Reports (1980-Present)
Jones and Stokes Associates (1989)

A brief synopsis of each report is presented below.

1953

Ward Cove was surveyed by the Alaska Water Pollution Control Board (1953) to obtain information on the chemical, physical, hydrological, and biological conditions of the cove before wastes from the pulp mill were discharged. The survey was conducted from October 1951 through September 1952, with over 940 chemical, 100 bacteriological, 60 bottom, and 70 plankton samples taken from eight stations in the cove. The following information is summarized from the Board's report.

Dissolved oxygen (DO) concentrations were generally >80 percent of saturation during the winter and spring months. Although the water temperature increased during the summer months, the upper water layer became supersaturated with oxygen as a result of photosynthesis. The increase in DO was observed in water to the depths of over

100 ft. There was a decline in DO in lower depths in the fall, coinciding with the end of the heavy plankton bloom. Biochemical oxygen demand (BOD_5) varied from a low of almost 0 ppm to a high of almost 1.0 ppm in late summer, coinciding with the end of the plankton bloom and a high input of dead plankton and plant material.

Winter plankton samples were dominated by filamentous algae, fragments of Ulva sp. and Fucus sp., ctenophores, and many species of diatoms. With the increasing temperatures of summer, many pelagic eggs and larvae were represented in the samples. Larval clams, starfish, barnacles, and snails as well as diatoms and other plankton reached such high abundances that the surface of the water looked smokey.

Bottom samples were taken from depths of 20-185 ft. Collections contained limpets, calcareous tube worms, clams (including Macoma), nermerteans, polychaetes, brittle stars, and algae. The substrate varied from a rocky bottom through sand and gravel to a "slimy" mud at the cove entrance. It was noted that some benthic samples contained well-preserved sawdust (still brown and solid to touch) originating from a sawmill which operated in the 1920s.

The results of the 1952 study strongly indicate that Ward Cove supported a typical marine ecosystem, but the persistence of sawdust suggested a limited ability to decompose woody organic material.

1957

A follow-up study by the Alaska Water Pollution Control Board, suggested in the 1953 report, was implemented in 1955 after the pulp mill had been in partial operation for 15 months and at full capacity (525 tons pulp processed per day) for 4 months. A total of 258 samples were collected from 10 stations in August and December 1955 and March 1957 (Alaska Water Pollution Control Board 1957).

Oxygen depletion was noted at night time in cove waters near the pulp mill, although phytoplankton activity replenished the oxygen in the day. During the winter, when planktonic activity was low, dying fish were occasionally observed during the study, and fish kills were reported to the scientists by fishermen and U.S. Fish and Wildlife personnel. Bottom samples, collected near the outfall, included clams, of which approximately 50 percent were dead.

1965

Water samples were collected at 13 stations on 28 August 1965 by the Federal Water Pollution Control Administration (1965). The cove water was stably stratified (density increasing with depth), which inhibited downward mixing of surface discharged wastes. At this time, the main effluent discharge averaged 34.4 mgd. The effluent had a BOD_5 of 610 mg/l, a sulfite waste liquor (SWL) content of 7,285 mg/l, suspended solids content of 2,800 mg/l, and a volatile solids content of 160 mg/l.

The maximum DO concentrations were found between 5 and 10 m depth, with values of 7.33 mg/l (85 percent saturation) in Tongass Narrows and 5.59 mg/l (64 percent saturation) in Ward Cove. DO in Ward Cove decreased to 1.76 mg/l (21 percent saturation) towards the surface and 1.96 mg/l at 40 m depth. Near-surface depressions in DO were attributed to the presence of pulp mill wastes, while near-bottom decreases in DO were attributed to the high oxygen demand of settleable solids in the pulp mill discharge (Federal Water Pollution Control Administration 1965).

1970

A total of 413 DO measurements were taken during the study by the Federal Water Quality Administration (1970). Of the total, 37 percent were below 6 mg/l. High SWL concentrations were found in Ward Cove and Tongass Narrows. Of 276 water samples taken in the top 20-m layer from May 1968 through May 1969, 50 percent had SWL concentrations greater than 44 ppm, 35 percent had SWL concentrations greater than 100 ppm, and 11 percent were greater than 500 ppm.

1975

A total of 266 water samples were taken by EPA from nine stations in Ward Cove and nine stations in Tongass Narrows at depths of 1, 7, 10, and 12 m for one week in September 1974 (EPA 1975). Mill discharges at this time were 42 mgd.

Data from the studies revealed that 24 percent of all samples had less than 6.0 mg/l of dissolved oxygen, and that 69 percent of near-surface samples (1 m) had DO values below 6.0 mg/l. On one of four observations at the head of Ward Cove near the water surface, DO was 1.0 mg/l. EPA concluded that there had been no major improvements in the DO concentrations in Ward Cove since the 1968-1969 study by its predecessor (Federal Water Pollution Control Administration).

The report also notes that SWL at concentrations of 50 mg/l are toxic to phytoplankton and fishfood organisms; at concentrations of 10 mg/l they cause damage to immature fish and shellfish (Department of the Interior 1967). SWL was distributed in the upper 7 m of water with the highest concentrations at the surface. All the water samples taken at 1-m depth had SWL concentrations of 50 mg/l or more at least once, and 10 mg/l concentrations were observed 97 percent of the time at all 1-m samples except those from two areas with apparently strong flushing or dilution. The maximum SWL concentration recorded was 872 mg/l, and 41 of 64 surface samples had concentrations over 100 mg/l.

Chemical analyses of bottom sediment showed high concentrations of organic nitrogen (0.36-0.75 percent) and total sulfides (0.15-0.43 percent). The chemical oxygen demand ranged from 147-655 percent (dry weight) and volatile solids from 11.1-46.9 percent (dry weight). The highest values were downstream of the main outfall. As a reference, the report noted that uncontaminated marine deposits have values of less than 0.1 percent organic nitrogen and sulfides, and less than 5 percent of both volatile solids and chemical oxygen demand.

Visual observations of the benthos revealed a paucity of organisms; with the majority being pollution-tolerant polychaetes. No macroscopic animals were observed at the head of the cove.

1980-1989

Since 1980, KPC has monitored dissolved oxygen, salinity, and temperature in Ward Cove in accordance with its NPDES permit. Some of this data is used for validation of the computer model outlined in the technical analysis section of this document. Figure 3 depicts the results of KPC's recent data collection.

1989

The Jones and Stokes (1989) report included a review of the previous studies as well as field work to assess water quality impacts. Water quality sampling again indicated that Ward Cove dissolved oxygen fell below the state standard.

While other water quality concerns were discussed in the report, a major concern identified was the level of DO in the surface waters of Ward Cove.

APPENDIX B

APPLICABLE WATER QUALITY STANDARDS

Ward Cove has been designated as water quality-limited. The pollutant of concern is dissolved oxygen (DO). In the state of Alaska, water quality standards are published in the Section 18 AAC 70 of the Alaska Code. Through the adoption of water quality standards, Alaska has defined the beneficial uses to be protected in its waters and the criteria necessary to protect these uses.

Beneficial Uses Affected

Ward Cove is protected under the Alaska Water Quality Standards for the following beneficial uses:

> Water supply for aquaculture, seafood processing, and industrial uses.
> Contact and secondary recreation.
> Growth and propagation of fish, shellfish, other aquatic life, and wildlife.
> Harvesting for consumption of raw mollusks or other raw aquatic life.

Ward Cove's most impaired beneficial use is the ability to support growth and propagation of fish, shellfish, other aquatic life, and wildlife. Recent and historic studies provide a picture of a biologically declining marine environment in the cove, particularly with respect to DO levels. State of Alaska officials have observed a number of fish kills in the summer months, further indicating that the decline in water quality threatens the cove's ability to support fish, shellfish, and other aquatic life.

Water Quality Criteria

The State of Alaska water quality standards establish the following criteria for minimum concentrations of DO in marine waters:

> "Surface dissolved oxygen (D.O.) concentrations in coastal water shall not be less than 6.0 mg/l for a depth of one meter except when natural conditions cause this value to be depressed. D.O. shall not be reduced below 4 mg/l at any point beneath the surface. D.O. concentrations in estuaries and tilal tributaries shall not be less than 5.0 mg/l except when natural conditions cause this value to be depressed."

Because Ward Cove is considered both coastal and estuarine, the more stringent coastal criterion (6 mg/l) is applied at the surface, while the estuarine criterion (5 mg/l) is applied at depth. The focus of this assessment is the level of DO in the surface waters of Ward Cove.

APPENDIX C

AVAILABLE MONITORING DATA

The State of Alaska's Department of Environmental Conservation (ADEC) tabulated the number of times the DO measured by KPC in the surface water was less than the State of Alaska water quality standard (DO = 6.0 mg/l) during the years 1985-87.

Summary of DO Values in Ward Cove
(one meter depth)

Date	# of samples above 6 mg/l	# of samples below 6 mg/l	Percent above 6 mg/l standard
May 1985	12	0	0
May 1986	12	0	0
May 1987	11	1	8
June 1985	6	6	50
June 1986	12	0	0
June 1987	9	3	25
July 1985	6	6	50
July 1986	0	6	100
July 1987	2	4	67
August 1985	0	6	100
August 1986	1	11	92
August 1987	5	7	58
September 1985	0	11	100
September 1986	0	12	100
October 1985	9	3	25
October 1986	6	0	0

Values were taken from the results of sampling surveys taken at stations 41-46 (See Figure 2 for map of station locations) during the period May through October for the years 1985-1986 and May through September of 1987.

Source: Kruse and Viteri, Alaska Department of Environmental Conservation

APPENDIX D

CURRENT DISCHARGE CONDITIONS AT KPC

Effluent Quality. The quality of KPC's effluent is governed by their National Pollutant Discharge Elimination System (NPDES) permit. This permit limits the amount of 5-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), temperature, and pH of the discharge. The BOD_5 and TSS in the discharge have traditionally been the Environmental Protection Agency's (EPA) main concern with regard to the mill's effluent composition. The permit also mandates a water quality monitoring program.

Effluent Quantity and Temperature. KPC discharges between 25-50 million gallons/day (mgd) of wastewater through three different outfalls into Ward Cove. These discharges are referenced in their NPDES permit as outfalls 001, 002, and 003.

Outfall 001 is the main outfall line. The effluent discharged through Outfall 001 normally accounts for at least 50 percent of the total discharge volume and receives no wastewater treatment. The temperature of the discharge runs from a low of 20°C to an average temperature of 32-35°C, although it can have a maximum daily average temperature approaching 40°C.

Outfall 002 is a combination of primary and secondary treated wastewater. The average discharge temperature, 25-30°C, is generally cooler than that of the main outfall.

Outfall 003 is the discharge from the mill's water supply treatment (filtration) plant. The mill's water supply is from Lake Connell, an impoundment basin which drains to Ward Creek. The water treatment plant's wastewater has an average flow of 5.4 mgd, with a high volume of 8 mgd. Its discharge temperature is essentially the same as that of Ward Creek.

Combined, these three discharges flow at a rate that is normally around 30-35 mgd on an average basis for each month and between 40-45 mgd as a monthly maximum. During summer months, when rainfall is small, the mill discharges can exceed the flow in Ward Creek.

Discharges 001 and 002 take place behind a log boom which confines the foam that is produced by the discharge to the area between the boom and the immediate vicinity of the mill. Log rafts and log booms along the west shore of the cove effectively leave a narrow, open water channel along the shore out to Tongass Narrows.

APPENDIX E

TECHNICAL ANALYSIS AND CONCLUSIONS

Identification of Significant Sources

In Ward Cove there are a number of possible sources for low DO in the surface water. These sources include 1) respiration of phytoplankton; 2) upwelling of oxygen-depleted water from oceanic sources or Ward Cove bottom water; and 3) discharge of organic, oxygen-demanding material by KPC and/or by the Ward Cove Packing Co.'s seafood processing plant.

