

Appendix B

Kenai River Estuary
Sediment and Water Quality Investigations

by
Kennetic Laboratories Incorporated

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EXECUTIVE SUMMARY

This report provides results of the 1997 Kenai River Estuary Sediment and Water Quality Investigations performed for the Alaska Council of Trout Unlimited by Kinnetic Laboratories, Inc. (KLI) of Anchorage, Alaska. The purpose of the investigation was to establish a database of environmental data from the lower Kenai River and its estuary using a sediment triad approach. This approach included looking at chemical, toxicological, and biological parameters that could be used to help evaluate the levels of contaminants and the potential effects of contaminant discharges on the Kenai River Estuary. The parameters and methods selected for the program were intended to be consistent with earlier work performed in the river by the Alaska Department of Fish and Game (ADF&G).

Sediment quality was assessed by performing chemical analyses for the parameters of total organic carbon (TOC); particle grain size (PGS); total metals (barium, cadmium, chromium, copper, lead, manganese, selenium, and zinc); pesticides and polychlorinated biphenyls (PCBs); and semivolatile organics (including polycyclic aromatic hydrocarbons [PAHs]). Toxicity testing was used to help assess potential effects of contaminants on the biota of the estuarine sediments. A Microtox[®] bioassay was used; this is a sensitive toxicity testing method using bacteria that emit light. The biological component of the program included identification of the benthic infauna population at each location sampled. This component was included to determine the presence or absence of infauna that might be monitored in the future as indicators to reflect the health of the ecosystem. In addition, water quality parameters were assessed at each station, including salinity, conductivity, temperature, dissolved oxygen, and pH. Water samples were collected at two stations for the analysis of turbidity, alkalinity, total phosphorus, total suspended solids (TSS), and color.

The sampling was conducted on 15-16 August 1997 at seven locations in the lower Kenai River. The sampling locations were chosen to best evaluate conditions and potential effects of point and non-point discharges associated with development at the mouth of or within the estuary of the Kenai River. These discharges include permitted discharges as well as those from drainage areas within the City of Kenai. Samples were collected at River Mile 0, 0.5, 0.8 (benthics only), 1, 2, 3, and 6.5. The River Mile 6.5 station was considered a control located upriver from most developed activity associated with the City of Kenai. This station is downstream, however, from the developed area around Soldotna.

For the most part, pesticides, PCBs, and semivolatile organic compounds (including PAHs) were not found at levels above method detection limits at most of the stations. Some of these contaminants did appear at detectable levels at River Mile 2, where sediments were found to contain DDTs, a PCB compound, and two pesticide compounds. When compared to National Oceanic and Atmospheric Administration (NOAA) guidance levels, these exceeded lower levels where an effect might be seen, but were still well below median levels above which effects would be considered probable. In addition, one pesticide was found at River Mile 6.5, and one semivolatile organic compound was found at River Mile 3. No pesticides, PCBs, or semivolatile organic compounds were detected at River Miles 0, 0.5, or 1.

Concentrations for most of the metals were consistent across all stations, with the lowest levels typically seen at River Miles 0 and 2. Most metals were found to be highly correlated with PGS (silt/clay) and TOC. This means that variations in silt/clay and TOC content accounted for much of the variability seen in the metals concentrations. The exception to this was cadmium, which appeared to be higher at River Mile 2 than could be accounted for by the differences in silt/clay or TOC content. With the exception of copper, concentrations of metals were all below the NOAA lower potential effects levels. Copper was found to slightly exceed the lower level at four of the six stations, but was still well below the median effect level.

Sediment toxicity was determined by Microtox[®] bioassay methodology for each of the six sediment samples. Sediments from River Mile 3 were found to be the most toxic, while those from River Miles 1 and 2 also showed toxicity within the concentration ranges tested. Sediments from the other three locations, River Miles 0, 0.5, and 6.5, were not found to be toxic within the range of concentrations tested.

Biological sampling of the benthic infauna indicate a somewhat sparse but typical community for a lower tidal-influenced river that is characterized by a dynamic environment. Only five taxa were found, with the dominant species being the bivalve clam, *Macoma balthica*.

Water quality sampling within the lower Kenai River and its estuary indicated that the water conditions near the mouth of the river were much more turbid and higher in suspended sediments than the upstream location (River Mile 6.5). Water quality sampling and profiling were performed at low tide, therefore, marine influences were found to be negligible. The water column profiling indicated little spatial variation in any parameter with dissolved oxygen near saturation at all locations.

1.0 INTRODUCTION

This report documents the Kenai River Estuary Sediment and Water Quality Investigations performed for the Alaska Council of Trout Unlimited by Kinnetic Laboratories, Inc. (KLI) of Anchorage, Alaska. The investigation was performed in August 1997 in conjunction with work being conducted by KLI for the Cook Inlet Regional Citizens' Advisory Council (CIRCAC).

2.0 STUDY DESIGN

2.1 Program Objectives

The purpose of the Trout Unlimited Kenai River investigation was to collect environmental data that can be used to:

- Establish an aquatic habitat/water quality database using sediment quality data for status and trend analysis of the Kenai River Estuary
- Identify the presence or absence of benthic invertebrates for possible future use as estuarine bio-indicators
- Supplement existing water quality data that has been collected by the Alaska Department of Fish and Game (ADF&G) along the river.

