



IDAHO BLM

TECHNICAL BULLETIN

**A Management Analysis of BLM Lands
on the Lower Coeur d'Alene River**

Prepared for
Coeur d'Alene District
Bureau of Land Management

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BUREAU OF LAND MANAGEMENT
IDAHO STATE OFFICE
3380 Americana Terrace
Boise, Idaho 83706

**A MANAGEMENT ANALYSIS OF BLM LANDS
ON THE LOWER COEUR D'ALENE RIVER**

Prepared for:

**United States Department of the Interior
Bureau of Land Management
Coeur d'Alene District
Coeur d'Alene, Idaho**

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in association with:

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August 31, 1990

MANAGEMENT ANALYSIS of BLM LANDS
ON THE LOWER COEUR D'ALENE RIVER

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1.0 EXECUTIVE SUMMARY

Schafer and Associates and Roy F. Weston have completed a management analysis of the Lower Coeur d'Alene River (LCDAR) area for the Bureau of Land Management. This study is intended to provide guidance to BLM for future management of the area giving full consideration to the potential environmental and human health issues in the river and its lateral lakes caused by the presence of large quantities of mining wastes. These wastes were discharged directly into the South Fork of the Coeur d'Alene River eventually contaminating the LCDAR and Lake Coeur d'Alene as well.

The objectives of the study were several:

- Review the past and current management practices of BLM as well as other agencies in the area and assess the possible impact of these practices in light of the environmental problems,
- Review and summarize the numerous environmental studies which have been conducted in the area to identify the significant environmental and health risks and other issues that BLM must consider in its management plans,
- Evaluate current BLM capabilities to manage the area considering the special management requirements that may be necessary to address the issues. Identify physical and jurisdictional constraints that are imposed on BLM,
- Evaluate physical and administrative alternatives that are available to BLM to address the issues related to management of the area; and finally,
- Recommend actions which BLM should consider to improve its management of the resources in this area identifying the scope of such actions and the resources best qualified to carry them out.

The study included a Level 1 endangerment assessment which evaluated the impact of lead, zinc and cadmium on three principle receptor groups: fish, waterfowl and sportsmen, through the consumption of fish. The risks to casual recreational users through drinking water and airborne particulate exposure were not believed to be significant. This assessment concludes that although fish and waterfowl are chronically impacted showing elevated metal levels in their internal organs and to a much lesser extent in edible tissues. Sportsmen were not felt to be significantly at risk through the consumption of locally

obtained fish based on an analysis of gamefish consumption. Special note was made of direct soil ingestion by small children as a potential pathway for significant contaminant uptake. However, for occasional recreational users, this is likely to be an uncommon and non-recurring type of exposure.

Since wildfowl and fish in the LCDAR do not appear to be acutely affected and humans impacted only at a very low level, urgent measures to remediate existing problems do not appear to be justified. Habitat management programs in severely impacted areas are discouraged unless they are totally non-disruptive to the existing habitat. Given time, these areas will mend to a significant extent on their own if some level of vegetation can be established which. Development of wildlife habitat and fisheries in less severely impacted areas of the LCDAR appears to be a better way to improve the numbers and health of waterfowl and fish in the area. Public awareness programs including informational brochures and strategically located hazard warning signs are recommended as a means of assuring that recreational users understand the types of risk in the area and ways to reduce exposure, small though it may be.

BLM is constrained to a significant extent in habitat management by the location and size of its current properties as well as its lack of authority over rules regarding the taking of game. The Idaho Department of Fish and Game (IDFG) is much better suited for this because of the large blocks of wetlands it controls. BLM wildlife programs are probably best done in concert with the IDFG. BLM's recreational opportunities are substantial primarily because of the lands it controls around Killarney Lake. Additional development at Killarney Lake could be undertaken safely with proper precautions for the potential users. A program to investigate the development of camping areas at Killarney Lake is outlined. This program would identify specific health hazards if any, properly remedy such problems and concentrate camping activity a safe distance from the lake. Such measures may provide a better situation than an unmanaged approach where boaters are free to camp at beach areas which may have a higher level of contamination.

2.0 INTRODUCTION

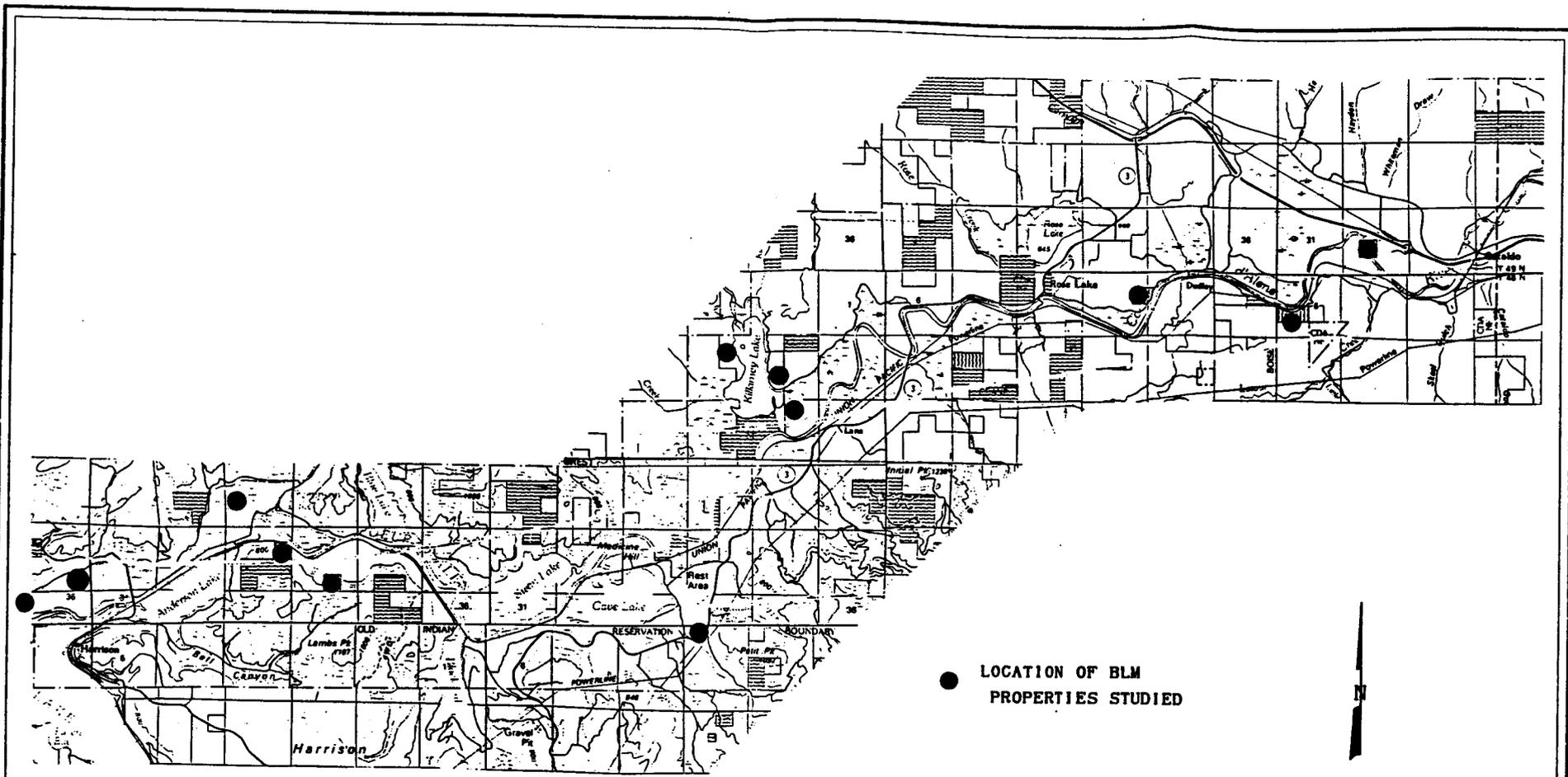
2.1 Background

Historic and on-going mining and milling of metals in the South Fork Coeur d'Alene River (SFCDAR) drainage has resulted in the transport of over 70 million tons of mine and mill waste into the Coeur d'Alene River and Lake system (Weston, 1989). While there has been a significant decrease in the amount of waste discharged directly into the SFCDAR since the 1970's, it is estimated that 7,300 to 27,000 pounds of waste per year are added to the SFCDAR by NPDES permitted-point and non-point sources. These mine wastes contain significant quantities of lead (Pb), cadmium (Cd), copper (Cu), zinc (Zn) and Mercury (Hg). According to the Idaho Department of Fish and Game, fluvial transport of the mine waste has impacted over 10,000 acres of wetlands on the mainstem Coeur d'Alene River between Pinehurst and Lake Coeur d'Alene. Average lead content of sediment throughout the area is estimated at 2,500 parts per million (ppm).

The Bunker Hill Superfund site, encompassing 21 square miles, was established by the EPA in late 1982 in response to evidence of adverse health affects to humans (primarily, elevated blood-lead levels in children) (Savage, 1986). The western boundary of the site is located near Pinehurst (see Figure 2.1 for a general location map), thus the riparian area impacted by fluvially transported contaminated sediment is outside the Superfund site boundaries.

Historic contaminant sources to the Lower Coeur d'Alene River Valley included direct discharge of acid mine water discharged from underground mines (until 1965), lead smelter and zinc plant wastes (until 1974), and central impoundment and gypsum pond water (until 1973) to the South Fork. On-going contaminant sources include central impoundment area seepage, accidental spills into tributaries due to equipment failure, surface runoff, and reworking of unconfined mine tailings into the river (Weston, 1989). Additionally, the National Pollutant Discharge Elimination System (NPDES) permit issued to Bunker Hill Mining Company in 1986 allows the discharge of 11,000 pounds of lead into the South Fork annually (Neufeld, 1987).

Tundra swan kills from lead poisoning were reported as early as 1924 (Krieger, 1989). Annual mortality of waterfowl from lead poisoning is documented with the last large scale deaths occurring in the spring of 1982 when 200 out of 1200 tundra swans died along with 12 Canadian geese. Episodic deaths of whistling swans have also been reported



● LOCATION OF BLM
PROPERTIES STUDIED

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LOWER COEUR D'ALENE RIVER
MANAGEMENT ANALYSIS

FIGURE 2.1 LOCATION MAP OF THE LOWER COEUR D'ALENE RIVER AREA

CLIENT: BUREAU OF LAND MANAGEMENT		LOCATION:	
SHEET OF	DRAWING NUMBER: BS100CP	REVISION NUMBER: 1	
DATE: JUN 21, 1989	SCALE: 1:100,000	DRAWN BY: SRJ	CHECKED BY:

(Krieger, 1989). Wildfowl lead poisoning deaths appear to be correlated with water levels and winter floods (Neufeld, 1987). Ingestion of contaminated sediment as grit and sediment-laden vegetation, especially Equisetum, appear to be the most important contributors to swan mortality (Neufeld, 1987).

Prior to the construction of settling ponds in 1968, sediment loads in the SFCDAR were too high for aquatic life to survive. Since that time, however, water quality has improved enough for re-establishment of some species of fish in the South Fork (Neufeld, 1987). Fish species in Lake Coeur d'Alene include yellow perch, cutthroat, and rainbow trout, Kokanee, large-mouth bass, and brown bullhead. A study by Hornig, et al. (1988) found elevated Cd levels in the liver and kidneys of several game fish species from Lake Coeur d'Alene, the mainstem CDAR and the South Fork, but found no significant accumulation of heavy metals in edible tissue. There are no records of fish kills in the recent past.

Threats to human health are not well understood at this time. Potential health risk is determined by both contaminant levels in soil, air, and water and also exposure pathways. The mainstem CDAR receives intensive recreational use by boaters, campers, fishermen, and waterfowl hunters. It appears that the primary potential pathways of exposure are through consumption of game birds and fish and by "pica uptake" of contaminated sediments by small children (Weston, 1989). Inhalation of contaminated dust and ingestion of surface water are considered less important (Weston, 1989).

The Bureau of Land Management (BLM) owns 1150 acres of land adjacent to the mainstem CDAR between Lake Coeur d'Alene and Pinehurst. It was determined that four parcels, the Killarney Lake area; Thompson Lake area; Cataldo area; and Dudley area, were impacted significantly by fluvial transport of contaminated sediments (Weston, 1989). The BLM conducted a Site Inspection (SI) of the lower CDAR and found a Hazard Ranking Score high enough to place the site (Killarney Lake) on the National Priorities List indicating a potential for an imminent threat to public health or the environment.

In response to the SI, the BLM contacted Schafer and Associates and Roy F. Weston to review and evaluate management plans, review and summarize health and environmental risks present in the Lower CDAR area, to present management alternative to minimize or reduce risk, and to present a preferred management alternative.

The Bureau of Land Management owns a number of tracts of land in the wetlands area and is concerned about the effect heavy metal contamination on human health and safety, and the environment key issues have been identified and are discussed below.

2.2 Statement of Objectives

The objectives of this report are to review the available information as it applies to BLM resources on the Lower Coeur d'Alene River and to focus this information on the salient issues. The report should be a guide to BLM in the formation of management policies for this area in the future. Such policies involve not only the management of currently owned lands, but also the possibility of increasing BLM's land holdings through direct acquisition or land exchanges.

2.3 Summary of Key Information Resources

Hundreds of papers and documents have been written on heavy metal contamination by mine wastes in the lower Coeur d'Alene River Valley. Studies have been conducted on a variety of topics including meteorology/air quality, geology, soils, groundwater, surface water, aquatic ecology, terrestrial biota, recreation, human health, mine wastes, and reclamation, rehabilitation and revegetation. Several key compendia and annotated bibliographies have also been assembled. Documents which were particularly useful for this report include the following:

- 1) Savage, N.L. (1986). A topical review of environmental studies in the Coeur d'Alene River-Lake system up to the date of issue. Idaho Water Resources Research Institute, Moscow, Idaho.

This report presents 239 references on past work pertaining to environmental impact of mining and other activities in the Coeur d'Alene River-Lake system. Ms. Savage summarizes studies that have been completed, studies in progress, and suggests studies that need to be done with respect to basic and applied research in the area. She describes the environmental problems that have been remedied and identifies problems that still exist.

- 2) Roy F. Weston, Inc. (1989). Final report - site investigation of the Thompson Lake, Killarney Lake, Dudley, and Cataldo areas along the main stem of the Coeur d'Alene River, Kootenai County, Idaho. Prepared for U.S. BLM. CERCLA No. D980497481.

This report presents findings of a site investigation at four sites on the main stem Coeur d'Alene River. Included in the report are discussions on potential pathways for contamination migration, potential exposure pathways, contaminant characteristics, and effects on human health and the environment.

- 3) Krieger, R.I. (1989). Draft report - toxicity and bioavailability studies of lead and other elementals in the lower Coeur d'Alene River. Prepared for U.S. BLM, BLM I.D. 060-09-4760-10-2691.

Dr. Krieger's report summarizes studies conducted on waterfowl deaths and illnesses, lead and other elementals in the environment, lead and animals, and discusses mitigating hazards of sedimentary lead and areas for additional study.

- 4) Neufeld, J. (1987). A summary of heavy metal contamination in the lower Coeur d'Alene River Valley with particular reference to the Coeur d'Alene River wildlife management area.

Mr. Neufeld's report summarizes studies and observations on the impact of heavy metal contamination by mine wastes on waterfowl and small animals in the lower Coeur d'Alene River Valley.

3.0 REVIEW OF AREA LAND MANAGEMENT POLICIES

The lower Coeur d'Alene River watershed, including Lake Coeur d'Alene, is comprised of lands and waterways which are managed by several local, state and federal agencies with various management objectives. Lands immediately adjacent to Lake Coeur d'Alene and the Main Stem of the Coeur d'Alene River downstream of Cataldo are managed primarily to provide hunting and water-based recreational activities for the public. The following is a summary of past and current management practices and objectives of the various agencies involved in the oversight of lands along the lower Coeur d'Alene watershed. The first part of the summary will address previous, current and future management practices and plans of the BLM. The second part will address the management plans and objectives of other agencies involved in the oversight of land and resources in the lower Coeur d'Alene River watershed.

3.1 Bureau of Land Management Lands

The BLM owns and manages several scattered tracts of land totaling approximately 1150 acres along the Lower Coeur d'Alene River including submerged lands. In the recent past BLM has managed its land holdings in the Lower Coeur d'Alene river basin primarily for public recreational use including, fishing, hunting, boating and camping. BLM has constructed and maintained boat ramps, picnic areas and firepits at several locations to meet the recreational desires of the public.

A 1983 study by the Idaho Department of Parks and Recreation (Statewide Comprehensive Outdoor Recreation Plan, SCORP) indicates that recreational use of the Lower Coeur d'Alene is increasing and public support appears to be behind the further development of recreational facilities and opportunities in the area. BLM has also begun to keep statistical records on recreational use of its managed areas to provide information for management decisions.

The Emerald Empire and Chief Joseph Management Framework Plan (BLM, 1981) is the basic planning document used by BLM for administrative guidance. This document did not address the issue of management of areas with environmental and health hazards. The MFP was inadequate in other areas as well. In particular it did not provide a basis for evaluating public lands for retention, sale or exchange in order to better serve the

national interest. In 1989 the MFP was amended by the Land Tenure Adjustment Plan Amendment for the Emerald Empire and Chief Joseph Management Framework Plans. This document provided a basis for making adjustments to BLM land holdings which would enhance its capability in providing resources for the public benefit. This document raised the question of hazard management as an issue in the planning process in its discussion of the Killarney Lake Management area.

Toward the goal of satisfying public desires for additional recreational opportunities, the BLM completed a Pre-Plan Analysis of the Lower Coeur d'Alene River Recreational Area Management Plan (PPA). This plan examines possible additional management actions and changes to the current Emerald Empire and Chief Joseph Management Framework Plan and future land management decisions. The PPA addresses several concerns and management issues. Improvement and continued maintenance of access facilities, particularly boat ramps located at Killarney Lake, are of concern to BLM. The Killarney Lake boat ramp is heavily used for camping, although no camping facilities are present, indicating a possible need for camping facilities in the area. Addition of toilet facilities and the development of drinking water are also desirable. Handicapped access at the other BLM lands around Killarney Lake is also needed.