Oxygen demand associated with phytoplankton respiration is a function of the rate of primary productivity. Jones & Stokes (1989) measured rates of primary productivity in Ward Cove during August 1988. Their results showed that primary productivity was low; they concluded that oxygen production was minimal in Ward Cove. When oxygen production by phytoplankton is low, respiration is also low. Therefore, based upon the results of the Jones & Stokes studies (1989), phytoplankton respiration was assumed to be of little significance for the DO budget in Ward Cove.

Upwelling can cause low DO in the surface water of estuaries when the oceanic source water is low in DO or when the bottom water from the estuary itself has been depleted of oxygen by sediment demand. Low DO associated with oceanic source water in Tongass Narrows may occur, but has not been documented in the studies surveyed for this report. Low DO in the bottom water has been observed in several studies (e.g., EPA, 1975; Jones & Stokes, 1989). When low DO in the surface is a result of upwelled water, DO just below the surface should be equal to or less than surface DO. Of the several data sets surveyed, only the Jones & Stokes (1989) DO data from August and September 1988 has characteristics which could be interpreted as being caused by upwelled water. However, the preponderance of the water quality data from Ward Cove, including measurements made by KPC, show DO increasing with depth. Under conditions for which DO increases with depth the mechanism of upwelling does not explain low DO in the surface water. While Jones & Stokes (1989) concluded that their data support the hypothesis that upwelling can lead to low DO in the surface, the results of the other field studies support the hypothesis that the source of oxygen demand originates in the surface, or near-surface waters of the estuary.

Additional support for the hypothesis that the source of oxygen demand originates in the surface, or near-surface waters, and, furthermore, that it is associated with discharge from the KPC pulp mill is provided by the measurements of Pearl Benson Index (PBI) reported in KPC's receiving water monitoring program. Measurements of PBI provide an index of the amount of sulfite waste liquor present. Since the only source of sulfite waste liquor in Ward Cove is the KPC mill, one way of testing this hypothesis is to determine if there is a positive correlation between PBI measurements and DO deficit in Ward Cove. Such an analysis was performed, using KPC receiving water quality data for the calendar year 1986. KPC measures temperature, salinity, DO, pH and PBI at depths of 1 and 5 meters at the 12 locations shown in Figure 2. Data collected on the dates shown in Table E1 were included in the analysis. These data were used to make estimates of the total amount of PBI and DO deficit in a one- meter thick surface layer of Ward Cove.

Table E1
Estimates of total PBI and DO deficit
in the surface waters of Ward Cove during 1986

Estimates obtained from water quality measurements made by KPC as part of their NPDES permit.

Date	Total PBI (kilograms)	DO Deficit (kilograms)
January 9	2273	3072
January 29	5497	2555
February 12	2716	3221
February 28	4965	4091
March 21	8841	3411
March 31	6358	2980
April 21	3936	1872
May 20	6157	2408
May 30	4770	3230
June 24	2625	2855
July 30	8887	5616
August 19	24300	4833
August 29	29680	7008
September 9	9971	4286
September 29	19070	6024
October 24	4205	2923
November 14	1173	2030
November 30	4402	2230
December 19	2879	2466
December 30	3272	3039

The DO deficit was defined as the difference between the 100% DO saturation level at the observed temperature and salinity and the observed DO. The total PBI and DO deficit in the surface layer for each of the survey dates were estimated in the following. First, Ward Cove was divided into several discrete, equal elements as shown in Figure E1. Ordinary kriging (Journel, 1989) was then used to estimate the values of temperature, salinity, DO and PBI at the center of each of the discrete elements. The 100% saturation level of DO was determined for each element based upon the following relationship (Mills et al, 1985):

$$DO_{sat} = 14.6244 - 0.367134T + 0.0044972T^2 - 0.0966S + 0.0002739S^2$$

where,

DO_{sat} = the saturation concentration of dissolved oxygen, mg/l
T = the water temperature, °C
S = the salinity, parts per thousand (o/oo)

The DO deficit, DDO, for each element was estimated as

$$DDO = DO_{sat} - DO$$

Total estimated PBI and DO deficit in Ward Cove for each of the survey dates in Table E1 are plotted as a time series in Figure E2. A regression analysis was also performed on these data. Results are shown in Figure E3. In spite of the fact that the processes leading to the decay of PBI and DO deficit are different, linear regression accounts for 74% of the variance in the analysis.

The other major source of organic loading to Ward Cove is the Ward Cove Packing Company. The magnitude of their discharge with respect to organic loading is significant. In 1988, for example, Ward Cove Packing Co. reported that 3,847,117 pounds of fish were processed during a 35-day processing period. According to EPA (1975) guidelines, on the average, 45.5 pounds of BOD_5 are generated by every 1000 pounds of salmon processed. For the 1988 season, this corresponds to a daily average BOD_5 discharge from Ward Cove Packing Co. of approximately 5000 pounds. The discharge generally occurs during the critical months of July, August, and September. However, the discharge is made through a submerged outfall located at a depth of 58.0 feet below Mean Lower Low Water (MLLW). This discharge may have a significant impact upon the DO levels in the intermediate and deep waters of Ward Cove. However, based upon the analysis of DO data, as described above, the contribution of Ward Cove Packing Co.'s discharge to water quality impacts in the surface water was assumed to be of minor importance compared to the KPC discharge. In consideration of the factors described above, the analysis of DO in the surface waters of Ward Cove focus upon the organic loading from the KPC pulp mill and the physical, chemical and biological processes which describe the fate of oxygen-demanding material. The development of the model for characterizing the DO budget is described in the following section.

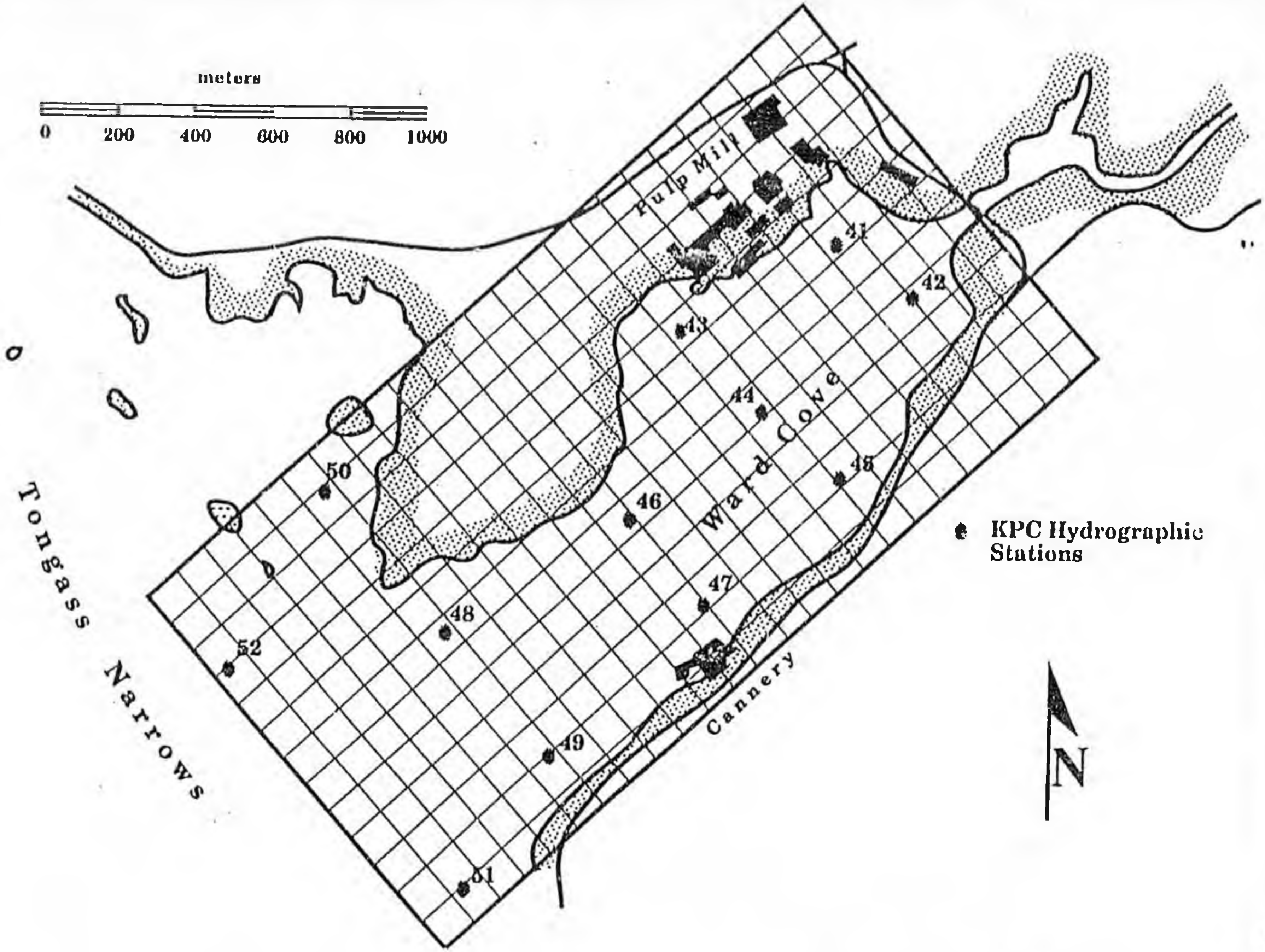

Figure E1: Finite difference grid for steady-state model of BOD and DO in Ward Cove near Ketchikan, Alaska.

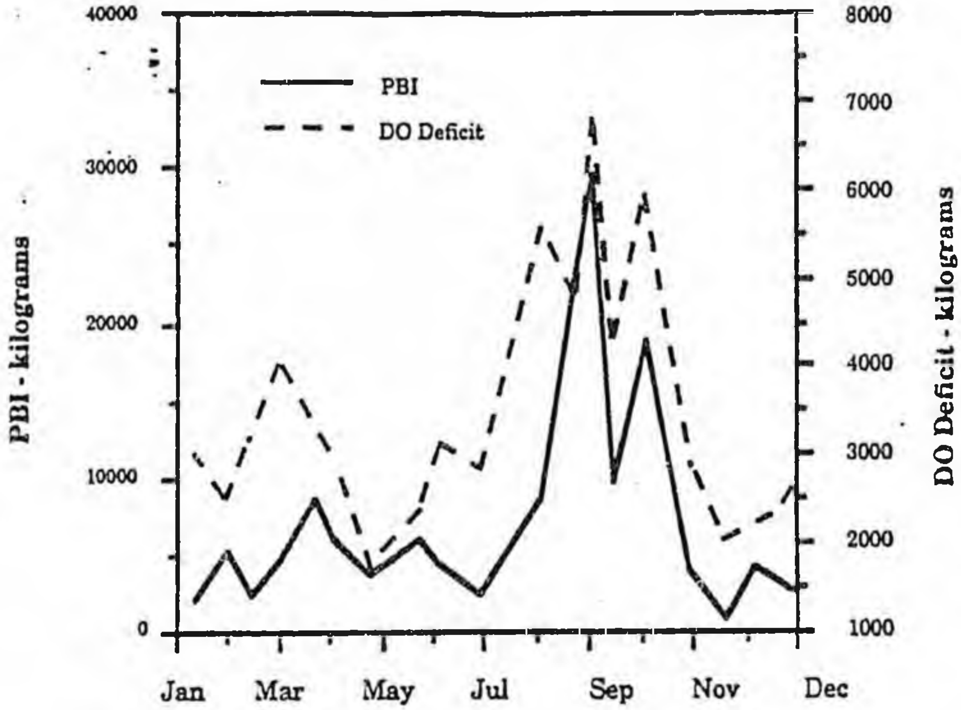

Figure E2: Time series of total PBI and DO deficit in the surface layer (thickness=1 meter) in Ward Cove during 1986