2.2 Sampling Design

The Trout Unlimited sediment and water quality sampling was conducted on 15-16 August 1997 and completed at the seven locations listed in Table 1. Depths provided in the table are actual water depths at time of collection; no attempt has been made to correct for river stage, tidal influence, or to tie measurements into a vertical datum. These locations were chosen to best evaluate the presence of and effects of identified point and non-point contaminant discharges associated with industrial and urban development at the mouth of or within the estuary of the Kenai River. These discharges include those authorized by National Pollution Discharge Elimination System (NPDES) permits as well as those from swampy drainages and or other urban areas within the City of Kenai. This includes areas designated for cleanup by Alaska Department of Conservation (ADEC) as well as those contained in a Notice of Intent for clean water violation. Sampling stations and their proximate discharges included:

- River Mile 0: storm drain, Kenai City Wastewater Treatment Plant (WWTP)
- River Mile 0.5: small boat harbor and vessel activity, drainage stream entry
- River Mile 0.8: three processors (Pacific Star Seafoods, Salamatof Seafoods, and Dagnet Fisheries Co. Inc.), harbor activity
- River Mile 1: storm drain, harbor activity
- River Mile 2: harbor activity
- River Mile 3: two processors (Wards Cove Packing and Inlet Salmon), harbor activity
- River Mile 6.5: control station located upriver from most developed activity associated with the City of Kenai, but downstream from potential discharges from the Soldotna area

Table 1. Station Locations and Sampling Information.

Station Location	Matrix	Sample Date	Sample Time (ADT)			Depth (m)	Global Positioning System (GPS) Coordinates			
			Latitude (N)	Longitude (W)			Latitude (N)	Longitude (W)		
River Mile 0	Sediment Benthics Water	8/16/97	8/16/97	8/16/97	1107	1107	1206	0	1.5	4.0
60% 33' 00.1"	60% 33' 00.1"	60% 33' 00.1"	151% 15' 36.6"	151% 15' 36.6"	151% 15' 36.6"					
River Mile 0.5	Sediment Benthics Water	8/16/97	8/15/97	8/16/97	1044	1742	1156	0	2.2	4.5
60% 33' 03.7"	60% 33' 03.7"	60% 33' 03.7"	151% 13' 58.1"	151% 13' 58.1"	151% 13' 58.1"					
River Mile 0.8	Benthics	8/15/97	1722	2.9	60% 32' 42.6"				151% 13' 22.0"	
River Mile 1	Sediment Benthics Water	8/16/97	8/16/97	8/16/97	1547	1612	1146	4.9	4.8	2.2
60% 32' 35.5"	60% 32' 34.9"	60% 32' 34.9"	151% 13' 25.2"	151% 13' 27.8"	151% 13' 27.8"					
River Mile 2	Sediment Benthics Water	8/16/97	8/16/97	8/16/97	1510	1529	1134	5.1	5.1	4.0
60% 32' 29.2"	60% 32' 28.0"	60% 32' 28.0"	151% 14' 20.2"	151% 14' 19.9"	151% 14' 19.9"					
River Mile 3	Sediment Benthics Water	8/16/97	8/16/97	8/16/97	1411	1445	1124	3.1	4.4	3.2
60% 32' 04.4"	60% 32' 04.2"	60% 32' 04.2"	151% 15' 21.8"	151% 14' 58.1"	151% 14' 58.1"					
River Mile 6.5	Sediment Benthics Water	8/16/97	8/16/97	8/16/97	2048	2048	1046	0	1.5	3.7
60% 32' 0.90"	60% 32' 0.90"	60% 32' 0.90"	151% 10' 37.4"	151% 10' 37.4"	151% 10' 37.4"					

2.3 Analytical Strategy

Analytical strategy for the program included the use of a sediment quality triad approach examining chemical, toxicological, and biological parameters to help evaluate the levels and potential effects of contaminant discharges on the Kenai River Estuary and its biota. The parameters and methods selected for the program were consistent with prior work performed in the

river by ADF&G.

Sediment quality assessment included the chemical analysis of sediment for the following:

- Total organic carbon (TOC) and particle grain size (PGS)
- Total metals (barium, cadmium, chromium, copper, lead, manganese, selenium, and zinc)
- Pesticides and polychlorinated biphenyls (PCBs)
- Semivolatile organic compounds (including polycyclic aromatic hydrocarbons [PAHs]).

Toxicity testing was used to help assess potential effects of contaminants on the biota of the estuarine sediments. A Microtox[®] bioassay was used (Beckman Instruments, 1982; Long and Markel, 1992). This is a sensitive toxicity testing method using bacteria that emit light. The strengths of this type of bioassay are that it is rapid, it is less expensive than other bioassay tests, and it can be used with various types of sediments regardless of PGS or salinity of interstitial water contained in the sediments.

The biological component of the sediment triad included sorting and taxonomic identification of the benthic infauna population at each location sampled. This component was included to determine the presence or absence of infauna that could potentially be monitored as indicators to reflect the health of the ecosystem.

In addition to the sediment quality parameters, water quality parameters were assessed. Hydrographic profiles were obtained at each station including salinity, conductivity, temperature, dissolved oxygen, and pH. Water samples were collected at two stations for the analysis of turbidity, alkalinity, total phosphorus, total suspended solids (TSS), and color.

2.4 Contractor

Kinnetic Laboratories, Inc. of Anchorage, Alaska performed the Trout Unlimited Kenai River sediment and water quality sampling, project coordination, and reporting. Mr. Dennis Randa of Trout Unlimited participated with KLI in the field sampling for the program, which was conducted from the F/V *Corrina Kay* or Mr. Randa's aluminum skiff. Field sampling was performed in conjunction with CIRCAC studies being performed in Cook Inlet and the Kenai River

Infaunal samples were sent to KLI's Santa Cruz, California laboratory for preliminary sorting and identification. Marine biologists Steen Trump and Kristine Atkinson performed this analysis, while KLI taxonomist Jon Toal provided quality assurance/quality control. Mr. Gene Ruff of Ruff Systematics in Puyallup, Washington provided consulting services by identifying polychaetes for the project.

Analytical support for the chemistry and toxicological components of the program was provided by a variety of laboratories. Semivolatile organic analyses were performed by CT&E Environmental Services, Inc., also of Anchorage. ToxScan, Inc. of Watsonville, California provided analysis for pesticides, PCBs, total metals, and Microtox[®] toxicity. The Geochemical and Environmental Research Group (GERG) of Texas A&M University in College Station, Texas provided analysis for TOC and PGS. Northern Testing Laboratories, Inc. (NTL) of Anchorage provided analysis of water samples for alkalinity, total phosphate, TSS, and color. Turbidity samples were analyzed at KLI in Anchorage.