As a way satisfying the increasing demand for recreational use of the area BLM is considering the acquisition of additional lands in the area. Specific parcels have not been identified. This has merely been suggested as an available management option which BLM has used successfully in the past. The decision to procure additional lands will obviously be driven by factors such as location, use potential, accessibility and availability of a given tract of land.

Recent management actions by BLM include the restriction of camping to a 14 consecutive day maximum stay, in part to reduce the amount of exposure to potentially dangerous levels of heavy metals. BLM is also considering improvements at the Killarney Lake boat launch. Minimum criteria are required to meet the requirements of a fee collection area and BLM is considering the conversion to a fee area in the future. The potential revenue gained from fees may help to offset some of the costs of maintenance and additional manpower required to enforce the 14 day camp stay maximum.

3.2 Other Agency Management Practices

3.2.1 Idaho Department of Fish and Game

The Idaho Department of Fish and Game (IDFG) is one of the agencies most heavily involved with the management of the lower Coeur d'Alene watershed resource. The IDFG 5 Year Work Plan (July 1, 1986 through June 30, 1990) for the Coeur d'Alene River Wildlife Management Area (CDAR-WMA) outlines the IDFG management goals.

A primary management objective of the IDFG is to provide adequate access and recreational opportunities to the public in the form of waterfowl hunting and fishing through the increased production of waterfowl. Measures taken by the IDFG towards reaching this goal include maintenance of dikes and water control structures and protection of fields adjacent to marshlands to provide habitat and breeding grounds for the waterfowl. The construction and maintenance of roosting islands and structures, planting of wild rice and other cereal grains and population monitoring of disease, poisoning and production have also been implemented to achieve management goals. A target goal is to produce 175 Canada geese, 5,000 mallards, 1,000 wood ducks and 750 other ducks annually by 1990 and to allow for 10,000 waterfowl hunter days, 2,500 hunter visits for big game and upland bird and 25,000 public fishing visits through June of 1990.

Managing the resource to maintain the present levels of fishing and big game hunting is another priority of the IDFG. IDFG intends to improve and maintain the access areas and continue the monitoring and evaluation of fish and game harvests. Additional related management objectives include the maintenance of 2 hiking trails, erection of 20 osprey nesting platforms and maintenance of 150 bluebird boxes.

3.2.2 United States Forest Service

Most of the United States Forest Service (USFS) lands in the lower Coeur d'Alene River watershed are located in upland areas within the borders of the Coeur d'Alene National Forest. However, the USFS does own and manage approximately 1500 acres of land adjacent to the lower reaches of the Coeur d'Alene River, including the Rainy Hill rest/picnic area located east of Cave Lake. These lands are managed in cooperation with IDFG for the enhancement of wildlife and recreational opportunities. The USFS primary management goals for the upland areas in the Coeur d'Alene watershed as stated in the Idaho Panhandle National Forests Forest Plan (August, 1987), include timber management, wildlife management, recreation and visual resource preservation.

The Rainy Hill area consists of two boat launch areas, one on Medicine Lake and one on the Coeur d'Alene River, and three toilets. Two of these toilets were installed in 1989. The area is used informally for overnight camping much like BLM's Killarney Lake areas are. On the Medicine Lake side the camping activities and use of shoreline for beaching boats has caused considerable erosion. USFS plans to expand the Rainy Hill site at Medicine Lake in 1993 to provide a more structured overnight camping environment and to construct an erosion control wall at the water's edge (Dorrell, personal communication). The wall will consist of driven timber piling and will provide for tying up boats. The issue of heavy metal contamination is being considered although no specific testing has been done to quantify the problem in this particular area. The Corps of Engineers has specifically prohibited any excavation of soils on the beach area and this is the reason that piles will be driven. The project is driven not so much by a desire to

expand activities but by a need to control the disturbances to the area that are resulting from unmanaged recreational activity.

USFS in conjunction with IDFG is also planning facilities at Blue Lake which will consist of a boat dock and parking area for overnight camping in recreational vehicles with pedestrian access to the boat dock area.

3.2.3 Idaho Department of Lands

Lands in the Lower Coeur d'Alene River watershed also fall under the auspices of the State of Idaho Department of Lands (IDL). The stated purpose of IDL is to regulate and control the use and disposition of all state-owned lake beds, so as to provide for their commercial, navigational, recreational and other public use and that the public health, interest, safety and welfare be served in the rendering of any decisions.

The State of Idaho Department of Lands (IDL) owns and regulates all river and lake beds below the natural high water mark and the water and airspace overlying all navigable rivers and lakes in the state. The primary role of the IDL is to oversee the state Lake Protection Act of 1974. IDL regulates encroachment permits for such activities as dock, dike or jetty construction and erosion control measures. The board also expressly reserves the right, through the director, to seek injunctive relief under section 58-149, Idaho Code and mitigation of damages under Section 58-150 Idaho Code.

3.2.4 Kootenai County

The Kootenai County Commission last year passed a law prohibiting water skiing in the Lower Coeur d'Alene River above the second bridge from its mouth at Lake Coeur d'Alene, a distance upstream of approximately two miles (Bruce, personal communication). No wake zones were also established. The primary purpose of these laws was to prevent bank erosion, which could possibly contribute heavy metal-contaminated soils and/or mine waste to the river.

The county has a number of other broad jurisdictional responsibilities as well which it enforces through various ordinances (Cobb, personal communication). There is no shoreline ordinance as such which would govern use of river and lake fronts. Most land along the river is zoned agricultural which does permit a fairly broad range of use. The county has adopted a Floodplain Management Ordinance which requires permits for dredging, fill, regrading or the erection of structures in floodplain areas. The 1988 Uniform Building Code Ordinance has been adopted which would apply to general building construction activities. The county also feels that provisions of the Clean Lakes Act will eventually require ordinances to be adopted to put the county in compliance.

The Kootenai County Waterways Advisory Board makes recommendations for boating facilities provided and maintained by Kootenai County. The Board also has responsibility for boating safety. The County Sheriff has a Marine Division for enforcement of public laws on waterways. This group does have authority for Killarney Lake where BLM has an especially prominent position. According to county officials, there are both informal and formal agreements between the County and BLM for maintenance of certain BLM facilities such as toilets and boat docks.

3.2.5 Save Our River Environment (SORE)

SORE is a private interest group which has been organized to press for action to prevent streambank erosion on the LCDAR (Bruce, personal communication). They are currently active lobbying the state government for a program to stabilize streambanks in the area. County officials have indicated that the group has independently attempted small scale stabilization measures involving riprap, tree planting and sodding.

3.3 Interagency Actions

The involvement of several private, local, state and federal agencies in the management of the lower Coeur d'Alene watershed requires that the agencies work together and that the interests and management plans of a particular group or agency be in concert with those of other agencies. A cooperative relationship has developed among the various agencies operating within the area. This relationship stems from what appear to be common management goals to enhance the existing natural resources of the area to accommodate pressures from increasing public use. The construction of wildfowl nesting areas by the Idaho Department of Fish and Game (with approval of the Army Corps of Engineers) on BLM and Forest Service lands near Killarney Lake is an example of such joint actions. A cooperative agreement to implement this wetlands Habitat Management Plan (HMP) on BLM lands was negotiated between BLM and IDFG under the authority of the Sikes Act (BLM, 1983). It should be noted that this particular joint action was not a highly successful one. The potential for environmental hazards were essentially ignored, the number of authorized nesting sites was exceeded and the Corps of Engineers rescinded its authorization for similar programs in other areas.

To promote a cooperative approach to area management with particular emphasis on the environmental problems in the Lower Coeur d'Alene River, the Coeur d'Alene Basin Interagency Group was formed in 1988. Participants in the group consist of agency administrators, researchers and local government officials. In August 1989, three subcommittees were set up to address separate components of a basin-wide management plan. These components and the respective committee chairmen are:

- 1) Lake Coeur d'Alene: Dr. Paul Woods, USGS
- 2) Coeur d'Alene River: Dr. Fred Rabe, U of I
- 3) Lateral Lakes: Dr. Val Chamberlain, U of I

Just recently, an Interagency Coordinator, Mr. Ed Javorka, was selected to coordinate the efforts and interests of each agency towards the development of a master Management Plan for the lower Coeur d'Alene watershed. Mr. Javorka operates under the auspices of the Panhandle Health District.

The selection of an Interagency Coordinator and the movement towards additional studies aimed at defining the degree and extent of mine waste contamination should foster interagency cooperation and, used in conjunction with the results of research, enable the formulation of an integrated, basin-wide management plan that will promote recreational activity while minimizing potential risks to human health.

The Soil Conservation Service, acting through the Interagency Group, has submitted a proposal for funding of a study of the Lower Coeur d'Alene River (Post). The study proposed is broad-based looking at a variety of impacts including streambank erosion, logging impacts, and other resource use impacts. An important part of the study is a better characterization of the mining waste impacts.

4.0 ENVIRONMENTAL HAZARDS AND ENDANGERMENT ASSESSMENT

4.1 Scope

A Level 1 Endangerment Assessment has been conducted using the guidance provided in The Endangerment Assessment Handbook (EPA, 1985). The endangerment assessment process evaluates the collective demographic, geographic, physical, chemical and biological factors at a site to determine whether there is a significant risk to public health or welfare or the environment as a result of a threatened or actual release of a hazardous substance or waste. EPA policy requires an endangerment assessment be conducted to support all administrative and judicial enforcement actions under CERCLA and RCRA. The objectives of this specific endangerment assessment include providing BLM with the necessary information to introduce human health and environmental risk as factors in future natural resource management decisions within the Coeur d'Alene Wildlife Management Area. To meet this important objective the following key issues were identified:

- Contaminants of concern in all relevant media
- Environmental fate and transport mechanisms of contaminants
- Exposure pathways and extent of exposure
- Populations at risk
- Contaminant toxicological properties, and
- Characterization of risk.

Key contaminants and critical receptors in the Lower Coeur d'Alene System (CDA) were examined and evaluated with respect to transport mechanisms and exposure routes. The complexity of the Lower CDA ecosystem required that the list of contaminants and critical receptors be narrowed to permit a sufficiently in depth analysis of those considered most important. Based on this approach the contaminants of concern include lead, zinc, and cadmium. The critical receptors that have been identified include recreational users,

game fish, and wildfowl. These contaminants of concern and critical receptors were selected based on several factors. These factors include existing data and studies, contaminant toxicity and occurrence, likelihood of impacting BLM future/present natural resource management decisions, and receptor vulnerability.

4.2 Contaminants of Concern

For the purposes of this report, lead, zinc, and cadmium have been selected as the contaminants of concern. A site investigation conducted in the Lower CDA (WESTON, 1989) lists mean and maximum sediment concentrations for these three metals from four different areas. The mean zinc concentrations ranged from 1075 to 3375 mg/kg, lead was 2918 to 6272 mg/kg, and cadmium 8.5 to 32 mg/kg. Surface water concentrations of these contaminants have not been as completely characterized, and this is an important data gap, with particular respect to the Lower CDA and lateral lakes. However, the concentrations of heavy metals remain above EPA drinking water standards, and acute and chronic freshwater toxicity standards at some stations along the South Fork (Woodward-Clyde et.al., 1986).

4.2.1 Lead

Lead is a Group IV metal that is intermediate between hard and soft acids in its interactions with ligands and has more than one stable oxidation state. Group IV elements are capable of forming organoderivatives which are economically very important and constitute an important environmental source of lead. Organometallic species are often more toxic than inorganic species of the same metal.

Background concentrations of lead in surface waters are discussed by Kelly (1988). A summary of this discussion is presented here. Background concentrations of lead include 0.000006 to 0.000050 mg/l measured in remote streams in the USA (Settle and Patterson, 1980). However these concentrations are two orders of magnitude lower than the minimum concentrations reported for unmineralized streams in North Wales (Elderfield et al., 1971), and three orders of magnitude lower than background concentrations in rivers in the New Lead Belt in Missouri, prior to mining (0.004-0.006 mg/l, Wixson, 1972). Concentrations greater than 1 mg/l are rare, although, based on equilibrium calculations, they are theoretically possible.

Lead is most stable under normal, oxidizing, conditions in its lower oxidation state lead (II). Below pH 7.1 it is present mainly as the free ion and above this as the carbonate and hydroxide (Vuceta and Morgan, 1978). At pH 7.5 the carbonate is assumed to act as the major controlling solid (Jorgensen and Jensen, 1984): the hydroxide is insoluble only above pH 10.0 (Moore and Ramamoorthy, 1984). At acid pH values the sulfate may control solubility (Laxen and Harrison, 1983). As with other metals, adsorption

plays an important role in controlling concentrations in solution.

Transport of lead in the atmosphere depends on particle size, chemical form, and distribution and height of release. Larger particles are rapidly deposited, while smaller particles may be widely dispersed and deposited on soil. Runoff and erosion introduce lead into surface waters as suspended solids, resulting in increased sediment concentration (Penwak et. al., 1981).

Lead can bioconcentrate in aquatic organisms up to two to four orders of magnitude above water concentrations and bioconcentration factors of 200 for freshwater plants and invertebrates, and 60 for freshwater fish have been reported (Chapman et.al., 1968). There is little evidence to suggest that lead bioaccumulates in aquatic food chains (Penwak et. al., 1981). Studies conducted by Lu et. al., (1975) of ecosystems containing microorganisms, algae, snails, mosquito larvae, and fish show the lead was concentrated most by mosquito larvae and least by fish. Lu's research is supported by a study conducted in the CDA basin (Funk et.al., 1975) that reported higher concentrations of lead in algae and other vegetation than in higher trophic levels.

Lead transported to soil is strongly absorbed, and under most environmental conditions is not subject to leaching. However, lead transport through soil erosion or fluvial processes is common. Lead uptake by plants can occur, although only a small portion of the total lead in soils is readily available for plant uptake. Bioconcentration factors in plants are generally less than 1, although root content may be slightly higher (Penwak et.al., 1981). It is speculated that lead-bearing sediments can coat various plant species, particularly during flood events. Typically plants with rough surfaces upon which sediment can accumulate are most affected. This phenomena has been hypothesized as a contributing factor in migrating wildfowl deaths in the CDA Basin (Neufeld, 1987).

4.2.2 Zinc

Zinc has only one stable oxidation state zinc (II). It is quite soluble relative to other metals. In the pH range of most natural waters the free ion is the predominate form. The atmospheric fate of zinc has not been extensively studied, although it is known that high temperature process emissions have a long residence time in the atmosphere (EPA, 1984). Most of the zinc introduced into the aquatic environment is partitioned into the sediments by sorption onto hydrous iron and manganese oxides, clay minerals, and organic materials, with a small percentage of zinc present as soluble zinc compounds. Zinc complexes with inorganic and organic ligands may increase mobility in aquatic environments, but these complexes have a tendency to adsorb strongly onto sediments (EPA, 1979).

Zinc is an essential nutrient and is bioaccumulated by all organisms from both food

and water. However, higher concentrations of zinc are extremely toxic to fish and other aquatic organisms, EPA (1987) feels that high zinc and cadmium concentrations are the major limiting factors for continuing restoration of aquatic biota in the CDA River. The chemical form in which zinc occurs has a significant effect on its availability for bioaccumulation. It appears from limited data that biota are a relatively minor sink when compared to sediments (EPA, 1979).

4.2.3 Cadmium

The atmospheric fate of cadmium has not been studied comprehensively, but it is removed from the atmosphere primarily by wet and dry deposition. Its atmospheric half life is dependent on particle size and density (EPA, 1984). Like zinc, cadmium is relatively mobile in the aquatic environment. Sorption processes onto clays or organic matter and subsequent sedimentation are the dominant removal processes, with increasing effectiveness as pH increases (EPA, 1979). Cadmium is strongly accumulated through both food and water by freshwater organisms. Bioconcentration factors for cadmium in freshwater invertebrates are as high as 1,190, and up to 2,213 for fish. In fish, most cadmium accumulates in the non-edible portions (with respect to humans), and particularly the kidney (EPA, 1979). The potential for cadmium biomagnification up the food chain is small (Kinkade and Erdman, 1975).

4.3 Transport of Metals in the Freshwater Environment

Fluvial transport and deposition of contaminants is assumed to be the dominant process with respect to BLMs natural resource management concerns in the Lower CDA basin. The air route is not thought to be significant because the contaminants are non volatile and tailings have been transported and deposited through fluvial processes. The size fraction of the majority of this material is thought to be large enough to preclude it being suspended in the air. It is difficult to make firm conclusions about the behavior of heavy metals in the aquatic environment. The following discussion is taken from a literature review by Kelly (1988). Much of the dissolved metal which enters rivers is going to be sorbed onto particulates, or under certain conditions (high alkalinity or pH), precipitate out (Kelly, 1988). Along with this much metal rich dust, smelter particulates, tailings pond and effluents may undergo little or no change after entering a river. The average residence times of these particles in rivers is typically of the order of days or weeks, and is too short for the establishment of stable, dynamic equilibria between the water and suspended material (Bowen, 1975). The same may not be true for lakes which are in contact with metal rich sediments.

Once the metal is associated with the solid phase then it can be transported for great distances so long as the critical velocity of the river is high enough to keep it in suspension. As the flow regime of the river changes so the concentration of suspended

metal will also fluctuate. Metal concentrations in suspended material were lowest during periods of high flows as a result of dilution by rainfall and runoff in a study conducted by Bradley and Lewin, 1982). As discharge declines, sorption and co-precipitation by manganese and iron complexes act as metal sinks. As the flow of a river changes, settling or resuspension of particulate material may occur. Thus the sediments may contain higher concentrations of heavy metals at points where the flow is particularly low. The sediments and benthos may also act as metal sinks.

Major changes in flow occur when rivers enter lakes (Kelly, 1988). The decrease in velocity may result in deposition of the suspended material. In most cases the metal concentrations in bottom sediments decreases away from river deltas. This situation is complicated by voluminous sediment transport during periodic flooding.