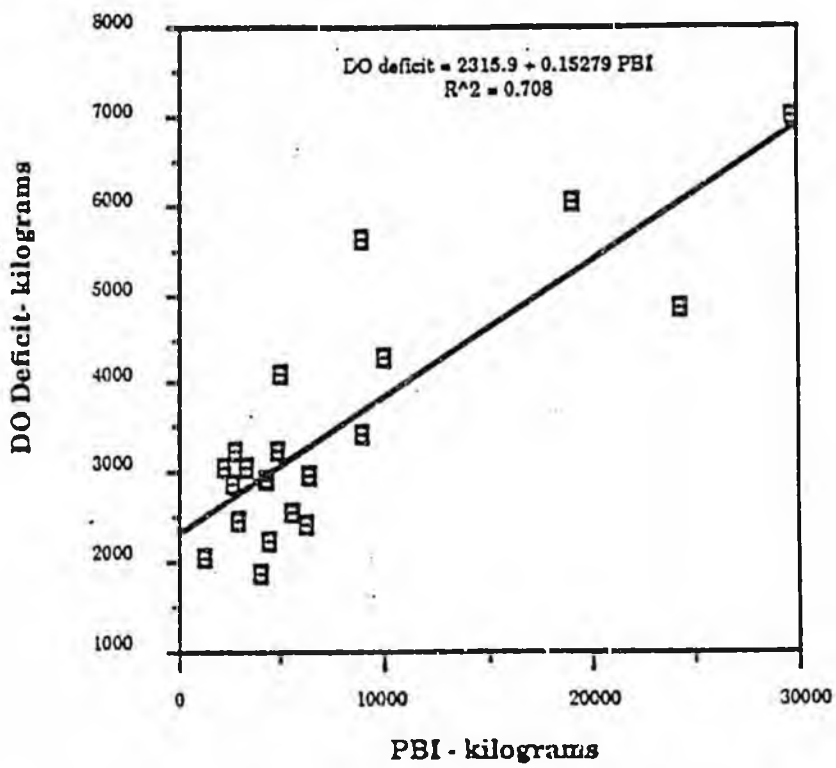

Figure E3: Regression of PBI on DO deficit in the surface water of Ward Cove for water quality data collected during 1896. Also shown are the least squares fit of linear relationship and R^2

Model of the Dissolved Oxygen Budget

Model Structure

The model chosen for characterizing the DO budget of the surface waters of Ward Cove was a three-dimensional, steady-state finite-difference model which included the following processes: 1) horizontal and vertical turbulent diffusion; 2) horizontal advection; 3) first-order stabilization of biological oxygen demand (BOD); 4) first-order transfer of DO across the air-water interface. The justification for choosing a steady-state model was developed from an evaluation of local meteorologic and hydrologic data. Specific emphasis was given to the months of July, August and September, for which water quality impacts have historically been the greatest.

Continuous hydrologic data from Ward Creek, the primary source of fresh water, was collected during the period 1949-1958, only. The record subsequent to October 1953 reflects the effects of diversion to KPC's water treatment plant upon streamflow in Ward Creek. For the months of July, August and September the records from 1953 to 1958 show that flow in Ward Creek remains relatively stable over periods of five to forty-five days. Flow in Ward Creek responds primarily to precipitation in the watershed, but it is also controlled by the regulation of releases from Connell Lake Dam. Rainfall events in the watershed typically have a five to ten day recurrence during the critical months. The frequency response of the Ward Creek watershed is smoothed further by the operation of the dam, particularly during the summer low flow months. Wind speed also appears to be an important factor in determining the level of DO in Ward Cove. Wind mixing provides a source of oxygen reaeration and is source of kinetic energy for turbulent mixing processes. Analysis of wind speed characteristics in the vicinity of Ward Cove have been done by Alaska Water Pollution Control Board (1957) and Jones & Stokes (1989). Although both of these reports consider only a limited data set, the results are consistent with the assumption that wind speeds are lowest during the critical months and that there are often periods of five to six days between meteorological events with wind speeds greater than 7 knots (Jones & Stokes, 1989).

Given these data and discretizing the water body of interest into volume elements as shown by the grid in Figure E1, a material balance on each element (Figure E4) for DO and BOD leads to the following equations:

Biological Oxygen Demand (BOD)

$$\frac{K_x \Delta y \Delta z (L_{i-1,j,k} - L_{i,j,k})}{\Delta x} + \frac{K_x \Delta y \Delta z (L_{i+1,j,k} - L_{i,j,k})}{\Delta x}$$

$$+ \frac{K_y \Delta x \Delta z (L_{i,j-1,k} - L_{i,j,k})}{\Delta y} + \frac{K_y \Delta x \Delta z (L_{i,j+1,k} - L_{i,j,k})}{\Delta y}$$

$$+ \frac{K_z \Delta x \Delta y (L_{i,j,k-1} - L_{i,j,k})}{\Delta z} + \frac{K_z \Delta x \Delta y (L_{i,j,k+1} - L_{i,j,k})}{\Delta z}$$

$$+ \sum_{x} Q_{in,x} L_{in,x} + \sum_{y} Q_{in,y} L_{in,y} - \sum_{x,y} Q_{out,x,y} L_{i,j,k}$$

$$- K_1 L_{i,j,k} \Delta x \Delta y \Delta z + \Lambda(i,j,k) = 0.0 \qquad (1)$$

Dissolved Oxygen (DO)

$$\frac{K_x \Delta y \Delta z (O_{i-1,j,k} - O_{i,j,k})}{\Delta x} + \frac{K_x \Delta y \Delta z (O_{i+1,j,k} - O_{i,j,k})}{\Delta x}$$

$$+ \frac{K_y \Delta x \Delta z (O_{i,j-1,k} - O_{i,j,k})}{\Delta y} + \frac{K_y \Delta x \Delta z (O_{i,j+1,k} - O_{i,j,k})}{\Delta y}$$

$$+ \frac{K_z \Delta x \Delta y (O_{i,j,k-1} - O_{i,j,k})}{\Delta z} + \frac{K_z \Delta x \Delta y (O_{i,j,k+1} - O_{i,j,k})}{\Delta z}$$

$$+ \sum_{x} Q_{in,x} O_{in,x} + \sum_{y} Q_{in,y} O_{in,y} - \sum_{x,y} Q_{out,x,y} O_{i,j,k}$$

$$+ (K_2(O_{sat} - O_{i,j,k}) - K_1 L_{i,j,k}) \Delta x \Delta y \Delta z + \Theta(i,j,k) = 0.0 \qquad (2)$$

where,

$L_{i,j,k}$ = the BOD concentration of the i,j,kth volume element, mg/l;

$O_{i,j,k}$ = the DO concentration of the i,j,kth volume element, mg/l;

O_{sat} = the saturation level of DO in the i,j,kth volume element, mg/l;

$Q_{in,x}$ = the inflow rate to the i,j,kth element in the x-direction, meters^3/second;

$Q_{out,x}$ = the outflow rate of the i,j,kth element in the x-direction, meters^3/second;

$Q_{in,y}$ = the inflow rate to the i,j,kth element in the y-direction, meters^3/second;

$Q_{out,y}$ = the outflow rate of the i,j,kth element in the y-direction, meters^3/second;

κ_x = the coefficient of turbulent diffusion in the x-direction, meters^3/second;

κ_y = the coefficient of turbulent diffusion in the y-direction, meters^3/second;

κ_z = the coefficient of turbulent diffusion in the z-direction, meters^3/second;

K_1 = the deoxygenation rate, seconds^{-1};

K_2 = the reaeration rate, seconds^{-1};

$\Lambda(i,j,k)$ = the source term for BOD, meters^3-mg/l/second;

$\Theta(i,j,k)$ = the source term for DO, meters^3-mg/l/second.

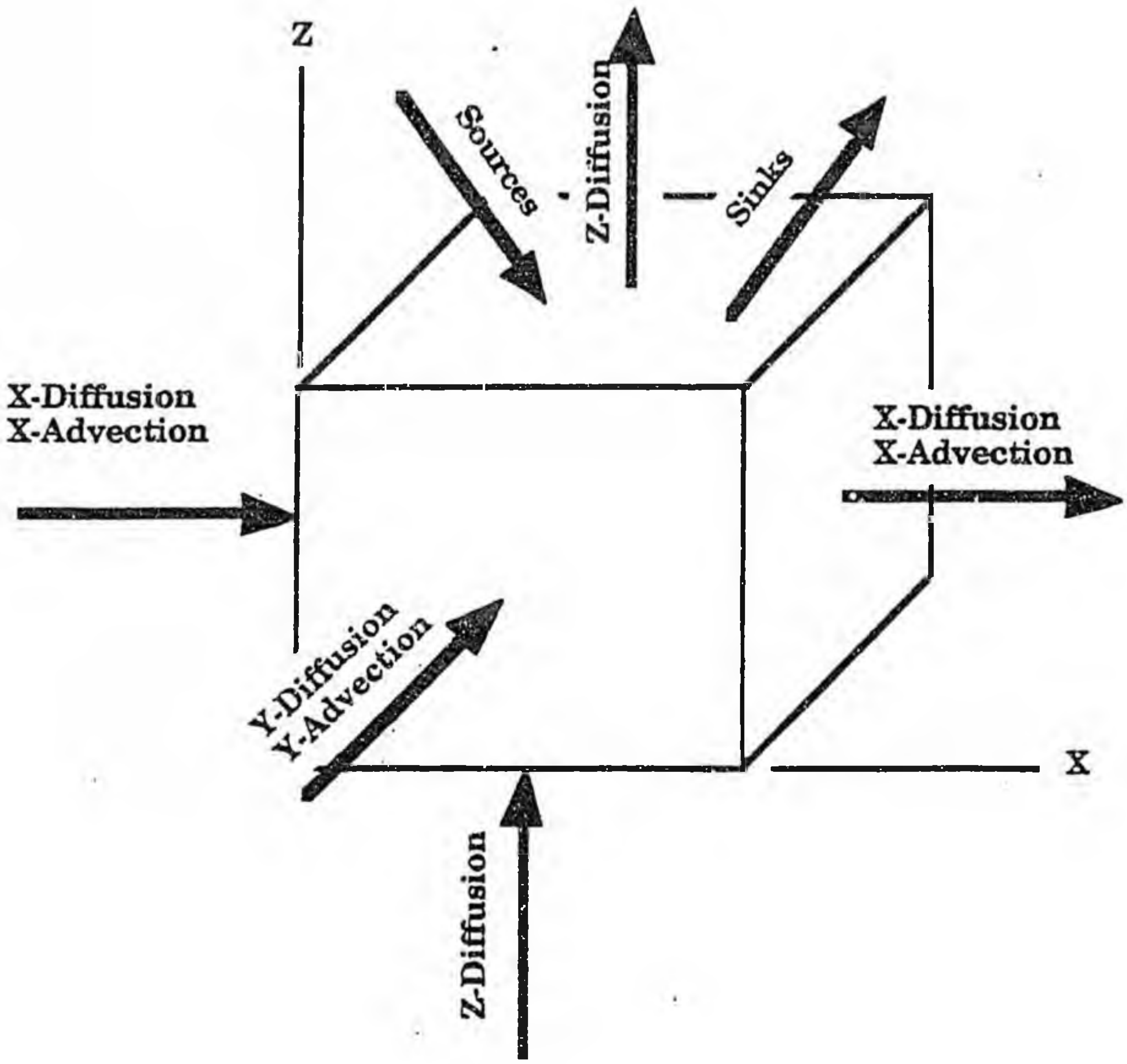

Figure E4: Typical element in numerical scheme showing material balance for modes of constituents subject to advection, diffusion, sources and sinks.