3.0 METHODS

3.1 Field Methods

3.1.1 Sediment Collection

Samples were collected for chemical, toxicological, and benthic analysis. Subtidal sediment sampling was performed using modified van Veen grabs. Subtidal chemistry and toxicological samples were collected using a Teflon-coated 0.1-m² grab. Intertidal chemistry and toxicological sediments and were collected manually using Teflon-coated stainless steel scoops. Benthic samples were collected with either the Teflon-coated 0.1-m² grab or a smaller stainless steel 0.06-m² grab.

Each subtidal sample included several successful drops of the van Veen grab. A grab was considered successful if it contained relatively undisturbed overlying water; if the sediment surface appeared largely undisturbed; and if the grab contained sufficient sediment for the full suite of samples to be collected but had not over-penetrated the sediment. Surficial sediment samples for chemistry or toxicity analysis were collected from the top 0 - 2 cm of the sediment within the grab, excluding sediment in contact with the grab surfaces. Sediment was composited in Teflon-coated stainless steel containers. Intertidal samples were composited by manually scooping surficial sediment from a 1-m² area.

Samples were placed in appropriate pre-labeled plastic containers (bags or high density polyethylene [HDPE] jars) or pre-cleaned glassware. Chemistry/toxicity samples were placed on ice immediately after sampling and remained chilled until analysis at the laboratory.

Sediment samples designated for benthic infaunal analysis were processed on board the sampling vessel. For each benthic sample, a surface area of approximately 0.1 m² was sampled, and the entire contents of the grab(s) were passed through a standard 1.0-mm sieve. The organisms were relaxed using propylene phenoxtyol and fixed with 10 percent (%) buffered formalin solution. All benthic samples were labeled twice (inside and outside of jar) to ensure integrity of sample data. Samples were transferred to 70 % ethanol within 24 hours of receipt by the laboratory.

The van Veen grab and sampling utensils were decontaminated between each station. Decontamination procedures included removal of residual sediment by washing with Alconox and rinsing with seawater. The gear was then rinsed with acetone to remove residual water, with hexane to remove any organic contamination, and allowed to air dry before reuse.

Sample documentation included project-specific pre-printed sediment chemistry logs, sediment chemistry effort logs, sample identification/chain of custody forms, and sample labels. These documented information such as the survey and station designation, date, time, depth, navigational information, observations of sediment characteristics, and names of sampling personnel. Sample identification and integrity were ensured by a rigidly-enforced chain of custody program. Sample identification/chain of custody forms (COCs) provided specific

information concerning the identification, handling, and shipment of samples. The field leader was responsible for review and approval of all field documentation.

Navigation and station location included the use of nautical and topographic charts, radar, and a global positioning system (GPS). A hand-held GPS was used to obtain the coordinates of both intertidal and subtidal stations.

3.1.2 Water Collection

Water samples were collected directly into appropriate pre-cleaned labeled sample bottles by dipping the container approximately m below the water surface. Each container was rinsed three times with site water prior to filling. Water samples for alkalinity, TSS, total phosphorus, and color analyses were collected in 1-L HDPE bottles. Turbidity samples were collected in a separate 125-mL HDPE bottle, and one field duplicate was collected in conjunction with turbidity. Samples were placed on ice and kept chilled until receipt at the analytical laboratory. Salinity samples were collected at each water quality station for CTD calibration purposes by filling glass salinity bottles. These samples required no refrigeration.

Hydrographic profiles were obtained at each station using a CTD (an *in situ* conductivity, temperature, and depth sensor). A microprocessor-controlled Seabird SEACAT SBE-19 CTD was used. Salinity was calculated from the conductivity, temperature, and depth measurements. Dissolved oxygen and pH data were also obtained with the CTD.

3.2 Laboratory Methods

Standard protocols were used for the analysis of sediment and water samples. Refer to Table 2 for information regarding the method, preservation, and holding time for each analysis. A brief description for each of the methods is provided below. The reader is referred to the appropriate EPA method where applicable for more comprehensive information.

Table 2. Sediment and Water Quality Preservation and Analysis Methods.

Parameter	Preservation	Maximum Holding Time	Analysis ^a
SEDIMENT			
Total Organic Carbon	Freeze	Not Applicable	SOP 8907 ^b
Particle Grain Size	Cool, 4°C	Not Applicable	Folk (1974)
Total Metals	Cool, 4°C	28 days	SW 6020
Total Selenium	Cool, 4°C	28 days	SW 7741
Pesticides and PCBs	Cool, 4°C	40 days after extraction	SW 8080
Semivolatile Organics	Cool, 4°C	40 days after extraction	SW 8270
WATER			
Turbidity	Cool, 4°C	ASAP	SM 2130
Alkalinity as CaCO ₃	Cool, 4°C	14 Days	SM 2320B
Total Phosphate-P ³	Cool, 4°C	H ₂ SO ₄ to pH<2 E	28 Days SM 4500-P
Total Suspended Solids	Cool, 4°C	7 Days	SM 2540D
Color - Apparent Color - True		Cool, 4°C	48 Hours SM 2120B

^a “EPA” refers to the EPA document *Methods for Chemical Analysis of Water and Wastes*, revised March 1983, Document No. EPA-600/4-79-020; “SM” refers to *Standard Methods for the Examination of Water and Wastewater*, 19th ed., 1995. “SW” refers to the EPA Manual SW 846, *Test Methods for Evaluating Solid Waste*. 3rd Ed., 1986.

^b Refers to Texas A&M University’s Geochemical and Environmental Research Group (GERG) Standard Operating Procedure.