For both rivers and lakes the nature of the sediments is an important factor controlling their incorporation of metals. Adsorption and precipitation are functions of the surface area and the capacities of sediments for these processes will increase as the organic content increases and the particle size decreases (McDuffie et.al., 1977 and others).

Superimposed on the physical and chemical processes, however, is the influence of the biota. In lakes, the biological cycle is confined mostly to the upper water (euphotic zone) (Kelly, 1988). Phytoplankton and other particulates take up trace metals (Baccini et.al., 1978). When they die the metals, both in dissolved and particulate forms, are released by bacterial decomposition (Jackson, 1978). A study by Welsh and Denny (1979) suggested that certain phytoplankters which over winter on bottom mud may take up lead and carry it with them when they rise to the upper water column in the spring. The lead may subsequently return to the sediments when the plankton bloom "crashes". Similarly, zinc and cadmium may be transported by zooplankton during daily migrations from the sediments to the water column making these metals available to the rest of the biota (Van Duyn-Henderson and Lasenby, 1986).

In shallow or non-stratified lakes and fluvial systems, metals may be transported close enough to the sediments for direct adsorption to occur. In shallow rivers and lakes a benthic reservoir, composed of either algae or macrophytes, may also be important.

In shallower parts of lakes and rivers, pathways from the sediments back to water include uptake by macrophyte roots and along food chains from sediment-dwelling invertebrates, which often ingest large amounts of mineral matter.

4.4 Uptake and Accumulation of Heavy Metals

Accumulation of heavy metals by aquatic organisms provides an essential link between the concentrations of metals in the environment and the effect that these have

on the biota. There is a particular interest in biomagnification process, when heavy metals are passed through food chains which may end with man (Kelly, 1988). However, zinc for example is an essential micronutrient to plants and animals and cannot be considered solely as a pollutant. Thus, it is reasonable to assume, organisms are going to possess the mechanisms to accumulate at least small quantities of these metals (Kelly, 1988).

The ratio of the concentration in the organism to the concentration in the water is called the concentration factor. This concept is a useful tool for comparison between metals and for estimating the range of metal concentrations in tissues based on surface water concentrations. Kelly (1988) states "that it will become apparent how far there still is to go to understand thoroughly the processes of metal uptake."

4.4.1 Plants

Uptake and accumulation of heavy metals by plants is a documented process. Aquatic plants display a number of different growth strategies, each of which present different opportunities for metal accumulation. Proximity to sediments especially via roots in higher plants is one of the more obvious of these. The water column and sediments are potential sources of metals, even for the lower plants. Some planktonic algae over winter on the bottom muds (Denny and Welsh, 1979) whilst many attached forms are in almost continual contact with their substratum (Kelly, 1988). Concentration factors in plants can be relatively high. Typically these fall in the 1000 to 10000 range (Keeney et.al., 1976; Trollope and Evans, 1976) although Kelly (1988) shows the large amount of variation in enrichment ratio that occurs within as well as between species reflecting other environmental factors. The extent to which plants use minerals is dependent both on the species and the metal but in most cases the root contains higher concentrations than that in the shoot. Some studies show copper as being capable of accumulating in shoots, while lead remained in the roots (Welsh and Denny, 1979). This partial exclusion of some metals is similar to the mechanism proposed for heavy metal tolerance in terrestrial plants (Bradshaw and McNeilly, 1981). Generally, submerged plants have the highest concentrations of metals, followed by floating leaved species and emergent (Kelly, 1988).

4.4.2 Animals

Although some workers have suggested (Anderson, 1977) that the position in the food chain determines the degree of metal exposure in freshwater animals, several workers have disputed this (Burrows and Whitton, 1983; Smock, 1983a). As with plants, the sediments play an important role. In insects, burrowing species accumulate the highest concentrations of metals followed by filter feeders, while surface feeders and carnivores contained the lowest concentrations (Smock, 1983b). Only a few correlations between metal concentrations in animals and water have been reported.

Many species of fish which are eaten regularly by man are carnivorous; however, as for invertebrates, there are not necessarily higher metal concentrations in these groups. In a contaminated eutrophic lake in Michigan the fish contained lower metal concentrations of lead than macrophytes, zooplankton, or sediment (Mathis and Kevern, 1975). Tissue localization studies generally show that the highest concentrations of heavy metals are found in the liver (Abo-Rady, 1979; Bendell-Young et.al., 1986) along with the gills (Solbe and Cooper, 1976; Norris and Lake, 1984) and the kidneys (Cowx, 1982) while concentrations in the muscle are among the lowest (Merlini and Pozzi, 1977; Murphy et.al., 1978). Kelly (1988) concludes that "these are unlikely to represent a major human health hazard unless fish constitute a major part of the diet."

With organisms as mobile as fish it has been difficult to establish good relationships between environmental and tissue concentrations of metals (Kelly, 1988); however approximate relationships have been found for lead concentrations in three species of trout in the western USA (Pagenkopf and Neuman, 1974) and a general enrichment of metals has been observed in the brook trout in the River Leine, West Germany (Abo-Rady, 1979) for perch between metal-enriched lakes and control lakes in Switzerland (Hegi and Geiger, 1979), and for a variety of species in the CDA system (Rabe and Bauer, 1977; Krizenbeck, 1978; Wolfin, 1985; and Margolis, 1986).

Kelly (1988) presents a discussion of a variety of field studies involving a different combination of heavy metals and states that two general points emerge:

- as for plants (Whitton and Diez, 1980) there is a general reduction in the number of species recorded as the aqueous concentration of metals increases;
- certain taxa (in particular, Oligochaeta, Mollusca, Crustacea, Trichoptera, Salmo) appear to be more sensitive to heavy metals than others.

4.4.3 Synergism, Additivity, and Antagonism

In the environment in areas impacted by mine waste several heavy metals are generally present. The combined toxic effect of these may either equal the sum of the toxicities (additivity), may exceed the sum (synergism) or it may be less (antagonism). Generalizations are difficult to make with respect to mine wastes. Although, all three types of response have been observed in laboratory studies (Kelly, 1988). With respect to fish, Kelly (1989) cites several studies that concluded that copper and zinc can have either additive or synergistic toxicological effects.

4.5 Critical Receptors

The CDA ecosystem is complex despite the fact that declines in certain mammal

populations have probably occurred as a result of direct toxicity of heavy metal contamination and associated secondary effects on cover and food supply (Blus et.al., 1986). Habitats in the Lower CDA consist of a series of wetlands including the river, marshes, and lakes. These habitats support a variety of waterfowl, resident and migratory fish, marshbirds, predatory birds including seasonal bald eagles, marshland and other mammals. Each of these faunal groups are potential receptors of potential heavy metal exposure from mining wastes.

A summary of documented receptor impacts to heavy metals in the CDA basin is presented below. Waterfowl mortality, associated with the mining and smelting activities, has occurred in the area since at least the early 1900's (Chupp and Dalke, 1955; Benson et.al., 1986; Krieger, 1986,1987,1989-draft). Metal concentrations once precluded the existence of certain fish species in the South Fork CDA, although Horner (1985) reports that afluvial fish have once again moved into this portion of the river. There is some controversy whether gamefish caught in the CDA Basin are safe for human and predatory bird consumption due to heavy metal content in organs and tissues. Metal contamination in mammals other than humans have been described --domestic dogs and livestock (Rabe and Flaherty, 1974; and Burrows et.al., 1981). Relatively high metal concentrations have been encountered in small mammals trapped near Kellogg and Thompson Lake (Herman, 1975; Blus et.al., 1986).

For the purposes of this study a group of critical receptors will be evaluated in a Level 1 Risk Analysis (EPA, 1985). The critical receptors we have identified include resident gamefish and wildfowl, both of which were selected because they may effect future BLM natural resource management decisions, because of their susceptibility to heavy metal contamination, available data, and the fact that the tissue of both groups represent potential contaminant exposure pathways to sportsmen. Sportsmen represent the third group of critical receptors that will be evaluated for this study.

4.6 Contaminant Migration Pathways

In this section, the routes of exposure to wildfowl, gamefish, and sportsmen from lead, zinc and cadmium is examined. A graphic illustration of the key migration pathways is presented in Figure 4.1.

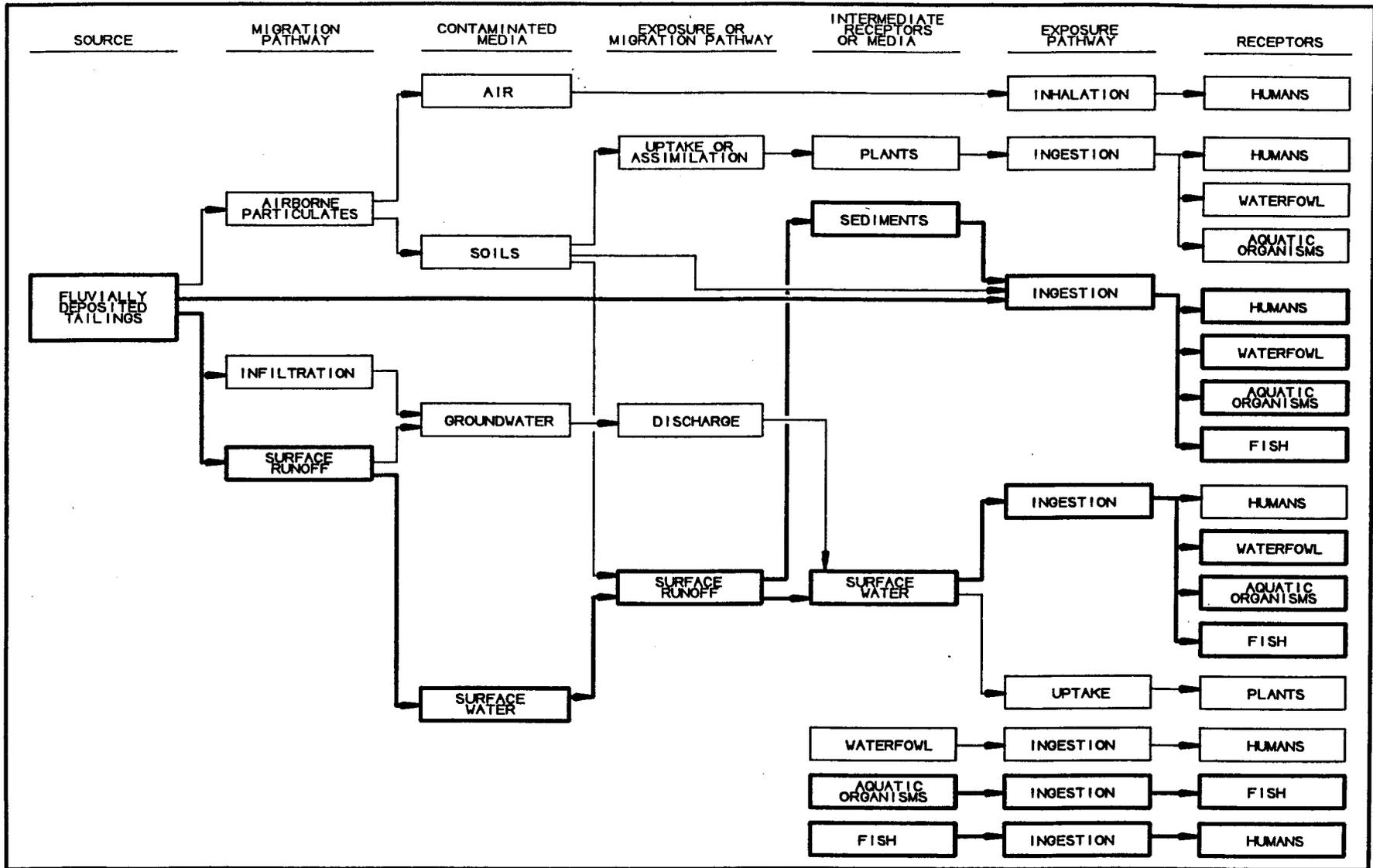


Figure 4.1 Migration pathways for Pb, Cd, and Zn in the Lower Coeur d'Alene River. (Significant pathways are in bold).

during the 1985 season were examined to determine how much lead they had accumulated from their diet of aquatic vegetation. The level of liver lead was low especially when compared to waterfowl indicating that vegetation may not be an important source of lead, at least relative to direct ingestion. This is further supported by the results of Welsh and Denny's (1979) study that suggested that lead tends to remain plant roots. In addition, wildfowl occasionally carry lead shot or ingest pellets which can cause mortality. A relatively high rate of lead pellet ingestion in the area (Shipley, 1985; and Krieger, 1986)- up to 20-30% of ducks tested -- compounds the lead poisoning problem. The Idaho Fish and Game delineated a steel shot zone including the CDA Wildlife Management Area in 1986-87 to address this problem.

In addition to the wildfowl mortality problem, studies show that despite every appearance of being healthy, coots, mallards, and wood ducks show evidence of excessive lead exposure and tissue accumulation. Tissue levels were elevated even though there were no overt signs of toxicity (Krieger, 1986). However, Krieger concluded that human consumption of duck flesh would not significantly increase the amount of lead consumed with the daily diet. Elevated intake would result if liver was eaten. Under normal circumstances risk related to ingestion of liver would be very small or negligible, and that a specific warning concerning consumption by sportsmen was not warranted in his opinion. A comparison of roast duck and uncooked duck indicated that cooking did not release any additional lead from bones where preferential accumulation is thought to occur.

4.6.2 Gamefish

Historical and operative mines and mills along the South Fork of the CDA are the main source of heavy metal contamination in the CDA system. Kemmerer (1923) noted that "the river was so laden with silt that it can be traced far out into the clear waters of Lake Coeur d'Alene." The main mechanism for tailing disposal at least into the 1950's was discharge to the South Fork. Ellis (1932) concluded that "suspended solids had made the river uninhabitable to most aquatic life." The construction of tailings ponds and decrease in mining activities greatly improved the situation although lead, zinc, and cadmium as dissolved ions and adsorbed to suspended sediment continued to inhibit aquatic species diversity.

Heavy metal concentrations have been reduced enough to allow afluvial fish to once again move into the South Fork of the CDA (Horner, 1985). Gamefish present in the CDA system including the lateral lakes continue to be exposed to heavy metal contamination.

The main contaminant exposure pathways to gamefish include consumption of contaminated surface water, ingestion of contaminated suspended or bottom sediment, and transfer of contaminants through the food chain. These pathways will continue to subject

gamefish to heavy metal contamination well into the future. However, as Horner (1985) points out the situation is improving. The potential negative impact of this "improvement" is the fact that large numbers of aquatic organisms including gamefish may now be exposed to chronic heavy metal effects and subsequently pass this contamination through the food chain. When metal concentrations were in the acute toxicity range less transfer through the food chain probably occurred due to avoidance of these areas or mortalities.

4.6.3 Sportsmen

The CDA basin is widely used by sportsmen. Sportsmen are receptors of heavy metal contamination through consumption of fish and wildfowl tissues. Direct ingestion of contaminated surface water and/or sediments (with the notable exception of pica uptake-by small children) are not thought to be important exposure pathways, nor is inhalation of contaminated dust.

4.7 Characterization of Risk

An endangerment assessment has been made for the three critical receptor groups identified in this study. Wildfowl are the most clearly endangered group. Annual mortalities have been well documented (Neufeld, 1987). Gamefish were absent from portions of the CDA system due to acutely toxic levels of heavy metals and siltation. This receptor group is making a comeback and has moved into previously uninhabited waters. While this indicates a reduction in the toxicity present to gamefish, a greater risk may be posed to other higher trophic levels through contaminate transfer through the food chain, including the third receptor group-- sportsmen. In addition to gamefish consumption, wildfowl tissue consumption will be used to conduct the endangerment assessment of sportsmen.

4.7.1 Wildfowl

One has only to read some of the numerous studies documenting wildlife mortality in the CDA basin to conclude that migratory and resident wildfowl are endangered by the heavy metal contamination (particularly within sediments) in the area. Section 6.2 will describe some potential resource management practices that may reduce the heavy metal risk to wildfowl.

4.7.2 Gamefish

Several studies have documented that fish are endangered by the heavy metal concentrations in the CDA system. Going back to Ellis (1933) live box tests resulted in

complete mortality within 72 hours at locations in the South Fork of the CDA. Most recent studies have been conducted on gamefish to assess the risk posed to human consumption. Therefore, these studies will be described in the following section which characterizes the risk to sportsmen. The endangerment to gamefish as they begin to once again inhabit previously acutely toxic portions of the CDA system has not been studied.

4.7.3 Sportsmen

It is apparent that a degree of risk due to metal exposure in the lower Coeur d'Alene Natural Resource Management Area exists to sportsmen, particularly from cadmium and lead. Sportsmen of the area are exposed through the consumption of game and fish. In this section, an evaluation of the human health risks due to the consumption of fish and fowl will be discussed. The evaluation consists of a comparison of tissue data that has been collected in previous studies with the Allowable Daily Intake (Reference Doses) of metals in food.

Human exposure to lead, and cadmium via the food-chain pathway can result in metal poisoning which may cause serious medical complications. On the other hand, zinc is less toxic to humans because humans utilize zinc for nutritional purposes. In food, Reference Doses (RfD) of metals and other chemical compounds have been derived by various health organizations such as the World Health Organization (WHO), Food and Drug Administration (FDA), Environmental Protection Agency (EPA), Centers for Disease Control (CDC), and the Ministry of Agriculture-Great Britain (AM-GB) in order to protect the public from possible health risks associated with over exposure to inorganic and organic hazards. Reference Doses set forth by the various organizations differ. This is because the allowable daily intakes are estimated calculations which have been performed by each organization, although the RfD calculation technique of each organization is comparable.

