WATER QUALITY STATUS REPORT ● REPORT NO. 80

CROOKED RIVER
Idaho County, Idaho
1987

Prepared by
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&
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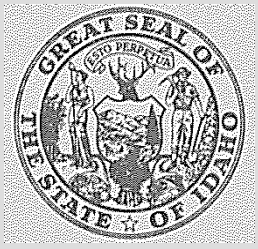

Department of Health & Welfare
Division of Environment
Water Quality Bureau
Boise, Idaho

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ABSTRACT

Crooked River is located approximately 120 miles southeast of Lewiston, Idaho. Specific designated uses for the river have not been identified in the Idaho Water Quality Standards however the current uses would indicate that a special resource classification would be appropriate. Dredging operations between 1936 and 1948 left large piles of gravel in the natural watercourse causing the river to meander. Between the meanders, impoundments of water exist which are fed by infiltration from the river and surface runoff. A number of the ponds do not have direct surface flow to Crooked River.

Crooked River is a primary anadromous fisheries resource. Fisheries biologists from the Nezperce National Forest are considering the realignment of the existing stream channel. This includes connecting six ponds to Crooked River by constructing 500 feet of new channel. In addition, 1000 feet of intermittent channel will be modified to assure perennial flows. The objective is to provide additional off channel rearing for the juvenile anadromous salmonids that inhabit the stream system.

As part of this study, a test fisheries enhancement project was completed during 1987 to determine if the disturbance of dredge ponds and spoils would mobilize any toxic levels of chemicals to Crooked River. Fisheries biologists introduced flows to three ponds by constructing about 150 feet of connecting channel. The test enhancement project was timed so as not to adversely effect anadromous fish migration .

During 1986 and 1987 we found total and dissolved water column concentrations of Ar, Cu, Hg, Ag, and Zn in Crooked River and adjacent dredge ponds to be below detection limits. In Crooked River total Fe exceeded EPA freshwater criteria for aquatic life but only during the construction phase of the fish enhancement project.

A concurrent EPA study found dredge pond bottom sediments for Ar, Cd, Cu, Fe, Pb, Hg, and Zn to be below EPA 95th percentile concentrations. Also, a in-situ bioassay produced no acute toxic effects on steelhead trout or chinook salmon young-of-the-year.

INTRODUCTION

Crooked River originates on the northeast perimeter of the Gospel Hump Wilderness area and flows north approximately 14 miles to its confluence with the South Fork Clearwater River (Figure 1). The 44,914 acre watershed recieves 40 inches of precipitation annually which yields approximately 76,300 acre feet of water. The granitic Idaho batholith forms the geologic parent material for the area. The drainage is primarily under management of the Nezperce National Forest although some private ownership exists.

Two branches form the headwaters of Crooked River, both beginning at about 7,000 feet elevation on the northern edge of Columbia Ridge. The streams drop rapidly to their confluence at Old Orogrande; Crooked River then flows for 5 miles to a gentler grade in a wider valley which has been dredged. Most of the dredge piles in this river segment are in windrows generally parallel to the streamcourse. The river then enters the 2.5 mile "narrows" section which has only a few tailings piles in the widest areas. Sediment from the road reportedly has the greatest impact on fish habitat in this portion of the river. Downstream from the "narrows" the valley widens again. That portion of the river was also dredged, but the tailings piles are short and perpendicular to each other, forming "T" and "L" shapes. The river is forced around these dredge piles in a symmetrical, right angled course, in a fashion similar to a natural meander pattern. Numerous ponds formed by the dredging operations lie adjacent to the river.

Four different dredge operations between 1936 and 1958 greatly affected the river. The first recorded dredge (a 2 cubic foot bucket line system) operated at the mouth of the river in 1936. A four cubic foot YUBA boat dredge operated from 1939 until 1942. From 1951 to 1953, a 2 cubic foot bucket dredge operated in the vicinity of Five Mile Creek. In 1958, a small dragline and washing plant operated from 1.5 miles below Relief Creek to Five Mile Creek.

Most of the valley bottom occupied by Crooked River is covered by a mixed assemblage of unconsolidated fluvial material. Large areas of this material have been reworked by dredging activity. This sorting has left rock and gravel overlying sand. The gravel and sand assemblage is very permeable due to a low percentage of silt and clay. Most of the natural clays probably eroded downstream during dredging. The silts and sands have undergone oxidation and are now reddish-brown. The average thickness of the fluvial material is unknown but in one backhoe pit bedrock was exposed at 7 feet.

Idaho Water Quality Standards and Wastewater Treatment Requirements (1985) designate the South Fork of the Clearwater as "Special Resource Water," indicating its high priority due to outstanding aquatic characteristics. As previously mentioned, a like classification for Crooked River would seem appropriate. The Idaho Department of Fish and Game and the Nezperce National Forest consider the South Fork to be of primary importance for their anadromous fisheries objectives.

Fisheries biologists propose to realign a portion of the existing stream channel of Crooked River to introduce flow to the ponds, thereby providing additional salmonid rearing habitat. However, concern was expressed that since water exchange has been very slow within the ponds, potentially harmful concentrations of heavy metals may have accumulated within them. Thus, any efforts to alter the Crooked River channel may mobilize and possibly flush toxic levels of metals into Crooked River and subsequently into the South Fork of the Clearwater River.

The objectines of the study were to: (1) determine trace metal concentrations in the dredge ponds adjacent to Crooked River; (2) monitor the water quality effects of fish habitat enhancement.

METHODS

SAMPLE STATIONS

Division of Environment Stations

Two sets of sample stations were established by the Idaho Department of Health and Welfare-Division of Environment (DOE) during 1986 and 1987. They were sample stations within the project area and comparison sample stations from nearby tributaries.

There are ten project area stations in Crooked River. Stations S-R-1, S-P-A, S-P-B1, S-P-C1, S-P-D1, and S-R-4 were sampled in 1986. In 1987, project design changes required the sampling of two additional ponds (S-P-B2 and S-P-C2). Also, two instream stations S-R-2 and S-R-3 were added to the study stations (Figure 1). STORET (STOrage and RETrieval computer data system) descriptions are listed in Table 1.