Parameter Estimation

Once the model structure has been defined (Equations (1) and (2)), it is necessary to estimate the model parameters. In this case the parameters are K_1, K_2, k_x, k_y, k_z, $Q_{in,x}$, $Q_{out,x}$, $Q_{in,y}$, $Q_{out,y}$, θ(i,j,k), and A(i,j,k). In principle, each of these parameters must be estimated for every one of the discrete elements given in Figure 4. This cannot be done with the available data. Estimates can be obtained, however, by placing certain restrictions upon the parameter set. The restrictions used in this analysis were 1) K_1, K_2, k_x, k_y, and k_z are constant throughout the estuary 2) A(i,j,k), and θ (i,j,k) are non-zero only for the elements which receive the discharge from KPC and Ward Creek 3) The magnitudes of $Q_{in,x}$, $Q_{out,x}$, $Q_{in,y}$ and $Q_{out,y}$ are a functions of the discharges from KPC and Ward Creek and location, only 4) Volume changes due to tidal fluctuations are negligible in the continuity equation when averaging over several tidal periods. Given these restrictions, available data were used in both a qualitative and quantitative manner to obtain parameter estimates. Following is a description of the way in which each of the parameters was estimated.

Horizontal Velocity Structure

Current structure was estimated using field data as a guide, where it was available. Drogue tracks comprise most of the field data relating to the velocity. AWPCB (1953) used a Gurley-type meter to make current measurements in Ward Cove and reported only that most of the movement was in the surface water at depths less than three feet. Drogues released in Ward Cove (AWPCB, 1957; Jones & Stokes, 1989) have a more or less random pattern when released in the central portion of Ward Cove. Drogues released near the KPC discharge (AWPCB, 1957), however, tended to stay in the vicinity of the shore until they exited the estuary. The two major sources of freshwater discharge in Ward Cove are the KPC discharge and Ward Creek. Based upon the qualitative information available from visual observations and measurements of drogue tracks, it was assumed in this study that the KPC discharge is initially distributed uniformly over the top two meters of the surface. Furthermore, it was assumed that the maximum horizontal velocity occurs near the discharge point and decreases in the direction of the opposite shore. In the seaward direction, it was assumed that the shape of this plume flattens out, or disperses with increasing distance from the discharge point.

A similar approach was used to characterize the horizontal current distribution associated with the Ward Creek Flow. It was assumed that the discharge from Ward Creek is to the surface layer of one meter thickness and is distributed approximately uniformly across the estuary.

Deoxygenation Rate (K_1)

Water samples were collected at Stations 43, 44 and 45 (Figure 2) in Ward Cove on October 25, 1989, preserved and handled according to the quality assurance plan (Bodien, 1989) and shipped to the EPA Regional Laboratory at Manchester, Washington. Standard methods (American Public Health Service, 1985) were used to determine the 5-, 10-, 15- , 20- and 60-day BOD of each sample. The simplex method (Nelder and Mead, 1965) for minimizing a nonlinear function, using the FORTRAN software implementation given by Press et al. (1986), was used to estimate both the rate constant, K_1, and the ultimate BOD of each sample. Estimates of these parameters are given in Table E2 below.

Table E2

Estimates of the ultimate BOD and the deoxygenation rate, K_1, for samples collected at three stations in Ward Cove, October 1989.

Station numbers correspond to locations on Figure B1.

Station	Ultimate BOD(mg/l)	Deoxygenation Rate, K_1 (days^{-1})
43	8.52	0.127
44	2.34	0.097
45	2.19	0.165

Reaeration Rate (K_2)

According to Bowie et al (1985), there is very little research available for estimating the magnitude of the reaeration rates in lakes and estuaries. Their summary includes reaeration coefficients which are appropriate primarily for well-mixed estuaries. Bowie et al (1985) also summarize a number of reaeration formulae from lakes. These formulae for lakes are all given in terms of surface transfer rates and are either constant, first- or second-order functions of the wind speed. In view of the lack of available, reliable information regarding the reaeration rate, it was treated in this report as a variable to be estimated from the observations of dissolved oxygen.

BOD and DO Source Terms, A(i,j,k), θ(i,j,k)

The source terms for BOD and DO, A(i,j,k), and θ(i,j,k), are a function of discharge and concentration. For the KPC discharge, daily measurements of BOD_5 and flow rate are available as a requirement of the NPDES discharge permit. Five-day moving averages of these measurements were used to estimate the loadings. BOD_5 was converted to ultimate BOD using the rate constant obtained from the field measurement in the standard formulation:

$$BOD_{ultimate} = BOD_5/(1. - e^{-5. * K1}) \qquad (3)$$

It was assumed that the DO in the KPC discharge was 5.0 mg/l.

For the Ward Creek source terms, it was assumed that the ultimate BOD was zero and the DO was 90% of saturation. These values are consistent with measurements of water quality from Ward Cove prior to the operation of the KPC facility (AWPCB, 1953). The five-day average flow in Ward Creek was treated as a variable to be estimated from the water quality data.

Coefficients of Turbulent Diffusion, k_x, k_y, and k_z.

Coefficients of horizontal and vertical turbulent diffusion were treated as variables to be estimated from the water quality data.

Estimation Method

Given limitations and assumptions described above, a total of five parameters remained to be estimated from the water quality data. These five parameters were:

k_x, k_y, and k_z; coefficients of turbulent diffusion
K_2; reaeration rate
$Q_{Ward\ Creek}$; the five-day average flow in Ward Creek.

KPC's water quality monitoring program includes observations of temperature, salinity, and DO at 12 locations in Ward Cove and Tongass Narrows (Figure 2). Water quality samples collected on three different dates, August 19, 1986; August 29, 1986; and September 19, 1986, were chosen for the analysis. Data from these surveys were used to solve the inverse problem of finding values of the five unknown parameters which provide the best solution to eqs. (1) and (2), given the 12 observations. For the purposes of this analysis, the best solution was defined as that which minimizes the sum of the squared differences between the observed and simulated state variables. Given a parameter set, q, with a cost function, J(q), defined as

$$J(q) = (z - x)T(z - x) \qquad (4)$$

where,
z = the vector of observations, and
x = the vector of state variables generated by the model,

the parameter estimate is the set of parameters, q*, for which

$$J(q^*) = \min (J(q)) \qquad (5)$$

The problem, as formulated, is a non-linear estimation problem, and, therefore, cannot be solved by standard least-squares methods (Larsen and Marx, 1981). In this case, a two-stage approach was used to find an optimal estimate of the parameters; one which satisfied eq. (3). The first step was an attempt to obtain an approximation to the optimal estimate. This was done by characterizing the five parameters as random variables with distributions estimated from available information. The reaeration rate, expressed in terms of a surface transfer rate, and the coefficients of eddy diffusivity were assumed to have log-normal distributions with mean and coefficient of variation as shown in Table B2. Empirical cumulative distribution functions (CDF) were computed for the five-day average flow in Ward Creek using the streamflow data collected at USGS gage 15062000 during the period 1953-1958. CDF's for the five-day average flow during the months of August and September, for this period, are shown in Figures E5 and E6.

Table BE3

Means and coefficients of variation used for initial estimate of parameters

Parameter	Mean	Coefficient of Variation
k_x	10 meters^2/second	1.0
k_y	1 meters^2/second	1.0
k_z	5×10^{-5} meters^2/second	1.0
K_2	0.5 days^{-1}	2.0
$Q_{Ward\ Creek}$	1.0 meters^3/second	0.5

Values for the five parameters were then chosen at random, based upon the assumed distributions. Solutions to eqs. (1) and (2) were obtained with the full parameter set and the squared difference between observed and simulated state variables (eq. (4)) was calculated. 200 such simulations were performed with data from each of the three field studies. The parameters giving the minimum estimate of the cost function, J(q), were then used in the second step as the initial values for finding the best local minimum with the downhill simplex method (Nelder and Mead, 1965).

While this process of parameter estimation generally leads to a local minimum, it does not guarantee that such a minimum is unique. Nor does it guarantee that the resulting model is acceptable. Additional criteria must be developed to define model acceptability. For this study, two criteria were developed to define acceptability, one based upon the difference between simulated and observed at all sampling locations, the other based upon the mean of the differences. It was assumed that the errors were normally distributed and a confidence interval of 0.999 was chosen. For a confidence interval of 0.999, the specific criteria were:

1) the difference between observed and simulated was less than 3.3 standard deviations of the calibration error of the measurements

2) the mean of the differences was less than 3.3 times the standard error of the mean of the calibration error based upon 18 samples (the number used in the parameter estimation process).

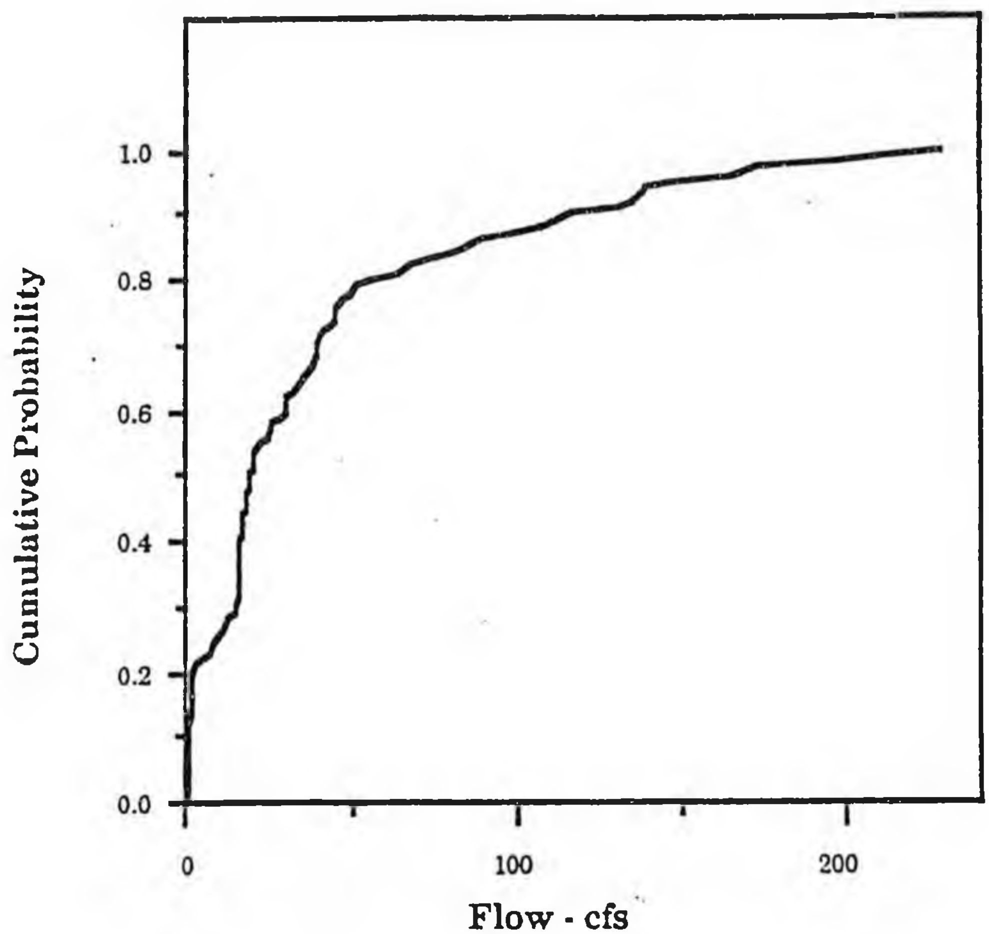

Figure E5: Empirical cumulative distribution function for 5-day averaged streamflow in Ward Creek, Alaska, during the month of August. Based upon data from USGS gage 1506200 for the period 1953-1958.