3.2.1 Sediment Analyses

Total Organic Carbon

Total organic carbon analysis was performed as described by GERG SOP-8907 using a 500-mg aliquot of freeze-dried sediment. The sediment was placed in an induction furnace designed to burn samples in an oxygen atmosphere. Gases produced by the combustion were processed and put through an infrared detector for quantification of carbon dioxide. This method is similar to EPA 415.1 used to determine TOC in water and aqueous waste samples. Total organic carbon was determined after sample acidification. Results were reported in percent TOC on a dry weight basis. Laboratory quality control included the analysis of one duplicate sample, one method blank, and one standard reference material (SRM) per batch.

Particle Grain Size

The determination of PGS was performed using a method adapted from Folk (1974) as described by GERG SOP-8908. Sediment samples were homogenized and a subsample of 15 - 20 g was removed for analysis. The subsample was treated and washed to oxidize organic matter and remove soluble salts prior to the addition of dispersant. After agitation, the sediment solution was sieved to separate the gravel/sand fraction from the silt/clay fraction. Dry-sieve techniques were then used to determine the sand and gravel fractions. Silt and clay fractions were determined by pipetting. Results were reported in percent gravel, sand, silt, and clay on a dry weight basis. Laboratory quality control included the analysis of one duplicate sample per batch.

Total Metals

Total metals concentrations were determined using digestion and subsequent analysis by inductively coupled plasma mass spectroscopy (ICP/MS) or atomic absorption (AA) spectroscopy. Metals concentrations were reported in mg/kg (parts per million [ppm]) on a dry weight basis following a percent solid determination (EPA 160.3) for each sample.

Total barium, cadmium, chromium, copper, lead, manganese, and zinc concentrations were determined using ICP/MS following procedures described in SW 6020. The ICP/MS method measures light emitted from the elements (or metals) by mass spectrometry. Samples were reduced to an aerosol form and transported to a plasma torch, where emission line spectra were produced by inductively coupled plasma. Mass spectrometry was used to determine the concentrations of the metals.

Total selenium concentrations were determined following SW 7741 using the hydride AA technique. This method involved digesting the sample, converting the selenium in the sample to a volatile hydride, and analyzing the absorbance of this compound on an AA spectrophotometer.

Laboratory quality control for metals analyses included the use of a method blank, matrix spike/matrix spike duplicate, and SRM. Quality control analyses were performed with the regular sample batch for all the metals tested. In addition, a laboratory duplicate was performed for the percent solids determination.

Pesticides and Polychlorinated Biphenyls (PCBs)

Pesticides and PCBs were determined using a gas chromatograph as described by SW 8080. Concentrations were reported in $\mu\text{g}/\text{kg}$ (parts per billion [ppb]) on a dry weight basis following a percent solid determination (EPA 160.3) for each sample.

Laboratory quality control included the use of a surrogate spike solution added to each sample, a method blank, matrix spike/matrix spike duplicate, and a laboratory control sample. Quality control analyses were performed with the regular sample batch.

Semivolatile Organics

Semivolatile organic analyses were performed as described by EPA SW 8270, a gas chromatograph/mass spectrometer (GC/MS) method. Semivolatile concentrations were reported in mg/kg (ppm) on a dry weight basis following determination of total solids using SM 2540G.

Laboratory quality control that was reported included the use of a surrogate spike solution added to each sample. In addition, in accordance with the laboratory's quality control plan and the specified method, other quality control samples such as method blanks and matrix spike/matrix spike duplicates were also performed with the regular sample batch.

Microtox® Bioassay

Microtox® testing was performed following procedures described in the Microtox® Operating Manual (Beckman Instruments, 1982) and by Long and Markel (1992). The Microtox® method depends on a bioluminescent bacterium (*Photobacterium phosphoreum*) which produces light from its electron transport system. This natural luminescence indicates the metabolic state of the bacteria. When the bacteria are dosed with a chemical contaminant, decreased bioluminescence is indicative of toxicity, and measurement of the amount of decrease over time is used as a quantitative measure of toxicity.

The bioassay included the use of a chemical extraction procedure specific for neutral compounds such as aromatic and chlorinated hydrocarbons. It is not specific for metals or other types of contaminants such as acidic and basic organic compounds. Extraction procedures followed those provided in *Recommended Protocols for Conducting Laboratory Bioassays on Puget Sound Sediments* (TetraTech, Inc. and E.V.S. Consultants, 1986). Organic extraction of 3.3 gram subsamples of sediment was accomplished using spectral-grade dichloromethane as the extraction solvent and sodium sulfate as a drying agent. Samples were centrifuged

during the triple-extraction procedure to increase extraction efficiency. The extract was concentrated and volume-adjusted through boiling (60°C water bath), use of a tube heater, and the addition of dichloromethane, hexane, and ethanol. Extraction blanks were prepared for quality control purposes by following an identical procedure without the sediment.

Freeze-dried bacteria were prepared for testing by reconstituting with distilled charcoal-filtered water and placed in Microtox® cuvettes. A stock test solution of each sediment extract and Microtox® diluent was prepared. Seven dilutions (100, 50, 25, 12.5, 6.25, 3.125, and 0 %) of this stock test solution were prepared for each sample and adjusted to 2 % sodium chloride (NaCl) using a NaCl solution. The 0 % dilution was a reagent blank that was used to measure the natural decrease of light production which occurs in the bacteria independent of treatment.

Seven Microtox® cuvettes were prepared with a 20 &L aliquot of the bacterial suspension and 500 &L of the Microtox® diluent. After incubation of each cuvette for 15 minutes (min) to ensure temperature equilibration, light emission was measured to obtain initial levels prior to addition of the extract. The extract dilutions were added to the cuvettes at regular time intervals to ensure measurement prior to the gradual natural decrease in bioluminescence. Each dilution of every sample, including the 0 % dilution (reagent blank), was tested in duplicate for a total of 14 cuvettes per sample.

