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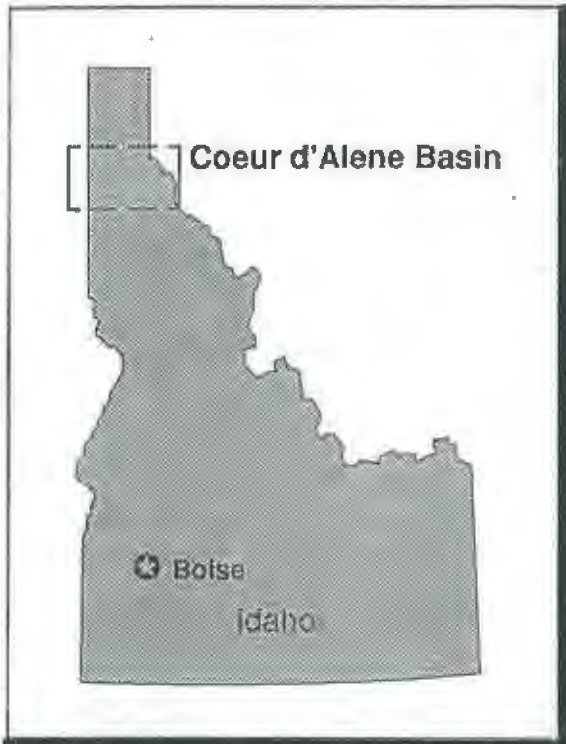
Coeur d'Alene Basin
EPA Water Quality Monitoring

1972-1986



U.S. Environmental Protection Agency

Region 10

Coeur d'Alene Basin -- EPA Water Quality Monitoring (1972-1986)

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ABSTRACT

The Region 10 Office of the U.S. EPA has conducted chemical and biological monitoring during low-flow conditions from 1972 to 1986 along the South Fork Coeur d'Alene River in northern Idaho, a stream with a long history of severe metals pollution from mining activities. During 1986, metals analysis of sediments and tissues from the lower Coeur d'Alene River and Coeur d'Alene Lake was also conducted. Due chiefly to effluent controls at the Bunker Hill Complex, low-flow season South Fork concentrations of zinc, cadmium, and lead downstream of Kellogg were reduced during the 1970's from 13.6 mg/l, 0.24 mg/l, and 0.75 mg/l to levels of 5.0 mg/l, 0.03 mg/l, and 0.03 mg/l, respectively. During the 1986 low-flow survey, metal loadings were primarily a result of nonpermitted inputs to the stream, chiefly from the vicinity of the Bunker Hill Central Impoundment Area and from Canyon Creek, a tributary near Wallace. Although levels of zinc and cadmium remain well above national criteria for protection of cold water biota in both the South Fork and lower mainstem of the Coeur d'Alene, recovery of aquatic life has been substantial, with the lower mainstem now supporting a successful sports fishery. Sediments in the lower Coeur d'Alene system remain heavily contaminated with toxic metals, although high levels in edible fish tissue were not found. In terms of immediate benefits to the mainstem biota, the cessation or treatment of the major discrete CIA seep at the Bunker Hill Superfund Site is estimated to reduce mainstem summer low-flow zinc concentrations by over 150 ug/l. Allowable permit limits (as of 1986) for metals (primarily cadmium) have the potential of increasing in-stream metals concentrations substantially above the levels resulting from nonpermitted sources. Water quality-based permits are particularly important for aquatic life protection of the South Fork upstream of Mullan and the mainstem downstream of the S.F. confluence. Water quality management should take a basin-wide, integrated approach that considers effects on downstream reaches from upstream sources, cost of rehabilitation of mine tailings and control of seeps, further control of point and nonpoint sources, and habitat recovery.

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INTRODUCTION

Wholesale deposition of mine tailings directly into the South Fork Coeur d'Alene River occurred from the 1880s until construction of tailing ponds during the 1960s. In 1972, the Clean Water Act was passed, requiring effluent limits on all industrial and municipal point source discharges and mandating the Environmental Protection Agency to oversee implementation of these controls. At the same time, EPA's Region 10 Office began a monitoring program on the South Fork of the Coeur d'Alene to update conditions, document improvements, and identify remaining important sources of heavy metals. These studies, conducted during late summer low-flow periods, focused on inputs from permitted dischargers and groundwater seeps and characterized conditions during the most critical season to stream biota. Recommendations generated by the EPA studies has led to stricter control of dischargers and fewer "plant upsets", particularly in the Bunker Hill complex.

EPA conducted late-summer, low-flow season monitoring for heavy metals during 1972, 1974, 1975, 1976, 1979, 1980, 1982, 1984, and 1986. The most recent survey included analysis of fish tissues and sediments from the lower Coeur d'Alene River, including the lateral lakes, and from Lake Coeur d'Alene. This report summarizes the water quality trends during the 1970s and describes current conditions. 1986 study sites and analyses are listed in Tables 1 and 2 and located on basin maps (Maps 1 and 2). Details on methods, including quality assurance aspects, and data printouts of chemistry and macroinvertebrate survey results are available from Region 10's Water Monitoring and Analysis Section. A considerable amount of additional data sources and study results from the Coeur d'Alene system are available and have recently been compiled (Wai, et al. 1985; Savage, 1986; Woodward-Clyde Consultants and Terragraphics, 1986; Neufield, 1987; Tetra Tech, Inc. and Morrison-Knudsen Engineers, Inc., 1987).

HEAVY METAL LOADINGS AND CONCENTRATIONS, 1972-1986[1]

The heavy metals of concern on the Coeur d'Alene system have been zinc, cadmium, and copper for aquatic life impact and lead and cadmium for animal and human health concerns. From 1972 through 1986, low flow season concentrations of these metals upstream of the Bunker Hill (BH) complex in Kellogg (at Bunker Avenue bridge) have been relatively constant while water quality downstream of the BH complex (near Airport Avenue Bridge) has improved considerably (Figs. 1-4).

The differences in metals concentrations between these two sites can be explained by loadings upstream of and from the Bunker Hill complex (Table 3). Zinc loadings upstream of the Bunker Avenue bridge showed no apparent trends: 1984 level (1100 #/day) was similar to that during 1972 (1153 #/day), while the 1986 level (591 #/day) was similar to the 1979 level (682 #/day). Cadmium loadings also did not vary noticeably: 1972 and 1986 values were 8 and 6

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[1]All Values are for totals (dissolved and total results for metals during the low-flow sampling seasons have consistently been nearly equal).

