1998 Lake Lowell Water Quality Assessment
Deer Flat National Wildlife Refuge
Planning Aid and Contaminants Study

for

U.S. Bureau of Reclamation
Snake River Area Office
Boise, Idaho

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Introduction

Sediment, water, and biological samples were collected and analyzed to evaluate alternatives to improve water quality in Lake Lowell (Lake) at Deer Flat National Wildlife Refuge (NWR). These samples were collected by the U.S. Fish and Wildlife Service (Service) who are assisting the U.S. Bureau of Reclamation (Bureau) in performing the study. This report describes the sampling activities performed, sampling locations, and deviations from the Sampling and Analysis Plan (SAP) developed by the Service for the Lake Lowell contaminant evaluation, and presents the analytical data. In addition, recommendations for further studies at Lake Lowell are provided.

Present Conditions at Lake Lowell

Description of the project area

Lake Lowell (formerly Deer Flat Reservoir) is located in Southwest Idaho, in Canyon county. This reservoir was formed by the construction of three embankments between 1906 and 1908 as a means to provide off-stream irrigation storage for the Bureau's Boise Project. The Boise Project was developed to provide irrigation water to lands in the Boise and Payette River drainages. Lake Lowell is operated by the Boise Project Board of Control, which oversees the delivery of stored water to the irrigation districts. Water is diverted from the Boise River at the Boise River Diversion Dam, with delivery of up to 2,800 cubic feet per second (cfs) of water into the New York Canal. This canal ends at Lake Lowell about 64 kilometers (km) (40 miles) downstream from the point of diversion. Inflows to the reservoir are a combination of diverted Boise River water and irrigation return flows. Although the water quality in the upper Boise River is relatively good, agricultural return flows contribute significant quantities of nutrients and salts to the New York Canal between the Boise River diversion and Lake Lowell (USBR 1977).

Lake Lowell is approximately 14 km (9 miles) long with a maximum width of 2.5 km (1.5 miles) and is relatively shallow. The impoundment has a surface area of 3.980 hectares (ha) (9,835 acres) and active capacity of 208.5 x 10^6 cubic meters (169,000 acre-feet).

The Lake is situated in a depression on a low plateau between the confluence of the Boise and Snake Rivers. Surrounding topography is generally flat with some rolling hills. Elevations range from 762 meters (m) (2500 feet(ft)) to 805 m (2640 ft). The climate is temperate with warm, dry summers and cold, moist winters; the mean annual temperature is about 10° Centigrade (C) (50° Fahrenheit (F)) with an average annual minimum of 19° C (-3° F) and an average maximum of 41° C (105° F). The average growing season is 210 days. Annual precipitation is 33 centimeters (cm) (13 inches (in)). The project area is 4,688 ha (11,585 acres) in size, most of which is Lake Lowell. Land use in the area is primarily irrigated agricultural, with local farms producing grains, alfalfa, sugar beets, vegetables, and fruit.

Fish and Wildlife Resources

The wildlife resources in the Lake Lowell Reservoir area are managed by the Service as part of the national refuge system. The Deer Flat National NWR was established in 1909 by Executive Order and is comprised of the reservoir and surrounding lands.

Upland vegetation in the project area is dominated by shrub steppe-grass cover types. Dominant species include sagebrush (*Artemesia spp*), rabbitbrush (*Chrysothamus spp*) and various native and exotic grasses. Dominant tree species include cottonwood (*Populus trichocarpus*) in the palustrine forested wetlands, and willow (*Salix spp*). Palustrine emergent wetlands are dominated by smartweed (*Polygonum spp*), cattail (*Typha spp*), and bulrushes (*Scirpus spp*). Service wetland mapping in 1981 indicated that 56% of the area is open water, 22% is upland, and the remaining 22% of vegetative communities are lacustrine or palustrine wetlands.

Lake Lowell supports a significant, naturally reproducing, warm water fishery. Largemouth bass (*Micropterus salmoides*) are the premier gamefish (24% of the reservoir's species composition) and Lake management is targeted for this species by Idaho Fish and Game (Moore et al. 1986). Other introduced game are listed below.

bluegill (*Lepomis macrochirus*) 41%
yellow perch (*Perca flavescens*) 22%
smallmouth bass (*Micropterus dolomieui*) 6%
black crappie (*Pomoxis nigromaculatus*) 3%
rainbow trout (*Salmo gairdneri*) <1%
Lahontan cutthroat (*Salmo clarkii*) <1%

The Boise Valley is a major waterfowl wintering area in the Pacific Flyway. Many of these birds nest in Canada and migrate through western Montana to eastern Idaho, following the Snake River to Lake Lowell (USFWS 1985). Lake Lowell provides a feeding and resting area for large numbers of migratory and wintering waterfowl species. Historically, peak waterfowl populations are dominated by mallards (*Anas platyrhynchos*) and Canada geese (*Brant canadensis*). Small numbers of pintail (*Anas acuta*), American wigeon (*Mareca americana*), and common merganser (*Mergus merganser*) also occur at Lake Lowell. Waterfowl nesting at the reservoir is limited by habitat availability. Localized marsh habitats support some breeding wood ducks (*Aix sponsa*). Resident geese nest on islands in the Snake River to the south.

Important nesting marsh and water birds include the western grebe (*Aechmophorus occidentalis*), great blue heron (*Ardea herodias*), and black-crowned night-heron (*Nycticorax nycticorax*). Other marsh and water birds observed on the Lake include common loons (*Gavia immer*), pied-billed grebes (*Podilymbus podiceps*), American white pelicans (*Pelecanus erythrorhynchos*), and double-crested cormorants (*Phalacrocorax auritus*).