FIGURE 1 : MAP OF CROOKED RIVER STATIONS

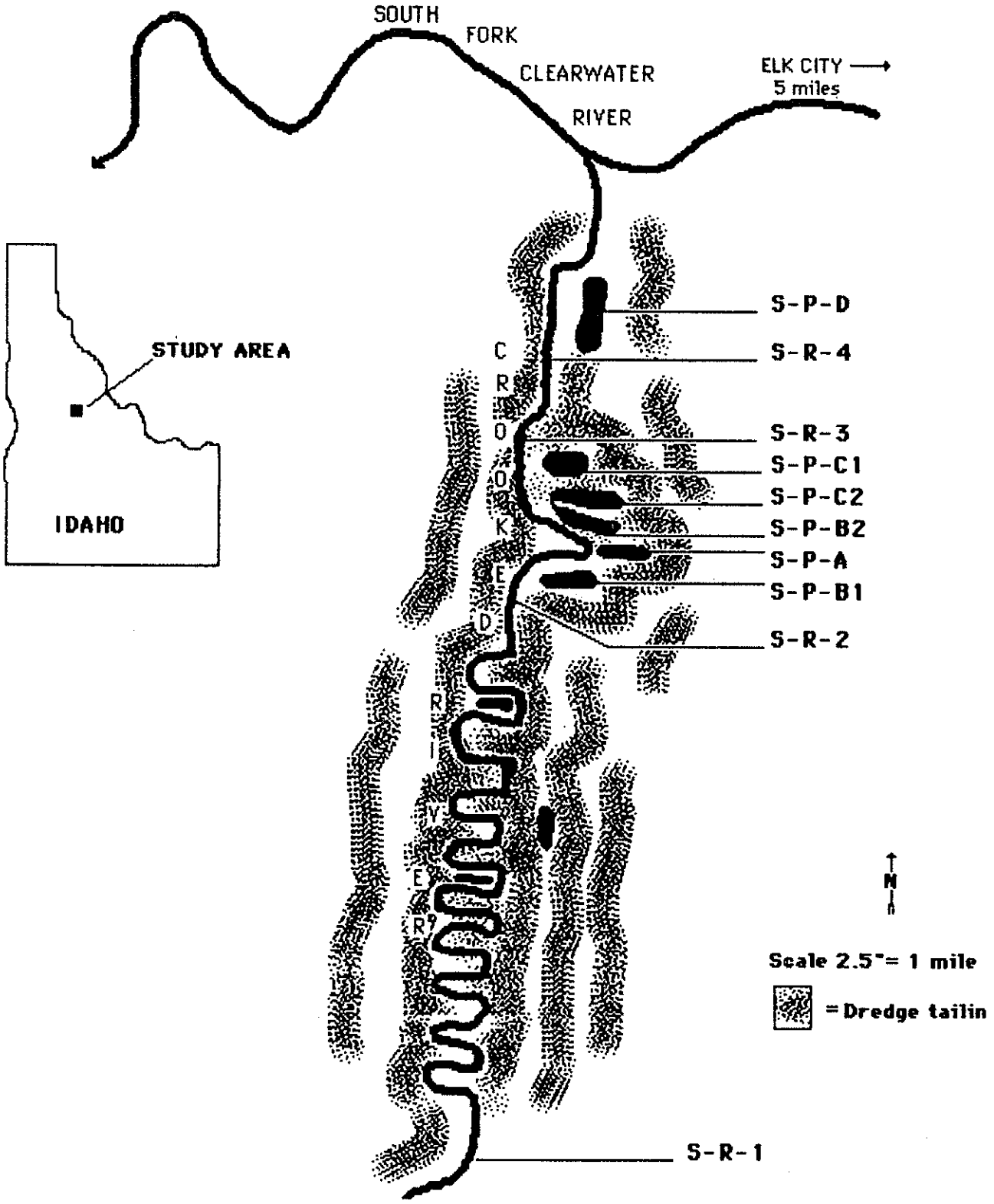


TABLE 1: List of Crooked River monitoring stations, Idaho County, Idaho

Station	Description	Latitude/Longitude	River Mile	Elevation	Storet Numbers
S-R-1 -1-	Crooked River above meanders	45°47'37"/ 115°31'55"	324.3/139.3/74.7 58.4/2.6	3960'	2020293
S-R-2 -2-	Crooked River above dredge ponds	45°48'38"/ 115°31'40"	324.3/139.3/74.7 58.4/1.1	3880'	2020301
S-P-A -5-	Dredge Pond	45°48'41"/ 115°31'40"	324.3/139.3/74.7 58.4/1.0	3880'	2020295
S-P-B1 -6-	Dredge Pond	45°48'53"/ 115°31'35"	324.3/139.3/74.7 58.4/1.0	3880'	2020296
S-P-B2 -7-	Dredge Pond	45°48'57"/ 115°31'35"	324.3/139.3/74.7 58.4/1.0	3880'	2020300
S-P-C1 -8-	Dredge Pond	45°49'08"/ 115°31'35"	324.3/139.3/74.7 58.4/1.0	3880'	2020297
S-P-C2 -9-	Dredge Pond	45°49'12"/ 115°31'35"	324.3/139.3/74.7 58.4/1.0	3880'	2020293
S-P-D -10-	Dredge Pond	45°49'25" 115°31'35"	324.3/139.3/74.7 58.4/0.3	3840'	2020298
S-R-3 -3-	Crooked River below dredge ponds	45°49'18" 115°31'35"	324.3/139.3/74.7 58.4/0.3	3840'	2020292
S-R-4 -4-	Crooked River near mouth	45°49'36" 115°31'37"	324.3/139.3/74.7 58.4/0.3	3840'	2020298

Station River 1 (S-R1): Rivermile 2.6. Control station upstream of test project activities. Water quality, trace metals, minerals and flow data collected.

Station River 2 (S-R-2): Rivermile 1.0. Control station 100 feet above test enhancement project activities. Water quality, trace metals, and minerals data collected.

Station Pond A (S-P-A): Rivermile 1.0. The upstream dredge-pond of the pond sampling series. Water quality trace metals and mineral data collected. To determine contribution of releasing trace metals to Crooked River in conjunction with S-P-B1, S-P-C1, S-P-C2.

Station Pond B1 (S-P-B1): Rivermile 1.0. Dredge-pond sampled for water quality, trace metals and minerals data. Not sampled in 1987. Pond deleted from enhancement project plan.

Station Pond B2 (S-P-B2): Rivermile 1.0. Dredge-pond sampled for water quality, trace metals, and minerals data.

Station Pond C1 (S-P-C1): Rivermile 1.0. Dredge-pond sampled for water quality, trace metals, and minerals data. Not sampled in 1987. Pond deleted from enhancement project plan.

Station Pond C2 (S-P-C2): Rivermile 1.0. Dredge-pond sampled for water quality, trace metals and minerals data.

Station River 3 (S-R-3): Rivermile 1.0. River sample station 100 feet below test project area to monitor any cumulative changes in water quality to Crooked River from enhancement activities. Water quality, trace metals, and minerals data collected.

Station River 4 (S-R-4): Rivermile 0.3. Near mouth, serves as comparison station to S-R-3 to determine any downstream transport of pollutants and any delivery of pollutants to the South Fork Clearwater River. Water quality, trace metals, minerals and flow data collected. The U. S. Geological Survey stream discharge station has been removed. The U.S.G.S. now maintains a stream thermograph at this site. Idaho Department of Fish and Game drilled a 285 foot well approximately 100 feet east of station S-R-4. Trace metal samples were collected from the artesian outflow of the well.

S-Pond D (S-P-D): Rivermile 0.3. Dredge-pond sampled for water quality, trace metals and minerals data. Not sampled in 1987 due to change in enhancement project plan.

Four comparison stations, tributaries to South Fork Clearwater River, were sampled. Trace metals concentration levels from these tributaries were compared with Crooked River data.

Station Tributary 1 (S-T-1): American River - at mouth - water quality, trace metals, minerals, and flow data collected.

Station Tributary 2 (S-T-2): Red River- at mouth- water quality, trace metals, minerals, and flow data collected.

Station Tributary 3 (S-T-3): Deadwood Creek - at mouth - water quality, trace metals, minerals and flow data collected.

Station Tributary 4 (S-T-4): Newsome Creek - at mouth - water quality, trace metals, minerals and flow data collected.

U.S. Environmental Protection Agency Stations

A concurrent U.S. Environmental Protection Agency (EPA) study, funded under contract 68-03-3249, characterized water quality parameters and in-situ toxicity for nine Crooked River sample sites (Baldigo,1986). Four stations were located at DOE sites while the remaining five were in the same general study area. EPA stations 323, 326, 327 & 328 correspond to DOE stations S-R-1, S-P-C1, S-R-4, and S-P-D respectively.

WATER CHEMISTRY

In 1986 five sample sets (May through September) were collected for Crooked River stations S-R-1, S-P-B1, S-P-C1, S-P-D1, and S-R-4. S-P-A was sampled once during May of 1986. Two sample sets were collected in July, 1987 and one set collected in September 1987 for stations S-R-1, S-P-4, S-P-B2, S-P-C2, S-R-3, and S-R-4. South Fork Clearwater River tributary comparison stations S-T-1, S-T-2, S-T-3, and S-T-4 were sampled once during September 1987. Parameters measured include flow,

temperature, oxygen, pH, specific conductance, common ions, trace metals, iron, zinc, copper, arsenic, lead, mercury, and silver. STORET numbers for sample parameters are displayed in Table 2.

Field parameters were measured with portable meters. Dissolved oxygen, temperature, and specific conductance were measured with YSI Model 54 ARC and Model 33 SCT meters respectively. The pH was measured with a Corning Model 103 meter. All field instruments were calibrated at the beginning and during each survey sample set. Two one-liter grab samples were collected, to include total metals and dissolved metal. The dissolved metal sample was field-filtered through a 45 micron filter using a Mit-Y-Vac hand-operated vacumn pump. The liter samples in plastic cubitainers were preserved with 10 ml of 1:1 redistilled nitric acid. All samples were transported on ice to the laboratory.

FLOW

Stream flow was measured using standard techniques (Leopold and Stevens 1978, USGS 1977, USDI 1967). A Marsh-McBirney, Model 201, water current meter was used to determine flow (discharge in cubic feet per second).

IN-SITU BIOASSAY

The EPA funded in-situ bioassay provided information concerning the effects of trace metals concentrations on the physiology of juvenile summer steelhead trout (Salmon gairdneri) and juvenile summer chinook salmon (Oncorhynchus tshawytscha). At each of the four Crooked River and five contiguous pond sites, two live boxes, one containing twelve young-of-the-year steelhead and one containing eleven young-of-the-year chinook were placed in the stream for 144 hours . Because of suspected low dissolved oxygen levels at pond S-P-C1, this bioassay was conducted in an aerated aquaria. Water chemistry parameters (dissolved oxygen, temperature, pH, specific conductance, and trace metals in water and sediment, iron, zinc, coppper, lead, cadmium, selenium, calcium, and magnesium) were sampled at all the live box sites.