FIG. 1. ZINC CONCENTRATIONS
UPSTREAM AND DOWNSTREAM OF
BUNKER HILL COMPLEX

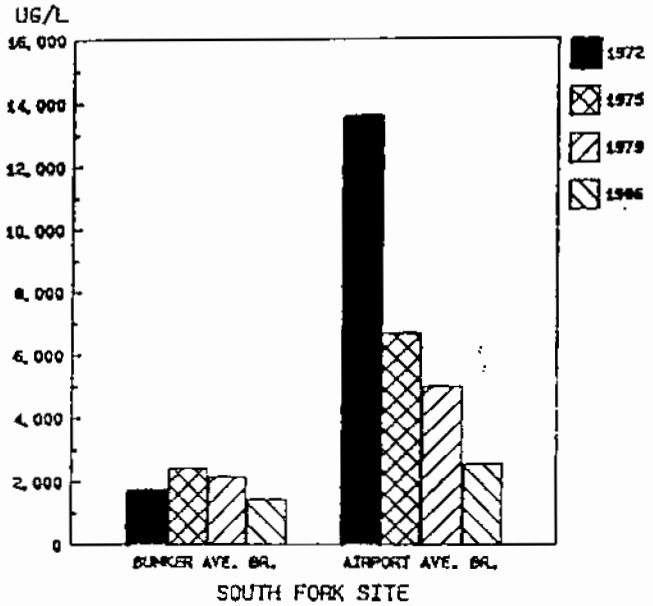


FIG. 2. CADMIUM CONCENTRATIONS
UPSTREAM AND DOWNSTREAM
OF BUNKER HILL COMPLEX

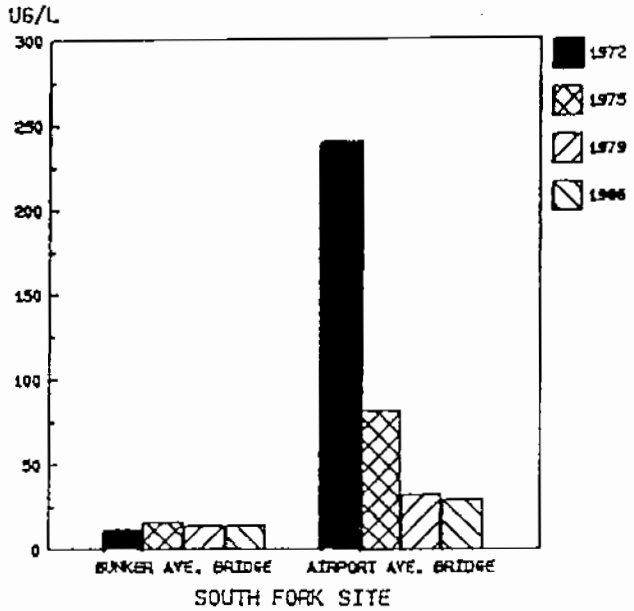


FIG. 3. LEAD CONCENTRATIONS
UPSTREAM AND DOWNSTREAM OF
BUNKER HILL COMPLEX

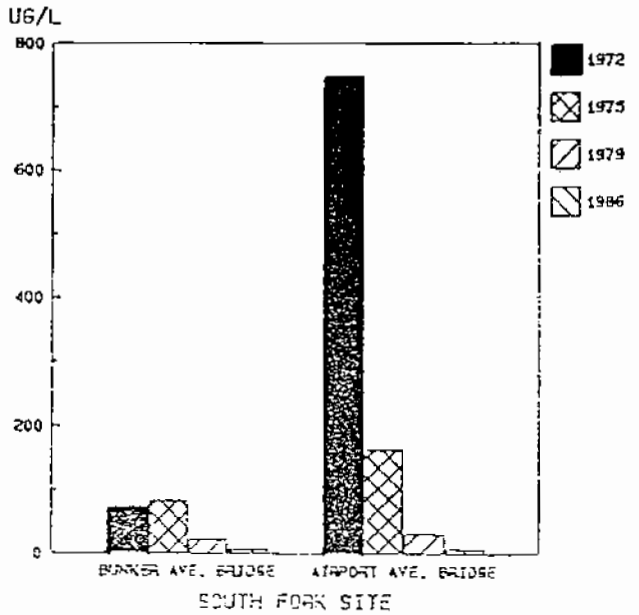
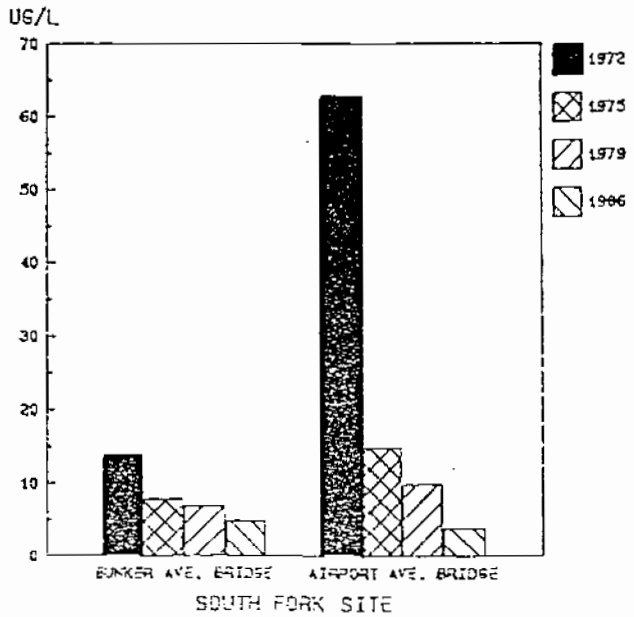


FIG. 4. COPPER CONCENTRATIONS
UPSTREAM AND DOWNSTREAM OF
BUNKER HILL COMPLEX



#/day, respectively, while 1975 and 1984 both had loadings of 11 #/day. There is some evidence of a trend in upstream lead loadings: values varied between 18 and 49 #/day from 1972 to 1976 and between 9 and 13 from 1979 to 1984. The lead loading during the 1986 survey was three #/day.

The difference in metal levels between the Bunker Avenue bridge site and the site immediately above Bunker Creek reflect loadings immediately adjacent to the Bunker Hill CIA (Table 3). Although the CIA remains a major contributor of zinc to the basin, substantial reductions of CIA zinc loadings occurred since the 1970s: zinc loads (#/day) to this stream reach ranged from 1025 to 3692 prior to 1982, and from 365 to 582 during the mid-1980s.

CIA contribution of cadmium has always been relatively minor, with load increases between the two sampling sites that bracket the CIA varying between 0 and 5 #/day. Some loading of lead over this reach was evident during the earlier surveys: 27, 24, and 16 #/day during 1974, 1975, and 1976, respectively. However, almost no lead loadings were apparent here from 1980 through 1986.

The next EPA sampling site downstream on the South Fork is located near the Airport Avenue bridge. This site and the above Bunker Creek site bracket Bunker and Government (Silver King) Creeks and differences in load values between these sites reflect loads released from the Bunker Hill complex to the South Fork via these two creeks. Up until the mid-1970s, this area experienced massive loadings of cadmium and lead in addition to further substantial loads of zinc (Table 3). The implementation of effluent controls at the Bunker Hill complex has resulted in a dramatic success story as evidenced by the monitoring data: during the mid 1970s, zinc contributions ranged from 1852 to 2919 #/day, cadmium loads from 33 to 57 #/day, and lead loads from 48 to 78 #/day. Between 1979 and 1986, however, load increases over this reach of the South Fork did not exceed 288 #/day for zinc, 9 #/day for cadmium and 13 #/day for lead. In summary, the Bunker Hill Complex was responsible for the great majority of the metals loading observed in the early 1970s. Between 1972 and 1986, the low-flow loads of zinc, cadmium, and lead from the tributaries and seeps of the Bunker Hill complex were reduced respectively from 8247, 158, and 469 pounds to 509, 7, and 2 pounds (Table 3).

1986 SURVEY RESULTS

Heavy Metal Loadings and Concentrations

Although loadings of metals into the S.F. Coeur d'Alene have decreased substantially since 1972, low-flow concentrations of zinc and cadmium remain well above national criteria levels for protection of aquatic life (Figs. 5 and 6).[1] The first major upstream increases of these metals are a result of nonpoint source loadings from Canyon Creek (located between the S.F. above Canyon Creek and S.F. above Lake Creek sites).

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[1]National criteria for many metals are dependent on hardness and vary accordingly along the Coeur d'Alene system.

FIG. 5. ZINC CONCENTRATIONS
1986 COEUR D'ALENE
LOW FLOW SURVEY

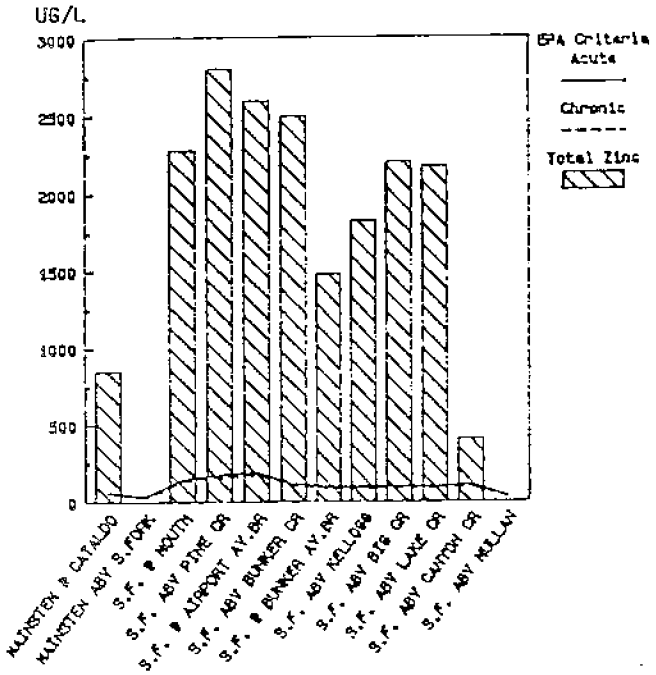
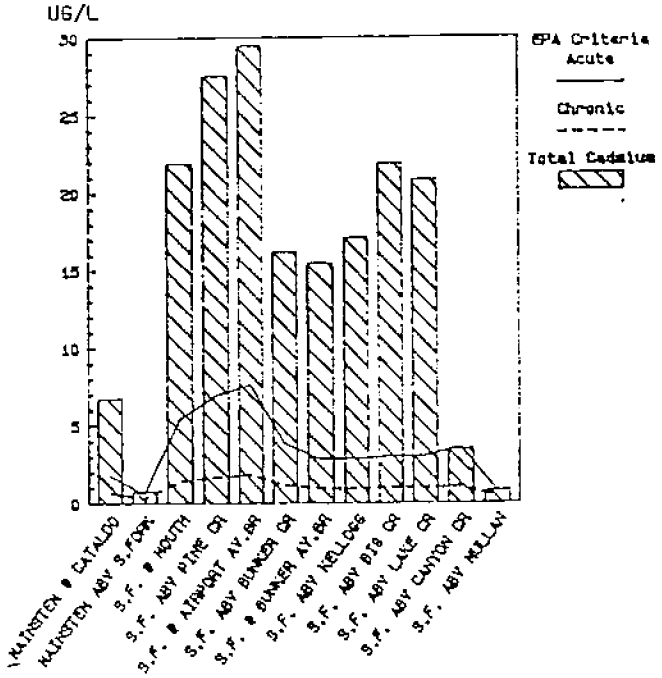


FIG. 6. CADMIUM CONCENTRATIONS
1986 COEUR D'ALENE
LOW FLOW SURVEY



The next major increase of zinc occurs along the South Fork river reach bordering the Bunker Hill Central Impoundment Area (CIA). The zinc concentration in the South Fork increased here (between Bunker Avenue bridge and Bunker Creek) from 1480 to 2500 ug/l. Although much of this increase might be attributed to diffuse contamination, a single discrete seepage running from the base of the CIA to the river that was sampled during the EPA 1986 survey had a concentration of 15,900 ug/l and a gaged flow of 2.35 cfs. The loading of over 200 lbs/day of zinc from this seep accounted for 528 ug/l concentration at the above Bunker Creek site or over 50% of the zinc increase found over this reach. Curtailment or treatment of this seep alone would translate to a low-flow season reduction of over 150 ug/l or 18% of the zinc concentration on the mainstem Coeur d'Alene.

A substantial increase for cadmium occurred at the Airport Avenue Bridge in Kellogg, due to point and nonpoint discharges directly to the South Fork and to Bunker Creek. The lead values in the water column during low-flow season fall between the national acute and chronic criteria levels, while copper levels remained below both chronic and acute criteria (Figs. 7 and 8). Iron and manganese, which are not generally considered as toxic problems for aquatic life, show highly elevated levels on the South Fork along and downstream of the Bunker Hill Site, and these metals could well be adding to the water quality problems along this reach (Figs. 9 and 10). Of particular note is the obvious flocculent deposits in the vicinity of the Bunker Hill Site, which continues to affect the benthic habitat quality.