Most years in late summer and early fall, when the lake is drawn down from irrigation demands,

extensive mud flats are exposed, attracting shorebirds. American avocets *(Recurvirostra americana)*, white-faced ibis (*Plegadis chihi*), western grebes, sandhill cranes (*Grus canadensis*). and marbled godwits (*Limosa fedoa*) have been observed on these mud flats on the reservoir (USFWS 1985). Various species of shorebirds and gulls have been observed during spring, summer, and fall. Most abundant are killdeer (*Charadrius vociferus*), western sandpipers (*Calidris mauir*), California gulls (*Larus californicus*), and ring-billed gulls (*Larus delawarensis*). Abundance and occurrence varies annually depending on the lake level which, in turn, determines the timing and extent of mudflats exposed for shorebird feeding (USFWS 1986).

Resident upland game birds include the ring-necked pheasant *(Phasianus colchicus)*, California quail (*Lophortyx californicus*), and gray partridge (*Perdix perdix*); with pheasants being the primary game species. Pheasants and quail seek the vegetative cover found on the NWR. Cover is particularly important in winter. Mourning doves (*Zenaida macroura*) nest locally and are commonly observed in spring and summer.

Raptors that inhabit the project area include bald eagles (*Haliaeetus leucocephalus*), golden eagle (*Aquila chrysaetos*), rough-legged hawk (*Buteo lagopus*), ferruginous hawk (*Buteo regalis*), Swainson's hawk (*Buteo swainsoni*), red-tailed hawk (*Buteo jamaicensis*), peregrine falcon (*Falco peregrinus anatum*), prairie falcon (*Falco mexicanus*), American kestrel (*Falco sparverius*), merlin (*Falco columbaris*), osprey (*Pandion haliaetus)*, northern harrier (*Circus cyabeus*), sharp shinned hawk (*Accipiter striatus*), Cooper's hawk (*Accipiter cooperii*), northern goshawk (*Accipiter gentilis*), common barn-owl (*Tyto alba*), long-eared owl (*Asio otus*), northern saw-whet owl (*Aegolius acadicus*), western screech-owl (*Otus kennicottii*), and great horned owl (*Bubo virginianus*).

A total of 115 breeding passerine bird species occur in Idaho (Morache 1985) and most of those species have been observed at the Lake. Representative species include the flycatchers (family Tyannidae), swallows (family Hirundinidae), jays (family Corvidae), blackbirds (family Icteridae), warblers (family Alaudidae), sparrows (family Fringillidae), chickadees (family Paridae), and thrushes (family Turdidae).

The Lake Lowell area provides habitat for a variety of mammals. The most conspicuous large mammals include elk (*Cervus canadensis*) and mule deer (*Odocoileus hemionus*), which inhabit the forested zones around the lake, particularly on the south side. The major mammalian predator is the coyote (*Canis latrans*) which inhabits the sagebrush upland areas. Other predators are fox (*Vulpes vulves*), skunks (*Mephitis mephitis*), weasels (*Mustela* spp.), and badger (*Taxidea taxus*).

Mammals that inhabit wetlands and riparian zones include beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), bushy-tailed woodrats (*Neotoma cinerea*), deer mice (*Peromyscus spp*), shrews (*Sorex spp*), voles (*Microtus spp*), tree squirrels (*Sciurus* and *Tamiasciurus spp*), and raccoons (*Procyon lotor*).

Small mammals of the uplands include voles, deer mice, pocket mice (family Heteromyidae), ground squirrels (*Spermophilus spp*), shrews (*Sorex spp*), and rabbits (*Sylvilagus nutallii, Brachylagus idahoensis, Lepus californicus*).

There is an occupied bald eagle territory on the southwest side of the Lake. It was first discovered in 1988, but may have been occupied in 1987 (Melquist 1989). A pair of eagles has nested there every year since but has had limited success fledging young. The bald eagle is currently listed as threatened under the Endangered Species Act. Bald eagles use the reservoir area during the winter generally from November to March, feeding mostly on wintering waterfowl.

Water Quality

Lake Lowell has persistent problems with water quality including extensive algal blooms, oxygen depletion, and fecal coliform bacteria counts which often exceed Idaho's water quality standards. The Lake is on the State's 1998 303(d) (of the Clean Water Act) list for nutrients as a pollutant. Inflows to the reservoir are a combination of diverted Boise River water and irrigation return flows.

Water is withdrawn from the reservoir during the irrigation season (April through August), but reservoir levels normally rise from September through April. Nutrient rich inflows from the New York Canal and irrigation return flows, combined with the shallow depth and high water exchange rate in the Lake have led to reports of dense blue-green algal blooms for over 60 years (Stanford 1938; USBR 1979). A comparison of conductivity in inflows and outflows indicates the outflows from the Lake have more than twice the quantity of dissolved solids present in the inflows (USBR 1979). . Evaporation is thought to play an insignificant role in the increase in dissolved solids within the Lake (USBR 1979). In addition, nonpoint source runoff may contain toxic constituents which could accumulate to levels that are harmful to fish, wildlife, and/or humans. Open drains that collect surface and irrigation runoff are common throughout the area (USBR 1991). This runoff includes drainage from agricultural, industrial, and residential areas around the Lake area.

In addition to water quality issues, fish contamination is also a primary concern. Aquatic organisms are likely exposed to a broad range of agricultural and industrial chemicals including dieldrin, DDT and analogs, dacthol, PCB's, hexachlorobenzene, hexachlorocyclohexane, and pentachlorophenol and heavy metals which can potentially affect the food chain.