Table 2 Sample Parameters, Crooked River Study

Parameter	Units	STORET CODE
1) Discharge	cfs	00061
2) Water Temperature	°C	00010
3) Dissolved Oxygen	mg/l	00300
4) pH	S.U.	00400
5) Electrical Conductivity	µmhos/cm	00665
6) Hardness as $CaCO_3$	mg/l	00900
7) T. Alkalinity as $CaCO_3$	mg/l	00410
8) Arsenic, Total	µg/l	01002
9) Mercury, Total	µg/l	71900
10) Silver, Total	µg/l	01077
11) Lead, Total	µg/l	01051
12) Arsenic, Dissolved	µg/l	01000
13) Mercury, Dissolved	µg/l	71890
14) Silver, Dissolved	µg/l	01075
15) Lead, Dissolved	µg/l	01049
16) Zinc, Total	µg/l	01092
17) Zinc, Dissolved	µg/l	01090
18) Copper, Total	µg/l	01042
19) Copper, Dissolved	µg/l	01040
20) Iron, Total	µg/l	01045
21) Iron, Dissolved	µg/l	01046

RESULTS & DISCUSSION

A major study objective was to determine if toxic metal concentrations would be released to Crooked River from dredge-mine ponds during the proposed fish habitat enhancement project. Three dredge-mine formed ponds, which lacked connecting channels to Crooked River, were selected by Nezperce National Forest biologists for the test enhancement project. Connecting the ponds to Crooked River would provide additional rearing habitat for juvenile salmonids. An inlet, two connecting channels, and an outlet were excavated among three ponds (Figure 2). During the 1987 channel construction approximately 2100 cubic yards of dredge spoils were excavated and removed from the site (Paradise, 1987)

WATER CHEMISTRY

Dissolved Oxygen

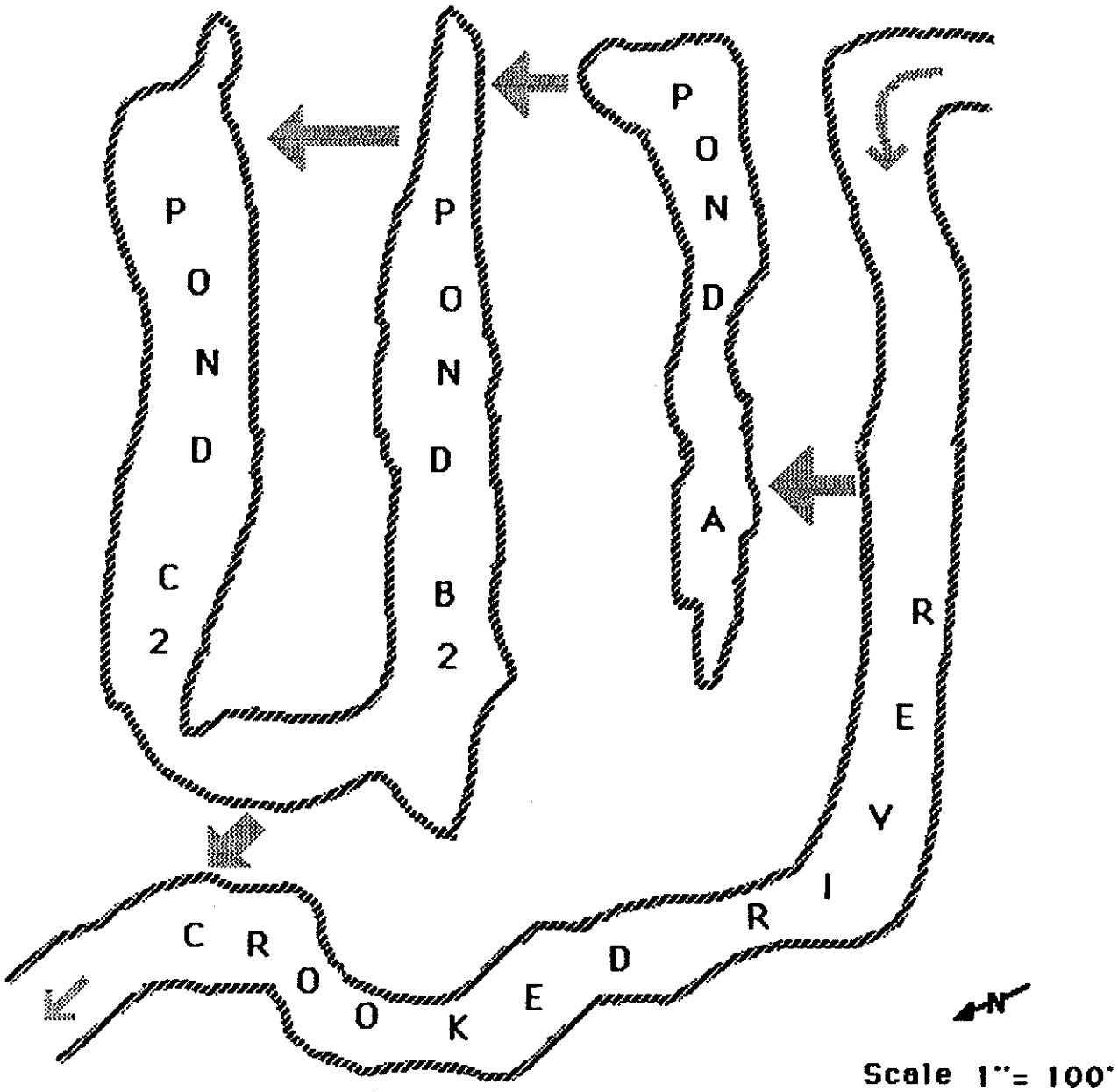
Mean dissolved oxygen (DO) values for Crooked River and the contiguous dredge-ponds were 8.9 mg/l and 8.1 mg/l respectively (Figure 3). These values exceeded the one day minimum DO criteria of 8.0 mg/l for the physiological requirments of the early life stages of coldwater fish (EPA 1986).

Temperature

Mean instream water temperature for Crooked River, taken during the months of May to September in 1986 and 1987, was 15.0 degrees centigrade (° C). While water temperatures in the dredge-ponds for the same period was 18.8 °C (Figure 4). These temperatures would seem not to limit juvenile salmonid summer rearing as cited in Rieser (1979). He found that successful salmonid growth is limited at temperatures above 20.3 °C.

FIGURE 2:

MAP OF TEST CROOKED RIVER FISH HABITAT ENHANCEMENT PROJECT



Bold arrows indicate connecting channels constructed during 1987 enhancement project

FIGURE 3 : MEAN CONCENTRATIONS OF DISSOLVED OXYGEN FOR CROOKED RIVER STUDY DURING 1986,1987

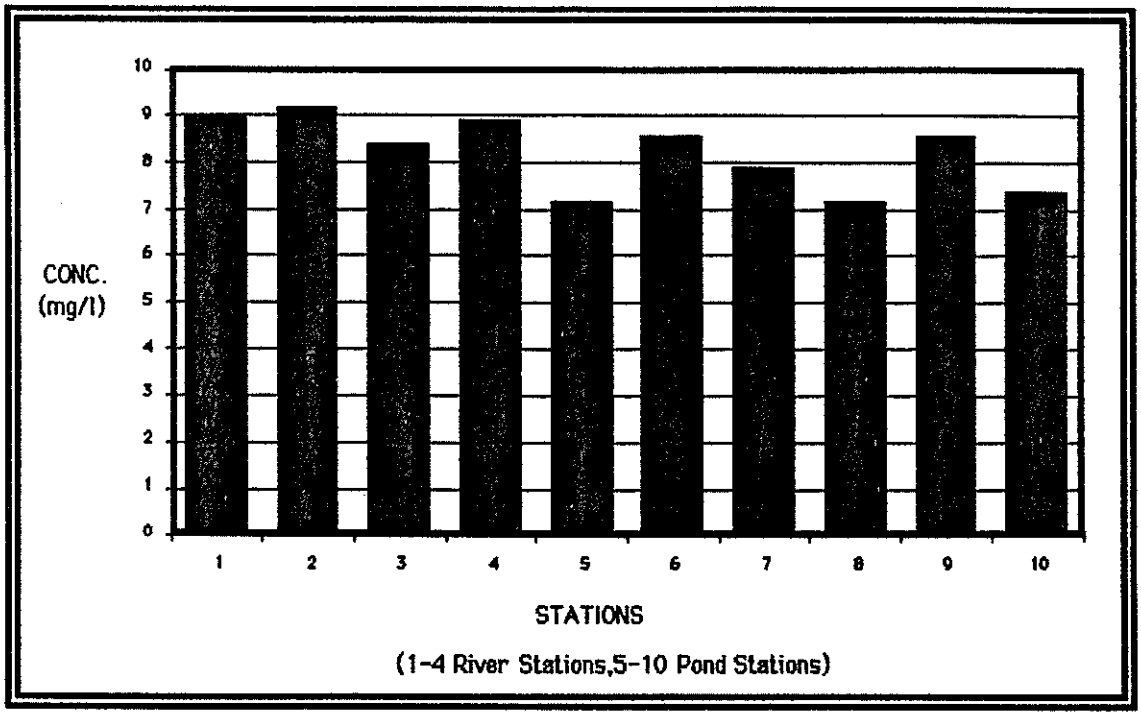
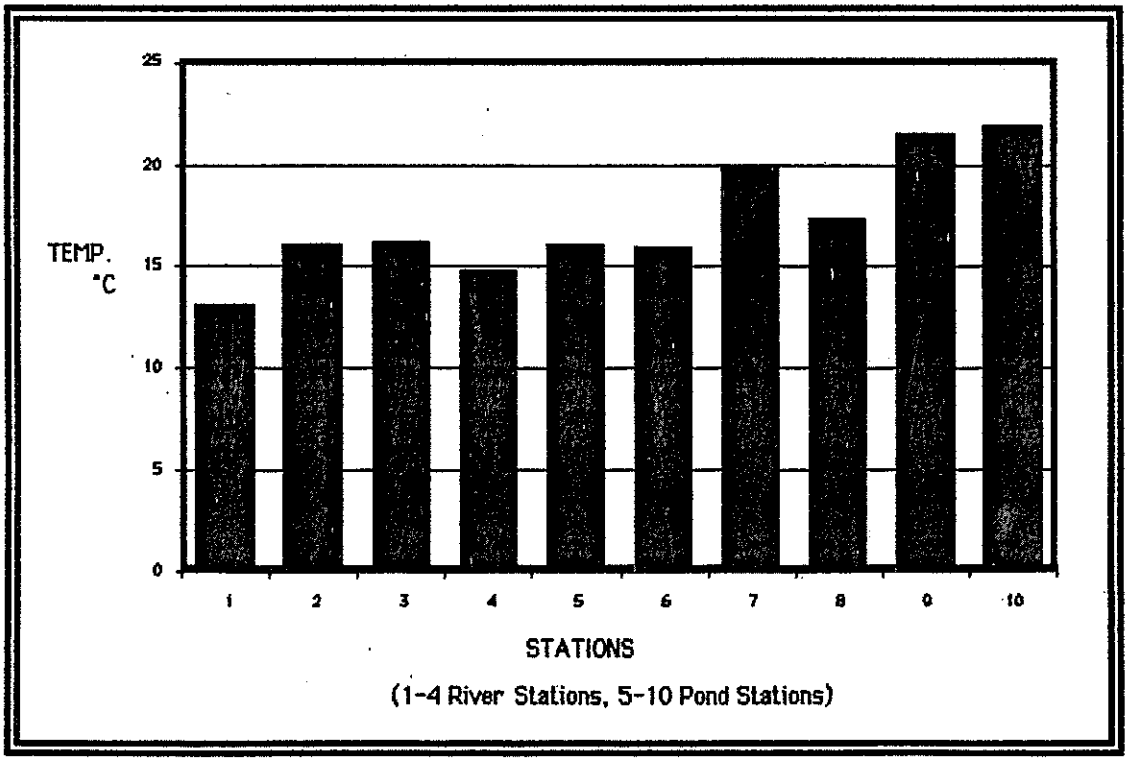


