APPENDIX A

SUMMARY OF AQUATIC RESOURCES IN THE STUDY AREA

CONTENTS

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ACRONYMS AND ABBREVIATIONS

ADFG	Alaska Department of Fish and Game
B.C.	British Columbia
BERA	baseline ecological risk assessment
BPA	Bonneville Power Administration
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COPC	chemical of potential concern
CSM	conceptual site model
EPA	U.S. Environmental Protection Agency
LRFEP	Lake Roosevelt Fisheries Evaluation Program
NWPPC	Northwest Power and Conservation Council
RM	river mile
SD	standard deviation
STI	Spokane Tribe of Indians
U.S.	United States
UCR	Upper Columbia River
USBR	U.S. Bureau of Reclamation
USDHEW	U.S. Department of Health, Education and Welfare
USGS	U.S. Geological Survey
WDFW	Washington State Department of Fish and Wildlife

UNITS OF MEASURE

°C	degrees Celsius
μg	microgram(s)
$\mu g/m^3$	micrograms per cubic meter
amsl	above mean sea level
cm	centimeter(s)
ft	feet
g	gram(s)
in.	inches
kg	kilogram(s)
lb	pound(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
mg	milligram(s)
mg/kg	milligrams per kilogram
mg/m^2	milligrams per square meter
mg/m^3	milligrams per cubic meter(s)
mm	millimeter(s)
yd	yard(s)

1 INTRODUCTION

This appendix provides a summary of available information to describe the major aquatic organism assemblages (i.e., aquatic receptors) found in the Upper Columbia River (UCR). These data provide support for other components of the baseline ecological risk assessment (BERA) work plan such as refining the conceptual site model (CSM) and identifying ecological receptors of concern. The objective of this appendix is to document and synthesize the existing information on each major biological group with an emphasis on factors that may affect the exposures of aquatic receptors to chemicals of potential concern. Generally, these factors include preferred habitats, spatial and temporal patterns in the distributions of organisms, prey types, migrations and timing of breeding and other factors related to life histories. Site-specific information on these subjects ranges from absent to good for organisms in the UCR, with the best data available for fish.

The studies evaluated in this appendix are historical and were not necessarily conducted for the UCR remedial investigation/feasibility study (RI/FS) and BERA and may not meet the current standards of practice and/or the data quality requirements necessary for completion of the BERA. However, for purposes of this BERA work plan, the data and analyses are assumed to be adequate to assist in identifying data gaps and describing general site characteristics, but may not be acceptable for use in future deliverables in their current form.

As the BERA progresses, the quality of the existing data, data analysis procedures, and suitability for inclusion in the BERA will be assessed according to procedures that will be reviewed and approved by the U.S. Environmental Protection Agency (EPA). In addition, clear explanations of the data used in evaluations, evaluation methodology, and statistical analysis documentation will be provided in future documents.

This appendix provides summary information on the biology, ecology, and spatial and temporal trends within the UCR of the following aquatic receptors:

- Algae (periphyton and phytoplankton)
- Zooplankton
- Macrophytes
- Benthic macroinvertebrates
- Fish
- Amphibian early life stages.

The amount and types of site-specific information on each group varies. General information on the biology and ecology of some organism groups has been drawn from the literature in cases where there were important gaps in site-specific data. A list of federal and Washington state aquatic species of concern is provided in Table 1.

2 AQUATIC RECEPTORS

This section summarizes the available information on the major biological assemblages that make up the aquatic communities in the UCR. These include algae (periphyton, phytoplankton), zooplankton, macrophytes, benthic macroinvertebrates (including mussels), fish, and amphibian early life stages.

2.1 ALGAE

Algal communities in aquatic systems can be considered as one or the other of two major types—periphyton, also called "benthic algae", and phytoplankton. Both groups consist of several broad categories of autotrophic organisms and are the primary producers (along with vascular and algal macrophytes). Both periphyton and phytoplankton are constrained by the availability of light for photosynthesis; periphyton occupy littoral habitats, growing on benthic substrates, including in sediment interstices, as well as on plants and large wood; phytoplankton access the photic zone throughout the reservoir, but are restricted in flowing waters (Wetzel 2001).

2.1.1 PERIPHYTON

The first studies of periphyton distribution and abundances in the UCR were initiated in the late 1980s and early 1990s, in response to the presence of floating mats of green algae, and concerns that they might be related to large phosphorus inputs to the system (Broch and Loescher 1988, 1990, 1992; Loescher and Brock 1993). Between 1999 and 2005, colonization rates of periphytic algae were monitored by the Lake Roosevelt Fisheries Evaluation Program (LRFEP) using artificial growing substrates. Results of these studies provide the most complete and systematic information on periphyton in the UCR, and are summarized below.

2.1.1.1 DISTRIBUTION OF PERIPHYTON

Studies of periphyton blooms in the 1980s and early 1990s involved qualitative samples of benthic algae, collected by raking the surface of bottom substrates in bays, shoals, and major tributaries of the UCR between the U.S.-Canada border and river mile (RM) 600 near Grand Coulee Dam. These studies documented the presence of nuisance growths of the filamentous green algae Cladophora, also known as blanket weed. Cladophora was found in the UCR at water depths ranging from 2 to 10 m below surface. Cold water temperatures and reservoir level fluctuations limited early summer productivity, but abundances increased as the season progressed. Using chlorophyll *a* concentrations to estimate biomass in August, periphyton standing stock biomass showed no observable longitudinal trend along the UCR, and ranged from 6 to 87 mg/m^2, less than nuisance levels (i.e., 100 mg/m^2). Periphyton biomass modeling provided a preliminary indication that with a one-half reduction in phosphorus loading to the UCR from all sources, Cladophora biomass could be reduced below a perceived nuisance level.

Between 1999 and 2005, colonization rates of periphytic algae were monitored by LRFEP using artificial growing substrates, beginning in August and continuing until late October in embayment/littoral habitats near Gifford (RM 674), Porcupine Bay (Spokane Arm), Seven Bays (RM 634), and Spring Canyon (RM 599). Algae were allowed to colonize glass microscope slides anchored at depths of 1.5 m (5 ft) and 4.6 m (15 ft) below the reservoir surface at the beginning of the incubation period. There were five colonization periods examined, which included 2, 4, 6, 9, and 11 week time increments. Slides were collected and frozen following each colonization period, and sent to Eastern Washington University's, Water Research Center for speciation, enumeration, biovolume estimation, and determination of chlorophyll *a* concentration.

Periphyton collected by LRFEP in 1999 and 2000 was dominated by diatoms, which were 96 percent of periphyton density in 1999 (McLellan et al. 1999), and 94 percent of total periphyton density in 2000 (Lee et al. 2003). Chlorophyceae (green algae, 4.0 percent of densities in 1999, including 2.1 percent *Cladophora* sp.) and Cyanophyceae (0.1 percent) made up the remaining periphyton taxa (McLellan et al. 1999). Detailed taxonomy of the attached algae appearing on artifical substrates in 2000 shows the variety and importance of the diatom class Bacillariophyceae, and the large relative importance of Achnanthes species (Table 2). Taxonomy of periphyton was only reported in the first few years of monitoring.

Recent periphyton productivity in the UCR has not been as high as in the late 1980s and early 1990s. In most years of sampling, periphyton productivity, as measured by chlorophyll *a* levels, was highest at the station nearest to the Grand Coulee dam (Spring Canyon, RM 599) and also high in the Spokane Arm (Porcupine Bay), with lower levels downstream of the Spokane confluence at Seven Bays (RM 635) and Gifford (RM 674) (Figure 1). Mean standing stock biomass of periphyton (as determined by chlorophyll *a* concentration), with the exception of levels measured at Spring Canyon in 1999, were consistently lower than the 20 mg/m^2 threshold between oligotrophic and mesotrophic conditions established by Dodds et al. (1998, as cited in Scofield et al. 2004).

2.1.2 PHYTOPLANKTON

Data describing the phytoplankton communities in the UCR are more extensive than for periphyton. In general, phytoplankton are limited to the lacustrine portion of the Site, and are less likely to occur in flowing waters because of the abrasion resulting from turbulence and coarse substrates in flowing waters (Wetzel 2001). Historical information on phytoplankton is available from a number of studies of Lake Roosevelt over the past 60 years (including

USDHEW 1953; Robeck et al. 1954; Ecology 1972; Stober et al. 1981; Beckman et al. 1985). The primary sources of data for this summary were the annual reports from 1998 to 2005 from LRFEP. This program, funded by the Bonneville Power Administration (BPA) and led by the Spokane Tribe of Indians (STI) Department of Natural Resources, has systematically evaluated limnological and fisheries resources over a variety of sampling locations between the Marcus Flats area (RM 710) and the Grand Coulee Dam (RM 599).

Between 1998 and 2002, LRFEP collected phytoplankton at 10 to 11 pelagic locations throughout Lake Roosevelt and in the Spokane and Sanpoil arms; beginning in February 2002, the number of sampling stations was reduced to five (Table 3). Frequency of sampling varied across years of the study, with most sampling concentrated in the late spring through early fall months (Table 4). Phytoplankton were collected using an integrated sampling tube to extract a column of water from the surface to the bottom of the euphotic zone, and analyses included speciation, enumeration, and estimation of biovolumes. Chlorophyll *a* was measured with an in-field fluorometer between 1998 and 2002, and beginning in 2003, with a spectrophotometer in the laboratory.

2.1.2.1 PHYTOPLANKTON TAXONOMY

Bacillariophyceae (diatomic algae), Cryptophyceae, and Chlorophyceae (green algae) are the dominant taxa among the phytoplankton collected from the UCR (Table 4). Both historically and more recently, diatoms have been a substantial component of the phytoplankton community. Diatoms dominated the phytoplankton community over most of Stober et al.'s (1981) study, and diatoms represent a significant portion of the phytoplankton community in more recent evaluations as well (e.g., comprising approximately 40 percent of annual mean phytoplankton density in LRFEP collections [e.g., Table 5]).

2.1.2.2 TEMPORAL AND SPATIAL PATTERNS IN PHYTOPLANKTON

Based on samples collected between the Grand Coulee Dam forebay and Northport (RM 732) in late September of 1952, USDHEW (1953) identified low nutrient concentrations in the water column, the high ratio of inflowing water to reservoir capacity, and other physical factors as contributing to "very poor" biological conditions. This conclusion was supported by few phytoplankton, sparse bottom fauna, and few game fish. USDHEW (1953) observed phytoplankton to be extremely limited throughout the UCR, both in the water column and from samples taken near bottom. In monthly sampling from December 1979 to September 1980 at sites between the Grand Coulee Dam forebay and Evans Landing (RM 710), Stober et al. (1981) identified peak chlorophyll *a* levels between 7 and 14 mg/m^3 in late spring/early summer months indicating a mesotrophic (i.e., moderately productive) condition. More recent sampling between May and October at four monitoring locations between Spring Canyon (RM 600) and Gifford (RM 674) (Table 3) has shown mean chlorophyll *a* at or below

2.5 mg/m^3 since 1997, and consistently below 1.5 mg/m^3 from 2001 to 2005 (Lee et al. 2006) (Table 6), indicating that the UCR is oligotrophic (Wetzel 2001).

Phytoplankton communities in the lacustrine portions of the UCR cycle annually, increasing in response to an influx of nutrients (nitrogen and phosphorus) with early spring runoff, and declining in number into the summer, as the phytoplankton deplete available nutrients and zooplankton grazing on phytoplankton increases. Stober et al. (1981) identified coincident phytoplankton declines with decreases in nitrate and orthophosphate water column concentrations over the course of the summer. Similar seasonal trends, with the highest chlorophyll *a* concentrations in May and June, are seen in more recent data from LRFEP (Figure 2).

Studies by Stober et al. (1981), Ecology (1972), Beckman et al. (1985), and Robeck et al. (1954) demonstrated that average phytoplankton standing crops, are highest near the mouth of the Spokane River (RM 634) and decrease both upstream and downstream from this location. Late spring declines in chlorophyll *a* concentrations may be attributable to nutrient depletion. Wilson et al. (1996) attributed lower phytoplankton production to reduced nutrient levels in 1994 and 1995. LRFEP sampling indicates that the highest chlorophyll *a* values are still found in the Spokane Arm (Figure 3), though chlorophyll *a* has declined over time throughout Lake Roosevelt, as discussed above.

2.1.3 ALGAE AS A FOOD RESOURCE IN THE UCR

Algae are primary producers in the UCR, providing the autochthonous sources of energy to higher trophic levels. Consumption of algae by fish in the UCR, either as phytoplankton or periphyton, has not been as well established as consumption of zooplankton, invertebrates and other fish. This may be because algal materials are digested rapidly by fish and cannot be clearly identified in fish stomach contents. Zooplankton are the primary consumers of phytoplankton. Periphyton, which grows in visible colonies and sometimes in mats in hard, immobile substrates, may be a more significant food source to grazers (other than zooplankton) than phytoplankton, which are small, mobile, and spatially dispersed. Moreover, purely algal periphyton communities are rare in aquatic systems. Instead, periphyton exist in biologically complex communities called “aufwuchs,” that include periphytic algae but also molds, bacteria, crustaceans, and even some insects. The presence of organisms other than algae, including heterotrophs which provide proteins and fatty acids to consumers, adds to the appeal of the aufwuchs community as a food source for grazers.

2.2 ZOOPLANKTON

Data describing the zooplankton communities and zooplanktivory in UCR fish are available and documented in annual reports from 1998 to 2005 from the LRFEP. This series of LRFEP annual reports has established that zooplankton are important to the ecology of the UCR by providing a significant food source for fish.

Approximately 28 zooplankton species[1] were identified over the 8 years of sampling from 1998 through 2005 conducted in the UCR (Table 7). Copepods are the dominant component of zooplankton density across all sampling areas throughout the LRFEP data set (refer to Map 1 for sampling stations), and copepods and daphnids each make up approximately half the total biomass at all sampling areas across the complete data set of 1998 through 2007, although copepods are numerically more abundant (Scofield et al. 2007). In 2003 and 2004, copepods consistently constituted the majority of individuals in the index sampling areas across the UCR and in the Spokane Arm (Figure 4). In 2005, daphnids made up the greatest proportion of zooplankton taxa towards the upstream end of the LRFEP sampling areas and in the Spokane Arm (Figure 4).

The zooplankton community in the UCR is dominated by two primary taxonomic groups–the orders Copepoda (copepods) which tend to be smaller (<1 mm diameter) and Cladocera (cladocerans), which range in size (length) from about 0.5 mm to greater than 8 mm. Among Cladocera, the family Daphnidae encompasses the genus *Daphnia*, the largest zooplankton genus known to occur in the UCR (Scofield et al. 2007). Mature *Daphnia* are usually greater than 1.0 mm in length in the UCR.

Zooplankton play a key role in the transfer of energy and biomass from primary producers (phytoplankton) in Lake Roosevelt up to fish, and on to higher trophic levels, including many terrestrial species and people. The discussion here focuses on these aspects of zooplankton in the UCR

- Long term trends in zooplankton abundances
- Spatial trends in zooplankton abundance
- Seasonal trends in zooplankton abundance.

2.2.1 LONG-TERM TRENDS IN ZOOPLANKTON ABUNDANCES

Reports dating back to the late 1940s have identified low productivity of zooplankton among the limiting factors in management efforts to enhance the UCR sport fisheries, particularly upstream from the Spokane River mouth (RM 640). USDHEW (1953) and Wilson et al. (1996) reported similar findings, and Stober et al. (1981) confirmed earlier observations of the importance of hydraulic residence time on the development of zooplankton populations in the UCR. Moreover, the overall productivity of zooplankton and production of *Daphnia* have declined since 1997 (Lee et al. 2006; Underwood et al. 2004). Underwood et al. (2004) noted a

[1] A few species were identified only to genus, so the precise number of species is not known.

rapid decline in *Daphnia* abundance beginning in 1997. Consistent with this trend, annual mean *Daphnia* biomass reported by Lee et al. (2006) from 1997 through 2004 was less than 20 percent of the biomass found from 1994 through 1996. Baldwin and Polacek (WDFW 2002) noted that although large *Daphnia* (i.e., >1.0 millimeters [mm]) were present in the UCR, the low densities indicated that *Daphnia* biomass and population structure were limited by cool water temperatures, low phytoplankton productivity, and high flows, rather than by fish predation.

2.2.2 SPATIAL TRENDS IN ZOOPLANKTON ABUNDANCE

Between 1998 and 2005, annual average zooplankton biomass ($\mu g/m^3$) was highest in the area of the UCR closest to Grand Coulee Dam (RM 597) and in the Spokane Arm at Porcupine Bay (Figure 5). The annual average zooplankton biomass declined with distance upstream from the Grand Coulee Dam, with the lowest biomass in the two upper reservoir sampling areas above the Marcus Flats area at RM 702 and RM 710 (<200 $\mu g/m^3$) throughout the years sampled; (see Figure 5). Gangmark and Fulton (USFWS 1949), using vertical tows with a plankton net in the upper 10 m of the water column, observed that "*meager plankton hauls in the upper reservoir were not indicative of good productivity in that portion of the lake*" and "*plankton hauls revealed fair-to-good abundance in the lower reservoir as compared to rather sparse concentrations in the upper reservoir*." The upper UCR sampling stations were located near the mouths of Flat Creek (RM 730), the Kettle River (RM 705), and the Colville River (RM 698); and lower UCR sampling stations were located near the mouths of the Spokane River (RM 639) and Sanpoil River (RM 614).

These low zooplankton biomass values are consistent with the transition upstream of Marcus Flats from a lacustrine to a riverine hydrology, because zooplankton biomass is generally lower in riverine systems than in lakes (Allan 1995). Zooplankton have limited means of locomotion, and therefore cannot maintain their presence in rapidly flowing waters (Wetzel 2001). Zooplankton taxa found in rivers, including copepods and cladocerans, tend to be restricted to sheltered areas such as backwater eddies and stable pools (Pennak 1989).

Based on work completed by Scofield et al. (2007), zooplankton are more abundant in littoral than in pelagic habitats. Scofield et al. (2007) noted that shallow[2] zooplankton tows in the UCR yielded higher biomass than deeper tows. In years when paired littoral and pelagic zooplankton tows were collected by LRFEP, greater densities (number/m^3) and biomass were obtained in most littoral sampling areas relative to pelagic areas during summer and fall (Figures 6 and 7). These differences were consistent across major taxa including copepods and daphnids (McLellan et al. 1999).

[2] Scofield et al. (2007) does not define the depth of "shallow" and "deep" areas, but does equate them with "littoral" and "pelagic," respectively.

2.2.3 SEASONAL TRENDS IN ZOOPLANKTON ABUNDANCE

Zooplankton densities in the UCR varied seasonally. The highest densities in all reaches occurred in the summer and early fall, and lowest densities were in the winter months (Figure 7) (Stober et al. 1981; Beckman et al. 1985; Lee et al. 2006). Zooplankton densities increased during spring to a peak in June, and subsequently declined by August. During the spring, zooplankton communities were dominated by rotifers; copepods were most abundant during summer. Cladoceran abundances increased from spring to summer, representing up to 12 percent of the total zooplankton density (Stober et al. 1981). Peak *Daphnia* density in the UCR was comparable to peak densities at Lake Pend Oreille and Banks Lake (Stober et al. 1981).

Zooplankton densities may be influenced seasonally or inter-annually by the rates of inflows and outflows of water, or hydraulic retention time in the reservoir, both of which affect nutrient inputs and nutrient cycling that control the population dynamics of phytoplankton, the primary food of zooplankton. Beckman et al. (1985) found that increased hydraulic residence times were associated with increased densities of zooplankton in Lake Roosevelt. Higher zooplankton densities and biomass occurred in littoral areas relative to pelagic areas during summer and fall.

The presence of large-bodied *Daphnia* in the zooplankton community during all seasons indicates that size-selective fish predation has not removed all of these nutritionally important organisms, and that food is not likely limiting the production of zooplanktivorous fish in the UCR (BPA 2005a; WDFW 2002).

2.2.4 ZOOPLANKTON AS A FOOD RESOURCE IN THE UCR

Zooplankton provide a critical link between the primary production of the phytoplankton and zooplanktivorous fish. By grazing on phytoplankton in the lacustrine areas of the UCR, the zooplankton community creates a conduit to higher trophic levels of both organic energy created by phytoplankton, and chemicals in the tissues of or adsorbed to phytoplankton, including chemicals of potential concern (COPC). Species of fish that consume zooplankton are found throughout the UCR, from the Grand Coulee Dam to the U.S.-Canada border.

Certain species and life history stages of fish may forage for zooplankton in different habitats of the UCR. Several zooplanktivorous fish species including peamouth, longnose sucker, northern pikeminnow, yellow perch, and black crappie, tend to be found in shallower waters throughout their life histories, while others including kokanee, rainbow trout, and lake whitefish are found over a broader range of depths in the water column (Table 8). Zooplankton provide a source of food for fish in pelagic waters, habitats not typically populated by significant numbers of insects and other invertebrates in the littoral areas of the reservoir and in the riverine portion of the UCR. From the ecological literature it is known that consumption of zooplankton is important for juvenile stages of many fish species found in the UCR, although the diet of many species transitions to include greater proportions of macroinvertebrates and other fish with age. Water level manipulations have reduced littoral benthic habitat and productivity relative to what might be expected in a natural lentic system (Spotts et al. 2002; Beckman et al. 1985), so adult fish in Lake Roosevelt may rely more heavily on zooplankton as a food source than they might in other lake systems (Black et al. 2003), making them a potentially more significant factor in the exposure of fish to COPCs than they may be in other aquatic systems.

However, not all fish use zooplankton (Section 2.5.4), so their importance differs in different species, as well as in the pelagic and littoral habitats. The degree of importance of zooplankton to the diets of each fish species is discussed in greater detail Section 2.5.

2.3 MACROPHYTES

There have been few systematic surveys of macrophytes in the UCR. Those of Broch and Loescher (1991), and Moore (1991, 1993). Broch and Loescher (1991) identified 16 species of macrophytes, all of which were located in protected areas, primarily in embayments and on shoals, as well as in the less turbulent areas. Macrophyte biomass has been observed to be very low in July and August, and greater in October. Moore (1991, 1993) evaluated the occurrence of macrophytes in Reaches 1 through 3, primarily to determine the distribution of Eurasian milfoil (*Myriophyllum spicatum*). No floating fragments or established plants were found at RM 170, 735, or 737. In 1991, the author found three macrophyte species (i.e., *M. spicatum*, *Potamogeton* sp., and *Elodea* sp.) at Deadman's Eddy (RM 738). No macrophytes were found at the mouth of Big Seep Creek, and were only near Deadman's Eddy.

More recent observations by Washington State Department of Fish and Wildlife (WDFW) personnel provide a general perspective on the distribution of aquatic macrophytes in the UCR (McLellan 2008, pers. comm.). Macrophyte beds are absent in Reach 1, except in a few embayments (e.g., Crown Creek). Further downstream, macrophytes become more common starting at around the island across from the Evans boat ramp. Tributary mouths are frequently occupied by macrophytes, in both the Marcus Flats area and throughout the lacustrine portions of the UCR. Macrophyte beds are known to occur in the following areas:

- China Bend
- Upstream in an embayment in the mouth of the Kettle River
- Mouth of the Colville River, on both sides of the highway bridge
- Snaag Cove
- Hall Creek

- Stranger Creek (on both sides of the UCR)
- Nez Perce Creek
- Hunters Creek
- Alder Creek
- Enterprise (east side of UCR)
- Wilmot Cove or Creek
- Ninemile Creek (series of embayments)
- Upstream from Spokane Arm about 4 to 5 miles on a flat on the east side of the UCR
- Spokane Arm (Harker and Mill Canyons)
- Hawk Creek
- Upper end of Sanpoil Arm
- Keller Ferry
- Swawilla Basin (large flats NE of a tributary).

Where they occur, macrophytes typically are found in areas with shallow bathymetry (i.e., alluvial fans) and embayments. Spring drawdown generally retards the ability of macrophytes to establish, and late summer drawdown desiccates them down to a water depth of about 10 ft. They primarily occur at depths of 15 to 20 ft at high pool.

2.4 BENTHIC MACROINVERTEBRATES

Descriptive qualitative studies of benthic macroinvertebrates have been conducted in the UCR.

2.4.1 MACROINVERTEBRATES IN THE UCR

Four studies conducted between 1989 and 1993 (Johnson 1991; Griffith et al. 1992; Voeller 1993; Bortleson et al. 2001) described benthic macroinvertebrate communities in the UCR, and evaluated the factors that controlled their structure and distribution. These investigators collected sediment grab samples from several water depths, and sieved samples using 0.25 mm (Bortelson et al. 2001) or 0.5 mm mesh screens (Johnson 1991; Griffith et al. 1992; Voeller 1993). An additional study was completed in the Columbia River upstream from the UCR site and above Trail, B.C. These studies describe the distributions of various macroinvertebrate taxa, and evaluated how potential stressors (water depth, metals concentrations in sediments, and reservoir drawdown) affect the richness and diversity of various aquatic invertebrate species.

Dipterans and oligochaetes dominated most samples collected by Johnson (1991) at four UCR sites between U.S. Geological Survey (USGS) RM 728 and 605, one sample from the Spokane River Arm (USGS RM 8), and one sample from the Sanpoil River Arm (USGS RM 4). Bortelson et al. (2001), Griffith et al. (1992), and Voeller (1993) confirmed that dipterans and oligochaetes were the dominant taxa. Stoneflies (Plecoptera) were not observed by Johnson (1991), and mayflies (Ephemeroptera) were found only at one location.

There appears to be a depth-related trend for some taxa (Griffith et al. 1992; Voeller 1993). Low abundances and diversity were found in samples from relatively deep water (i.e., 80 ft) (Table 9 and Figures 8 and 9) (Johnson 1991; Griffith et al. 1992; Bortleson et al. 2001; Voeller 1993). Griffith et al. (1992) evaluated differences in the macroinvertebrate community at varying water depths, below elevation 1,210 ft, between 1,240 to 1,211 ft, and 1,290 to 1,241 ft (precise depths not reported but were approximately <49, 50 to 79, and >80 ft). In general, gastropods are more abundant at shallow sites (0 to 49 ft) and bivalves are more abundant at deeper sites (80 ft), but both gastropods and dipterans were collected from 80-foot depths. Chironomidae seen by Voeller (1993) were generally most abundant at mid-depth (50 to 85 ft) sites and Oligochaeta were most abundant at deepwater (85 ft) sites.

Griffith et al. (1992) observed gastropod families Lymnaeidae, Planorbidae, and Physidae. Bivalves (Sphaeriidae) were also important at the Gifford, Porcupine Bay, and Spring Canyon deepwater sites (Table 10). Gastropod families observed by Voeller (1993) also include Lymnaeidae, Planorbidae, and Physidae, but they were less abundant than in the earlier study by Griffith et al. (1992). In contrast to what was found by Griffith et al. (1992), bivalves (Sphaeriidae) were not found and gastropods were low in abundance at all sites in 1993 (Voeller 1993). Bivalves (Sphaeriidae) were abundant at some sites, such as China Bend (Bortleson et al. 2001).

Voeller (1993) found amphipods (*Gammarus* sp.) at all sites and depths sampled, except at Gifford (USGS RM 676), where they were found only at the shallow depth (Table 11). No amphipods were found at any location by the other investigators.

2.4.2 MACROINVERTEBRATES IN AREAS UPSTREAM OF THE UCR

Information on macroinvertebrates in the Columbia River upstream of the U.S.-Canada border is also available. In April and October 1992, the benthic macroinvertebrate community structure was evaluated at five nearshore sites in the Columbia River between the Hugh L. Keenleyside Dam and the Columbia-Kootenay Rivers confluence (R.L. & L. Environmental 2000). This study was developed to evaluate baseline conditions before upstream reservoir management changes were implemented. Most samples were collected with a Waters-Knapp sampler (0.22 mm mesh net) in shallow areas (<30 cm depth). In addition, some samples were collected with a modified Surber/Hess sampler (0.20 mm mesh net) that allowed sample collection with substrate larger than 20 cm diameter (Norecol 1993). All samples were sieved with a 0.2 mm mesh sieve (Norecol 1993).

In general, chironomids, oligochaetes, round worms (nematodes), harpacticoid copepods, gastropods, and cnidarians (*Hydra*) were the dominant taxonomic groups found (R.L. & L. Environmental 2000). Ephemeroptera, Plecoptera, and Trichoptera (caddisflies) were generally not abundant, contributing 0 to 16 percent of the total number of benthic macroinvertebrates during the two 1992 surveys (R.L. & L. Environmental 2000). Other long-term studies of nearshore areas between the Hugh L. Keenleyside Dam and the Columbia-Kootenay Rivers confluence cited in the R.L. & L. Environmental (2000) report found that dipterans, oligochaetes, nematodes, snails, and water mites contributed from 84 to 100 percent of the macroinvertebrates collected. Caddisfly taxa have been collected in this river reach, downstream from Castlegar, B.C., and at Waneta, when ultraviolet light traps were used (Aquametrix Research Ltd. 1994; R.L. & L. Environmental 2000). The R.L. & L. Environmental (2000) report suggests that caddisflies may inhabit deeper water in this reach of the river and are not affected by daily flow fluctuations of the river.

2.4.3 MACROINVERTEBRATES AS A FOOD SOURCE IN THE UCR

Macroinvertebrates generally can use a very wide range of food sources, so the various macroinvertebrate taxa may occupy a range of trophic positions. The dominant taxa found in several benthic surveys were the insect order Chironomidae and subclass Oligochaeta; both are deposit-feeding detritivores.

For those fish that eat insects, chironomid larvae are generally dominant among the insect food sources (Table 12), which may be a reflection of their relatively high abundances across the Site. Oligochaetes were not observed in any fish stomachs, but their presence in fish diets can be difficult to detect, because they consist mostly of soft tissues, and are thoroughly digested by their predators.

Although amphipods are rarely used by fish, isopods (also crustaceans) are important to the diets of burbot that live in deeper waters (Polacek et al. 2006). Isopoda were found to be in the diet of two benthic fish (Table 12). Isopods as a group have a wide range of feeding capabilities; the feeding habits of isopods cannot be broadly classified. Gastropods, which typically graze on periphyton, make up a large fraction of the diets of sculpins, mountain whitefish, and rainbow trout. Otherwise, besides the ubiquity of zooplankton in the diets of fish, data describing fish diets suggests that most fish species use one or more macroinvertebrate taxa occasionally and probably opportunistically. As a result, the role of macroinvertebrates the chemical transfer pathways within the aquatic food webs may be difficult to generalize in exposure or other models.

2.5 FISH

Lake Roosevelt has been the subject of extensive study with regard to the fish community and fisheries. This section summarizes the historical literature which addresses broad patterns in the fish community, and describes diet and life histories of the species for which such data are available.

2.5.1 HISTORICAL FISH STUDIES

Prior to 1930, an annual average of 1.1 million adult salmon (i.e., Chinook, coho, sockeye), and steelhead migrated past the current site of Grand Coulee Dam. Other fish species that maintained significant populations in the area included white sturgeon, Pacific lamprey, cutthroat, and redband/rainbow trout (Gillin and Pizzimenti 2004). Because the Grand Coulee Dam was not outfitted with a fish ladder, native populations of salmon and steelhead were eliminated from the UCR following construction of the dam. Installation of the Grand Coulee Dam changed the UCR from a primarily lotic (running) to semi-lentic (standing) system, to one with greatly altered instream and riparian habitats. This once salmonid-based ecosystem became a system dominated by cyprinid (minnow), centrarchid (sunfish), and catostomid (sucker) species, with remnant populations of redband trout and kokanee (i.e., non-anadromous sockeye salmon) (Scholz et al. 1986; USFWS 1949).

Studies of Lake Roosevelt fisheries began within the first decade of the reservoir's existence, and extend to the present (Scholz et al. 1986; Bechman et al. 1985). Investigators focused on understanding the distribution and success of the remaining salmonids (rainbow trout and kokanee), and on describing changes in the fish community. Notable changes subsequent to the construction of the Grand Coulee Dam include the introduction of walleye (*Sander vitreum*) in the 1950s; ecological effects of the impoundment (increases in kokanee populations and entrainment in turbines); the decline in relative abundances of northern pikeminnow (*Ptychocheilus oregonensis*) from 65 percent in 1949 to 15 percent in the 1980s, and peamouth (*Mylocheilus caurinus*) from 64 percent in 1949 to 7 percent in the 1980s; and the implementation of hatchery programs for kokanee and rainbow trout.

During the early to mid-1980s the Northwest Power Planning Council (NWPPC) (now Northwest Power and Conservation Council) initiated plans to implement fish restoration and enhancement projects in Lake Roosevelt. The proposed Lake Roosevelt program was initiated in 1988 with the Lake Roosevelt Monitoring and Evaluation Program.

2.5.2 LAKE ROOSEVELT FISHERIES EVALUATION PROGRAM RESULTS

The LRFEP has conducted a monitoring program since 1998, with spring, summer, and fall electrofishing and gill net surveys of fish throughout the UCR. The systematic survey is designed to detect changes in species composition throughout the reservoir and at specific sites, refer to Map 2 for fish sampling sites. Samples are taken from 9 to 11 sites between Evans (RM 708) and the Grand Coulee Dam. Table 13 summarizes the relative abundance of the fish species collected with electrofishing and horizontal gill nets over a 10-year period (1995 to 2004).

Each sampling method selects for specific sizes and captures fish only in habitats where the sampling method can be effective. As a result, the sample is not necessarily representative (is biased) relative to the actual fish community present. For example, electrofishing tends to capture species of fish that reside along the shore; fish in deeper waters will not be represented in these samples. The true relative abundance for each species is not captured by any one method. Nevertheless, fish sampling using the same equipment over many years or at several locations are considered comparable. As such, the LRFEP monitoring data provide perspective on temporal trends in the fish species and size classes detected with the methods used.

Walleye, largescale sucker, rainbow trout, kokanee, and smallmouth bass are the dominant species captured via electrofishing surveys. Lake whitefish, burbot, walleye, and longnose sucker have dominated the gill net catches. Relative abundances of the captured fish species are not uniform throughout the UCR, since fish respond to variability in habitats across the Site. A series of pie charts (Figure 10) illustrate the relative abundances of each species captured at the 10 fisheries monitoring stations used by the LRFEP in 2004.

2.5.3 FISH LIFE HISTORIES

The general life history characteristics of the fish species most commonly found by LRFEP, and the white sturgeon, are presented below and summarized in Table 14.

2.5.3.1 LARGESCALE SUCKER (*CATOSTOMUS MACROCHEILUS*)

The largescale sucker has a subterminal mouth that is not overhung by the snout, and has more rays in the dorsal fin and larger scales than the longnose sucker. It is native to the Pacific Northwest, widespread (Scott and Crossman 1973), and the predominant sucker species in the Columbia River and its tributaries. The species accounted for 94 percent of all suckers in the Columbia main stem, Lake Roosevelt, and the Spokane River (Wydoski and Whitney 2003). In recent gill net and electrofishing surveys, the fish community in Lake Roosevelt has been dominated by largescale suckers (BPA 2006a), although Lee et al. (2006) report that the population of largescale suckers in Lake Roosevelt has decreased annually according to creel surveys. Lee et al. (2006) conducted electrofishing and gill net surveys in Lake Roosevelt in 2004, which yielded 139 largescale suckers averaging 500 mm (19.7 in.) in length (± 109 mm standard deviation [SD]) and 1,513 g (3.3 lb) in weight (± 639 g SD).

Largescale suckers live in close association with the lake or stream bottom and prefer habitat near the mouths of streams entering lakes. The species prefers shallow water but can be found as deep as 80 ft. Adults appear to move toward shorelines at night and deeper habitats during the day. Larvae are pelagic and are found primarily along the shorelines of river systems where water velocity is relatively low. In rivers, largescale sucker fry occupy the mud and cobble substrate of shallow pools and backwaters. This species has been observed in embayments of Lake Roosevelt while surface feeding near dense clusters of zooplankton (Behnke 2002).

In tagging studies performed in Lake Roosevelt and Box Canyon Reservoir, the majority of adults were recaptured at or near tagging locations (Wydoski and Whitney 2003). The remaining fish were generally recaptured within 6 miles of the tagging location, indicating relatively limited home ranges for this species. More extensive movement has been observed in the upper and lower fluvial reaches of Columbia River (Wydoski and Whitney 2003).