Sample Collection

For this reconnaissance level investigation, a total of fifteen locations were selected for collection of water and sediment samples. The first round of samples were collected August 10-12, 1998. Eight of these locations were irrigation return flows that enter the Lake (Figure 1). These sites included the following drains: Bernard, Coulee, Donaldson, Farner, Garner, Highline-1, and

Highline-3. The New York Canal was also selected as a sample site. An additional drain, Lewis Lane, was added after the SAP had been written because it was being evaluated for a wetland demonstration project. Six sampling sites were within the Lake. Water samples only were collected on September 2, 1998, to document any changes that may have occurred from the previous round of sampling. All sampling followed guidelines presented in the SAP.

The Lake sample locations (Figure 1) represent a mixture of past inflows, in essence a composite of recent past inflows as mixing in the Lake has occurred. The eight drains selected for sampling are the major drains that have the highest potential for transporting contaminants. Other minor drains were not sampled because this is a reconnaissance investigation and not meant to be comprehensive, but to identify potential problem areas. Surface water samples were collected to determine what contaminants were entering the lake at a given point in time while sediment samples are used to evaluate what constituents may have been in the water in the past. The New York Canal was sampled because it is the main source of water to the Lake and has the potential to become contaminated as it passes through 40 miles of agricultural land and urban areas in the Boise-Nampa area.

Fish tissue samples were collected during one round of sampling on September 30, 1998. Three sampling locations, Upper Dam, Murphy's Neck, and Gott's Point (see Figure 1) were selected for the collection of fish. Whole body and fillets samples from each location were submitted to the laboratory for mercury analysis.

Parameters of Interest and Detection Limits

The main parameters of interest in the Lake Lowell reconnaissance investigation are pesticides and herbicides that have been used in the past and may be currently used in local agricultural practices. Since this is a screening level evaluation and a large number of chemicals have historically been used in the local agriculture, a wide range of pesticides, herbicides, chlorinated hydrocarbons and heavy metals were selected for analysis. In addition, water samples were analyzed for common ions and nutrients to assess the effect of eutrophication along with toxic contamination. Table 1 lists the classes of chemicals that were analyzed in water and sediment samples and the EPA method number of analysis. The main parameter of interest in the fish tissue sampling was mercury. Mercury had been found in the water column samples at concentrations that exceeded the chronic criteria and it was also detected in the sediment samples. Since mercury is known to boiaccumulate, it is likely that the fish are exposed and contaminated with mercury which, in turn may affect organisms higher in the food chain (i.e. piscivorous birds) that feed on the fish in the Lake.

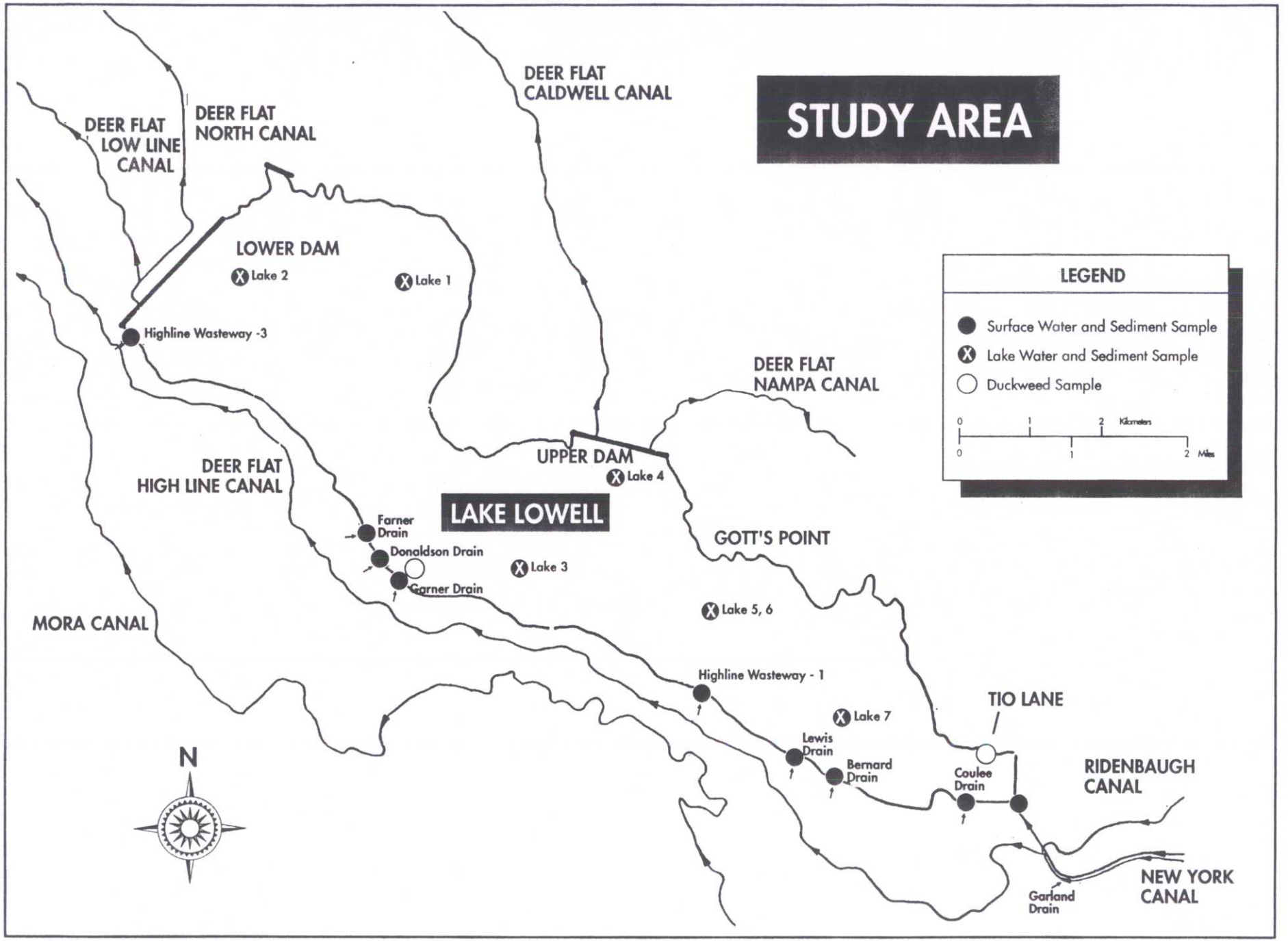
STUDY AREA
DEER FLAT CALDWELL CANAL
DEER FLAT NORTH CANAL
DEER FLAT LOW LINE CANAL
LOWER DAM
Lake 2
Lake 1
Highline Wasteway -3
DEER FLAT NAMPA CANAL
UPPER DAM
Lake 4
DEER FLAT HIGH LINE CANAL
LAKE LOWELL
Farner Drain
Donaldson Drain
Garner Drain
Lake 3
GOTT'S POINT
Lake 5, 6
MORA CANAL
Highline Wasteway - 1
Lake 7
TIO LANE
Lewis Drain
Bernard Drain
Coulee Drain
RIDENBAUGH CANAL
NEW YORK CANAL
Garland Drain
N
LEGEND
Surface Water and Sediment Sample
Lake Water and Sediment Sample
Duckweed Sample
0 1 2 Kilometers
0 1 2 Miles