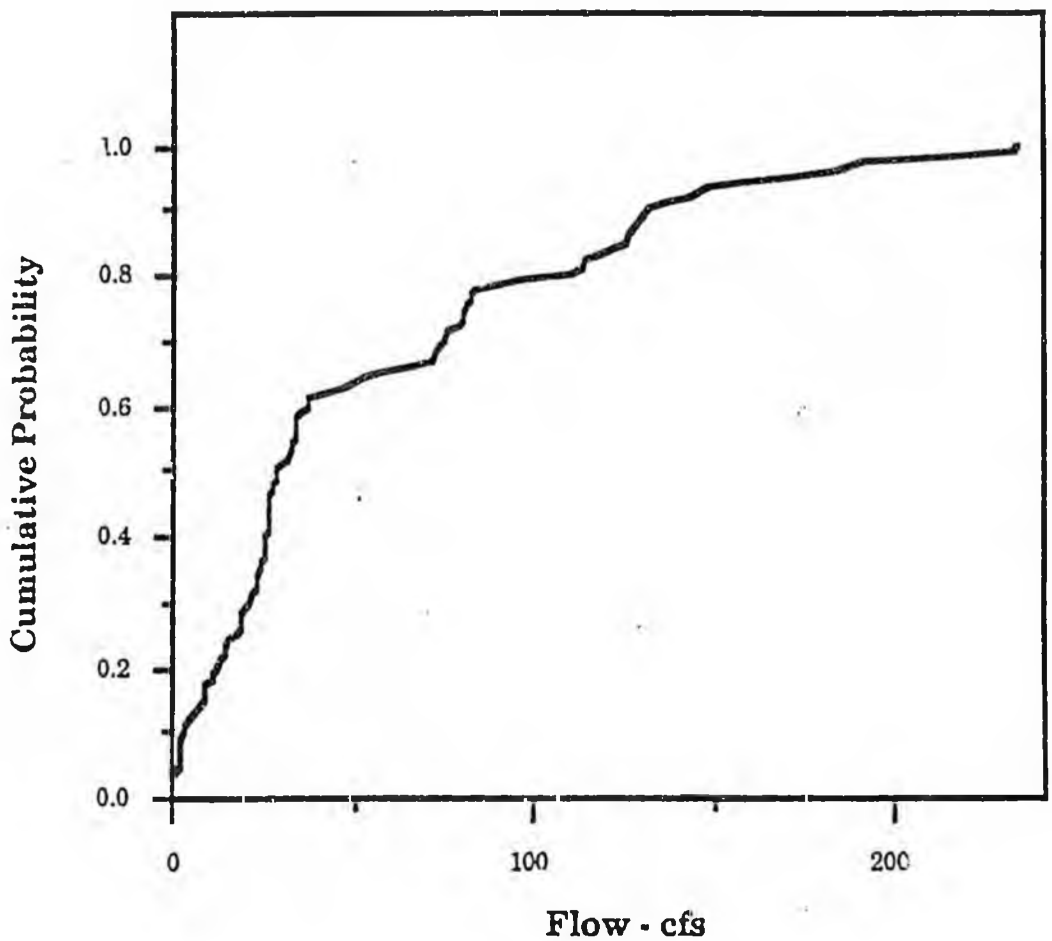

Figure E6: Empirical cumulative distribution function for 5-day averaged streamflow in Ward Creek, Alaska, during the month of September. Based upon data from USGS gage 1506200 for the period 1953-1958.

Sampling error was estimated from intercalibration results performed in the August 1988 studies of Ward Cove (Jones & Stokes, 1989). Differences between KPC DO measurements and measurements made by two other sampling parties (Kinnetic Labs, Inc. and Alaska Department of Environmental Conservation) had standard deviation of 1.23 mg/l and 0.79 mg/l, respectively. A standard deviation of 1.0 mg/l was chosen, implying that the standard error of the mean difference was $1.0/(18)^{1/2}$ = .236. The resulting criterion for acceptability was a difference between observed and simulated DO levels at each sample location of no more than 3.3 mg/l and mean difference no greater than 0.78.

The parameter estimates for each of the three studies, as a result of the second minimization step are given in Table E4.

Table E4

Optimal parameter estimates for water quality measurements made by KPC on three different days during late summer of 1986.

Parameter units are the same as given in Table B2.

Parameter	August 19	August 29	September 9
k_x	6.83	4.45	4.36
k_y	3.73	1.10	3.68
k_z	0.99×10^{-5}	1.99×10^{-5}	3.97×10^{-5}
K_2	0.203	0.058	0.433
$Q_{Ward\ Creek}$	0.581	0.453	0.960

Predicted and observed DO levels for each station, as well as their differences, mean differences and standard error of the mean difference are shown in Tables E5, E6, and E7. Parameter estimates for field studies on August 19, 1986 and September 9, 1986 lead to models which meet the criterion for model acceptability. The steady-state model, as formulated above, does not, however, meet this criterion for the August 29, 1986, due to an extremely low observation of DO at the surface of Station 49. The steady-state model given by eqs. (1) and (2) was, therefore, rejected for this set of data.

Table E5

Comparison of simulation using the optimal parameter set and observed DO at nine locations in Ward Cove for the KPC water quality survey of August 19, 1986.

Station	Depth (meters)	Predicted DO (mg/l)	Observed DO (mg/l)	Difference (mg/l)
41	1	4.5	3.0	1.5
41	5	7.3	7.3	0.0
42	1	5.1	3.6	1.5
42	5	7.4	8.0	-0.6
43	1	3.9	6.3	-2.4
43	5	7.2	8.1	-0.9
44	1	4.3	2.2	2.1
44	5	7.3	8.8	-1.5
45	1	4.5	3.0	1.5
45	5	7.3	7.6	-0.3
46	1	5.1	4.6	0.5
46	5	7.5	8.4	-0.9
47	1	5.2	7.9	-2.7
47	5	7.5	6.8	0.7
48	1	7.2	6.9	0.3
48	5	7.9	7.3	0.6
49	1	6.9	5.3	1.6
49	5	7.8	7.0	0.8

Table E6

Comparison of simulation using the optimal parameter set and observed DO at nine locations in Ward Cove for the KPC water quality survey of August 29, 1986.

Station	Depth (meters)	Predicted DO (mg/l)	Observed DO (mg/l)	Difference (mg/l)
41	1	2.9	2.8	0.1
41	5	4.9	6.1	-1.2
42	1	4.2	2.8	1.4
42	5	5.5	5.1	0.4
43	1	2.3	1.4	0.9
43	5	4.5	5.5	-1.0
44	1	3.2	1.7	1.5
44	5	5.1	6.3	-1.2
45	1	3.7	0.9	2.8
45	5	5.2	5.7	-0.5
46	1	4.0	1.4	2.6
46	5	5.7	6.4	-0.7
47	1	4.5	2.8	1.7
47	5	5.8	6.6	-0.8
48	1	6.8	7.3	-0.5
48	5	7.5	8.0	-0.5
49	1	6.5	2.0	4.5
49	5	7.1	7.2	-0.1

Table E7

Comparison of simulation using the optimal parameter set and observed DO at nine locations in Ward Cove for the KPC water quality survey of September 9, 1986.

Station	Depth (meters)	Predicted DO (mg/l)	Observed DO (mg/l)	Difference (mg/l)
41	1	6.0	5.5	0.5
41	5	6.1	6.4	-0.3
42	1	6.4	5.5	0.9
42	5	6.4	6.6	-0.2
43	1	5.3	4.9	0.4
43	5	5.8	6.6	-0.8
44	1	5.6	4.5	1.1
44	5	6.0	6.1	-0.1
45	1	5.8	4.4	1.4
45	5	6.0	6.2	-0.2
46	1	6.3	5.5	0.8
46	5	6.6	7.0	-0.4
47	1	6.4	7.6	-1.2
47	5	6.6	7.7	-1.1
48	1	8.0	8.3	-0.3
48	5	8.1	8.2	-0.1
49	1	7.8	7.7	0.1
49	5	7.9	7.9	0.0

The parameter estimates for the acceptable models (Tables E5 and E7) can be used to develop an interpretation of the environmental factors which result in low water quality in Ward Cove. This can be done by examining the characteristic time scales of the various processes which comprise the model. For the parameter values, typical of those which resulted in the two acceptable models:

Turbulent diffusion coefficient, $k = 5.0$ meters^2/second
Freshwater inflow, $Q_{Ward\ Creek} = 1.0$ meters^3/second
Deoxygenation rate, $K_1 = 0.130$ days^{-1}
Reaeration rate, $K_2 = 0.200$ days^{-1}
Volume of top five meters, $V = 5.0 \times 10^6$ meters^3
Length, $L = 2 \times 10^3$ meters

the characteristic time scales are:

Diffusion:
$t_{diff} = L2/k = 4 \times 10^6/5 = 8 \times 10^5$ seconds = 9.3 days
Advection:
$t_{adv} = V/Q_{Ward\ Creek} = 5 \times 10^6/1. = 5 \times 10^6$ seconds = 57.9 days
Reaeration:
$t_{reaer} = 1/K_2 = 1/.2 = 5.0$ days
Deoxygenation:
$t_{deoxy} = 1/K_1 = 1/.130 = 7.7$ days.

The role of turbulent diffusion is greater than that of freshwater discharge in terms of characterizing the exchange times of Ward Cove, while deoxygenation and reaeration have similar time scales approximately equal to the residence time implied by horizontal diffusion. The picture that emerges from this is one of poor exchange characteristics resulting from low runoff and low levels of energy from tides and winds. Low levels of energy available for turbulent mixing also give rise to longer time scales for reaeration, the transfer of oxygen from the atmosphere to oxygen-depleted surface waters. Lastly, the relatively high water temperatures during the summer months lead to maximum deoxygenation rates by providing optimal conditions for the microorganisms which stabilize the BOD of organic material. Based on the available data, the parameter estimates support the hypothesis that these factors, in conjunction with high levels of organic loading, result in degradation of the water quality of Ward Cove.

Application of Model

The parameters estimated in the development of the model are diagnostic rather than predictive. That is, they are really only correct estimates for the data set used to make the estimate. Using these model results to estimate the effects that changes in loading from point sources will have upon water quality is predictive only if it is assumed that the hydrographic and meteorologic conditions for which the parameter estimates were made could occur again. This is a reasonable assumption, given that water quality problems in Ward Cove have historically been greatest during the late summer.

The steady-state BOD/DO model system was used to estimate the effect upon water quality for various BOD loading rates from the KPC mill. Such estimates were obtained for the optimal parameter sets from both the August 19, 1986 and the September 9, 1986 data sets.

Although it was assumed in the model development that the DO content of the KPC discharge was 5.0 mg/l, there was no direct measurement at that time to support the assumption. In the analysis, therefore, the DO level of the KPC was varied along with the BOD loading. An estimate of the minimum DO in Ward Cove was obtained as a function of BOD loading for several levels of discharge DO and for each of the two parameters sets. The minimum DO, as function of BOD_5 loading from KPC, for the various levels of discharge DO are shown in Figures E7 and E8. Information recently submitted by KPC indicates that aggregate DO levels in the discharges for the three outfalls into Ward Cove average approximately 6 mg/l.