According to Black (1953), the optimal growth temperature for the largescale sucker is 18.9 °C. Spawning occurs in April and June depending on location, generally in shallow water about 8 in. in depth. Spawning generally occurs along the edges and downstream ends of pools in streams having a bottom of fine gravel and sand, with occasional boulders. Females may produce from 6,000 to 20,000 eggs depending on size, and generally broadcast their eggs along the substrate. Eggs hatch in about 2 weeks. Yolk sac larvae generally drift for a few days after hatching before occupying warmer, low-velocity shoreline and backwater habitats for rearing.

When near the surface, small largescale suckers forage on zooplankton. As they grow larger and transition to life in the benthic environment, their diet switches to aquatic insect larvae, with small diatoms and other plant material; larger suckers feed on crustaceans, larvae, earthworms, snails, and detritus (Dauble 1986; Scott and Crossman 1973). Largescale suckers consume *Daphnia* and other cladocerans, aquatic and terrestrial insects, aquatic worms, and aquatic snails (Table 12).

2.5.3.2 LONGNOSE SUCKER (*CATOSTOMUS CATOSTOMUS*)

Longnose suckers have long snouts that overhang a subterminal mouth, and they are found east of the Cascades, primarily in the Columbia River system. Compared to the largescale sucker, occurrence is somewhat limited in the larger river systems, preferring smaller, cold streams. Longnose suckers constituted only 3 percent of the total number of suckers in the Columbia River, Lake Roosevelt, and the Spokane River (Wydoski and Whitney 2003).

During limnetic surveys in Lake Roosevelt, a small number of longnose sucker were captured, ranging in size from 200 to 700 mm (7.8 to 27.6 in.) (WDFW 2002). According to Lee et al. (2006), the relative abundance of longnose sucker in Lake Roosevelt has increased annually since 2002. In 2004, Lee et al. (2006), primarily observed longnose suckers from Hunters (USGS RM 660) upstream to the U.S.-Canada border, and found largescale suckers to be most common downstream of Hunters. Gill net studies in 2003 revealed most longnose suckers were captured below 60 m (BPA 2006a).

Wydoski and Whitney (2003) report that longnose suckers recaptured during tagging studies in Box Canyon Reservoir were generally recaptured at the tag site or within 3 miles of the tagging location. A small number of fish were recaptured up to 6 miles from the tagging location. In the British Columbia reach of the Columbia River, nearly 33 percent of fish were recaptured near the tagging location, while the majority of the remaining fish were located 5 miles or less from the tagging location. One fish in this study was located 20 miles from the tagging site, indicating that some individuals may have much more extensive home ranges (Wydoski and Whitney 2003).

Lee et al. (2006) conducted electrofishing and gill net surveys in Lake Roosevelt in 2004, which yielded 190 longnose suckers averaging 357 mm (14.0 in.) in length (± 92 mm SD) and 632 g (1.4 lb) in weight (± 357 g SD). The average lifespan is 8 years and the age at maturity appears to vary with location (Wydoski and Whitney 2003). In more northern latitudes, males appear to mature at age 4 and females at age 5 (Wydoski and Whitney 2003). Spawning takes place in swift riffles of streams where early spawners from lakes may remain up to 3 weeks. During spawning, females are accompanied by several males, who fertilize eggs broadcast on gravel substrate. The number of eggs per female correlates to the size of the fish and varies considerably from 10,000 eggs for smaller females to more than 60,000 for larger fish. Hatched young may remain in the substrate for 1 to 2 weeks before moving from the spawning area (Wydoski and Whitney 2003).

Longnose suckers feed on plants, benthic macroinvertebrates, crustaceans, and fish eggs. In Lake Roosevelt, longnose sucker were found to feed primarily on midge larvae, with zooplankton, snails, caddisflies, bugs, spiders, stoneflies, and plant seeds constituting supplemental food (Wydoski and Whitney 2003).

2.5.3.3 KOKANEE (*ONCORHYNCHUS NERKA*)

Kokanee are the adfluvial life history form of sockeye salmon; they spend their entire life in fresh water. There is some uncertainty as to where and how kokanee originally became established in Lake Roosevelt, and whether the reservoir was initially colonized by wild stocks from upstream or by hatchery fish derived from Whatcom stock. Recent genetic evidence suggests that wild kokanee residing in Lake Roosevelt have ancestral ties to the upstream populations and little to no relationship to the Lake Whatcom stock (Young et al. 2002). Although the Sanpoil River may support some kokanee spawning, no other tributaries to Lake Roosevelt are believed to support substantial numbers of spawners and no shoreline spawning populations have been documented. Reservoir drawdown would likely impede successful shoreline spawning. A plausible explanation for the continued abundance of wild kokanee in Lake Roosevelt is that they are produced in tributaries and lakes in the Canadian portion of the upper Columbia River and migrate downstream to Lake Roosevelt. Kokanee are well known for their downstream migration and are commonly entrained in turbines (BPA 1996, 2001a).

Typically, kokanee adults spawn naturally between August and November. Hatchery and wild fish spawning behavior is similar; however, wild fish tend to spawn earlier (BPA 2001b; 2002a,b,c,e; 2003). Wild spawners are typically 4 to 5 years old, whereas hatchery spawners are typically 3 to 4 years old. The few successfully constructed redds in Lake Roosevelt tributaries (primarily in the Sanpoil River) give rise to emerging fry in late winter or early spring. Fish migrate out of the tributaries during the first year of life, live within the reservoir until age 4 or 5, and then return to their natal stream.

Lake Whatcom hatchery fish were originally introduced into Lake Roosevelt from 1942 through 1946, but apparently did not develop a sustainable population. Recent attempts to build a hatchery-based kokanee fishery began in 1988, once again using fry (250 to 500 to the pound) from Lake Whatcom Hatchery stock. The hatchery fish were not readily distinguishable from wild fish and therefore the contributions of hatchery fish to the fishery and natural spawning areas were not defined. It is generally believed that fry plants did not contribute significantly to the fishery due to predation by walleye, burbot, and rainbow trout predation on sub-yearling kokanee. In response, the hatcheries began rearing kokanee to yearling age before release.

2.5.3.4 RAINBOW TROUT (*ONCORHYNCHUS MYKISS*)

Rainbow trout are the most prominent game fish in Lake Roosevelt, providing approximately 50 percent of total angler harvest, which are mostly of hatchery origin. For the most part, the hatchery and wild fish differ by subspecies, where the hatchery fish are coastal rainbow trout (*Oncorhynchus mykiss irideus*) and the wild fish are predominantly redband trout (*Oncorhynchus mykiss gairdneri*) (Behnke 2002).

Lake Roosevelt has primarily been stocked with a non-native stock maintained at the WDFW Spokane Hatchery. Selective breeding for fall spawning has allowed the hatcheries to grow fish to a larger size for spring releases (Behnke 2002). Hatchery fish have been observed spawning in the spring and are likely contributing to the wild population to an unknown extent. Rainbow trout captured in Lake Roosevelt either have the appearance of the wild stock (strong, long, sleek, and darkly spotted) or are hatchery fish (short, fat, and silvery with an adipose clip). In 2001, the hatchery began producing sterile rainbow trout by triploiding their chromosomes. Triploid fish are released in areas believed to contain populations of wild fish, such as those near Kettle Falls.

Wild rainbow trout are believed to be primarily redband trout and naturalized hatchery fish. The Sanpoil River contains the largest population of redband trout. Based on the morphology of the Sanpoil redband, some believe it is derived from a remnant steelhead population. Redband trout inhabit many Lake Roosevelt tributaries and are found within the reservoir itself near tributary mouths. The native fish exhibit a mix of adfluvial and fluvial life history patterns. The adfluvial fish rear in their natal stream for 1 to 2 years and then migrate to the reservoir until becoming adults at age 4 or older. Fluvial fish remain in their natal tributary from birth to death. Adfluvial fish are generally of larger size than fluvial life forms, suggesting that rainbow trout grow faster in the reservoir than in the tributaries. Wild redband spawn in Lake Roosevelt tributaries during the spring. Fry emerge from redds in late spring through early summer. If adfluvial, the juvenile fish reside in the tributary for approximately 1 to 2 years and then migrate to the reservoir. Adult fish return to the tributary at age 3 or older and spawn.

2.5.3.5 LAKE WHITEFISH (*COREGONUS CLUPEAFORMIS*)

Lake whitefish are distinguished from other species of whitefish in the state of Washington by their unique morphology. The species has two flaps between the nostrils versus the single flap present in mountain whitefish. The historical range of lake whitefish included much of northern North America, from British Columbia east and extending north of northern Minnesota. In Washington, lake whitefish are in the UCR system throughout Lake Roosevelt and the McNary Reservoir. It appears that the species was not directly stocked into Lake Roosevelt, but that the Columbia River system was colonized by fish that entered the system via Lake Pend Oreille, Idaho (Wydoski and Whitney 2003).

Lake whitefish occur in large rivers, lakes, and reservoirs, preferring deep, cold habitats. In deep pelagic habitats of Lake Roosevelt, lake whitefish are prevalent. As reported by Baldwin and Woller (2006; BPA 2006a), recent horizontal and vertical gill net surveys revealed that lake whitefish was the predominant species captured throughout the reservoir, followed by walleye and rainbow trout. The majority of captured lake whitefish ranged from 201 to 700 mm (7.9 to 27.5 in.) (BPA 2006b). In August and October 2004, Baldwin and Woller (BPA 2006c) surveyed the limnetic zone of Lake Roosevelt using a combination of gill nets and hydroacoustics. In August, numerical species composition showed walleye were most abundant, followed by lake whitefish and rainbow trout. Most captured lake whitefish ranged from 401 to 700 mm in length (15.8 to 27.5 in.).

The species can live up to 17 years and, on average, attain a size of 24 in. and 3 to 5 lb (Wydoski and Whitney 2003). In 2003, scale analysis conducted on lake whitefish collected in Lake Roosevelt (generally captured below 60 m) determined that individuals were age 0 to 8 and ranged from 122 to 580 mm in length (BPA 2006a).

Lake whitefish is a fall spawner and appears to have strong fidelity to spawning sites (Wydoski and Whitney 2003). Congregations of lake whitefish are observed annually in the Hawk Creek embayment (USGS RM 633) where spawning is believed to occur (based on data provided in BPA (2006a). Other Lake Roosevelt spawning sites have not been documented. Although sexual maturity generally occurs between 4 and 5 years, males may become mature as early as age 2. Spawning is dependent upon local conditions and may not occur annually. Spawning occurs from October to January when water temperatures reach 5°C (Wydoski and Whitney 2003). Females broadcast semi-buoyant eggs over substrates of silt-covered stones, boulders, cobbles, and detritus. Wydoski and Whitney (2003) report that spawning in an Ontario, Canada, lake occurred in the littoral zone at mean depths of approximately 9 ft. Average fecundity is about 10,000 eggs per female per pound of fish. Eggs incubate for approximately 1 month prior to hatching at temperatures of 10°C (Wydoski and Whitney 2003).

The diet of juvenile whitefish appears to consist primarily of zooplankton including *Daphnia* (Wydoski and Whitney 2003). As they grow larger, they transition to bottom feeders and the diet becomes much more opportunistic and variable. Stomach content analyses conducted in Lake Roosevelt in 2003 revealed that lake whitefish fed primarily on isopods, followed by *Daphnia* (BPA 2006a). During a similar analysis conducted in 2004, Lee et al. (2006) determined that *Daphnia* was the most important diet item. It appears that they feed primarily on isopods in August and on both amphipods and isopods in October (BPA 2006c). Small fish (sculpin and stickleback), cladocera (water fleas), clams, chironomids, spiders, worms, fish eggs, and a variety of terrestrial insects are also consumed by lake whitefish in Lake Roosevelt (Wydoski and Whitney 2003).

2.5.3.6 SMALLMOUTH BASS (*MICROPTERUS DOLOMIEU*)

As the name implies, this species has a relatively small mouth compared to the largemouth bass. The native range for this species extended east of Minnesota as far north as Quebec and south to Georgia; however, the range was expanded by plantings in the Pacific Northwest in the 1800s and 1900s (USEPA 2002). In Washington, it was introduced into several western lakes including Lake Washington and stocked into the Yakima River, thereby becoming established in the Columbia River and its tributaries (Simpson and Wallace 1982; Wydoski and Whitney 2003).

The smallmouth bass occurs in cool, clear lakes and reservoirs as well as cool streams with moderate to swift current over gravel or rocks. In streams, it prefers deep, still pools and appears to display little migratory behavior, with limited home range. Tagging studies conducted by Munther (1970) in the Snake River determined that most smallmouth bass remained in the same pool or location as where they were tagged, while the remainder of fish tagged moved less than 0.75 mile from the tagging site. Todd and Rabeni (1989) monitored the movement of stream-dwelling smallmouth bass in Missouri, and determined that individuals occupied restricted home ranges for most of the year but dispersed in spring, with 75 percent returning to their home pool during the same season.

In lakes, smallmouth bass generally move within a definite home range that may increase significantly depending on the size of the lake and available resources. Home ranges in an 877-acre lake in Maine ranged from nearly 950 yd for 11-in. fish to 2,654 yd for fish over 16 in. (Wydoski and Whitney 2003). Other reported home ranges in lakes have been estimated at less than 2.5 to approximately 106 acres (Wydoski and Whitney 2003); however, Ridgway and Shuter (1996) observed larger home ranges (175 to 733 acres) in a 14,500-acre oligotrophic lake. Ridgway and Shuter (1996) also determined that relocated smallmouth bass return to their home ranges after spending approximately 1 week at a release site. Such strong fidelity to home ranges has also been observed in relocation and tracking studies conducted in Washington. In Lake Sammamish, 41 percent of smallmouth bass relocated up to 6 miles away from capture sites returned to the area of original capture within a year (Wydoski and Whitney 2003). Lake Roosevelt smallmouth home range has not been explored, but is assumed to be similar to that of fish inhabiting large lakes.

In Washington, smallmouth bass may live over 14 years old and attain lengths of 17 to 19 in. with weights up to 8 lb (although most are considerably lighter). In a study conducted by USEPA (2002), the body weight of smallmouth bass collected from the Columbia River ranged from 1,300 to 1,400 g (2.9 to 3.1 lb). In 2004, Baldwin and Woller (2006) collected scales from several smallmouth bass in Lake Roosevelt. Analysis of the scales determined that the fish were all age 3 and averaged 301 mm (11.8 in.) in length.

According to Carlander (1977), the optimal temperature for smallmouth bass growth is 26.4°C. Sexual maturity is reached at age 3 or 4. Spawning occurs in the spring when water temperatures are between 12.7 and 18.3°C. Females produce between 2,000 and nearly 21,000 eggs that are deposited into nests excavated down to coarse rubble or bedrock along the shoreline (Wydoski and Whitney 2003). If eggs fail to hatch, a second spawning may occur. Eggs incubate for about 1 month depending on temperature, and the fry generally emerge between July and August. Males guard the nests until the young emerge and exit, and in some cases, the male may continue to guard fry up to 28 days, but more typically for 2 to 10 days. Nests are usually located near overhead cover and along the margins of deeper pools where the current is slow. In areas where low-velocity pools are not present, spawning will not occur.

The smallmouth bass is essentially carnivorous. Fry initially consume copepods and cladocerans and transition to insects and small fish when they attain lengths of 2 to 5 cm (Hubbs and Bailey 1938; USEPA 2002). Adults feed on insects, crayfish, and fishes. In Lake Roosevelt, fish account for between 34 and 67 percent of the species' diet. Fish consumed in Lake Roosevelt included sculpin, minnows, salmonids, yellow perch, black crappie, and bass (WDFW 2002; Wydoski and Whitney 2003). In a 2001 diet analysis conducted in Lake Roosevelt, Scofield et al. (2004) determined that smallmouth bass fed mainly on Cottidae, although salmonids were also prey items. During a 2004 stomach contents analysis, Lee et al. (2006) determined that *Daphnia* was the most important diet item for smallmouth bass and that Osteichthyes was the most common fish consumed. According to Baldwin and Polacek (2002), one potential limiting factor for hatchery salmonid success in Lake Roosevelt includes piscivory by smallmouth bass, along with walleye and burbot.

2.5.3.7 BURBOT (*LOTA LOTA*)

Burbot, which have a single barbel under their chin, are the only freshwater member of the cod family in Washington State. The species has a circumpolar distribution. In North America, the species inhabits the northern part of the U.S., throughout Canada, and into Alaska. In Washington, the species occupies several deep lakes and reservoirs within the Columbia River basin, including the Spokane River drainage (Wydoski and Whitney 2003). Little attention has been paid to this species in the Pacific Northwest and less is known about occurrence and abundance in Lake Roosevelt. Between 4 and 15 percent of fish collected during recent gill net surveys in Lake Roosevelt were burbot (Baldwin et al. 2003; BPA 1997; 1999; 2002b,c; 2005a; 2006a). The Lake Roosevelt population appears to have increased from 4 to 12 percent of the gill net survey catch during the period 1994 to 2004 (Lee et al. 2006). The increased burbot population may be attributed to an increase in available prey items due to stocking of kokanee and rainbow trout (Wydoski and Whitney 2003).

Burbot home range appears to be small. Burbot occupy the same local area within seasons and between years based on sonic tracking studies conducted over 3 years in Lake Opeonogo, Ontario, Canada (Carl 1995). According to Wydoski and Whitney (2003), home range is limited and foraging areas are small and vary little from year to year. During gill surveys conducted in Lake Roosevelt in August 2004, burbot were found as deep as 110 m, while surveys conducted in October observed burbot between 31 to 40 m (BPA 2006a). The relatively dramatic shift in vertical position from summer to fall is likely due to thermal conditions because cooler waters found at deeper depths are preferred during summer months (BPA 2006a).

According to Scott and Crossman (1973), optimal growth temperatures for burbot range from 15.6 to 18.3°C. The life span and size of the burbot appears to vary considerably based on location; however, in Washington State, fish may live up to 14 years and attain sizes in the range of 22 in. in length and up to 17 lb (although most weigh much less) (Wydoski and Whitney 2003). Baldwin and Polacek (2002) analyzed burbot (ages 2 to 9) in Lake Roosevelt from 1998 to 1999, and determined that the fish ranged in length from 347 to 560 mm (13.6 to 22.0 in.) and weighed between 252 and 900 g (0.6 to nearly 2 lb). In 2003, otolith analyses conducted on burbot collected in Lake Roosevelt determined that captured burbot (generally collected by gill nets below 60 m) were ages 3 to 6, and ranged in length from 400 to 700 mm (15.7 to 27.5 in.) (BPA 2006a).

Males generally mature at age 3 and females at age 4. Spawning typically occurs in the winter to early spring, December/January to early March, when water temperatures reach approximately 1.7°C. Mean fecundities are relatively high, from 64,000 to more than 1.4 million depending on the size of the female. Eggs are deposited in shallows of the lake and adjacent tributary mouths at night over clean sand, gravel, or rocky substrates. At 6.1°C, eggs incubate for about 30 days; incubation periods are longer or shorter depending on temperature. Burbot hatch in early to late spring, generally from April through May.

Young burbot feed mainly on insects and other invertebrates, but by the age of 5, the diet transitions to become primarily piscivorous (ADFG 2005). Fish consumed by burbot include sculpin, whitefish, stickleback, perch, kokanee, rainbow trout, and other burbot (ADFG 2005; WDFW 2002; Wydoski and Whitney 2003). In Lake Roosevelt, the burbot diet consists primarily of fish (sculpin, suckers, smallmouth bass, walleye, kokanee, and rainbow trout) with smaller contributions of cottids, chironomids, crayfish, vegetation and organic matter, and a variety of terrestrial and aquatic insects (BPA 2005b; 2006c; Wydoski and Whitney 2003). In a 2001 Lake Roosevelt survey, burbot fed mainly on perch, although salmonids were also prey items (BPA 2004). These results were confirmed during a 2004 stomach contents analysis in which Lee et al. (2006) determined that perch was the most important diet item for burbot.

Lake Roosevelt burbot were observed congregating near kokanee spawning areas, consuming kokanee weighing up to 1 lb (Wydoski and Whitney 2003). According to Baldwin and Polacek (WDFW 2002), one potential limiting factor for hatchery salmonid success in Lake Roosevelt includes piscivory by burbot, walleye, and smallmouth bass.

2.5.3.8 WALLEYE (*SANDER VITREUM*)

Walleye are non-native to the Columbia River (Scott and Crossman 1998) and were believed to be introduced into Lake Roosevelt during the 1950s by the U.S. Fish and Wildlife Service (Williams and Brown 1983). Over the past 40+ years, walleye have become one of the predominant species in Lake Roosevelt, and are currently managed to maximize harvestable numbers.

Walleye normally spawn from late March through early May. The preferred spawning temperature ranges from 4.4 to 10°C. Males arrive at the spawning grounds before females and tend to stay a little later (Scott and Crossman 1998; Wydoski and Whitney 2003). Spawning generally occurs in water less than 15 ft deep over a variety of substrates, such as flooded vegetation, coarse gravel, and boulders. Although walleye do not have a restricted home range, they tend to spawn in the same location each year (Wydoski and Whitney 2003). Walleye primarily spawn near Little Falls Dam in the Spokane Arm in Lake Roosevelt, but also likely spawn in the Sanpoil Arm and upper reservoir near the U.S.-Canada border where the reservoir is most river-like.

Egg development varies with water temperature. Hatching occurs from 7 days at water temperatures greater than 12.8°C to 26 days at 4.4°C (Wydoski and Whitney 2003). The yolk sac of walleye fry is relatively small and is usually fully absorbed within 2 to 3 days (Becker 1983). Fry initially feed on zooplankton and within the first few months of life progress to larger forms of invertebrates and small fish (BPA 1999). From that point on, their diet is composed almost exclusively of fish. The dietary transition from invertebrates to fish coincides with movement from the surface to a bottom habitat (Scott and Crossman 1998).

Walleye can live longer than 15 years, but do not typically live longer than 8 years in Lake Roosevelt (BPA 1999). They can tolerate a variety of environmental conditions, but prefer shallow, turbid waters (Scott and Crossman 1998). Walleye have a special eye configuration that allow them to see exceptionally well at night and therefore feed at dawn, dusk, and night (Scott and Crossman 1998). In open water, walleye travel in loose aggregations and schooling is common when feeding and spawning (Becker 1983).

Walleye typically spawn in the spring to early summer, and first spawning occurs at ages 2 or 3 for males and ages 3 or 4 for females (Scott and Crossman 1998, Williams and Brown 1983), and appears to be mainly size- rather than age-dependent. Female walleye deposit 25,000 to 40,000 eggs per pound of body weight (Becker 1983). Spawning occurs at night and usually involves one female and up to two males, or two females and up to six males (Scott and Crossman 1998). Most females broadcast their eggs over the streambed in one night, while males spawn over a longer period (Ellis and Giles 1965). After release, the sticky eggs attach to one another and to adjacent vegetation or streambed material. After an hour or two, they water-harden, lose their adhesive properties, and settle onto weed mats or drop into crevices in the substrate (Scott and Crossman 1998). After spawning, adults can migrate great distances. Spawners from the Spokane Arm were recovered over 150 miles away near the U.S.-Canada border within weeks of being tagged (Bechman et al. 1985).

2.5.3.9 WHITE STURGEON (*ACIPENSER TRANSMONTANUS*)

White sturgeon are the largest and longest-lived freshwater species in North America (Scott and Crossman 1998). They can grow up to 6 m long, weigh more than 800 kg, and live beyond 100 years. They have a cartilaginous skeleton, a tube-like mouth with barbells, a hard protruding snout, and are shielded with bony plates called scutes.

The white sturgeon is a facultative anadromous species that inhabits large rivers, estuaries, and nearshore areas of the Pacific Ocean from Ensenada, Mexico, to the Aleutian Islands. The Columbia, Fraser, and Sacramento rivers contained historically large spawning populations. The construction of Grand Coulee Dam isolated them from downriver feeding and rearing areas and from breeding with downriver fish. This isolated population is believed to be unique and considered by many to be part of a distinct population that resides in Lake Roosevelt upstream to Hugh Keenleyside Dam, 35 river miles upstream of the U.S.-Canada border.

White sturgeon genetic studies have consistently documented decreasing genetic differences with distance upstream (Anders and Powell 2002, in press; Barley et al. 1985; BPA 1987; Brown et al. 1990; McKay et al. 2002). The total number of haplotypes[3] was negatively correlated with inland distance from the Pacific Ocean in all rivers systems that have been studied (Anders and Powell 2002, in press). The frequency of anadromy appears to decrease in upper portions of basins, which may be an expression of genetic differences with lower river populations. Brannon et al. (1987) found that Lake Roosevelt white sturgeon were genetically distinct from other Columbia River sturgeon populations.

White sturgeon typically mature and begin spawning at 25 to 30 years old. They spawn during spring and early summer in fast-flowing river reaches. The only well-documented spawning site for the Lake Roosevelt population is the Waneta Dam tailrace at the mouth of the Pend Oreille River. A recent survey also indicates that spawning also occurs near Northport (McLellan 2006, pers. comm.). The females and males congregate and release their eggs and sperm over the streambed. The fertilized eggs cling to the streambed by a sticky coating until water-hardened. Hatching occurs 5 to 10 days later, and is dependant on water temperature. After hatching, the larvae swim up into the water column and are dispersed downstream by the currents. The dispersed sturgeon hide in the substrate for 20 to 25 days until they absorb the yolk sac. After yolk absorption, the fry move out from under the substrate to forage for food. During the first year of life, sturgeon remain associated with rough substrate for cover. They live on or near the bottom throughout their life.

[3] Haplotype is a combination of very closely linked alleles or markers that tend to be transmitted as a unit to the next generation.

In the UCR, minimal effective recruitment of juvenile sturgeon has been documented since 1985, although successful spawning has been documented annually (UCWSRI 2002a). Due to poor recruitment, UCR white sturgeon are considered imperiled and a plan has been developed to recover the population (UCWSRI 2002b). A key strategy of the recovery plan is rearing juvenile sturgeon in a hatchery to reestablish the population. Juveniles are released as 1-year olds, when they no longer appear to be susceptible to high rates of mortality. Release of tagged hatchery fish also allows researchers to conduct studies. At this point, the unnatural low flows during the spring, lack of spring riparian flooding, water temperatures, low turbidity, food availability, predation, and contaminants are considered possible reasons for the failed recruitment of young fish.

2.5.4 FISH DIETS

One result of the LRFEP is an extensive series of data describing the diets of fish in the UCR. Quantitative information on the use of different prey by consumers in different habitat areas is critical to characterizing chemical transport pathways within the aquatic habitats of the UCR. Detailed diet information is valuable both for illuminating the types of habitats actually used by fish, and in developing realistic models for calculating exposure of fish to COPCs.

Data describing fish stomach contents provided in LRFEP reports were compiled and summarized in Table 12. This summary presents the average percent, by mass, of each of several taxonomic categories of fish prey. The average presented is a weighted average, in which the number of fish stomachs analyzed in each year that was included in the average was used to weight the prey taxa in the calculation of the overall average of all the years combined.

As illustrated within Table 12, zooplankton is an important dietary component of several species within the UCR, including both pelagic (e.g., kokanee, whitefish) and benthic (e.g., sucker) fish species. It also suggests a differentiation of feeding guilds likely to result in differing exposures among broad categories of fish. This information is therefore useful in selecting indicator species as representative of broader receptor groups.

The majority of fish species collected by the LRFEP (16 out of 21 species for which gut content analyses were performed) contained zooplankton in their stomachs during one or more years of sampling. According to details provided in the LRFEP reports, daphnids make up a large proportion of the diet of numerous fish species, and the larger daphnids are selected by fish. Copepods are also present in the diets of several fish species. Kokanee (*Oncorhyncus nerka*), rainbow trout (*O. mykiss*), yellow perch (*Perca flavescens*), and black crappie (*Pomoxis nigromaculatus*) consistently had the highest proportions of zooplankton in their stomachs (Table 12).

Very few fish appear to be specialized feeders, with the exceptions of kokanee and the piscivorous largemouth bass and walleye. The diets of burbot and brown trout are dominated by fish, although the diets of burbot captured offshore consist mainly of isopods while the nearshore burbot, those represented in the LRFEP data (Table 12), are predominantly fish (Polacek et al. 2006). Piscivory is common among the larger fish, with parts of bony fishes found in the stomachs of all of the salmonids except kokanee, yellow perch, black crappie, northern pikeminnow, sculpins, and the brown bullhead, in addition to those discussed above. Chironomids and other dipterans also make up a large portion of the diets of several species, and insects generally are found in most fish stomachs. The crustaceans are better represented by isopods than by amphipods in the stomachs of UCR fish.

2.6 AMPHIBIAN EARLY LIFE STAGES

Incidental observations by WDFW (McLellan 2008, pers. comm.) have noted tadpoles in Porcupine Bay (of the Spokane Arm), Hawk Creek, the mouth of the Colville River, and the Seven Bays shoreline.

There are 10 species of amphibians that could occur in the UCR, including upland areas. Table 15 lists the amphibian species, and the habitats and foods required by their early life stages, as described by Leonard et al. (1993). The species most likely to spend prolonged periods in water are the tiger salamander, spotted frog, green frog, and the bull frog. Tiger salamanders in dry climates may even reach maturity in the aquatic form, never leaving the water as adults as other salamanders typically do (i.e., they are neotenous). Bullfrog tadpoles may reside in water for two or three summers before emerging as adults, and adult bullfrogs are found along shorelines of lakes, ponds and reservoirs. Both species are omnivorous, eating other amphibians, fish, eggs, and invertebrates. These characteristics, prolonged aquatic life history stages, including use of lakes and reservoirs and ingestion of higher trophic level foods during juvenile life stages, enhance the likelihood of exposures to COPCs in their aquatic life stages.

Other species of amphibians that may be found in the UCR are adapted to the dry climate, meaning they have a limited dependency on water, with rapidly developing embryos and emergence to adult forms taking a matter of weeks. These life history characteristics mean that these amphibians can take advantage of ephemerally wetted environments to breed opportunistically with favorably wet weather.

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FIGURES

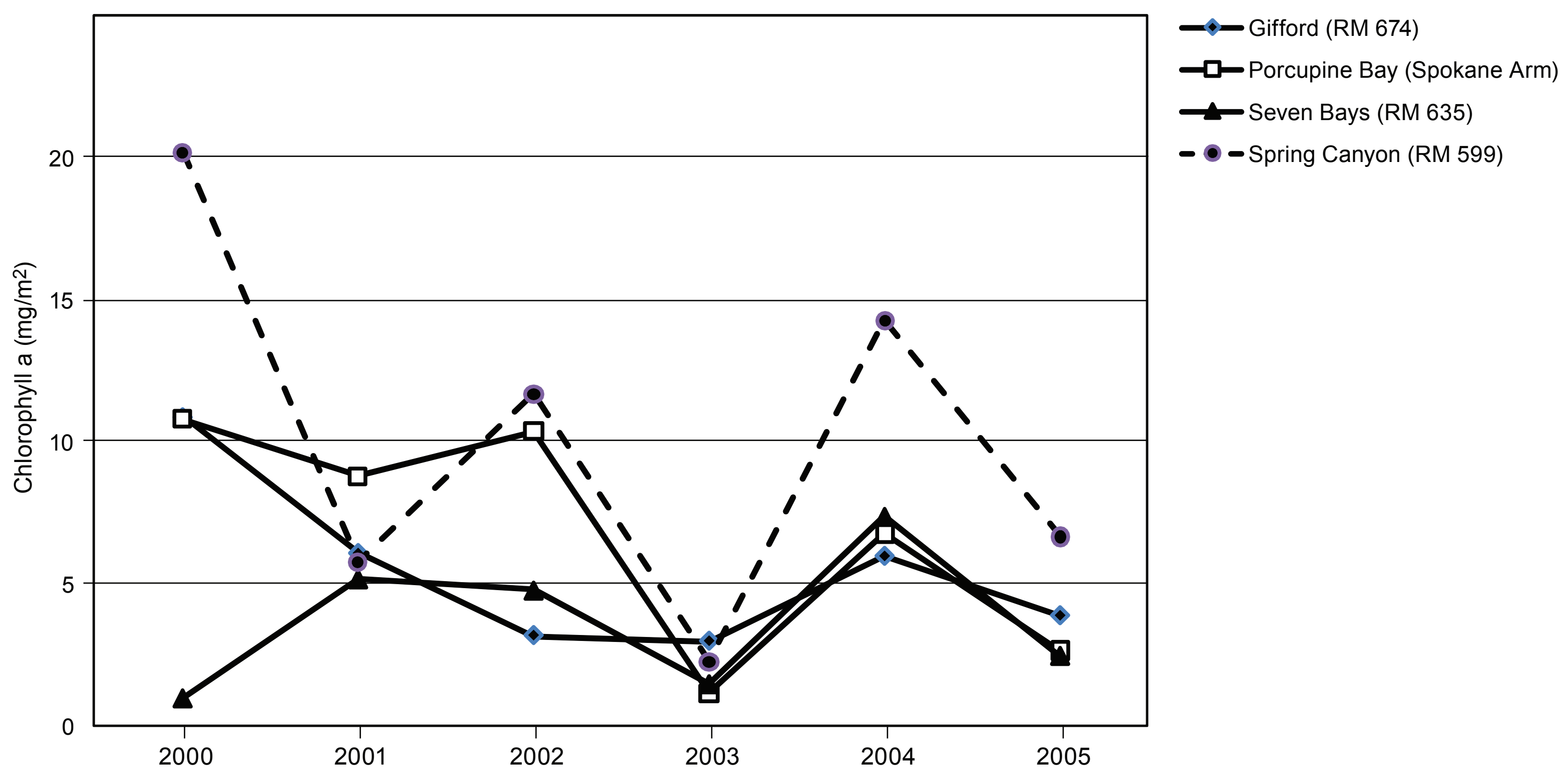


Figure 1. Average Annual Periphyton Chlorophyll *a* (mg/m^2) Measured from Colonized Artificial Substrates Set at Four Sites in the UCR from August to October (2000-2005)
Source: LRFEP

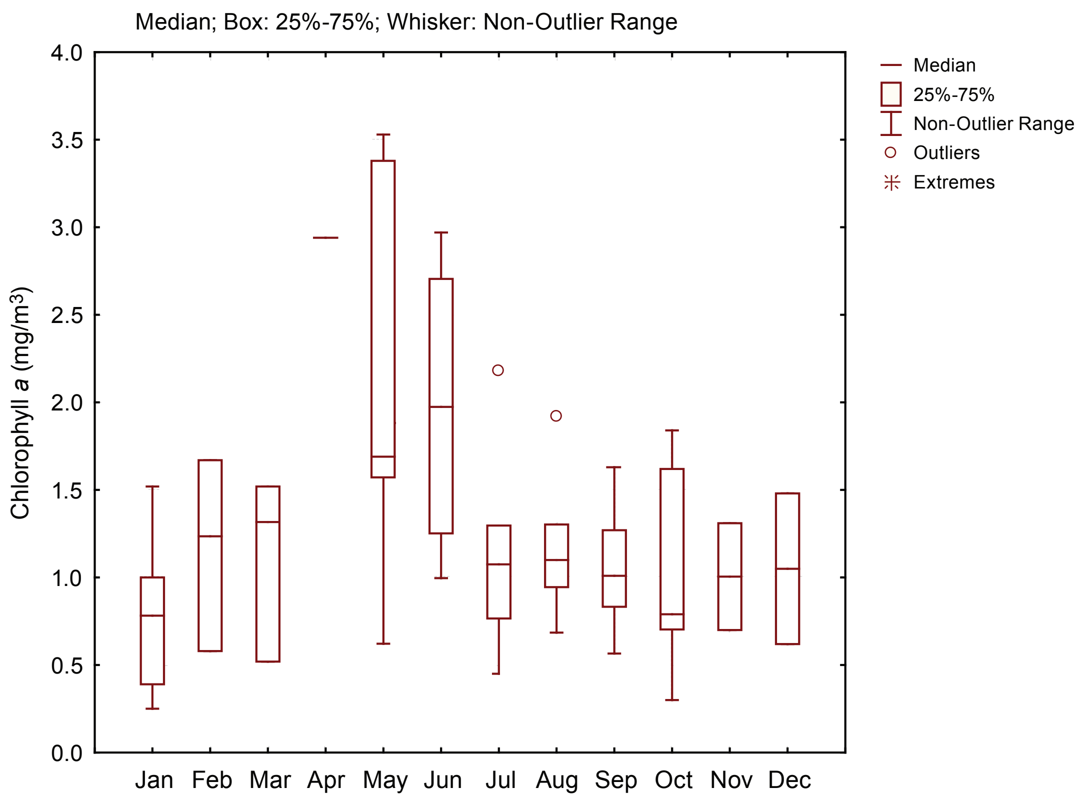


Figure 2. Monthly Mean Chlorophyll *a* Concentrations from 2000 to 2005 in the UCR (LRFEP)