TABLE 1
Parameters of Interest and Methodology

Parameter	EPA Method Number
Organochlorine Pesticides	8081 or 8081A
Chlorinated Hydrocarbons	8270
Organophosphorus Pesticides	8141A/8270
Chlorinated Herbicides	8151
RCRA Metals	
Arsenic	7060A/I-3026-85/6020
Barium	7081/208.2
Cadmium	7131A/213.2
Chromium	7191/218.2
Lead	7421/239.2
Mercury Liquid	7470A/245.1
Mercury Solid	7471A
Selenium	7740/I3667-85
Silver	7770/272.2
COD	410.1
Ammonia-Nitrogen	350.3
Nitrite	354.1 or 300
Nitrate	353.3 or 300
Total Organic Nitrogen	351.2
Total Phosphorous	365.3
Orthophosphorous	365.3
TDS	160.1
TSS	160.2

Method numbers are from *EPA SW-846* or from *Greenberg, A.E. et al.* Standard Methods for Evaluating Water and Waste Water, 18th Ed. 1992. American Public Health Association, Washington D.C.

First Sampling Event: August 10-12, 1998

The first sampling round was conducted from August 10 through August 12, 1998. Both water and sediment was collected at each of the fifteen sampling locations (Figure 1). In addition, two biological samples consisting of duckweed (*Lemna* and *Spirodela spp.*) were collected for analysis.

Sediment and Water Samples

At each of the drains, a water sample was obtained by filling the sample bottles directly from the flowing water, with the mouth of the sample bottle submerged. Four to six sediment samples were collected below the water line, mixed in a stainless steel pan and then placed into the clean sample container. All samples were kept on ice until delivered to the laboratory for subsequent analyses. Measures of specific conductance, temperature, and dissolved oxygen (DO) were collected in the field at each site. Due to equipment malfunction pH was not measured. See Table 2 for results of the field parameters measurements.

TABLE 2
Field Parameters

Station	Depth (lake only) (feet)	Standard Conductance (μmhos/cm)	Dissolved Oxygen (mg/L)	Temperature (° C)
Highline-3	-	170	8.26	19
Farner	-	90	8.00	20.5
Donaldson	-	165	7.65	22
Garner	-	390	6.75	21
Highline-1	-	120	7.25	25
Bernard	-	190	7.07	25
Coulee	-	200	8.05	18.4
Lewis	-	200	7.05	21
Lake 1	10	140	7.60	24
Lake 2	8	170	6.87	24
Lake 3	5	190	6.67	24.5
Lake 4	40	180	7.27	24
Lake 5	10	200	8.33	25
Lake 6 duplicate of 5	10	200	8.33	25.2
Lake 7	6	220	10.00	26.1
New York	6	100	8.62	19.8

Water samples collected from locations within the New York Canal and the Lake were obtained using a Van Dorn sampler deployed from a boat. However, the sampler would not remain in the locked position, therefore, one end of the sampler was left open and allowed to slowly settle in the water before being retrieved. Clean sample containers were filled directly from the Van Dorn sampler. Sediment samples were collected with a dredge sampler, placed into a stainless steel pan and mixed. Sediment was placed into clean sample containers. All samples were immediately placed on ice and were frozen upon arrival at the laboratory.

Biological Samples

Aquatic invertebrates were not readily available during sampling, therefore a decision was made in the field to collect aquatic plants instead of invertebrates. Two samples of duckweed (*Lemna* and *Spirodela spp.*) were collected as biological samples; one from the Tio Lane area where the New York Canal enters the Lake Lowell and the other from Garner Drain where it enters the Lake (Figure 1). Duckweed was collected by net or by hand and placed into a stainless steel pan to remove debris. Duckweed was placed into two clean sample jars, weighed, and placed on ice until received at the laboratory that same day, where they were then frozen.