Reference Doses Intakes were developed to identify a maximum daily intake of a compound to which an individual can be exposed without any reasonable expectation of adverse chronic or subchronic non-carcinogenic health effects (e.g., organ damage, biochemical alterations, birth defects). Health organizations such as the EPA calculate RfDs by dividing the No Observed Adverse Effect Level (NOAEL) or Lower Observed Adverse Effect Level (LOAEL) times a Body Weight (BW) by an Uncertainty Factor (UF) times a Modifying Factor (MF):

$$RfD = \frac{NOAEL (LOAEL) * BW}{UF * MF}$$

Uncertainty Factors are based on previous studies and scientific judgement. Usually the UF of 10 is used to account for fluctuations in human sensitivity. Other safety margins are included in the MF which is usually another 10 fold factor. Therefore, these factors are

included into the equation for variance in the population and provide for a safe margin of error (EPA, 1989).

Reference Doses of Pb and Cd are based on all routes of exposure (i.e. inhalation, dermal contact, and oral) to the receptor. The Reference Dose is generally viewed as a "soft" estimate, whose bounds of uncertainty can span an order of magnitude (EPA, 1988). In other words, if the RfDs for Pb and Cd are slightly exceeded (<1 times), then an individual may not be at risk due to the safety margin built into the calculation of the RfD. However, if an individual exceeds the RfD for Pb and Cd more than 2 times, then that individual may be at risk because the safety margin may be exceeded. Because an RfD is based on all routes of exposure, it is important to note that an additive response may exist.

Oral metal RfDs such as Pb are broken down into subgroups of sensitive and less sensitive populations. For example, the potential for Pb exposure to children and related health risks are much higher than an adult, due to the fact, that children are more prone to Pb uptake via soil consumption (pica) and are more vulnerable to systematic encephalopathy (Central Nervous System Disorder) which can lead to decrease in IQ. Therefore, separate lead RfDs for food stuff have been developed for adults and children.

Fish and fowl can bioaccumulate Pb and Cd in various parts of their tissues (i.e. liver, kidney, muscle). Sportsmen primarily consume muscle tissue from fish and fowl, and also bioaccumulate Pb and Cd in their tissues. Cadmium is preferentially accumulated in fish and wildfowl kidney tissue that is not normally consumed by humans, so lead represents the main human contaminant of concern. An estimation of the health significance of human Pb and Cd uptake can be performed using the RfDs for the metals. Several studies of the Coeur d'Alene area have used this technique to calibrate the extent of the human health dangers associated with fish and fowl consumption. Most of the research concentrated in the Lake Coeur d'Alene area. Anticipated fish tissue metal concentrations can be calculated based on surface water metal concentrations using fish bioconcentration factors. Lack of reliable surface water data and fish tissue data from the main stem of the CDA, and lateral lakes is a limiting factor in this study. Hence, in the absence of specific studies on various fishing areas throughout the CDA basin, fish sampling results from Lake CDA have been extrapolated to determine relative consumption concentrations of Pb and Cd in humans. Wildfowl tissue was assumed to be at a lower risk than fish tissue because of annual migration away from the area, limited hunting seasons, and lower Pb and Cd in muscle tissue concentrations. Furthermore, Dr. Krieger concludes that consumption of CDA Basin wildfowl does not likely pose a "significant" threat to human health (Krieger, 1989).

Fish studies of the Coeur d'Alene area have been performed (Rabe and Bauer, 1977; Krizenbeck, 1978; Wolfen, 1985; Margolis, 1986; Krieger, 1989) and have focused on

contamination of the fish population. However, fish studies with an emphasis upon human consumption are limited to the EPA (1986), CDC (1986), and Upper Columbia United Tribes (UCUT) Fisheries Center (1989). Each agency developed their own opinions of human health risks associated with consumption of fish in Lake CDA. These studies are summarized below.

The EPA conducted a fish study of Chinook and Kokanee salmon caught in a fishing derby in the summer of 1986 at Lake Coeur d'Alene. Sixteen salmon samples were collected and analyzed for various metals (i.e. Pb, and Cd). The EPA calculated the RfDs of Pb and Cd in fish filets. EPA concluded the salmon were safe to eat despite Cd levels that ranged to levels greater than 5.0 mg/kg wet weight (Margolis, 1986).

The Centers for Disease Control (CDC) of Atlanta, Georgia, conducted a similar study using a larger sample size. The CDC study found children and adults could exceed the RfDs of Pb and Cd through fish consumption. CDC used EPA derived RfDs for Pb and Cd (Margolis, 1986). The RfD for Pb is 98 $\mu\text{g}/\text{day}$ (adults) and 14 $\mu\text{g}/\text{day}$ (children). Cadmium has an RfD of 20.3 $\mu\text{g}/\text{day}$ for adults and 2.9 $\mu\text{g}/\text{day}$ for children. Serving size was estimated to be 170g of fish for an adult and 70g of fish for a child. In adults the RfD for Cd was exceeded in 4 of 12 cases using the 170 g daily intake rate. In the cases that did exceed the RfD, the values ranged from 1 to 5 times the RfD value. The RfD for Pb in adults was exceeded in three cases. Cases that exceeded the RfD for Pb ranged from 2 to 5 times the RfD. In children, the RfD for Cd was exceeded in 9 of 12 cases using the 70 g fish consumption rate. In the cases where Cd exceeded the RfD, the values ranged from 2 to 14 times the RfD. The RfD for Pb in children was exceeded in 3 of 3 cases and Pb intake doses ranged from 2 to 15 times the RfD.

Conflicting opinions on the extent of the human health threat through consumption of Lake Coeur d'Alene fish between EPA and CDC exist. In conjunction with Eastern Washington University the Coeur d'Alene Tribe have proposed to conduct a study to resolve this uncertainty (UCUT, 1989). The Coeur d'Alene Tribe reside in the area and at one point consumed wild fish as a primary source of protein supplement in their diet. This is no longer the case due to the uncertainty in the health risk. The UCUT proposal suggested that tribal members typically consume greater volumes of fish per meal. Metal intake calculations were based on these higher numbers which resulted in more fish tissue samples exceeding RfDs. The EPA and CDC study used a consumption rate of 170 g/day in adults and 70 g/day in children and the UCUT study proposed consumption rates of 485 g/day in adults and 185 g/day in children. The UCUT proposal suggested both a child and adult exceeded RfDs by more than 2 to 15 times the recommended daily intake for Pb and Cd. In addition, the UCUT proposal questioned the validity of the two other studies citing inadequate sample size in the EPA study and inadequate sample preparation in the CDC study.

These studies had various objectives, and used different assumptions, and concluded conflicting results. It is not yet clear whether consumption of fish from lake Coeur d'Alene poses a human health threat. If a health threat exists it is chronic rather than acute.

Comparison Study

Present and future BLM management decisions regarding sportfishing will center on the consumption of fish and the associated health risk in the lateral lakes and the main stem of the CDA system. Killarney and Thompson Lakes both support a large population of game fish. Gamefish are making a comeback in the main stem of the CDA river. Limited metal concentration data on either surface water and fish tissue presently exist in these areas. The Washington Animal Disease Diagnostics Laboratory conducted a study of fish in Thompson Lake for IDFG which showed liver tissue in most species less than 1 ppm but 7.27 ppm in tench. Cadmium levels ranged from 0.69 to 2.45 ppm. Other studies are in progress (Mr. David Fortier, Oral Communication, 1989). An equal or greater human health threat may be posed in the lateral lakes versus Lake CDA. Both Killarney and Thompson Lakes are shallower than Lake CDA. These lakes are also underlain and surrounded by as much heavy metal-laden sediment per acre as Lake CDA. Therefore, it is reasonable to suspect as great if not greater heavy metal concentrations in fish tissue due to less significant dilution.

Data collected by EPA (EPA, 1987) over the period 1972-1987 was used to evaluate the human health threat posed by consumption of fish from the lateral lakes and the main stem. Our methodologies and assumptions are documented below, but in general were similar to those used by EPA (1986), CDC (1986), and UCUT (1989). EPA RfDs were compared with calculated contaminant exposure from fish ingestion. Metal data (EPA, 1987) from Station 36 - Coeur d'Alene River near I-90 bridge at Cataldo, Station 37 - Mission Flats Slough near Cataldo, and Station 39 - Killarney Lake were selected for the study. Station 36 provided Pb and Cd water concentrations while stations 37 and 39 contained fish tissue data of Pb and Cd. Station 36 had a total of two samples taken in the fall of 1986 and contained an average Cd concentration of 6.8 µg/L and an average Pb concentration of 1.0 (below detection limit) µg/L. Station 37 and 39 fish tissue containing Cd and Pb concentrations taken in the winter of 1987 were used. Fish tissues included different types of fish; Yellow Perch, Bullhead, Northern Pike, and Largemouth Bass. Station 37 had a total of three samples for both Cd and Pb. Cd average concentrations were 0.016 mg/kg and average Pb concentrations in fish were 0.050 mg/kg. Station 39 had a total of five samples for Cd and Pb and had average concentrations of 0.016 mg/kg and 0.11 mg/kg respectively. Refer to Table 4.1.

Several assumptions were created to allow for calculation of contaminant exposure from fish ingestion which included a consumption rate of 0.030 kg/day for a 70 kg adult

(EPA, 1986). This number is less than consumption rates used in previous studies. It was developed by the EPA (1989) to represent a reasonable worst case exposure for the consumption of recreational fish/shellfish from large bodies of water, calculated from the west coast area. The range for the consumption rate was 30-140 g/day. EPA RfDs for Cd and Pb were used to compare exposure doses. The RfD for Cd was set at 0.001 mg/kg/day and the RfD used for Pb was 1.4×10^{-3} mg/kg/day.

Table 4.1 Fish tissue analyses in the LCDAR

	<u>Station 36</u>	<u>Station 37</u>	<u>Station 39</u>
	<u>(mg/kg)</u>	<u>(mg/kg)</u>	<u>(mg/kg)</u>
Average Cd Conc. Water	6.8	N/A	N/A
Average Pb Conc. Water	1.0 undetected	N/A	N/A
Average Cd Conc. Fish Tissue	0.551	0.016	0.016
Average Pb Conc. Fish Tissue	0.049	0.050	0.110

Fish tissue concentrations were calculated from Pb and Cd water concentrations (Station 36). This was accomplished by multiplying the contaminant concentration in water (mg/L) by the fish Bioconcentration Factor (BCF) (L/kg) for the contaminant:

$$\begin{array}{l} \text{Contaminant} \\ \text{Concentration} \\ \text{in Fish} \end{array} = \begin{array}{l} \text{Concentration} \\ \text{in Water} \\ \text{(mg/L)} \end{array} * \begin{array}{l} \text{Bioconcentration} \\ \text{Factor} \\ \text{(L/kg)} \end{array}$$

Station 36 calculated fish concentrations were equal to 0.5508 mg/kg Cd and 0.049 mg/kg Pb.

After calculating concentrations Cd and Pb in fish in Station 36, an exposure dose was calculated for Stations 36, 37 and 39 using the assumptions set forth by the EPA. The contaminant Exposure from Fish Ingestion Dose was calculated using the concentration in fish multiplied by a Daily Fish Consumption Rate times the reciprocal of Body Weight (BW):

Contaminant			Daily Fish	1
Exposure from	=	Concentration	Consumption *	-----
Fish Ingestion		in Fish	Rate	BW
(mg/kg/day)		(mg/kg)	(kg/day)	

Station 36 Fish Ingestion Dose for Cd was calculated to be 0.002 mg/kg/day and 2.1×10^{-5} mg/kg/day for Pb. Fish Ingestion Doses for Station 37 were estimated to be 6.86×10^{-6} mg/kg/day for Cd and 2.14×10^{-5} mg/kg/day for Pb. Station 39 Fish ingestion doses were equal to 7.02×10^{-6} mg/kg/day for Cd and 4.71×10^{-5} mg/kg/day.

Calculated Fish Ingestion Doses for Cd and Pb were then compared to the specified RfDs for each of the contaminants listed above. Exceedance of the RfD occurred in one instance only, the Cd fish ingestion exposure dose of Station 36. The calculated fish ingestion dose for Cd was 0.0002 mg/kg/day while the RfD for Cd has been set at .0001 mg/kg/day. This represents an exceedance of less than one order of magnitude. Stations 37 and 39 were all well below the RfDs for both Cd and Pb.

Station 36 proved to be the only location where exceeding the RfD for Cd occurred. However, the RfD for Cd was exceeded less than one order of magnitude. The RfD for Cd was established to protect the population from renal damage caused by chronic Cd exposure.

Previous studies conducted on human health effects related to Lake CDA fish consumption used different fish uptake ratios and compared them to different RfDs. For example, both EPA (1986) and CDC (1986) used fish uptake ratios of 170 g/day for adults and 70 g/day for children, and compared them to RfDs for Cd and Pb of 0.29 $\mu\text{g}/\text{kg}/\text{day}$ and 1.4 $\mu\text{g}/\text{kg}/\text{day}$ respectively. Most recent EPA guidance (Superfund Public Health Evaluation Manual, 1986) reflect a change in Cd RfD from 0.29 $\mu\text{g}/\text{kg}/\text{day}$ to 0.10 $\mu\text{g}/\text{kg}/\text{day}$. The RfD for Pb has not changed and remains 1.4 $\mu\text{g}/\text{kg}/\text{day}$. To evaluate the various uptake ratios used in past studies and to compare these to RfDs some additional calculations were made. The results of the calculations are presented below.

At Station 36, fish consumption rates of 170 g/day and 450 g/day were compared to Pb and Cd RfDs of 0.1 $\mu\text{g}/\text{kg}/\text{day}$ and 1.4 $\mu\text{g}/\text{kg}/\text{day}$ respectively. For both the 170 and 450 g/day fish consumption rates RfDs for Cd were exceeded, however, the RfD for Pb was not exceeded in either case. At Station 37 the RfD for Cd was slightly exceeded using the 450 g/day consumption rate and not exceeded using the 170 g/day consumption rate. The RfD for Pb at Station 37 was not exceeded using the calculated fish concentrations. In Station 39, RfDs for Cd and Pb using both 170 and 450 g/day consumption rates were not exceeded.

In summary, Stations 36, 37, and 39 calculated fish ingestion doses using fish

consumption rates of 170 and 450 g/day resulted in a slightly higher consumption rate than a fish consumption rate of 30 g/day. However, the fluctuation in ingestion doses did not produce a significant difference with respect to the RfDs. Comparing fish consumption rates of 30, 170 and 450 g/day gives a broad range of intake rates which likely represents an appropriate approximation range of heavy metal consumption rates for sportsmen in the Lake Coeur d'Alene area. The most conservative results being the 450 g/day consumption rate and the least conservative results being the 30 g/day consumption rate. The findings found no significant shift in ingestion doses compared to the appropriate RfDs for Cd and Pb. The only area which demonstrated an exceedance of any of the RfDs for Cd and Pb was Station 36. Station 36 fish ingestion doses calculated with all three ingestion rates exceeded the RfD for Cd. Stations 37, and 39 did not exceed RfDs for both Pb and Cd using the three consumption rates.

4.8 Hazard Mapping

Overlay maps of the LCDAR area have been prepared and submitted to BLM separately to provide a generalized picture of hazard areas as they relate to BLM properties, physical features and land use. The overlays cover the six USGS 7.5 Minute Series topographic maps from the Cataldo area to Lake Coeur d'Alene. One set of maps is used to show hazards; a separate set of overlays defines land use.

Hazard overlays are based primarily on aerial photo interpretation. This is supported by confirmation of soil and sediment analyses when these are available for the area. Several sources provided spot analyses. Two levels of hazard were defined. Hazard A, the highest level of contamination, was assigned to an area when aerial photos showed impacts on vegetation sufficiently great to severely limit growth. Hazard B was assigned to areas which did not show such severe impacts on vegetation but are known to have elevated metal levels in soils and sediments or are likely to be impacted due to their proximity to and elevation from the main river channel. Vegetation can be inhibited either by high metal concentrations in soil materials or by exceptionally thick layers of deposition.

Land use overlays were developed by aerial photo interpretation using six categories of classification: agricultural, forest/range, residential/commercial, wildlife habitat, recreational, and seasonally flooded (generally unsuitable for any of the other use classifications). USGS maps were also used to define forest and recreational areas.

During development of the overlays it was observed that the higher hazard areas tended to be concentrated upstream toward Cataldo. This might be expected since this area is the closest to the point of discharge. However, near Lake Coeur d'Alene other high hazard areas were identified in areas where channel dredging has been done. This interpretation may be due partly to the negative impact on vegetation from dredging itself. However, it is probable that the thickness of metal-contaminated soils in dredged areas is

contributing to the poor growth of vegetation in these areas. Extensive areas of high hazard were notably lacking on the south side of the river. We attribute this to the presence of the Union Pacific tracks which may have limited the quantity of material deposited in these areas after the tracks were constructed.

5.0 KEY MANAGEMENT ISSUES AND MANAGEMENT ANALYSIS

Based on the discussions of area land management practices and the environmental hazard analysis of Sections 3.0 and 4.0, several key issues have been identified which are relevant to BLM resources. These issues are described in detail below. In this Section we also address the impact that BLM land management policy has on these issues and assess the capability of the Bureau to meet the complex management requirements an area such as this one may have.

5.1 Key Management Issues

5.1.1 Fishery Management

It has been demonstrated that gamefish are being reestablished in the mainstem of the Lower Coeur d'Alene River. However, these fish do have elevated lead and cadmium levels in edible tissues. Selection of fishery management alternatives is complicated by the potential health risk of fish consumption. The potential risk to sportsmen taking fish for consumption does not appear to be resolved in that there have been conflicting conclusions drawn particularly related to the Indian population of the area which has had a relatively high proportion of fish in its diet in the past.

5.1.2 Waterfowl Management

Waterfowl have also been shown to have been adversely affected by metal levels in the area. Although waterfowl toxicity is not a common occurrence, management options which reduce the incidence of periodic waterfowl mortality may be required. Waterfowl deaths have been tied to ingestion of vegetation contaminated with metal-enriched soil during flood years. The issue of risk to human health due to consumption of waterfowl in the area does not appear to be an important factor. Metal levels in edible tissue are lower than in fish and human consumption rates are likely to be much less than fish.