CORRECTION

THIS DOCUMENT
HAS BEEN REPHOTOGRAPHED
TO ASSURE LEGIBILITY

Diffusion:

$t_{diff} = L2/k = 4 \times 10^6/5 = 8 \times 10^5$ seconds = 9.3 days

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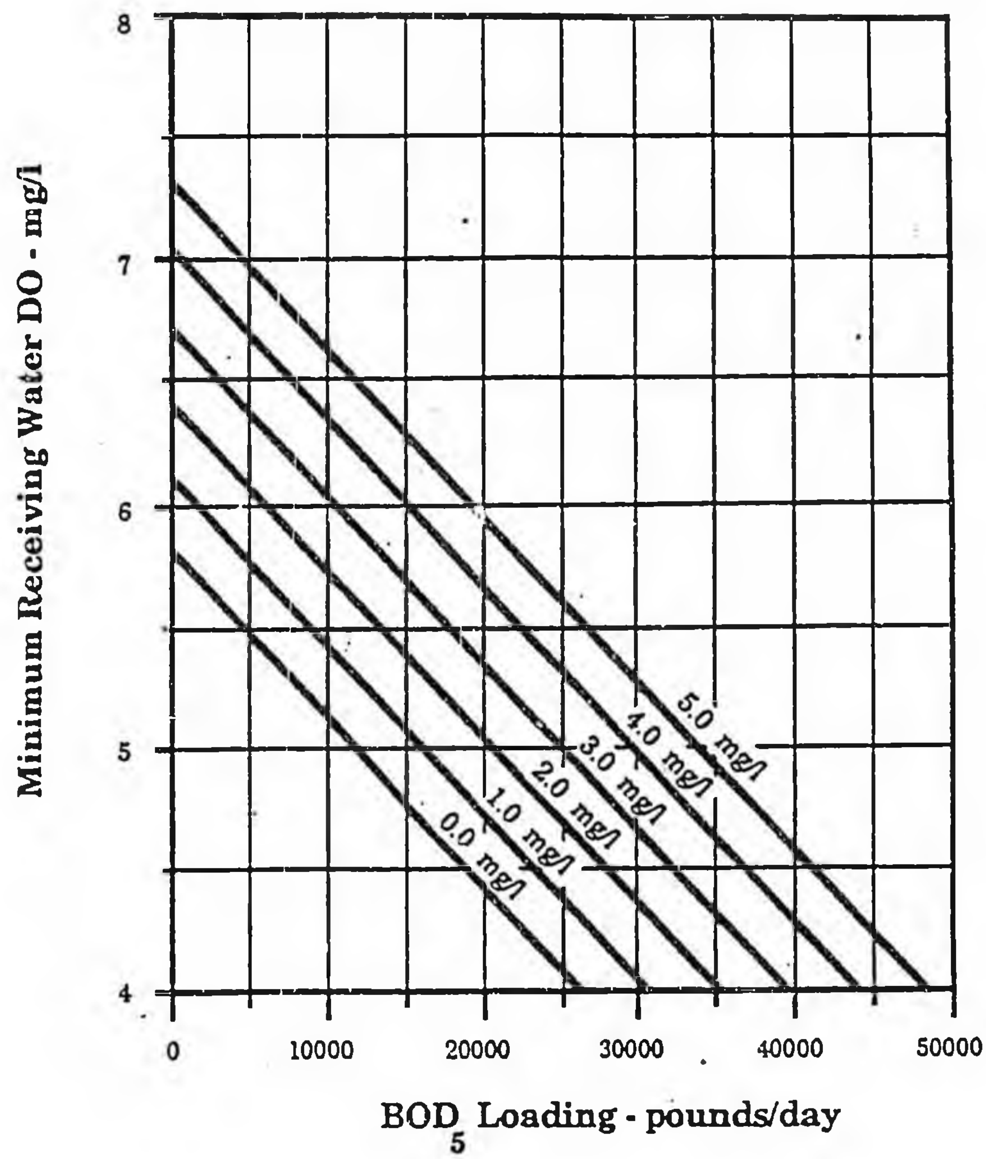


Figure E7: Minimum receiving water DO in Ward Cove as a function of BOD loading from KPC for various levels of DO in the discharge. Based upon model parameter estimates using August 19, 1986 sampling data.

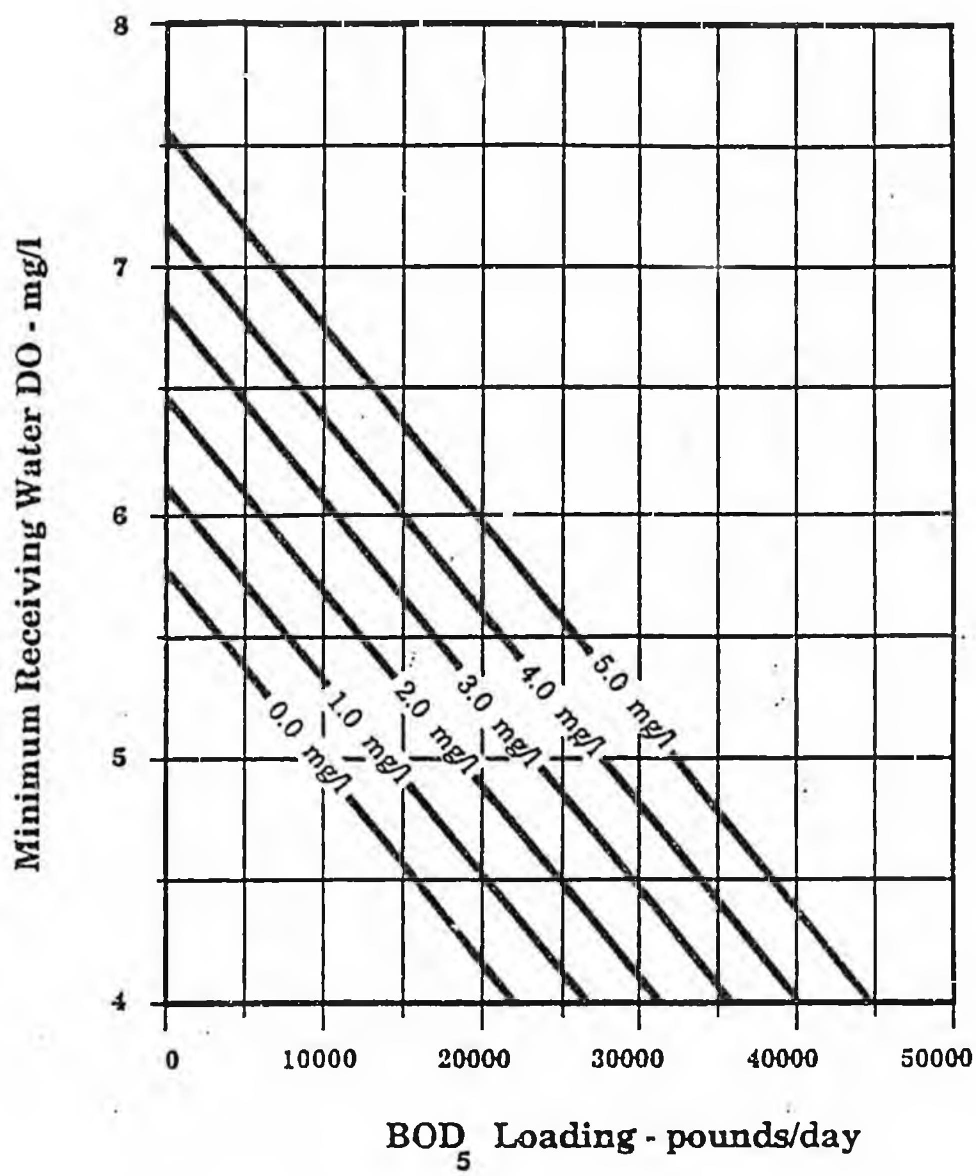


Figure E8: Minimum receiving water DO in Ward Cove as a function of BOD loading from KPC for various levels of DO in the discharge. Based upon model parameter estimates using September 9, 1986 sampling data.

The results of the analysis for the two acceptable parameter sets are similar. When the DO of the discharge is less than 1.0 mg/l, the model predicts that the minimum DO in Ward Cove will be less than 6.0 mg/l, even when the BOD_5 in the discharge is very close to zero. For DO levels in the discharge of 5.0 mg/l, the model estimates that DO will remain above the water quality standard for BOD_5 loadings as high as 20,000 pounds/day.

Conclusions

The following conclusions are based on the results of this analysis of the quality in the surface waters of Ward Cove:

Numerous water quality surveys, beginning soon after the construction of the KPC mill, have noted severe water quality problems in Ward Cove, particularly with respect to DO. These problems have continued over time, according to data collected by KPC in the late summers of 1987, 1988 and 1989.

Low DO in the surface waters of Ward Cove are associated with high levels of PBI, a constituent unique (in Ward Cove) to the discharge of the KPC pulp mill.

For two out of three water quality data sets, using data collected in August and September of 1986, a three-dimensional, steady-state model of DO and BOD was identified which satisfied specific criteria for the difference between observed and simulated values of DO.

Parameter estimates for the three-dimensional, steady-state model support the hypothesis that water quality problems, typified by conditions in August and September 1986, are due to conditions of reduced freshwater flow, low levels of mixing and exchange, relatively high water temperatures and high organic loadings from the KPC mill.

For environmental conditions in Ward Cove similar to those of August and September 1986, the State of Alaska's water quality standard for DO will be violated for any KPC discharge of average volumetric rate when the effluent DO is less than 1.0 mg/l or for a loading rate of approximately 20,000 pounds/day when the effluent DO is at least 5.0 mg/l.

TOTAL MAXIMUM DAILY LOAD FOR BIOCHEMICAL OXYGEN DEMAND IN WARD COVE, ALASKA

PROBLEM AT A GLANCE:

Water Quality-limited?	*Yes*
Segment Identifier:	*10102-601*
Parameter of Concern:	*Dissolved Oxygen (DO)*
Uses Affected:	*Aquatic Life*
Known Sources:	*Point Sources: Pulp Mill Fish Processor*

Background

Section 303(d)(1)(C) of the Clean Water Act and EPA's implementing regulations (40 CFR Part 130) require the establishment of Total Maximum Daily Loads (TMDL) for the achievement of state water quality standards. A TMDL is an implementation plan which identifies the degree of pollution control needed to maintain compliance with standards using an appropriate margin of safety. The focus of the implementation plan is the reduction of pollutant inputs to a level (or "daily load") that fully supports the beneficial uses of a given waterbody; however, other considerations are needed to complete the TMDL process. The components used to address water quality problems through the TMDL process include effluent limits and monitoring requirements.

The state of Alaska has identified Ward Cove as being water quality-limited for dissolved oxygen. Based on an assessment of the problem of low dissolved oxygen (DO) in Ward Cove (which accompanies this document), a TMDL is proposed for this waterbody. The TMDL is established for Biochemical Oxygen Demand (BOD), a parameter directly related to the impact of a discharge on DO resources in the receiving water.

Loading Capacity and Wasteload Allocation

Loading Capacity

As indicated in the problem assessment, the cove's capacity to assimilate BOD loading is dependent not only on BOD loading but also on dissolved oxygen. Therefore, the loading capacity is defined in terms of both BOD and DO. Based on the modelling results from the problem assessment, a loading capacity of 20,000 lbs/day BOD is proposed for the surface layer of Ward Cove. Based on the same analysis, a minimum dissolved oxygen concentration of 5 mg/l is proposed for discharges from the Ketchikan Pulp Company (KPC) facility.

Wasteload Allocation

The BOD loading capacity of Ward Cove must be allocated to the sources identified as contributing pollutant loads to the surface waters. In this case, a single significant source, wastewater discharges from KPC, has been identified.

In accordance with the regulations, a margin of safety is established to account for uncertainty in the data analyses. A margin of safety may be provided (1) by using conservative assumptions in the calculation of the loading capacity of the waterbody and (2) by establishing allocations that in total are lower than the defined loading capacity. In the case of the Ward Cove analysis, the latter approach is used to establish a safety margin. The following uncertainties have been considered in establishing the margin of safety:

- Potential contributions of BOD to the surface layer from the seafood processing facility discharge and bottom sediments
- Potential contributions of BOD to the surface layer from non-point source pollution in the watershed.
- Uncertainty about assumptions used in modelling the dissolved oxygen budget

Based on the information available at this time, EPA proposes the following allocations among these sources:

Source	BOD Allocation (% of Total)		Minimum DO
Ketchikan Pulp Co.	16,000 lbs/day	(80%)	5 mg/l
Non-Point Source	2,000 lbs/day	(10%)	-
Margin of Safety	2,000 lbs/day	(10%)	-

The allocation for the KPC facility forms the basis of the BOD limitations in the draft permit (reissuance). The allocation and limitations are established for the summer months (June through October), when dissolved oxygen violations in Ward Cove have been documented.