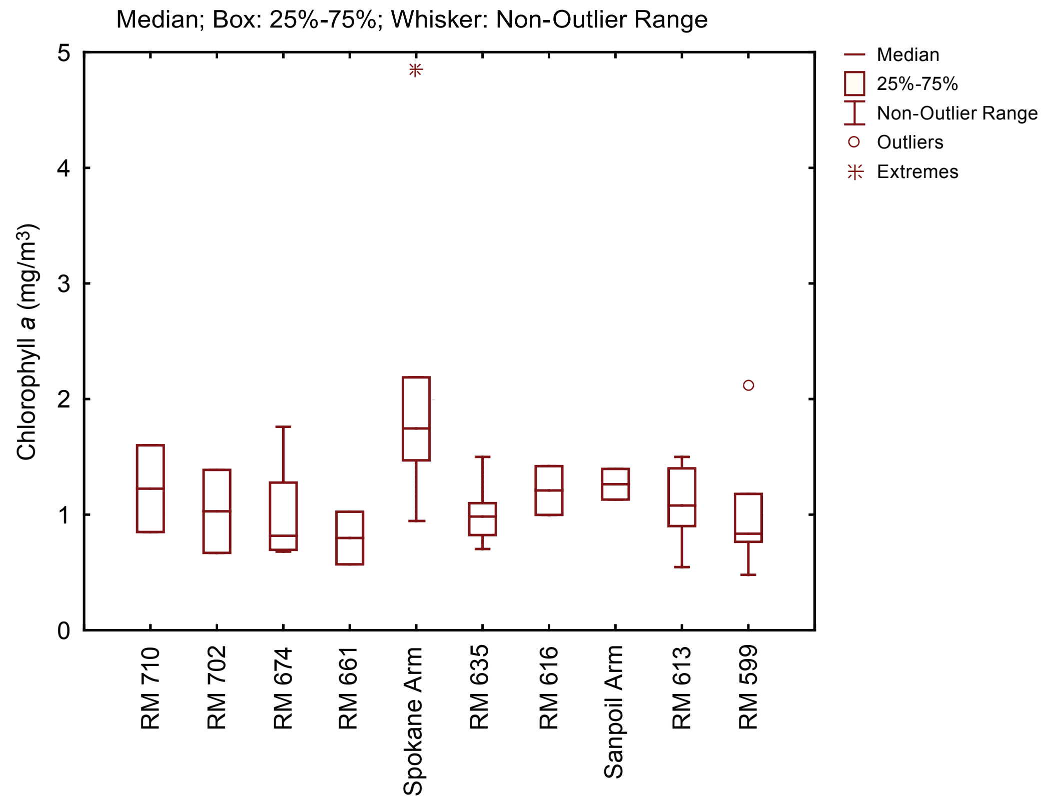


Figure 3. Annual Mean Chlorophyll *a* Concentrations from 2000 to 2005 in the Upper Columbia River (LRFEP)

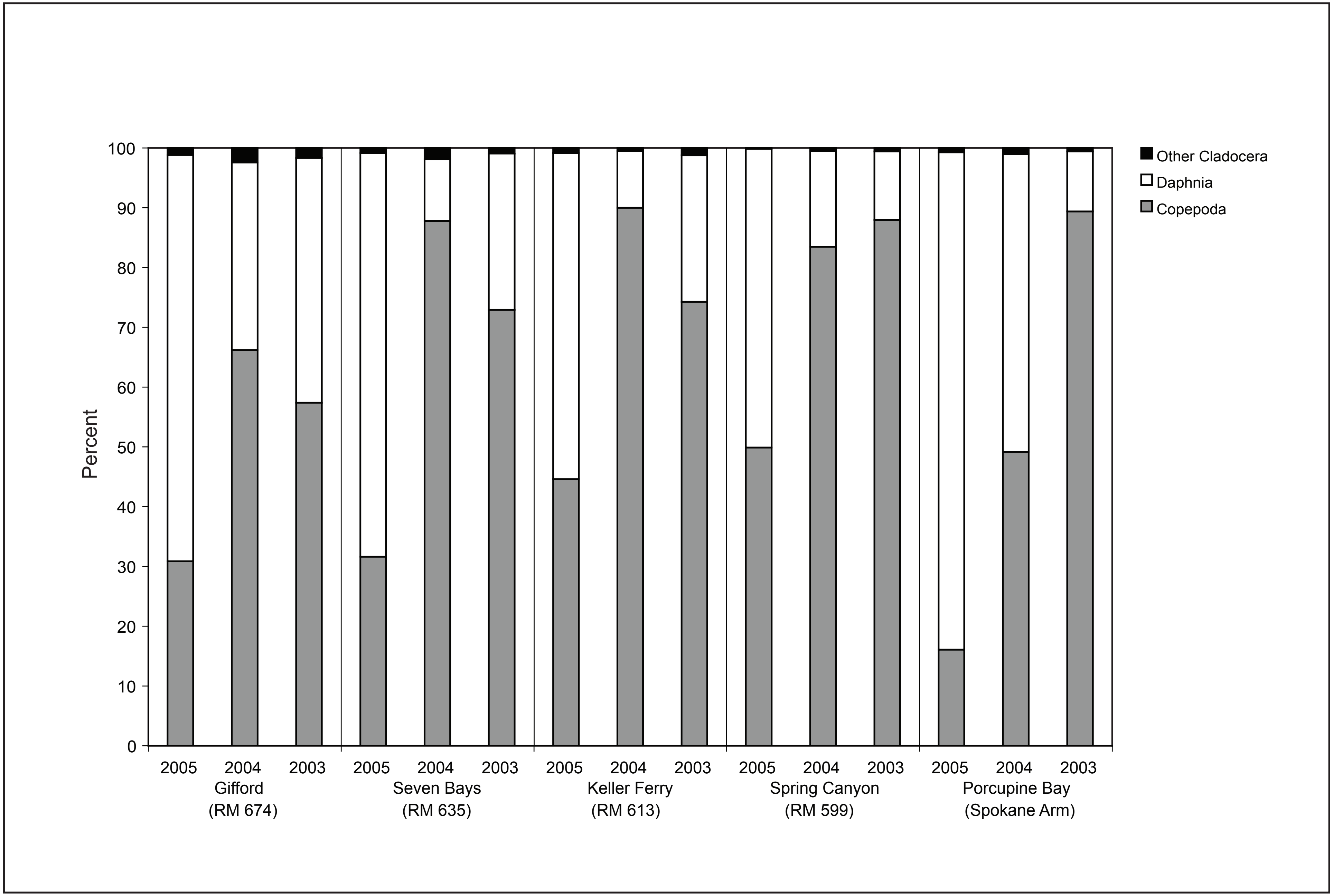


Figure 4. Relative Abundances of Major Zooplankton Taxa from Five Lake Roosevelt Fisheries Evaluation Program Index Stations, 2003–2005

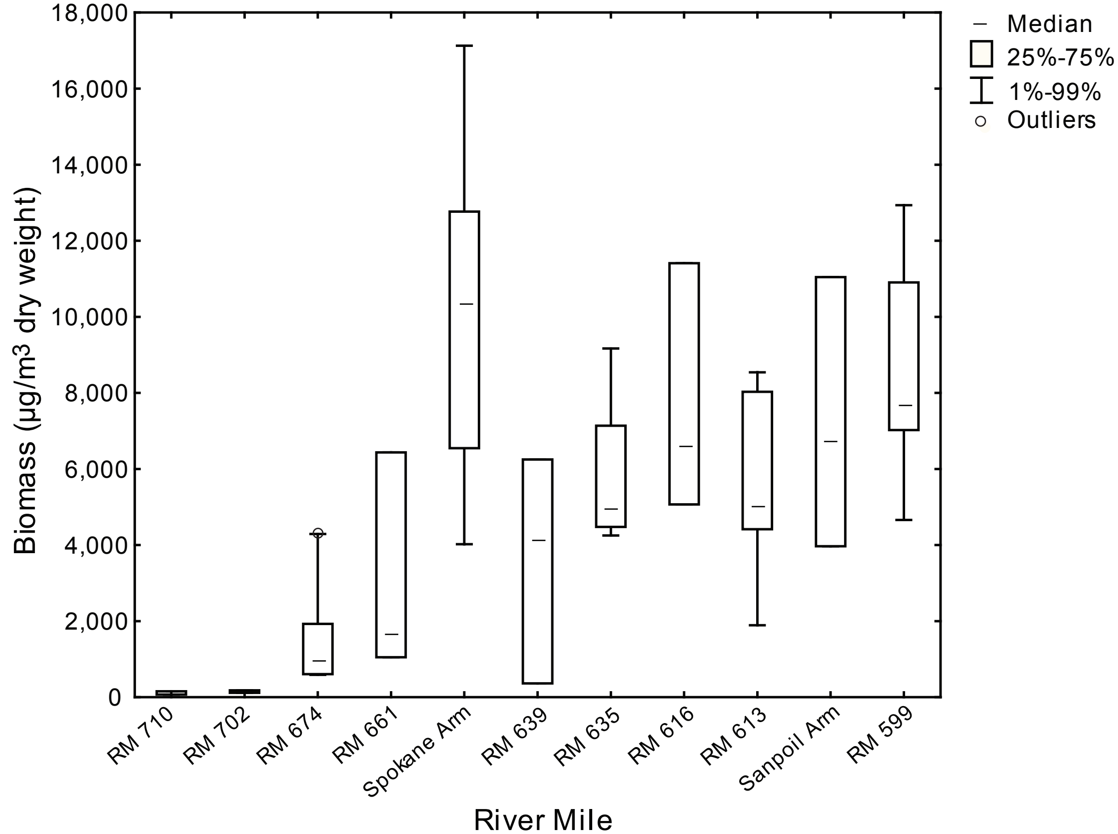


Figure 5. Annual Average Biomass Estimates for Lake Roosevelt Fisheries Evaluation Program Zooplankton Sampling Areas

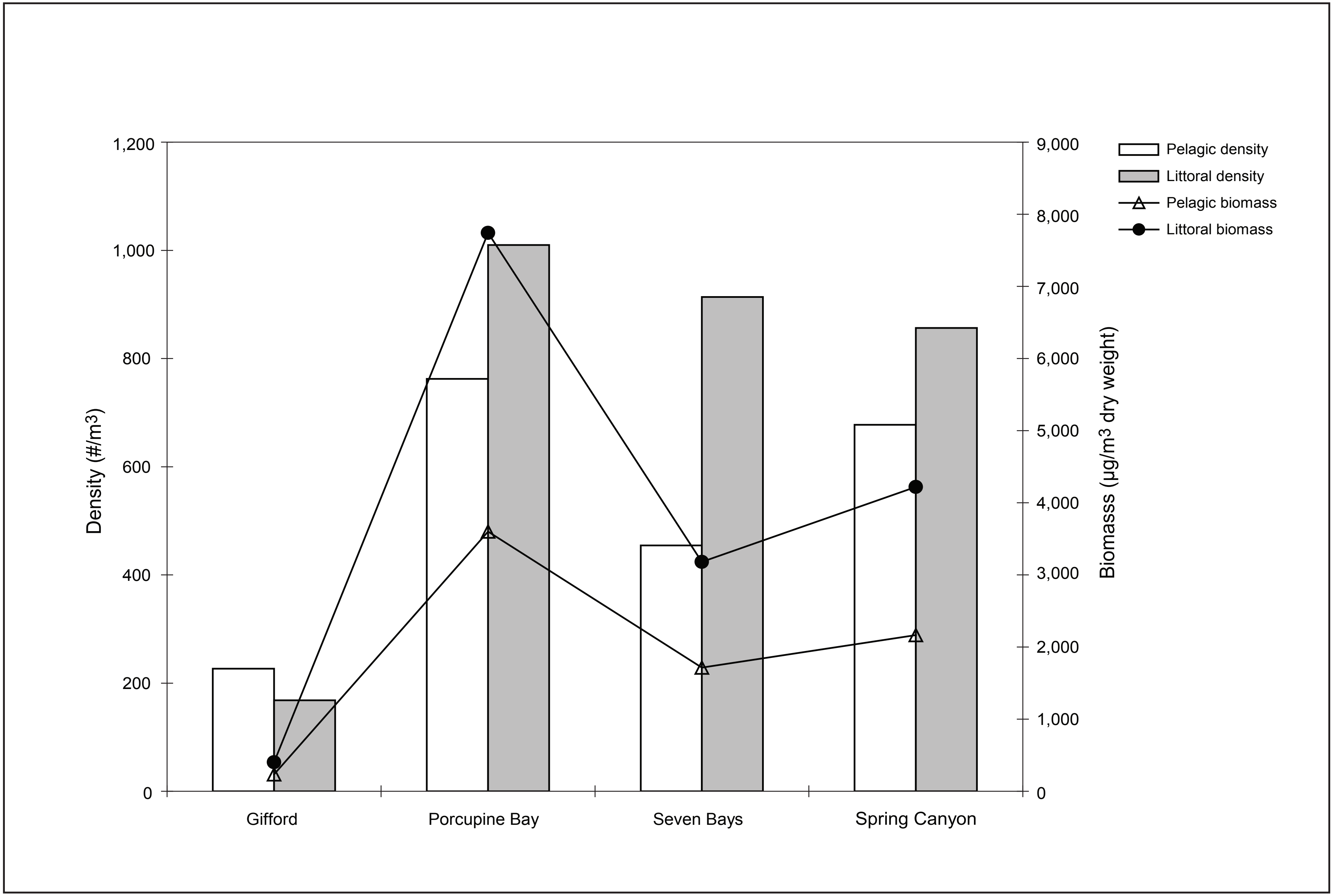


Figure 6. 1999 Lake Roosevelt Fisheries Evaluation Program
Littoral and Pelagic Zooplankton Densities and Biomass

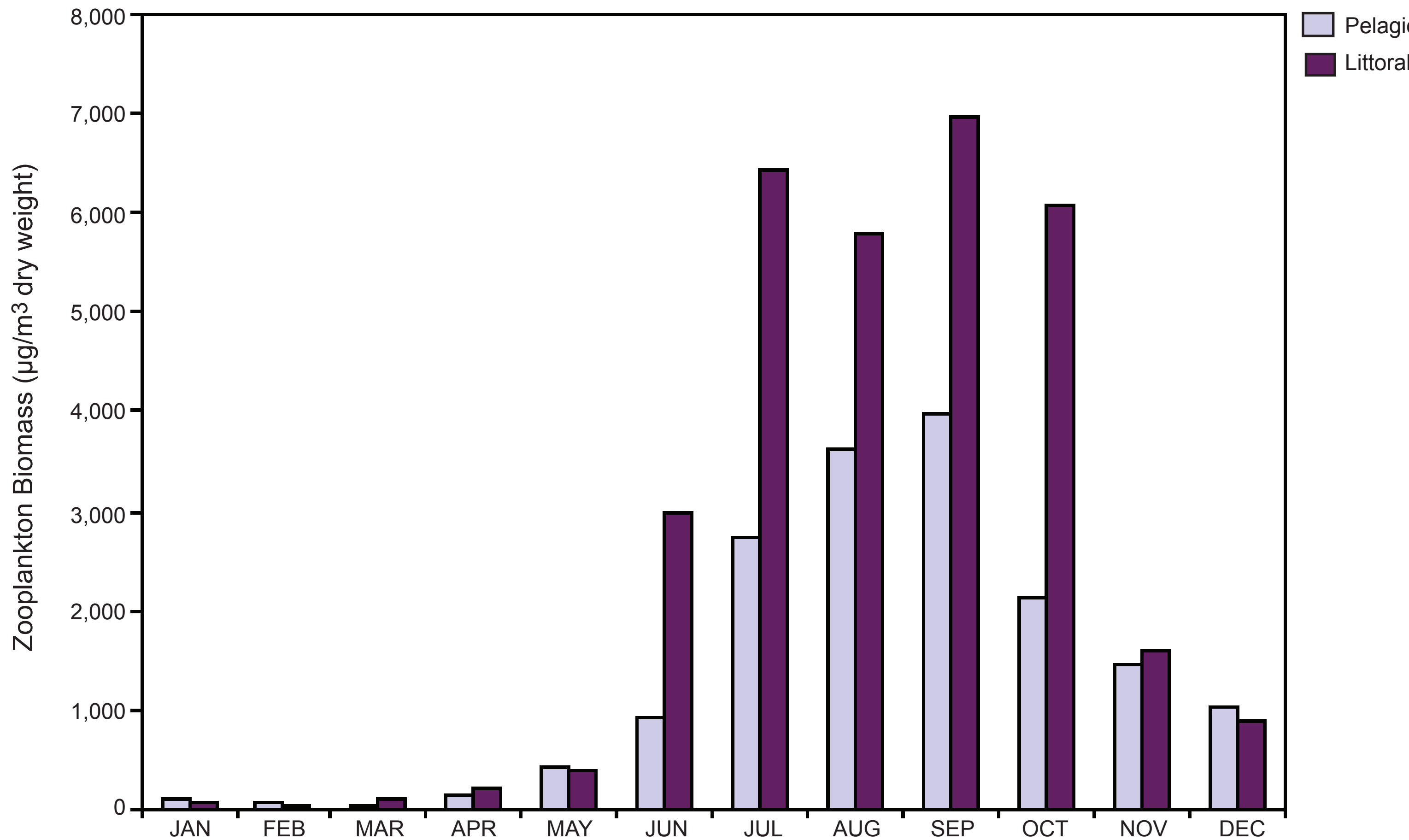


Figure 7. 1999 Average Zooplankton Biomass (µg/m^3 Dry Weight) in Lake Roosevelt Across all Sampling Locations within Littoral and Pelagic Zones by Month in 1999
Source: McLellan et al. (1999).

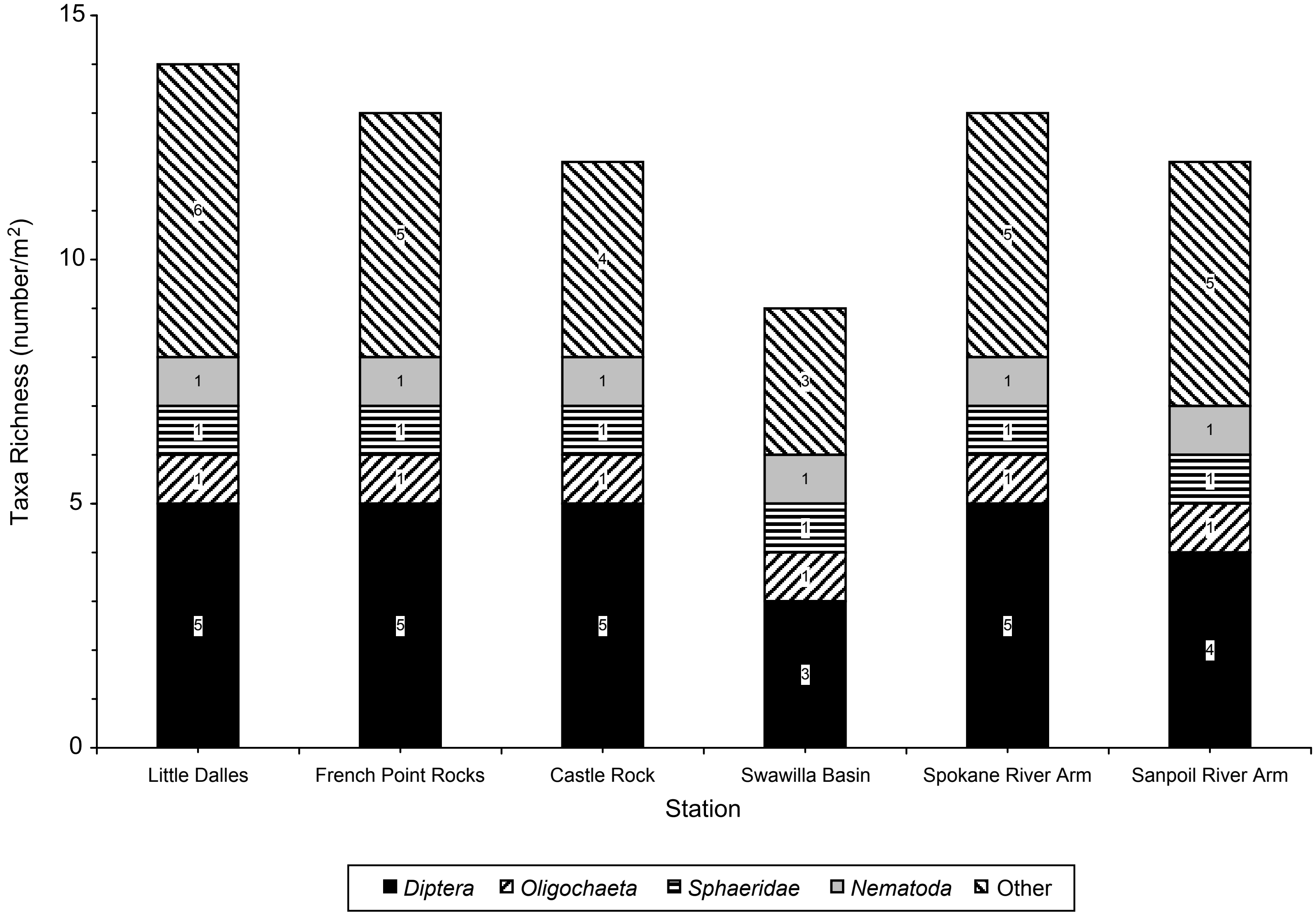


Figure 8. Richness of Benthic Macroinvertebrate Taxa Collected at 40 to 80 feet in the UCR in 1989
Source: Johnson (1991).

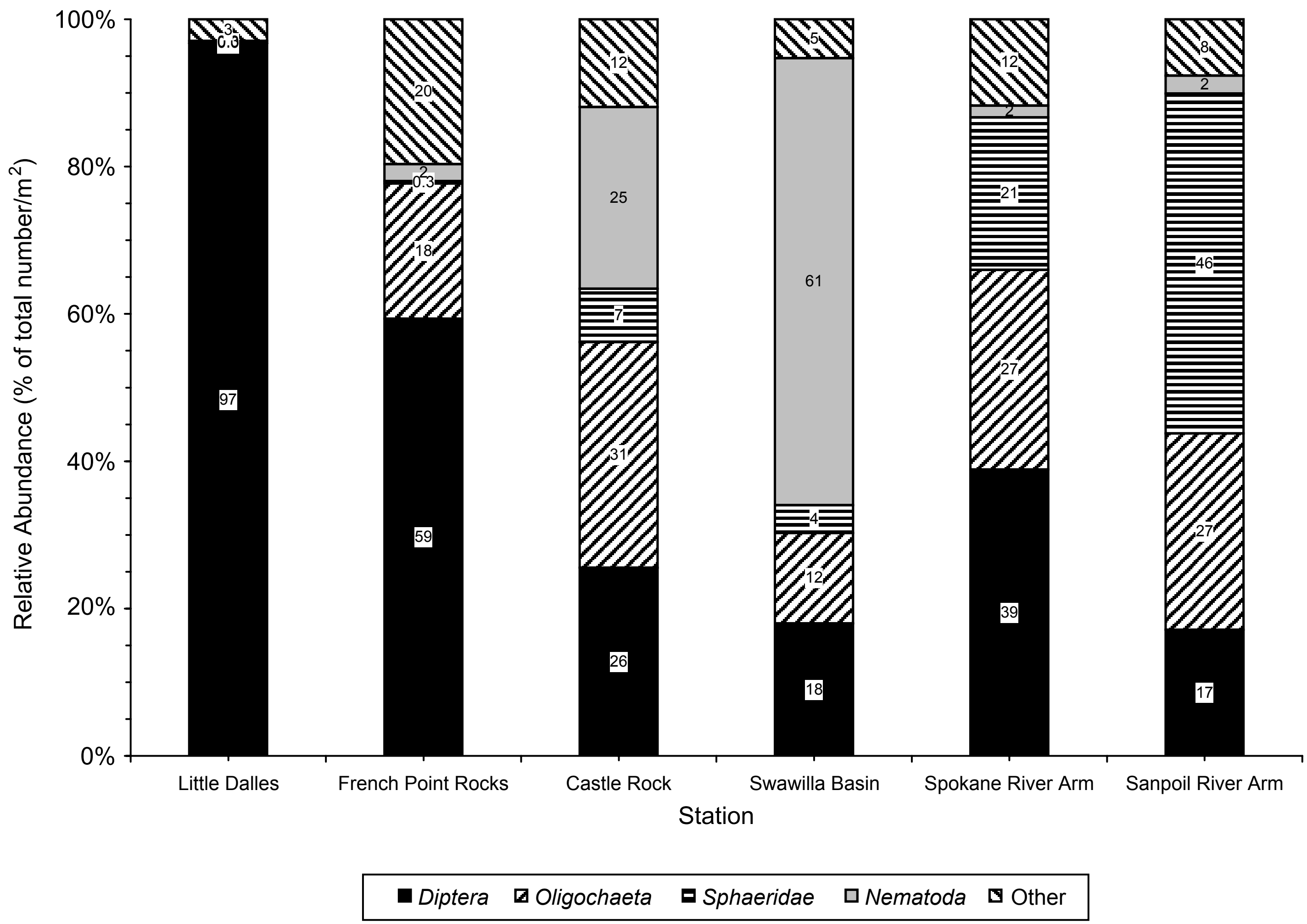


Figure 9. Relative Abundance of Key Taxa Collected at 40 to 80 feet in the UCR in 1989
Source: Johnson (1991).

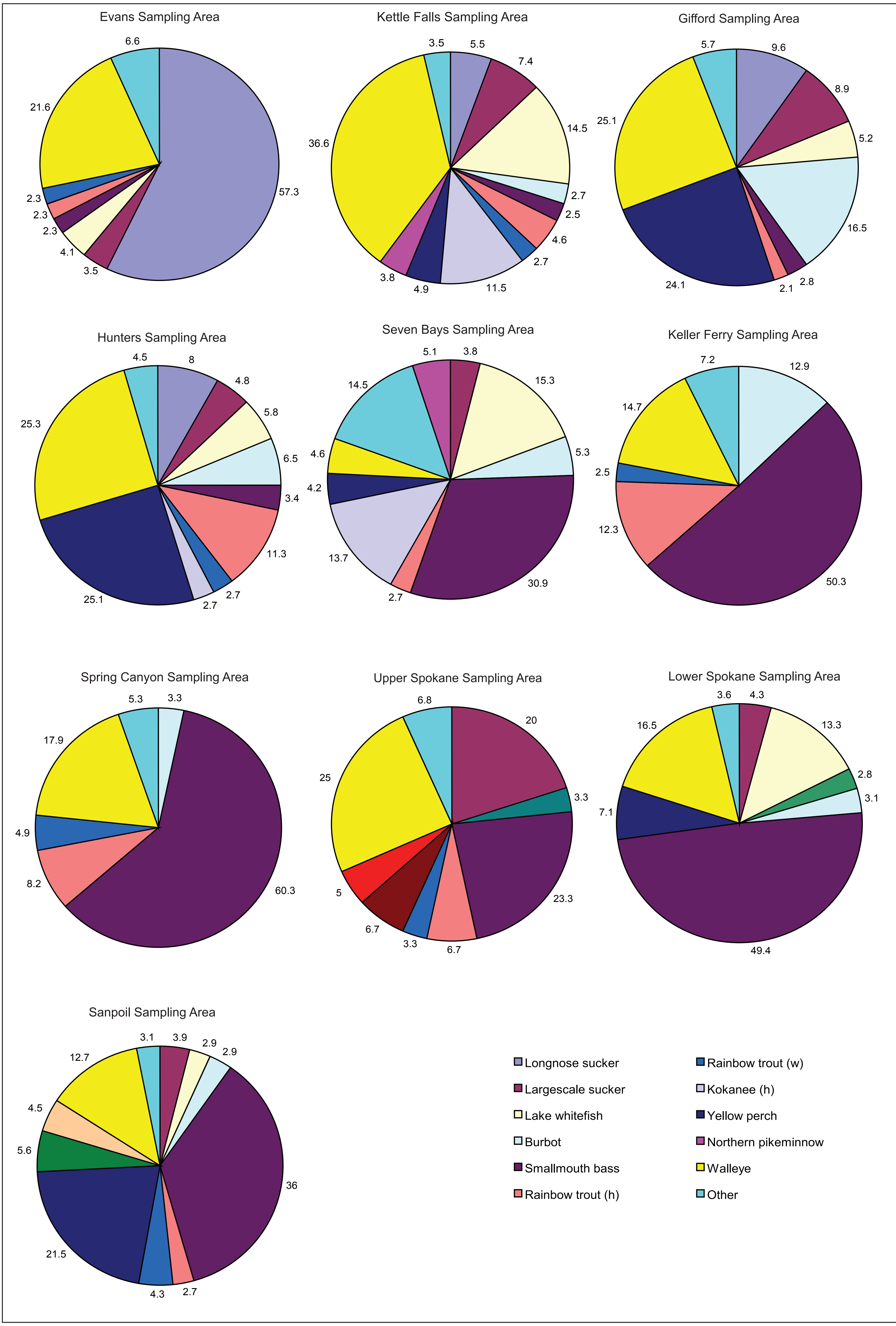
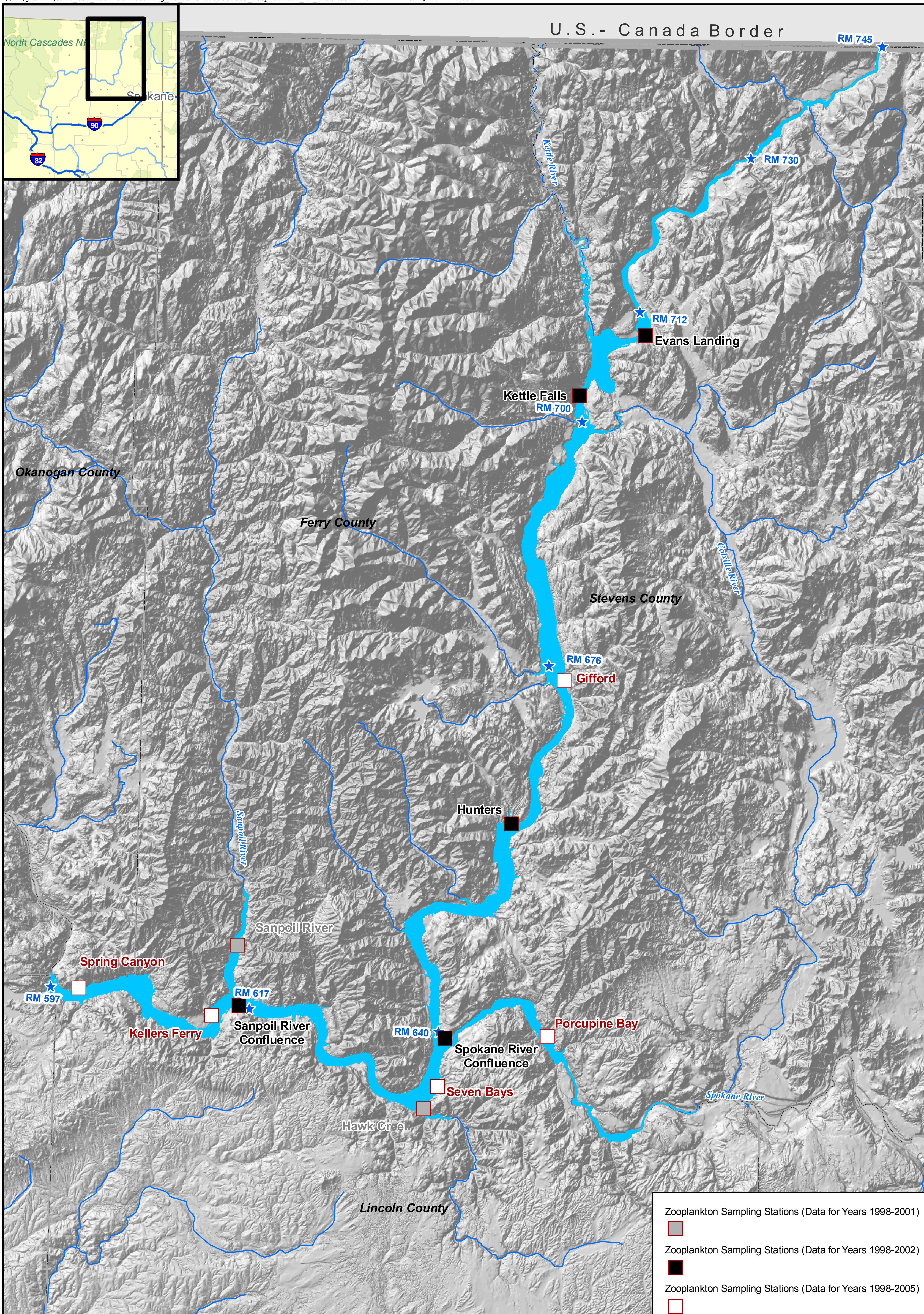


Figure 10. Relative Abundance of Fish Species Collected in Various Sampling Areas by the Lake Roosevelt Fisheries Evaluation Program in 2004.
Source: Lee et al. (2006).
Notes: h = hatchery
w = wild
"Other" includes longnose sucker, common carp, sculpin, largemouth bass, peamouth, kokanee (h), kokanee (w), mountain whitefish, and tench.