5.1.3 Risks to Recreational Users

Potential risks to recreational users within the lower Coeur d'Alene River have been identified. In addition to the possible risk from fish consumption by individuals with unusually high dietary intake of locally obtained fish, there is a potential risk to small

children through direct ingestion. With the exception of these two groups, the general population does not appear to be at risk. This is especially true for recreational users who use the area only on an intermittent basis.

5.1.4 Impacts from Recreational Use

A general characterization of the area is one with low level human health risks over a very large area. The mine waste has been deposited throughout the LCDAR floodplain since inception of mining. The size of the area contaminated is often cited as the most prominent concern and this is the primary reason why the site scored high on the hazard ranking evaluation conducted by Weston. Because of the length of time that the system has been exposed to contamination and the quantity of material involved, elimination of environmental risk from mine waste contamination could not occur without enormous cost. However, reduction in contamination has occurred through elimination of new waste at the source and natural revegetation of tailings deposits. Periodic disturbances to the system, such as flood events, can result in changes that will increase risk levels by exposing new material with higher levels of soluble metals. For the same reason the use of the area has the potential to impact the level of risk at least on a local level. Disturbance of contaminated materials is not recommended as this may promote the oxidation of contained minerals, thereby increasing their solubility. The physical stability of these materials may also be affected particularly if vegetative cover is removed. This consideration was the basis for applying a no-wake zone to the Lower Coeur d'Alene River. It is also why projects such as the construction of wildfowl nesting areas should be discouraged without provisions for revegetating or mechanically restabilizing disturbed areas.

5.1.5 Potential Legal Issues

While the Coeur d'Alene River below Pinehurst has not been included in the designated Superfund NPL site at Bunker Hill it is clear that significant problems exist downstream and future EPA actions would affect this area as well. The provisions of Superfund legislation and CERCLA in particular, provide for establishing legal and financial responsibility for clean-up activities. Management actions or land development activities which adversely affect the level of contamination in surface water must be avoided. Such actions taken by any owner of property in designated areas may cause them to be named as a Potentially Responsible Party (PRP) which carries with it the possibility of financial responsibility even if the party is in fact also an injured party. As unjust as this situation appears, it is the current state of the law as we understand it and will likely remain so unless successfully challenged in litigation. Many of the issues pertaining to CERCLA are as yet unclear due to the limited number of judicial precedents.

In view of the apparent improvement in aquatic habitat in recent years, the likelihood of this scenario occurring is probably quite low. However, it does raise some legal issues which should be addressed. First, if there is potential legal and financial responsibility associated with land ownership in the area, does BLM want to increase its exposure through land acquisitions? Second, through active development of its lands, BLM actions could conceivably increase risk levels thereby providing a basis for being named a PRP.

5.2 Analysis of BLM Management

5.2.1 Prior Policy Impacts

In the past, BLM policy and management practices in the Lower Coeur D'Alene River (LCDAR) area have been directed towards the development and management of BLM lands for recreational uses including boating, fishing and waterfowl hunting. Past policies have had an impact on the resources of the LCDAR as discussed in the following subsections.

Recreational Management

Prior BLM policy has provided recreational access and opportunities for the general public. The public has benefitted by having access to more lands and waters along the LCDAR to pursue fishing, hunting and boating activities. Much of the recreational activity on BLM land is centered at Killarney Lake. The Bureau maintains 3 sites at the lake where boat docks, launching facilities and picnic areas are available. Swimming, predominantly by children, is common around the Killarney boat launch area.

Tent camping also occurs at all BLM sites at Killarney Lake, although the site is not a designated camping area. Thus, partly because of existing developments, the area has become suitable for overnight stays and extended use. A growing body of information and concern about the presence of heavy-metal contaminated mine wastes has brought to attention the possible effects on human health, especially in view of the increasing use of the LCDAR as a recreational area. Although the apparent human health effects are such that the area is categorized as low level risk, the encouragement of extended human use can only increase the risk of exposure unless provisions are made for simultaneously reducing the level of exposure.

Ingestion of contaminated soils by young children is of particular concern. Although the potential for exposure through these pathways is present, the extent

and degree of contamination has not been fully documented and the health effects of metal contamination through direct contact or the ingestion of fish is not fully understood (Roy F. Weston 1989).

Fisheries Management

Fisheries management in the LCDAR area is and has been the primary responsibility of the Idaho Department of Fish and Game (IDFG), in conjunction with the USDFW. The role of BLM has been to provide access through their lands to allow for increased access for fishermen. It is possible that increased boating and fishing activity on waters adjacent to BLM lands may increase the disturbance of contaminated bottom sediments and/or bank sediments which may lead to a corresponding increase in the levels of metals in the aquatic environment. Currently, BLM is continuing to manage its lands in concert with the management practices of the IDFG.

Waterfowl Management

In 1983 the Army Corp of Engineers, in an agreement with BLM and IDFG, approved the construction of over 500 nesting islands for waterfowl in the backwater area around Killarney Lake. Some of the materials used for construction of the islands were comprised of heavy-metal-laden river bottom sediments and mine wastes. When these materials are exposed to weathering conditions, they react with atmospheric oxygen and water and hydrolysis reactions occur. These reactions result in the formation of soluble metal salts and the production of free H⁺ ions (acid). The lower pH results in a mobilization of the metals, which can also contaminate water upon dissolution of the metal salts. Since there were no provisions for neutralization or revegetation of disturbed soils, the exposure of the LCDAR system was probably increased by this action.

The IDFG has reported what appears to be periodic toxic exposure to waterfowl in the Lower Coeur d'Alene River resulting in unusually high rates of mortality. A recent study on swan mortality by Kreiger (1989) indicated that the primary cause of the deaths was due to ingestion of contaminated sediments during consumption of vegetation. However, it is possible that the islands contribute to this threat to the wildfowl which utilized them because of the lack of adequate soil restabilization. In addition, the liberation of metals from the islands during high flow or precipitation events (dissolution of metal salts) probably contributes to the degradation of water quality and the subsequent effect on aquatic life forms.

5.2.2 Direction of Current Policy and Bureau Capabilities

Current BLM policy in the LCDAR area reflects the concern and desire of BLM to address the potential land use problems associated with mine waste contamination. The Bureau hopes to be able to provide increased recreational opportunities and improved facilities in response to public demand while minimizing the potential contamination threat to the environment and public health. Several management alternatives exist to meet this goal and will be discussed in Section 6.0.

The Bureau is considering the procurement of additional tracts of land in the LCDAR area to meet increased recreational needs. Expansion of existing recreational sites is also under consideration. Recreational development may increase the exposure of humans to contaminants in the LCDAR. Additionally, increased recreational activity may mobilize contaminated sediments and mine wastes by boating activity and increased erosion, thus potentially impacting the aquatic environment. As a result, before any specific management actions can be taken the location and extent of mine waste contaminants on affected BLM lands or lands to be considered for procurement need to be defined.

The study and evaluation of the toxicological problems of the area are generally beyond the capabilities of current BLM personnel. BLM has correctly addressed this situation by employing qualified consultants to provide needed information. BLM may elect to continue operating in this manner or might consider hiring its own health/environmental toxicologist if the assessment for continuing needs is such that a full time position is warranted. This decision depends in large part on whether BLM decides to continue its policy of expanded development in the area for recreational and wildlife management programs. Such new programs would entail considerably more field sampling than has been done in the past. BLM staff, often trained in earth sciences where field data collection and interpretation are routine activities, could perform much of the field sampling and coordination.

Legal services will also be required to determine to what extent BLM would be responsible and liable for any actions or lack of action taken on existing tracts of BLM lands and those tracts considered for procurement in the future. The role of BLM in interagency decisions and potential liability for joint actions would also need to be clearly defined.

5.2.3 Assessment of Future Policy Needs

Several factors need to be considered in defining BLM's future policy objectives in view of recent findings on the potential risk to water quality, riparian resources, fish, wildlife, and human health posed by heavy metal-contaminated mine wastes. These factors

will be of primary importance in guiding future management decisions pertaining to existing BLM lands as well as lands considered for procurement and development. Lands targeted for procurement should be studied in sufficient detail to adequately define the level of contamination. The Bureau may want to work out an agreement on funding with the persons or agency involved in the procurement process. Should BLM consider independent study of contamination on their existing lands, a source of funding may also be required. In addition to addressing these factors, interagency coordination issues also need to be considered. It is also important to have an understanding of the legal issues involved as they pertain to liability for environmental degradation or human health effects caused by potential contamination on BLM lands. This issue should be examined very carefully when considering the procurement of new lands or the swapping of existing lands.

The desire to provide increased recreational access sites along the LCDAR needs to be balanced against the possible risk to human health posed by the presence of heavy metal-contaminated mine wastes. Increased use of BLM lands will result in a corresponding increase in the possibility of exposure to mine wastes. Also, increased use and activity will create situations that will elevate the susceptibility of the environment to potential contamination. These include the potential for increased erosion and suspension of mine waste in river bottom sediments through increased turbulence caused by boat wakes and propeller wash. Increased fishing and hunting activity can also make banks more susceptible to erosion.

Further complicating the issue of managing lands and resources in the LCDAR area is the lack of sufficient information to adequately characterize the location and extent of mine waste contamination and the effect of this contamination on the environment and human health. Although several recent studies have illuminated to some extent the effect of metal contamination on waterfowl and fish and the threat to human health posed by consumption of fish and exposure to mine wastes, there is a need for additional site-specific information. There are two primary ways in which BLM can address the data gaps identified: 1) cooperation in an interagency, basin-wide study program and 2) a site-by-site evaluation of potential contamination on BLM lands on an as needed basis.

Basin-wide Mine Waste Study

A basin-wide study which would define the aerial extent of contamination and delineate locations of maximum waste thickness and metal concentrations ("hot spots") would greatly enhance the ability of involved agencies to safely and properly manage the resources of the LCDAR. This approach would likely require interagency coordination in order to define appropriate study goals and to fund the study. It would also most likely be very expensive. Comparisons to similar Superfund sites suggests that an adequate characterization of surface water, groundwater, and contaminated soils and sediments would cost tens of millions of dollars. Assessment of mine waste contamination alone could cost

up to \$1,000,000. It is unlikely this type of action would be taken without the intervention and coordination of the EPA. Funding for such an effort is also unlikely to be available unless the area would be designated as a Superfund site.

There are a number of similarities between the LCDAR area and the Silver Bow Creek Superfund site in southwestern Montana. Both areas contain potentially valuable water resources which have been contaminated by heavy metals from mine wastes associated with mining. Both areas also had the source of contamination, Bunker Hill in this case and Butte Hill in the case of Silver Bow Creek, first designated as a Superfund site. As the degree and extent of contamination became better understood, the boundaries of the Superfund site originally restricted to the area proximal to Butte Hill moved downstream to eventually include Silver Bow creek and the entire Clark Fork river from its source at the junction of Silver Bow and Warm Springs creeks downstream to the Milltown Reservoir, over 100 river miles.

It is possible that as data accumulates on the nature of contamination in the LCDAR area, it too may be considered for study under Superfund. This would significantly affect the use and management of all lands within the LCDAR and should be taken into consideration before any studies or long-term management plans are formulated. However, there are significant differences in the two sites that suggest reasons that the Bunker Hill site has been restricted to its current boundaries. First, the ore mined at Bunker Hill is a lead-zinc ore with considerably less potential for acid production than the pyritic copper ores of Butte Hill. Second, the area of the LCDAR is not nearly so arid as the Butte area. This significantly reduces the potential for the sudden release of large quantities of accumulated soluble metals in a runoff event. This mechanism is responsible for periodic massive fish kills on the Clark Fork River. Finally, the LCDAR is a much larger drainage system capable of more effective dilution of the adverse affects of the tailings. This is particularly true because of the input from the North Fork of the Coeur D'Alene River.

Location-Specific Site Assessment:

The second approach BLM can pursue in the management of its lands in the LCDAR area is the execution of a site by site inventory and study of mine waste contamination. This would comprise defining the location, extent and thickness of mine waste. The initial step of this process has been done in this management analysis by defining probable impacted areas based on aerial photograph interpretation and examination of available sediment and soil analyses. (See USGS map overlays of contaminated areas and land use for the six quadrangles in the study area). For sites which may be selected for expansion or new development, this initial survey should be followed by ground-truthing so the aerial extent and location of the contaminated soils and mine wastes could be accurately delineated. Soil sampling should be performed within a

grid to determine thicknesses across the area and to analyze metal concentration. In this way the degree as well as the location and extent of overall contamination and "hotspots" could be defined. Mine waste located in geomorphic positions which would make it more susceptible to erosion, such as at the mouths of small gullies and along undercut banks, could also be delineated. Given the extent of BLM holdings in the LCDAR area and assuming a cost of roughly \$100 to \$500 per acre to sample and analyze soils/mine waste (depending on the quantity of mine waste encountered), the cost to BLM for its entire land holdings would be on the order of \$100,000 to \$500,000. A more site-specific approach, in which only BLM areas of very high use or areas subject to possible new development are studied, may be warranted.

Once obtained, this information could be used to rank the benefits of the use of a given area for recreation against the potential for environmental degradation and the threat to human health. It may also be possible to selectively manage a given tract of land by placing access points, boat ramps and camping and sanitary facilities in areas defined as having the lowest potential threat to human health. Limited efforts to stabilize mine waste in erosion prone areas may also be necessary. This would enable an area to meet recreational demands while at the same time safeguarding the public and the environment from possible exposure to and contamination by mine wastes. This approach could be taken as a preliminary step for lands which BLM is considering procuring or could be implemented on existing lands. It would be particularly beneficial at Killarney Lake due to the high use of that particular tract.

In conjunction with management actions, remediation measures such as removal, isolation or chemical amendment of wastes could be implemented at "hot spot" areas to augment management practices and minimize the threat to human health and the environment. These options will be discussed in detail in the following chapter.

5.2.4 Constraints on Implementation of Policy

BLM is restricted to some extent in what it can do independently. Some of the factors constraining BLM are:

- Lack of suitable sites. For the most part BLM's holdings are not the kind of properties that should be developed for either recreational or wildlife management. The notable exceptions are Killarney Lake, valuable primarily for recreational use, and Thompson Lake for wildlife management. Most other sites do not provide an environment sufficiently attractive for development.
- Scattered land holdings. BLM's lands in the LCDAR are generally small and scattered. This makes it difficult to implement broad plans for recreational development and habitat management.

- Jurisdictional problems. BLM does not have authority to make or administer rules regarding fishing and hunting activities. It therefore has no effective control over this critical area of wildlife management.

6.0 MANAGEMENT OPTIONS AND RECOMMENDATIONS

6.1 Statement of Policy Goals

Possible management options for the LCDAR are numerous and implementation of any actions should be consistent with the policy goals established by BLM for the area. Thus, a definitive statement of these goals is in order. It is not the purpose of this document to establish BLM policy, but to provide information and analysis of the issues that will be useful in making decisions for formulating and administering policy. Nonetheless, the analysis of the current BLM management plans reveals the essential elements of its policy which we summarize below.

It is the clear desire of BLM to meet the needs of increasing recreational use in the area if this is possible. In particular, BLM sees a need for additional facilities at Killarney Lake. However, because of the special nature of the LCDAR management area, the minimization of health risks to recreational users must be an essential policy goal. This is particularly true because there is the issue of potential legal liability associated with actions which might increase the level of risk. Improved wildlife habitat and fisheries have been part of past policy and are certainly worthy future policy goals which BLM wants to pursue.

A question facing BLM relates to whether both recreational and wildlife management goals can be achieved simultaneously on its limited holdings in the area. It is our belief that additional recreational development can be done without increasing health risks, perhaps even reducing them, using appropriate project selection and implementation techniques. Clearly, increased recreational use does not appear to be compatible with the goals of improved wildlife habitat and improved fisheries. Excessive hunting and fishing do have a direct negative impact on game populations though it may not be detrimental to the habitat supporting those species. These recreational activities are traditionally managed with bag/creel limits and seasonal restrictions. Programs to improve habitat are generally intended to support a higher level of use by sportsmen without adversely impacting the overall quality of fishing and hunting in an area. Other types of recreation such as camping and boating can have a significant impact on the habitat itself by reducing the degree of seclusion available in breeding and feeding areas. Boat propellers have a direct impact on fish habitat by disturbing stream sediments. This

is especially important in an area with sediment-related environmental hazards. However, if the entire region is not targeted entirely toward recreational use, it may be possible to achieve both recreational opportunities and wildlife habitat on a more limited scale in selected areas. This is the basic goal of a selective use policy. Selective use should be a basic part of any area management plan that attempts to promote the area for both recreation and wildlife management purposes.

6.2 General Description and Evaluation of Management Alternatives

Management alternatives available to BLM have meaning as applied both to current resources and to future resources that may be acquired or developed. Management actions may be directed at one or more of the management goals identified above. The alternatives may be administrative in nature or they may be physical actions designed to attain policy goals. In order to document some of the options which may be available to BLM, Tables 6.1 and 6.2 have been compiled. Table 6.1 is a compilation of options which may have some useful application in the LCDAR. Because the nature and purpose of possible applications is quite broad, it was difficult to rule out many of the possibilities as totally unapplicable. Those alternatives which have been considered but do not have useful application for area management are compiled in Table 6.2. A general discussion of the applicability of the various alternatives follows these tables. An examination of specific BLM study sites for implementing some of these management options is made in Section 6.3.

Table 6.1 Summary of Applicable Management Options for the LCDAR

Option Classification	Option Description	Screening Comments
Administrative Methods		
<u>Selective Use</u>	No Boating Areas	Appropriate for preservation of wildlife habitat or in shallow areas where propeller action may disturb sediments.
	No Fishing Areas	Appropriate for encouraging reestablishment of desirable species which are currently not present or present in only a small population. Appropriate if fish have a high level of

(continued)

Table 6.1 (Continued)

Option Classification	Option Description	Screening Comments
		metal values in their edible tissues which is clearly a threat to human health through consumption. This does not appear to be the case in the LCDAR.
	Creel Limits	Appropriate for limiting human exposure through ingestion as well as for promoting an ample population of gamefish.
	No Wake Zones	Clearly, this is a useful strategy for reducing disturbance to both the streambanks and river bottom which contain high metal levels in most areas. Appropriate where wildlife habitat is being encouraged. Suitable for critical fish habitat zones especially spawning areas. Appropriate from a safety standpoint because of the limited navigability of the river.
	No Motor Zones	Appropriate for habitat preservation
	No Swimming Areas	Designation of heavily contaminated shorelines as no swimming areas would reduce opportunities for exposure through this activity. Although swimming would appear to provide a high level of risk, the exposure potential from swimming is felt to be small since actual ingestion of metal bearing materials is required. Lead levels in the water itself are not exceptionally high and swimmers do not tend to swallow water in any event. Posting areas frequented by swimmers to advise of potential hazards may be more appropriate (see item below).