Light emission was measured exactly 5 min after the addition of the extract dilutions and again at 15 min after extract addition. Linear regression analyses were used to estimate the 15-min EC_{50} , which was defined as the concentration of extract required to cause a 50 % reduction in bioluminescence. These analyses took into effect the percent decrease of bioluminescence recorded at each test concentration (100, 50, 25, 12.5, 6.25, and 3.125 %) over the period of the test normalized for the natural decrease in light production over time (from the reagent blank at 0 %). An additional statistical procedure was used where appropriate to calculate a 95 % confidence interval for the EC_{50} .

Benthic Infauna

Benthic samples were transferred to 70 % ethanol upon arrival at the laboratory. Samples were sorted with the aid of low-power microscopes to remove animals from the screened sediment. Infauna were initially sorted into major taxonomic categories, such as annelids, crustaceans, mollusks, echinoderms, and “others”.

All organisms were identified to the lowest possible taxonomic level using high-powered microscopes. All whole infaunal specimens and identifiable parts of each taxon were kept individually by sample in separate vials with a complete specimen label. Specimens were stored in 70 % ethanol.

3.2.2 Water Analyses

Turbidity was determined following the nephelometric procedure described by Standard Methods 2130; turbidity was reported in nephelometric turbidity units (NTUs). Alkalinity was reported in mg/L (ppm) using a titration method described by Standard Method 2320B. Total phosphate

in mg/L (ppm) was determined following Standard Method 4500-P E, a colorimetric method. Total suspended solids were determined by filtering the samples and measuring the dried residue on the filters as described by Standard Method 2540D; these were reported in mg/L (ppm).

Color was determined using visual comparison methods and reported in color units. Apparent color was determined following Standard Method 2120B; true color was determined following EPA 110.2. The true color method was used for one sample because of a high degree of sediment masking which precluded the use of the apparent method.

In addition, salinity for the calibration samples was determined following Standard Method 2520B, an electrical conductivity method. Salinity was reported in parts per thousand (ppt or ‰).

4.0 RESULTS AND DISCUSSION

This section provides an overview of the results from this program. Analytical reports may be found in the appendices of this document. Due to the limited scope of this program, results have not been compared to any other local data sets, including NPDES discharge data in the lower river or earlier data collection efforts in the upper river.

4.1 Sediment Quality

A total of six sediment quality locations were sampled in the lower portion of the Kenai River and its estuary extending from River Mile 0 (at the marker of the estuary entrance) to River Mile 6.5. Refer to Table 1 for station locations.

4.1.1 Total Metals, Particle Grain Size, and Total Organic Carbon

Total metal results by station are summarized in Table 3, and complete laboratory reports can be found in Appendix A. Most of the metals concentrations were relatively consistent across stations with no one station exhibiting substantially higher levels compared to any other. With the exception of cadmium, the lowest levels of all metals were seen at River Miles 0 and 2. Cadmium was low at River Mile 0, but at River Mile 2 was similar in concentration to that seen at the other stations.

The lower concentration of most metals at River Miles 0 and 2 can probably be attributed to the lower percentages of silt/clay and/or TOC at these two locations. To test these relationships, regression analyses of the concomitant parameters silt/clay and TOC were performed for each of the metals and are presented in Table 4 as r^2 values. With the exception of cadmium, correlations with either silt/clay or TOC explained 89 to 98 % of the variability seen in the metals. Correlations with cadmium were lower, due to the higher concentration previously mentioned at River Mile 2, with r^2 values of 0.67 and 0.68 for TOC and silt/clay, respectively. The high correlations with the other metals would indicate that when the metals concentrations are normalized to either the silt/clay fraction or TOC, no significant differences would be seen between stations. For cadmium, the lower correlation indicates that the higher concentration at River Mile 2 may be significant since it cannot be explained by differences

in silt/clay or TOC content.

Sediment metal results were compared to the Effects Range-Low (ER-L) and Effects Range-Median (ER-M) levels associated with adverse biological effects as defined by the National Atmospheric and Oceanic Administration (NOAA; Long et al., 1993). These criteria should generally be interpreted as representing three ranges: no biological effects are expected below ER-L; effects are possible at levels between the ER-L and the ER-M; and effects are probable at levels above the ER-M. With the exception of copper, concentrations of metals were all below ER-L guidance levels. Copper was found to slightly exceed the ER-L of 34 ppm at four of the six stations, but was still well below the ER-M level of 270 ppm. The highest copper concentration was seen at River Mile 0.5 at 51 ppm.

Table 3. Sediment Quality Results.

Table 4. NOAA Guideline Levels and Correlations for Metals.

Parameter	Effects Range - Low (ppm)	Effects Range - Median (ppm)	Correlation (r ²) with TOC	Correlation (r ²) with Silt/Clay
Barium	not available	not available	0.95	0.98
Cadmium	1.2	9.6	0.67	0.68
Chromium	81	370	0.95	0.97
Copper	34	270	0.95	0.97
Lead	46.7	218	0.90	0.91
Manganese	not available	not available	0.89	0.96
Selenium	not available	not available	0.92	0.97
Zinc	150	410	0.94	0.97

Silt/clay for the six sediment samples ranged from 17 to 97 %, with much coarser sediments seen at River Mile 0 and 2. Total organic carbon concentrations were low at all sites, ranging from 0.27 to 0.71 %, with the lowest concentrations at River Mile 0 and 2. These two stations were located near mid-channel in the river and therefore experienced relatively fast currents that tend to winnow the finer-grained sediments and TOC.

All laboratory quality control was found to be within acceptable limits for total metals, TOC, and PGS.

4.1.2 Pesticides and PCBs

Six sediment samples were analyzed for both pesticides and PCBs according to standard EPA methodology (refer to Section 3), and complete laboratory reports are presented in Appendix A. For the most part, concentrations of these compounds were below detection limits at all locations (Table 3). An exception was the sample taken at River Mile 2 where a number of pesticides and one PCB compound, Aroclor-1254, were found. When compared to NOAA guidance criteria, the total PCBs of 24 ppb at River Mile 2 slightly exceeded the ER-L of 22.7 ppb, but were well below the ER-M of 180 ppb. Similarly, the total DDTs of 7.4 ppb

at River Mile 2 exceeded the ER-L of 1.58 ppb, but were well below the ER-M of 46.1 ppb. A number of the compounds detected at River Mile 2, including the DDTs and PCBs, are no longer manufactured or used in commercial applications. Therefore, the source of these contaminants is unknown. In addition to those seen at River Mile 2, one pesticide (heptachlor) was detected at a concentration of 2 ppb at River Mile 6.5.