MAPS

\\Mi\gis\mi\C306_UCR_Teck-Cominco\Fig_16_UCRbioresources_Zooplankton_T2_02082008.mxd JP @ 05-27-2008



Integral Parametrix

Km 0 5 10

Miles 0 5 10

N

Map 1. **Lake Roosevelt Fisheries Evaluation Program**
Zooplankton Sampling Stations

Upper Columbia River, WA

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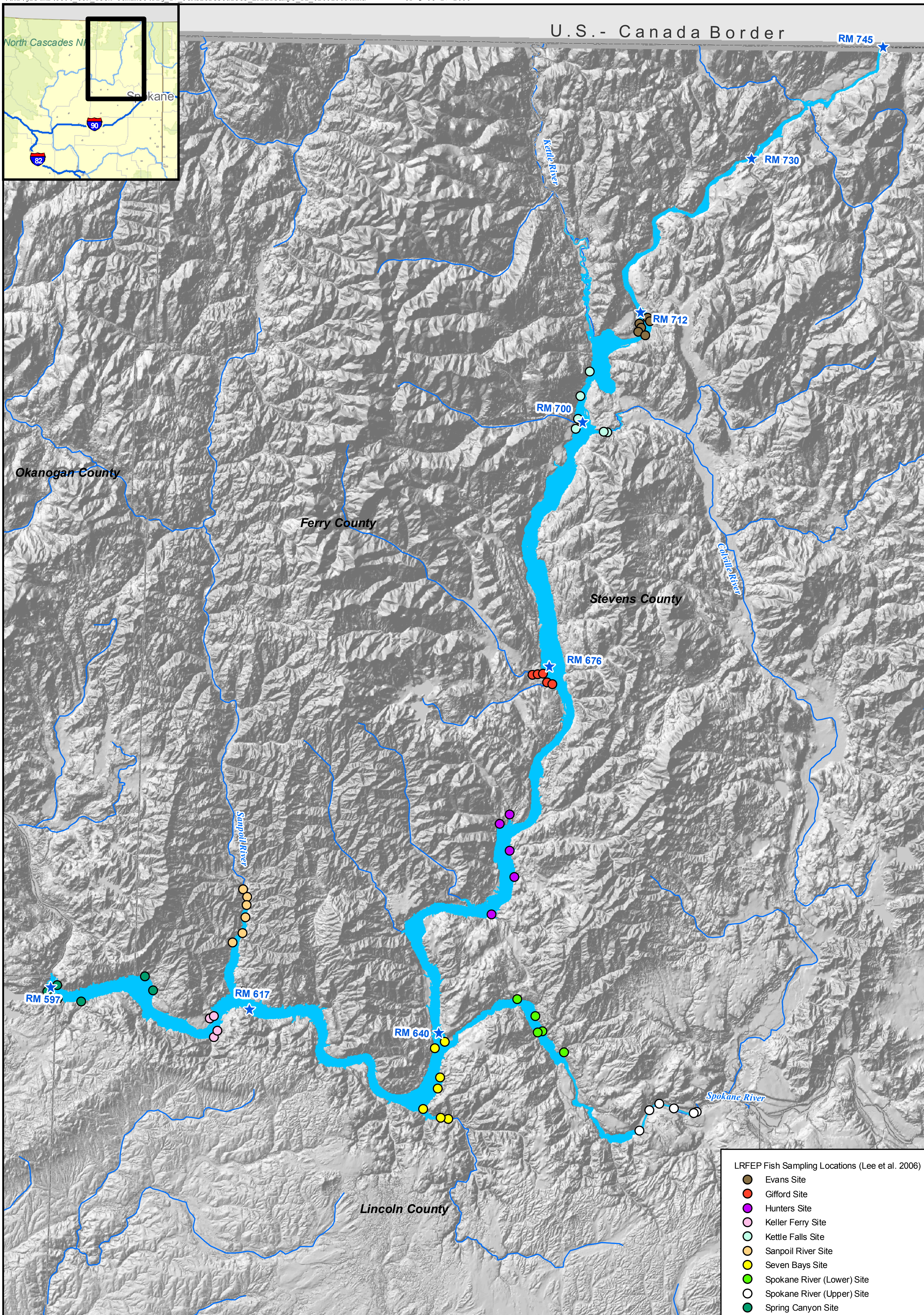

Integral Parametrix

0 5 10 Km

0 5 10 Miles

N

Map 2. **Lake Roosevelt Fisheries Evaluation Program**
Fish Sampling Sites

Upper Columbia River, WA

TABLES

Table 1. List of Federal and Washington State Aquatic Species of Concern

Scientific Name	Common Name	Federal Status	State Status
Fish			
Acipenser medirostris	Green sturgeon	FT	
Catostomus platyrhynchus	Mountain sucker		SC
Clupea pallasi	Pacific herring	FCo	SC
Cottus marginatus	Margined sculpin	FCo	SS
Couesius plumbeus	Lake chub		SC
Gadus macrocephalus	Pacific cod (S&C Puget Sound)	FCo	SC
Lampetra ayresi	River lamprey	FCo	SC
Merluccius productus	Pacific hake (Pacific-Georgia Basin DPS)	FCo	SC
Novumbra hubbsi	Olympic mudminnow		SS
Oncorhynchus keta	Chum salmon (Hood Canal Su)	FT	SC
Oncorhynchus keta	Chum salmon (Lower Columbia)	FT	SC
Oncorhynchus kisutch	Coho salmon (Lower Columbia/SW WA)	FT	
Oncorhynchus mykiss	Steelhead (Lower Columbia)	FT	SC
Oncorhynchus mykiss	Steelhead (Middle Columbia)	FT	SC
Oncorhynchus mykiss	Steelhead (Puget Sound)	FT	
Oncorhynchus mykiss	Steelhead (Snake River)	FT	SC
Oncorhynchus mykiss	Steelhead (Upper Columbia)	FT	SC
Oncorhynchus nerka	Kokanee (Lk Sammamish)	FC	
Oncorhynchus nerka	Sockeye salmon (Ozette Lake)	FT	SC
Oncorhynchus nerka	Sockeye salmon (Snake R.)	FE	SC
Oncorhynchus tshawytscha	Chinook salmon (Lower Columbia)	FT	SC
Oncorhynchus tshawytscha	Chinook salmon (Puget Sound)	FT	SC
Oncorhynchus tshawytscha	Chinook salmon (Snake R. Fall)	FT	SC
Oncorhynchus tshawytscha	Chinook salmon (Snake R. Sp/Su)	FT	SC
Oncorhynchus tshawytscha	Chinook salmon (Upper Columbia Sp)	FE	SC
Prosopium coulteri	Pygmy whitefish	FCo	SS
Rhinichthys falcatus	Leopard dace		SC
Rhinichthys umatilla	Umatilla dace		SC
Salvelinus confluentus	Bull trout	FT	SC
Sebastes auriculatus	Brown rockfish	FCo	SC
Sebastes caurinus	Copper rockfish	FCo	SC
Sebastes elongatus	Greenstriped rockfish		SC
Sebastes entomelas	Widow rockfish		SC
Sebastes flavidus	Yellowtail rockfish		SC
Sebastes maliger	Quillback rockfish	FCo	SC
Sebastes melanops	Black rockfish		SC
Sebastes nebulosus	China rockfish		SC
Sebastes nigrocinctus	Tiger rockfish		SC
Sebastes paucispinis	Bocaccio rockfish	FE	SC
Sebastes pinniger	Canary rockfish	FT	SC
Sebastes proriger	Redstripe rockfish		SC
Sebastes ruberrimus	Yelloweye rockfish	FT	SC
Thaleichthys pacificus	Eulachon	FT	SC
Theragra chalcogramma	Walleye pollock (So. Puget Sound)	FCo	SC

Table 1. List of Federal and Washington State Aquatic Species of Concern

Scientific Name	Common Name	Federal Status	State Status
Mollusk			
Anodonta californiensis	California floater	FCo	SC
Cryptomastix hendersoni	Columbia oregonian		SC
Cryptomastix populi	Poplar oregonian		SC
Fisherola nuttalli	Giant Columbia River limpet		SC
Fluminicola columbiana	Columbia pebblesnail	FCo	SC
Haliotis kamtschatkana	Northern abalone	FCo	SC
Monadenia fidelis minor	Dalle's Sideband		SC
Ostrea lurida	Olympia oyster		SC
Prophysaon coeruleum	Bluegray Taildropper		SC

Source: WDFW (2008).
Federal Status Codes:
FE = federal endangered
FT = federal threatened
FC = federal candidate
FCo = federal species of concern
State Status Codes:
SC = state candidate
SS = state sensitive

Table 2. Attached Algae (Periphyton) Taxa List, Relative Density, and Relative Biovolume from All Locations on Lake Roosevelt, WA (2000)

Division	Class	Species	% of Total Density	% of Total Biovolume
Chlorophyta				
	Chlorophyceae		**5.0**	**14.8**
		Ankistrodesmus falcatus	0.0	0.0
		Closterium sp.	0.0	0.0
		Mougeotia sp.	4.9	14.8
		Scenedesmus dimorphus	0.1	0.0
Chrysophyta				
	Bacillariophyceae		**94.0**	**85.1**
		Achnanthes sp.	71.5	13.2
		Amphipleura sp.	0.0	0.0
		Amphora sp.	2.7	11.4
		Asterionella formosa	0.0	0.0
		Cocconeis sp.	0.1	0.2
		Cyclotella sp.	0.0	0.1
		Cymbella sp.	0.0	0.1
		Fragilaria crotonensis	0.4	0.6
		Fragilaria sp.	5.0	4.1
		Gomphonema sp.	1.5	5.8
		Melosira italica	0.0	0.1
		Melosira varians	2.6	36.2
		Navicula sp.	1.3	1.3
		Pinnularia sp.	0.1	2.0
		Synedra sp.	8.1	0.9
		Tabellaria sp.	0.7	9.2
Cyanophyta				
	Cyanophyceae		**1.0**	**0.0**
		Merismopedia sp.	0.9	0.0
		Oscillatoria sp.	0.1	0.0

Source: Lee et al. (2003)

Table 3. Location of Pelagic Phytoplankton Sampling Across Years in the Lake Roosevelt Fisheries Evaluation Program

Location	River Mile	1998[a]	1999[b]	2000	2001	2002[c]	2003	2004	2005
Evan's Landing	710	x	x	x	x				
Kettle Falls	702	x	x	x	x				
Gifford	674	x	x	x	x	x	x	x	x
Hunter's	661	x	x	x	x				
Porcupine Bay	Spokane Arm	x	x	x	x	x	x	x	x
Spokane R. Confluence	639	x	x						
Seven Bays	635	x	x	x	x	x	x	x	x
Sanpoil R. Confluence	616	x	x	x	x				
Sanpoil R.	Sanpoil Arm	x	x	x	x				
Keller Ferry	613	x	x	x	x	x	x	x	x
Spring Canyon	599	x	x	x	x	x	x	x	x

Notes:

[a] Chlorophyll *a* is denoted as measured at these locations, but results are not presented on a site-by-site basis in the 1998 report (Shields et al. 2002).

[b] Problems with fluorometer (used to measure chlorophyll *a*) noted in January through May of 1999, so these data are not used in summary analyses in this document.

[c] All 11 sites sampled in January, but only 5 index sites sampled for remainder of year.

Table 4. Frequency of Phytoplankton Sampling Events by the Lake Roosevelt Fisheries Evaluation Program

Month	1998	1999[a]	2000	2001	2002	2003	2004	2005
Jan	1	1	1	1	1	1	1	1
Feb	1	1	1	1	0	0	0	1
Mar	2	2	1	1	0	0	0	1
Apr	0	0	1	0	0	0	0	0
May	2	2	2	2	1	1	1	2
Jun	2	2	2	2	0	1	1	2
Jul	2	2	2	2	1	1	1	2
Aug	2	2	2	2	0	1	1	2
Sep	2	2	2	2	0	1	1	2
Oct	2	2	1	1	1	1	1	1
Nov	1	1	1	0	0	0	0	0
Dec	1	1	1	0	0	0	0	0

Note:

[a] Problems occurred with fluorometer (used to measure chlorophyll *a*) from January through May 1999, so these data were not used in summary analyses.

Table 5. Phytoplankton Taxa List, Relative Density, and Relative Biovolume from all Locations on Lake Roosevelt, WA (January and March 2001)

Division	Class	Species	% of Total Density	% of Total Biovolume
Chlorophyta				
	Chlorophyceae		**17.6**	**9.8**
		Ankistrodesmus falcatus	1.0	**0.3**
		Chlamydomonas sp.	12.9	7.0
		Eudorina elegans	3.1	2.1
		Raciborskiella sp.	0.3	0.4
		Scenedesmus bijuga	0.3	0.1
		Scenedesmus quadricauda	0.1	0.0
Chrysophyta				
	Bacillariophyceae		**32.1**	**61.6**
		Achnanthes sp.	0.0	0.0
		Amphora sp.	0.0	0.1
		Asterionella formosa	21.4	41.8
		Cocconeis sp.	0.0	0.1
		Cyclotella sp.	0.5	3.1
		Fragilaria crotonensis	1.3	2.9
		Fragilaria sp.	1.5	0.9
		Gomphonema sp.	0.8	0.2
		Melosira distans	0.3	0.7
		Melosira italica	0.9	3.2
		Melosira varians	0.4	5.3
		Navicula sp.	0.0	0.1
		Rhizosolenia sp.	0.8	2.3
		Syndedra sp.	4.2	0.9
Chrysophyta				
	Chrysophyceae		**2.8**	**4.3**
		Dinobyron sertularia	2.4	2.1
		Mallomonas sp.	0.3	2.3
Chrysophyta				
	Cryptophyceae		**22.4**	**16.3**
		Cryptomonas sp.	1.6	6.3
		Rhodomonas sp.	20.7	10
Cyanophyta				
	Cyanophyceae		**7.5**	**4.5**
		Gloeocapsa sp.	1.4	0.8
		Oscillatoria sp.	6.1	3.7
		Microplankton	**17.7**	**3.3**

Source: Lee et al. (2003)

Table 6. Annual Mean, Standard Deviation (SD), Sample Size (n) and Ranges of Phytoplankton Chlorophyll *a* (mg/m^3) in Pelagic Sampling Stations of Lake Roosevelt (Scofield et al. 2007)

Year	Mean	SD	n	Min	Max
1997	1.905	2.426	202	0.258	16.801
1998	2.458	1.682	198	0.411	10.732
1999[a]	1.787	1.418	117	0.005	5.49
2000	1.796	3.004	134	0.005	22.475
2001	1.43	1.259	289	0.005	7.05
2002	1.339	1.388	29	0.005	4.55
2003	0.862	0.591	54	0.005	2.798
2004	0.933	1.084	60	0.005	5.383
2005	1.014	1.125	65	0.005	5.511

Note:

[a] Problems with fluorometer (used to measure chlorophyll *a*) were noted during the first 6 months of sampling in 1999 (McLellan et al. 1999), so these data may not be accurate.

Table 7. Zooplankton Taxa Collected by LRFEP between 1998 and 2005 and Years in Which Taxa Occurred in Samples

		Years Identified in Samples							
Family	Species	1998	1999	2000	2001	2002	2003	2004	2005
Phylum Arthropoda, Sub-class Crustacea, Order Branchipoda									
Daphniidae	*Ceriodaphnia quadrangula*	X	X	X	X	X	X	X	X
	Ceriodaphnia reticulata				X	X			
	Daphnia galeata	X	X	X	X	X	X	X	X
	Daphnia pulex	X	X	X	X	X	X	X	X
	Daphnia retrocurva	X	X	X	X	X	X	X	X
	Daphnia rosea			X	X		X		
	Daphnia thorata	X	X	X	X	X	X	X	
	Daphnia schødleri	X							
Chydoridae	*Acroperus* sp.			X	X	X			
	Alona quadrangularis	X	X	X		X	X	X	X
	Chydorus sphaericus	X	X	X	X		X		
	Graptoleberis testudinaria				X				
Sididae	*Diaphanosoma bergei*	X	X	X					X
	Diaphanosoma brachyurum	X	X		X	X	X	X	X
	Sida crystallina	X	X	X	X	X	X	X	X
Bosminidae	*Bosmina longirostris*	X	X		X		X		X
Leptodoriidae	*Leptodora kindtii*	X	X	X	X	X	X	X	X
Polyphemidae	*Polyphemus pediculus*	X							
Macrothricidae	*Ilyocriptus acutifrons*			X	X				
	Ilyocriptus sordidus			X	X				
	Macrothrix hirsuticornis				X	X			
Phylum Arthropoda, Sub-class Copepoda, Sub-order Calanoida									
Diaptomidae	*Leptodiaptomus ashlandi*	X	X	X	X	X	X	X	X
Temoridae	*Epischura nevadensis*	X	X	X	X	X	X	X	X
Phylum Arthropoda, Sub-class Copepoda, Sub-order Cyclopoida									
Cyclopodiae	*Diacyclops bicuspidatus thomasi*	X	X	X	X	X	X	X	X
	Mesocyclops edax	X	X	X		X	X	X	X
	Unknown *Cyclopoid* sp.	X							
Phylum Arthropoda, Sub-class Copepoda, Sub-order Harpacticoid									
Harpacticoidae	*Harpacticoid* sp.	X		X	X				
	Byrocamptus sp.	X		X	X	X			

Notes:
LRFEP = Lake Roosevelt Fisheries Evaluation Program.
x = species identified in samples from the year indicated.

Table 8. Habitat Associations and Adult and Juvenile Diets of Zooplanktivorous Fish Species of the UCR

Species	Habitat Preferences	Ref.	Zooplankton identified in diet in LRFEP studies?	Feeding Behavior - Adult	Ref.	Feeding behavior -Larval/Juvenile	Ref.
Peamouth	Young reside in very shallow waters. Adults stay in deep water during day and stay near the bottom, but move to shallows at night. In general, prefer waters deeper than 60 ft. During spawning (late May/early June), fish approach the shallows at dawn and dusk.	a	Y	Plankton, invertebrates, and occasionally smaller fish.	a	Young of the year eat zooplankton	a
Northern pikeminnow	Prefers lakes or slow-moving streams. School in shallow backwaters.	b	Y	Eats many types of aquatic insects. Adults feed primarily on other fish. Significant predator of salmon and trout.	b	NA	
Longnose sucker	Young remain in shallow weedy areas while adults occupy deeper water during the day. Adults move to shallows at night.	a	Y	Larger fish eat both plant material and other food, including invertebrates and fish eggs. Insect larvae are a large component of diet.	a	Smaller suckers feed mainly on plant material. Cladocerans have been observed in diet of larval longnose sucker.	f
Largescale sucker	Commonly found in headwaters between streams/lakes. Generally resides at the bottom in shallow, warmer waters.	a	Y	Change to a diet of insect larvae, diatoms, and plant material as they become bottom dwellers. Large fish eat invertebrates and detritus.	a	Pelagic young eat zooplankton	a
Yellow bullhead	Prefer clear, slow moving water with abundant plant life. Reproduction and nesting occurs in (preferably) stagnant water 1.5 to 4 ft deep.	a	Y	Feeds opportunistically at night only. Eats insects, molluscs, crustaceans, plant matter, and both live and dead fish.	a	NA	
Lake whitefish	Prefer deep, cold water and is most abundant at 50-90 ft. Will follow colder water.	a	Y	Young up to 2 years feed almost exclusively on zooplankton. The change to bottom organisms is very gradual. Occasionally eat smaller fish.	a	Young up to 2 years feed almost exclusively on zooplankton.	a
Mountain whitefish	Prefer fast moving water and riffle communities. Usually no more than 30 ft below the surface, and prefer temperatures between 48 and 52°F.	a	Y	Feed primarily on larval stages of bottom organisms. Also eat crustaceans, leeches, fish eggs, and small fish.	a	NA	
Rainbow trout	Prefer cooler water, usually less than 70°F, but can survive from 32 to 80°F. If the water rises above 70°F, they will follow cooler water.	a	Y	Primarily feed on bottom organisms. Occasionally eat small fish.	a	NA	
Kokanee	If the salmon have just returned/migrated to the lake environment, they may be found any where in the water column, even as shallow as 6 ft. However, they prefer deeper waters (40-60 ft) and a temperature around 48°F.	a	Y	Feed largely on zooplankton (usually crustaceans).	a	Feed largely on zooplankton (usually crustaceans).	a
Brown trout	Can live in warmer waters than other trout. In warmer waters, brown trout are often dominant trout. Resilient to varied levels of dissolved oxygen, turbidity, and other water parameters. Stays in deep pools or under banks, emerging only at night to feed.	a	Y	Very young brown trout eat tiny bottom organisms, while older fish eat crustaceans, other invertebrates, frogs, and fish. Other fish including minnows, darts, suckers, and sculpin compose a large part of the diets of bigger brown trout.	a	Very young brown trout eat tiny bottom organisms	a
Eastern brook trout	Prefer clear, cold headwaters and spring-fed areas. If the bottoms of water bodies are cold with high oxygen, they can be found there. Will follow cooler water. Active in morning and afternoon, and lie dormant under banks and other shelter at night.	a	Y	In larger water bodies and streams, they feed almost exclusively on midges and other aquatic insect larvae. Will opportunistically eat crustaceans, worms, and other invertebrates, and feed on terrestrial and flying insects during the summer.	a	Young eat primarily zooplankton.	a
Sculpin (*Cottid* spp.)	Slimy sculpin: riffles in fast flowing streams or gravel beaches of lakes near inlets; Prickly sculpin: along lake shores, with smaller individuals generally in vegetated areas in shallow water; shorthead sculpin: generally fast-moving rivers, sometimes shorelines and backwaters with gravel bottoms		Y	Sculpin diet is similar across many speies; a wide variety of bottom organisms are eaten.		Stomach contents found in lower reservoir sculpin 4-9 mm were cyclopoid copepods (73%), calanoid copepods (12%), and daphnids (15%).	e
Smallmouth bass	Prefer warm, clear water with a slight current. Stays near rocky or gravel areas. Ideal temperatures between 70 and 80°F. Will move to stay on the edge of currents for feeding; feed only in the early morning and lie dormant in rocky substrate at night.	a	Y	Very young eat zooplankton, but soon switch to insects and small fish. Adults feed on crustaceans, insects, and other fish, including their own young.	a	Very young eat zooplankton	a
Largemouth bass	Shallow, weedy lakes and river backwaters, preferring clear water with mud, sand, and organic matter substrate, often associated with aquatic vegetation. Seldom are found deeper than the littoral zone of rooted macrophytes. Often associated with woody debris and other cover.	d	N	Consume zooplankton as juveniles, although benthic invertebrates and other fish more common components of diet	d	Consume zooplankton as juveniles	a

Table 8. Habitat Associations and Adult and Juvenile Diets of Zooplanktivorous Fish Species of the UCR

Species	Habitat Preferences	Ref.	Zooplankton identified in diet in LRFEP studies?	Feeding Behavior - Adult	Ref.	Feeding behavior -Larval/Juvenile	Ref.
Black crappie	Generally found in clear waters with abundant aquatic vegetation. Can be found feeding in weedy areas usually less than 10 ft deep, and feeds most actively in spring. Retreats to deeper water in summer. Have lower site fidelity than other fish and move around a lot.	a	Y	Young feed almost exclusively on zooplankton, but increase consumption of insect larvae as they age. Larger fish are dependent on smaller fish as food. In general, black crappie do not thrive unless there are abundant forage fishes.	a	Young feed almost exclusively on zooplankton	a
Yellow perch	Prefer clear lakes with moderate vegetation. Adults stay near the bottom, but can sometimes be found between 15 and 25 ft. Smaller perch are found in shallow water in spring and summer, but also move to deeper waters in the fall. Rest dormant on the deep bottom at night.	a	Y	Incorporate more insects and larvae into diet as they age. Fish older than 1 year eat mainly midges and larvae while fish older than 3 years eat mainly forage fish and crustaceans.	a	Young feed on zooplankton in shallows. Stomach contents found in lower Lake Roosevelt yellow perch 5-25 mm total length were: calanoid copepods (55%), cyclopoid copepods (23%), daphnids (12%), and other, primarily *Ceriodaphnia* spp. and *Leptodora kindtii* (11%).	e
Walleye	Prefer large lakes and streams with rocky, gravely bottoms. Feed in shallow waters at night and move to deeper waters in the day. Tolerate a wide range of temperatures.	a	Y	Begin to feed on other fish when they are about 3 inches long. By 6 inches they feed primarily on other fish, but supplement with crustaceans and insects.	a	Young feed primarily on zooplankton. Stomach contents found in lower Lake Roosevelt walleye 8-24 mm total length were: calanoid copepods (66%), cyclopoid copepods (21%), daphnids (3%), and other, including larval fish (9%). Walleye 9-22 mm total length from Porcupine Bay (Spokane Arm) had a 7 times higher rate of larval fish in their diets compared to those in the lower reservoir.	e
Burbot	Inhabit large lakes and reservoirs, usually found in deep waters (has been found as deep as 300 ft), as well as ponds, streams, and rivers. Young fish are found beneath stones and sometimes are abundant in lake shallows. Prefer to be near bottom in areas of low light intensity.	c	N	Diet quickly transitions to molluscs and insects, then to piscivory as adults.	c	Zooplankton consumed in first few months of life.	c

Notes:
NA = not available
LRFEP = Lake Roosevelt Fisheries Evaluation Program

[a] Wydoski and Whitney (2003).
[b] Montana Field Guide on Montana's State Website (http://fieldguide.mt.gov/detail_AFCJB35030.aspx).
[c] http://animaldiversity.ummz.umich.edu/site/accounts/information/Lota_lota.html.
[d] http://www.fishbase.org/Summary/SpeciesSummary.php?id=3385.
[e] Wunderlich Faurot and White (1994).
[f] FishBase. www.fishbase.org. Accessed June 10, 2008.

Table 9. Macroinvertebrate Indices for Samples Collected in UCR Sediments in August 1989

	Sample Station (segment, river mile and water depth [ft])					
Macroinvertebrate Indices	Little Dalles (2, 728; 40)[a]	French Point Rocks (4a, 692; 80)	Castle Rock (4b, 644; 80)	Swawilla Basin (6, 605; 80)	Spokane River Arm (NA, 7.8; 80)	Sanpoil River Arm (NA, 3.9; 80)
Community Indices						
Total Abundance, (number/m^2)	779	61	47	94.6	87	154
Diversity (Shannon H')	1.4	3.1	2.9	1.92	2.7	2.2
Total Richness	14	13	12	9	13	12
Relative Abundance, % of total abundance (number/m^2)						
Cnidaria	1.2	3.0	4.7	1.5	0.7	0.0
Nematoda	0.3	2.3	25	61	1.6	2.5
Sphaeridae	0.0	0.3	7.2	3.8	20.7	46
Hirudinea	0.0	0.0	0.0	0.0	2.5	0.0
Oligochaeta	0.0	18.4	31	12.3	27.1	27
Copepoda	0.6	2.6	4.3	3.2	7.1	6.0
Isopoda	0.0	0.0	0.0	0.0	0.7	0.0
Ostracoda	0.9	0.0	0.0	0.0	0.0	0.0
Eubranchiopoda	0.0	8.5	0.0	0.0	0.0	0.1
Arachnida	0.1	0.7	0.9	0.6	0.7	0.9
Diptera	97	59	26	18	39	17
Ephemeroptera	0.0	0.0	0.0	0.0	0.0	0.1
Trichoptera	0.0	4.9	2.1	0.0	0.0	0.5

Source: Johnson (1991)
Notes: NA = Not appicable.
[a] = Physiographic information are defined in parenthesis, UCR study segment, river mile and sample depth (feet).

Table 10. Abundance of Macroinvertebrates Found at Various Water Depths in the UCR, July to October 1991

Sample Station	Segment	River Mile	Sample Depth (feet)	Snails (number/m^2)	Bivalves (Sphaeriidae) (number/m^2)	Diptera (number/m^2)	Trichoptera (number/m^2)	Oligochaeta (number/m^2)
Gifford, Columbia River	4a	676	80	21	204	3068	37	1247
Gifford, Columbia River	4a	676	50-79	16	24	1868	16	1077
Gifford, Columbia River	4a	676	0-49	996	0	3190	55	587
Seven Bays, Columbia River	5	634	80	7	14	1572	31	524
Seven Bays, Columbia River	5	634	50-79	0	0	1072	0	368
Seven Bays, Columbia River	5	634	0-49	0	0	3302	52	335
Spring Canyon, Columbia River	6	601	80	95	102	1242	149	305
Spring Canyon, Columbia River	6	601	50-79	196	0	886	110	147
Spring Canyon, Columbia River	6	601	0-49	185	0	2217	0	661
Porcupine Bay, Spokane River	NA	21	80	0	970	5995	0	678
Porcupine Bay, Spokane River	NA	21	50-79	10	168	2670	21	1205
Porcupine Bay, Spokane River	NA	21	0-49	168	0	1807	0	2055

Source: Griffith et al. (1992)

Notes: NA = Not applicable.
In all cases the value is the mean of macroinvertebrates for more than two sample events.

Table 11. Abundance of Macroinvertebrates Found at Various Water Depths in the UCR, May to September 1993

Sample Station	Segment	River Mile	Sample Depth, feet	Chironomidae (no./m^2)	Oligocheata (no./m^2)	Gammarus (no./m^2)	Trichoptera (no./m^2)	Snails (no./m^2)	Hydracarina (no./m^2)
Gifford, Columbia River	4a	676	85	212	176	0	6	0	7
Gifford, Columbia River	4a	676	50-85	394	100	0	20	0	193
Gifford, Columbia River	4a	676	0-49	369	81	8	4	0	9
Seven Bays, Columbia River	5	634	85	223	104	223	9	0	0
Seven Bays, Columbia River	5	634	50-85	334	70	222	5	0	0
Seven Bays, Columbia River	5	634	0-49	84	6	13	2	0	0
Spring Canyon, Columbia River	6	601	85	179	80	55	4	2	0
Spring Canyon, Columbia River	6	601	50-85	57	45	7	0	0	1
Spring Canyon, Columbia River	6	601	0-49	40	17	25	2	0	0
Porcupine Bay, Spokane River	NA	21	85	243	94	171	0	3	0
Porcupine Bay, Spokane River	NA	21	50-85	253	35	24	2	0	0
Porcupine Bay, Spokane River	NA	21	0-49	103	14	3	0	0	2

Source: Voeller (1993)

Notes: NA = Not applicable

In all cases the value is the mean number of macroinvertebrates for more than two sample events.

Table 12. Weighted Average[a] of Stomach Contents (as percent by dry mass) of Fish Collected by the LRFEP, 1999-2005

Species	Black Crappie	Bridgelip Sucker	Bown Bullhead	Brook Trout	Brown Trout	Burbot	Chinook Salmon	Cottidae	Kokanee	Lake Whitefish	Largemouth Bass	Largescale Sucker	Longnose Sucker	Mountain Whitefish	Northern Pikeminnow	Peamouth	Rainbow Trout	Redside Shiner	Smallmouth Bass	Tench	Walleye	Yellow Bullhead	Yellow Perch
Fish																							
Osteichthyes	17.78	0.00	87.01	55.35	81.93	73.69	64.36	53.80	0.00	1.16	87.66	0.00	0.00	0.07	45.08	0.00	7.52	0.00	72.82	0.00	96.15	0.00	38.87
Crayfish																							
Astacidae	0.00	0.00	0.00	0.00	6.24	18.09	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	4.33	0.00	3.35	0.00	11.81	0.00	0.02	21.51	10.14
Amphibians																							
Anura	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.18	0.00	0.00
Zooplankton (Daphnia and other cladocerans)																							
Zooplankton	52.75	0.00	0.00	21.80	3.41	0.00	0.00	5.54	95.39	44.63	0.00	10.32	0.21	6.35	12.07	56.08	28.01	0.00	3.30	0.00	0.34	12.90	25.44
Dipterans (true flies)																							
Chironomids	17.21	0.03	0.00	6.86	1.95	0.24	20.79	0.00	1.59	4.25	0.00	3.16	8.57	45.61	0.90	0.00	2.04	0.00	0.31	2.28	1.81	0.00	1.43
Non-Chironomid Diptera	5.57	0.00	0.00	0.09	0.34	0.00	0.00	0.00	0.00	0.35	0.00	0.61	0.12	9.67	0.00	0.00	0.53	0.00	0.05	0.00	0.04	0.00	0.00
Molluscs																							
Gastropoda	0.00	0.00	0.00	4.91	0.04	0.68	0.00	18.13	0.00	0.05	0.00	2.05	0.01	18.05	2.81	10.15	20.72	0.00	0.00	0.00	0.00	0.00	0.18
Pelecypoda	0.00	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Non-dipteran Insects																							
Coleoptera	0.00	0.01	0.00	0.04	0.50	0.00	0.00	0.00	0.00	7.40	0.00	0.28	0.02	1.07	0.00	0.00	0.28	0.00	0.09	0.00	0.00	0.00	0.00
Megaloptera	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hemiptera	1.47	0.05	0.00	5.42	0.01	0.00	0.00	0.00	0.00	0.06	3.30	0.26	0.01	0.00	2.23	0.00	1.47	0.00	0.25	0.00	0.00	0.00	0.84
Lepidoptera	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	4.70	0.00	0.10	0.01	1.49	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	1.04
Odonata	0.00	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.49	0.00	0.02	0.00	2.08
Trichoptera	0.03	0.17	0.00	0.21	0.02	0.82	0.00	0.00	0.00	1.13	0.00	0.33	3.08	7.67	4.12	0.00	0.76	0.00	0.09	0.00	0.04	0.00	0.18
Plecoptera	0.00	0.00	0.00	0.12	0.00	1.18	0.00	0.00	0.00	0.00	0.00	0.02	0.24	0.00	0.13	0.00	0.02	0.00	0.03	0.00	0.01	65.60	0.98
Ephemeroptera	0.00	0.09	0.00	0.08	0.01	0.00	0.00	0.00	0.00	8.75	0.00	0.00	0.00	1.10	0.00	0.00	0.24	0.00	0.01	0.00	0.00	0.00	0.04
Homoptera	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neuroptera	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Benthic Macroinvertebrates																							
Arachnoidea	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.01	0.00	0.00	0.00	0.00
Amphipoda	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.17	0.00	0.00	0.00	0.01
Annelida	0.00	0.15	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	5.12	0.08	0.05	0.00	2.46	0.00	0.85	0.00	1.15	0.00	0.04	0.00	0.70
Nematoda	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00
Platyhelminthes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.77
Isopoda	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.24	0.00	0.00	0.00	0.00	0.00	5.83	0.00	0.00	0.85	50.00	0.08	0.00	0.07	0.00	0.00
Lithobiomorpha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Terrestrial Invertebrates																							
Terrestrial	0.00	0.05	0.00	0.18	1.05	0.05	0.00	0.00	0.00	0.13	2.59	0.03	0.01	0.44	0.06	0.00	8.99	0.00	0.46	0.00	0.12	0.00	0.00
Unidentified Arthropods																							
Arthropoda	4.81	0.00	7.91	1.59	1.39	0.01	0.00	0.00	0.19	0.92	0.00	3.73	1.17	0.11	9.61	0.00	2.33	50.00	0.36	0.00	0.01	0.00	0.18
Miscellaneous																							
Other	0.16	98.03	5.80	1.67	2.80	4.32	14.85	0.00	2.75	25.55	1.33	78.62	86.51	2.53	16.19	33.77	21.41	0.00	6.48	97.72	1.14	0.00	9.08
Total % of Diet	100	100	101	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Total N per Species	**30**	**9**	**1**	**44**	**33**	**46**	**1**	**10**	**328**	**35**	**9**	**457**	**34**	**31**	**33**	**3**	**1159**	**2**	**432**	**1**	**778**	**1**	**110**

[a] To compute weighted averages of stomach contents, the average of each species average dietary contents per year was calculated, with each species averages weighted by number of individual fish of that species collected
LRFEP - Lake Roosevelt Fisheries Evaluation Program

Table 13. Fish Species Detected Over a 10-Year Period (1995-2004) in Lake Roosevelt

Taxon (Family)	Genus Species	Common Name	ESA Listing	State Listing	Origin	Relative Abundance	
						Electrofish	Gillnet
Acipenseridae	*Acipenser transmontanus*	White sturgeon	No	No	Native	0	<1
Cyprinidae	*Acrocheilus alutaceus*	Chiselmouth	No	No	Native	<1	<1
	Cyprinus carpio	Common carp	No	No	Exotic	1	<1
	Mylocheilus caurinus	Peamouth	No	No	Native	<1	<1
	Ptychocheilus oregonensis	Northern pikeminnow	No	No	Native	2	2
	Richardsonius balteatus	Redside shiner	No	No	Native	<1	0
	Tinca tinca	Tench	No	No	Exotic	<1	<1
Catostomidae	*Catostomus catostomus*	Longnose sucker	No	No	Native	1	**8**
	Catostomus columbianus	Bridgelip sucker	No	No	Native	<1	<1
	Catostomus macrocheilus	Largescale sucker	No	No	Native	**21**	3
	Ameiurus natalis	Yellow bullhead	No	No	Exotic	<1	<1
Salmonidae	*Coregonus clupeaformis*	Lake whitefish	No	No	Exotic	<1	**35**
	Prosopium williamsoni	Mountain whitefish	No	No	Native	<1	1
	Oncorhynchus clarki	Cutthroat trout	No	No	Native	0	0
	Oncorhynchus mykiss	Rainbow trout	No	No	Native	**15**	4
	Oncorhynchus nerka	Kokanee salmon	No	No	Native	**11**	2
	Oncorhynchus tshawytscha	Chinook salmon	No	No	Native	<1	0
	Salmo trutta	Brown trout	No	No	Exotic	<1	<1
	Salvelinus confluentus	Bull trout	Yes	Yes	Native	0	0
	Salvelinus fontinalis	Eastern brook trout	No	No	Exotic	2	0
Gadidae	*Lota lota*	Burbot	No	No	Native	2	**11**
Cottidae	*Cottus* spp.	Sculpin	No	No	Native	NA	NA
Centrarchidae	*Lepomis gibbosus*	Pumpkinseed	No	No	Exotic	0	0
	Micropterus dolmieui	Smallmouth bass	No	No	Exotic	**10**	**8**
	Micropterus salmoides	Largemouth bass	No	No	Exotic	<1	0
	Pomoxis nigromaculatus	Black crappie	No	No	Exotic	1	<1
Percidae	*Perca flavescens*	Yellow perch	No	No	Exotic	**6**	3
	Sander vitreus	Walleye	No	No	Exotic	**25**	**23**

Source: Lee et al. (2006)
Notes: **Bold** indicates species with a relative abundance of 5 percent or greater.
Table includes the federal and state listing status, and the origin of wild populations with 10-year average relative abundance based on electrofishing and gillnet surveys.