FIGURE 4 : MEAN WATER TEMPERATURES FOR CROOKED RIVER STUDY DURING 1986,1987



pH

The mean pH for Crooked River, measured during the study period, was 7.4 (Figure 5). The mean pH for the dredge-pond stations was 7.2. These pH values fall within the EPA (1986) recommended criteria range of 6.5-9.0 for freshwater aquatic life.

Conductivity

Crooked River had a mean conductivity (corrected to 25 ° C) of 41 µhmos/cm while the dredge ponds had a mean conductivity of 45 µhmos/cm (Figure 6). The EPA has not established a conductivity criteria for freshwater aquatic life.

Hardness and Alkalinity

Mean hardness was found to be 14 mg/l for Crooked River and 17 mg/l for the dredge-ponds (Figure 7). There is no established EPA criteria for hardness, although hardness does effect the criteria toxicity limits of metals such as arsenic, copper, lead, and zinc (EPA 1986).

Mean alkalinity of 20 mg/l and 25 mg/l were recorded for Crooked River and the dredge ponds, repsectively (Figure 8). Alkalinity is an important chemical component of freshwater aquatic systems because it buffers pH and can reduce the toxicity of some metals (EPA 1986). The recommended EPA criteria is 20 mg/l or more as calcium carbonate.

METALS

Sampling of the ambient water column indicated that all selected metals, except for iron, were within EPA freshwater criteria for aquatic life.

Iron

Reddish iron oxidized stream bottom materials give Red River, a comparison tributary, its descriptive name (Thiessen, 1987). Iron is the fourth most common element in the earth's crust and varies in water according to lithology and water chemistry synergism (EPA 1986).