FIG. 7. LEAD CONCENTRATIONS
1986 COEUR D'ALENE
LOW FLOW SURVEY

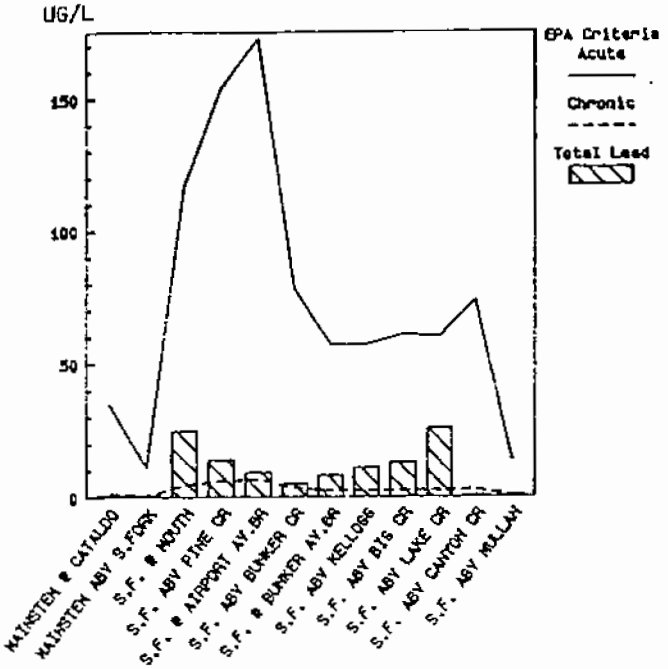


FIG. 8. COPPER CONCENTRATIONS
1986 COEUR D'ALENE
LOW FLOW SURVEY

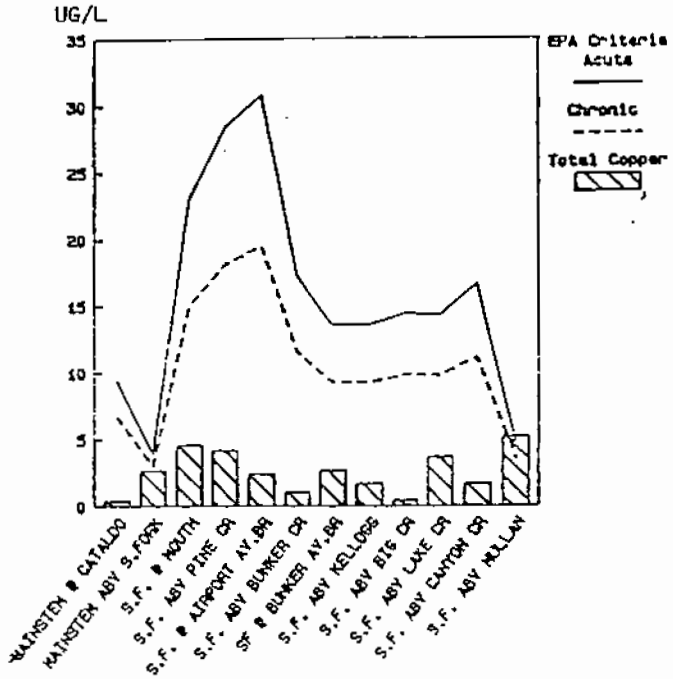


FIG. 9. IRON CONCENTRATIONS
1986 COEUR D'ALENE
LOW FLOW SURVEY

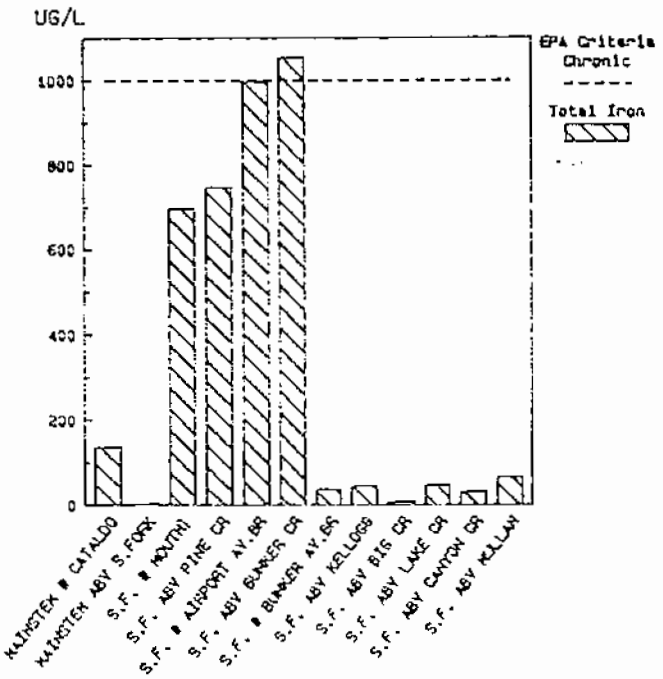
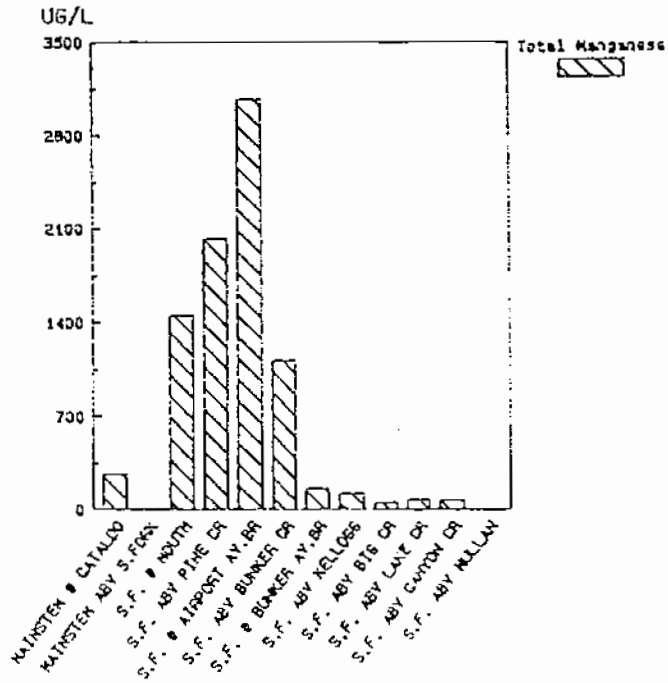


FIG. 10. MANGANESE CONCENTRATIONS
1986 COEUR D'ALENE
LOW FLOW SURVEY



Point and Nonpoint Contributions

Largely due to depressed silver prices during the summer of 1986, the majority of mining operations along the South Fork were either sharply reduced or curtailed. As a result, the relative contribution of metals from point sources, as calculated from the industries' September, 1986, Discharge Monitoring Reports, was generally minor (Figs. 11 and 12). The one relatively important point source loading at the time of the study was cadmium from the Syringa discharge to Bunker Creek. However, recent startup of additional control equipment decreased the cadmium contribution from Syringa about 10-fold from September to November of 1986 (Discharge Monitoring Reports, Syringa, Inc).

An estimate of "worst-case" conditions for point source contribution of zinc and cadmium (using 1986 NPDES permit limits) does, however, indicate that point sources do have the potential for substantial contribution of these metals to the system (Figs. 13 and 14).[1] These conditions would be realized if all permitted discharges were contributing their maximum allowable average load during the lowest 7-day flow conditions that is expected to occur on the average of once every 10 years. Of particular note, is the potential importance of permitted zinc and cadmium loading to the water quality of the South Fork upstream of Canyon Creek at Wallace and (to a lesser extent) of permitted cadmium loading to water quality throughout the system.

Toxicity Tests

Results of 1986 EPA livebox bioassays with hatchery rainbow trout fingerlings showed considerable acute mortality downstream from Canyon Creek at Wallace (Table 4). Similar livebox bioassays conducted during previous EPA low flow surveys showed similar patterns of toxicity. Considering the levels of cadmium and zinc in the water are each well above acute criteria levels, these results are not surprising.

Dilution series acute toxicity tests conducted with hatchery cutthroat trout during the 1986 survey resulted in an LC50 of 2 to 3% (i.e. a mixture of approximately 2 to 3% Bunker Hill CIA seep water to 97-98% control water caused mortality to half the exposed fish). The LC50 of South Fork Coeur d'Alene water collected above Pine Creek was approximately 10% (Table 5).

Chronic and acute toxicity tests conducted at the Duluth EPA Lab with the water flea, *Ceriodaphnia dubia* and the fathead minnow, *Pimephales promelas,* and at the Region 10 lab with the algae, *Selenastrum capricornutam* also confirmed the toxic conditions found along the S.F. Coeur d'Alene (Tables 6, 7, and 8). Particularly toxic was the CIA seep, which showed acute toxicity to *Ceriodaphnia* at the 1% dilution level.

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[1]This analysis excluded several of the permitted dischargers, where load limits for specific metals were not defined in the permits.