Table 14. UCR Fish Species and Life History Information

Family	Common Name	Latin Name	General Habitat	Home Range	Spawning Time	Primary Juvenile Prey Items	Primary Adult Prey Items
Acipenseridae	White sturgeon	*Acipenser transmontanus*	Benthic, prefers rough substrate	Large	Spring and early summer (Waneta Dam and Northport)	Insects, insect larvae, benthic invertebrates, snails	Insects, benthic invertebrates, fish, annelids, snails
Catastomidae	Bridgelip sucker	*Catostomus columbianus*	Cold water and gravel or rocky bottoms; quieter backwaters or edges of rivers with sand and mud bottom; lake margins	Narrow	Spring to June	Periphyton, plant material	Periphyton, detritus, zooplankton, aquatic insects, benthic invertebrates, mussels, annelids
Catastomidae	Largescale sucker	*Catostomus macrocheilus*	Benthic in lakes or streams, near tributary mouths (shallow to 80 ft)	Large	April - June	Zooplankton	Periphyton, detritus, zooplankton, aquatic insects, benthic invertebrates, snails, annelids
Catastomidae	Longnose sucker	*Catostomus catostomus*	Benthic fish in lakes and tributary streams	Narrow	Spring	Periphyton, plant material	Periphyton, detritus, zooplankton, aquatic insects, benthic invertebrates, snails, annelids
Centrarchidae	Black crappie	*Pomoxis nigromaculatus*	Associated with large beds of aquatic plants and sandy to mucky bottoms	Narrow	Spring-Summer	Zooplankton and aquatic insects	Zooplankton, aquatic insects, and fish
Centrarchidae	Largemouth bass	*Micropterus salmoides*	Warm quiet waters with low turbidity, soft bottom, and beds of aquatic plants	Narrow	Spring and Summer	Zooplankton and aquatic and terrestrial insects, fish (sculpin)	Zooplankton and aquatic and terrestrial insects, fish (sculpin)
Centrarchidae	Pumpkinseed	*Lepomis gibbosus*	Prefers shallow, quiet, clear water with aquatic vegetation and some organic debris	Narrow	Spring and Summer	Aquatic insects, small molluscs, zooplankton, benthic invertebrates	Aquatic insects, small molluscs, zooplankton, benthic invertebrates
Centrarchidae	Smallmouth bass	*Micropterus dolomieui*	Deep still pools	Narrow	Spring	Zooplankton and aquatic insects	Fish (sculpin, perch, salmonids), zooplankton, aquatic insects
Cottidae	Mottled sculpin	*Cottus bairdi*	Prefers pools with quiet water with substrates of sand, gravel, or rubble	Narrow	February - June	Zooplankton and aquatic insects	Zooplankton, aquatic insects, benthic invertebrates, fish eggs
Cottidae	Prickly sculpin	*Cottus asper*	Prefers pools with quiet water with substrates of sand, gravel, or rubble	Narrow	April - June	Zooplankton and aquatic insects	Zooplankton, aquatic insects, benthic invertebrates, small fish, fish eggs
Cottidae	Shorthead sculpin	*Cottus confusus*	Inhabit cold swift riffle reaches with rubble or gravel substrates	Narrow	Spring	Zooplankton and aquatic insects	Zooplankton, aquatic insects, benthic invertebrates, fish eggs
Cottidae	Slimy sculpin	*Cottus cognatus*	Found along gravel or soft sediment beaches and stream inlets	Narrow	Spring	Zooplankton and aquatic insects	Zooplankton, aquatic insects, benthic invertebrates, fish eggs
Cottidae	Torrent sculpin	*Cottus rhotheus*	Inhabit cold swift riffle reaches with rubble or gravel substrates	Narrow	January - April	Zooplankton and aquatic insects	Zooplankton, aquatic insects, benthic invertebrates, small fish, fish eggs
Cyprinidae	Carp	*Cyprinus carpio*	Usually in shallow water with abundant vegetation and little or no current	Narrow to Large	Spring and Summer	Algae, zooplankton	Algae, periphyton, detritus, zooplankton, aquatic insects
Cyprinidae	Chiselmouth	*Acrocheilus alutaceus*	Shallow water near margins of lakes and in flowing pools and runs over sand and gravel in creeks and small to medium rivers	Narrow	June-July	Algae, zooplankton, aquatic and terrestrial insects, detritus	Algae, zooplankton, aquatic and terrestrial insects, detritus
Cyprinidae	Longnose dace	*Rhinichthys cataractae*	Inshore waters of lakes over gravel or boulder bottoms. May move offshore to deeper water in summer in warm lakes	Narrow	Spring and Summer	Aquatic insects, insect larvae	Aquatic insects, insect larvae
Cyprinidae	Northern pikeminnow	*Ptychocheilus oregonensis*	Shallows near shore in the summer, and move off to benthic habitats in the winter	Narrow	May - Aug.	Aquatic and terrestrial insects, benthic invertebrates	Fish (sculpin, perch, salmonids), zooplankton, aquatic and terrestrial insects, benthic invertebrates

Table 14. UCR Fish Species and Life History Information

Family	Common Name	Latin Name	General Habitat	Home Range	Spawning Time	Primary Juvenile Prey Items	Primary Adult Prey Items
Cyprinidae	Peamouth chub	*Mylocheilus caurinus*	May occur in shallows at night, deep water by day, and spawns in shallows over gravel or rubble	Narrow	May-June	Zooplankton and aquatic and terrestrial insects	Zooplankton and aquatic and terrestrial insects, snails
Cyprinidae	Redside shiner	*Richardsonius balteatus*	Slow current; usually over mud or sand, often near vegetation	Narrow	June-July	Algae, zooplankton, terrestrial insects	Zooplankton, aquatic and terrestrial insects, benthic invertebrates, fish eggs
Cyprinidae	Speckled dace	*Rhinichthys osculus*	Usually found in shallow water, and rocky substrates	Narrow	Early spring to late summer	Zooplankton	Zooplanktons, aquatic insects, insect larvae, algae, periphyton, benthic invertebrates
Cyprinidae	Tench	*Tinca tinca*	Shallow portions of lakes and ponds, backwaters and other slow-moving areas of small to large rivers	Narrow	May-June	Algae, zooplankton	Zooplankton, detritus, aquatic insects, snails
Gadiformes	Burbot	*Lota lota*	Between 31-110 m deep, cooler waters	Narrow	Dec./Jan to Mar.	Zooplankton and aquatic insects	Fish (sculpin, perch, salmonids), zooplankton, aquatic insects
Ictaluridae	Yellow bullhead	*Ictalurus natalis*	Shallow weedy parts of clear warm lakes	Narrow	Spring - early summer	Periphyton, plant material, aquatic insects, molluscs	Periphyton, plant material, aquatic insects, molluscs
Percidae	Walleye	*Sander vitreum*	Generally in moderately deep waters. Avoids bright light.	Large	March to May (Little Falls Dam and upper reaches of Sanpoil Arm)	Zooplankton, aquatic insects, fish	Fish (sculpin, perch, salmonids), zooplankton, aquatic insects
Percidae	Yellow perch	*Perca flavescens*	Associated with aquatic plants and shallow water in lakes	Narrow	Spring	Zooplankton and aquatic insects	Zooplankton, aquatic insects, and fish (sculpin)
Salmonidae	Brook trout	*Salvelinus fontinalis*	May move from streams into lakes to avoid high temperatures in summer	Large	Late summer or Fall	Zooplankton	Zooplankton, aquatic insects, fish
Salmonidae	Brown trout	*Salmo trutta*	Deep water pools	Large	Late summer or Fall	Aquatic insects, benthic invertebrates	Aquatic insects, zooplankton, fish (perch, salmonids)
Salmonidae	Bull trout	*Salvelinus confluentus*	In lakes, inhabits all depths in fall, winter, and spring; moves to cooler, deeper water for summer.	Large	Late summer or Fall	Aquatic and terrestrial insects, benthic invertebrates, fish	Aquatic and terrestrial insects, benthic invertebrates, fish
Salmonidae	Chinook salmon	*Oncorhynchus tshawytscha*	Deep water	Large	Stocked - do not reproduce in Lake Roosevelt	Zooplankton and aquatic and terrestrial insects	Zooplankton and aquatic and terrestrial insects
Salmonidae	Cutthroat trout	*Oncorhynchus clarki*	Primarily in tributaries or deep water pools.	Large	March-July	Zooplankton and aquatic and terrestrial insects	Zooplankton and aquatic and terrestrial insects
Salmonidae	Kokanee	*Oncorhynchus nerka*	Warm quiet waters; remain in fresh water	Potentially large	Aug. - Nov.	Zooplankton and aquatic and terrestrial insects	Zooplankton and aquatic and terrestrial insects
Salmonidae	Lake whitefish	*Coregonus clupeaformis*	Prefers deep cold waters, deeper pelagic areas of Lake Roosevelt and McNary Reservoir	Narrow	Fall (Oct. - Jan.); (Hawk Creek Embayment of Lake Roosevelt)	Zooplankton	Zooplankton, aquatic and terrestrial insects, benthic invertebrates
Salmonidae	Mountain whitefish	*Prosopium williamsoni*	Cold mountain lakes (to depths of at least 10 m) and fast, clear or silty streams with large pools	Large	Sept - Dec	Zooplankton and aquatic insects, benthic invertebrates	Zooplankton and aquatic insects, benthic invertebrates
Salmonidae	Rainbow trout (wild and hatchery)	*Oncorhynchus mykiss*	Often in cool clear lakes and cool swift streams with silt-free substrate	Narrow	Spring - Fall	Zooplankton and aquatic insects	Zooplankton and aquatic insects, snails, annelids, small fish

Notes:

Information in this table compiled from Black et al. (2003); Lee et al. (2003, 2006), BPA (2004b), Scofield et al. (2004), Pavlik-Kunkel et al. (2005), and Wydowski and Whitney (2003).

Table 15. Habitat Requirements of Early Life Stages of Amphibians Found in the UCR

Scientific Name	Common Name	Breeding Time and Habitat	Rearing Habitat	Larval Prey
Salamanders				
Ambystoma macrodactylum	Long-toed salamander	November or December. Eggs in small clumps attached to sticks or rocks in temporary pools.	Eggs develop rapidly, larvae occupy temporary pools. Larvae spend 6 or more months in water.	Crustaceans (fairy shrimp), copepods, tadpoles, salamander larvae
Ambystoma tigrinum	Tiger salamander	April or May. Eggs are deposited in lakes, reservoirs, ponds.	Eggs attach to sticks, rocks, and plants in shallow water; larvae spend 3 to 15 months in water. Neoteny may occur in dry climates.	Macroinvertebrates, tadpoles, salamander larvae
Frogs and Toads				
Bufo boreas	Western toad	February to April at low elevations. June or July in arid regions.	Wetlands and ponds, among vegetation.	
Bufo woodhousii	Woodhouse's toad	April through June.	Wetlands adjacent to streams, ponds, lakes canals and ditches	Plant materials
Hyla regilla	Pacific treefrog	February through June at low elevations.	Shallow, vegetated wetlands, marshes, shrubby thickets. Embryos develop rapidly, hatching in 2 - 3 weeks.	
Spea intermontana	Great basin spadefoot	Periods of warm, wet weather.	Wetlands and ponds. Embryos hatch after 2 - 3 days.	Various, including both plants and animals
Rana catesbeiana	Bullfrog			
Rana clamitans	Green frog			Algae and vegetation
Rana pipiens	Northern leopard frog			
Rana luteiventris	Columbia spotted frog	Columbia spotted frog.	February to March at low elevations; late may - June at higher elevations. Eggs are laid in ponds or wetlands, with site fidelity.	

APPENDIX B

TERRESTRIAL RESOURCE INVENTORY

CONTENTS

LIST OF MAPS

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

BERA	baseline ecological risk assessment
CTFWD	Colville Tribes Fish and Wildlife Department
EPA	U.S. Environmental Protection Agency
GIS	geographic information system
ICBEMP	Interior Columbia Basin Ecosystem Management Program
LRF	Lake Roosevelt Forum
LRNRA	Lake Roosevelt National Recreation Area
NPS	National Park Service
NWHI	Northwest Habitat Institute
NWI	National Wetlands Inventory
RI/FS	remedial investigation/feasibility study
UCR	Upper Columbia River
U.S.	United States
USFWS	U.S. Fish and Wildlife Service
UTM	Universal Transverse Mercator
WDFW	Washington State Department of Fish and Wildlife
WDNR	Washington State Department of Natural Resources
WNHP	Washington State Natural Heritage Program

UNITS OF MEASURE

cm	centimeter(s)
ft	feet
in.	inches
km	kilometer(s)
m	meter(s)

1 INTRODUCTION

This appendix provides an overview of the terrestrial habitat and wildlife species present in and around the Upper Columbia River (UCR) Site. The objective of this appendix is to provide information that can be used to focus any future investigations, as well as to identify any important data gaps with respect to the distribution of key resources along the UCR.

The studies evaluated in this appendix are historical and were not necessarily conducted for the UCR remedial investigation/feasibility study (RI/FS) and the baseline ecological risk assessment (BERA) and may not meet the current standards of practice and/or the data quality requirements necessary for completion of the BERA. However, for purposes of this BERA work plan, the data and analyses are assumed to be adequate to assist in identifying data gaps and describing general site characteristics, but may not be acceptable for use in future deliverables in their current form.

As the BERA progresses, the quality of the existing data, data analysis procedures, and suitability for inclusion in the BERA will be assessed according to procedures that will be reviewed and approved by the U.S. Environmental Protection Agency (EPA). In addition, clear explanations of the data used in evaluations, evaluation methodology, and statistical analysis documentation will be provided in future documents

Spatial data were obtained from the following organizations:

- Interior Columbia Basin Ecosystem Management Program (ICBEMP)—Large and Small Snags, predicted animal distributions (Quigley et al. 2001)
- Northwest Habitat Institute (NWHI)—Habitat classification data (NWHI 2002)
- United States (U.S.) Department of Agriculture, Forest Service—Ecoregion data (McNab et al. 2007)
- U.S. Fish and Wildlife Service (USFWS)—National Wetland Inventory (NWI) (USFWS 2008)
- Washington State Department of Fish and Wildlife (WDFW)—Priority Habitats and Animal Species, Bald Eagle Management Zones (WDFW 2008a)
- Washington State Natural Heritage Program (WNHP)—Rare and Priority Upland and Riparian Vegetation, Endangered Ecosystems (WDNR 2008).

Major terrestrial resources discussed in the following appendix are:

- Current vegetation distribution
- Endangered ecosystems
- Priority habitat
- Rare and threatened plant species

- Wetlands
- Invertebrates
- Amphibians
- Reptiles
- Birds
- Mammals
- Threatened/endangered animal species.

Finally, resources for which little or no publicly available spatial data exist are identified.

2 INFORMATION FOR SPECIFIC RESOURCES

This section presents detailed information collected for terrestrial resources at the UCR.

2.1 VEGETATION

2.1.1 Ecoregions

The predominant ecoregion type present across the UCR Site is Northern Rocky Mountain Forest-Steppe - Coniferous Forest - Alpine Meadow Province (Map 1). This ecoregion type is characterized by an overall climate that is cool with warm, dry summers and cold, moist winters with heavy snowfall (McNab et al. 2007). Vegetation is mainly evergreen and deciduous, needleleaf forest including western white pine (*Pinus monticola*), Douglas-fir (*Pseudotsuga menziesii*), and western larch (*Larix occidentalis*), with interspersed mountain grasslands. This area is dominated by rounded landforms that resulted from continental glaciation. The subsections found within the ecoregion provide further ecological detail based on geomorphic process and surficial geology, in addition to subregional climatic data and soil orders. For example, the Okanogan Semiarid Foothills Subsection occurs along River Reaches 5 and 6, and is characterized by fewer trees and more shrub-steppe shrublands than the Columbia Valley and Foothills subsection that occurs along River Reaches 1 through 4 (Map 1).

The Intermountain Semi-Desert Province ecoregion occurs at the southern end of the UCR Site, south of Lake Roosevelt and the Grand Coulee Dam (Map 1). Within this ecoregion, the climate is semiarid, cold with warm to hot, dry summers and cold, dry winters (McNab et al. 2007). The portion of this ecoregion near the UCR is a large, high-elevation plain with rolling hills. Dominant vegetation includes big sagebrush (*Artemisia tridentata*), mountain grasslands, and ponderosa pine (*Pinus ponderosa*). The subsections found within the ecoregion detail local geomorphology that is differentiated by many side canyons near the river and flat plateau areas further south of Lake Roosevelt.

2.1.2 Vegetation Distribution

As described by the ecoregions of the area, the climate of the UCR and surrounding area varies a great deal from the north to the south, with the southern portion near Grand Coulee Dam generally being hotter and drier. Map 2 shows the upland habitat type trend across the UCR according to satellite imagery interpretation mapped at approximately a 30 m by 30 m scale (NWHI 2002).

The dominant habitat type immediately adjacent to the northern portion of the UCR (River Reaches 1 through 4) includes a mix of urban or agricultural lands with ponderosa pine and eastside white oak (*Quercus alba*) forests, wetlands and riparian forests, and eastside grasslands (Map 2). There is a large wetland complex and agriculture mix east of the UCR along the Colville River. The uplands are predominantly mixed conifer forest, with some alpine grassland and montane mixed conifer forest habitat. In the southern portion of the UCR (River Reaches 4b, 5, and 6), the habitat type is dominated by shrub-steppe shrublands, with occasional ponderosa pine and eastside white oak forests mixed with agriculture (Map 2).

The trends in occurrence for these vegetation types are discussed in greater detail by Hebner et al. (2000) and the Lake Roosevelt Forum (LRF) (2008) for the UCR around Lake Roosevelt National Recreation Area (LRNRA). Vegetation in the southern area (Grand Coulee Dam to Keller Ferry, River Reach 6) includes steppe/shrub-steppe and agriculture. Common species within this section of the reservoir are grasses such as bluebunch wheatgrass (*Pseudoroegneria spicata*), needle-and-thread grass (*Hesperostipa comata*), and Idaho fescue (*Festuca idahoensis*); forbs such as arrowleaf balsamroot (*Balsamorhiza sagittata*), northern buckwheat (*Eriogonum* spp.), brittle prickly pear (*Opuntia* spp.), alumroot (*Heuchera* spp.), and lupine (*Lupinus* spp.); and shrubs such as big sagebrush, rabbitbrush (*Chrysothamnus nauseosus*), and antelope bitterbrush (*Purshia tridentata*) (Hebner et al. 2000; LRF 2008).

Between Keller Ferry and the upper end of the Spokane River Arm at Little Falls Dam (River Reach 5) is a transition from shrub/steppe to ponderosa pine forest (Hebner et al. 2000), with common trees including ponderosa pine and Douglas-fir. Grasses and forbs in the steppe/shrub-steppe zone are also common. Additional forbs present include; snowberry (*Symphoricarpos albus*), greasewood (*Sarcobatus vermiculatus*), and service berry (*Amelanchier arborea*) (Hebner et al. 2000; LRF 2008). Trees in this portion of the UCR include Douglas-fir, ponderosa pine, and black cottonwood (*Populus trichocarpa*).

Areas around the middle and upper reservoir, between the Spokane River and Kettle Falls (River Reaches 4a and 4b), receive approximately 43 to 51 cm (17 to 20 in.) of precipitation a year (LRF 2008). This area is covered with a dense mix of ponderosa pine and Douglas-fir (Hebner et al. 2000; LRF 2008). Grasses in this region of the reservoir include those present in the lower reservoir with the addition of pinegrass (*Calamagrostis rubescens*). Common forbs include hairy goldstar (*Crocidium multicaule*), phlox (*Phlox* spp.), and nodding onion (*Allium cernuum*); shrubs include chokecherry (*Prunus virginiana*), serviceberry, wild rose (*Rosa acicularis*), Douglas hawthorn (*Crataegus douglasii*), snowberry, occasionally some smooth sumac (*Rhus glabra*), and blue elderberry (*Sambucus cerulea*) (Hebner et al. 2000). Alder (*Alnus* spp.), willow (*Salix* spp.), hazelnut (*Corylus cornuta*), and black cottonwood are common along riparian areas (Hebner et al. 2000). Rocky Mountain juniper (*Juniperus virginiana*) can be found next to the shoreline and on rocky river bars.

The majority of the uplands around the middle to northern portion of the UCR (i.e., north of Kettle Falls to Onion Creek near the U.S.-Canada border, or River Reaches 1 through 3) are comprised of Eastside Mixed Conifer forest dominated by Douglas-fir with ponderosa pine at lower elevations or on drier sites. Among the pines and in dry, rocky areas, a variety of shrubs occur, including mallow ninebark (*Physocarpus malvaceus*), creeping Oregon grape (*Berberis repens*), elderberry, chokecherry, snowberry, deer brush (*Ceanothus sanguineus*), and red-stem ceanothus (*Ceanothus velutinus*) (Hebner et al. 2000). On moist sites, grand fir (*Abies grandis*), western redcedar (*Thuja plicata*) and/or western hemlock (*Tsuga heterophylla*) are dominant or co-dominant with Douglas-fir. Other conifers include western larch and western white pine on mesic sites, and lodgepole pine (*Pinus contorta*) and subalpine fir (*Abies lasiocarpa*) on colder sites (NWHI 2002). Dominant grassland species include bluebunch wheatgrass, Idaho fescue, and pinegrass (*Calamagrostis rubescens*) (Hebner et al. 2000; LRF 2008).

2.1.3 Endangered Ecosystems

Data on endangered ecosystems were obtained from the Washington State Department of Natural Resources (WDNR) and WNHP (WDNR 2008). The only rare ecosystem near the UCR is an occurrence of an old unlogged stand of ponderosa pine forest on steep rocky slopes approximately 37 km (23 miles) east of Lake Roosevelt on the Spokane River. The ponderosa pine forest ecosystem status currently is unknown in the state, but may be rare (WDNR 2008). Other WNHP ecosystems occurring across the UCR, including Douglas-fir—mallow ninebark, are classified as secure (Table 1).

2.1.4 Priority Habitat

WDFW maintains a list of habitats and species that are priorities for conservation and management throughout the state (WDFW 2008a). The general locations for each habitat and species can be mapped with geographic information software (GIS) as shown in Maps 3 through 9 (WDFW 2008b). The priority habitats are habitat types or elements with unique or significant value to a diverse assemblage of species (WDFW 2008a). A priority habitat may consist of a unique vegetation type or dominant plant species, a described successional state (e.g., old growth forest), or a specific habitat feature (e.g., cliffs).

Priority habitats found within the UCR Site (WDFW 2008a):

- **Shrub-steppe.** A nonforested vegetation type consisting of one or more layers of perennial bunchgrasses and a conspicuous but discontinuous layer of shrubs. Less disturbed soils have a layer of algae, mosses, or lichens. More disturbed areas contain non-native species like cheatgrass (*Bromus tectorum*) or crested wheatgrass (*Agropyron cristatum*). Shrub-steppe contains a variety of overall features, including diverse topography with a blend of riparian areas and canyons. This habitat is only found near River Reaches 5 and 6 in the southern portion of the UCR.

- **Riparian Zones.** Areas adjacent to flowing or standing freshwater. Riparian habitat includes the entire extent of the floodplain and riparian areas of wetlands that are directly connected to stream courses or other freshwater. The vegetation, water tables, soils, microclimate, and wildlife inhabitants of the terrestrial ecosystems are influenced by perennial or intermittent water. Priority riparian habitats mapped in Maps 3 through 9 additionally are defined by criteria including high fish and wildlife density, high fish and wildlife species diversity, important fish and wildlife breeding habitat, important wildlife seasonal ranges, important fish and wildlife movement corridors, high vulnerability to habitat alteration, and unique or dependent species. Mapped WDFW riparian zones occur along or near River Reaches 1 through 5, but none occur near River Reach 6 near Grand Coulee Dam.
- **Wetlands.** Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands have one or more of the following attributes: the area supports hydrophytic plants, the substrate is predominantly undrained hydric soils; and/or the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year. Mapped WDFW wetland habitat occurs near most sections of the UCR, along or near River Reaches 2,3,4, and 6.
- **Cliffs.** Habitat feature with heights greater than 7.6 m (25 ft) and occur below 1524 m (5000 ft). There is no specific rationale given for the listing of cliffs as a priority habitat feature; however they are generally known to be unique habitat features of high importance value for some wildlife. WDFW cliff habitat occurs near River Reach 5 in the southern portion of the UCR.

2.1.5 National Wetlands Inventory

The NWI 1:24,000 quadrangle GIS data layers corresponding with the UCR Site were downloaded from the USFWS webpage in August 2008 (USFWS 2008). These NWI digital data files are records of designated wetlands locations developed by USFWS by photointerpretation of aerial photography with varying limitations due to scale, photo quality, inventory techniques, and other factors (USFWS 2008). The maps tend to show wetlands that are readily photo-interpreted, given consideration of photo and map scale. Also, maps based on older black-and-white photographs from the 1970s tend to be very conservative and may not show forested and drier emergent wetlands. Maps 3 through 9 show wetlands occurring throughout the length of the UCR area. Wetlands are more densely distributed along and near the northern River Reaches than the drier southern River Reaches.

2.1.6 ICBEMP Habitat Features

Other habitat features such as current and historical levels of large and small snags (Maps 10 and 11) are detailed by Quigley et al. (2001) from the ICBEMP. These features can provide nesting, perching, and foraging habitat for a variety of wildlife. An ICBEMP data set based on field and modeled data was generated as a way to understand the current relative numbers of snags as compared to characteristics of historic numbers of snags. The "current" period is defined as generally occurring between 1994 and 2004, while the "historic" timeframe is not defined in the metadata. Multiple types of standing and dead wood density (number per acre) data are available on a subwatershed basis. These data are intended for use at the broad-scale, and should not be used to draw conclusions about occurrence at smaller spatial scales. The numbers of large and small snags are greatest in the northern reaches of the UCR, in the hills around River Reaches 1 through 4a. There are no large snags and few small snags along River Reach 5 and 6 near the Grand Coulee Dam (Maps 10 and 11).

2.1.7 Rare and Threatened Riparian Plant Species

WNHP maintains a GIS dataset with locations of rare and priority riparian and upland plant species (Table 1; Maps 3 through 9; WDNR 2008). Although the original data are provided as circles encompassing general locations, the circles were truncated at the shoreline in the present analysis for ease of viewing and because these species are not expected to be found in open water, since they are upland plants as opposed to emergent vegetation. WNHP data restrictions and cautions include:

- To balance the interests of data users with species protection, the precise locations of rare plant populations are not included. These locations are instead represented by "areas-of-concern." Occurrences of species considered critically imperiled are generalized as larger areas-of-concern polygons.
- WNHP cautions that data are limited only to available records; some areas may not have been thoroughly surveyed, and absence of listed species should not be assumed to indicate evidence of absence.
- The appropriate scale for use of these map data is 1:24,000, or 1 in. = 2,000 ft. It is inappropriate to depict natural heritage features on very fine-scale maps (such as 1 in. = 500 ft), because WNHP data were not compiled at this level of detail.

No Federal Threatened or Endangered Plant species are located near the UCR. The only state endangered species that occurs along the UCR is the Columbia crazyweed (*Oxytropis campestris* var. *columbiana*). This plant species occurs solely along gravel bars or stony river shores between 1200 and 3000 ft in elevation along the Columbia River north of the Spokane River, and is only found along River Reach 1 (Map 3). It is most likely dependent on natural water level fluctuations in the rivers and lakes, and most of the populations have been extirpated due to habitat destruction by the construction of the Grand Coulee Dam (WDNR 2008).

There are two state threatened species of plants that occur along the UCR in the WNHP GIS dataset; little bluestem (*Schizachyrium scoparium* var. *scoparium*), and Palouse milkvetch (*Astragalus arrectus*). The little bluestem is found along the Columbia River growing on gravel bars above and below the high water line and in old river ox-bows (WDNR 2008). It is a major component of the Midwestern tall-grass prairie, but is found in high quality riparian plant communities in Washington. It is only found along the UCR on River Reach 1 (Map 3). The Palouse milkvetch has a wide distribution in the state, but most occurrences are small in size. The plant's habitat is grassy hillside, sagebrush flats, river bluffs, and open ponderosa pine/Douglas-fir forests in grassy or shrub dominated openings growing in soil from rocky and dry to moist and rich. The only occurrence of this plant species along the UCR is along River Reach 5 (Map 8).

Four vascular plant species are classified as sensitive in the state; Nuttall's pussy-toes (*Antennaria parvifolia*), least bladdery milkvetch (*Astragalus microcystis*), fuzzytongue penstemon (*Penstemon eriantherus* var. *whitedii*), and black snake-root (*Sanicula marilandica*). Nuttall's pussy-toes is a state sensitive species that occurs in dry, open areas with sandy or gravely soil along riparian areas, usually in ponderosa pine forests. The known distribution is solely in the north-eastern section of the state, and is found on River Reaches 3 and 4a,b along the UCR (Maps 5 through 7). The least bladdery milkvetch occurs in eastern Washington along gravelly to sandy areas, from riverbanks to open woods. This plant species is only found on River Reach 1 (Map 3). The fuzzytongue penstemon grows on west facing slopes of small canyons, and in dry and rocky habitats. There have been fewer than 15 documented occurrences of the taxon in Washington (WDNR 2008), and one of those occurs along River Reach 6 (Map 9). Black snake-root occurs on moist, low ground such as riparian flood plains and marsh edges. There are less than 40 documented occurrences in Washington (WDNR 2008), and is found near the UCR along River Reaches 1 and 2 (Maps 3 and 4).

Two species of forbs are of potential concern for the state of Washington along the UCR; narrowleaf skullcap (*Scutellaria angustifolia* spp. *micrantha*), and orange balsam (*Impatiens aurella*). The narrowleaf skullcap grows in dry, rocky soil on barren talus slopes and sagebrush grasslands, and occasionally found in ponderosa pine woodlands. There are less than 10 known occurrences in the state (WDNR 2008), with one occurring along River Reach 2 (Map 4). WNHP has not produced field guide information for the orange balsam as of September 2008. However, they are known to occur along moist streambanks and meadows in the steppe or lower montane zones (Klinkenberg 2007). The only occurrence along the UCR is on River Reach 3 (Map 5).

2.1.8 Rare and Threatened Upland Plant Species

The following plant species occur in the uplands near River Reaches 1 and 2 close to the Canada border (Maps 3 and 4; Table 1). These include one species that is of special Federal concern, but listed as "sensitive" for the state (WDNR 2008). Five species are classified as "sensitive" for the state, and one species is classified as "threatened" for the state.

The plant species classified as threatened for the state is hoary willow (*Salix candida*). The only known Washington locations of the hoary willow are in three locations in the Colville National Forest near the UCR. They occur in swampy areas in peat soils at 608 to 912 m (2000 to 3000 ft) in elevation, and are very sensitive to changes in the hydrologic regime (WDNR 2008).

The following plants are state sensitive species; crenulate moonwort (*Botrychium crenulatum*), Steller's rockbrake (*Cryptogramma stelleri*), yellow mountain-avens (*Dryas drummondii*), black snake-root, and the kidney-leaved violet (*Viola renifolia*). Natural history for black snake-root was discussed in the previous section. The crenulate moonwort occurs in moist areas such as moist meadows, along the margins of perennial or intermittent streams, and in seeps. It generally occurs in western redcedar and western hemlock forests with greater than 70 percent canopy cover at an elevation ranging from 608 to 1585 m (2000 to 5200 ft). However, recent surveys have failed to find the crenulate moonwort, with the last observation in or before 1996 (Table 1; WDNR 2008). Steller's rockbrake is a boreal species that grows on moist, shaded cliffs and ledges at an elevation of 914 to 1829 m (3000 to 6000 ft). There are less than five known current occurrences of Steller's rockbrake in the state of Washington (WDNR 2008). Likewise, there are only a few known occurrences of yellow mountain-avens in the state. This species prefers crevices of steep, rocky, dry cliffs, and on limestone rock along rivers. These two cliff species occur near each other on the rocky cliffs south of River Reach 1 (Map 3). Kidney-leaved violets may be found from lowland coniferous forest to subalpine slopes. It is generally found in moist, forested sites, and sometimes along ditches or streams (WDNR 2008).

2.1.9 Summary

The trend of climate change from north to south across the UCR is mirrored in vegetation type, with mixed conifer forests dominant in the northern areas and shrub/steppe vegetation occurring in the drier southern section of the UCR. Table 2 shows the location of specific terrestrial resources of concern by river reach. The only state ecosystem of concern near the UCR is a ponderosa pine forest that occurs 37 km upstream along Spokane River east of the UCR. Most of the priority habitats occur throughout the UCR, with cliffs and the shrub/steppe habitat type only occurring along the most southern River Reaches. The state endangered Columbia crazyweed only occurs along River Reach 1, as do the threatened species little bluestem and Hoary Willow. The state threatened Palouse milkvetch plant species only occurs along River Reach 5. State sensitive and special concern plants occur along each River Reach except Reach 5.

2.2 WILDLIFE

There are 99 species of upland mammals, 250 species of birds, 15 species of reptiles, and 10 species of amphibians reported to occur near the UCR Site (Table 3; Maps 3 through 9). Two comprehensive surveys were used to generate occurrence information for wildlife species around the UCR; Hebner et al. (2000) and Craveling and Renfrow (1986). Hebner et al. (2000) generated a list of species for an Environmental Assessment of the LRNRA. Craveling and Renfrow (1986) studied the area from the Grand Coulee Dam to the U.S.-Canada border from the reservoir to the surrounding ridges for planning related to dam operations. Another comprehensive source of information used to assess species presence was from ICBEMP (Quigley et al. 2001; Marcot et al. 2003). ICBEMP produced individual species range data layers for the entirety of the interior Columbia basin area. The species range maps were derived from a variety of publications, unpublished data, and from expert review (Marcot et al. 2003). The final species ranges were investigated to determine overlap with the UCR Site. As an additional data source for bird species, Seattle Audubon Society (SAS 2006) hardcopy species maps were checked for occurrence in the UCR if the species was determined to be present in the surveys of Hebner et al. (2000) or Craveling and Renfrow (1986), but absent in the ICBEMP range map. Wildlife species of concern from the Colville Tribes Fish and Wildlife Department (CTFWD) were checked against the results of the other surveys (CTFWD 2006).

The WDFW (2008a) dataset was checked for state and federal protected status for species determined to be present in the UCR. These species include wildlife that require special efforts to ensure their perpetuation because of their low numbers, sensitivity to habitat alteration, tendency to form vulnerable aggregations, or because they are of commercial, recreational, or tribal importance (WDFW 2008a). It is worthy to note that because the WDFW mapped areas for priority species represent known use areas, it is not a comprehensive presence/absence dataset.

Additional species distributions (WDFW 2008a) are mapped on a site-wide basis, including:

- Mule deer (*Odocoileus hemionus*) wintering and fawning areas (Map 12)
- White-tailed deer (*Odocoileus virginianus*) wintering and fawning areas (Map 12)
- Elk (*Cervus elaphus*) winter range areas (Map 12)
- Blue grouse (*Centrocercus urophasianus*) wintering areas (Map 13).

2.2.1 Soil Invertebrates

Terrestrial invertebrate occurrences are not reported in the results of either Hebner et al. (2000) or Craveling and Renfrow (1986). ICBEMP (Quigley et al. 2001; Marcot et al. 2003) details ranges for several ubiquitous terrestrial invertebrates near the UCR; thatch ant (*Formica obscuripes*), western black widow spider (*Latrodectus hesperus*), and western yellow jacket (*Vespula pensylvanica*). The only invertebrate of concern that occurs in the counties near the UCR is the silver-bordered fritillary (*Boloria selene atrocostalis*), which is a state candidate species. This butterfly is an extremely colonial species with disjunct populations and lives in boggy meadows and true bogs that support violets (Larsen et al. 1995). The observation in the WDFW database is east of the UCR Site in the Colville River wetlands (WDFW 2008a). There are several invertebrates that are special status at the state and federal levels that could likely occur near the UCR. Three butterflies are state endangered – Mardon skipper (*Polites mardon*), Taylor's checkerspot (*Euphydryas eitha taylori*) and Oregon silverspot butterfly (*Speyeria zerene hippolyta;* which is also federally threatened). There are 21 other insects that are species of concern at either the state and federal levels (Table 3).