Second Sampling Event: September 2, 1998

The second round of sampling was conducted on September 2, 1998. Water samples only were collected from previous sampling sites at all the drains and from the Lake. The objective of this sampling was to determine metal concentration variability over time. Samples from the second round were not analyzed for the organic parameters.

Water Samples

Water samples were collected following the same sampling techniques as used in the first sampling event. Field parameters were not measured nor were biological samples collected.

Third Sampling Event: September 30, 1998

The third round of sampling was conducted on September 30, 1998. Biological samples in the form of fish tissue were collected at Upper Dam, Murphy's Neck, and Gott's Point (Figure 1).

Tissue Samples

Fish tissue samples were collected at each of the Lake sampling locations and submitted to a laboratory for analysis. A total of 23 smallmouth bass, 12 carp, 11 largemouth bass, 7 suckers, 5 bluegill, and 2 crappie were collected by electrofishing techniques in cooperation with Idaho Department of Fish and Game. Fish were euthanized and placed in clean plastic bags and stored on ice. Samples were later divided into whole body or fillets, placed in clean bags and kept frozen until analysis.

Results and Discussion

A total of 16 sediment, 32 water, 2 botanical, and 60 fish tissue samples were collected and submitted for laboratory analysis of inorganic and organic constituents. Six of the water samples were submitted for metal analysis only, and fish tissues were analyzed for mercury. All other samples were analyzed for the parameters in Table 1. All water samples collected in this study were submitted to the Bureau of Reclamation Pacific Northwest Laboratory in Boise, Idaho for metal and common ion analysis. Samples of sediment that were submitted for organic analysis, the duckweed, and fish tissue were sent to Anatek Laboratory in Moscow, Idaho.

Metals

Water

Tables 3A and 3B present the results of metals analyses for water samples. All results are for total metals, no dissolved analyses were performed. Of the eight metals analyzed, cadmium, selenium, and silver were always below detection limit. Lead concentrations appeared to be above the fresh water chronic criteria of 2.5 micrograms per liter (μg/L = parts per billion) (at 100 parts per million (ppm) $CaCO_3$ hardness). However, hardness values were not measured in water samples at the time of sample collection. These exceedences of criteria were detected in

the irrigation drains that feed into the Lake. Because these samples were measured for total and not dissolved metals, the lead may be associated with the high sediment load that was being transported down the drains at the time of sampling.

Total mercury concentrations were above the fresh water chronic criteria of 0.012 μg/L. Mercury levels as high as 0.40 μg/L were observed in samples from Lake-5 (Table 3A). Mercury was only detected in water collected during the first round of sampling, and was not detected in any of the samples collected during the second round in September (Table 3B). An algae bloom was occurring during the first round of Lake water sampling, therefore the mercury could have been associated with the algae. Lead was detected in concentrations as high as 15.0 μg/L in one Lake sample (see Table 3A). Predatory birds could ingest fish or other birds that may have lead and mercury in their tissues. However, because lead does not bioaccumulate or bioconcentrate in tissues it is of less concern than mercury.

Table 3A
Metal Concentrations in Water Samples (μg/L)
First Sampling Event August 10-12, 1998

Station	Arsenic	Barium	Cadmium	Chromium	Mercury	Lead	Selenium	Silver
Highline-3	6.0	ND	ND	5.0	ND	2.0	ND	ND
Farner	5.0	170.0	ND	17.0	ND	11.0	ND	ND
Donaldson	8.0	180.0	ND	16.0	ND	8.0	ND	ND
Garner	25.0	ND	ND	5.0	ND	2.0	ND	ND
Highline-1	6.0	ND	ND	ND	ND	ND	ND	ND
Bernard	9.0	270.0	ND	28.0	ND	15.0	ND	ND
Coulee	6.0	120.0	ND	11.20	ND	6.0	ND	ND
Lewis	6.0	ND	ND	3.10	ND	ND	ND	ND
Lake 1	6.0	ND	ND	ND	ND	ND	ND	ND
Lake 2	5.0	ND	ND	3.0	0.30	ND	ND	ND
Lake 3	6.0	ND	ND	ND	0.30	ND	ND	ND
Lake 4	6.7	ND	ND	ND	0.37	ND	ND	ND
Lake 5	6.0	ND	ND	ND	0.40	ND	ND	ND
Lake 6 (Duplicate of 5)	6.0	ND	ND	ND	0.22	ND	ND	ND
Lake 7	6.0	ND	ND	ND	0.26	ND	ND	ND
New York	3.0	ND	ND	ND	ND	ND	ND	ND
Detection Limits	**2.0**	**100.0**	**1.0**	**2.0**	**0.2**	**2.0**	**2.0**	**2.0**

Table 3B
Metal Concentrations in Water Samples (μg/L)
Second Sampling Event September 2, 1998

Station	Arsenic	Barium	Cadmium	Chromium	Mercury	Lead	Selenium	Silver
Highline-3	3.0	ND	ND	3.0	ND	ND	ND	ND
Farner	3.0	ND	ND	5.0	ND	ND	ND	ND
Donaldson	6.0	ND	ND	12.0	ND	5.0	ND	ND
Garner	10.0	ND	ND	3.0	ND	ND	ND	ND
Highline-1	3.0	ND	ND	ND	ND	ND	ND	ND
Bernard	7.0	ND	ND	23.0	ND	10.0	ND	ND
Coulee	2.0	ND	ND	6.0	ND	ND	ND	ND
Lewis	11.0	ND	ND	ND	ND	ND	ND	ND
Lake 1	8.0	ND	ND	ND	ND	ND	ND	ND
Lake 2	8.0	ND	ND	ND	ND	ND	ND	ND
Lake 3	6.0	ND	ND	ND	ND	ND	ND	ND
Lake 4	8.0	ND	ND	ND	ND	ND	ND	ND
Lake 5	7.0	ND	ND	ND	ND	ND	ND	ND
Lake 6	8.0	ND	ND	ND	ND	ND	ND	ND
New York	3.0	ND	ND	ND	ND	ND	ND	ND
Detection Limits	**2.0**	**100.0**	**1.0**	**2.0**	**0.2**	**2.0**	**2.0**	**2.0**