With one exception, laboratory quality control samples were found to be within acceptable limits. One of the matrix spikes for DDT was found to be low compared to the matrix spike duplicate, resulting in a high relative percent difference (RPD). However, both matrix spikes for DDT were within the acceptance range, and this did not impact the overall quality of the data.

4.1.3 Semivolatile Organic Compounds

Six sediment samples were analyzed for semivolatile organic compounds according to standard EPA gas chromatograph/mass spectrometer methodology specified in Section 3. With the exception of one semivolatile organic compound, 4-methylphenol (p-Cresol), that was detected at River Mile 3, no semivolatile organic compounds were detected at any of the six locations (Table 3). Refer to Appendix A for laboratory results.

All laboratory quality control samples performed in conjunction with the semivolatile organic analyses were within acceptable limits.

4.2 Sediment Toxicity

Sediment samples from six locations were tested for toxicity by Microtox[®] bioassay methodology. Results of the test are summarized in Table 5 with complete laboratory results in Appendix B. Data are presented as EC₅₀ values (concentration at which effects are seen in 50 % of the test organisms exposed), where lower numbers are considered more toxic. The EC₅₀ concentrations are only presented where the 95 % confidence limits were within the range of ± 2 EC₅₀ values.

Table 5. Microtox[®] Sediment Toxicity Results.

Parameter	River Mile 0 TUN97MCT0001	River Mile 0.5 TUN97MCT0007	River Mile 1 TUN97MCT0003	River Mile 2 TUN97MCT0004	River Mile 3 TUN97MCT0005	River Mile 6.5 TUN97MCT0006
5-Minute EC (mg/mL)						
Replicate 1	> ⁵⁰ 1.63	>1.63	0.87	1.06	0.19	>1.63
Replicate 2	>1.63	2.92 ^a	1.03	0.87	0.16	>1.63
15-Minute EC (mg/mL)						
Replicate 1	> ⁵⁰ 1.63	>1.63	1.21	1.21	0.20	>1.63
Replicate 2	>1.63	>1.63	1.24	0.97	0.16	>1.63

^a Extrapolated value

Due to limitations inherent in the organic extraction procedure, the highest concentration which can be tested is 1.63 mg of sediment/mL of extract or 49.4 % of the stock test solution. Three of

the sediment samples tested (River Miles 1, 2, and 3) produced sufficient light inhibition at the highest concentration to allow calculation of an EC₅₀ value within the concentration range tested. The sample from River Mile 3 showed the highest toxicity (lowest EC₅₀) among the six sediments tested. This sample was collected offshore of two fish processors⁵⁰ and exhibited a strong hydrogen sulfide odor. River Miles 1 and 2 also showed toxicity within the concentration ranges tested and were approximately equally toxic.

The analysis software also has the capability to extrapolate an EC₅₀ and 95 % confidence limits for samples where data regressions produced a reliable slope⁵⁰ (Microbic Corporation, 1992). Sediments from one replicate at River Mile 6.5 yielded extrapolated EC₅₀ values just above the tested range of concentrations, but within acceptable 95 % confidence⁵⁰ limits. The other replicates from River Mile 6.5 showed similar EC₅₀ values but with unacceptably wide confidence limits (refer to Appendix B). Sediments at this location are probably not toxic, although one replicate indicated potential toxicity at this site. Sediments from River Miles 0 and 0.5 were clearly non-toxic.

Quality assurance assays (extraction blanks and phenol reference toxicant tests) were also run as part of the test. The extraction blanks were assayed twice. The extraction blank assays produced negative or low gamma readings indicating no toxicity. The two phenol reference toxicant assays performed during the project had EC₅₀ values of between 19.3 and 19.7 mg/L. Mean EC₅₀ for phenol was 19.5 Å 0.30 mg/L, which falls within the limits of the laboratory's control chart.

4.3 Benthic Infauna

Benthic infaunal results are provided in Appendix C and summarized below. Species richness among all stations was low. A total of five taxa were identified from all stations combined. The total number of taxa per station ranged from zero taxa at River Miles 0.5 and 6.5 to three taxa at River Mile 0.8 and 1. Of the five taxa, two were polychaete annelids (segmented worms), one was an isopod crustacean, one was an amphipod crustacean, and one was a pelecypod (bivalve) mollusc. The low species richness found is not surprising, given the small number of samples and the physically harsh environment being sampled.

Altogether, there were 51 organisms identified from the seven stations. Station abundances ranged from zero individuals at River Miles 0.5 and 6.5 to 17 individuals at River Mile 1 (Table 6). The bivalve clam *Macoma balthica* was most abundant (26 individuals) and occurred at four of the seven stations. The isopod *Saduria entomon* occurred at three stations and was next most abundant (13 individuals), followed by the amphipod *Lagunogammarus setosus* (10 individuals) which occurred at two stations. The polychaetes *Scolecopsis foliosa* and *Eteone* spp. each occurred only once at different stations.

Table 6. Abundances of Invertebrate Taxa.