FIG. 11. ZINC CONCENTRATIONS
1986 COEUR D'ALENE STUDY
POINT VS. NONPOINT CONTRIBUTIONS

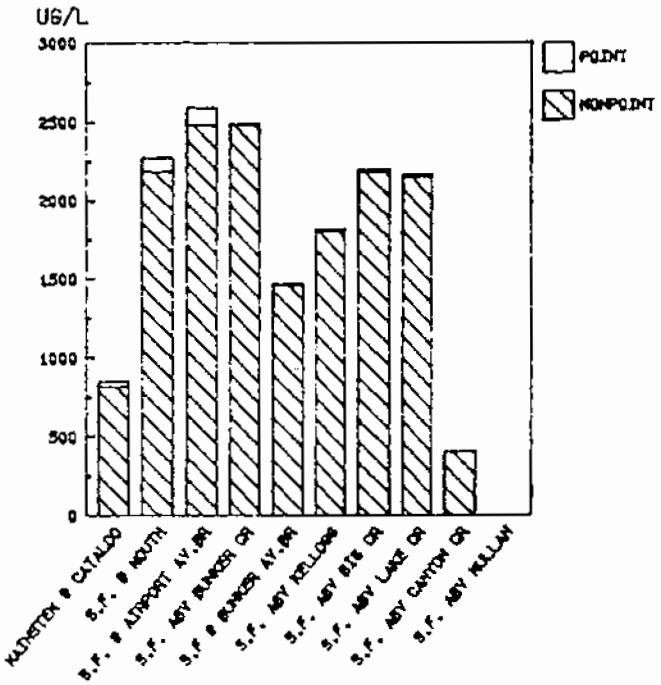


FIG. 12. CADMIUM CONCENTRATIONS
1986 COEUR D'ALENE STUDY
POINT VS. NONPOINT CONTRIBUTIONS

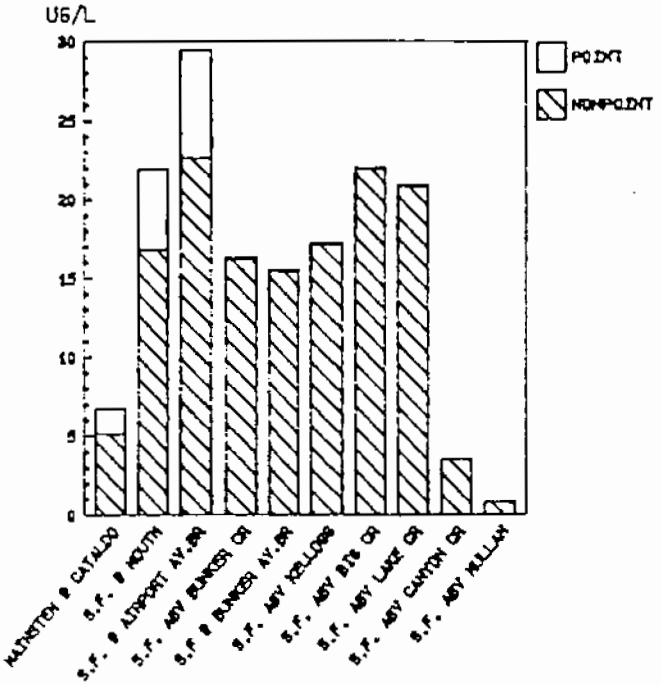


FIG. 13. ZINC CONCENTRATIONS
1986 COEUR D'ALENE STUDY
WORST-CASE CONDITIONS

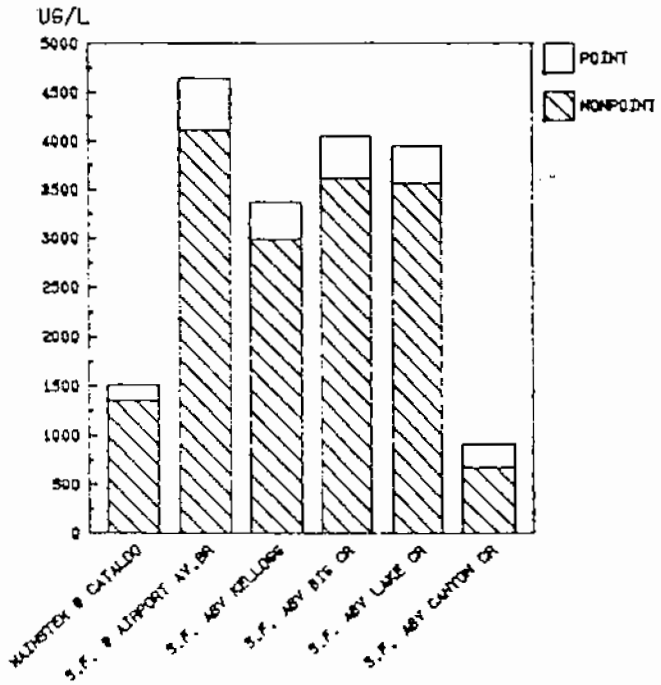
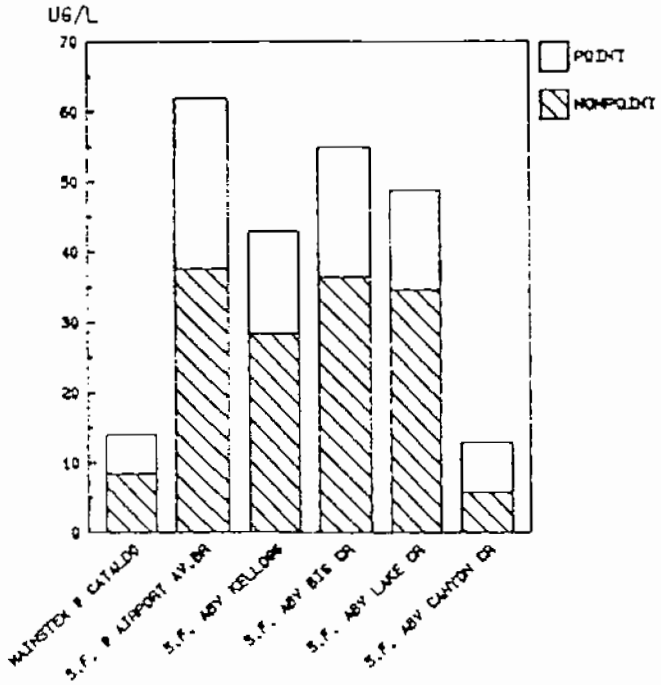


FIG. 14. CADMIUM CONCENTRATIONS
1986 COEUR D'ALENE STUDY
WORST-CASE CONDITIONS



Benthic Invertebrate Survey

An invertebrate survey was conducted during mid-August, 1986, of the South Fork Coeur d'Alene from upstream of the mining district (above Mullan) to its mouth (at Enanville), the mainstem above the confluence of the South Fork (unimpacted background site), and the mainstem downstream of the South Fork confluence at Cataldo. The purposes of the survey were to 1) determine the availability of a salmonid food base, 2) provide information on the actual biological consequences of the Silver Valley pollution, including determination of the degree to which the more sensitive indigenous cold-water species are present in the impacted areas, 3) document effectiveness of previous controls towards restoring Coeur d'Alene biota, and 4) provide baseline information to be used towards assessing further recovery of system or for detecting unexpected pollution events.

Surveys conducted in the early 1930s (Ellis, 1932), early 1950s (Wilson, 1952), and early 1960s (Olson, 1963) found virtually no benthic invertebrates throughout the impacted areas of the South Fork and mainstem Coeur d'Alene River downstream of the South Fork. In the late 1960s and early 1970s, with the advent of Silver Valley tailings ponds and subsequent decrease of discharge of mine slimes to the stream bottom, the more tolerant midge fly larvae (Chironomidae) became established first on the mainstem (Cataldo site) and later on the impacted reaches of the South Fork Coeur d'Alene. By 1971, the ubiquitous mayfly species, *Baetis tricaudatus,* and riffle beetles had also been collected from impacted sites on the mainstem and lower South Fork (Stokes, 1969; Savage and Rabe, 1973). EPA Region 10 collections in 1975 yielded numerous midges and a few mayflies from the South Fork and impacted mainstem. Caddisflies were also common in the mainstem collection, with a few collected from the lower South Fork.

The EPA Region 10 1986 survey demonstrated that recovery of benthic invertebrates has made considerable further progress. Species richness, although depressed along the impacted South Fork compared to control sites (South Fork upstream of Mullan and mainstem upstream of the South Fork), showed a remarkable recovery from earlier times (Fig. 15). Total insect numbers at the affected sites were also comparable to that found at the control sites and sufficient to eliminate lack of food as a limiting factor for fish populations (Fig. 16).[1] The reestablishment of the Coeur d'Alene fauna coincides with the implementation of South Fork effluent controls and the resultant large reductions in South Fork metals concentrations.

The 1986 biological survey provides insight on the relative sensitivity of the major groups (orders) of insects. The mayflies were the most sensitive to the Silver Valley metals pollution, with all but one species virtually absent from all impacted sites. The stoneflies exhibited intermediate sensitivity to the Silver Valley contaminants, with numbers and diversity similar at the more moderately impacted sites (South Fork just above Canyon

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[1]The high nutrient levels and profuse algal growth at the above Pine Creek site (downstream of the Smelterville POTW effluent) are the probable causes of the excessive numbers of organisms (chiefly filter-feeding black flies and caddisflies).

FIG. 15. TAXA RICHNESS
1986 COEUR D'ALENE STUDY
INVERTEBRATE SURVEY

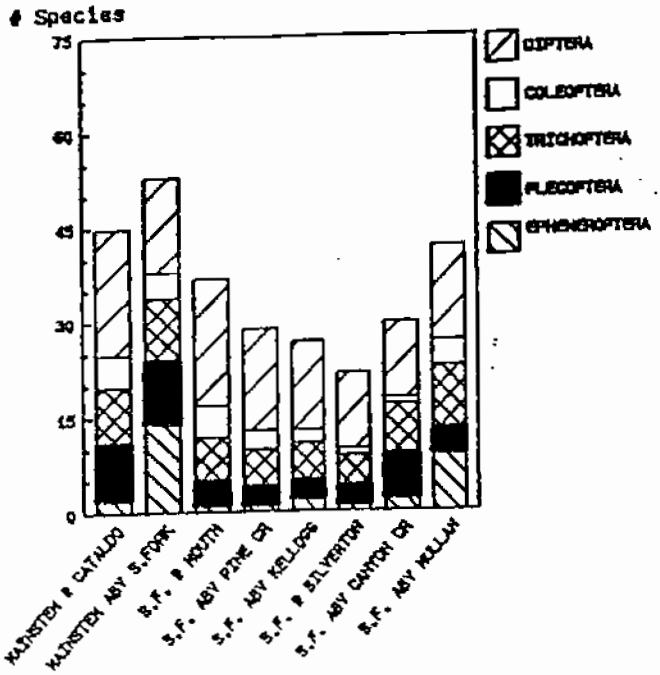
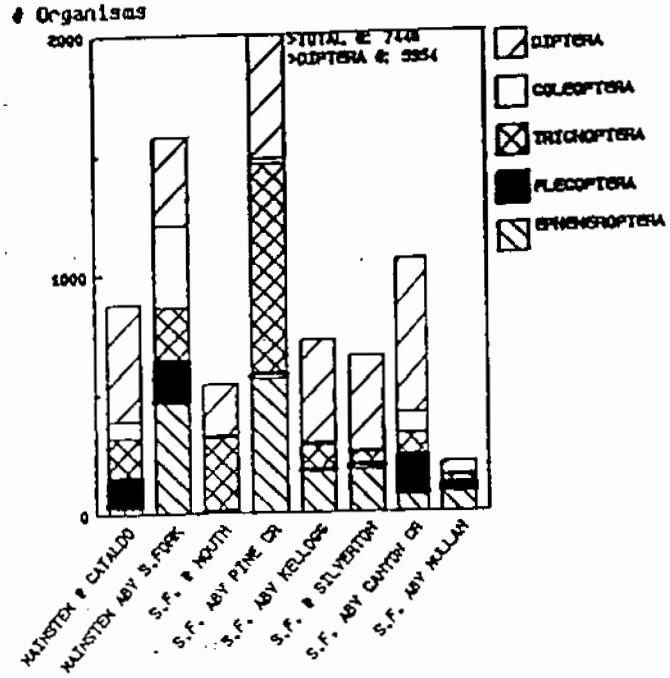


FIG. 16. NUMBER OF ORGANISMS
1986 COEUR D'ALENE STUDY
INVERTEBRATE SURVEY



Creek and mainstem downstream of the South Fork at Cataldo) to those at the unimpacted sites. Greatest tolerance to metals pollution was demonstrated by the caddisflies and true flies: their numbers and diversity were similar at all sites. Several inter-specific and inter-generic differences in metals tolerances were also indicated, particularly among the mayflies, crane flies, and riffle beetles.