2.2.2 Amphibians

Generally, amphibians are important ecological species that occupy terrestrial and aquatic habitats and many species populations are declining in areas around the world. They are potentially exposed to contaminants through several routes in both terrestrial and aquatic ecosystems. Two salamander species, two toad species, and six frog species have been reported to occur in the UCR area (Table 3; Maps 3 through 9) (Hebner et al. 2000; Craveling and Renfrow 1986; Quigley et al. 2001; Marcot et al. 2003; WDFW 2008b). ICBEMP range maps (Quigley et al. 2001; Marcot et al. 2003) show the great basin spadefoot (*Spea intermontana*) and bullfrog (*Rana catesbeiana*) to only occur in the southern section of the UCR along River Reaches 5 and 6, and the tiger salamander's range extends up to and including River Reach 2. The other four species with ranges detailed by ICBEMP occur throughout the UCR area.

2.2.3 Reptiles

Reptile species observed in the UCR area include the painted turtle (*Chrysemys picta*), five lizard species, western skink (*Eumeces skiltonianus*), and eight snake species (Hebner et al. 2000; Craveling and Renfrow 1986; Quigley et al. 2001; Marcot et al. 2003; WDFW 2008b). The range maps detailed in Marcot et al. (2003) show that the painted turtle, rubber boa (*Charina bottae*) and two garter snake species (*Thamnophis* sp.) occur throughout the UCR. The ranges for the other six reptile species are smaller areas within the UCR Site (Marcot et al. 2003).

2.2.4 Birds

Birds species observed along or near the UCR are listed in Table 3 and in Maps 3 through 9 (Hebner et al. 2000; Craveling and Renfrow 1986; Quigley et al. 2001; Marcot et al. 2003; SAS 2006; WDFW 2008a,b). They include raptors such as osprey, eagles, falcons, hawks, harriers, and kestrels. Passerine birds (songbirds) include swallows, finches, jays, chickadees, kinglets, ravens, magpies, robins, sparrows, flycatchers, blackbirds, and juncos (see Table 3 for scientific notation for birds and mammals). Water birds include mallards, pintails, teal, goldeneyes, canvasbacks, grebes, coots, scaup, mergansers, loons, and geese. Shorebirds include plovers, killdeer, sandpipers, gulls, snipes, grebes, and yellowlegs. Grassland birds include grouse, doves, pigeons, pheasant, and turkeys.

2.2.5 Mammals

Surveys and range maps for upland mammals have listed 99 species that occur along the UCR (Table 3; Maps 3 through 9 and Map 12; Hebner et al. 2000; Craveling and Renfrow 1986; Quigley et al. 2001; Marcot et al. 2003; WDFW 2008a,b). Large mammals include black bear and grizzly bear, elk, lynx, mountain lion, bighorn sheep, whitetail deer, mule deer, and moose. Smaller mammals include beavers, otters, moles, muskrats, mink, badgers, raccoons, skunks, bobcats, coyotes, foxes, porcupines, rabbits, squirrels, chipmunks, marmots, pikas, bats, gophers, rats, voles, shrews, and mice.

Additionally, small mammals were trapped along a series of transects throughout riparian areas of the LRNRA (McCaffrey et al. 2003). Baited Sherman live traps and Museum Special snap traps each were placed every 15 m along 150 m transects. Traps were placed nonrandomly near microhabitat features and mammal signs for three to five consecutive nights. Universal Transverse Mercator (UTM) coordinates used to plot the trapping stations (most accurate to within 10 m) were used as the basis for plotting the spatial data on the reach-by-reach site maps (Maps 3 through 9). Species trapped at each station are provided in the maps in the report; additional data in the report also include number of mammals trapped per station, as well as relative abundance of each species.

2.2.6 Threatened/Endangered Species

Mapped priority species (WDFW 2008a) shown on Maps 3 through 9 include:

- Bald eagle (*Haliaeetus leucocephalus*) nest sites[1].

[1] Bald eagles were removed from the federal endangered species list in 2007 (Federal Register 2007), but bald eagles and their nests are still protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act.

- Bald eagle management zones (400 ft radius for individual nests or communal roosts; if along a shoreline, 800 ft radius for communal roosts plus the 250 ft to the shoreline (shoreline buffer) within 1/2 mile of nest).
- Golden eagle (*Aquila chrysaetos*) nest sites.
- Point data for individual species observations (e.g., great blue heron [*Ardea herodias*]).

Some wildlife species reported within the UCR and the surrounding watershed are listed as threatened or endangered (state and/or federal), including the northern leopard frog, American white pelican, ferruginous hawk, northern goshawk, sage and sharp-tailed grouse, sandhill crane, upland sandpiper, pygmy rabbit, western gray squirrel, gray wolf, fisher, woodland caribou, grizzly bear, and Canada lynx (Table 3).

There are also many wildlife species reported within the area whose possible decline is a matter of concern to federal and state resource agencies. These species are identified in Table 3 as any of the following: federal candidate, state candidate, state sensitive, state monitored, proposed sensitive, and proposed threatened. Species of concern include the western toad, Columbia spotted frog, sagebrush lizard, common loon, osprey, northern goshawk, golden eagle, peregrine falcon, burrowing owl, Columbia sharp-tailed grouse, loggerhead shrike, Pacific water shrew, myotis bats, Townsend's big eared bat, Washington ground squirrel, western pocket gopher, and wolverine.

WDFW (2008b) list waterfowl concentrations in their priority habitats and species list considered to be priorities for conservation and management. These waterfowl are defined as birds of genus *Anatidae*, excluding Canada geese in urban areas, where there are significant breeding areas, or habitat for regular concentrations in winter. There are several locations throughout the UCR mapped as areas supporting waterfowl concentrations, mostly on wetlands or riparian habitats away from the main UCR channel (Maps 3 through 9).

2.2.7 Summary

Table 4 shows the location of specific resources by river reach number. This occurrence information was derived from the WDFW (2008a) observation database, along with the potential habitats published by Marcot et al. (2003). Most of the species of concern were observed or have habitat throughout the UCR. However, there were some species that are confined to the upper or lower reaches of the UCR. The species that are found mostly in the dry sagebrush habitat and larger expanses of open water along River Reach 5 and 6 are; American white pelican, black-crowned night heron, ferruginous hawk, sage and sharp-tailed grouse, loggerhead shrike, sage sparrow, grasshopper sparrow, pallid bat, pygmy rabbit, Washington ground-squirrel, and sagebrush vole. The species that are observed in the cooler and more forested northern sections include; all of the five woodpecker species, boreal chickadee, northern waterthrush, bobolink, pygmy shrew, red-tailed chipmunk, northern bog lemming, and woodland caribou. Overall, there is no river reach that has significantly more or less species observed or predicted to occur than any of the other river reaches.

3 POTENTIAL SOURCES OF NEW INFORMATION

The National Park Service (NPS) recently completed a vegetation mapping project for the LRNRA. These surveys are part of a broader cooperative mapping effort by the USGS and the NPS to classify, describe, and map vegetation communities in national park units across the U.S. This study provides ground-truthed digital data for riparian and upland vegetative communities of the LRNRA with a minimum mapping unit of 0.5 hectare and classification accuracy of 80 percent (NPS 2008). Vegetative classification and photo-interpretation to create generalized current vegetation maps for LRNRA have not yet been completed (NPS 2008).

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MAPS

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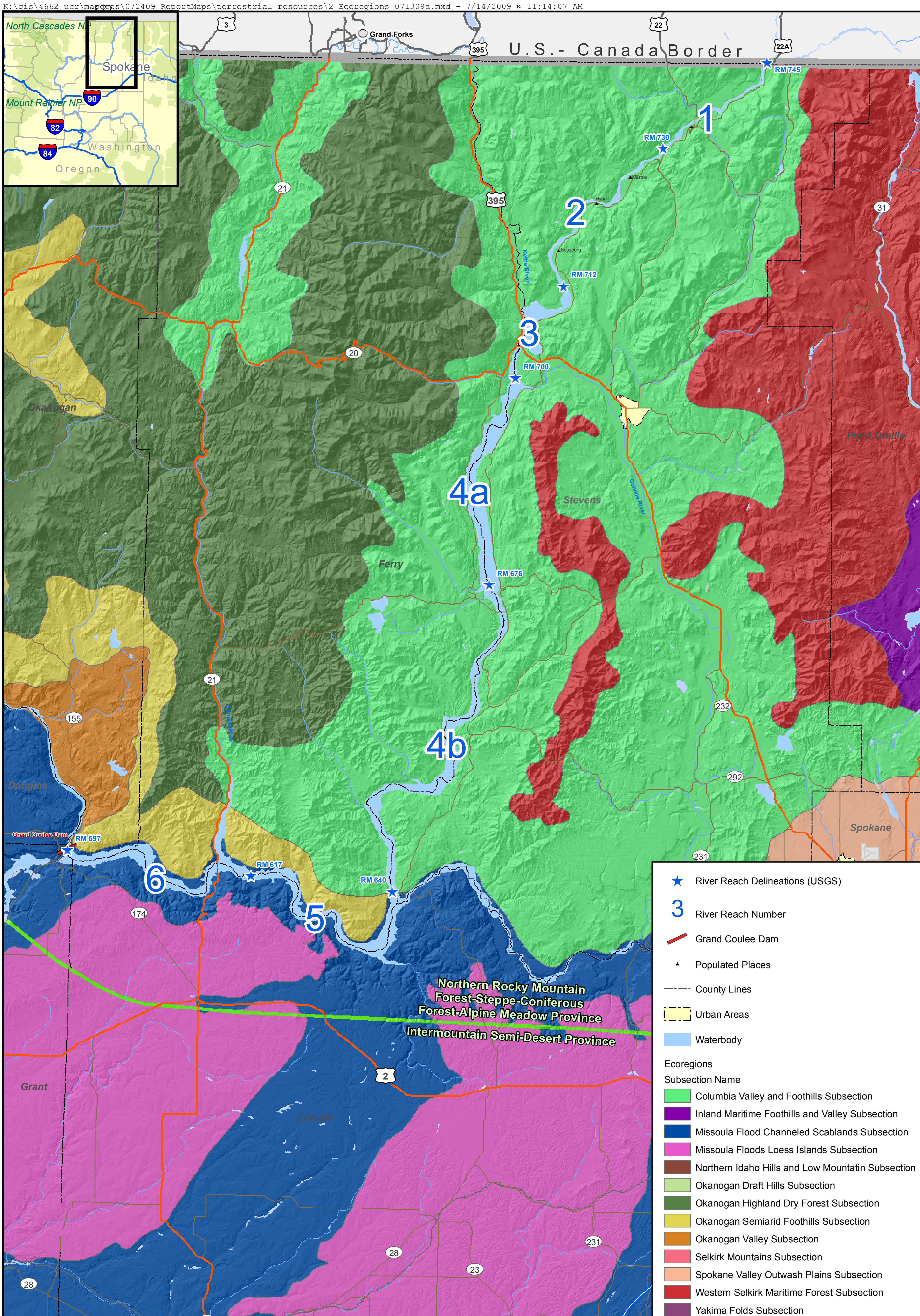

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Map 1. **Ecoregions of the UCR and Surrounding Areas**

Upper Columbia River, WA

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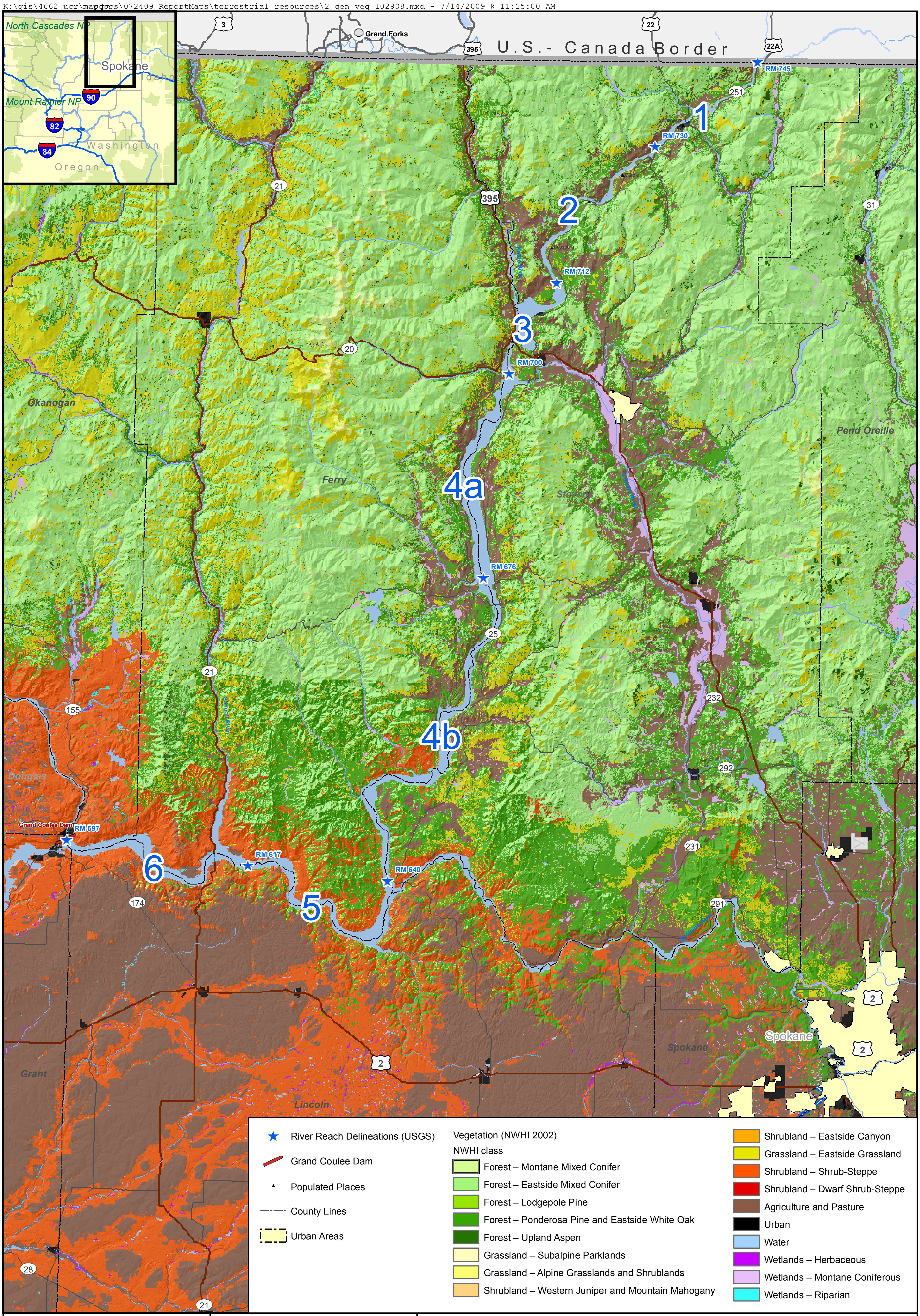

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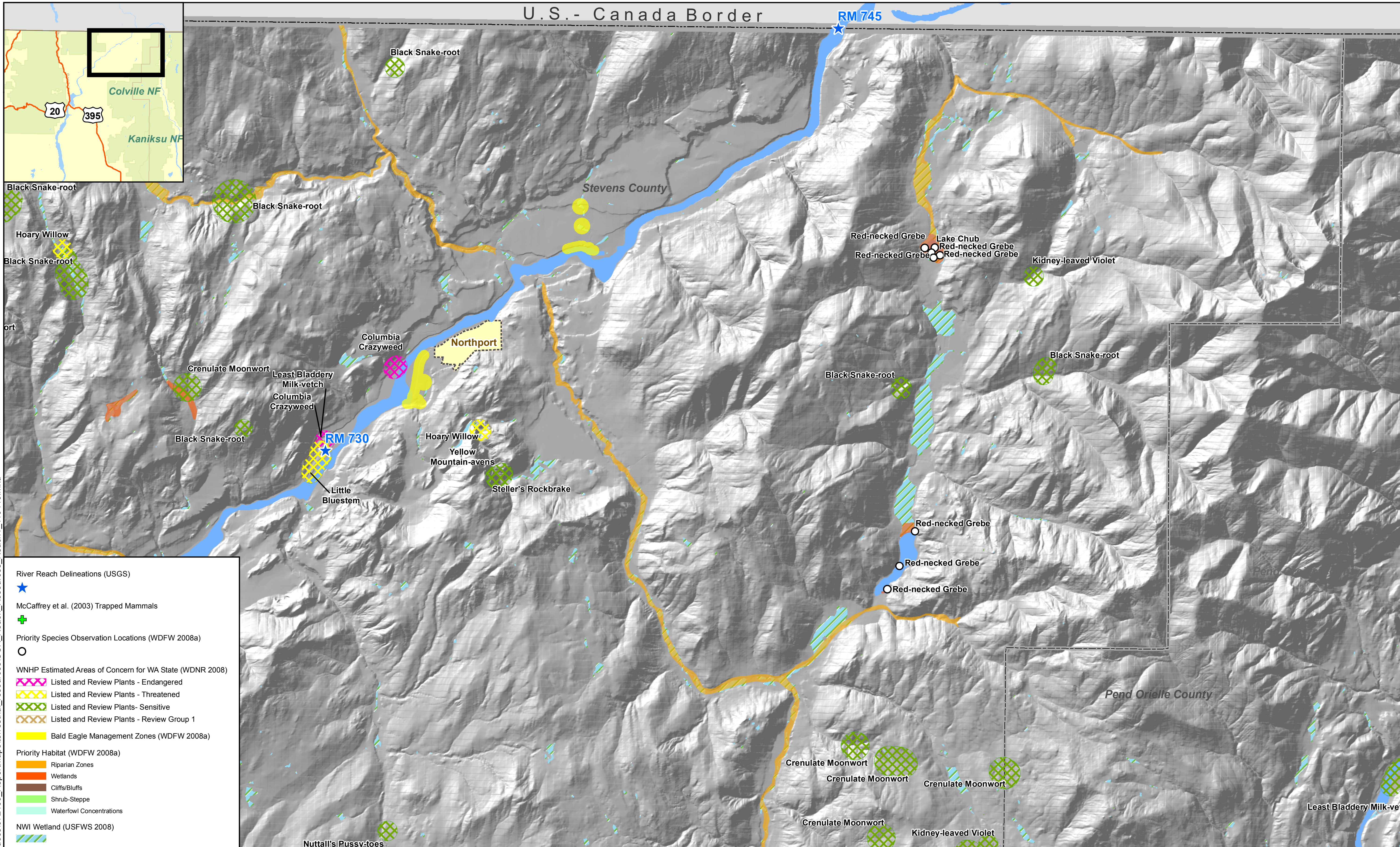
Map 2. **General Vegetation of the UCR and Surrounding Areas**

Upper Columbia River, WA



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Map 3. **Endangered and Rare Terrestrial Vegetation and Wildlife Associated with UCR Reach 1 - River Mile 730 to 745**

Upper Columbia River, WA

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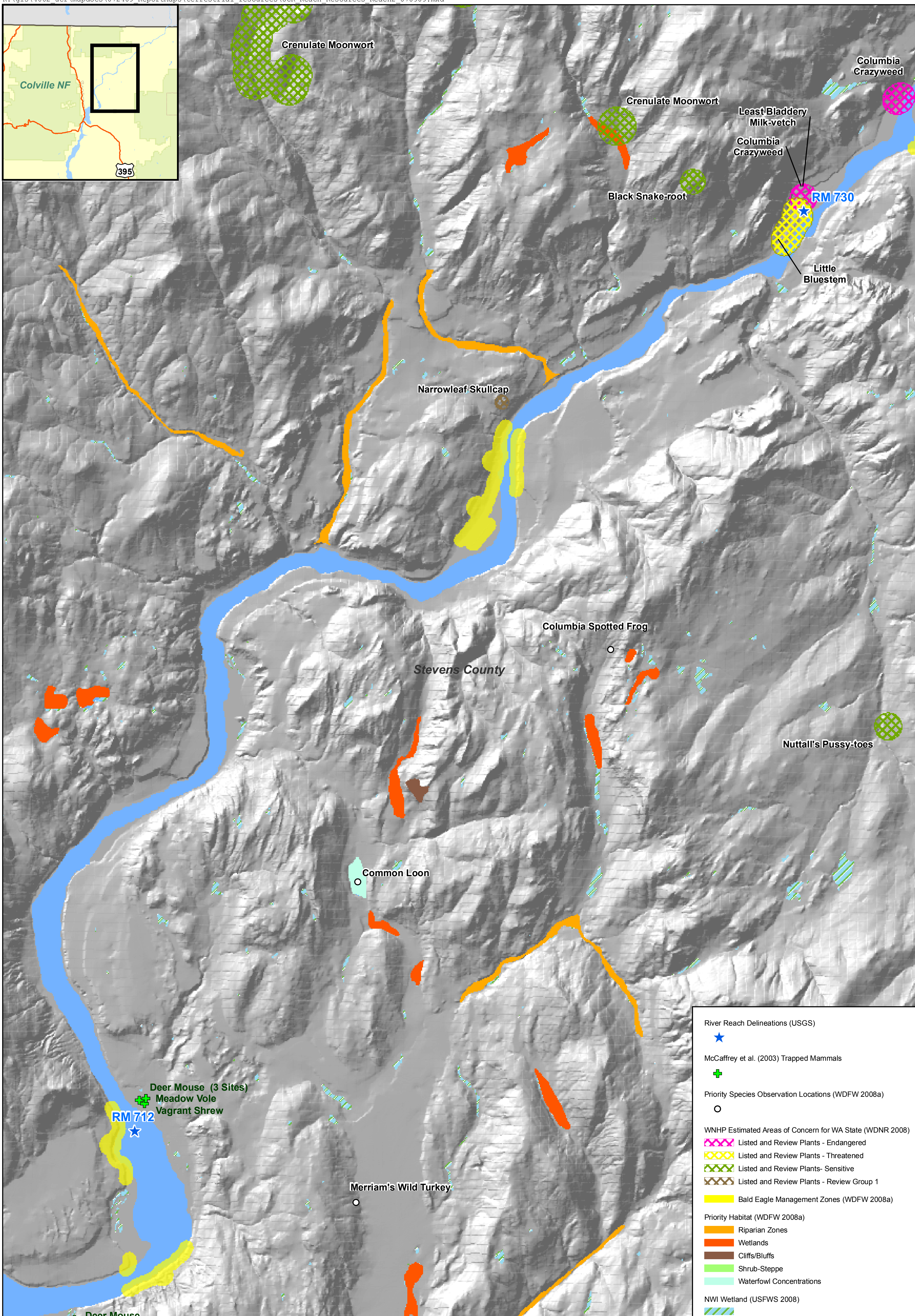

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Map 4 **Endangered and Rare Terrestrial Vegetation and Wildlife Associated with UCR Reach 2 - River Mile 712 to 730**

Upper Columbia River, WA

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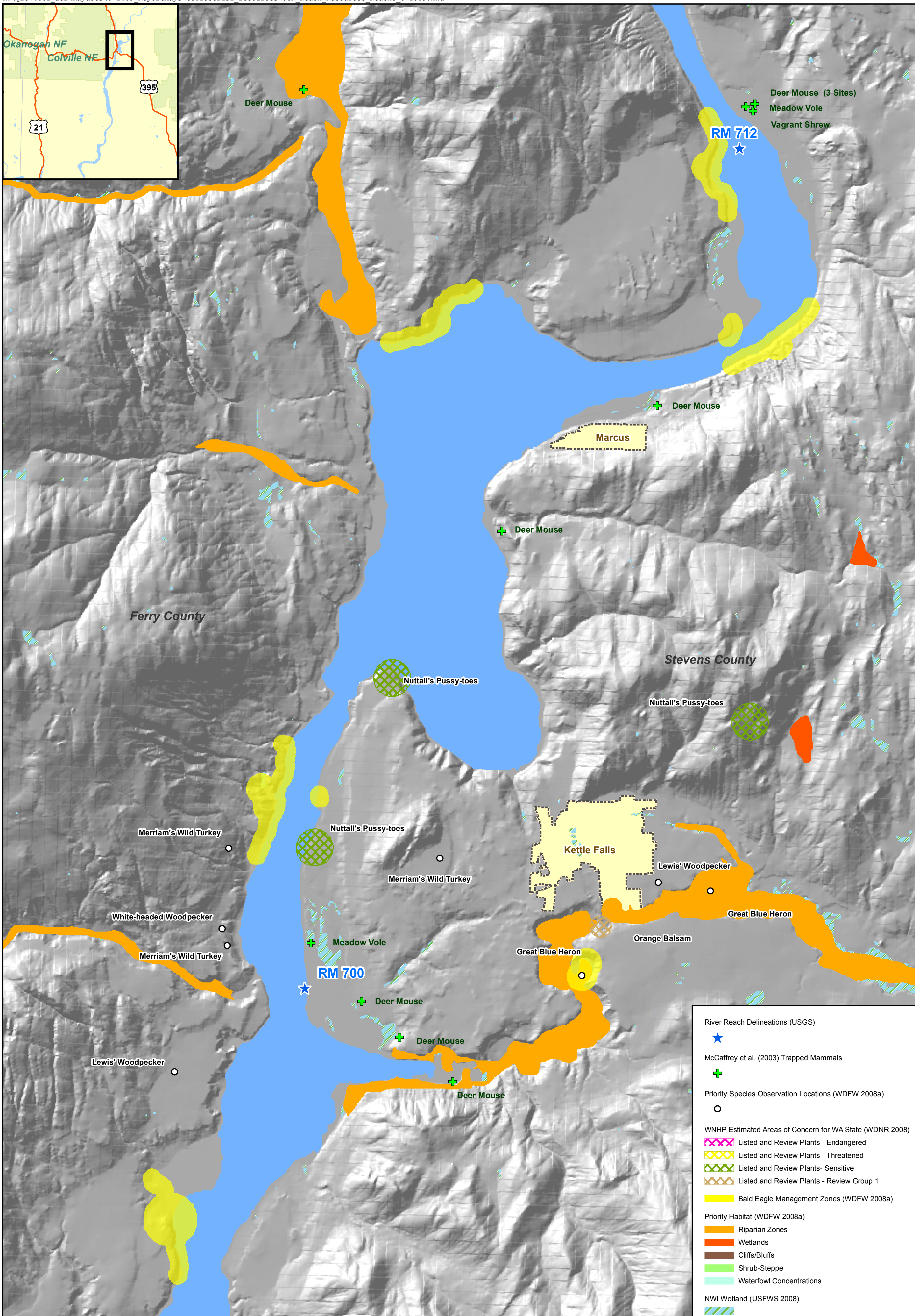

Integral Parametrix

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Map 5. **Endangered and Rare Terrestrial Vegetation and Wildlife Associated with UCR Reach 3 - River Mile 700 to 712**

Upper Columbia River, WA

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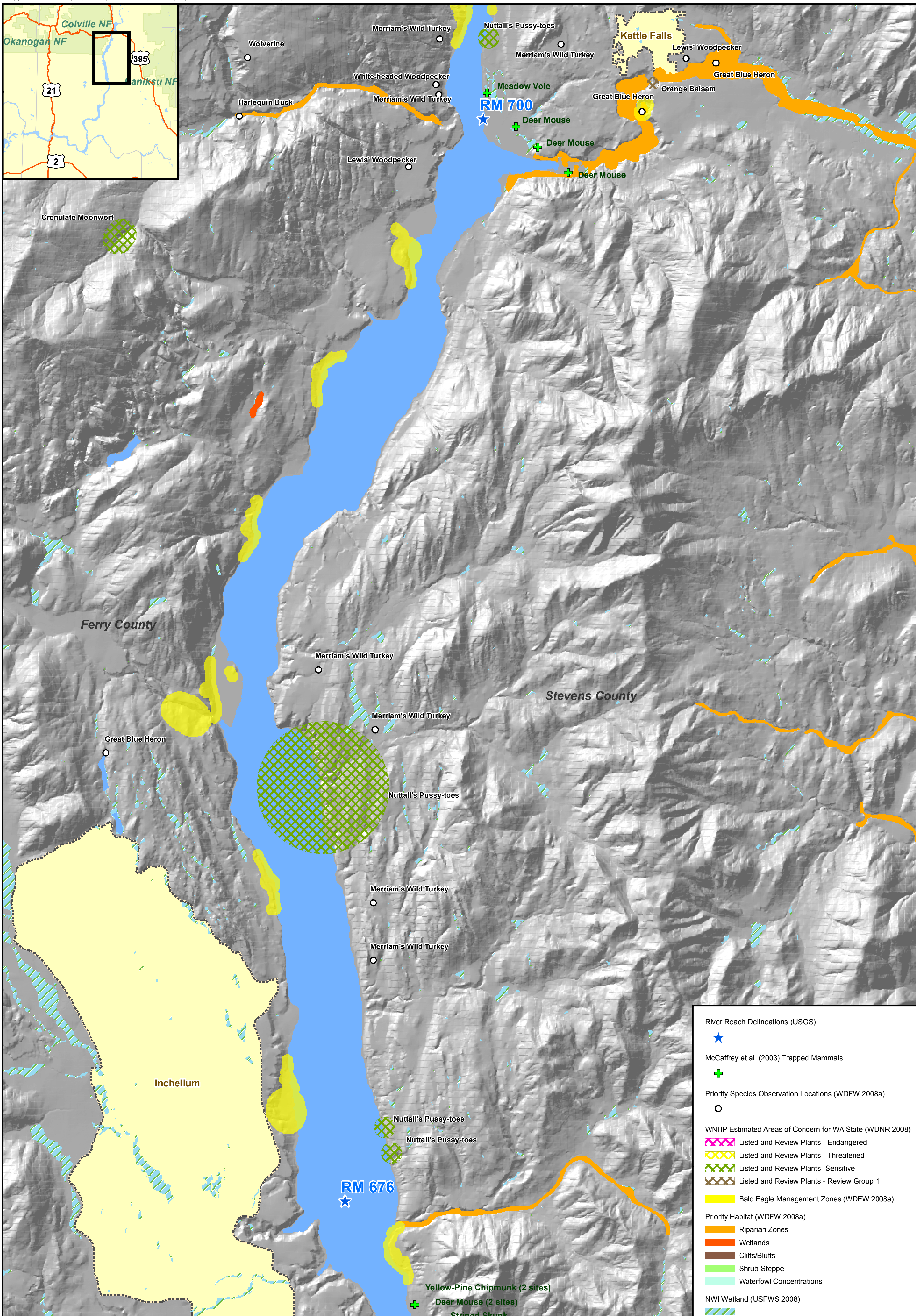

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Map 6. Endangered and Rare Terrestrial Vegetation and Wildlife Associated with UCR Reach 4a - River Mile 676 to 700

Upper Columbia River, WA

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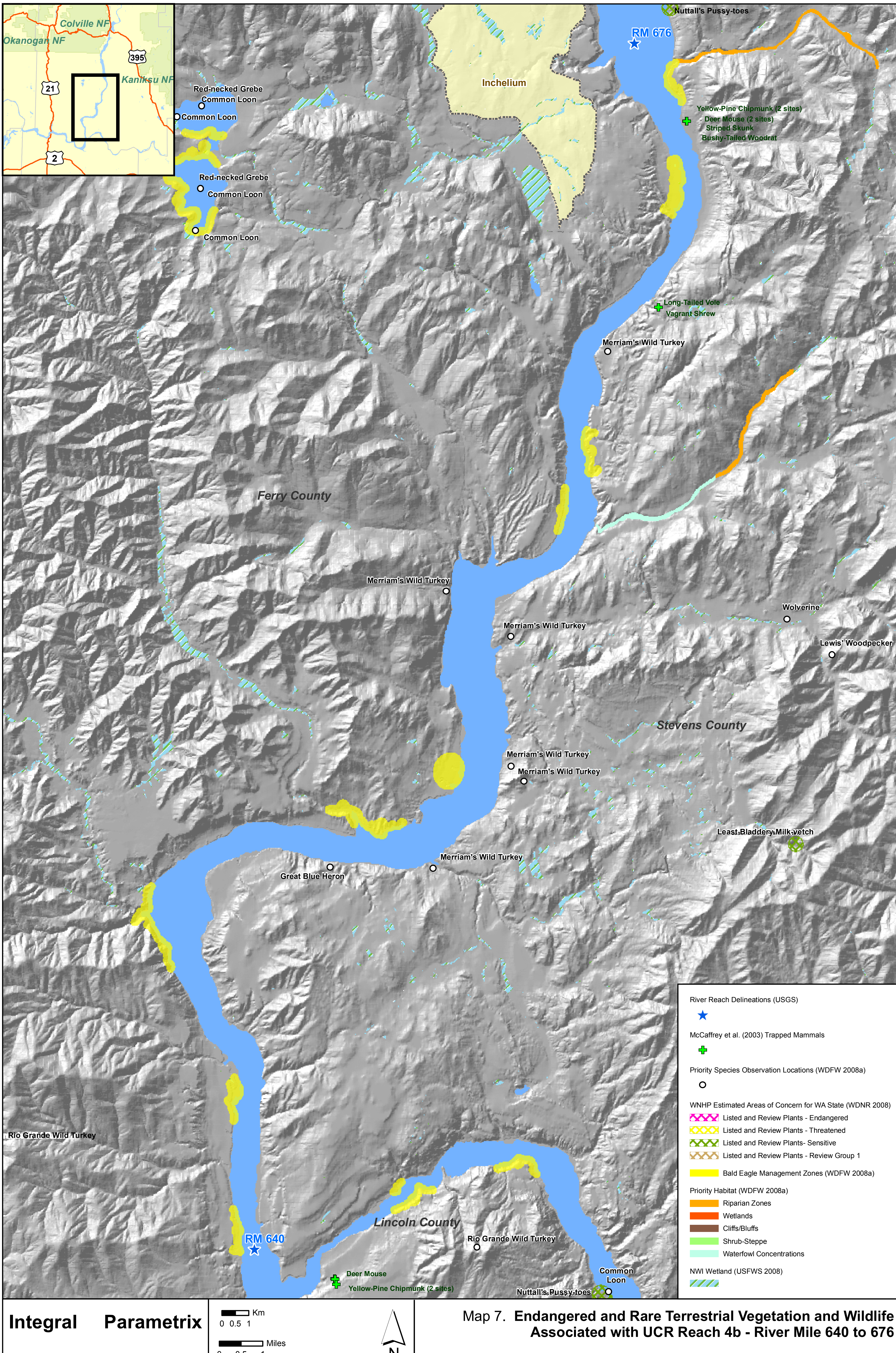