TAXA	River Mile 0 TUN97BEN0001	River Mile 0.5 TUN97BEN0007	River Mile 0.8 TUN97BEN0002	River Mile 1 TUN97BEN0003	River Mile 2 TUN97BEN0004	River Mile 3 TUN97BEN0005	River Mile 6.5 TUN97BEN0006
Pelecypoda							
<i>Macoma balthica</i>	6		9	8	3		
Isopoda							
<i>Saduria entomon</i>			4	7		2	
Amphipoda							
<i>Lagunogammarus setosus</i>					2	8	

Polychaeta							
<i>Scolelepis foliosa</i>	1						
<i>Eteone</i> spp.			1	17	11	2	
TOTAL	7	0	14				0

All five taxa identified in this survey are considered typical inhabitants of the benthic environment found in the lower tidal-influenced reaches of Pacific Northwest rivers and estuaries. This is a physically dynamic environment characterized by large fluctuations in salinity and relatively unstable, coarse-grained sand sediments containing variable amounts of silt and organic detritus from both riverine and marine sources (Simenstad, 1983). Tidal and riverine currents and seasonal ice flows may all contribute to the shaping and reshaping of bottom sediments. The abundance of benthic organisms is usually low and often patchy in both time and location, correlating with areas of silt and organic accumulation caused by currents and eddies. The low abundance of organisms found in this survey, therefore, is not unusual, especially with so few samples.

The tellinid bivalve clam *Macoma balthica* is widely distributed in circumboreal seas, extending south to central California in the Pacific and South Carolina in the Atlantic (Bernard, 1979; Coan, 1971). It is a small (3-4 cm) clam commonly found in muddy sand, mud, or silt of bays and estuaries, especially in brackish environments. It buries itself up to 20 cm deep in the sediment and feeds by sweeping its extended siphons over the bottom and sucking up detritus (Morris et al., 1980).

The idoteid isopod *Saduria entomon* is a relatively robust motile opportunist that preys on or scavenges whatever it encounters as it plows along the sediment surface. Attaining a size of 3 cm, it is most often found on beaches or on mud, sand, or gravel bottoms in brackish bays and inlets. However, it is widespread, occurring from central California to the Arctic, intertidally and to depths as deep as 813 meters (Schultz, 1969). It is often considered to be a key species within brackish communities.

The gammarid amphipod *Lagunogammarus setosus* is a common omnivore in the cold estuaries, glacial river mouths, and brackish bays of Canada and Alaska (Bousfield, 1979). It occurs mainly in shallow waters or intertidally on muddy sand, mud, and silt bottoms.

The spionid polychaetes, which include *Scolelepis foliosa*, are generally tube-building deposit feeders, using ciliated palps to select food particles from the surface of the sediment. Members of the genus *Scolelepis* are often found in shifting sands of beaches and estuaries, building loosely constructed burrows or living entirely free (Fauchald and Jumars, 1979).

The phyllodocid polychaete genus *Eteone* is considered mainly carnivorous, although many will scavenge or ingest sediments when necessary. Intertidal and estuarine members of this genus are known to prey on spionid polychaetes, including *Scolelepis* (Fauchald and Jumars, 1979).

4.4 Water Quality

Water quality sampling included obtaining discrete water quality samples at two locations representing upstream and downstream influences. In addition, hydrographic profiles were obtained using *in-situ* self-recording instrumentation at the six sediment quality locations.

4.4.1 Water Chemistry

Water quality results for the two stations sampled in the Kenai River are presented in Table 7. Laboratory data are provided in Appendix D.

Table 7. Water Quality Results.

Parameter (unit)	MDL^a	River Mile 0 TUN97WQL0001	River Mile 6.5 TUN97WQL0006
Alkalinity (mg/L)	1.00	24.7	25.8
Total Phosphate (mg/L)	0.04	<MDL	<MDL
TSS (mg/L)	3.0	88.0	23.0
Turbidity (NTU ^b)	0.1	19.7	8.9/6.8 ^c
Color (color unit)	0	5 ^d	5

^a Method detection limit

^b Nephelometric turbidity unit

^c Represents sample and duplicate results

^d This sample run as true color due to heavy sediment masking

Alkalinity as calcium carbonate (CaCO₃) was detected at River Mile 0 at 24.7 ppm and at River Mile 6.5 at 25.8 ppm. Total phosphate was not detected above the detection limit of 0.04 ppm at either station.

As expected, due to tidal exchange and mixing of sediments near the mouth of the river, results for TSS and turbidity were higher downriver than at the upstream station. The sample collected at River Mile 0 showed TSS and turbidity values of 88 ppm and 19.7 nephelometric turbidity units (NTU), respectively. In contrast, farther upstream at River Mile 6.5, TSS decreased to 23 ppm and turbidity to 8.9 NTU. A duplicate turbidity sample collected at River Mile 6.5 showed 6.8 NTU.

Values of 5 color units were exhibited by both samples. The sample collected at River Mile 0 was analyzed using the true color method due to heavy sediment masking. The sample collected at River Mile 6.5 was analyzed using the apparent color method.

4.4.2 Hydrographic Profiles

A total of six hydrographic water column profiles were obtained at mid-channel at the same location or nearby the sediment/benthic infauna stations (refer to Table 1). Data are summarized in Table 8 for near-surface, middle, and bottom depths at each location. Complete hydrographic profile data and computer plots are presented in Appendix D.

Hydrographic profiles were obtained on 16 August 1997 at low-tide conditions in the Kenai River Estuary. Negligible marine water influences were seen in the data. Water temperatures were consistent across all locations with a range of 11.16 to 11.51 °C. Conductivity and salinity indicated freshwater conditions at all locations with no noticeable marine influence. The pH was also consistent across all locations, ranging from 7.72 to 7.89. Dissolved

oxygen was found to be high at all locations and depths, with most values near saturation. Hydrographic values as a whole would

Table 8. Hydrographic Data.