The increase in metal levels immediately downstream of the Bunker Hill Superfund Site did not show a corresponding increased impact on the late-summer benthic invertebrates as collected at the above Pine Creek site. This may be partly due to the increase in water hardness that occurs from Kellogg to Pine Creek and to the high organic matter at the Pine Creek Site. Dissolved organic matter can decrease bioavailability by increasing chelation (binding) of metal ions (Stephenson and Mackie, 1988). However, these factors are much less important in the mainstem downstream of the South Fork confluence, due to a 2:1 dilution of softer waters from the upstream mainstem, and less nutrients.

A 15% to 20% decrease in zinc concentrations, as would occur with cessation of the principal CIA seep channel, could be expected to improve the biological health of the lower mainstem. For example, the more metals-sensitive populations of benthic fauna will continue to reestablish themselves, allowing further recovery towards a more diverse "natural" community. In addition, chronic or sublethal effects of heavy metals on the resident and migrating mainstem fish populations should be reduced (e.g. less of the biological energy "budget" could be allocated to detoxification needs and more towards growth, disease resistance, reproduction, etc).

Coeur d'Alene System Sediment and Fish Tissue Heavy Metal Loads

Mining operations in the Silver Valley from the last century and into the 1960s resulted in approximately 72 million tons of contaminated tailings released into the South Fork Coeur d'Alene River. These tailings were washed into the lower Coeur d'Alene River and Lake system (Keely, et al. 1976). Bottom sediment sampling conducted in the early 70s confirmed that levels of metals in the Coeur d'Alene delta area were comparable to that found in the mine tailings themselves and that high levels of contamination extended throughout the northern two-thirds of Lake Coeur d'Alene, Coeur d'Alene River and the lateral lakes (Funk et al., 1973; Maxfield, et al., 1974a,b; Rabe and Bauer, 1977; Reece et al., 1978).

The purpose of the 1986 sampling was to provide a general update of the extent and degree of sediment contamination, particularly of the metals of greatest concern to human health: cadmium and lead. Nine locations on Coeur d'Alene Lake, two locations on the lower Coeur d'Alene River, and one each from two of the lateral lakes were sampled. In addition, sediments were collected from 10 sites within the South Fork Coeur d'Alene basin.

Results from these analyses indicate that heavy metal contamination of sediments remains severe throughout the South Fork, lower mainstem, and northern two-thirds of the lake (Table 9). Levels of lead are essentially the same as that found in the early seventies, while cadmium levels have decreased approximately five fold. Sediment toxicity tests performed on the amphipod, *Hyalella azteca* with sediments from some of these sites indicate the toxicity of metals in these sediments to aquatic organisms is currently low (Table 10). Similar conclusions cannot be made from results of the *Daphnia magna* tests, as this species showed high mortality in the "clean" sediments collected near the mouth of the St. Joe River.

The Region 10 Laboratory conducted heavy metal analyses on composites of several species of game fish collected by the Idaho Department of Fish and Game from Coeur d'Alene Lake, the mainstem lateral lakes, and the South Fork at Mullan. The purpose of these analyses was not to provide a full human health risk assessment, but rather to get a general picture of the degree of contamination in edible tissues, and to locate which species and locations would be candidates for follow-up analyses. The preliminary results from these analyses indicate that the heavy metals, which are at very elevated levels in the sediments, are not accumulating in edible fish tissue at levels considered dangerous to sports fishermen (Table 11). High levels of cadmium, however, were found in liver and kidney organs, which indicates that this metal remains bioavailable and points to the potential of using these organs for assessing long term trends in cadmium levels.

CONCLUSIONS AND DISCUSSION

Although heavy metal concentrations in the South Fork and lower mainstem Coeur d'Alene River have been dramatically reduced over the last two decades, concentrations of cadmium and zinc remain well above criteria levels for protection of aquatic life. Acute toxicity test results conducted on laboratory invertebrates and hatchery trout confirm the toxicity of the river water. Nevertheless, conditions are now suitable on the South Fork for many of the less sensitive indigenous populations of aquatic biota, while conditions on the mainstem are supporting a successful sports fishery.

This apparent contradiction is not surprising, considering that many other waters with high metal content also support aquatic life (LaPoint et al., 1984). Metals toxicity varies with differing combinations of the numerous characteristics of water, e.g. hardness, pH, organic and inorganic constituents (Connell and Miller, 1984). Field and laboratory tests also show fish and invertebrate tolerance to metals will increase when exposed to sublethal levels (Thomas, et al., 1985; Brown, 1976).

Concentrations of cadmium and zinc are the major limiting factors for continued restoration of aquatic biota in the South Fork and mainstem Coeur d'Alene River. Although much of the loading of these metals are diffuse, at least one discrete seepage channel (at the Bunker Hill CIA) contributes to a substantial proportion of the total zinc loading into the system. Its cessation or treatment should result in further recovery of the downstream biota.

The potential for relatively important metals contributions from point sources to the system indicates the need here for water quality-based permitting. Water quality-based controls on the South Fork are of particular importance upstream of Mullan and on the mainstem downstream of the South Fork confluence, where State Standards currently include protection of aquatic life.

Additional substantial sources of these metals from Wallace downstream may not be so easily addressed since they are generally related to contaminated aquifers and diffuse seepages from tailings, particularly in the Kellogg area and along Canyon Creek. Restoration plans of tailings along the South Fork and tributaries have been developed (Eisenbarth and Wrigley, 1978; Gross, 1982). However, cost estimates for restoration together with the potential for introduction of contamination resulting from reclamation activities have not yet been determined. As with point sources, nonpoint source controls on the South Fork need to address metal levels and aquatic life protection of the mainstem downstream of the South Fork confluence.

A whole basin environmental management approach to the Coeur d'Alene system should also address the relative importance of habitat degradation and other factors (e.g. nonpoint impacts from agricultural or forestry practices) in the prevention of full potential of aquatic resources. The dynamics of cadmium and lead in the ecosystem also needs to be further addressed, including the relative importance of the contribution of present South Fork loadings of these metals to the downstream sediments and biota.

Monitoring and Research Needs

Future assessments should further document status and condition of populations, particularly of those fish that inhabit the mainstem Coeur d'Alene and lateral lakes and the salmonids that use the Coeur d'Alene River for migration to spawning areas upstream of the South Fork confluence.

Now that inputs from point source and groundwater seeps have been characterized, and in the case of point sources, largely reduced, a critical issue to be resolved is the loading of heavy metals from high-flow runoff events. This is particularly important for lead due to its high affinity to binding with sediments. Monitoring of Silver Valley pollutants should therefore be conducted year round, with particular emphasis placed on collection of samples during high-flow events.

Because of the possibility that periodic grab samples of water chemistry will "miss" unsuspected pollution events caused by tailings failures or "plant upsets", integrative monitoring methods should also be employed for purposes of detecting their occurrence and possibly locating their sources. Sampling of benthic invertebrates is well suited for this purpose, as weeks or months are required for these relatively sessile animals to recover from a toxic event. When an effect on the biota is detected, the source may be located by sampling upstream to where the effect begins (Hynes, 1960). If a point source is suspected, follow-up investigations might then include use of automatic water samplers for more frequent surveillance of water quality. Fortunately, invertebrate density and diversity have recovered in the Coeur d'Alene system to the point that they can be used for this purpose. Continuous monitoring techniques using indicator parameters, such as data pods with conductivity probes, may also be useful for flagging a spike of heavy metal pollution.

Research efforts should be encouraged that elucidate how the specific physical, chemical, and biological characteristics of the Coeur d'Alene River and Lake system may affect the availability and toxicity of Silver Valley metal pollutants to the different components of the ecosystem. Results from such studies, together with continued assessments of water quality and biota in the Coeur d'Alene River (mainstem and South Fork) can then be used towards predicting environmental results of control actions.

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Table 1. COEUR D'ALENE BASIN SAMPLE SITES.

MAP STATION #	STORET STATION #	STATION NAME AND LOCATION
01	153541	S.F. Coeur d Alene R. @ Culvert @ Shoshone Park above Mullan
02	153368	S.F. Coeur d Alene R. below Lucky Friday #003
03	03#052	Hecla Star Morning #002 discharge
04	03E011	S.F. Coeur d Alene R. below Hecla Star Morning #002 discharge
05	153097	S.F. Coeur d Alene R. 100-ft above Canyon Creek at Wallace
06	153125	Canyon Creek at mouth at Wallace
07	153132	Ninemile Creek at mouth at Wallace
08	153100	S.F. Coeur d Alene R. 100-ft above Lake Creek
09	153137	Lake Creek at mouth
10	153369	S.F. Coeur d Alene R. at Silverton
11	153104	S.F. Coeur d Alene R. at bridge above Big Creek
12	153147	Big Creek at mouth
13	03#009	Sunshine Mine effluent
14	03E009	S.F. Coeur d Alene R. above Kellogg
15	153148	Milo Creek near mouth
16	153108	S.F. Coeur d Alene R. at Bunker Ave Bridge, Kellogg
17	03Z038	Cook Creek near mouth
18	03#061	Bunker CIA seep #1 to S.F. Coeur d Alene R., 1986
19	03#062	Bunker CIA seep #2 to S.F. Coeur d Alene R., 1986
20	03#063	Bunker CIA seep #3 to S.F. Coeur d Alene R., 1986
21	03#064	Bunker CIA seep #4 to S.F. Coeur d Alene R., 1986
22	03#065	Bunker CIA seep #5 to S.F. Coeur d Alene R., 1986
23	03#066	Bunker CIA seep #6 to S.F. Coeur d Alene R., 1986
24	153362	S.F. Coeur d Alene R. 100-ft above Bunker Creek
25	03#055	Bunker Ltd. discharge #006 (CIA)
26	153165	Bunker Creek at mouth
27	153152	Silver King (Government) Creek at mouth
28	153110	S.F. Coeur d Alene R. at Airport Ave Bridge, Kellogg
29	153616	Page Pond STP effluent channel
30	153810	S.F. Coeur d Alene R. below Smelterville
31	153333	S.F. Coeur d Alene R. above Pine Creek
32	153207	Pine Creek near mouth
33	153023	S.F. Coeur d Alene R. at mouth
34	03A056	Coeur d Alene R. near Enaville at EPA Bioassay Trailer site
35	153019	Coeur d Alene R. 150-m above mouth of South Fork at Enaville

Table 1 (cont.). COEUR D'ALENE BASIN SAMPLE SITES.