(continued)

Table 6.1 (Continued)

Option Classification	Option Description	Screening Comments
<u>Educational Programs</u>	Posting of Hazard Areas	<p>Areas containing high levels of metals should be posted particularly where they may invite human activity. Beach areas where children may want to play are likely candidates.</p>
	Informational Brochures	<p>Public education is an important part of managing this problem. If the public is made aware that a possible health risk is present and of ways that this risk can be minimized, a substantial reduction in actual exposure could be effected.</p>
	Public Relations Programs	<p>The public can also be made aware that the health problems which the area poses are not extreme but are manageable ones. New projects which are undertaken can produce a positive impact by demonstrating how specific problems were addressed during execution of the project.</p>
	Safety Training	<p>Employees working in the area on maintenance and construction projects should be aware of the potential health hazards and procedures for reducing exposure.</p>
<u>Establish Planning Criteria</u>	Acquisitions Planning	<p>A thorough planning effort to develop a clear idea of how a property will be used and detailed information on the extent of site hazards is essential for any new acquisition in view of the hazards in the area.</p>
	New Developments Planning	<p>Before new projects are undertaken, detailed knowledge of the site regarding level and extent of contamination should be obtained</p>

(continued)

Table 6.1 (Continued)

Option Classification	Option Description	Screening Comments
		<p>and evaluated for possible impacts on the project.</p> <p>Collected data could be used for design of methods for reducing risks to workers during construction and after completion to the facility users whether they are humans, wildlife or fish.</p>
Physical Methods		
<u>Removal of Tailings</u>	Streambank Excavation	<p>Suitable for remediation of severely impacted areas only.</p> <p>Requires suitable site for placement of excavated material.</p> <p>Causes significant disturbance to materials which may already be stabilized to a significant extent.</p>
<u>Isolation/Stabilization of Tailings</u>	Water Level Control	<p>Impractical for the main river channel because of the need for maintaining navigability.</p> <p>Possible application in lateral lakes or other wildfowl feeding areas to minimize soil ingestion caused by fluctuating water levels and flood-related disturbances.</p>
	Soil Capping	<p>Relatively inexpensive.</p> <p>Useful for minimizing direct contact opportunities.</p> <p>Useful in improving vegetative growth.</p>
	Erosion Control	<p>Difficult to use except in open areas.</p> <p>Relatively inexpensive.</p>

(continued)

Table 6.1 (Continued)

Option Classification	Option Description	Screening Comments
		Useful for preventing further disturbances to deposited tailings materials.
		Useful for protecting other stabilization measures to assure long-term viability.
	Flood Control	<p>Impractical for the main river channel due to the need to maintain navigability.</p> <p>Perhaps applicable to some lateral lakes where access by boat from the river is not required or wanted.</p> <p>May be useful in protecting lateral lakes from additional tailings contamination. However, consideration should be given to the effect of restricting water movement into and out of the lakes as this might result in higher soluble metal levels.</p>
<u>Chemical Alteration of Tailings</u>	Lime Incorporation	<p>Appropriate where production of acidity is evident by low measured pH or elevated soluble metal values. Useful in combination with soil capping methods to reestablish vegetation on severely impacted sites.</p> <p>Difficult to utilize in areas with established growth of trees.</p> <p>Moderately expensive.</p>
<u>New Habitat Development</u>	Feeding Areas	Ingestion is an important exposure pathway to both wildfowl and fish. Development of new feeding areas (probably only practical for wildfowl) in uncontaminated areas would reduce the level of risk.
	Nesting Areas	Encouragement of wildfowl nesting sites outside the hazard areas should improve

(continued)

Table 6.1 (Continued)

Option Classification	Option Description	Screening Comments
		the health of at least some members of the resident wildfowl population.
	Spawning Areas	The upper sections of the tributaries of the LCDAR are likely to be totally uncontaminated. These areas, if not already used as spawning areas, might be exploited for some species. Thus, if fry or fish embryos are known to be more susceptible to metal toxicity than fingerlings and adults, a method may be available to help establish species in the river system.

Table 6.2 Summary of Rejected Management Options for the LCDAR

Option Classification	Option Description	Screening Comments
Administrative Methods		
<u>Total Restriction</u>		<p>Appropriate only for extreme hazard areas, none of which have been identified in the study area.</p> <p>Poor public acceptance</p> <p>Difficult to enforce</p>
Physical Methods		
<u>Removal of Tailings</u>	Channel Dredging	<p>Suitable for remediation of severely impacted areas only.</p> <p>Requires suitable site for placement of excavated material.</p> <p>Causes significant disturbance to materials which may already be stabilized to significant extent.</p> <p>Relatively expensive.</p> <p>Because of the transport capabilities of streams, redeposition of similar materials and reestablishment of the same problem is likely to occur without other physical actions affecting the flow of the river itself.</p>
<u>Physical Alteration of Tailings</u>	Solidification	<p>Difficult to utilize in saturated soil conditions which are likely to be common in affected areas.</p>
	Vitrification	<p>Technology not fully demonstrated.</p>

6.2.1 Administrative Alternatives

Administrative alternatives generally provide low cost options for implementing policy decisions and for managing problems without providing a permanent remedy. They are not appropriate for remediation of problems. Administrative controls only work where ongoing human activities contribute to a problem or otherwise interfere with the attainment of a policy goal. Consequently, they should be applied to the LCDAR in the following situations:

- To promote selective use of certain areas to meet specific BLM policy goals where there may be a conflict with other policy goals.
- To control public access in areas where relatively high health risk is identified.
- To minimize possible additional adverse impacts resulting from public use.
- To educate the public in the nature of the possible health risks which may be encountered in the area.

Administrative controls which have been identified were categorized as total restriction, selective use, educational programs, and planning programs. Of these options, "total restriction" appears to be unsuitable. It is not likely that such a policy would be enforceable in an area with relatively high and increasing use. Public acceptance of such a policy would not be easily obtained.

Selective use includes such actions as no boating areas, no fishing areas, creel limits and no wake zones. Such measures may not be observed by all but even partial compliance should produce beneficial effects. Public acceptance of such measures is more readily obtained especially if the restrictions are not applied in areas which are already established as favorite recreation spots.

Educational programs appear to be especially useful. Public awareness of the environmental problems is essential to helping users minimize their exposure while using the area. Also, it would seem that if BLM wants to promote the use of an area with a low level health risk, it is at least morally obligated to advise users of these risks. At the same time, educational programs provide a mechanism for generating public and administrative support for desired projects by demonstrating that BLM is competently addressing the special requirements of this area.

Planning programs are essential unless the Bureau opts for a management philosophy that provides only for maintenance of existing facilities and resources. New developments of any kind will need planning mechanisms that address the environmental

concerns associated with the tailings. This will likely mean that the costs for new developments will be greater than might otherwise be the case because of the need to gather the site data necessary to make informed decisions. A necessary new planning tool is discussed in Section 5.2.3 where location-specific site assessments are completed for candidate development tracts.

6.2.2 Physical Alternatives

Physical alternatives tend to be more costly to implement than administrative ones. Implementation of such physical measures generally implies that a serious problem exists or would be created by a contemplated action and that administrative measures are not adequate to deal with the problem. From a human health standpoint the existence of a serious problem has not been demonstrated. If this were the case the existing Superfund site boundaries would include the area of the LCDAR.

Considering the situation in the LCDAR from a purely environmental standpoint it is clear that a problem does exist. Whether this is a serious problem requiring costly solutions might be a topic for debate. Vegetation along the river has definitely been adversely affected. Aerial photos clearly show low-lying areas devoid of vegetation to an extent indicating more than simple erosion and flooding effects. Wildfowl have been subject to high mortality including fairly recent episodes. Fish populations have been impacted in the past and continue to show elevated metal levels in tissues. This is indicative of conditions which are less than healthy. On the other hand, the area is a picturesque one in which waterfowl do live and reproduce and gamefish appear to be making a comeback. This is true even in the more severely impacted South Fork. Thus, if physical alternatives are to be invoked to remedy existing problems these will likely be targeted at strictly environmental problems -- problems producing noticeable impacts on either fish or wildfowl.

Fish mortality does not appear to be a critical problem in the LCDAR. There are no indications of recent massive fish kills in the area. Rather, the aquatic habitat is characterized by a significant degree of improvement since controls were placed on metal mining waste disposal practices. Contributions to dissolved metal levels from streambank tailings and river sediments probably still occur but their effect on fish is not acute. This may be due to a significant degree of natural stabilization, a climate with plenty of precipitation which prevents accumulation of oxidized metal compounds at the surface, and the dilution effects of the North Fork and many other small tributaries which are not impacted by mining. Physical methods are available to reduce metal input to the stream from deposited tailings. These include:

- Selective excavation of severely impacted areas away from the stream to reduce

their impact on stream water quality,

- Construction of erosion control structures to minimize the reexposure of currently isolated tailings,
- Isolation of impacted areas by soil capping and revegetation,
- Reduction of metal mobility by lime incorporation to control acidity (this is most useful with pyritic tailings which have the highest potential for acid production),

Fish are also subject to the effects of heavy metal contamination through the consumption of food sources living in the metal-rich sediments and specimens from the area do show elevated metal levels in liver and kidney tissue. Except for the tendency for bioaccumulation of metals only in these inedible portions this might be a serious problem for humans as well. Tailings are so widely distributed in the stream bed and so subject to disturbance and displacement that permanent remedies to improve this situation measurably would be massive projects. In view of the fact that fish are surviving in this environment, such efforts do not appear to be justified.

Wildfowl are believed to be exposed to heavy metals primarily through consumption of food sources contaminated by sediments. Documented swan fatalities appear to have been tied to flood events that leave a residue of metal-bearing sediments on vegetation. Reduction of risk to wildfowl may be a more attainable goal which can be accomplished using physical measures. Among the measures which might be effective are:

- Flood control measures to reduce sediment input into areas frequented by waterfowl or to maintain flooded conditions in affected areas during nesting,
- Development of new habitat in areas of low contamination to encourage wildfowl to frequent these areas instead of heavily contaminated ones,
- As a corollary to this last item, habitat destruction to discourage use might even be considered if the threats in certain areas are judged to be sufficiently great. This would be indicated for areas demonstrating recurring high mortality rates. Destruction of habitat would probably result in a smaller population of resident species. This is a clear drawback even though the general health of the resulting population might be improved.

Physical alternatives have special significance when new projects are undertaken. Often such projects will bring substantially increased use to an area. In such instances it would be prudent to take additional measures to protect users from possible exposure. Ideally, the first step in this process would be to select sites without extensive

contamination. When this does not appear to be a viable option, the use of physical remediation techniques to reduce the potential dangers in the project area should be considered. Implementation of a project may result in disturbances which increase the level of exposure in an area. Such projects should include an assessment of worker protection requirements during construction and for restabilization of disturbed areas prior to use.

Appropriate methods for the construction phase of such projects include:

- Dust filtering face masks for workers doing excavation work or whenever dust levels are expected to be excessive (OSHA 1910.120 rules),
- Adequate on-site facilities for worker cleanup before lunch breaks, and
- Provision for containment of excavated materials to prevent erosion or runoff from placing additional metal bearing materials into the stream channel.

Appropriate methods for reducing potential risks to users at a project site and restabilizing disturbed areas include:

- Removal of localized highly contaminated materials,
- Lime incorporation to promote the establishment of vegetation which provides a significant level of stabilization,
- Soil capping to reduce exposure opportunity and promote reestablishment of vegetation where liming alone will not establish suitable growing conditions, and
- Protection of constructed or stabilized features by appropriate erosion control techniques .

6.3 Site-Specific Management Options on Current BLM Holdings

Specific land management actions which BLM should consider for its current holdings are discussed below. The land parcels described are grouped by location in USGS range designations beginning at the upper end of the river in the Cataldo area and following the river downstream to Lake Coeur d'Alene.

T.48N, R.1E. B.M.

Section 6: Lots 9, 10, 11, SE $\frac{1}{4}$ SW $\frac{1}{4}$, and NW $\frac{1}{4}$ SE $\frac{1}{4}$

This 191.77 acre parcel, which adjoins a similar 318.63 acre parcel in T.48N R.1W, is characterized by its relatively high elevation compared to most other land holdings in the area. Because of this and its isolation from the river by the Union Pacific railroad tracks, the majority of this land has probably not been severely impacted by mine tailings. Its relatively large size and low hazard ranking make it a potentially useful property. Unfortunately, the very things that have spared this property from impact also restrict its usefulness for development.

The elevation has prevented the development of wetland areas useful for waterfowl habitat. The parcel suffers from poor access characteristics which limit its value to recreational users who might reach the area by boat. This is primarily because of the close proximity of the railroad to the river in this area but also because it is located over 25 miles from the mouth of the river at Lake Coeur d'Alene. The property does provide river access to fishermen. However, access by motor vehicles is less than ideal because of the location on the south side of the river away from the highway and the railroad situated between the river and unimproved access road. This property might be useful for non-wetland game management. BLM should also consider its value for potential land exchanges for parcels more suited to recreational, fishing and hunting use.

T.49N, R.1E. B.M.

Section 32, Lots 4, 8, and 9

This 49.53 acre parcel of land is divided by the river and located in an area prone to flooding and channel movement. Vegetation is quite sparse. Hazard mapping suggests that the area is heavily contaminated with mine tailings. Its small size, susceptibility to flooding and high hazard ranking makes it generally unsuitable for development. The parcel is close to the highway which might make it useful for a boat launching area. However, because of the high hazard potential the site is probably best left undeveloped. A large area to the northwest of BLM's property appears to have been subject to past flooding events. This particular area might benefit from flood control measures to prevent additional flood deposition of metal-bearing sediments.

T.48N, R.1W, B.M.

Section 1, Lots 6 and 7, N $\frac{1}{2}$ SW $\frac{1}{4}$, SE $\frac{1}{4}$ SW $\frac{1}{4}$, and SE $\frac{1}{4}$

This is a 318.63 acre parcel adjoining the parcel described in T.48N, R.1E. The analysis of that section applies to this piece of land as well. Since together the two parcels comprise about one-half of the total BLM lands studied in this report and are physically connected, these tracts are important to BLM. However, they do not appear to be suited to development in line with BLM management goals for the area.

Section 2, Lot 6 and Section 3, and SE $\frac{1}{4}$ NE $\frac{1}{4}$

These adjoining parcels totaling 51.66 acres front the river for 1700 feet on the north side. This area appears to have been subjected to heavy traffic either from logging activities or other truck access. Aerial photos show this portion of the river is used for staging of log rafts. Because of existing access roads it is a good candidate for evaluation as a boat ramp site providing access to the upper portion of the river. The site does not appear to be particularly useful for wildlife management.

T.48N, R.2W, B.M.

Killarney Lake Area

This area includes 104.0 acres of property in Section 10 on the west side of Killarney Lake and Popcorn Island, 101.0 acres in Section 11 on the east side of the lake, and 25.0 acres of wetlands in Section 14 on the southeast corner of the lake. This area is the most developed of BLM's holdings and is the most heavily used. Section 10 includes developed picnic sites on Popcorn Island. Section 11 has a boat ramp, several boat docks and developed picnic sites. The holdings in Section 14 are included in the area developed jointly with IDFG and the Corps of Engineers for swan nesting sites.

The areas in Sections 10 and 11 are BLM's best candidates for additional recreational development in the LCDAR. They are located on the north end of the lake where the distance from the main river channel has probably reduced the sediment loads substantially. Stream flow from Killarney Creek, Fortier Creek and Armstrong Creek is also a positive factor which should tend to keep this end of the lake relatively clean. BLM's holdings in Section 11 may have been protected from contamination by the access road from Rose Lake, though early flooding events preceding the construction of the road may have brought some sediments further inland.

Subject to the site specific studies described in Section 5, we would feel comfortable with development of more extensive recreational facilities in this area. Overnight tent camping facilities could be developed on both sides of the lake on suitable ground. However, we would recommend that such sites be located away from the lake by 100 feet or more requiring users to walk between their camp sites and boats. Signs should be posted at the beach areas prohibiting camping except in developed camp sites. On the east side we recommend that the areas adjacent to the access road, particularly on the east side of the road, be given consideration as a possible drive-in campsites. Steep terrain may become limiting, however, as one move farther from the lake shore. These steps would assure that the use sites are relatively uncontaminated and would discourage extensive use of the beach areas. Water would need to be developed for these sites. A program to identify suitable drinking water and verify low levels of metal contamination would also be required.

Killarney Lake, especially its north end and the streams entering the lake there, might also be a good area for fisheries management programs. This would be desirable to complement recreational developments which would inevitably result in greater fishing use. If Killarney, Fortier and Armstrong Creeks are not already extensively used as spawning areas by game species, programs to introduce species which would use these streams and the lake itself should be considered. Since neither the management of these streams nor the taking of fish falls within the jurisdiction of the BLM, this sort of development would require joint action with other agencies.

The 25 acres in Section 14 are most logically suited to waterfowl management simply because they are wetlands. This is the purpose for which they have been used in the past. However, this management approach may have disregarded the potential environmental threats of this area because of its close proximity to the river channel. This area has been and continues to be subject to flooding events which bring in additional contaminated sediments and disturb previously deposited material. The channel providing access between the lake and the river passes through the area developed with nesting islands. As such the area tends to be frequented by recreational users. According to BLM personnel, there has not been an apparent impact on the use of this area as a wildlife management area because of the heavy recreational use. However, potential conflicts of use such as this is a factor which we feel should be considered for future projects as a part of a policy to implement a pattern of selective use.