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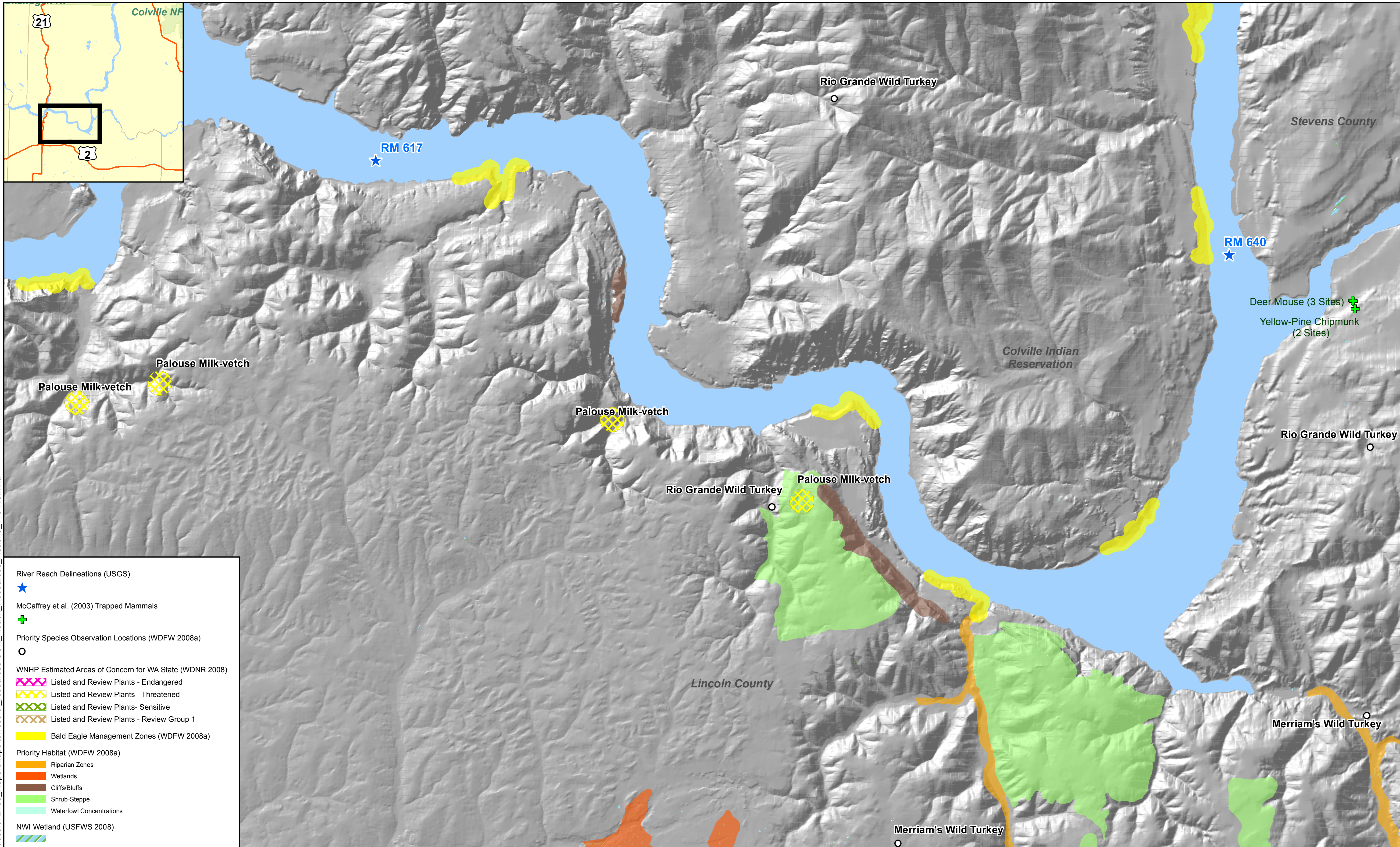
Map 7. **Endangered and Rare Terrestrial Vegetation and Wildlife Associated with UCR Reach 4b - River Mile 640 to 676**

Upper Columbia River, WA



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Integral **Parametrix**

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Miles
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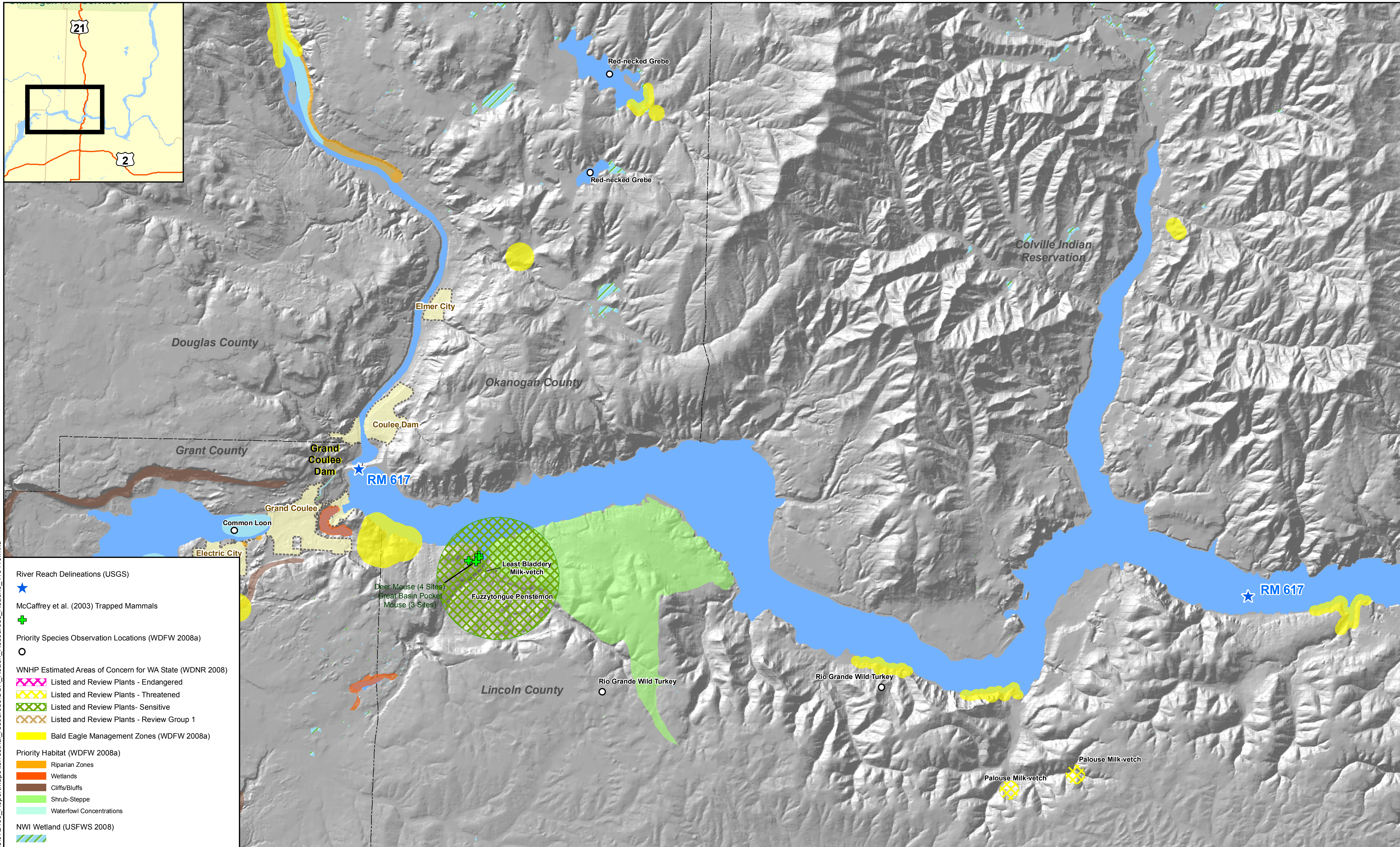
Map 8. **Endangered and Rare Terrestrial Vegetation and Wildlife Associated with UCR Reach 5 - River Mile 617 to 640**

Upper Columbia River, WA



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Integral Parametrix

Map 9. **Endangered and Rare Terrestrial Vegetation and Wildlife Associated with UCR Reach 6 - River Mile 597 to 617**

Upper Columbia River, WA

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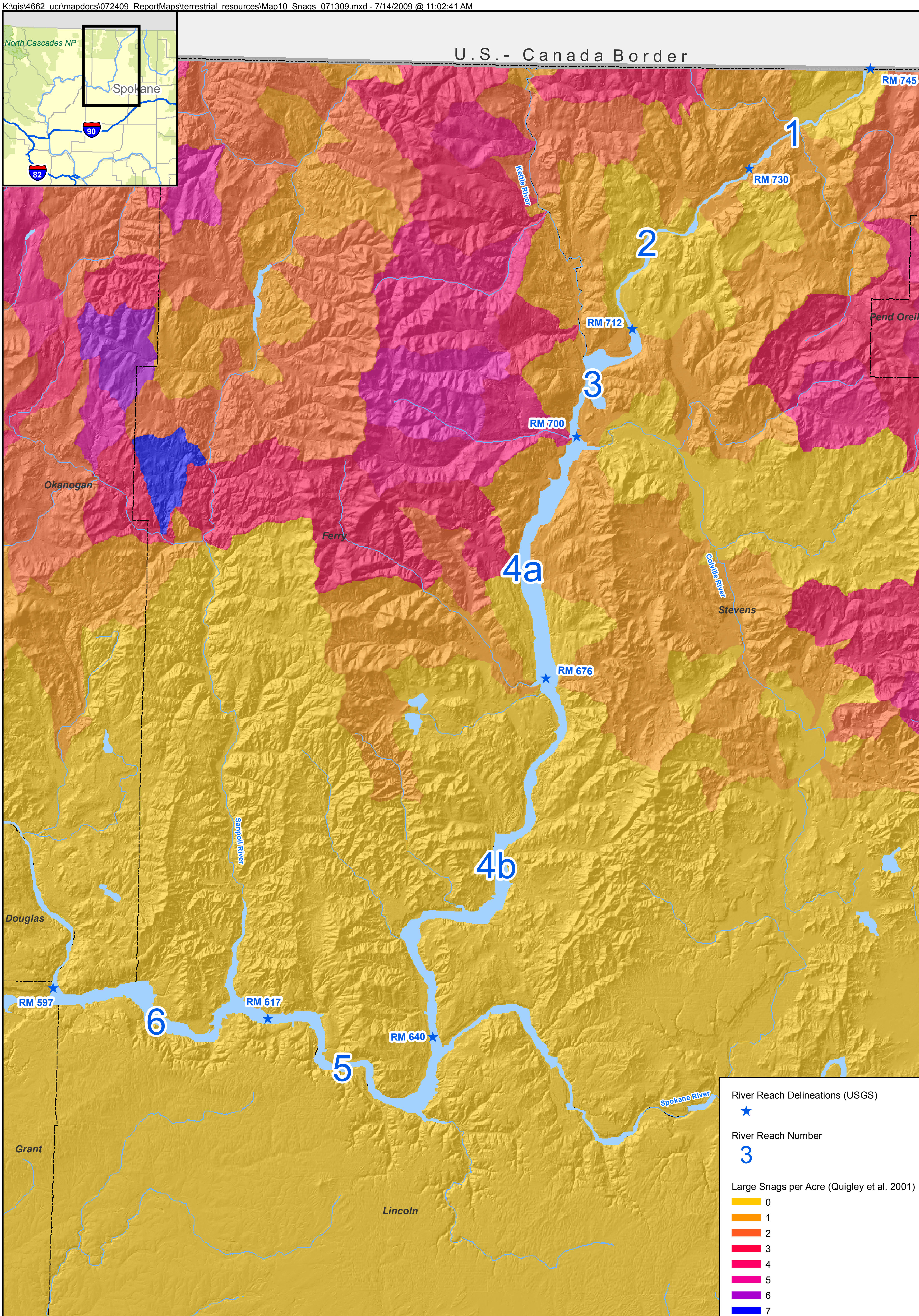

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0 5 10 Miles

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Map 10. **Number of Large Snags (Standing Dead Trees) per Acre in Surrounding Watersheds**

Upper Columbia River, WA

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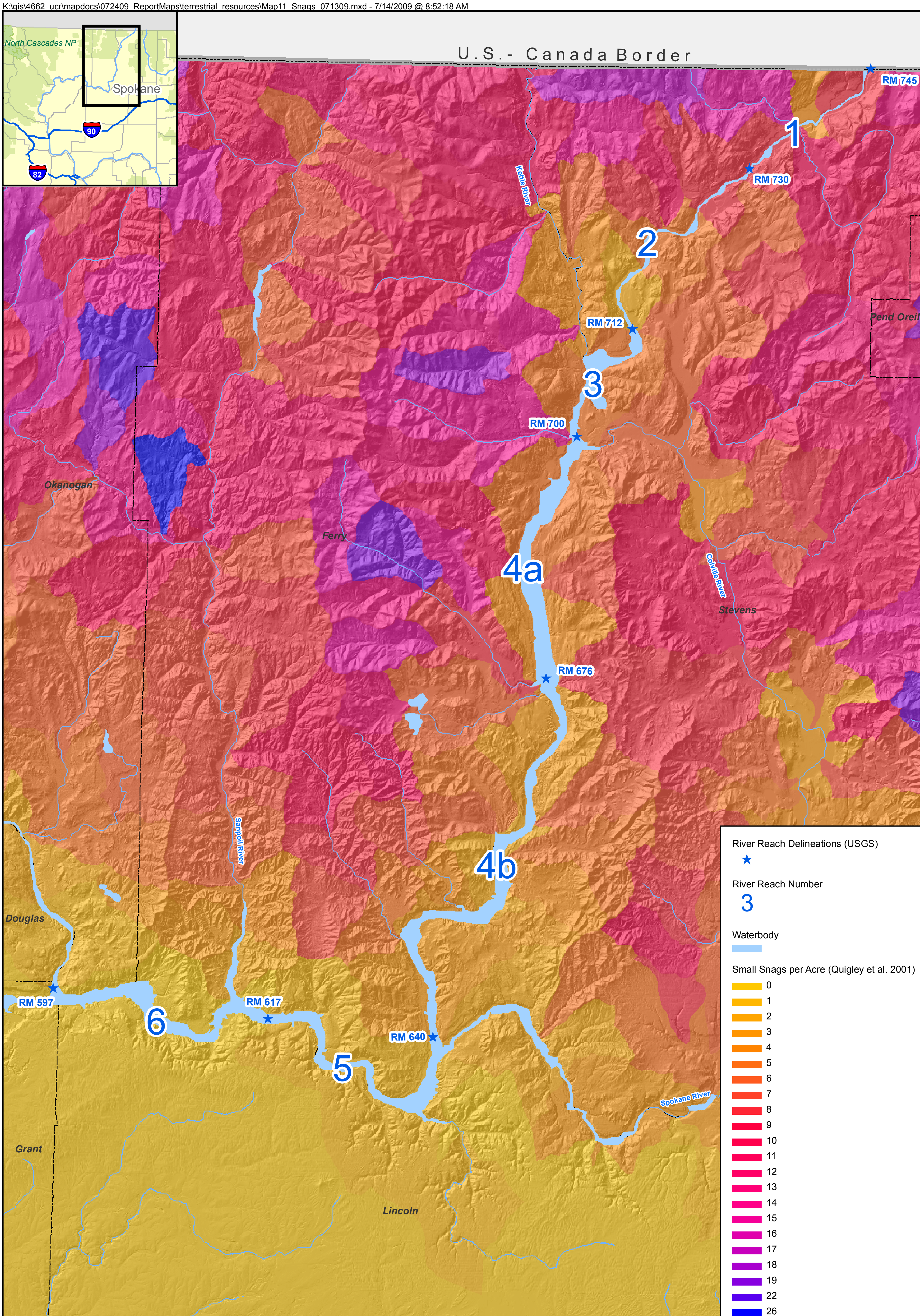

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Map 11. **Number of Small Snags (Standing Dead Trees) per Acre in Surrounding Watersheds**

Upper Columbia River, WA

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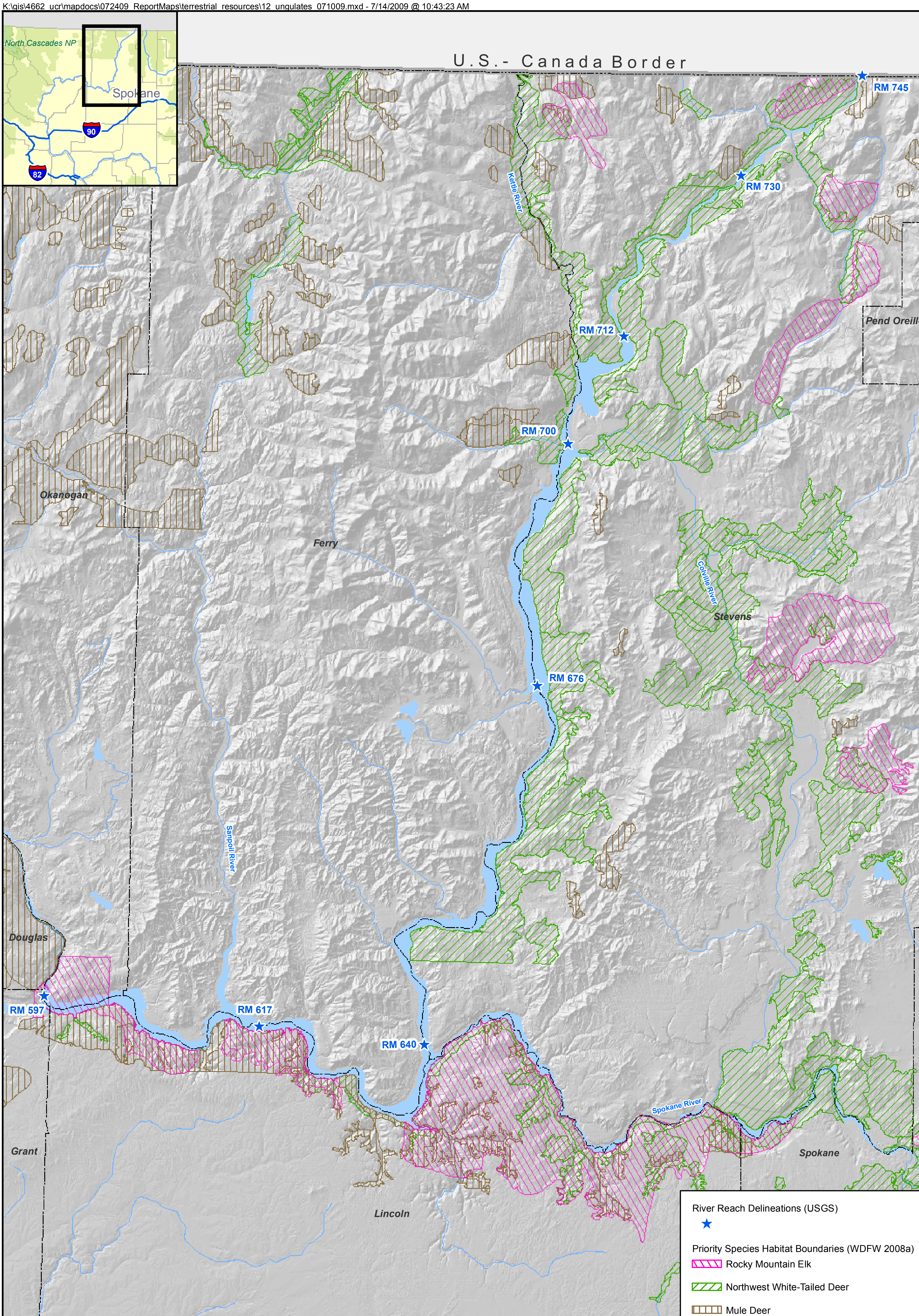

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Map 12. **Distribution of Elk, White-Tailed Deer and Mule Deer Wintering and Fawning Habitats**

Upper Columbia River, WA

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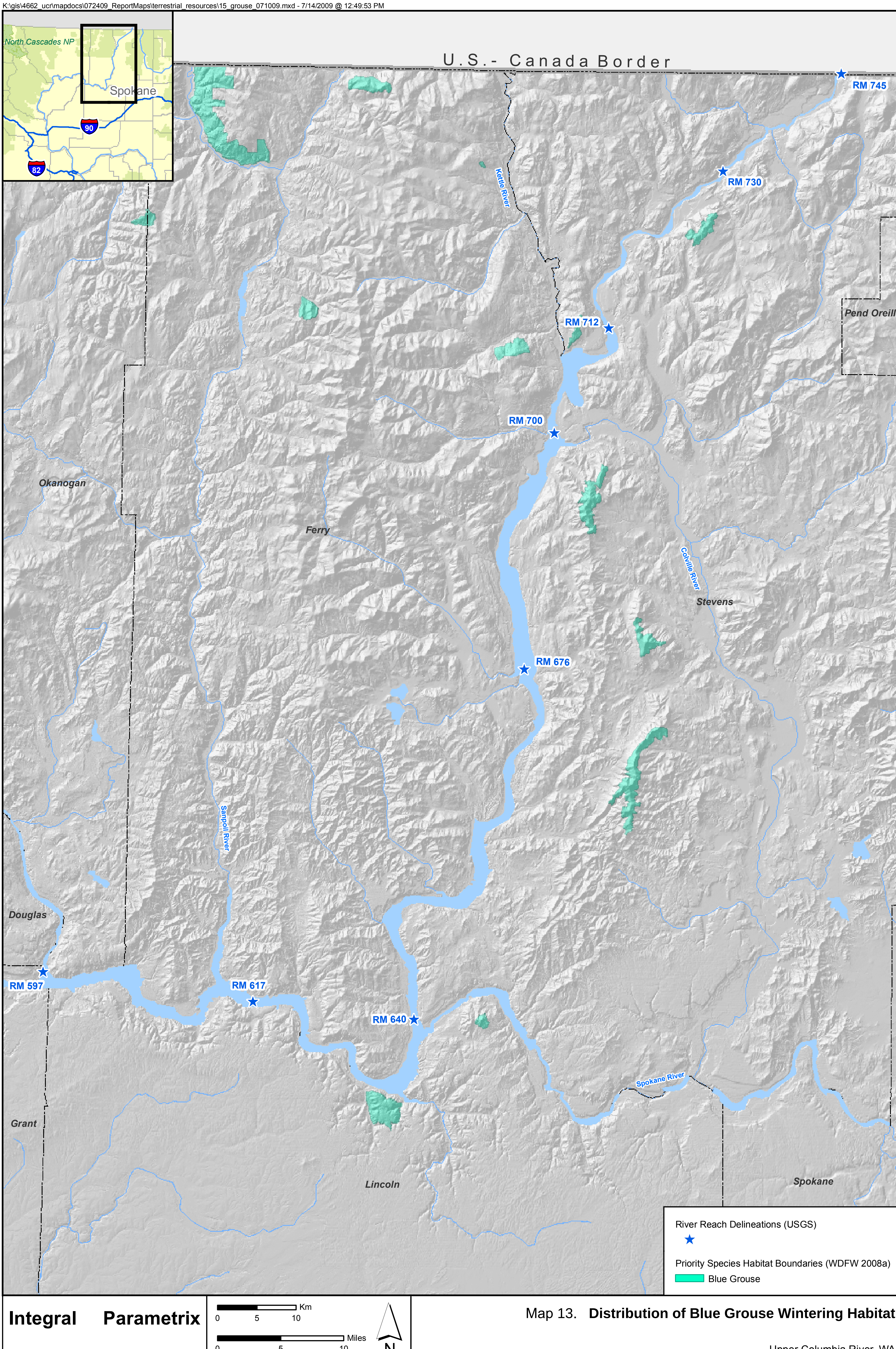

Integral Parametrix

Map 13. **Distribution of Blue Grouse Wintering Habitat**

Upper Columbia River, WA

TABLES

Table 1. Extant Rare Vascular Plant Species (WDNR 2006) near the UCR

Scientific Name	Common Name	Federal Status	State Status	State Rank	Global Rank	Last Observation	Occurrence Rank
Riparian Rare Vascular Plants							
Antennaria parvifolia	Nuttall's pussy-toes		S	S2	G5	1981	
Antennaria parvifolia	Nuttall's pussy-toes		S	S2	G5	1981	
Antennaria parvifolia	Nuttall's pussy-toes		S	S2	G5	1980	
Antennaria parvifolia	Nuttall's pussy-toes		S	S2	G5	1980	
Antennaria parvifolia	Nuttall's pussy-toes		S	S2	G5	1996	
Antennaria parvifolia	Nuttall's pussy-toes		S	S2	G5	2001	
Astragalus arrectus	Palouse milkvetch		T	S2	G2G4	1995	
Astragalus arrectus	Palouse milkvetch		T	S2	G2G4	1982	
Astragalus microcystis	Least bladdery milkvetch		S	S2	G5	1982	
Astragalus microcystis	Least bladdery milkvetch		S	S2	G5	1996	
Impatiens aurella	Orange balsam		R1	S3?	G4?	1981	
Oxytropis campestris var. *columbiana*	Columbia crazyweed		E	S1	G5T3	1996	
Oxytropis campestris var. *columbiana*	Columbia crazyweed		E	S1	G5T3	1987	
Oxytropis campestris var. *columbiana*	Columbia crazyweed		E	S1	G5T3	2002	
Penstemon eriantherus var. *whitedii*	Fuzzytongue penstemon		S	S2	G4T2	1982	
Sanicula marilandica	Black snake-root		S	S2	G5	2003	C
Schizachyrium scoparium var. *scoparium*	Little bluestem		T	S1S2	G5T5	2000	
Scutellaria angustifolia ssp. *micrantha*	Narrowleaf skullcap		R1	S2S3	G5T3T5	2003	E
Riparian/Upland Rare Vascular Plants							
Botrychium crenulatum	Crenulate moonwort	SC	S	S3	G3	1996	F?
Cryptogramma stelleri	Steller's rockbrake		S	S1S2	G5	2006	A
Dryas drummondii	Yellow mountain-avens		S	S2	G5	2006	A
Salix candida	Hoary willow		T	S1	G5	2006	A
Sanicula marilandica	Black snake-root		S	S2	G5	2002	
Sanicula marilandica	Black snake-root		S	S2	G5	2002	
Sanicula marilandica	Black snake-root		S	S2	G5	1998	
Sanicula marilandica	Black snake-root		S	S2	G5	1998	
Viola renifolia	Kidney-leaved violet		S	S2	G5	2002	

Table 1. Extant Rare Vascular Plant Species (WDNR 2008) near the UCR (continued)

Scientific Name	Common Name	Federal Status	State Status	State Rank	Global Rank	Last Observation	Occurrence Rank
High-Quality Terrestrial, Aquatic, or Wetland Ecosystems							
Pinus ponderosa cover type	Ponderosa pine forest			SU	GNR	1979	
Pseudotsuga menziesii / Physocarpus malvaceus	Douglas-fir/mallow-leaf ninebark			S4	G5	1979	
Pseudotsuga menziesii / Physocarpus malvaceus	Douglas-fir/mallow-leaf ninebark			S4	G5	1986	
Pseudotsuga menziesii / Physocarpus malvaceus	Douglas-fir/mallow-leaf ninebark			S4	G5	1996	AB
Pseudotsuga menziesii / Physocarpus malvaceus - Linnaea borealis	Douglas-fir/mallow-leaf ninebark – twinflower			S4	G4	1996	B

Federal Status
SC = Species of Concern. An unofficial status, the species appears to be in jeopardy, but insufficient information to support listing
State Status
E = Endangered
T = Threatened
S = Sensitive
R1 = Review Group 1 -- species of potential concern, but status not yet defined (additional fieldwork required)
Blank = No state status assigned
State Rank: Two codes represent an intermediate rank
S1 = Critically imperiled in the state
S2 = Imperiled in the state
S3 = Rare or uncommon in the state
S4 = Widespread, abundant, and apparently secure in the state
SU = Possible in peril in the state, but status uncertain
SNR = Sufficient time and effort not yet devoted to ranking of species
? = The specified rank is uncertain, more information may be needed to assign a rank with certainty.
Global Rank: Two codes represent an intermediate rank
G2 = Imperiled globally
G4 = Widespread, abundant, and apparently secure globally
G5 = Demonstrably widespread, abundant, and secure globally, though it may be quite rare in parts of its range, especially at the periphery.
GNR = Sufficient time and effort not yet devoted to ranking of species
T2 = Subspecies/variety is imperiled globally
T3 = Subspecies/variety is either very rare and local throughout its range or found locally in a restricted range or other factors making it vulnerable to extinction throughout its range
T5 = Subspecies/variety is demonstrably widespread, abundant, and secure globally, though it may be quite rare in parts of its range, especially at the periphery
? = The specified rank is uncertain, more information may be needed to assign a rank with certainty.
Occurrence Rank
A = Excellent quality and viability
B = Good quality and viability
C = Fair quality and viability
E = Verified extant
F = Failed to find

Table 2. Summary of the location of specific terrestrial resources by River Reach

		River Reach (Northeast to Southwest)					
Common name	Species name	1	2	3	4	5	6
Priority Habitat							
Shrub-steppe						X	X
Riparian zones		X	X	X	X	X	
Wetlands			X	X	X		X
Cliffs						X	
State Endangered							
Columbia crazyweed	*Ocytropis campestris* var. *columbiana*	X					
State Threatened							
Little bluestem	*Schizachyrium scoparium* var. *scoparium*	X					
Hoary willow	*Salix candida*	X					
Palouse milkvetch	*Astragalus arrectus*					X	
State Sensitive							
Nuttall's pussy-toes	*Antennaria parvifolia*			X	X [1]		
Least bladdery milkvetch	*Astragalus microcystis*	X					
Fuzzytongue penstemon	*Penstemon eriantherus* var. *whitedii*						X
Black snake-root	*Sanicula marilandica*	X	X				
Crenulate moonwort	*Botrychium crenulatum*	X					
Steller's rockbrake	*Cryptogramma stelleri*	X					
Yellow mountain-avens	*Dryas drummondii*	X					
Kidney-leaved violet	*Viola renifolia*	X					
State Potential Concern							
Narrowleaf skullcap	*Scutellaria angustifolia* ssp.*micrantha*		X				
Orange balsam	*Impatiens aurella*			X			

[1] Found on Reach 4a and not Reach 4b

Table 3. Terrestrial Wildlife Species Present in the UCR Area

Scientific Name	Common Name	Source of Occurrence Information						WDFW USE	Federal Status	State Status	Proposed State Status Listing
INVERTEBRATES											
Agonum belleri	Beller's ground beetle								FCo	SC	
Boloria selene atrocostalis	Silver-bordered fritillary									SC	
Cicindela columbica	Columbia River tiger beetle									SC	
Copablepharon fuscum	Sand-verbena moth									SC	
Donacia idola	Bog idol leaf beetle									SC	
Driloleirus americanus	Giant Palouse earthworm									SC	
Eanus hatchi	Hatch's click beetle								FCo	SC	
Euchloe ausonides	Island Marble								FCo	SC	
Euphydryas editha taylori	Taylor's checkerspot								FCo	SE	
Formica obscuripes	Thatch ant			IC							
Gomphus kurilis	Pacific clubtail									SC	
Gomphus lynnae	Columbia clubtail (dragonfly)								FCo	SC	
Habrodais grunus herri	Chinquapin hairstreak									SC	
Latrodectus hesperus	Western black widow spider			IC							
Leschius mcallisteri	Leschi's Millipede									SC	
Lycaena mariposa charlottensis	Makah copper								FCo	SC	
Mitoura grynea barryi	Juniper hairstreak									SC	
Mitoura johnsoni	Johnson's hairstreak									SC	
Ochlodes yuma	Yuma skipper									SC	
Oeneis nevadensis gigas	Great arctic								FCo		
Parnassius clodius shepardi	Shepard's Parnassian									SC	
Plebejus icarioides blackmorei	Puget blue									SC	
Polites mardon	Mardon skipper								FCo	SE	
Scaphinotus mannii	Mann's Mollusk-eating Ground Beetle									SC	
Speyeria zerene bremnerii	Valley silverspot								FCo	SC	
Speyeria zerene hippolyta	Oregon silverspot butterfly								FT	SE	
Vespula pensylvanica	Western yellow jacket			IC							
AMPHIBIANS											
Ambystoma macrodactylum	Long-toed salamander		BPA	IC							
Ambystoma tigrinum	Tiger salamander	NPS	BPA	IC				IO		SM	
Bufo boreas	Western toad	NPS	BPA	IC		WDFW			FCo	SC	
Bufo woodhousii	Woodhouse's toad		BPA					IO		SM	
Hyla regilla	Pacific treefrog	NPS	BPA	IC							
Rana catesbeiana	Bullfrog		BPA	IC							
Rana clamitans	Green frog		BPA								
Rana luteiventris	Columbia spotted frog		BPA	IC				IO	FCo	SC	PS
Rana pipiens	Northern leopard frog		BPA					IO	FCo	SE	
Spea intermontana	Great basin spadefoot	NPS	BPA	IC							
REPTILES											
Charina bottae	Rubber boa		BPA	IC							
Chrysemys picta	Painted turtle	NPS	BPA	IC							
Coluber constrictor	Racer			IC							
Crotalus viridis	Western rattlesnake	NPS	BPA	IC							
Elgaria coerulea	Northern alligator lizard		BPA	IC							
Eumeces skiltonianus	Western skink		BPA								
Hypsiglena torquata	Night snake		BPA			WDFW		IO		SM	
Phrynosoma douglassi	Short-horned lizard	NPS	BPA	IC							
Pituophis catenifer	Gopher snake	NPS	BPA	IC							

Table 3. Terrestrial Wildlife Species Present in the UCR Area (continued)

REPTILES (cont'd)											
Sceloporus graciosus	Sagebrush lizard	NPS	BPA			WDFW		IO	FCo	SC	
Sceloporus occidentalis	Western fence lizard		BPA								
Thamnophis elegans	Western terrestrial garter snake	NPS	BPA	IC							
Thamnophis ordinoides	Northwestern garter snake		BPA								
Thamnophis sirtalis	Common garter snake		BPA	IC							
Uta stansburiana	Side-blotched lizard		BPA	IC							
BIRDS											
Accipiter cooperii	Cooper's hawk		BPA	IC							
Accipiter gentilis	Northern goshawk		BPA	IC		WDFW		B	FCo	SC	PS
Accipiter striatus	Sharp-shinned hawk		BPA	IC							
Actitis macularia	Spotted sandpiper	NPS?	BPA	IC							
Aechmophorus occidentalis	Western grebe	NPS	BPA	IC				B		SC	
Aegolius acadicus	Northern saw-whet owl	NPS	BPA	IC							
Aegolius funereus	Boreal owl		BPA	IC				B		SM	
Aeronautes saxatalis	White-throated swift		BPA	IC							
Agelaius phoeniceus	Red-winged blackbird	NPS?	BPA	IC							
Aix sponsa	Wood duck		BPA	IC							
Alectoris chukar	Chukar	NPS	BPA	xIC	SAS						
Ammodramus savannarum	Grasshopper sparrow	NPS?	BPA	IC				B		SM	
Amphispiza belli	Sage sparrow	NPS?		IC				B		SC	PS
Anas acuta	Northern pintail	NPS	BPA	IC							
Anas americana	American wigeon		BPA	IC							
Anas clypeata	Northern shoveler		BPA	IC							
Anas crecca	Green-winged teal	NPS?	BPA	IC							
Anas cyanoptera	Cinnamon teal	NPS?	BPA	IC							
Anas discors	Blue-winged teal	NPS?	BPA	IC							
Anas platyrhynchos	Mallard	NPS	BPA	IC							
Anas strepera	Gadwall		BPA	IC							
Anser albifrons	Greater white-fronted goose		BPA								
Anthus rubescens	American pipit		BPA	IC							
Aquila chrysaetos	Golden eagle	NPS	BPA	IC		WDFW		B		SC	PS
Archilochus alexandri	Black-chinned hummingbird	NPS?	BPA	IC							
Ardea herodias	Great blue heron	NPS	BPA	IC		WDFW		B		SM	
Asio flammeus	Short-eared owl	NPS	BPA	IC							
Asio otus	Long-eared owl		BPA	IC							
Athene cunicularia	Burrowing owl		BPA	IC				B	FCo	SC	PS
Aythya affinis	Lesser scaup	NPS	BPA	IC							
Aythya americana	Redhead	NPS	BPA	IC							
Aythya collaris	Ring-necked duck		BPA	IC							
Aythya marila	Greater scaup		BPA	xIC	SAS						
Aythya valisineria	Canvasback		BPA	IC							
Bartramia longicauda	Upland sandpiper	NPS?		IC				B,RI		SE	
Bombycilla cedrorum	Cedar waxwing		BPA	IC							
Bombycilla garrulus	Bohemian waxwing		BPA	IC							
Bonasa umbellus	Ruffed grouse	NPS	BPA	IC							
Botaurus lentiginosus	American bittern		BPA	IC							
Branta canadensis	Canada goose	NPS	BPA	IC							
Bubo virginianus	Great horned owl	NPS	BPA	IC							
Bucephala albeola	Bufflehead	NPS	BPA	IC							
Bucephala clangula	Common goldeneye	NPS?	BPA	IC							

Table 3. Terrestrial Wildlife Species Present in the UCR Area (continued)