MAP STATION #	STORET STATION #	STATION NAME AND LOCATION
36	153018	Coeur d Alene R. near I-90 bridge at Cataldo
*37	03A058	Mission Flats Slough near Cataldo
38	153007	Coeur d Alene R. above bridge near Rose Lake
*39	03A057	Killarney Lake
40	03A041	Coeur d Alene R. adjacent to Blue Lake
41	03A042	Thompson Lake near center
42	03A043	Anderson Lake near center
43	03A048	Coeur d Alene River delta
44	03D005	Chatcolet Lake at Chatcolet (near St. Joe River mouth)
*45	03D007	Round Lake near Chatcolet
46	03D006	Lake Coeur d Alene 200-m east of Conkling Point
47	03D002	Lake Coeur d Alene centered between Conkling Point & Shingle Bay
48	03A047	Lake Coeur d Alene centered between Rockford and East Points
49	03A040	Lake Coeur d Alene centerline Rockford Bay near mouth
50	03A050	Lake Coeur d Alene at center of Carlin Bay
51	03A046	Lake Coeur d Alene center-off Carlin Bay
52	03A039	Lake Coeur d Alene at center of Delcardo Bay
53	03A049	Lake Coeur d Alene Echo Bay 400-m from mouth
54	03Z040	Wolf Lodge Creek at I-90 bridge
55	03Z039	Lake Coeur d Alene in Wolf Lodge Bay
56	03Z037	Lake Coeur d Alene in Wolf Lodge Bay btw Blue Creek & Beauty Bay
57	03A055	Lake Coeur d Alene Northern portion
58	03A051	Lake Coeur d Alene 500-m south of Sanders Beach
59	03A045	Lake Coeur d Alene at outlet

* Samples collected in the spring of 1987

Table 2. SAMPLE ANALYSES PERFORMED AT COEUR D'ALENE STUDY SITES DURING 1986 AND 1987. (See Table 1 for description of study sites and Figs. 1 and 2 for maps of study sites.)

		CHEMISTRY			BIOASSAYS				BIOSURVEY	
MAP SITE NUMBER	Gaging	Sediment	Water	Tissue	Sediment	Acute	Chronic	Livebox	Plankton	Benthos
01	X		X	X			X	X		X
02			X							
03			X							
04				X						
05	X		X				X	X		X
06	X		X							
07	X		X							
08	X		X							
09	X		X							
10										X
11	X		X				X	X		
12	X		X							
13			X							
14	X	X	X				X	X		X
15	X		X							
16	X	X	X				X	X		
17		X	X							
18		X	X			X	X			
19			X							
20			X							

Table 2 (cont.). SAMPLE ANALYSES PERFORMED AT COEUR D'ALENE STUDY SITES DURING 1986 AND 1987. (See Table 1 for description of study sites and Figs. 1 and 2 for maps of study sites.)

		CHEMISTRY			BIOASSAYS				BIOSURVEY	
MAP SITE NUMBER	Gaging	Sediment	Water	Tissue	Sediment	Acute	Chronic	Livebox	Plankton	Benthos
21			X							
22			X							
23			X							
24	X		X							
25			X							
26	X	X	X							
27	X	X	X							
28	X		X				X			
29		X								
30		X						X		
31	X	X	X			X	X	X		X
32	X		X							
33	X	X	X				X	X		X
34			X					X		
35	X		X							X
36	X	X	X				X	X		X
37				X						
38		X			X					
39				X						
40		X			X					

Table 2 (cont.). SAMPLE ANALYSES PERFORMED AT COEUR D'ALENE STUDY SITES DURING 1986 AND 1987. (See Table 1 for description of study sites and Figs. 1 and 2 for maps of study sites.)

		CHEMISTRY			BIOASSAYS				BIOSURVEY	
MAP SITE NUMBER	Gaging	Sediment	Water	Tissue	Sediment	Acute	Chronic	Livebox	Plankton	Benthos
41		X								
42		X								
43		X	X		X					
44		X		X	X					
45				X						
46		X			X					
47			X						X	
48			X						X	
49					X					
50		X								
51			X						X	
52		X								
53		X								
54				X						
55				X						
56			X						X	
57				X						
58		X							X	
59		X	X						X	

Table 3. HEAVY METAL CONTRIBUTIONS BY SOUTH FORK REACHES BETWEEN 1972 AND 1986.

YEAR	STREAM REACH: UPSTREAM OF BUNKER AV. BR.	BUNKER AV. BR. TO BUNKER CR.	BUNKER CR. TO AIRPORT BR.	BUNKER AV. BR. TO AIRPORT BR.
	ZINC LOADINGS (pounds/day)			
1972	1153	-	-	8247
1974	1494	1198	1852	3050
1975	975	2552	1947	4499
1976	1229	3692	2919	6611
1979	682	1167	0	1167
1980	1070	1025	123	1148
1982	991	570	288	858
1984	1100	582	23	605
1986	591	365	144	509
	CADMIUM LOADINGS (pounds/day)			
1972	8	-	-	158
1974	4	5	33	38
1975	11	0	57	57
1976	6	3	46	49
1979	4	1	7	8
1980	7	1	9	10
1982	4	3	5	8
1984	11	0	6	6
1986	6	0	7	7
	LEAD LOADINGS (pounds/day)			
1972	49	-	-	469
1974	21	27	48	75
1975	33	24	78	102
1976	18	16	67	83
1979	9	6	0	6
1980	13	0	13	13
1982	12	1	5	6
1984	9	0	2	2
1986	3	0	2	2

Table 4. SURVIVAL OF RAINBOW TROUT HELD IN LIVE BOXES AT SOUTH FORK AND MAINSTEM SITES. (Ten* hatchery rainbow trout 10-15 cm long were placed in each livebox.)

	NUMBER OF FISH ALIVE AT EXPOSURES OF:				
SITE	7-hrs	24-hrs	48-hrs	72-hrs	96-hrs
S.F. Coeur d'Alene River above Mullan	10	10	10	10	10
S.F. Coeur d'Alene River above Canyon Creek	10	10	10	10	10
S.F. Coeur d'Alene River above Big Creek	10	10	0	0	0
S.F. Coeur d'Alene River above Kellogg	9	4	1	0	0
S.F. Coeur d'Alene River at Bunker Ave.	10	10	3	3	3
S.F. Coeur d'Alene River below Smelterville	10	10	3	1	0
* S.F. Coeur d'Alene above Pine Creek	6	5	1	0	0
S.F. Coeur d'Alene River at mouth	10	10	7	7	6
Coeur d'Alene River at Enaville	10	10	10	10	10
Coeur d'Alene River at Cataldo	10	10	10	9	7

* Only six trout were placed in the chamber at Pine Creek.

Table 5. SURVIVAL OF CUTTHROAT TROUT EXPOSED TO BUNKER HILL CIA SEEP AND SOUTH FORK COEUR D'ALENE RIVER WATER. (Ten hatchery cutthroat trout 3-4 cm long were placed in each chamber.)[1]

AUGUST TEST (BUNKER HILL CIA SEEPS)

TEST HOUR	REP. #	SURVIVAL AND DILUTIONS 100%	50%	25%	12%	6.2%	3.1%	1.6%	0.8%	0%	LCI	LC50	UCI
24	1	0	2	5	5	8	8	10	9	10	16 ---	21 ---	29
	2	0	2	8	8	9	10	10	10	10			
48	1	0	0	0	0	0	5	8	8	10	2.7 ---	3.5 ---	4.4
	2	0	0	0	0	1	8	9	8	10			
72	1	0	0	0	0	0	2	8	7	10	1.9 ---	2.4 ---	3.1
	2	0	0	0	0	0	5	9	7	10			
96	1	0	0	0	0	0	2	7	7	10	1.7 ---	2.2 ---	2.8
	2	0	0	0	0	0	4	7	7	10			

SEPTEMBER TEST (ABOVE PINE CREEK)

TEST HOUR	REP. #	SURVIVAL AND DILUTIONS 100%	50%	25%	12%	6.2%	3.1%	0%	LCI	LC50	UCI
24	1	7	6	7	10	10	10	10		appx. 100	
	2	4	7	8	9	10	10	10			
48	1	1	0	1	4	10	10	10	9.6 ---	11.3 --	13.4
	2	0	1	0	3	10	10	10			
72	1	1	0	0	2	10	10	10	8.9 ---	10.1 --	11.6
	2	0	0	0	2	10	10	10			
96	1	1	0	0	0	10	10	10	8.6 ---	9.4 ---	10.4
	2	0	0	0	2	10	10	10			

[1]Tests conducted in on-site, mobile bioassay trailer operated by EPA Las Vegas Environmental Monitoring and Support Laboratory.