Medicine Lake Area

BLM owns a 20.0 acre tract on the south end of Medicine Lake which is now largely submerged because of water level control measures on Lake Coeur d'Alene. This is a somewhat unique area in that it is the only wetland area held by BLM south of the

Union Pacific tracks. Because of the protection provided by the tracks and the location of the property on the south end of Medicine Lake, well away from the river channel, there is a good likelihood that this area has not been heavily impacted by mining wastes. This would provide an area which could be suitable for waterfowl management purposes. Evans Creek flows into Medicine Lake in this area which should help keep water quality levels high. Fishery management programs similar to those suggested for Killarney Lake's north end might be considered here as well.

T.48N, R.3W. B.M.

Submerged Thompson Lake

This area is comprised of 67.50 acres of wetland bog on the south side of Thompson Lake. The river channel in this area has been maintained through dredging operations. Dikes containing mining wastes are apparent. It is probable that Thompson Lake itself has been subjected to frequent episodes of stream sediment deposition prior to the construction of a maintained river channel.

Thompson Lake is not suited to boating because of its boggy nature but appears to be an attractive area for habitat development programs since waterfowl do frequent this area. However, because of the probable level of contamination in bottom sediments, development programs which would disturb existing soils or sediments should not be attempted.

BLM would like to attempt to modify the wetland vegetation, which is dominated by Equisetum (horsetails), by destruction of this species and replacement with more desirable species for waterfowl management such as wild rice. However, before attempting such measures BLM should consider that methods which expose soils through destruction of vegetation or increase opportunity for erosion of currently stabilized areas may increase the availability of metals and temporarily increase hazard levels. We do not recommend any such programs except on a trial basis on limited areas. We would prefer to see establishment of other species through interseeding and natural competition to minimize the potential for destabilizing existing vegetation and reexposing contaminated soils.

Before such programs are undertaken it would be wise to demonstrate the viability of wild rice or alternative species in metal-enriched soils. Not all plants are tolerant of high metal levels. Equisetum may have become predominant in the area because of an inherent resistance to high metal levels in soil. Horsetails grow in heavily contaminated areas of the old Anaconda mill site where virtually nothing else is able to become established. Also, there are other areas, the Medicine Lake area or the north end of

Killarney Lake for example, which might provide a better testbed for these methods because of lower contamination levels than are likely to be found in the Thompson Lake area.

Lambs Peak Area

On the south side of the river across from Thompson Lake, BLM administers two noncontiguous parcels of 40.00 and 37.66 acres. These parcels are both located primarily on steep terrain rising away from the river and protected from the main river channel by the Union Pacific tracks. For the most part, these lands are likely to be largely uncontaminated because of their elevation above the river. However, like the large tract of land in Section 6 of T48N R1E and Section 1 of T48N R1W, these lands are poorly accessed. In general they do not offer development opportunities complimenting BLM's traditional management goals for the area. They are good candidates for sale or exchange. Failing that they are suitable only for management as non-waterfowl wildlife habitat.

T.48N, R.4W. B.M.

Section 25, S $\frac{1}{2}$ SE $\frac{1}{4}$ and Section 35, Lot 3

These two parcels totaling 116.0 acres are now submerged except for a few acres in Section 25 due to efforts to maintain a higher level in Lake Coeur d'Alene. They are located at the mouth of the river as it enters Coeur d'Alene Lake. Areas of higher hazard are identified nearby where dredging has brought metal-laden sediments ashore. The submerged areas are probably contaminated as well since they are situated in the delta area where large quantities of sediments are typically found. Because there is little usable land in BLM's holdings here and the area is likely to contain metal contaminants, these parcels are best left undeveloped or disposed of.

6.4. Recommended Action Plans

6.4.1 General Recommendations

The administrative management alternatives seem to be most appropriate for this area and emphasis should be placed on these since they can be implemented relatively quickly and produce beneficial results at low cost. Foremost among these should be the establishment of planning criteria since these will determine a basic framework for future development possibilities. BLM is already taking steps in this direction as this study will provide essential planning information. Establishment of selective use areas is going to be essential if wildlife habitat is to be preserved in an area of rapidly increasing recreational use. However, the implementation of such measures should first consider the possibilities

available under an area wide management plan as discussed above. With regard to educational programs, BLM should consider posting of high risk areas on its own property immediately. The criteria and data for establishment of these locations may be lacking at the present time. However we suggest that any areas with a combination of exposed tailings areas with frequent recreational use would be likely candidates. Other educational programs, such as publication of informational brochures, might be considered on an area wide basis if other land owners see a need for similar actions.

The implementation of physical remediation methods does not appear to be warranted from a human health standpoint but BLM may want to consider such methods for wildlife habitat and fisheries management. The least costly options for this are to encourage use of areas which present relatively low risk. Programs to develop new habitat in areas of low tailings impact should be adopted as one way of reducing the overall exposure to migratory waterfowl. It may be that some areas are not severely impacted but still subject to the effects of floods and high water events. These areas may be protected against further deterioration through flood control measures and water level control. It is less expensive to provide protective measures for habitat than to attempt reclamation of damaged habitat. Channel dredging in the area of Lake Coeur d'Alene has already provided a significant degree of flood control in this area. However, other less disruptive flood control measures should be employed to minimize potential for creating poorly vegetated high risk areas as dredging seems to do. Finally, because much of the affected habitat is wetland and work in such areas is difficult, physical remediation measures as a way of reclaiming habitat will be exceptionally costly. There may be certain areas along the river where large quantities of tailings materials have been deposited as a result of channel migration or flood events. Such areas might be considered as candidates for permanent stabilization and revegetation by soil capping, revegetation, and erosion control. Such actions may help to reduce the level of continuing impacts caused by major flood events.

For new BLM development projects, the choice of available alternatives should be left open until a detailed site characterization is made. Generally, these projects will affect relatively small areas. In this environment, appropriate measures can be taken without excessive cost to assure that human health and environmental quality are not put at risk. In all cases the consequences of proposed actions should be considered and necessary data on the extent of contamination at a given site should be gathered to provide a basis for making intelligent decisions regarding the project.

BLM has two primary mechanisms for taking action. It may act independently or it may choose to take cooperative actions with other regional land managers, primarily the IDFG and USFS. In the subsections below we recommend specific actions which should be taken either jointly or independently by BLM. We first address the current needs of the area for environmental and public health protection. This is followed by

recommendations for area land management with specific recommendations for all of BLM's current land holdings on the LCDAR and its lateral lakes.

6.4.2 Cooperative Actions for Environmental and Public Health Protection

The low level of public health risk in the LCDAR should not be cause for alarm or abandonment of the area for recreational use. However, educational programs to increase public awareness of the problems are advised. Informational brochures should be made available to users at all public access and use points. This would include all boat ramps, picnic areas, camping areas and administration offices. For BLM this would apply primarily to its sites in the Killarney Lake area. Brochures should briefly describe the health problem, explain who is most at risk, and suggest actions which will limit exposure while using the area. Boaters entering the river from Lake Coeur d'Alene should be advised of the potential health risks with a sign prominently located on the shore. This sort of program is effective only on an area-wide basis. Therefore, cooperative action is essential.

The brochure should explain that ingestion is the principle mechanism for exposure in both humans and wildlife. It should point out that although metal levels are slightly high in water and in the edible tissues of fish and waterfowl taken in the area, the degree of exposure to humans through these pathways is small. It should stress that only through direct ingestion of contaminated soils where metal concentrations are potentially thousands of parts per million will high exposure be obtained. Consequently, it should emphasize that small children are most at risk. A point should be made that the effects of metal poisoning are usually the result of repeated exposure and that a single incident of ingestion is not cause for alarm.

6.4.3 Independent Actions for Environmental and Public Health Protection

Certain BLM properties present higher human health risk than others. These are typically areas in which soils are poorly vegetated and thereby expose users directly to potential contact. Such areas should be posted to alert users to the higher level of exposure potential. We recommend that BLM take such measures whether or not they are adopted by other managing agencies in the area. It not only provides a reminder to users of the need for awareness and precautions but also demonstrates that BLM is not neglecting its responsibilities in management of an area with these special problems. Areas subject to especially high use should be posted as well to reinforce public awareness. Posting of the following BLM properties is recommended:

- Killarney Lake boat ramp; one sign required

- Killarney Lake picnic areas; three signs required
- Cataldo area (Section 32 of T.49N) river front on both sides of the river at property boundaries and at 2000 foot intervals between boundaries; four signs required
- Lake front in the river delta area (Section 25 of T.48N) at property boundaries and at 2000 foot intervals in between as required; two signs required

6.4.4 Cooperative Actions for Area Land Management and Development

Because BLM's holdings are scattered throughout the area, the first course of action should be to continue to work with other land owners considering land management problems from an area-wide standpoint. This will increase the possibility of creating managed areas of sufficient size to be effectively utilized. Barring the development of joint management actions, a cooperative atmosphere could expose opportunities for land exchange in which owners are able to match their management goals with land best suited to that purpose.

It appears that much of BLM's land, particularly the large tract in the Dudley area, is not suited to either recreational use or active wildlife management programs. These lands might best be used to acquire other tracts better suited to BLM management goals through exchanges.

6.4.5 General Recommendations for Evaluation of Possible Land Acquisitions

Land which has been least impacted by mining waste should be preserved for wildlife management whenever possible. Unlike recreational users, waterfowl and fish cannot be made aware of the environmental hazards around them and they are much more susceptible to exposure through ingestion which is the principal exposure pathway for metal contaminants. If BLM is interested in expanding its role in wildlife management, it may want to look at possible acquisitions on the south side of the river in the Cave Lake, Medicine Lake, Black Lake and Anderson Lake areas. The railroad has probably spared these areas from much of the adverse impacts of mining waste deposition.

For recreational use, Killarney Lake has much to offer and consolidation of holdings would increase management possibilities. The north end seems well suited to wildlife management and possibly fisheries management using the streams flowing into the lake there. The Black Lake area has characteristics similar to Killarney Lake which would make it an attractive recreational use area. These include a river access channel, an elongated shape providing an area well removed from the river (and its metal contaminated sediments) plus the protection from extensive contamination provided by the railroad. This area has greater physical relief than the Killarney Lake area and access

appears to be limited to the eastern and southern sides of the lake. These accessed areas are developed with private structures along the shoreline so the opportunities for acquiring lands for public development could be limited. There are also reported problems with algal blooms and low levels of cyanide which suggest that pollution in the lake may be a problem.

6.5 Implementation of Recommended Actions

6.5.1 Cooperative Actions

The existence now of the Coeur d'Alene River Basin Interagency Group provides a framework for planning joint actions in the LCDAR. We believe that it is appropriate to build on this organization for effective management and development of the area. We have recommended that a program to increase public awareness of the environmental problems in the LCDAR be initiated as a critical element in safe public use of the area. Members of the Interagency Group who should be involved in this activity include the USEPA, IDEQ, and the public land administrators in the area (BLM, USFS, IDL and IDFG). The lead role should be with either EPA or IDEQ. We suggest that IDEQ may be a better choice in that it may not leave the public with an impression that the problems are serious enough to require EPA involvement in a prominent way.

The Interagency Group should also provide the forum for airing views on cooperative land management actions. This would involve principally the public land administrators. IDFG should take the lead regarding wildlife habitat management. It has massive holdings in the wetland areas all along the river from Lake Coeur d'Alene to Rose Lake. In view of the size of IDFG's land holdings it must take the lead in any cooperative regional wildlife management plan. It may even be in a position to effectively provide for wildlife habitat management without cooperative agreements if it wants to take such a stance.

BLM may want to take the lead role with regard to cooperative recreational use agreements. It is the most prominent land holder in the Killarney Lake area. This area seems to offer the best recreational opportunities in the entire area and is in need of additional facilities to better accommodate the level of use it is experiencing.

6.5.2 Independent Actions

BLM's current opportunities for independent wildlife management programs are limited. Most of its holdings are too small for this purpose. Its present staff should be adequate to coordinate any required activities.

We are supportive of efforts to improve waterfowl habitat in the Thompson Lake area through an interseeding program but we strongly suggest that this be done on a trial basis to assess the persistence of such treatments. We also cannot recommend the destruction of existing vegetative growth in the area since establishing any vegetation in metal impacted areas is often very difficult. Success in establishing a sustainable growth of wild rice or other desired species could lead to more extensive programs to provide an improved feeding area. BLM should monitor growth for metal uptake and conduct a study to determine whether waterfowl use of the seeded areas is increased. The study should attempt to assess whether there are any adverse health effects on waterfowl using the area. If there appear to be adverse effects, it is not advisable to proceed with any programs that would encourage waterfowl to use this area.

BLM should make an inspection of its property on Medicine Lake to determine the potential for habitat management or improvement in this area. It may want to sample bottom sediments in this area to confirm our theory that this is an area of low-level contamination entirely suitable for waterfowl use. If this is the case, options for habitat management may be less constrained than on other properties.

High hazard areas and certain areas of high use which were identified in Section 6.4.3 should be posted to advise and/or remind recreational users of the potential hazards in the area. This is an activity BLM can conduct with its own personnel.

BLM should actively explore the possibilities for developed camping facilities at its Killarney Lake properties. The necessary steps for such a feasibility study are as follows:

- 1) A walk-through by BLM personnel to identify the number of sites that are physically suited for development as either tent camping sites or as recreational vehicle sites. Sites should be selected no less than 100 feet from the lake shore in accordance with our recommendation to keep the activities of users away from the shoreline as much as possible.
- 2) BLM should identify water sources to support potential camping sites. BLM may want to subcontract this portion of the study. Water from underground sources should be tested to confirm that it meets drinking water standards. A hydrologic study to assess the potential for sustaining the water quality for extended periods of use is also in order. The hydrologic study should specifically address the potential for contamination by lake water.
- 3) Soil sampling should be conducted randomly in potential camp sites to confirm that these areas are essentially free of high levels of metal contamination. Sampling of areas closer to the shoreline should also be done to quantitatively determine the

level and extent of metals in shoreline areas. This information is necessary to assess whether contamination is too high in these areas to allow extensive recreational use nearby. It will also provide information for evaluating the applicability of physical remediation measures such as excavation or soil capping which would reduce the potential hazards. BLM could conduct such soil sampling itself under a protocol established by a firm with expertise in characterization of mining impacted areas. However, interpretation of the data and assessment of the need for physical remediation measures would be best done by a reclamation specialist.

- 4) Evaluate alternative development concepts to arrive at a preferred arrangement for the number and type of facilities which are to be developed. BLM is best qualified to conduct this activity but would want to solicit technical input from specialists regarding hazard management issues.
- 5) Prepare preliminary plans for area facilities based on the preferred alternative. These documents, consisting of drawings, outline specifications, cost estimates and a narrative description of the planned facilities (as well as the alternates considered) will provide the basis for BLM administration to authorize and fund a development program. If BLM typically conducts such design efforts internally there is no reason that it cannot do the same here, again with technical input related to hazard issues as required from outside consultants.

This project would require a high level of effort, beyond the capabilities of the current BLM staff in the Coeur d'Alene office. Attention would not only be required to the usual development tasks but to the special environmental and human health considerations which make the project substantially more complex. Effective coordination would be necessary between the project officer, the design group and technical consultants to produce a functional and environmentally safe design.

Cost estimates and level of effort to conduct the programs discussed above are provided in Tables 6.3 through 6.6.

Table 6.3 Cost estimate for interseeding study at Thompson Lake.

	<u>Quantity</u>	<u>Cost</u>
Internal Labor Effort (4 year program)		
Background Data Acquisition	200 m-hr(P)	\$ 5,000
Trial Plot Construction (1 acre)	40 m-hr(P)	1,000
Trial Plot Monitoring - Vegetation	100 m-hr(P)	2,500
Trial Plot Monitoring - Wildlife	600 m-hr(P)	15,000
Technical Report and Recommendation	120 m-hr(P)	3,000
	40 m-hr(C)	600
Outside Services		
Analytical Services - Vegetation	30 samples	\$ 4,500
Analytical Services - Soils	6 samples	750
Materials and Equipment		
Seed	50 lbs.	\$ 200
Fertilizer	750 lbs.	225
Miscellaneous Office Supplies	Lot	200
Travel and Subsistence		
Mileage	3000 mi	\$ 750
Boat (Rental or Dept. Charge)	100 days	<u>1,000</u>
	Total	\$ 34,725

P = Professional C = Clerical T = Technician A = Administrative

Table 6.4 Cost estimate for wildlife habitat survey at Medicine Lake.

	<u>Quantity</u>	<u>Cost</u>
Internal Labor Effort (3 month program)		
Site Investigation and Sampling	10 m-hr(P)	\$ 250
Data Analysis	10 m-hr(P)	250
Report and Recommendation	16 m-hr(P)	400
	4 m-hr(C)	60
Outside Services		
Analytical Services - Vegetation	6 samples	\$ 900
Analytical Services - Soils	6 samples	725
Materials and Equipment		
Miscellaneous Office Supplies	Lot	50
Travel and Subsistence		
Mileage	20 mi.	\$ 5
Boat (Rental or Dept. Charge)	1 day	<u>10</u>
	Total	\$ 2,650
<p>P = Professional C = Clerical T = Technician A = Administrative</p>		

Table 6.5 Cost estimate for sign installation at critical BLM sites.

	<u>Quantity</u>	<u>Cost</u>
Internal Labor Effort (6 month program)		
Sign Design and Siting	24 m-hr(P)	\$ 600
Fabrication Contract Administration	24 m-hr(A)	840
	8 m-hr(C)	120
Field Installation	48 m-hr(T)	960
Outside Services		
Sign Fabrication	12 ea (2 spare)	\$ 1,440
Materials and Equipment		
10 ft steel posts	20 ea	\$ 200
Sac-Crete	700 lbs	30
Fasteners	Lot	10
Cement Mixer Rental	3 days	75
Travel and Subsistence		
Mileage	60 mi	\$ <u>15</u>
	Total	\$ 4,290

P = Professional C = Clerical T = Technician A = Administrative

Table 6.6 Cost estimate for campground feasibility study at Killarney Lake.