Sediment

Table 4 presents the results of the metals analyses for the sediment samples. Selenium concentrations ranged from <0.10-2.00 milligrams per kilogram (mg/kg = parts per million) of sediment. The toxicity threshold concentration for selenium in sediment is >4.0 mg/kg which may result in adverse effects to avian reproduction, and fish survival and reproduction (USBR 1998). However, it is also documented that as a general rule further investigation is not warranted unless the sediment selenium concentration is greater than 5 mg/kg. Therefore, selenium concentrations measured in sediment samples in this reconnaissance investigation do not presently appear to be of concern to fish and wildlife.

Table 4
Metal Concentrations in Sediment Samples (mg/kg dry weight)
First Sampling Event September 2, 1998

Station	Arsenic	Barium	Cadmium	Chromium	Mercury	Lead	Selenium	Silver
Highline 3	2.30	82.80	ND	11.00	ND	6.90	ND	ND
Farner	2.20	82.90	ND	10.80	ND	5.70	ND	ND
Donaldson	4.60	184.00	ND	21.10	ND	11.10	ND	ND
Garner	3.80	115.00	ND	14.10	ND	7.30	ND	ND
Highline 1	4.50	130.00	ND	15.80	ND	7.00	ND	ND
Bernard	3.30	160.00	ND	17.40	ND	9.40	ND	ND
Coulee	4.60	201.00	0.31	20.80	0.12	12.10	1.34	ND
Lewis	3.40	197.00	0.29	16.90	0.04	11.30	1.09	ND
Lake 1	3.60	123.00	ND	17.80	0.06	6.56	1.09	ND
Lake 2	9.10	188.00	ND	27.90	ND	19.50	2.00	ND
Lake 3	2.80	125.00	0.23	18.80	0.05	6.21	0.95	ND
Lake 4	11.40	244.00	0.79	38.30	0.09	24.40	1.32	ND
Lake 5	5.90	180.00	0.31	22.80	0.06	11.80	1.44	ND
Lake 6 (duplicate of 5)	5.30	157.00	0.25	20.50	0.03	10.70	0.93	ND
Lake 7	3.60	111.00	ND	16.60	0.08	8.84	0.90	ND
New York	7.00	143.00	0.40	19.80	0.04	11.80	0.85	ND
Detection Limit	0.10	0.05	0.10	0.10	0.01	0.10	0.10	0.10

Fish

Mercury concentrations in fish tissues ranged from 0.020-0.515 mg/kg. Table 5 (at the end of the report) presents the results of the mercury analysis for the fish tissue given in mg/kg dry weight. The fish were analyzed as both whole body and fillets. Whole body samples were taken to determine the potential food chain effects to the Service's trust resources, while the fillets were provided to the State to address possible human health concerns. The concentrations detected in the fish tissue are not currently at levels shown in literature to cause adverse effects to fish. However, it is important to note that because mercury bioconcentrates and biomagnifies, these concentrations may be harmful to other piscivorus predators, such as bald eagles and osprey. Mercury is of concern because it has been shown to bioconcentrates in a variety of aquatic organisms (USBR 1998). Fish have been shown to concentrate mercury as methyl mercury even when they are exposed to inorganic mercury. The documented effects of mercury on reproduction range from embryo lethality to sublethal behavioral changes in juveniles at low dietary levels. Effects of mercury include reduced hatch ability due to increases in egg mortality of embryos, some amount of eggshell thinning, reduced clutch size, increased number of eggs laid outside the nest, and aberrant behavior of juveniles (USBR 1998). Birds may show

significant adverse effects even at relatively low tissue concentrations if these concentrations result from chronic mercury exposure (USBR 1998). For example, it has been shown that dietary concentrations of 1-2 mg/kg of methyl mercury produced significant reproductive effects in adult birds (Schuehammer 1995). Furthermore, mallards exposed to mercury over three generations experienced adverse reproductive effects at concentrations as low as 0.078 mg/kg/day (Eisler 1987). Analysis of mercury in eggs has also been used to determine the amount of mercury that has been passed on from the female of a species to its young. Mercury concentrations of 2-5 mg/kg reduced reproductive success in ring doves, mallard ducks, and pheasants (Schuehammer 1987).

Both size and species of fish are important variables in mercury sensitivity. Smaller fish tend to accumulate mercury at greater rates than larger fish due to higher metabolic rates. Mercury concentrations in fish tissues collected from the Lake are at levels ranging from background mean to possible effects to piscivorus birds. Concentrations of mercury and especially methyl mercury in fish from the Lake should continue to be monitored. Further, fish eating birds should be evaluated to determine if mercury in accumulating in tissues.

Organics

Water

Only one water sample had a positive detection of the organic compounds that were analyzed. Gardner drain had a Dicamba concentration of 0.5 μg/L. No other organic compounds were present at quantities greater than their detection limits.

Sediment

Sediment samples that had one or more positive detects of pesticides are listed in Table 5. DDT and its metabolites DDE and DDD were the chemicals that were detected most often in the sediment samples, followed by Heptachlor and then dieldrin. All of these are long lived pesticides and DDT and dieldrin have been banned in the U.S. for more than 10 years.