Table 6. SURVIVAL AND REPRODUCTION OF *CERIODAPHNIA* EXPOSED TO BUNKER HILL CIA SEEP AND SOUTH FORK COEUR D'ALENE RIVER WATER.[1]

SITE	TEST CONC	MEAN # OF YOUNG	95 PERCENT CONIDENCE INTERVAL	7 DAY % SURVIVAL
Control Water Lake Superior	100%	22.6	17.9 -- 27.3	100
S.F. Coeur d' Alene R. above Mullan	100%	23.1	16.0 -- 30.1	90
S.F. Coeur d' Alene R. above Canyon Creek	100%	0*		0*
S.F. Coeur d' Alene R. above Big Creek	100%	0*		0*
S.F. Coeur d' Alene R. above Kellogg	100%	0*		0*
	30%	0*		0*
	10%	0*		0*
	3%	20.6	14.6 -- 26.8	90
	1%	19.7	15.4 -- 24.0	100
Dilution Control**		24.3	18.8 -- 29.9	90
S.F. Coeur d' Alene R. at Bunker Ave Br.	100%	0*		0*
Bunker CIA Seeps	10.0%	0*		0*
	3.0%	0*		0*
	1.0%	0*		0*
	0.3%	15.1	11.5 -- 18.7	90
	0.1%	18.6	16.2 -- 21.0	100
Dilution control**		17.4	14.8 -- 20.0	100
S.F. Coeur d' Alene R. at Airport Av. Bridge	100%	0*		0*

* Significantly lower than the control water value at $P < 0.05$.
** Dilution water was from Coeur d'Alene River above S.F. mouth.

[1]Tests conducted with *Ceriodaphnia dubia* at the EPA Duluth Environmental Research Laboratory.

Table 6 (cont.). SURVIVAL AND REPRODUCTION OF *CERIODAPHNIA* EXPOSED TO BUNKER HILL CIA SEEP AND SOUTH FORK COEUR D'ALENE RIVER WATER.

SITE	TEST CONC	MEAN # OF YOUNG	95 PERCENT CONIDENCE INTERVAL	7 DAY % SURVIVAL
S.F. Coeur d' Alene R. above Pine Creek	100%	0*		0*
	30%	0*		0*
	10%	0*		0*
	3%	22.0	15.9 -- 28.0	70
	1%	24.8	21.9 -- 27.7	90
Dilution Control**		27.3	24.9 -- 29.7	100
S.F. Coeur d' Alene R. at mouth	100%	0*		0*
Coeur d' Alene R. at Cataldo	100%	0*		0*

Table 7. SURVIVAL AND GROWTH OF LARVAL FATHEAD MINNOWS EXPOSED TO BUNKER HILL CIA SEEP WATER.[1]

SITE	TEST CONC	REPLICATES	INDIVIDUAL MEAN DRY WEIGTH (mg)	7 DAY % SURVIVAL
Bunker CIA Seeps	30.0%	A		0*
		B		0*
	10.0%	A		0*
		B		0*
	3.0%	A	0.345	60
		B	0.430	20
	1.0%	A	0.542	90
		B	0.466	80
	0.3%	A	0.780	90
		B	0.645	80
Dilution control		A	0.609	100
		B	0.633	100

* Significantly lower than the control water value at $P < 0.05$.
** Dilution water was from Coeur d'Alene River above S.F. mouth.

[1]Tests conducted with *Pimephales promelas* at the EPA Duluth Environmental Research Laboratory.

Table 8. GROWTH OF THE ALGAE, *SELENASTRUM CAPRICORNUTAM,* EXPOSED TO SOUTH FORK COEUR D'ALENE RIVER WATER.[1]

SITE	TEST CONC	FOUR DAY MEAN NUMBER OF CELLS/ML	FOUR DAY ALGAL STANDING CROP (MG/L, DRY WEIGHT)
Control--Algal Assay Medium (AAM) w/o EDTA*	0%	409,300	7.81022
S.F. Coeur d'Alene	6%	19,900	0.84629
R. above Pine Creek	12%	16,300	0.79296
September	25%	13,300	0.62169
	50%	14,500	0.54370
	100%	11,900	0.33755
w/o AAM Nutrients	100%	13,600	0.45162
S.F. Coeur d'Alene	6%	19,300	0.91600
R. above Pine Creek	12%	16,000	0.76108
October	25%	11,600	0.50324
	50%	15,400	0.52219
	100%	13,200	0.39388
w/o AAM Nutrients	100%	10,700	0.30920
S.F. Coeur d'Alene	6%	34,100	0.99366
R. above Kellogg	12%	19,000	0.80150
October	25%	14,400	0.69158
	50%	11,000	0.44748
	100%	11,000	0.32743
w/o AAM Nutrients	100%	11,900	0.31659

* This solution also served as the dilution water.

[1]Tests conducted with *Selenastrum capricornutam* at the EPA Region 10 Laboratory, Manchester, Washington.

TABLE 9. METAL LEVELS (mg/kg wet wt) IN SEDIMENTS COLLECTED DURING THE EPA 1986 SURVEY. Nationwide levels (Lyman, et al) are included for comparison purposes.

LOCATION	LEAD	CADMIUM	ZINC	ARSENIC	COPPER
LAKE COEUR D'ALENE NORTHERN PART					
Lake Outlet at Spokane River	1146	8.2	2740	16.4	64
500 meters south of Sanders Beach (City of Coeur d' Alene)	5732	7.8	5360	37.7	197
Echo Bay	4716	7.1	5190	56.4	176
Delcardo Bay	2718	7.3	4720	79.0	141
Carlin Bay	2262	6.6	4320	87.0	109
LAKE COEUR D'ALENE CENTRAL PART					
Rockford Bay	2136	7.7	3620	96.6	135
Coeur d'Alene River Delta	4158	8.0	3680	83.2	110
Coeur d'Alene River Delta (1971)*	3700	43.0	3800	-	115
LAKE COEUR D'ALENE SOUTH PART					
Blue Point (Conkling Park)	367	9.9	1310	14.5	36
Near St. Joe R. Mouth (Chacolet Lake)	10	0.6	77	3.9	26
LATERAL LAKES					
Anderson Lake	2492	9.7	2180	46.1	88
Thompson Lake	3386	8.9	2560	95.9	97

* Mean levels from surface layer of multiple core samples taken throughout the delta (Maxfield, et al. 1974b).

TABLE 9 (cont.). METAL LEVELS (mg/kg wet wt) IN SEDIMENTS COLLECTED DURING THE EPA 1986 SURVEY.

LOCATION	CADMIUM	LEAD	ARSENIC	COPPER	ZINC
LOWER COEUR D'ALENE RIVER					
Near Blue Lake	8.3	3992	77.5	124	4220
Rose Lake Bridge	7.2	3870	50.1	153	7300
At Cataldo	4.8	2310	90.0	52	1350
SOUTH FORK COEUR D'ALENE RIVER					
At Mouth	3.1	5768	180	220	29740
Abv. Pine Cr.	2.9	4298	230	210	26680
Page Pond STP Effluent Channel	3.1	4106	114	210	16520
At Airport Ave. Bridge	3.0	4967	191	160	4080
Silver King Cr. Mouth	4.0	5636	0.1	600	9780
Bunker Cr. Mouth	4.5	298	12	550	28400
CIA Seep Area	3.6	996	0.2	32	27260
Cook Cr. at Mouth	4.3	292	106	59	203
At Bunker Ave. Bridge	3.4	7048	232	160	1634
Abv. Kellogg	3.5	7897	57	185	10600
Median Level in sediments (nationwide)*	1.0	16	4.0	-	41
95% of sediments nationwide have levels below:*	12.0	199	39	-	379

*Lyman et al., 1987.

Table 10. SURVIVAL OF *DAPHNIA* AND *HYALELLA* EXPOSED TO COEUR D'ALENE RIVER AND LAKE SEDIMENTS.[1]

SITE	BEAKER	No. *Daphina* alive after 48-hr(n=10)	No. *Hyalella* alive after 96-hr(n=20)
Chatcolet Lake at Railroad Bridge (Control site)	A	4	17
	B	5	16
	C	1	20
Coeur d'Alene River near Rose Lake Bridge	A	7	13
	B	10	14
	C	5	12
Coeur d'Alene River near Blue Lake	A	3	5
	B	3	9
	C	2	8
Coeur d'Alene Lake at Coeur d'Alene River Delta	A	8	15
	B	7	18
	C	4	15
Coeur d'Alene Lake near Conkling Point	A	5	20
	B	6	20
	C	10	16
Coeur d'Alene Lake in Rockford Bay near mouth	A	9	18
	B	9	16
	C	8	12

[1]Sediment toxicity tests conducted with *Daphnia magna* and *Hyalella azteca* at the the EPA Corvallis Environmental Research Laboratory.

Table 11. METAL LEVELS (mg/kg wet wt) IN FISH TISSUE COLLECTED DURING THE EPA 1986-87 SURVEY.[1] (International legal limits for fish consumption included.)

SPECIES	ORGAN	METALS					
		Cadmium	Lead	Arsenic	Mercury	Copper	Zinc
COEUR D'ALENE LAKE							
Chinook	F	0.050.	0.02U	0.04	0.13	0.38	4.9
Chinook	K	5.27	0.50	0.10	0.07	2.60	36.5
Chinook	L	2.14	0.32	0.16	0.18	66.9	66.1
Chinook	CK	3.67	0.20	0.14	*	1.88	31.2
Chinook	CK	5.91	0.02U	0.22	*	4.64	32.5
Chinook	CL	1.73	0.08	0.28	*	33.4	66.5
Chinook	CL	1.92	0.16	0.02U	*	24.9	51.7
Kokanee	F	0.08	0.02U	0.06	*	1.12	8.7
Kokanee	F	0.13	0.02U	0.06	*	0.54	8.4
Kokanee	F	0.11	0.02U	0.14	*	0.58	6.7
Kokanee	F	0.22	0.46	0.02	*	1.12	8.9
Kokanee	F	0.17	0.02U	0.18	*	0.68	11.5
Kokanee	W	0.72	0.58	0.02U	*	2.16	48.3
Kokanee	W	0.79	0.20	0.02U	*	0.66	51.7
Kokanee	CF	0.012	1.12	0.04	0.039	0.22	4.5
Kokanee	CF	0.052	0.02U	0.12	0.032	0.44	9.2

* - Parameter not analyzed

U - Compound was not detected; number is the minimum detection limit.