Station (units)	Location	Date	Depth (m)	Temp ^a (%C)	Salinity (‰)	DO ^b (mg/L)	Oxy Sat ^c (%)	Conductivity (mmhos/cm)	pH				
River Mile 0	0.0674	0.0682	8/16/97	0.75	2.25	4.00	11.37	11.33	11.33	0.0320	0.0445	0.0449	0.0472
River Mile 0.5	0.0879	0.0937	8/16/97	0.75	2.50	4.50	11.41	11.33	11.33	0.0416	0.0573	0.0610	0.0629
River Mile 1	0.1029	0.1051	8/16/97	0.75	1.50	2.25	11.34	11.32	11.32	0.0667	0.0668	0.0682	0.1022
River Mile 2	0.0476	0.0486	8/16/97	1.00	2.50	4.00	11.34	11.29	11.29	0.0316	0.0323	0.0328	0.0466
River Mile 3	0.0463	0.0463	8/16/97	0.75	2.00	3.25	11.51	11.30	11.30	0.0118	0.0314	0.0314	0.0129
River Mile 6.5	0.0436	0.0433	8/16/97	0.75	2.25	3.75	11.45	11.16	11.16	0.0245	0.0298	0.0297	0.0348
							11.03	10.45	10.91	100.65	95.30	99.54	

^a Temperature

^b Dissolved oxygen

^c Oxygen saturation

indicate well-mixed freshwater conditions with negligible marine influence at low-tide conditions. No hydrographic measurements were obtained during other tidal stages such as high tide, when marine influences would be expected to be large and more pronounced.

5.0 SUMMARY

In general, data from the 1997 Kenai River Estuary Sediment and Water Quality Investigations indicate that a number of sediment chemistry parameters appear to be elevated near River Mile 2. Sediments at River Mile 2 were found to contain DDTs, one PCB compound, and two pesticide compounds. When compared to NOAA's guidance levels, the total DDTs and total PCBs exceeded the lower ER-L guidance level where an effect might be seen, but were still well below NOAA's ER-M guidance level (above which effects would be considered probable). Also, cadmium, when normalized to either silt/clay or TOC, was found to be elevated at River Mile 2 when compared to the other locations. In addition, one pesticide was found at River Mile 6.5, and one semivolatile organic compound was found at River Mile 3. No pesticides, PCBs, or semivolatile organic compounds were detected at the other three locations sampled (River Miles 0, 0.5, and 1).

Sediment toxicity was determined by Microtox[®] bioassay methodology for each of the six sediment samples. Sediments from River Mile 3 were found to be the most toxic (lowest EC₅₀) among the six sediments tested. River Miles 1 and 2 also showed toxicity within the concentration ranges tested and were approximately equally toxic. Sediments from the other three locations, River Miles 0, 0.5, and 6.5, were not found to be toxic within the range of concentrations tested.

Biological sampling of the benthic infauna indicate a typical community for a lower tidal-influenced

river that is characterized by a dynamic environment. This benthic environment experiences large salinity variations and has a relatively unstable coarse-grained bottom that is continuously reworked by natural physical forces. Only five taxa were found with the dominant species being the bivalve clam, *Macoma balthica*, the isopod, *Saduria entomon*, and the amphipod, *Lagunogammarus setosus*. All five of the tax identified in this survey are considered typical inhabitants for this type of environment in the Pacific Northwest.

Water quality sampling within the lower Kenai River and its estuary indicated that the water conditions near the mouth of the river were much more turbid and higher in suspended sediments than the upstream location. This difference was believed to be due to the tidal exchange and greater degree of mixing near the mouth of the river. Water quality sampling and profiling were performed at low tide, therefore, marine influences were found to be negligible. The water column profiling indicated little spatial variation in any parameter with dissolved oxygen near saturation at all locations.

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- (Bousfield, 1979) 14
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- (Fauchald and Jumars, 1979)14

Table 3. Kenai River Sediment Quality Results.

Parameter	River Mile 0	River Mile 0.5	River Mile 1	River Mile 2	River Mile 3	River Mile 6.5
	TUN97XXX0001 ^a	TUN97XXX0007	TUN97XXX0003	TUN97XXX0004	TUN97XXX0005	
TUN97XXX0006						
Total Organic Carbon (%)	0.29/0.27 ^b	0.68	0.62	0.39	0.71	0.66
Particle Grain Size (%)						
Sand	83.41	4.70/5.48	20.60	62.75	13.62	3.29
Silt	10.90	80.15/79.06	57.36	27.40	61.87	64.73
Clay	5.69	15.15/15.46	22.04	9.85	24.51	31.98
Metals (mg/kg dry weight) ^c						
Barium	180	370	320	210	310	350
Cadmium	ND (0.10)	0.23	0.24	0.26	0.25	0.25
Chromium	40	55	49	40	52	54
Copper	23	51	40	26	43	45
Lead	6.8	10	11	7.0	9.7	10
Manganese	360	600	510	440	510	590
Selenium	ND (0.10)	0.22	0.20	0.11	0.18	0.22
Zinc	51	81	72	51	72	76
Pesticides and PCBs (&g/kg dry weight) ^c						
alpha-Chlordane	ND (0.65)	ND (0.80)	ND (0.77)	1.1	ND (0.81)	ND (0.83)
4,4'-DDD	ND (0.65)	ND (0.80)	ND (0.77)	2.7	ND (0.81)	ND (0.83)
4,4'-DDE	ND (0.65)	ND (0.80)	ND (0.77)	2.3	ND (0.81)	ND (0.83)
4,4'-DDT	ND (0.65)	ND (0.80)	ND (0.77)	2.4	ND (0.81)	ND (0.83)
Endrin	ND (0.33)	ND (0.40)	ND (0.38)	0.62	ND (0.41)	ND (0.41)
Heptachlor	ND (0.33)	ND (0.40)	ND (0.38)	ND (0.32)	ND (0.41)	2.0
Aroclor-1254	ND (13)	ND (16)	ND (15)	24	ND (16)	ND (17)
Total PCBs	ND (13)	ND (16)	ND (15)	24	ND (16)	ND (17)
Semivolatiles by GC/MS (mg/kg) ^c						
4-Methylphenol (p-Cresol)		ND (0.43)	ND (0.47)	ND (0.46)	ND (0.43)	1.18 ND (0.41)

^a TUN97XXX000# - the XXX stands for TOC, PGS, MPS, or SVL

^b Value/duplicate value

^c ND = Not detected; method detection limit provided in parentheses