Sediments function as the primary sink for DDT and its metabolites (EPA 1975). Total DDT (DDE, DDD, and DDT) was detected in the sediment at several of the sampling locations in concentrations that fall into the "level of concern" category, the point at which a certain percent of the test species showed an effect where mortality was not the endpoint. Detectable concentrations of DDT ranged from 9 -98 mg/kg, DDE 4 - 279 mg/kg, and DDD 8 - 57 mg/kg. Levels of concern for DDT in sediment is 1.5 - 46 mg/kg, for DDE is 2.2 - 27 mg/kg, and for DDD is 8 - 110 mg/kg (USBR 1998). Based on the findings presented in Table 6, total DDT, DDE, and DDD are at concentrations that constitute concern because of the potential contamination to fish and thus, to piscivorus birds. In general, birds that feed on fish or other birds have greater tissue residues of contaminants than those that feed on vegetation or seeds (Stickel 1973, Blus 1996). Adverse effects associated with DDT poisoning include reproductive impairment, reduced fledgling success, and eggshell thinning. The concentrations detected in several of the locations at the Lake could be causing effects to fish and wildlife. Based on the

results of sediments sampled in the reconnaissance investigation presented in Table 6, total DDT is of concern to fish and wildlife.

Table 6
Pesticide Concentrations in Sediment Samples (mg/kg dry weight)
First Sampling Event August 10-12, 1998

Station	Heptachlor	DDE	DDT	DDD	Dieldrin
Highline 3	8.00	31.00	10.00	ND	ND
Farner	5.00	17.00	23.00	ND	ND
Donaldson	7.00	4.00	ND	ND	ND
Garner	22.00	15.00	ND	ND	ND
Highline 1	4.00	46.00	26.00	11.00	ND
Bernard	ND	51.00	12.00	8.00	7.00
Coulee	ND	153.00	31.00	25.00	ND
Lewis	ND	279.00	98.00	57.00	13.00
Lake 1	ND	ND	ND	ND	Nd
Lake 2	ND	7.00	9.00	ND	ND
Lake 3	ND	ND	ND	ND	ND
Lake 4	ND	8.00	ND	ND	ND
Lake 5	ND	8.00	ND	ND	ND
Lake 6 (duplicate of 5)	ND	7.00	ND	ND	ND
New York	ND	23.00	ND	ND	ND
Detection limit	5.00	5.00	5.00	5.00	5.00

Common Ions

Water

Common ions concentrations from the water samples collected in the first and second rounds of sampling are provided in Table 7. These data indicate that the drains and to some extent the New York Canal are transporting elevated nutrients (nitrogen and phosphorus) loads to the Lake. These nutrients are probably being consumed in the Lake by algae and thus algae blooms are common and have been documented to occur as far back as 1936 (Stanford 1938). In addition, the algal blooms create an anoxic environment which may result in the resuspension of metals into the water column. When metals are suspended rather than buried in the sediment, aquatic organisms are more likely to be contaminated.

Table 7
Common Ions Concentrations in Water (mg/L)
First Sampling Event August 10-12, 1998

Station	Nitrate	Ortho-p*	T-P*	Ammonia	TKN*	TDS*	COD*	SS*
Bernard	1.19	0.098	0.71	0.02	1.09	134	29.00	968.00
Donaldson	2.73	0.364	0.77	0.04	1.48	131	33.00	410.00
Farner	0.12	0.045	0.51	<0.01	0.86	72	17.00	545.00
Garner	1.92	0.088	0.22	0.10	0.58	298	10.00	79.00
Highline 1	0.18	0.033	0.066	0.04	0.28	84.00	5.00	6.00
Highline 3	0.42	.026	0.147	0.02	0.29	78.00	5.00	157.00
Lake 1	<0.01	.005	0.091	0.03	1.03	121.00	15.00	17.00
Lake2	<0.01	.015	0.065	0.07	0.64	117.00	9.00	6.00
Lake 3	<0.01	.009	0.07	0.03	0.56	128.00	10.00	13.00
Lake 4	<0.01	.013	0.046	0.06	0.46	124.00	8.00	6.00
Lake 5	<0.01	.003	0.109	0.08	0.92	119.00	18.00	13.00
Lake 6	<0.01	0.004	0.118	0.08	1.016	121.00	19.00	16.00
Lake 7	0.02	.003	0.162	0.13	1.60	138.00	27.00	26.00
New York	0.30	.036	0.055	<0.01	0.16	69.00	6.00	6.00
Coulee	0.96	.092	0.39	0.20	2.41	104.00	20.00	339.00
Lewis	0.85	0.28	0.40	0.38	1.68	158.00	18.00	63.00

Second Sampling Sampling Event September 2, 1998

Station	Nitrate	Ortho-p*	T-P*	Ammonia	TKN*	TDS*	COD*	SS*
Bernard	0.82	0.169	0.66	0.02	1.12	100.00	25.00	738.00
Coulee	0.21	0.148	0.22	0.02	0.50	75.00	12.00	157.00
Donaldson	2.24	0.356	0.60	0.14	1.40	108.00	25.00	267.00
Farner	0.04	0.046	0.18	0.01	0.38	59.00	8.00	<11.00
Garner	0.66	0.087	0.148	0.06	0.70	175.00	20.00	36.00
Highline 1	0.28	0.038	0.07	0.02	0.26	70.00	7.00	41.00
Highline 3	0.21	0.044	0.11	0.02	0.31	64.00	8.00	79.00
Lewis	3.72	0.428	0.51	0.15	0.96	302.00	19.00	19.00
New York	0.21	0.019	0.029	0.01	0.16	56.00	4.00	4.00

• T-P: *Total Phosphorus as P* **TKN:** *TKN as N* **TDS:** *Total Dissolved Solids* **SS:** *Suspended Solids* **COD:** *Chemical Oxygen Demand*

Conclusions and Recommendations

Samples collected and analyzed from Lake Lowell in 1998 indicate that there may be three problems occurring within the Lake: elevated mercury concentrations within the water column, elevated levels of DDT and its metabolites, and algae blooms or eutrophication of the Lake. Mercury was detected during the first round of sampling in Lake water at concentrations above Idaho's chronic water quality criteria. Mercury may have been in the algae bloom that was occurring during the first round of sampling. The actual source of the mercury needs to be identified and the frequency of the elevated mercury concentrations should be determined.