F - Single filet
K - Single kidney
L - Single liver
W - Single Whole fish

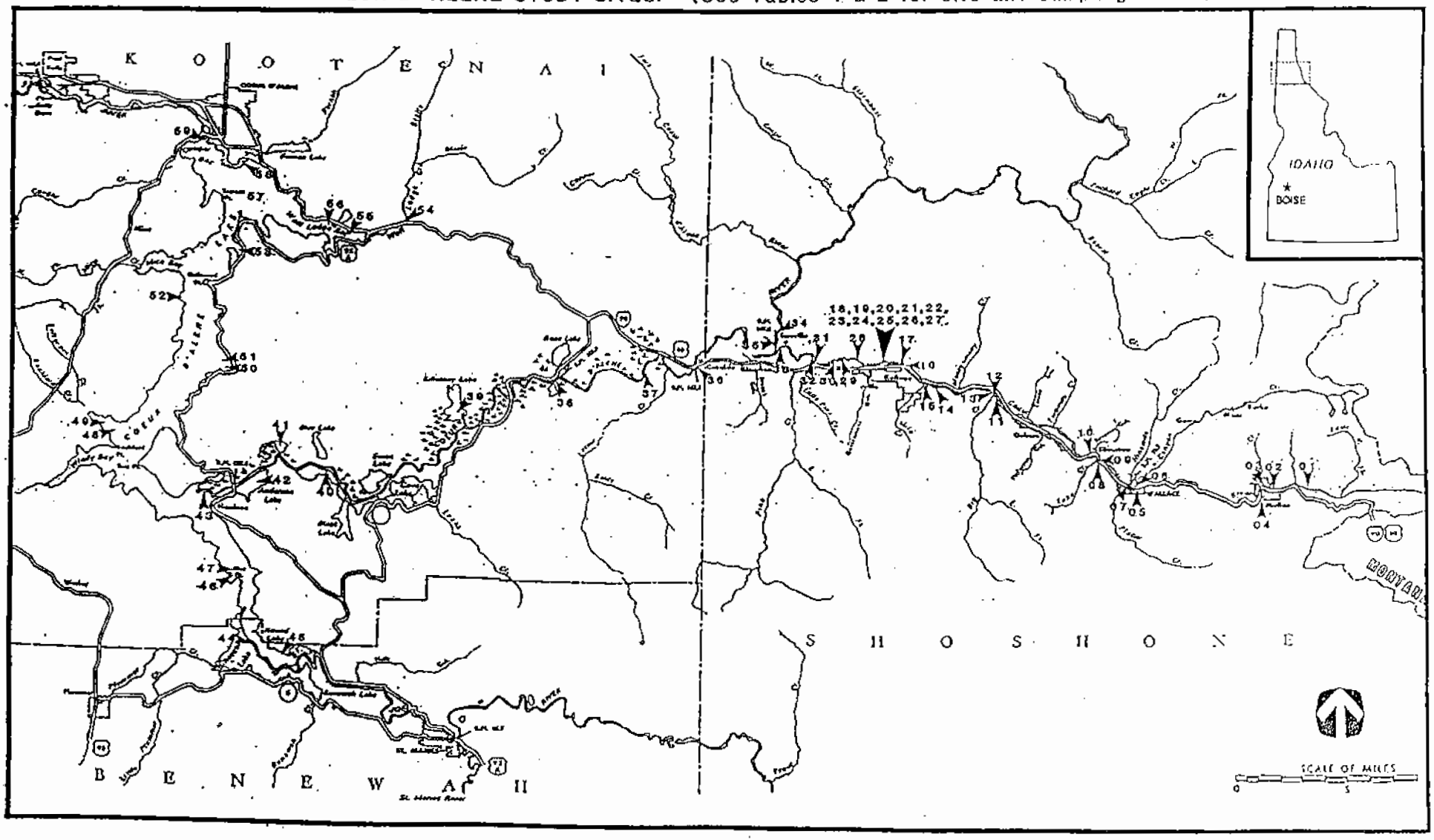
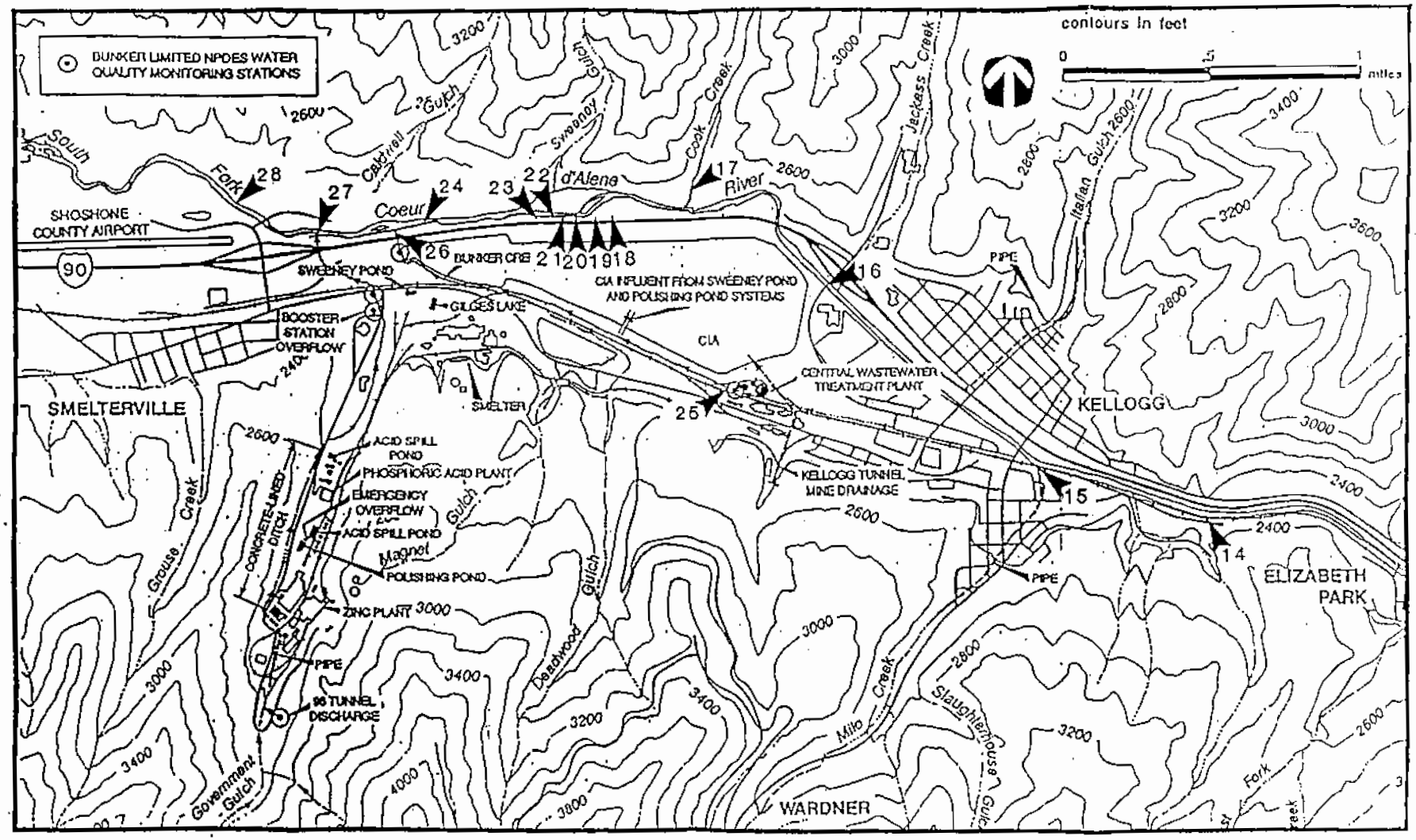
CF - Composite filet
CK - Composite kidney
CL - Composite liver

[1]All Salmonids were collected during August-September, 1986; other species collected during June, 1987.

Table 11(cont.). METAL (mg/kg wet wt) LEVELS IN FISH TISSUE COLLECTED DURING THE EPA 1986-87 SURVEY.

SPECIES	ORGAN	Cadmium	Lead	Arsenic	Mercury	Copper	Zinc
WOLF LODGE CREEK AT COEUR D'ALENE							
Cutthroat	F	0.032	0.20	0.02U	0.095	0.36	5.7
Chinook	CF	0.006	0.02U	0.02U	0.138	0.58	3.8
Chinook	CF	0.014	0.02U	0.12	0.164	1.9	8.1
Chinook	CF	0.006	0.02U	0.02U	0.141	0.24	3.9
MISSION SLOUGH							
B.Bullhead	F	0.03	0.08	0.15	0.035	0.28	6.4
Y.Perch	CF	0.006	0.06	0.22	0.063	0.14	4.6
N.Pike	CF	0.012	0.01U	0.09	0.034	0.24	4.3
KILLARNEY LAKE							
B.Bullhead	CF	0.031	0.49	0.12	0.14	0.39	5.5
Y.Perch	CF	0.011	0.03	0.18	0.086	0.22	7.8
B.Crappie	CF	0.022	0.01U	0.18	0.12	0.17	5.9
LgM.Bass	CF	0.007	0.01U	0.21	0.37	0.14	3.9
N.Pike	CF	0.011	0.01U	0.26	0.21	0.22	6.5
ROUND LAKE							
B.Bullhead	CF	0.008	0.01U	0.23	0.016	0.29	4.5
Y.Perch	CF	0.008	0.01U	0.11	0.088	0.11	5.1
B.Crappie	CF	0.011	0.11	0.30	0.28	0.13	6.1
LgM.Bass	CF	0.01	0.01U	0.25	0.18	0.30	4.4
N.Pike	F	0.007	0.01U	0.23	0.18	0.33	3.6
S.F. COEUR D'ALENE RIVER ABOVE MULLAN							
Rainbow	CF	0.01	0.02U	0.48	0.005	0.52	4.3
Salmonids	CF	0.06	0.02U	0.08	0.008	0.82	6.3
MEDIAN INTERNATIONAL LEGAL LIMITS FOR FISH CONSUMPTION (Nauen, 1983)							
		0.3	2.0	1.5	0.5	20	45

MAP 1. COEUR D' ALENE STUDY SITES. (See Tables 1 & 2 for site and sampling description).



MAP. 2. STUDY SITES IN VICINITY OF KELLOGG, IDAHO. (See Tables 1 & 2 for site and sampling description).