FIGURE 5: MEAN pH FOR CROOKED RIVER STUDY DURING 1986,1987

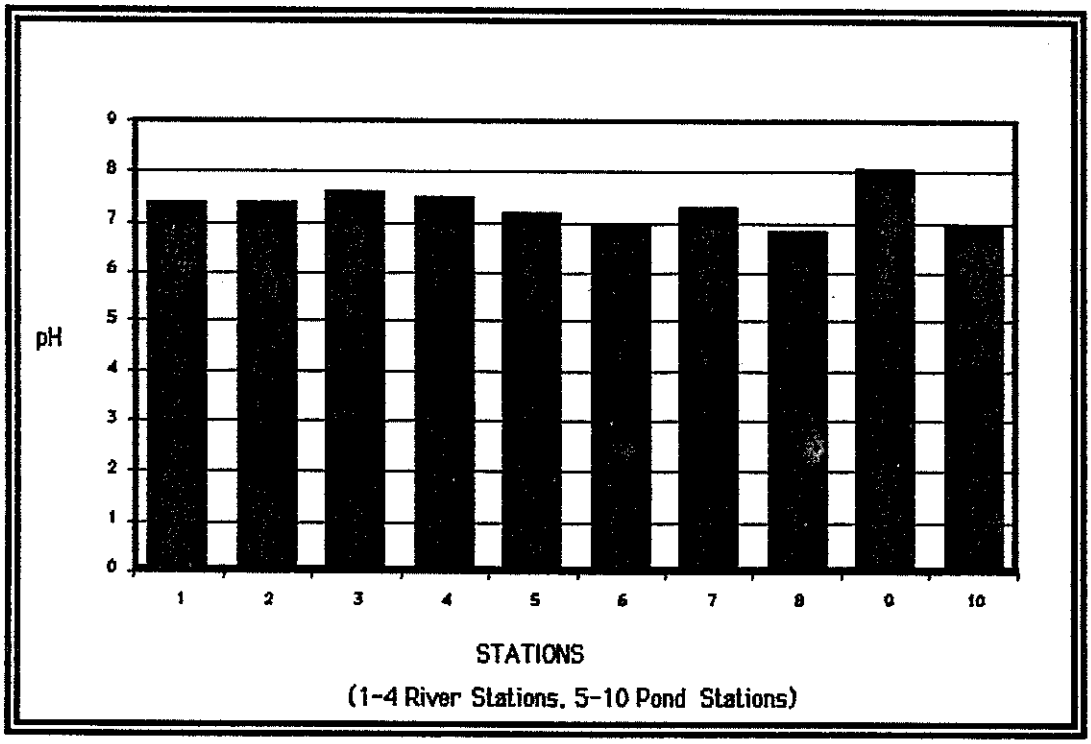


FIGURE 6: MEAN CONDUCTIVITY FOR CROOKED RIVER STUDY DURING 1986,1987

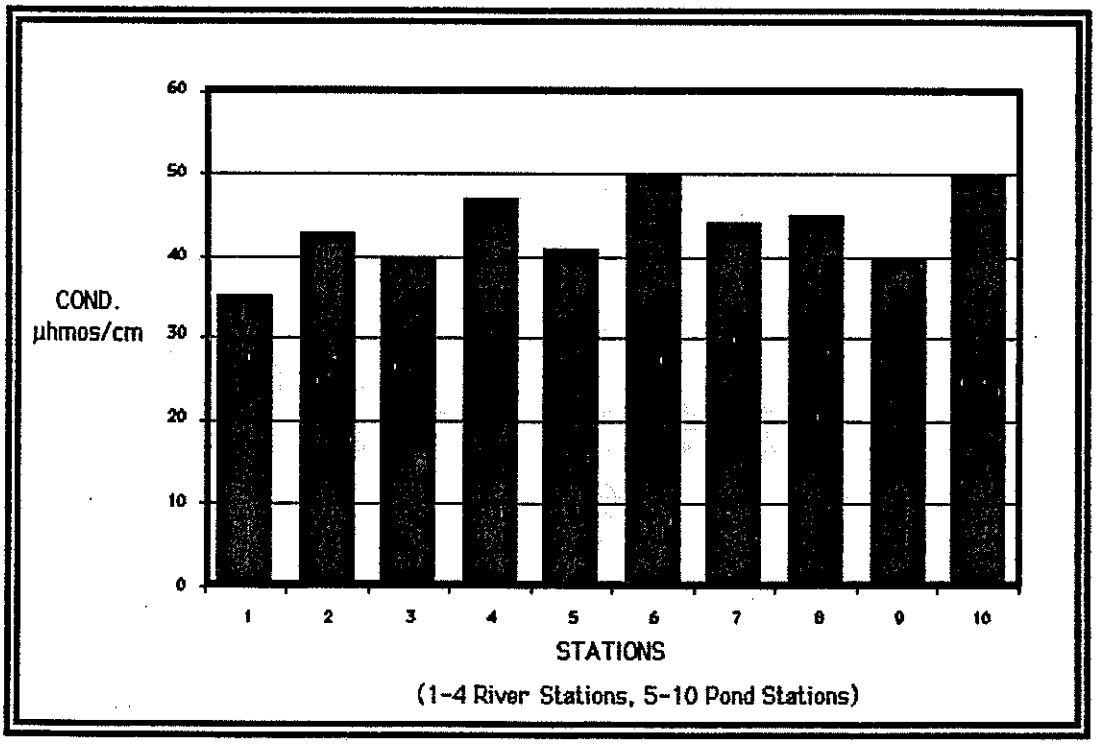


FIGURE 7: MEAN HARDNESS FOR CROOKED RIVER STUDY DURING 1986,1987

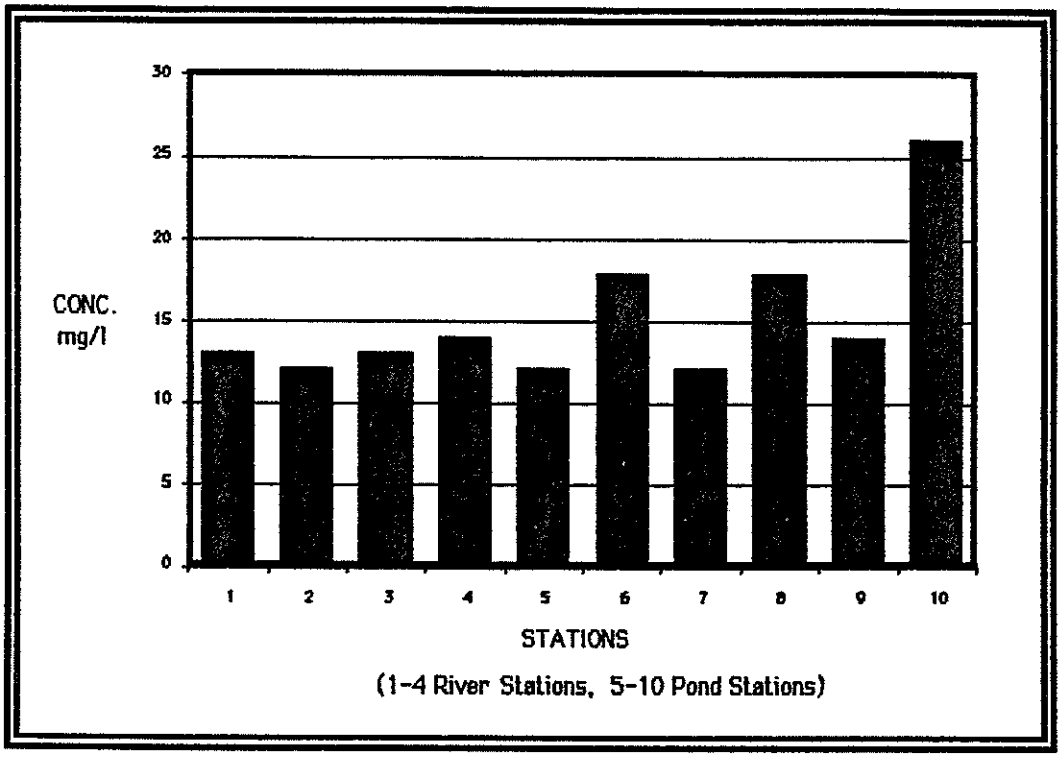
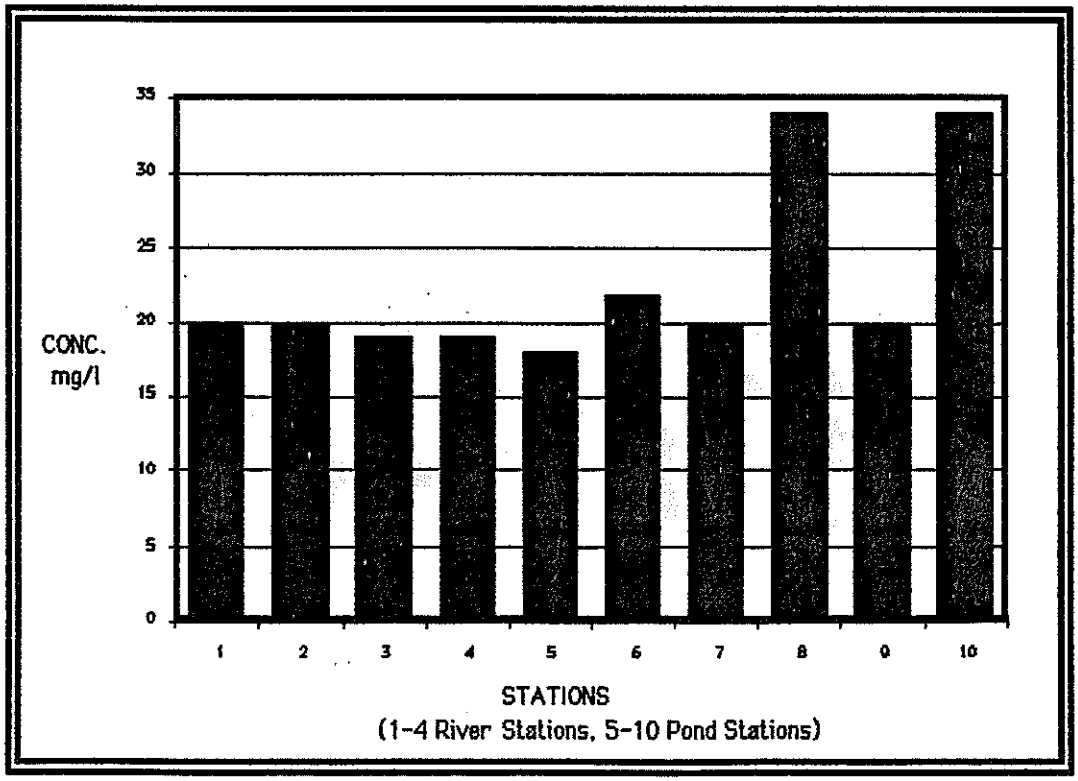


FIGURE 8: MEAN TOTAL ALKALINITY FOR CROOKED RIVER STUDY DURING 1986,1987



Iron's effect on aquatic macroinvertebrate is noted by Warnick and Bell (1969, as cited in EPA, 1976) who found 96-hour LC_{50} values of 0.32 mg/l iron for the mayflies, stoneflies, and caddisflies. Doudoroff and Katz (1953, as cited in EPA, 1976) found trout absent from a Colorado stream until iron concentrations were reduced to less than 1.0 mg/l. EPA (1976) recommends, based mainly on field observations, a criterion of 1.0 mg/l for freshwater aquatic life.

Thurston (1979), representing The American Fisheries Society (AFS), questioned the EPA 1.0 mg/l iron criteria for freshwater aquatic life as being too high. He recommended 0.30 mg/l or less as the total iron criteria due to the increased formation of iron floc (detrimental to fish embryo survival and spawning substrate quality) above 0.30 mg/l and the lethality for macroinvertebrates at 0.32 mg/l as cited in Warnick and Bell (1969).

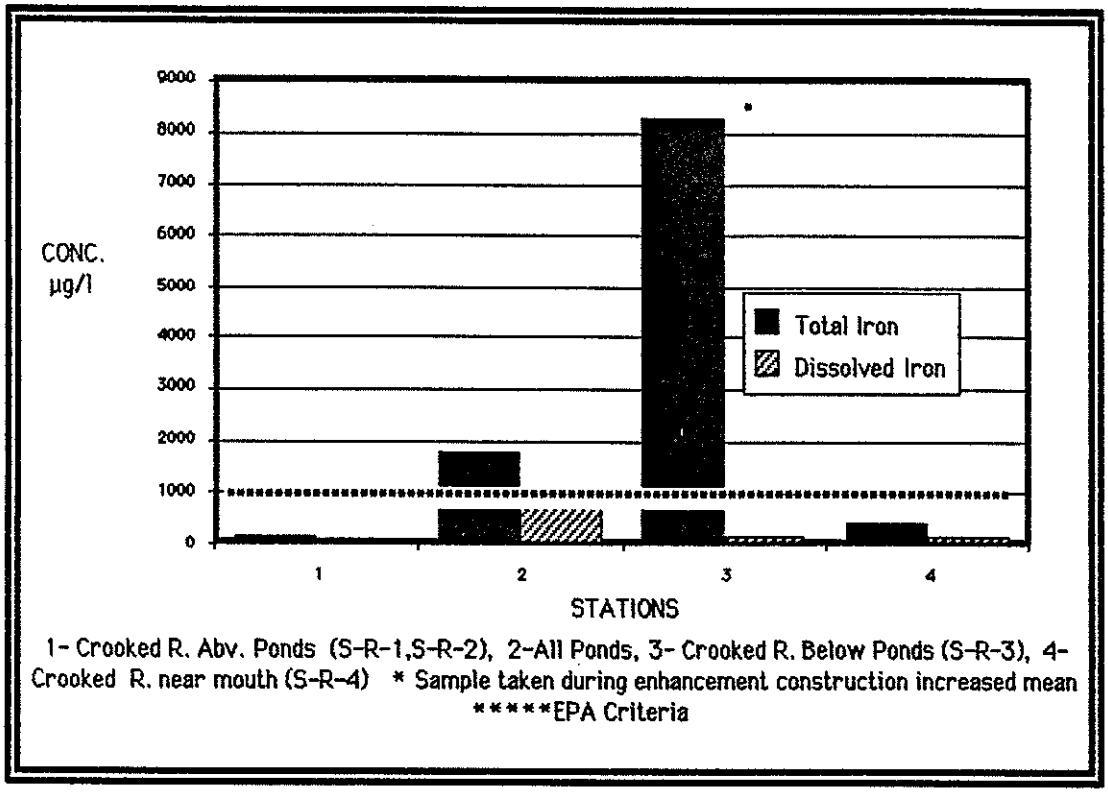
Stations (S-R-1, S-R-2), upstream of the project area, had the lowest measured levels of iron. Mean concentrations for the two stations were 0.150 mg/l total iron and 0.057 mg/l dissolved iron.