The algae blooms in the Lake have been well documented in the past. This study shows that the inflows to the Lake are likely contributing to the algae bloom problem. Reducing the amount of nutrients entering the Lake would likely reduce the amount and severity of the algae blooms.

Recommended Actions for Future Studies

Water samples should be obtained from the lake on a weekly basis and be analyzed for mercury in both the dissolved and total fractions.

A literature review of past studies involving DDT should be conducted. If the concentrations found during the 1998 round of sampling at the Lake are of significant concern additional sediment samples should be collected to better define the extent of the contamination.

Most studies to date at the Lake have been conducted during daylight hours only. A round of sampling for pH and dissolved oxygen for a 24 hour period would determine if large changes in these parameters are occurring during the time when algae are not photosynthesizing but are respiring. This can cause very large swings in the pH which can allow metals to become dissolved and enter the water column at night and precipitate out during the daylight hours.

Table 5
Mercury Concentration in Fish Tissue
Third Sampling Event September 30, 1999

Location	Type of Fish	Type of Sample	Mercury Concentration (mg/kg)
Upper Dam	Sucker	Whole Body	0.100
Upper Dam	Sucker	Whole Body	0.091
Upper Dam	Sucker	Whole Body	0.049
Upper Dam	Sucker	Fillet	0.515
Upper Dam	Sucker	Fillet	0.499
Upper Dam	Sucker	Fillet	0.372
Upper Dam	Sucker	Fillet	0.173
Upper Dam	Largemouth Bass	Whole Body	0.045
Upper Dam	Largemouth Bass	Whole Body	0.027
Upper Dam	Largemouth Bass	Fillet	0.093
Upper Dam	Largemouth Bass	Fillet	0.089
Upper Dam	Smallmouth Bass	Whole Body	0.177
Upper Dam	Smallmouth Bass	Whole Body	0.100
Upper Dam	Smallmouth Bass	Whole Body	0.095
Upper Dam	Smallmouth Bass	Whole Body	0.095
Upper Dam	Smallmouth Bass	Whole Body	0.093
Upper Dam	Smallmouth Bass	Whole Body	0.082
Upper Dam	Smallmouth Bass	Whole Body	0.077
Upper Dam	Smallmouth Bass	Fillet	0.360
Upper Dam	Smallmouth Bass	Fillet	0.192
Upper Dam	Smallmouth Bass	Fillet	0.131
Upper Dam	Smallmouth Bass	Fillet	0.104
Upper Dam	Smallmouth Bass	Fillet	0.098
Upper Dam	Smallmouth Bass	Fillet	0.069
Upper Dam	Bluegill	Whole Body	0.079
Upper Dam	Bluegill	Whole Body	0.064
Upper Dam	Bluegill	Whole Body	0.020
Upper Dam	Bluegill	Fillet	0.082
Upper Dam	Bluegill	Fillet	0.071
Murphy's Neck	Carp	Whole Body	0.308

Location	Type of Fish	Type of Sample	Mercury Concentration (mg/kg)
Murphy's Neck	Carp	Whole Body	0.303
Murphy's Neck	Carp	Whole Body	0.302
Murphy's Neck	Carp	Whole Body	0.289
Murphy's Neck	Carp	Whole Body	0.226
Murphy's Neck	Carp	Whole Body	0.044
Murphy's Neck	Carp	Fillet	0.330
Murphy's Neck	Carp	Fillet	0.323
Murphy's Neck	Carp	Fillet	0.281
Murphy's Neck	Carp	Fillet	0.256
Murphy's Neck	Carp	Fillet	0.220
Murphy's Neck	Carp	Fillet	0.195
Murphy's Neck	Smallmouth Bass	Whole Body	0.363
Murphy's Neck	Smallmouth Bass	Whole Body	0.343
Murphy's Neck	Smallmouth Bass	Fillet	0.381
Murphy's Neck	Largemouth Bass	Fillet	0.194
Gott's Point	Smallmouth Bass	Whole Body	0.354
Gott's Point	Smallmouth Bass	Whole Body	0.313
Gott's Point	Smallmouth Bass	Whole Body	0.311
Gott's Point	Smallmouth Bass	Fillet	0.358
Gott's Point	Smallmouth Bass	Fillet	0.358
Gott's Point	Smallmouth Bass	Fillet	0.314
Gott's Point	Smallmouth Bass	Fillet	0.292
Gott's Point	Largemouth Bass	Whole Body	0.051
Gott's Point	Largemouth Bass	Whole Body	0.023
Gott's Point	Largemouth Bass	Fillet	0.103
Gott's Point	Largemouth Bass	Fillet	0.088
Gott's Point	Largemouth Bass	Fillet	0.086
Gott's Point	Largemouth Bass	Fillet	0.077
Gott's Point	Crappie	Whole Body	0.033
Gott's Point	Crappie	Whole Body	0.030

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