	<u>Quantity</u>	<u>Cost</u>
Internal Labor Effort (6 month program)		
Site Investigation	40 m-hr(P)	\$ 1,000
Alternative Development Plans	160 m-hr(P)	4,000
Preliminary Plans, Preferred Alternative	320 m-hr(P)	8,000
	800 m-hr(T)	16,000
Project Administration	360 m-hr(A)	12,600
	240 m-hr(C)	3,600
Outside Services		
Hydrologic Investigation	Lump Sum	\$ 20,000
Analytical Services - Soils	24 samples	3,000
Land Reclamation Consultant	Lump Sum	6,000
Environmental Health Consultant	Lump Sum	6,000
Materials and Equipment		
Drafting Materials and Reproduction	Lot	\$ 1,000
Miscellaneous Office Supplies	Lot	50
Telephone, Postage etc.	Lot	300
Travel and Subsistence		
Mileage	1200 mi.	\$ 300
Subsistence	25 days	625
Lodging	20 days	1,000
Air Fare	5 trips	2,000
Car Rental	20 days	<u>900</u>
	Total	\$ 92,375

P = Professional C = Clerical T = Technician A = Administrative

REFERENCES

Environmental Health Issues

- Abo-rady, M.D.K. (1979). Gehalt an Schwermetallen (Cd, Cu, Hg, Ni, Pb, Zn) in Bachforellen im Leine-Raum Gottingen. Zeitschrift für Lebensmittel Untersuchung und Forschung, 259-63.
- Anderson, R.V. (1977). Concentration of cadmium, copper, lead and zinc in thirty-five genera of freshwater macroinvertebrates from the Fox River, Illinois and Wisconsin. Bulletin of Environmental Contamination and Toxicology, 345-9.
- Baccini, P., Hohl, H.&Bundi, T. (1978). Phenomenology and modelling of heavy metal distribution in lakes. Verhandlungen, Internationale Vereinigung für Theoretische und Angewandte Limnologie, 1971-5.
- Bendell-Young, L.I., Harvey, H.H.& Young, J.F. (1986). Accumulation of cadmium by White Suckers (Catostromus commersoni) in relation to fish growth and lake acidification. Canadian Journal of Fisheries and Aquatic Science, 806-11.
- Benson, W.W., Brock, D.W., Gabica, J. and Loomis, M. (1976). Swan mortality due to certain heavy metals in the Mission Lake Area, Idaho. Bulletin Environmental Contamination and Toxicology. 15:171-174.
- Blus, L.J., C.J. Henn, A. Anerson and R.E. Fitzner. (1985). Reproduciton, mortality, and heavy metal concentrations in great blue herons from three colonies in Washington and Idaho. Colonial birds 8(2)110-116.
- Bowen, J.J.M. (1975). Residence time of heavy metals in the environment. pp.1-19. In: Hutchinson, T.C. (Ed.) The Handbook of Environmental Chemistry Volume 1: Plenary, Futures, Analytical. Toronto, Ontario.
- Bradley, S.B. & Lewin, J. (1982). Transport of heavy metals on suspended sediments under high flow conditions in a mineralized region of Wales. Environmental Pollution Series 257-67.
- Bradshaw, A.D.& McNeilly, T. (1981). Evolution and Pollution. 76PP. Institute of Biology Studies in Biology No. 130. Edward Arnold, London.
- Burrows, G.E., J.W. Sharp, and R.G. Root. (1981). A survey of blood lead concentrations in horses in the north Idaho lead/silver belt area. Veterinary and Human Toxicology. 23:328-330.

REFERENCES

(Continued)

- Burrows, I.G. & Whitton, B.A. (1983). Heavy metals in water, sediments and invertebrates from a metal-contaminated river free of organic pollution. Hydrobiologia, 37-43.
- Chapman, W.H., et al. (1968). Concentration Factors of Chemical Elements in Edible Aquatic Organisms. Livermore, California. Lawrence Radiation Laboratory, VCRL-50564.
- Chupp, N.R. & Dalke, P.D. (1964). Waterfowl Mortality in the Coeur d' Alene River Valley, Idaho. Journal of Wildlife Management, Vo. 28: pp. 692-702.
- Cowx, I.G. (1982). Concentrations of heavy metals in the tissues of trout Salmo trutta and char Salvelinus alpinus from two lakes in North Wales. Environmental Pollution Series A, 101-10.
- Elderfield, H., Thornton, I. & Webb, J.S. (1971). Heavy metals and oyster culture in Wales. Marine Pollution Bulletin.
- Ellis, M.M. (1932). Pollution of the Coeur d' Alene River and Adjacent Waterways by Mine Wastes. Manuscript report to the commissioner. U.S. Bureau of Fisheries, Washington, D.C.
- EPA (1979). Water Related Environmental Fate of 129 Priority Pollutants. Vol.1, U.S. EPA, Office of Water and Waste Management; EPA-440/4-79-029A.
- EPA (1984). Health Assessment Document for Zinc. Revised Final Draft. ECAO-CIN-HO48.
- EPA (1985). The Endangerment Assessment Handbook. Prepared for U.S. EPA, Office of Waste Programs Enforcement, Washington, D.C. 20460.
- EPA (1986). Superfund Public Health Evaluation Manual. Prepared for U.S. EPA Emergency and Remedial Response, Office of Solid Waste and Emergency Response. Document No. 540/1-86/060, OSWER Directive No. 9285.4-1.
- EPA (1988). Reference Dose (RfD): Description and use in Health Risk Assessment. Technical Information Center, Document No. D-14.580.
- EPA (1987). Draft Final: Coeur d' Alene Basin - EPA Water Quality Monitoring (1972-1986).

REFERENCES

(Continued)

- EPA (1989). Exposure Factors Handbook. Document No. EPA/600/8-89//043. Prepared by the EPA, Office of Environmental Assessment Group.
- Fortier, D. (1989). Oral Communication with WESTON on October 20, 1989.
- Funk, W.H., et al. (1975). An Integrated Study on the Impact of Metallic Trace Element Pollution in the Coeur d' Alene Spokane Rivers - Lake Drainage System. Washington State University and University of Idaho. OWRT (Title II project C-4145).
- Hegi, H-R. & Geiger, W. (1979). Schwermetalle (Hg, Cd, Cu, Pb, Zn) in Lebern und Muskulatur des Flussbarsches (Perca fluviatilis) aus Bielersee und Walensee. Schweizerische Zeitschrift für Hydrologie, 94-107.
- Herman, S.G. (1975). Lead and cadmium in soils, vegetation, and small animals near Kellogg, Idaho. Evergreen State College, Olympia, Washington.
- Horner, N. (1985). Oral Communication with Woodward-Clyde Consultants. Cited in Woodward-Clyde et al. 1986. Interium site characterization report for the Bunker Hill Site. Report submitted to EPA, Seattle, WA.
- Jackson, T.A. (1978). A biochemical study of heavy metals in lakes and streams, and a proposed method for limiting heavy metal pollution of natural waters. Verhandlungen, Internationale Vereinigung für Theoretische und Angewandte Limnologie, 1945-6.
- Jorgensen, S.E. & Jensen, ?A. (1984). Processes of metal ions in the environment. pp. 61-103. In: Sigel, H. (Ed.) Metal Ions in Biological systems. Marcel Dedder Inc. New York & Basel.
- Keeney, W.L., Breck, W.G., Van Loon, G.W.&Page, J.A. (1976). The determination of trace metals in Cladophora glomerata - C. glomerata as a potential biological monitor. Water Research, 981-4.
- Kemmerer, G. et al. (1923). Northwestern Lakes of the U.S.: Biological and Chemical Studies with Reference to Possibilities in Production of Fish. Bulletin of the Bureau of Fisheries, Washington D.C. U.S. government Printing Office, Vol. 39, No. 944.
- Kelly, M., (1988). Mining and the Freshwater Environment, Elsevier Science Publishers LTD, New York and London.

REFERENCES

(Continued)

- Kinkade, M.L. and H. E. Erdman. (1975). The Incidence of Hardness Components (Ca²⁺ and Mg²⁺) in Water on Uptake and Concentrations of Cadmium in a Simulated Fresh Water Environment. *Environ. Res.* 10(2): 308-313.
- Krieger, R.I. (1982). Heavy metal poisoning in whistling swans. University of Idaho, W01 Regional Program Veterinary Medicine report to Idaho Department of Fish and Game. 4pp.
- Krieger, R.I. (1986). Letter to U.S. EPA Regarding Lead and Swans in the South Fork River Valley with two copies of Abstract. 13014.
- Krieger, R. I. (1986a). High water sediment deposits Coeur d'Alene River. W01 Regional Program Veterinary Medicine, University of Idaho report to Idaho Department of Fish and Game. 2pp.
- Krieger, R. I. (1986b). Muskrat liver leads, University of Idaho, W01 Regional Program Veterinary Medicine. Idaho Department of fish and Game. 2pp.
- Krieger, R. I. (1986c). Lead shot survey-ducks, Washington State University, Animal Disease Diagnostic Laboratory, Report to Idaho Department of Fish and Game. 12pp.
- Krieger, R. I. (1986d). Rose Lake marsh soil samples for lead determination, University of Idaho. W01 Regional Program, Veterinary Medicine, report to Idaho Department of Fish and Game. 2pp.
- Krieger, R. I. (1986e). Preliminary report regarding the lead status of the birds from the Hidden Island area, Washington State University, Animal disease Diagnostic Laboratory, Report to Idaho Department of Fish and Game. 8pp.
- Krieger, R. I. (1986f). Laboratory report on duck liver lead, Washington State University, Animal Disease Diagnostic Laboratory. 2pp.
- Krieger, R. I. (1987). Letter to Dr. Greg Nelson, Idaho Department of Agriculture, February 3, 1987.
- Krieger, R. I. (1987a). Laboratory report duck livers, Rose Lake and Coeur d'Alene River Islands, Washington State University, animal Disease Diagnostic Laboratory. 5pp.

REFERENCES

(Continued)

- Krieger, R. I. (1989). Toxicity and Bioavailability studies of lead and other elementals in the Lower Coeur d'Alene River. Prepared for U.S. Department of the Interior, Bureau of Land Management.
- Kriezenbeck, R.A. (1978). Analysis of cutthroat trout for heavy metals on the South Fork Coeur d' Alene River. U.S. EPA.
- Laxen, D.P.H. (1983). Physico-Chemical speciation of selected metals in the treated effluent of a lead-acid battery manufacturer and in the receiving water. Water Research, 71-80.
- Lu, P.V., et al. (1975). Model Ecosystem Studies of Lead and Cadmium and of Urban Sewage Sludge Containing These Elements. J. Environ. Quarterly, 4(4): 505-509.
- Margolis, S. (1986). Review of fish sampling results from Lake Coeur d' Alene, Idaho. USDHHS.
- Mathis, B.J. & Kevern, N.R. (1975). Distribution of mercury, cadmium, lead and thallium in a eutrophic lake. Hydrobiologia, 207-22.
- McDuffie, B., El-Barbary, I., Holland, G.J. & Tiberio, R.D. (1977). Heavy Metals in Susquehanna River bottom sediments - surficial concentrations, urban impacts and transport mechanism. pp.467-8. In: Hutzinger, O., Van Lelyveld, I.H. & Zoeteman, B.C.J. (Eds) Aquatic Pollutants: Transformation and Biological Effects. Pergamon Press Oxford.
- Merlini, M. & Pozzi, G. (1977). Lead and freshwater fishes. Part 1 - Lead accumulation and water pH. environmental Pollution, 167-72.
- Moore, J. W. & Ramamoorthy, S. (1984). Heavy Metals in Natural Waters. Applied Monitoring and Impact Assessment. Springer-Verlag, New York. 268 pp.
- Murphy, B.R., Atchinson, G.J. & McIntosh, A.W. (1978). Cd and Zn in muscle of bluegill (Lepomis macrochirus), and largemouth Bass (Micropterus salmoides) from an industrially contaminated lake. Environmental Pollution, 253-7.
- Neufeld, J. (1987). A Summary of Heavy Metal Contamination in the Lower Coeur d' Alene River Valley with Particular Reference to the Coeur d' Alene River Wildlife Management Area. Prepared by the Regional Wildlife Land Manager, Idaho Department of Fish and Game, Coeur d' Alene.

REFERENCES

(Continued)

- Norris, R.H. & Lake, P.S. (1984). Trace-metal concentrations in fish from the South Esk River, Northeastern Tasmania. Bulletin of Environmental Contamination and Toxicology, 348-54.
- Pagenkopf, G.F. & Neuman, D.R. (1974). Lead concentrations in native trout. Bulletin of Environmental Contamination and Toxicology, 70-5.
- Penwak, J., et al. (A.D. Little, Inc.), (1981). An Exposure and Risk Analysis for Lead. U.S. EPA, Office of Water Regulations and Standards, Washington, D.C.
- Rabe, F.W. & Bauer, S.B. (1977). Heavy metals in lakes of the Coeur d' Alene Valley, ID. Northwest Science, Vol. 51, No. 3. pp 183-197.
- Settle, D.M. & Patterson, C.C. (1980). Lead in Albacore: guide to lead pollution in Americans. Science, New York, New York.
- Shipley, J. (1985). Idaho gizzard project. Idaho State University memorandum.
- Smock, L.A. (1983a). The influence of feeding habits on whole-body metal concentrations in aquatic insects. Freshwater Biology, 301-11.
- Smock, L.A. (1983b). Relationships between metal concentrations and organism size in aquatic insects. Fresh Water Biology, 313-21.
- Solbe, J.F. de L.G. & Cooper, V.A. (1976). Studies on the toxicity of copper sulphate to stone loach Noemacheilus barbatulus (L.) in hard water. Water Research, 523-7.
- Upper Columbia United Tribes (UCUT) Fisheries Center, (1989). Scope of work for assessing the extent of mine waste pollution in the food chain of Lake Coeur d'Alene: Statement of Problem, background information, and proposed technical approach.
- Van Duyn-Henderson, J.A. & Lasenby, D.C. (1986). Zinc and cadmium transport by the vertically migrating Opossum Shrimp, Mysis relicta. Canadian Journal of Fisheries and Aquatic Science, 1726-32.
- Vuceta, J. & Morgan, J.J. (1978). Chemical modeling of trace metals in fresh waters: role of complexation and adsorption. Environmental Science and Technology. 1302-9.
- Welsh, R.P.H. & Denny, P. (1980). The uptake of lead and copper by submerged aquatic macrophytes in two English lakes. Journal of Ecology, 443-55.

REFERENCES

(Continued)

Weston, Roy F., (1989). Site Investigation of the Thompson Lake, Killarney Lake, Dudley, and Cataldo Areas along the Main Stem of the Coeur d'Alene River, Kootenai County, Idaho. CERCLA No. D980497481, FFIS No. ID1411A0006

Wixson, B.G. (1972). The Missouri Lead Study. An interdisciplinary investigation of environmental pollution by lead and other heavy metals by industrial development in the New Lead Belt of Southeastern Missouri. 2 Volumes. 1108 pp. Report submitted to NSF-RANN by the University of Missouri-Rolla.

Wolflin, J. (1985). Letter to K. Moser, Regional Supervisor, Idaho Dept. of Fish and Game, Coeur d'Alene, ID. Jan 29, 1985.

Woodward, Clyde and Terra Graphics, (1986). Interim Site Characterization Report for the Bunker Hill Site. EPA contract No. 68-01-6939

Land Management Issues

Bruce, D. (1990). Oral Communication with Schafer and Associates, May 18. Mr. Bruce is Kootenai County Facilities and Operations Director.

Bureau of Land Management (1981). Emerald Empire and Chief Joseph Management Framework Plans.

Bureau of Land Management and Idaho Department of Fish and Game (1983). Cooperative Agreement for Implementation of a Wetlands Habitat Management Plan in the Lower Coeur d'Alene River.

Bureau of Land Management (1989a). Land Tenure Adjustment Plan for the Emerald Empire and Chief Joseph Management Framework Plans.

Bureau of Land Management (1989b). Pre-Plan Analysis of the Lower Coeur d'Alene River Recreational Area Management Plan (PPA).

Cobb, S. (1990). Oral Communication with Schafer and Associates, May 18, 1990. Ms. Cobb is Kootenai County Planning Administrator.

Dorrell, J. (1990). Oral Communication with Schafer and Associates, May 20, 1990. Mr. Dorrell is USFS Recreation Officer, Coeur d'Alene.

REFERENCES

(Continued)

Idaho Department of Fish and Game (1985). Five Year Work Plan for the Coeur d'Alene River Wildlife Management Area.

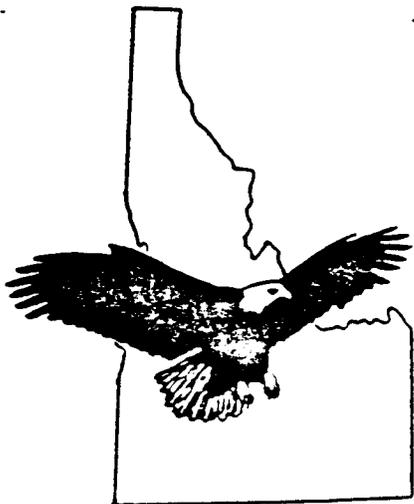
Idaho Department of Fish and Game (1986). Region 1 Wildlife Management Area Plans.

Idaho Department of Lands, (1987). Rules for the Regulation of Beds, Waters and Airspace Over Navigable Lakes in the State of Idaho. IDAPA 20.11

Idaho Department of Parks and Recreation (1983). Statewide Outdoor Comprehensive Recreation Plan, SCORP.

Post, G. (1990). Oral Communication with Schafer and Associates, June 20, 1990. Mr. Post is the Soil Conservation Service Area Conservation Administrator for the Northern Idaho Region, Moscow, Idaho.

United States Forest Service (1987). Idaho Panhandle National Forests Forest Plan.



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