The pond series of stations had mean iron values of 1.78 mg/l total and 0.762 mg/l dissolved iron which exceeds both the EPA and AFS criteria (Figure 9).

A sample collected at S-R-3 on July 17, 1987, during the breach of the Pond C2 outlet, exceeded both criteria with a total iron concentration of 24.4 mg/l; but the paired dissolved iron sample had comparatively low concentration of 0.33 mg/l, only slightly exceeding AFS criteria. A sample collected two hours later downstream at S-R-4 had total and dissolved iron concentrations of 1.190 and 0.130 mg/l, respectively. When iron levels were sampled two months later at stations S-R-3 and S-R-4, iron concentrations had returned to background levels.

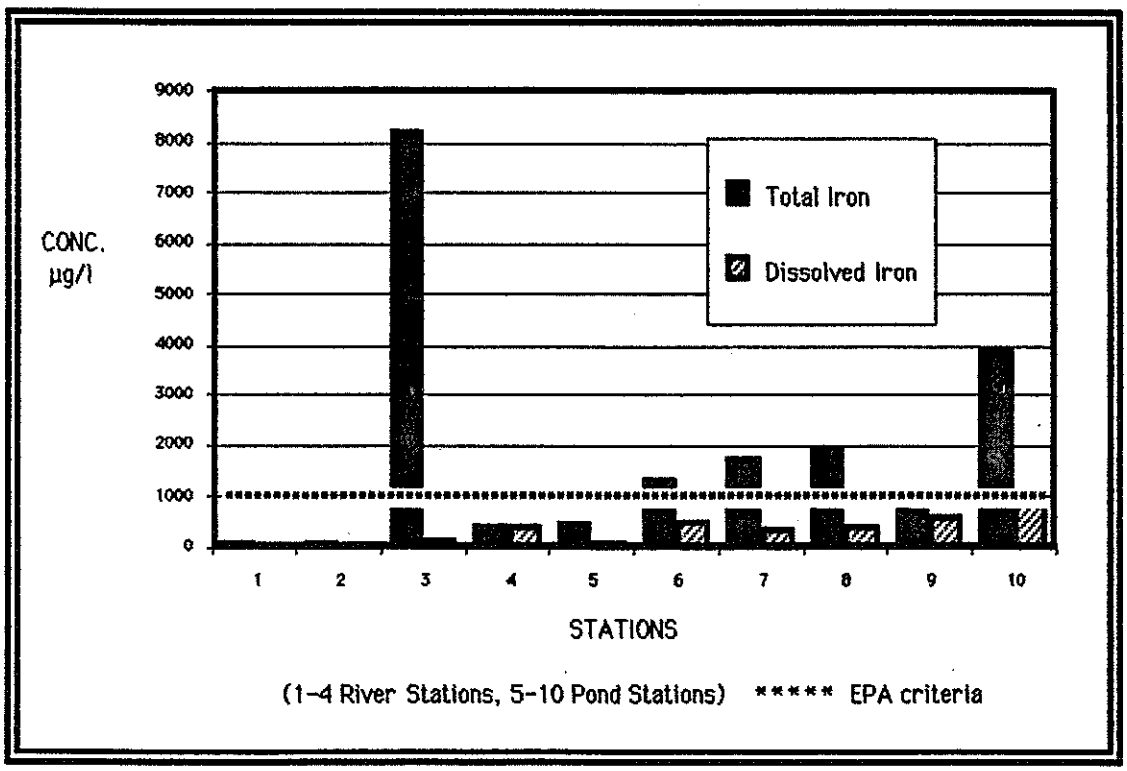
In this regard, dissolved metals are assumed to be the form most available for biological processes (Bauer, 1987). Although the data indicate that total iron levels sometimes exceeded criteria, the dissolved fraction did not and accordingly was not in a form that we would anticipate to adversely affect the biota of Crooked River. Figure 10 displays this total and dissolved iron relationship.

FIGURE 9: COMPARISON OF MEAN IRON CONCENTRATIONS AT GROUPED STATIONS FOR CROOKED RIVER STUDY DURING 1986, 1987



1- Crooked R. Abv. Ponds (S-R-1,S-R-2), 2-All Ponds, 3- Crooked R. Below Ponds (S-R-3), 4- Crooked R. near mouth (S-R-4) * Sample taken during enhancement construction increased mean
*****EPA Criteria

FIGURE 10: MEAN CONCENTRATIONS OF TOTAL AND DISSOLVED IRON FOR CROOKED RIVER STUDY DURING 1986,1987



(1-4 River Stations, 5-10 Pond Stations) ***** EPA criteria

The test program for the Crooked River enhancement project did not increase iron concentrations above background levels except for sample (S-R-3) taken during the construction phase of the project. No long term increases in iron concentrations were noted.

For those tributaries to the South Fork of the Clearwater that were sampled for comparison all metals tested were below detection limits, except for iron. These streams had total iron concentrations of 0.57 mg/l, 0.310 mg/l, 1.84 mg.l, and 0.16 mg/l for American River, Red River, Deadwood Creek, and Newsome Creek, respectively. Four sample sets collected by DOE in 1979 at both the American River and Red River stations had mean total iron concentrations of 0.323 mg/l and 0.378 mg./l respectively.

Three of the comparison streams and Crooked River had similar levels of total and dissolved iron (Figure 11).

The fourth stream, Deadwood Creek was the exception, exceeding the EPA criteria of 1.0 mg/l iron on September 3, 1987 with a value of 1.84 mg/l. Iron floc is present in the low gradient stream reaches of this system (Stowell, 1987). A DOE sample taken on October 24, 1984 during a major rain event had a total iron concentration of 11.5 mg/l. This suggests that stream flow events causing iron floc transport may temporarily elevate total iron concentrations, as was evident in Deadwood Creek.

BOTTOM SEDIMENTS

In the bottom sediments at the six pond sites sampled by Baldigo (1986) all metal concentrations were below the 95th percentile concentration level (EPA, 1985). The 95th percentile concentration relies upon the sediment-water equilibrum partitioning approach which in turn is based on toxicological data from EPA water quality criteria. The approach is dependent upon the assumption that chemicals in sediment are in continuous exchange among sediment, infauna, and water (EPA 1985). Mean total metal concentrations in Crooked River bottom sediments are shown in Table 3.

FIGURE 11: COMPARISON OF MEAN TOTAL AND DISSOLVED IRON CONCENTRATIONS FOR CROOKED RIVER AND OTHER STREAMS DURING 1986,1987

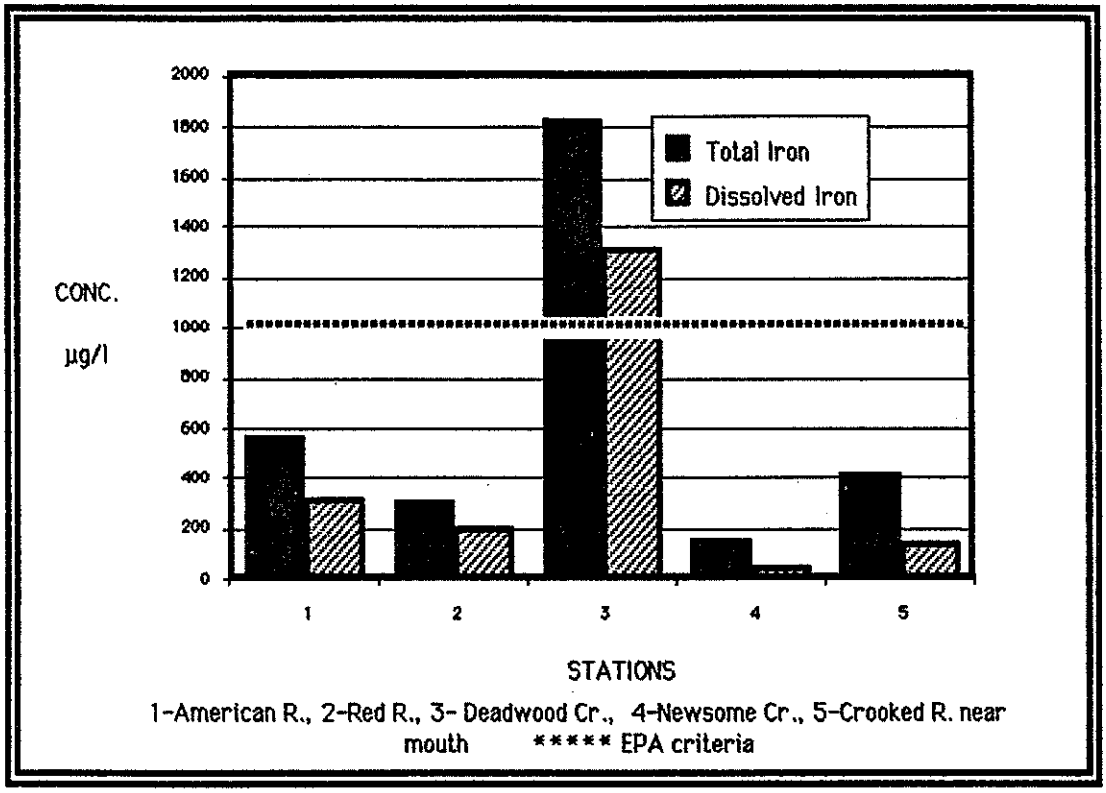


TABLE 3

Comparison of mean metal concentrations for sediments in dredged-mined ponds of Crooked River (Baldigo,1986) with EPA(1985) 95th Percentile Concentrations (mg/kg)