Monitoring Requirements

The ambient DO monitoring program conducted by KPC as required by its NPDES permit will continue under the reissued permit, as will monitoring of process wastewater discharges for BOD. The draft permit also requires the development of a stormwater monitoring program; this program will focus monitoring efforts on significant stormwater discharges, including those that may contribute significant BOD loadings to Ward Cove. For compliance purposes, stormwater BOD loadings will be added to process waste discharges to determine compliance with total BOD limitations.

Public Involvement

In conjunction with the Public Notice for the draft NPDES permit for Ketchikan Pulp Company, EPA is requesting comment on the Problem Assessment and proposed TMDL from all interested parties. All comments must be submitted to EPA before the expiration date of the Public Notice. After the expiration date of the Public Notice, EPA will make final determinations with respect to the TMDL issuance.

ALASKA PULP CORPORATION
4600 Sawmill Cr. Rd., Sitka, AK 99835 (907) 747-2211 FAX (907) 747-2268

DATE:

PAGES: 2 Incl. cover sheet

TO: Sen Jones.

FROM: Rollo Pool 747-2283, FAX 747-2268

SUBJECT:

The EPA spokesman was way off in his comparison of parts per quadrillion

PPQ = 1 oz. in 1000 cu. miles of liquid

CC:

Sitka Daily Sentinel
November 7, 1991

What's in Quadrillion?

By WILL SWAGEL
Sentinel Staff Writer

Ever miss a heartbeat over fear of toxic substances?

Well, if you live for 27 million years and miss only one heartbeat, you'd get an idea of the ever smaller amounts of toxic substances scientists are detecting in the laboratory.

Parts per million are now old hat.

Department of Environmental Conservation Sitka engineer Jim Clark said dioxin measurements are now being stated in parts per *quadrillion*.

In case you're wondering, a U.S. quadrillion is the number one followed by 15 zeroes: 1,000,000,000,000,000 (when in England, add nine more zeroes).

Recent Environmental Protection Agency reports on dioxin levels in Sitka gave readings in parts per trillion. Even the best labs haven't yet mastered techniques for making measurements in parts per quadrillion, authorities said.

One part per quadrillion is the relationship of just over one square inch to the area of the United States (including Alaska).

Or one grain of salt to 62 million tons of pretzels.

Or one heartbeat in 27 million years.

The equivalents are courtesy of Mark Buggins, who manages Sitka water and wastewater treatment programs.

He said the Alaska Water Management Association convention held in Petersburg last month, DEC safety trainer Tim Bigelow handed around a chart with some tongue-in-cheek comparisons that put things into perspective.

Reproduced below is the definitive chart of incredible shrinking equivalents:

Comparison Tables:

UNIT	1 PART/MILLION	1 PART BILLION	1 PART/TRILLION	1 PART/QUADRILLION
LENGTH	1 Foot/192 Miles	1 Foot/192,000 Miles	1 Foot/192,000,000 Miles (1 Foot/A roundtrip to the sun)	1 Foot/2,000 A.U. (1 Foot/1,000 roundtrips to the sun)
TIME	1 Minute/2 Years	1 Second/33.3 Years	1 Second/33.33 Milleniums	1 Second/33333 Milleniums
WEIGHT	1 lb. Salt/500 Tons Pretzels	1 oz. Salt/31,250 Tons Pretzels	1 Grain Salt/62,500 Tons Pretzels	1 Grain Salt/62 Million Tons Pretzels
VOLUME	1 oz. Vermouth/7,800 Gallons Gin	1 oz. Vermouth/186,000 Barrels of Gin	1 oz. Vermouth/1 Cubic Mile of Gin	1 oz. Vermouth/1,000 Cubic Miles of Gin
AREA	1 Sq. Ft./23 Acres	130 Sq. Ft./City & Borough of Sitka	1 Sq. Ft./State of Alaska	0.1 Sq. Ft./USA
ACTION	1 Bogey/56,000 Rounds of Golf	1 Lob/1,200,000 Tennis Matches	1 Missed Heartbeat/ 27,000 Years	1 Missed Heartbeat 27,000,000 Years
QUALITY	1 Bad Apple/2,000 Barrels	1 Typo Error/100,000 Novels	1 Misfire/833 Hours Driving a V-8	1 Misfire/2,300 Years Driving a V-8

1 pt Billion is one person in China.

SB

23

CORRECTION

THIS DOCUMENT
HAS BEEN REPHOTOGRAPHED
TO ASSURE LEGIBILITY

SB

23

SENATE COMMITTEE REPORT
FIRST COMMITTEE OF REFERRAL

DATE: 1/21/91 FURTHER: Finance

Date of 5-Day Notice: ____________
(in accordance with Uniform Rule 23)

DATE TURNED
INTO OFFICE: ____________

Resources Committee considered SENATE BILL NO. 23

"An Act establishing the Chelatna Public Use Area."

and recommended:

[ ] replace with ______ CS ____________________ [ ] same title
[ ] new title

[ ] attached amendment(s)

[ ] ____________________ letter of intent adopted

[ ] do pass

[ ] do not pass

[ ] no recommendation

[ ] individual recommendations

[ ] further referral to ____________________

ATTACHES NEW FISCAL NOTE(S):

Department(s)/Date:	Department(s)/Date:
[ ] fiscal note(s) ____________	[ ] zero fiscal note(s) ____________
[ ] appropriation-no fiscal note	[ ] Governor's bill w/fiscal note

SIGNING DO PASS: OTHER RECOMMENDATIONS:

____

Chair: Signature and Recommendation

FISCAL NOTE

STATE OF ALASKA **BILL NO. SB 23**
1992 LEGISLATIVE SESSION

Revision Date: 12/18/91
Title: Chelatna Public Use Area
Sponsor: Senator Kerttula
Requestor:

Department Affected: Fish and Game
BRU: Habitat
Component: Habitat
COMPONENT SERIAL NO. 486

Expenditures/Revenues: (Thousands of Dollars)

OPERATING	FY 93	FY 94	FY 95	FY 96	FY 97	FY 98
PERSONAL SERVICES						
TRAVEL						
CONTRACTUAL						
SUPPLIES						
EQUIPMENT						
LAND & STRUCTURES						
GRANTS, CLAIMS						
MISCELLANEOUS						
TOTAL OPERATING	0	0	0	0	0	0
CAPITAL	0	0	0	0	0	0
REVENUE FUND SOURCE:	0	0	0	0	0	0

FUNDING: (Thousands of Dollars)

GENERAL FUND						
FEDERAL FUNDS						
OTHER FUND SOURCE:						
TOTAL	0	0	0	0	0	0

POSITIONS:

FULL-TIME	0	0	0	0	0	0
PART-TIME	0	0	0	0	0	0
TEMPORARY	0	0	0	0	0	0

Estimate of current year impact: No impact on current year.

ANALYSIS: (Attach a separate page if necessary.)

Prepared By: Frank Rue, Director
Phone: 465-4105
Division: Division of Habitat
Date: 12/19/91
Approved by Commissioner: by Ron Somerville
Agency: Department of Fish and Game
Date: 12/20/91

Distribution (by preparer): Leg. Fin., Legislative Sponsor, Requestor, OMB/DBR, Gov. Legis. OSC., & Impacted Agency(ies).

Rev 10/7/91

STATE OF ALASKA

OFFICE OF THE GOVERNOR

BILL ANALYSIS

DEPARTMENT	DIVISION	BILL NUMBER	SPONSOR
Fish and Game	Habitat	SB 23	Senator Kerttula

SHORT TITLE OF BILL

An Act establishing the Chelatna Public Use Area

DEPARTMENT POSITION

Support

PREPARED BY	DATE	COMMISSIONER'S SIGNATURE	DATE
Frank Rue, Director	2-6-91	Don W. Wiley	2/7/91

SUMMARY

OTHER AGENCIES AFFECTED BY BILL	CONSTITUENT GROUPS AFFECTED BY BILL
Natural Resources	None known

ORGANIZATIONAL SUPPORT FOR BILL	ORGANIZATIONAL OPPOSITION TO BILL
None known	None known

FISCAL IMPACT ☐ NONE ☒ FISCAL NOTE ATTACHED

BACKGROUND/LEGISLATIVE INTENT

See attached

ANALYSIS OF BILL/PROGRAM EFFECTS

Senate Bill Number 23 conforms closely to the management intent adopted in the Susitna Area Plan. The Department of Fish and Game should support the bill. It maintains the area within the boundaries of the Chelatna Public Use Area for public recreation, fish and wildlife habitat, and public uses. SB 23 does not restrict lawful hunting, fishing, or trapping, and does not prohibit the Department of Fish and Game from engaging in enhancement of fish and wildlife habitat within the boundaries of the public use area. SB 23 would prohibit disposal of state land within the public use area.

AMENDMENTS PROPOSED

See attached

PLEASE ATTACH A SEPARATE SHEET FOR ADDITIONAL COMMENTS OR ANALYSIS

01-000 (Rev. 3-88)

Attachment to SB 23 Bill Analysis

Background/Legislative Intent: SB No. 23 would establish the Chelatna Public Use Area. The purpose of the area is to protect and maintain fish and wildlife habitat, particularly moose calving and wintering areas, trumpeter swan nesting areas, and other habitats important to furbearers, black and brown bear, and resident and anadromous fish so that traditional public uses of fish and wildlife populations may continue; perpetuate and enhance public enjoyment of fish and wildlife and their habitat, including fishing, hunting, trapping, viewing, and photography; perpetuate and enhance general public recreation in a quality environment; perpetuate and enhance additional public uses described in the Susitna Area Plan; and allow additional uses of the area in a manner compatible with the purposes specified above.

Management of the public use area, including the surface and subsurface estate will be the responsibility of the Commissioner of Natural Resources. SB No. 23 directs the commissioner to adopt a management plan for the area with the participation and consultation of the commissioner of Fish and Game. The bill does not specify a date when the plan is to be completed. The proposed legislation requires that the area shall be open to mineral entry except as provided in the plan to be developed. Until the management plan is developed, the mineral estate is to be managed under the provisions of the Susitna Area Plan. It should be noted that the Susitna Area Plan closed lands within 300 feet of Home Creek and lands within 1/4 mile of the unnamed tributary to Lake Creek just south of Home Creek that encircles the north side of Mt. Yenlo and Willow Mountain to mineral entry. These areas should remain closed to mineral entry. The bill allows for traditional access to the Chelatna Public Use Area by motorized or nonmotorized means of transportation to private land and for lawful hunting, fishing, trapping, and recreational purposes and requires the commissioners of Fish and Game and Natural Resources to jointly develop guidelines for traditional access to be included in the management plan. Disposal of the surface estate in state land is prohibited. Proposed legislation creating this area was reviewed as SB No. 407 in 1988 and SB No. 165 in 1989.

Amendments Proposed:

Page 1, line 8: Please revise existing language as follows: "...wintering[-OVER] areas,..."

Page 2, lines 29 and 30: Please revise existing language as follows: "... lawful [SPORT AND SUBSISTENCE] fishing, ..."

Page 3, line 1: Please revise existing language as follows: "(d) Subject to the provisions of the Susitna Basin Recreational Rivers Management Plan and the Susitna Area Plan [T]the commissioner..."