	Ar	Cd	Cu	Fe	Pb	Mn	Zn	Hg
95th:	39	12	32	-	199	-	379	1.0
Ponds: n=6	25	0.07	26	36260	11	950	45	0.6

GROUNDWATER

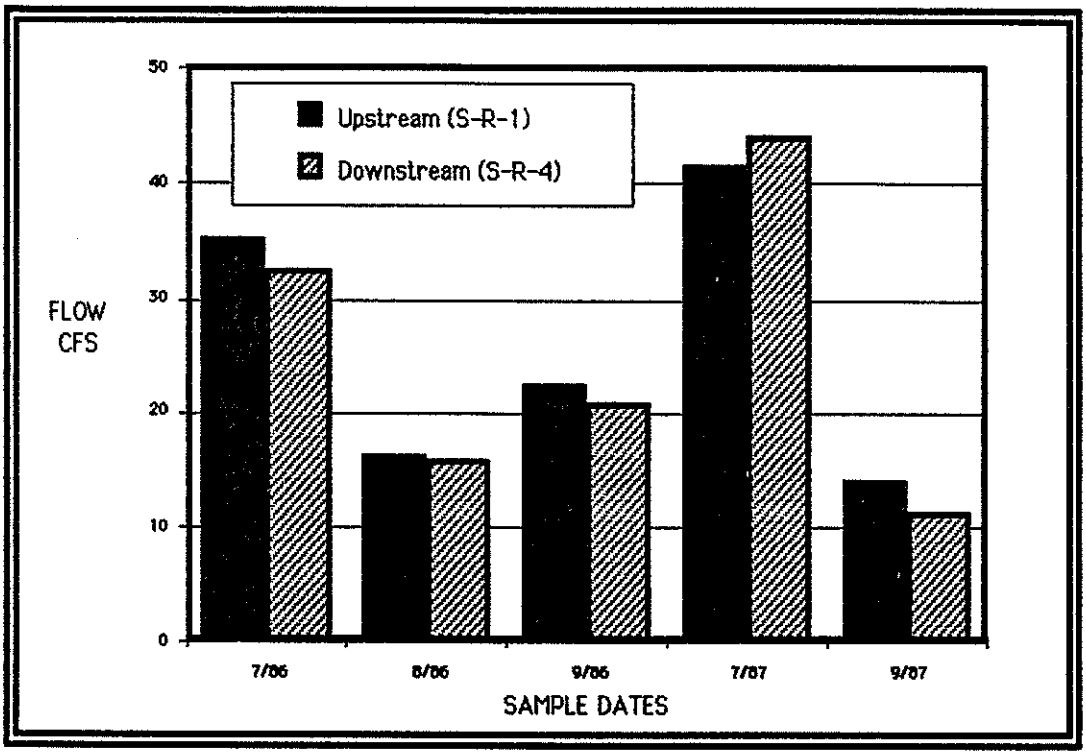
Groundwater from a 285 foot well, one hundred feet east of Station S-R-4, was found to have a total iron concentration of 0.60 mg/l . The well was drilled through an all granite formation (IDWR, 1986) which suggests the presence of an impermeable layer under the surface water. This 0.60 mg/l iron concentration (twice the 0.30 mg/l standard for Idaho Regulations for Public Drinking Water Systems) in conjunction with the iron levels in bottom sediments and surface water suggests that these iron concentrations are of natural geologic origin.

FLOW

Stream flow (discharge) had the typical regimen of a fourth order stream in the upper Clearwater River basin . The hydrograph usually peaks in May from a melting snowpack. Measured discharge for Crooked River during the study period ranged from 11.4 to 113.9 cubic feet per second (CFS).

Flows measured near the mouth of Crooked River (S-R-4) were consistently less than the flows measured 2.3 miles upstream at S-R-1 (Figure 12). The reduction of stream flow through the meandered study section indicates that stream volume is probably being lost to subsurface flow beneath and adjacent to the present channel. Several mechanisms for the loss of stream volume are possible. The disturbance of the channel bottom integrity by dredge mining and other activities may result in the loss of flow through the stream bed. Paradise (1987) observed this during the instream operation of heavy equipment while modifying the channel of Crooked River during fish habitat enhancement. Another is that dredge mining has increased meander length and resulted in an increase in wetted perimeter. Therefore infiltration through the stream banks increases.

FIGURE 12: COMPARISON OF STREAM FLOW AT UPSTREAM AND DOWNSTREAM STATIONS FOR CROOKED RIVER STUDY DURING 1986,1987



IN-SITU BIOASSAY

The response of steelhead trout and chinook salmon young-of-the-year (YOY) during the in-situ bioassay suggests that neither river or pond water is acutely toxic (Baldigo,1986). All chinook (YOY) survived for the duration of the 144 hour test at 4 river and 5 pond live box sites. The mean survival of steelhead (YOY) live box river sites was 96 percent. Steelhead (YOY) had 81 percent mean survival at pond sites excluding, due to experimental error, the sample from pond S-P-C1 (Table 4).

We noted that all chinook (YOY) survived while some steelhead (YOY) succumbed in the pond environment. Whether this difference in response between species is due to physiochemical or ecological influences is unclear. But apparently no acutely toxic responses were observed during this part of the study.

When inter-pond water circulation stabilizes from the the inlet of Crooked River through the dredge ponds, another series of live-box tests may provide some insight into the differences between chinook and steelhead survival.

QUALITY ASSURANCE

Quality assurance provided the means to evaluate data integrity in this water quality study. Iron, the metal of concern, was examined for sampling precision using duplicate sampling methods as described in Bauer (1986) and Bauer et al. (1986a). Precision is a measure of agreement among individual measurements of the property, under similar sampling conditions (Clark,1986). Precision was expressed in terms of percent relative range of sample means. Total and dissolved iron concentrations in duplicate samples were found to have a relative range of 3.2% (Appendix B) which is considered to be of acceptable sampling precision (Bauer,1986). Accuracy of samples was not determined in this study.

TABLE 4

Percent Salmonid Young-of-the-Year Surviving after 144 hours for
In-Situ(Live Box) Tests in Crooked River and Contiguous Dredge Ponds (after Baigido,1986)

STATION	River	River	River	River	Pond	Pond	Pond	Pond	Pond
	321	322	323 S-R-1	327 S-R-4	324	325	326 S-P-C1	328 S-P-D	329
% SURVIVAL Steelhead	92	100	100	92	83	67	33^	100	75
Chinook	100	100	100*	100	100	100	100	100	100

^Fish losses probably due to suffocation from experimenter's disturbance of bottom sediments
*Fish lost after 48 hours due to vandelism

CONCLUSIONS

The water quality of Crooked River was not significantly effected by the test fish habitat enhancement activities. Although the disturbance of dredge spoils and the release of dredge-pond water to Crooked River did temporarily elevate total iron concentrations above the EPA criteria.

The dredge ponds of Crooked River exceeded the EPA iron criteria but produced no acutely toxic effects on steelhead and chinook young-of-the-year during the bioassay by Baldigo (1986).

Bottom sediments sampled in the dredge-ponds of Crooked River were below 95th percentile concentrations established by EPA.

There is a reduction of stream flow (discharge) occurring below the meandered reach of Crooked River.

RECOMMENDATIONS

Although no acute toxic effects to fish populations were observed, the disturbance of dredge spoils and the release of pond water to Crooked River did release total iron concentrations that were temporarily above criteria limits. Activities of a greater magnitude and duration that disturb dredge mined areas may release concentrations of iron that could effect the fish population during the construction period.

-Therefore, activities need to be planned so that large volumes of dredge pond water are not rapidly introduced to Crooked River.

Activities that modify the stream channel and increase the wetted perimeter may compound the existing reduction in stream flow which was documented in the meandered section of Crooked River.

-Stream flow should be monitored continuosly during project construction to assure that the downstream reaches of Crooked River are not dewatered to a point affecting benefical uses.

In addition, the fish enhancement project plans should address the following concerns:

-Avoid construction during salmonid spawning periods.

-Identify for enhancement only dredge ponds of similar quality as those selected in the test study.

-Include customary precautions to reduce the sedimentation problems common to such activities.

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APPENDIX A: CROOKED RIVER STUDY WATER QUALITY DATA

LOCATION NAME	Nº	DATE	FLOW CFS	TEMP. °C	DO mg/l	pH SU	COND. µhmos C.25°C	HARD. mg/l	T. ALK. mg/l	T. FE µg/l	D.FE µg/l	T.ZN µg/l	D. ZN µg/l	T.CU µg/l	D.CU µg/l
CROOKED RIVER ABOVE MEANDERS	S-R-1	5/6/86	*500	3.8	11.1	7.2	-	4	13	400	90	2	2	<10	<10
		6/17/86	113.9	16.1	8	7.2	24	8	13	260	-	8	-	<10	-
		7/23/86	35.4	17.2	8.8	7.2	31	20	25	110	-	1	-	<10	-
		8/28/86	16.3	14.9	-	8.2	-	20	23	100	20	46	7	-	-
		9/24/86	22.4	8.2	-	7.2	-	12	19	80	10	4	5	<10	<10
		7/8/87	41.7	14.6	8.7	7.4	35	12	24	110	40	3	2	<10	<10
		9/2/87	14	17.0	8.3	7.6	48	16	21	50	10	<10	<10	<10	<10
		mean=	-	13.1	9	7.4	35	13	20	159	34				
CROOKED RIVER ABOVE PONDS	S-R-2	7/8/87	-	16.5	8.6	7.1	35	12	20	120	50	3	<2	<10	<10
		7/17/87	-	13.2	-	7.4	47	12	20	110	80	<2	<2	<10	<10
		9/2/87	-	17.0	9.7	7.8	48	12	21	190	110	<10	<10	<10	<10
		mean=		16	9.2	7.4	43	12	20	140	80				
DREDGE POND A	S-P-A	5/6/86	-	5.9	8.1	6.6	-	7	11	275	140	1	1	<10	<10
		7/8/87	-	22.0	8.6	7.4	38	12	20	290	180	7	2	<10	<10
		7/17/87	-	17.6	-	6.9	46	12	20	1320	210	<2	<2	<10	<10
		9/2/87	-	19.0	9.3	8	40	16	22	170	90	<10	<10	<10	<10
		mean=		16.1	8.7	7.2	41	12	18	514	155				

- DENOTES PARAMETER NOT MEASURED
* DENOTES ESTIMATE

T. = TOTAL
D. = DISSOLVED

C. = CORRECTED

LOCATION NAME	Nº	DATE	FLOW CFS	TEMP. °C	DO mg/l	pH SU	COND. µhmos C.25°C	HARD. mg/l	T. ALK. mg/l	T. FE µg/l	D.FE µg/l	T.ZN µg/l	D. ZN µg/l	T.CU µg/l	D.CU µg/l
DREDGE POND B1	S-P-B1	5/6/86	-	6.2	9.5	6.5	-	8	14	900	370	2	<1	<10	<10
		6/17/86	-	19.8	5.7	6.4	45	16	21	1020	-	8	5	<10	-
		7/23/86	-	21.2	10.6	7.2	55	20	26	1160	-	16	4	<10	-
		8/28/86	-	21.2	-	7.6	-	20	25	2420	810	1	6	-	-
		9/24/86	-	11.2	-	7.4	-	24	26	1300	530	44	10	<10	<10
		mean=		15.9	8.6	7.0	50	18	22	1360	570	14	6		
DREDGE POND B2	S-P-B2	7/8/87	-	22.6	7.5	7.1	38	12	20	1800	300	8	4	<10	,<10
		7/8/87	-	-	-	-	-	12	20	1810	290	10	2	<10	<10
		7/17/87	-	18.4	-	7	45	12	20	2590	470	<2	<2	<10	<10
		7/17/87	-	-	-	-	-	12	19	2600	510	<2	<2	<10	<10
		9/2/87	-	19.0	8.3	7.9	40	16	19	960	420	<10	<10	<10	<10
		9/2/87	-	-	-	-	-	8	20	920	430	<10	<10	<10	<10
		mean=		20.0	7.9	7.3	41	12	20	1780	403				
DREDGE POND C1	S-P-C1	5/6/86	-	6.5	8.2	6.5	-	12	17	760	390	<1	<1	<10	<10
		6/17/86	-	25.2	6.8	6.6	42	12	23	1690	-	12	-	<10	-
		7/23/86	-	23.2	6.7	6.9	47	20	73	3010	-	1	-	<10	-
		8/28/86	-	20.3	-	7.3	-	28	28	2260	580	4	3	-	-
		9/24/86	-	11.7	-	7.2	-	20	27	2220	380	39	4	-	-
		mean=		17.4	7.2	6.8	45	18	34	1988	450	14	3		

LOCATION NAME	Nº	DATE	FLOW CFS	TEMP. °C	DO mg/l	pH SU	COND. µhmos C.25°C	HARD. mg/l	T. ALK. mg/l	T. FE µg/l	D.FE µg/l	T.ZN µg/l	D. ZN µg/l	T.CU µg/l	D.CU µg/l
DREDGE POND C2	S-P-C2	7/8/87	-	23.6	-	8.2	35	12	18	900	590	<2	<2	<10	<10
		9/2/87	-	19.5	8.6	8	45	16	21	1310	760	<10	<10	<10	<10
		mean=		21.6	8.6	8.1	40	14	20	1105	675				
DREDGE POND D	S-P-D	6/17/86	-	27.6	6	6.7	41	18	23	3420	-	6	-	<10	-
		7/23/86	-	24.0	8.7	7.3	59	20	30	4695	-	6	-	<10	-
		8/28/86	-	23.1	-	7.2	-	46	42	3005	820	12	8	-	-
		9/24/86	-	12.8	-	6.9	-	20	40	4720	1215	44	6	-	-
		mean=		21.9	7.4	7.0	50	26	34	3960	1018	17	7		
CROOKED RIVER BELOW PONDS	S-R-3	7/8/87	-	18.0	8.7	7.2	35	12	18	190	90	4	2	<10	<10
		7/17/87	-	14.1	-	-	39	12	19	24400	330	29	<2	20	<10
		9/2/87	-	16.5	8.1	8	46	16	20	210	130	<10	<10	<10	<10
		mean=		16.2	8.4	7.6	40	13	19	8267	183				

LOCATION NAME	Nº	DATE	FLOW CFS	TEMP. °C	DO mg/l	pH SU	COND. µhmos C.25°C	HARD. mg/l	T. ALK. mg/l	T. FE µg/l	D.FE µg/l	T.ZN µg/l	D. ZN µg/l	T.CU µg/l	D.CU µg/l
CROOKED RIVER NEAR MOUTH	S-R-4	5/6/86	-	3.2	11.1	7.1	-	10	11	520	250	<1	<1	25	15
		6/17/86	-	17.1	8.1	7	24	10	12	215	-	6	<1	<10	-
		7/23/86	32.7	19.1	9.1	7.3	33	20	23	225	-	4	-	<10	-
		8/23/86	15.8	20.6	-	8.2	-	21	22	260	120	1	1	-	-
		9/24/86	20.8	9.8	-	7.6	-	14	20	540	125	26	5	<10	<10
		7/8/87	44.2	18.9	8.2	7.5	35	12	21	220	100	<2	<2	<10	<10
		7/17/87	*50	14.0	-	7.1	100	12	19	1190	130	<2	<2	<10	<10
		9/2/87	11.4	16.0	7.8	8	41	12	21	250	140	<10	<10	<10	<10
		mean=	25.0	14.8	8.9	7.5	47	14	19	428	144				
AMERICAN RIVER AT MOUTH	S-T-1	9/3/87	8.5	14.5	8.9	7.4	35	-	-	570	320	<10	<10	<10	<10
RED RIVER AT MOUTH	S-T-2	9/3/87	21.2	14.5	8.6	7.5	51	-	-	310	210	<10	<10	<10	<10

LOCATION NAME	Nº	DATE	FLOW CFS	TEMP. °C	DO mg/l	pH SU	COND. µhmos C.25°C	HARD. mg/l	T. ALK. mg/l	T. FE µg/l	D.FE µg/l	T.ZN µg/l	D. ZN µg/l	T.CU µg/l	D.CU µg/l
DEADWOOD CREEK AT MOUTH	S-T-3	9/3/87	0.4	14.0	8.7	7	51	-	-	1840	1320	<10	<10	<10	<10
NEWSOME CREEK AT MOUTH	S-T-4	9/3/87	12.3	15.0	8.2	7	37	-	-	160	50	<10	<10	<10	<10

Appendix B

Summary of Duplicate Samples for Total and Dissolved Iron at Crooked River Station S-P-B2 Collected for Estimate of Precision

Number	x1	x2	Mean	Range	Relative Range %
1	1800	1810	1805	10	0.55
2	2590	2600	2595	10	0.38
3	960	920	940	40	4.26
4	300	290	300	10	3.33
5	470	510	490	40	8.16
6	420	430	425	10	2.35
					Σ 19.03
n=6					mean 3.17