An error occurs in the legal description of the public use area on page 3 beginning with line 26, item 2. As indicated on the attached map depicting the boundaries of SB No. 23 this portion of the legal description describes a very small area along Yenlo Creek which is isolated from the remainder of the area. This was identified in our February 21, 1989 analysis of SB No. 165. Previous to that correspondence, we provided comments to former Senator Szymanski's office on the March 29, 1988 working draft of the bill that recommended two amendments to the boundaries. Part of our proposed addition was designated for settlement in the Susitna Area Plan and the Department of Natural Resources recommended that it be deleted. Natural Resources had no objection to the remaining portion of the Yenlo Hills that we recommended be added (Sunflower Basin 5a) because the original management intent was compatible with the public use area. Therefore, we believe an error was made in editing the legal description to omit lands designated for settlement. We request that the following amendments in the legal description be made to add important moose habitat and hunter use area in the Yenlo Hills to the Chelatna Public Use Area:

Page 3, line 23: Please add the following new item (1) and move the existing item (1) to item (2).

(1) Township 23 North, Range 11 West, Seward Meridian
Sections 1-4
Section 5: E1/2E1/2
Section 8: E1/2E1/2
Section 9
Sections 10-12
Section 13: W1/2,NE1/4
Sections 14-15
Section 16: E1/2
Section 22: E1/2, NW1/4
Section 23
Section 24: W1/2, SE1/4
Section 25: W1/2, NE1/4
Section 26
Section 27: NE1/4

Page 3, line 26:

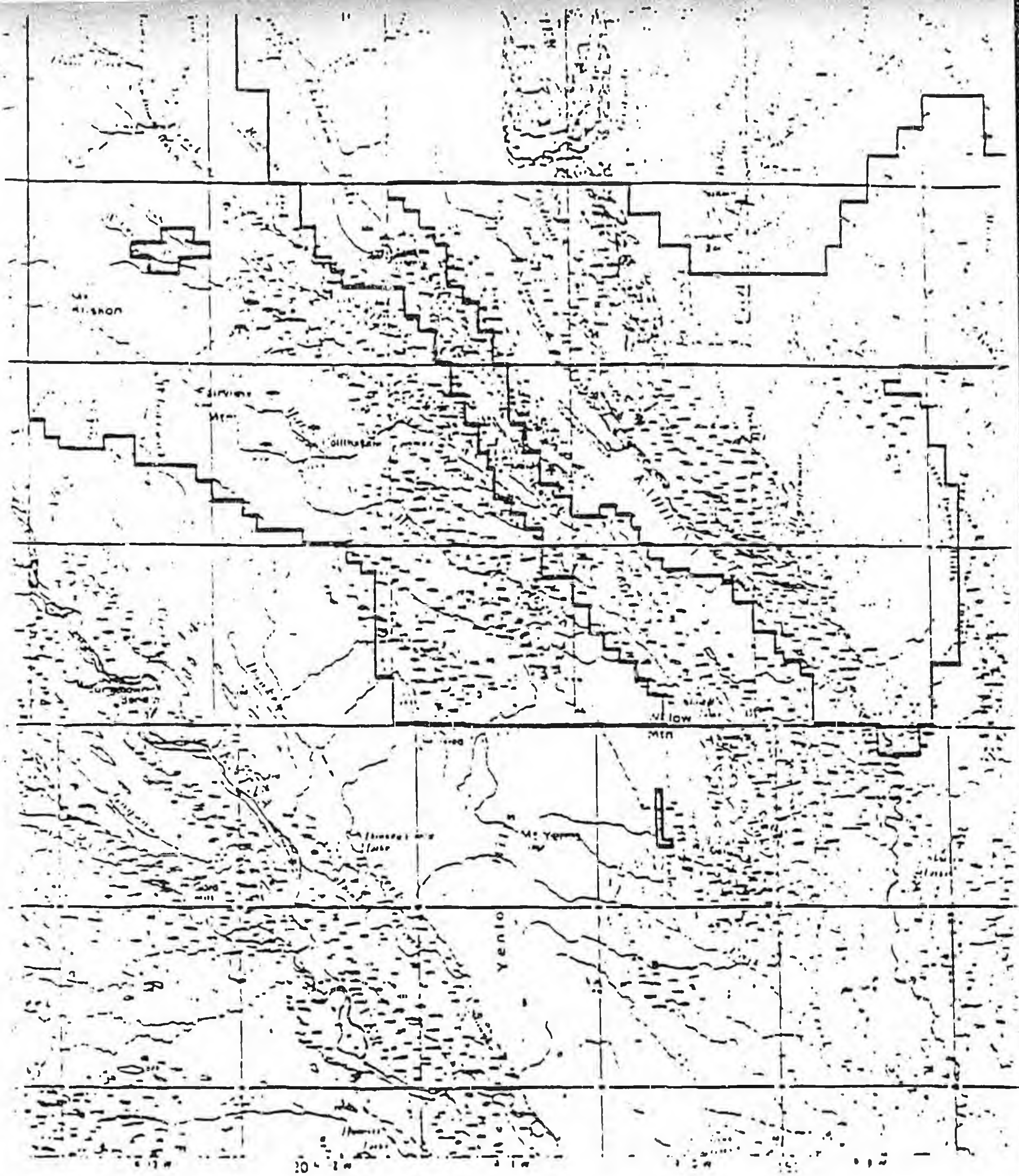
[(2) TOWNSHIP 24 NORTH, RANGE 10 WEST, SEWARD MERIDIAN
SECTION 16: W1/2W1/2
SECTION 21: W1/2W1/2, SE1/4SW1/4]

(3) Township 24 North, Range 10 West, Seward Meridian
Section 4: W1/2

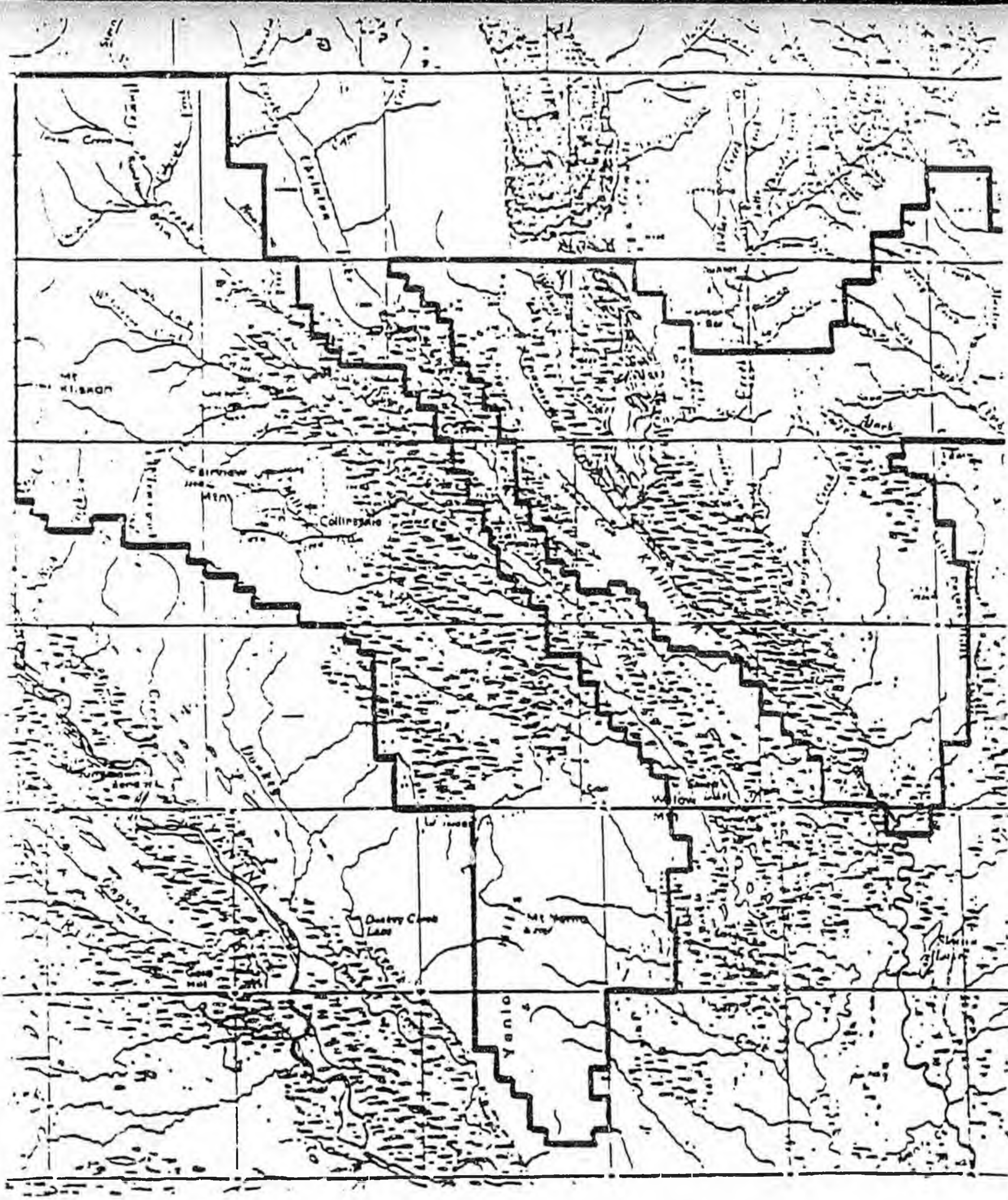
Sections 5-9
Section 16: W1/2W1/2
Sections 17-20
Section 21: W1/2W1/2
Section 28: W1/2
Sections 29-32
Section 33: W1/2

(4) Township 24 North, Range 11 West, Seward Meridian
Sections 1-4
Section 5: E1/2E1/2
Section 8: E1/2E1/2
Sections 9-16
Section 17: E1/2E1/2
Section 20: E1/2E1/2
Sections 21-28
Section 29: E1/2E1/2
Section 32: E1/2E1/2
Sections 33-36

Change the remaining item numbers to reflect these additions. Please see attached map depicting the proposed amendments to the boundaries of the Chelatna Public Use Area.



THIS IS THE 1991 SB 23 CHELATNA PUBLIC USE AREA BOUNDARY



CHELATNA PUBLIC USE AREA ADF&G PROPOSED AMENDMENT TO SB 23

FISCAL NOTE

STATE OF ALASKA
1991 LEGISLATIVE SESSION

BILL NO. SB 23

Revision Date: 2-7-91
Department Affected: Fish and Game
Title: Chelatna Public Use Area
BRU: Habitat
Component: Habitat
Sponsor: Senator Kerttula
Requestor:
COMPONENT SERIAL NO. 0 4 8 6

Expenditures/Revenues: (Thousands of Dollars)

OPERATING	FY 92	FY 93	FY 94	FY 95	FY 96	FY 97
PERSONAL SERVICES						
TRAVEL						
CONTRACTUAL						
SUPPLIES						
EQUIPMENT						
LAND & STRUCTURES						
GRANTS, CLAIMS						
MISCELLANEOUS						
TOTAL OPERATING	0	0	0	0	0	0

CAPITAL	0	0	0	0	0	0

REVENUE	0	0	0	0	0	0

FUNDING: (Thousands of Dollars)

GENERAL FUND						
FEDERAL FUNDS						
OTHER						
TOTAL	0	0	0	0	0	0

POSITIONS:

FULL-TIME	0	0	0	0	0	0
PART-TIME	0	0	0	0	0	0
TEMPORARY	0	0	0	0	0	0

Estimate of current year impact: No impact on current year

ANALYSIS: (Attach a separate page if necessary.)

Prepared By: Frank Rue, Director
Phone: 465-4105
Division: Habitat
Date: 2-7-91
Approved by Commissioner: Don W. Collinsworth
Agency: Department of Fish and Game
Date: 2/7/91

Distribution (by preparer): Legislative Finance, Legislative Sponsor, Requestor, OMB, & Impacted Agency(ies).

Rev 10/90