BIRDS (cont'd)											
Bucephala islandica	Barrow's goldeneye	NPS?	BPA	IC							
Buteo jamaicensis	Red-tailed hawk	NPS	BPA	IC							
Buteo lagopus	Rough-legged hawk	NPS	BPA	IC							
Buteo regalis	Ferruginous hawk		BPA	IC				B	FCo	ST	
Buteo swainsoni	Swainson's hawk		BPA	IC				B		SM	
Calcarius lapponicus	Lapland longspur			IC							
Calidris alba	Sanderling		BPA								
Calidris alpina	Dunlin		BPA	IC							
Calidris bairdii	Baird's sandpiper	NPS?	BPA	IC							
Calidris himantopus	Stilt sandpiper	NPS?	BPA	xIC	SAS						
Calidris mauri	Western sandpiper	NPS?	BPA	IC							
Calidris melanotos	Pectoral sandpiper	NPS?	BPA	IC							
Calidris minutilla	Least sandpiper	NPS?	BPA	IC							
Calidris pusilla	Semipalmated sandpiper	NPS?	BPA	IC							
Callipepla californica	California quail	NPS	BPA	xIC	SAS						
Carduelis flammea	Common redpoll		BPA	IC							
Carduelis pinus	Pine siskin		BPA	IC							
Carduelis tristis	American goldfinch	NPS?	BPA	IC							
Carpodacus cassinii	Cassin's finch	NPS?	BPA	IC							
Carpodacus mexicanus	House finch	NPS?	BPA	IC							
Carpodacus purpureus	Purple finch	NPS?	BPA	xIC	xSAS						
Cathartes aura	Turkey vulture		BPA	IC				B,CR		SM	
Catharus fuscescens	Veery		BPA	IC							
Catharus guttatus	Hermit thrush		BPA	IC							
Catharus ustulatus	Swainson's thrush		BPA	IC							
Catherpes mexicanus	Canyon wren		BPA	xIC*	SAS						
Centrocercus urophasianus	Sage-grouse	NPS	BPA	xIC*	xSAS			B,RSC	FC	ST	PS
Certhia americana	Brown creeper		BPA	IC							
Ceryle alcyon	Belted kingfisher	NPS	BPA	IC							
Chaetura vauxi	Vaux's swift		BPA	IC				B,CR		SC	PS
Charadrius semipalmatus	Semipalmated plover		BPA	IC							
Charadrius vociferus	Killdeer	NPS	BPA	IC							
Chen caerulescens	Snow goose		BPA	IC							
Chen rossii	Ross' goose		BPA								
Chlidonias niger	Black tern		BPA	IC				B	FCo	SM	
Chondestes grammacus	Lark sparrow	NPS?	BPA	IC							
Chordeiles minor	Common nighthawk		BPA	IC							
Cinclus mexicanus	American dipper		BPA	IC							
Circus cyaneus	Northern harrier	NPS	BPA	IC							
Cistothorus palustris	Marsh wren		BPA	IC							
Coccothraustes vespertinus	Evening grosbeak		BPA	IC							
Colaptes auratus	Northern flicker		BPA	IC							
Columba fasciata	Band-tailed pigeon	NPS?	BPA								
Columba livia	Rock dove		BPA	IC							
Contopus borealis	Olive-sided flycatcher		BPA	IC					FCo		
Contopus sordidulus	Western wood-pewee		BPA	IC							
Corvus brachyrhynchos	American crow	NPS	BPA	IC							
Corvus corax	Common raven	NPS	BPA	IC							
Cyanocitta cristata	Blue jay	NPS?	BPA	xIC	xSAS						
Cyanocitta stelleri	Steller's jay	NPS?	BPA	IC							

Table 3. Terrestrial Wildlife Species Present in the UCR Area (continued)

BIRDS (cont'd)										
Cygnus columbianus	Tundra swan			IC						
Dendragapus canadensis	Spruce grouse		BPA	IC						
Dendragapus obscurus	Blue grouse	NPS	BPA	IC		WDFW				
Dendroica coronata	Yellow-rumped warbler		BPA	IC						
Dendroica petechia	Yellow warbler		BPA	IC						
Dendroica townsendi	Townsend's warbler		BPA	IC						
Dolichonyx oryzivorus	Bobolink		BPA	IC					SM	
Dryocopus pileatus	Pileated woodpecker	NPS?	BPA	IC			B		SC	PS
Dumetella carolinensis	Gray catbird		BPA	xIC	SAS					
Empidonax hammondii	Hammond's flycatcher		BPA	IC						
Empidonax minimus	Least flycatcher		BPA	IC						
Empidonax oberholseri	Dusky flycatcher		BPA	IC						
Empidonax occidenetalis	Cordilleran flycatcher			IC						
Empidonax traillii	Willow flycatcher		BPA	IC				FCo		
Eremophila alpestris	Horned lark		BPA	IC						
Euphagus carolinus	Rusty blackbird	NPS?	BPA	xIC	xSAS					
Euphagus cyanocephalus	Brewer's blackbird	NPS?	BPA	IC						
Falco columbarius	Merlin		BPA	IC			B		SC	
Falco mexicanus	Prairie falcon	NPS	BPA	IC			B		SM	
Falco peregrinus	Peregrine falcon	NPS	BPA	IC		WDFW	B,RI	FCo	SS	
Falco rusticolus	Gyrfalcon			IC			RI		SM	
Falco sparverius	American kestrel	NPS	BPA	IC						
Fulica americana	American coot	NPS	BPA	IC						
Gallinago gallinago	Common snipe	NPS	BPA	IC						
Gavia immer	Common loon	NPS	BPA	xIC	SAS	WDFW	B		SS	PT
Geothlypis trichas	Common yellowthroat		BPA	IC						
Glaucidium gnoma	Northern pygmy-owl		BPA	IC						
Haliaeetus leucocephalus	Bald eagle	NPS	BPA	IC		WDFW	B,RSC,CR	FCo	SS	
Hirundo pyrrhonota	Cliff swallow	NPS?	BPA	IC						
Hirundo rustica	Barn swallow	NPS?	BPA	IC						
Histrionicus histrionicus	Harlequin duck		BPA	IC						
Icteria virens	Yellow-breasted chat		BPA	IC						
Icterus galbula	Northern oriole		BPA	IC						
Ixoreus naevius	Varied thrush		BPA	IC						
Junco hyemalis	Dark-eyed junco	NPS	BPA	IC						
Lanius excubitor	Northern shrike		BPA	IC						
Lanius ludovicianus	Loggerhead shrike		BPA	IC			B	FCo	SC	PS
Larus argentatus	Herring gull	NPS?	BPA	IC						
Larus californicus	California gull	NPS?	BPA	IC						
Larus delawarensis	Ring-billed gull	NPS?	BPA	IC						
Larus glaucescens	Glaucous-winged gull	NPS?	BPA	IC						
Larus philadelphia	Bonaparte's gull	NPS?	BPA	IC						
Leucosticte tephrocotis	Gray-crowned rosy-finch		BPA	IC						
Limnodromus griseus	Short-billed dowitcher			IC						
Limnodromus scolopaceus	Long-billed dowitcher		BPA	IC						
Limosa fedoa	Marbled godwit			IC						
Lophodytes cucullatus	Hooded merganser		BPA	IC						
Loxia curvirostra	Red crossbill		BPA	IC						
Loxia leucoptera	White-winged crossbill		BPA	IC						
Melanerpes lewis	Lewis' woodpecker		BPA	IC		WDFW	B		SC	PS

Table 3. Terrestrial Wildlife Species Present in the UCR Area (continued)

BIRDS (cont'd)											
Melanitta fusca	White-winged scoter		BPA	xIC	SAS						
Meleagris gallopavo	Wild turkey		BPA	IC							
Meleagris gallopavo intermedia	Rio Grande wild turkey					WDFW					
Meleagris gallopavo merriami	Merriam's wild turkey					WDFW					
Melospiza lincolnii	Lincoln's sparrow	NPS?	BPA	IC							
Melospiza melodia	Song sparrow	NPS?	BPA	IC							
Mergus merganser	Common merganser	NPS	BPA	IC							
Mergus serrator	Red-breasted merganser		BPA	xIC	SAS						
Molothrus ater	Brown-headed cowbird		BPA	IC							
Myadestes townsendi	Townsend's solitaire		BPA	IC							
Myiarchus cinerascens	Ash-throated flycatcher		BPA	xIC	xSAS			B		SM	
Nucifraga columbiana	Clark's nutcracker		BPA	IC							
Numenius americanus	Long-billed curlew	NPS?	BPA	IC				B,RSC		SM	
Nyctea scandiaca	Snowy owl		BPA	IC				RI		SM	
Nycticorax nycticorax	Black-crowned night-heron		BPA	IC				B		SM	
Oporornis tolmiei	Macgillivray's warbler		BPA	IC							
Oreoscoptes montanus	Sage thrasher			IC				B		SC	PS
Otus flammeolus	Flammulated owl		BPA	IC				B,RI		SC	PS
Otus kennicottii	Western screech-owl	NPS	BPA	IC							
Oxyura jamaicensis	Ruddy duck		BPA	IC							
Pandion haliaetus	Osprey	NPS	BPA	IC		WDFW		B		SM	
Passer domesticus	House sparrow	NPS?	BPA	IC							
Passerculus sandwichensis	Savannah sparrow	NPS?	BPA	IC							
Passerella iliaca	Fox sparrow	NPS?	BPA	IC							
Passerina amoena	Lazuli bunting		BPA	IC							
Passerina cyanea	Indigo bunting		BPA								
Pelecanus erythrorhynchos	American white pelican		BPA	IC				B,RSC		SE	
Perdix perdix	Gray partridge	NPSh	BPA	IC							
Perisoreus canadensis	Gray jay	NPS?	BPA	IC							
Phalacrocorax auritus	Double-crested cormorant			IC							
Phalaenoptilus nuttallii	Common poorwill		BPA	IC							
Phalaropus lobatus	Red-necked phalarope			IC							
Phalaropus tricolor	Wilson's phalarope		BPA	IC							
Phasianus colchicus	Ring-necked pheasant	NPS	BPA	IC							
Pheucticus melanocephalus	Black-headed grosbeak		BPA	IC							
Pica pica	Black-billed magpie	NPS	BPA	IC							
Picoides albolarvatus	White-headed woodpecker	NPS?	BPA	IC		WDFW		B,RI		SC	PS
Picoides arcticus	Black-backed woodpecker	NPS?	BPA	IC				B,RI		SC	
Picoides pubescens	Downy woodpecker	NPS?	BPA	IC							
Picoides tridactylus	Three-toed woodpecker	NPS?	BPA	IC				B,RI		SM	
Picoides villosus	Hairy woodpecker	NPS?	BPA	IC							
Pinicola enucleator	Pine grosbeak		BPA	IC							
Pipilo erythrophthalmus	Rufous-sided towhee		BPA	IC							
Piranga ludoviciana	Western tanager		BPA	IC							
Plectrophenax nivalis	Snow bunting		BPA	IC							
Pluvialis squatarola	Black-bellied plover		BPA	xIC	SAS						
Podiceps auritus	Horned grebe		BPA	IC				B		SM	
Podiceps grisegena	Red-necked grebe		BPA	IC				B		SM	
Podiceps nigricollis	Eared grebe		BPA	IC							
Podilymbus podiceps	Pied-billed grebe		BPA	IC							

Table 3. Terrestrial Wildlife Species Present in the UCR Area (continued)

BIRDS (cont'd)											
Poecile atricapillus	Black-capped chickadee	NPS?	BPA	IC							
Poecile gambeli	Mountain chickadee	NPS?	BPA	IC							
Poecile hudsonicus	Boreal chickadee	NPS?	BPA	IC				B		SM	
Poecile rufescens	Chestnut-backed chickadee	NPS?	BPA	IC							
Pooecetes gramineus	Vesper sparrow	NPS?	BPA	IC							
Porzana carolina	Sora		BPA	IC							
Rallus limicola	Virginia rail		BPA	IC							
Recurvirostra americana	American avocet		BPA	IC							
Regulus calendula	Ruby-crowned kinglet		BPA	IC							
Regulus satrapa	Golden-crowned kinglet		BPA	IC							
Riparia riparia	Bank swallow	NPS?	BPA	IC							
Salpinctes obscoletus	Rock wren		BPA	IC							
Sayornis saya	Say's phoebe		BPA	IC							
Seiurus noveboracensis	Northern waterthrush		BPA	IC						SM	
Selasphorus rufus	Rufous hummingbird	NPS?	BPA	IC							
Setophaga ruticilla	American redstart		BPA	IC							
Sialia currucoides	Mountain bluebird		BPA	IC							
Sialia mexicana	Western bluebird		BPA	IC				B		SM	
Sitta canadensis	Red-breasted nuthatch		BPA	IC							
Sitta carolinensis	White-breasted nuthatch		BPA	IC							
Sitta pygmaea	Pygmy nuthatch		BPA	IC							
Sphyrapicus nuchalis	Red-naped sapsucker			IC							
Sphyrapicus thyroideus	Williamson's sapsucker		BPA	IC							
Spizella arborea	American tree sparrow	NPS?	BPA	IC							
Spizella breweri	Brewer's sparrow	NPS?	BPA	IC							
Spizella pallida	Clay-colored sparrow	NPS?	BPA	xIC	xSAS						
Spizella passerina	Chipping sparrow	NPS?	BPA	IC							
Stelgidopteryx serripennis	Northern rough-winged swallow	NPS?	BPA	IC							
Stellula calliope	Calliope hummingbird	NPS?	BPA	IC							
Sterna forsteri	Forster's tern		BPA	IC				B		SM	
Sterna hirundo	Common tern		BPA	IC							
Strix nebulosa	Great gray owl		BPA	IC				IO		SM	
Strix varia	Barred owl		BPA	IC				B			
Sturnella neglecta	Western meadowlark	NPS	BPA	IC							
Sturnus vulgaris	European starling		BPA	IC							
Surnia ulula	Northern hawk owl		BPA	IC							
Tachycineta bicolor	Tree swallow	NPS?	BPA	IC							
Tachycineta thalassina	Violet-green swallow	NPS?	BPA	IC							
Tringa flavipes	Lesser yellowlegs	NPS?	BPA	IC							
Tringa melanoleuca	Greater yellowlegs	NPS?	BPA	IC							
Tringa solitaria	Solitary sandpiper	NPS?	BPA	IC							
Troglodytes aedon	House wren		BPA	IC							
Troglodytes troglodytes	Winter wren		BPA	IC							
Turdus migratorius	American robin	NPS	BPA	IC							
Tympanuchus phasianellus	Sharp-tailed grouse	*NPS	BPA	IC		WDFW		B,RSC	FCo	ST	PS
Tyrannus tyrannus	Eastern kingbird		BPA	IC							
Tyrannus verticalis	Western kingbird		BPA	IC							
Tyto alba	Barn owl	NPS	BPA	IC							
Vermivora celata	Orange-crowned warbler		BPA	IC							
Vermivora peregrina	Tennessee warbler		BPA	xIC	xSAS						

Table 3. Terrestrial Wildlife Species Present in the UCR Area (continued)

BIRDS (cont'd)											
Vermivora ruficapilla	Nashville warbler		BPA	IC							
Vireo gilvus	Warbling vireo		BPA	IC							
Vireo olivaceus	Red-eyed vireo		BPA	IC							
Vireo solitarius	Solitary vireo		BPA	IC							
Wilsonia pusilla	Wilson's warbler		BPA	IC							
Xanthocephalus xanthocephalus	Yellow-headed blackbird	NPS?	BPA	IC							
Zenaida macroura	Mourning dove	NPS	BPA	IC							
Zonotrichia albicollis	White-throated sparrow	NPS?	BPA	IC							
Zonotrichia atricapilla	Golden-crowned sparrow	NPS?	BPA	xIC	SAS						
Zonotrichia leucophrys	White-crowned sparrow	NPS?	BPA	IC							
Zonotrichia querula	Harris' sparrow	NPS?	BPA	IC							
MAMMALS											
Alces alces	Moose	NPS	BPA	xIC		WDFW					
Antrozous pallidus	Pallid bat	NPS?	BPA	IC				B,CR		SM	
Brachylagus idahoensis	Pygmy rabbit		BPA	IC				IO	FE	SE	
Canis latrans	Coyote	NPS	BPA	IC							
Canis lupus	Gray wolf					WDFW		IO	FE	SE	
Castor canadensis	Beaver	NPS	BPA	IC							
Cervus elaphus	Elk	NPS									
Cervus elaphus nelsoni	Rocky Mountain elk		BPA	IC		WDFW					
Clethrionomys californicus	Western red-backed vole	NPS?	BPA	xIC							
Clethrionomys gapperi	Southern red-backed vole	NPS?	BPA	IC							
Coryhorhinus townsendii	Townsend's big-eared bat	NPS?	BPA	IC		WDFW		B,CR	FCo	SC	PT
Coryhorhinus townsendii townsendii	Pacific Townsend's big-eared bat	NPS?				WDFW		B,CR	FCo	SC	PT
Eptesicus fuscus	Big brown bat	NPS?	BPA	IC							
Equus sp.	Horse						CTFWD				
Erethizon dorsatum	Porcupine	NPS	BPA	IC							
Euderma maculatum	Spotted bat	NPS?		IC				B,CR		SM	SM
Felis concolor	Mountain lion	NPS	BPA								
Glaucomys sabrinus	Northern flying squirrel		BPA	IC							
Gulo gulo	Wolverine		BPA	IC				IO	FCo	SC	
Lagurus curtatus	Sagebrush vole	NPS?	BPA	IC				IO		SM	
Lasionycteris noctivagans	Silver-haired bat	NPS?	BPA	IC							
Lasiurus borealis	Red bat	NPS?	BPA					B,IO		SM	
Lasiurus cinereus	Hoary bat	NPS?	BPA	IC							
Lepus americanus	Snowshoe hare		BPA	IC							
Lepus townsendii	White-tailed jack rabbit		BPA	IC				IO		SC	
Lutra canadensis	River otter	NPS	BPA	IC							
Lynx canadensis	Lynx		BPA	IC				IO	FT	ST	
Lynx rufus	Bobcat	NPS	BPA	IC							
Marmota caligata	Hoary marmot			IC							
Marmota flaviventris	Yellow-bellied marmot	NPS	BPA	IC							
Martes americana	Marten		BPA	IC							
Martes pennanti	Fisher		BPA	xIC				IO	FC	SE	PS
Mephitis mephitis	Striped skunk	NPS	BPA	IC			LRNRA				
Microtus longicaudus	Long-tailed vole	NPS?	BPA	IC			LRNRA				
Microtus montanus	Montane vole	NPS?	BPA	IC							
Microtus oregoni	Creeping vole	NPS?	BPA	xIC							
Microtus pennsylvanicus	Meadow vole	NPS?	BPA	IC			LRNRA				
Microtus richardsoni	Water vole	NPS?	BPA	IC							

Table 3. Terrestrial Wildlife Species Present in the UCR Area (continued)

MAMMALS (cont'd)											
Microtus townsendii	Townsend's vole	NPS?	BPA								
Mus musculus	House mouse	NPS?	BPA								
Mustela erminea	Ermine			IC							
Mustela frenata	Long-tailed weasel		BPA	IC							
Mustela vison	Mink	NPS	BPA	IC							
Myotis californicus	California myotis	NPS?	BPA	IC							
Myotis ciliolabrum	Small-footed myotis	NPS?	BPA	IC				B,CR	FCo	SM	
Myotis evotis	Long-eared myotis	NPS?	BPA	IC				B,CR	FCo	SM	
Myotis lucifugus	Little brown myotis	NPS?	BPA	IC							
Myotis thysanodes	Fringed myotis	NPS?	BPA	IC				B,CR	FCo	SM	
Myotis volans	Long-legged myotis	NPS?	BPA	IC				B,CR	FCo	SM	
Myotis yumanensis	Yuma myotis	NPS?	BPA	IC				B,CR	FCo		
Neotoma cinerea	Bushy-tailed woodrat		BPA	IC			LRNRA				
Neurotrichus gibbsii	Shrew-mole		BPA	xIC							
Ochotona princeps	Pika		BPA	IC							
Odocoileus hemionus hemionus	Mule deer	NPS	BPA	IC		WDFW					
Odocoileus virginianus	White-tailed deer	NPS	BPA	IC							
Odocoileus virginianus ochrourus	Northwest white-tailed deer					WDFW					
Ondatra zibethicus	Muskrat	NPS	BPA	IC							
Oreamnos americanus	Mountain goat			IC							
Ovis canadensis	Bighorn sheep					WDFW					
Perognathus parvus	Great basin pocket mouse		BPA	IC			LRNRA				
Peromyscus maniculatus	Deer mouse		BPA	IC			LRNRA				
Phenacomys intermedius	Heather vole	NPS?	BPA	IC							
Procyon lotor	Raccoon	NPS	BPA	IC							
Rangifer tarandus	Woodland caribou			IC				IO	FE	SE	
Rattus norvegicus	Norway rat	NPS?	BPA								
Reithrodontomys megalotis	Western harvest mouse		BPA	IC							
Scapanus orarius	Coast mole		BPA	xIC							
Scapanus townsendii	Townsend's mole		BPA								
Sciurus griseus	Western gray squirrel		BPA	xIC				IO	FCo	ST	
Sciurus niger	Fox squirrel		BPA								
Sorex bendirii	Pacific water shrew	NPS?	BPA					IO		SM	
Sorex cinereus	Masked shrew	NPS?	BPA	IC							
Sorex hoyi	Pygmy shrew	NPS?	BPA	IC				IO		SM	PS
Sorex merriami	Merriam's shrew	NPS?	BPA	IC				IO		SC	PS
Sorex monticolus	Dusky shrew	NPS?	BPA								
Sorex palustris	Water shrew	NPS?	BPA	IC			LRNRA				
Sorex trowbridgii	Trowbridge's shrew	NPS?	BPA	xIC							
Sorex vagrans	Vagrant shrew	NPS?	BPA	IC			LRNRA				
Spermophilus beecheyi	California ground squirrel		BPA	xIC							
Spermophilus columbianus	Columbian ground squirrel	NPS	BPA	IC							
Spermophilus lateralis	Golden-mantled ground squirrel		BPA	IC							
Spermophilus washingtoni	Washington ground squirrel		BPA	xIC				IO	FC	SC	
Spilogale gracilis	Spotted skunk		BPA								
Sylvilagus nuttallii	Nuttall's cottontail	NPS	BPA	IC							
Synaptomys borealis	Northern bog lemming			IC				IO		SM	
Tamias amoenus	Yellow-pine chipmunk	NPS?	BPA	IC			LRNRA				
Tamias minimus	Least chipmunk	NPS?	BPA	IC							
Tamias ruficaudus	Red-tailed chipmunk	NPS?	BPA	IC				IO		SM	

Table 3. Terrestrial Wildlife Species Present in the UCR Area (continued)

MAMMALS (cont'd)											
Tamias townsendii	Townsend's chipmunk	NPS?	BPA								
Tamiasciurus douglasii	Douglas' squirrel		BPA	xIC							
Tamiasciurus hudsonicus	Red squirrel	NPS	BPA	IC							
Taxidea taxus	Badger	NPS	BPA	IC							
Thomomys mazama	Mazama (Western) pocket gopher	NPS?	BPA	xIC				IO	FC	SC	
Thomomys talpoides	Northern pocket gopher	NPS?	BPA	IC							
Ursus americanus	Black bear	NPS	BPA	IC							
Ursus arctos	Grizzly bear		BPA	IC		WDFW		IO	FT	SE	
Vulpes vulpes	Red fox		BPA	IC							
Vulpes vulpes cascadensis	Cascade red fox								FT	SC	
Zapus princeps	Western jumping mouse	NPS?	BPA	IC			LRNRA				

Federal Status
SC, Species of Concern. An unofficial status, the species appears to be in jeopardy, but insufficient information to support listing.

Sources:
NPS = Hebner et al. (2000).
BPA = Creveling and Renfrow (1986).
IC = Quigley et al. (2001) and Marcot et al. (2003).
SAS = Seattle Audubon Society (2006).
WDFW = WDFW (2008a).
LRNRA = McCaffrey et al. (2003).
CTFWD = Colville Tribes Fish and Wildlife Department (2006).

Occurrence source coding:
NPS = specifically identified in NPS document, w/ or w/o scientific name; e.g., northern saw-whet owl.
NPSh = NPS document lists Hungarian partridge, which is a subspecies of gray partridge present in eastern Washington.
NPS? = general species identified in NPS document; e.g., pocket gophers (*Thomomys* spp.). All species within the group identified that were also identified in the BPA document were marked using this code.
BPA = specifically identified in BPA document
IC = species range as shown in GIS coverage from Quigley et al. (2001) overlaps preliminary analysis area (verified from updated map in Marcot et al. (2003).
xIC = species range as shown in GIS coverage from Quigley et al. (2001) does not overlap preliminary analysis area (verified from updated map in Marcot et al. (2003).
xIC* = species range as shown in GIS coverage from Quigley et al. (2001) slightly overlaps preliminary analysis area around Grand Coulee Dam.
SAS = species ranges as shown in Bird Web map overlaps preliminary analysis area. Bird Web was checked for each bird species coded as present in NPS or BPA document and not present in Quigley et al. (2001) and Marcot et al. (2003).
xSAS = species ranges as shown in Bird Web map does not overlap preliminary analysis area. Bird Web was checked for each bird species coded as present NPS or BPA document and not present in Quigley et al. (2001) and Marcot et al. (2003).
WDFW = identified in WDFW's Priority Habitats and Species database within the preliminary analysis area.

WDFW Use Codes:
B = breeding
CR = communal roost
IO = individual occurrence
RI = regular occurring individual
RLC = regular large concentration
RSC = regular small concentrations

Federal Status Codes:
FE = federal endangered
FT = federal threatened
FC = federal candidate
FCo = federal species of concern

State Status Codes:
SC = state candidate
SE = state endangered
SM = state monitor
SS = state sensitive
ST = state threatened

Proposed State Status Codes:
PS = proposed sensitive
PT = proposed threatened

Table 4. Location of Terrestrial Species of Concern by River Reach (WDFW 2008a; Marcot et al. 2003)

Scientific Name	Common Name	Federal Status	State Status	River Reach Occurrence (Northeast to Southwest)					
				1	2	3	4	5	6
AMPHIBIANS									
Ambystoma tigrinum	Tiger salamander		SM		X	X	X	X	X
Bufo boreas	Western toad	FCo	SC	X	X	X	X	X	X
Bufo woodhousii	Woodhouse's toad		SM						
Rana pipiens	Northern leopard frog	FCo	SE						
Rana luteiventris	Columbia spotted frog	FCo	SC	X	X	X	X	X	X
REPTILES									
Hypsiglena torquata	Night snake		SM						
Sceloporus graciosus	Sagebrush lizard	FCo	SC						
BIRDS									
Accipiter gentilis	Northern goshawk	FCo	SC	X	X	X	X	X	X
Aechmophorus occidentalis	Western grebe		SC	X	X	X	X	X	X
Aegolius funereus	Boreal owl		SM	X	X	X	X	X	X
Ammodramus savannarum	Grasshopper sparrow		SM				X	X	X
Amphispiza belli	Sage sparrow		SC					X	X
Aquila chrysaetos	Golden eagle		SC	X	X	X	X	X	X
Ardea herodias	Great blue heron		SM	X	X	X	X	X	X
Athene cunicularia	Burrowing owl	FCo	SC	X	X				
Bartramia longicauda	Upland sandpiper		SE			X	X	X	X
Buteo regalis	Ferruginous hawk	FCo	ST					X	X
Buteo swainsoni	Swainson's hawk		SM			X	X	X	X
Cathartes aura	Turkey vulture		SM	X	X	X	X	X	X
Centrocercus urophasianus	Sage-grouse	FC	ST						X
Chaetura vauxi	Vaux's swift		SC	X	X	X	X	X	X
Chlidonias niger	Black tern	FCo	SM	X	X	X	X	X	X
Contopus borealis	Olive-sided flycatcher	FCo	x	X	X	X	X	X	X
Dolichonyx oryzivorus	Bobolink		SM	X	X	X	X		
Dryocopus pileatus	Pileated woodpecker		SC	X	X	X	X		
Empidonax traillii	Willow flycatcher	FCo	x	X	X	X	X	X	X
Falco columbarius	Merlin		SC	X	X	X	X	X	X
Falco mexicanus	Prairie falcon		SM	X	X	X	X	X	X
Falco peregrinus	Peregrine falcon	FCo	SS	X	X	X	X	X	X
Falco rusticolus	Gyrfalcon		SM	X	X	X	X	X	X
Gavia immer	Common loon		SS					X[a]	

Table 4. Location of Terrestrial Species of Concern by River Reach (WDFW 2008a; Marcot et al. 2003) (continued)

				River Reach Occurrence (Northeast to Southwest)					
Scientific Name	Common Name	Federal Status	State Status	1	2	3	4	5	6
BIRDS (cont'd)									
Haliaeetus leucocephalus	Bald eagle	FCo	SS	X	X	X	X	X	X
Lanius ludovicianus	Loggerhead shrike	FCo	SC					X	X
Melanerpes lewis	Lewis' woodpecker		SC	X	X	X	X		
Myiarchus cinerascens	Ash-throated flycatcher		SM						
Numenius americanus	Long-billed curlew		SM	X	X	X	X	X	X
Nyctea scandiaca	Snowy owl		SM			X	X	X	X
Nycticorax nycticorax	Black-crowned night-heron		SM					X	X
Oreoscoptes montanus	Sage thrasher		SC				X	X	X
Otus flammeolus	Flammulated owl		SC	X	X	X	X	X	X
Pandion haliaetus	Osprey		SM	X	X	X	X	X	X
Pelecanus erythrorhynchos	American white pelican		SE						X
Picoides albolarvatus	White-headed woodpecker		SC			X	X		
Picoides arcticus	Black-backed woodpecker		SC	X	X	X			
Picoides tridactylus	Three-toed woodpecker		SM	X	X	X	X		
Podiceps auritus	Horned grebe		SM	X	X	X	X	X	X
Podiceps grisegena	Red-necked grebe		SM	X	X	X	X	X	
Poecile hudsonicus	Boreal chickadee		SM	X	X	X	X		
Seiurus noveboracensis	Northern waterthrush		SM	X	X	X			
Sialia mexicana	Western bluebird		SM	X	X	X	X	X	X
Sterna forsteri	Forster's tern		SM	X	X	X	X	X	X
Strix nebulosa	Great gray owl		SM	X	X	X	X	X	X
Tympanuchus phasianellus	Sharp-tailed grouse	FCo	ST					X	X
MAMMALS									
Antrozous pallidus	Pallid bat		SM					X	X
Brachylagus idahoensis	Pygmy rabbit	FE	SE					X	X
Canis lupus	Gray wolf	FT	SE	X	X	X	X	X	X
Coryhorhinus townsendii	Townsend's big-eared bat	FCo	SC	X	X	X	X	X	X
Coryhorhinus townsendii townsendii	Pacific Townsend's big-eared bat	FCo	SC						
Euderma maculatum	Spotted bat		SM	X	X	X	X	X	X
Gulo gulo	Wolverine	FCo	SC	X	X	X	X	X	X
Lagurus curtatus	Sagebrush vole		SM					X	X
Lasiurus borealis	Red bat		SM						
Lepus townsendii	White-tailed jack rabbit		SC	X	X	X	X	X	X
Lynx canadensis	Lynx	FT	ST	X	X	X	X	X	X

Table 4. Location of Terrestrial Species of Concern by River Reach (WDFW 2008a; Marcot et al. 2003) (continued)

Scientific Name	Common Name	Federal Status	State Status	River Reach Occurrence (Northeast to Southwest) 1	2	3	4	5	6
MAMMALS (cont'd)									
Martes pennanti	Fisher	FCo	SE						
Myotis ciliolabrum	Small-footed myotis	FCo	SM	X	X	X	X	X	X
Myotis evotis	Long-eared myotis	FCo	SM	X	X	X	X	X	X
Myotis thysanodes	Fringed myotis	FCo	SM	X	X	X	X	X	X
Myotis volans	Long-legged myotis	FCo	SM	X	X	X	X	X	X
Myotis yumanensis	Yuma myotis	FCo	x	X	X	X	X	X	X
Rangifer tarandus	Woodland caribou	FE	SE	X	X	X			
Sciurus griseus	Western gray squirrel	FCo	ST						
Sorex bendirii	Pacific water shrew		SM						
Sorex hoyi	Pygmy shrew		SM	X	X	X	X		
Sorex merriami	Merriam's shrew		SC			X	X	X	X
Spermophilus washingtoni	Washington ground squirrel	FC	SC					X	X
Synaptomys borealis	Northern bog lemming		SM	X	X	X	X		
Tamias ruficaudus	Red-tailed chipmunk		SM	X	X	X	X		
Thomomys mazama	Mazama (Western) pocket gopher	FC	SC						
Ursus arctos	Grizzly bear	FT	SE	X	X	X	X	X	X
Vulpes vulpes cascadensis	Cascade red fox	FT	SC	X	X	X			

[a] Common loon only seen along Spokane Arm (WDFW 2008a)

Federal Status Codes:
FE = federal endangered
FT = federal threatened
FC = federal candidate
FCo = federal species of concern

State Status Codes:
SC = state candidate
SE = state endangered
SM = state monitor
SS = state sensitive
ST = state threatened

APPENDIX C

SUMMARY OF SURFACE WATER QUALITY DATA

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LIST OF FIGURES

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ACRONYMS AND ABBREVIATIONS

AWQC	ambient water quality criteria
B.C.	British Columbia
BERA	baseline ecological risk assessment
CCME	Canadian Council of Ministers of the Environment
CEQG	Canadian environmental quality guidelines
COPC	chemicals of potential concern
DOC	dissolved organic carbon
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ESI	expanded site inspection
K_{ow}	octanol-water partition coefficient
LDPE	low-density polyethylene
LRFEP	Lake Roosevelt Fisheries Evaluation Program
MCL	maximum contaminant limit for drinking water
MDL	method detection limit
MRL	method reporting limit
NASQAN	National Stream Quality Accounting Network
ORP	oxidation-reduction potential
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-*p*-dioxin
PCDF	polychlorinated dibenzofuran
RI/FS	remedial investigation and feasibility study
RM	river mile
SPMD	semipermeable membrane device
SVOC	semivolatile organic compound
TCDD	tetrachlorodibenzo-p-dioxin
TCDF	tetrachlorodibenzo-furan
TCM	Teck Cominco Metals Limited
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
U.S.	United States
UCR	Upper Columbia River
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
VOC	volatile organic compound
WQS	water quality standard

UNITS OF MEASURE

°C	degrees Celsius
°F	degrees Fahrenheit
µg/L	micrograms per liter
cfs	cubic feet per second
ft	feet
km	kilometer
m	meters
mg/L	milligrams per liter
pg/L	picograms per liter

1 INTRODUCTION

This appendix contains a summary and evaluation of surface water quality data for the Upper Columbia River (UCR). The data presented in this appendix serves as a primary basis in support of identifying data gaps related to surface water in the UCR. Information from selected United States (U.S.) and Canadian studies and monitoring programs are presented herein.

The studies evaluated in this appendix are historical and were not necessarily conducted for the UCR remedial investigation and feasibility study (RI/FS) and baseline ecological risk assessment (BERA) and may not meet the current standards of practice and/or the data quality requirements necessary for completion of the BERA. However, for purposes of this BERA work plan, the data and analyses are assumed to be adequate to assist in identifying data gaps and describing general site characteristics, but may not be acceptable for use in future deliverables in their current form.

As the BERA progresses, the quality of the existing data, data analysis procedures, and suitability for inclusion in the BERA will be assessed according to procedures that will be reviewed and approved by the U.S. Environmental Protection Agency (EPA). In addition, clear explanations of the data used in evaluations, evaluation methodology, and statistical analysis documentation will be provided in future documents

The following appendix provides:

- Section 2—A summary of existing data on surface water
- Section 3—Interpretation of metals distributions in the UCR and tributaries
- Section 4—Interpretation of organic chemical distributions in the UCR and tributaries
- Section 5—An overview and interpretation of selected conventional analytes and measurements
- Section 6—References.

2 EXISTING SURFACE WATER QUALITY DATA

This section describes available water quality data for the UCR. Surface water quality data collected within the UCR has been limited to the U.S. Geological Survey (USGS), the Washington State Department of Ecology (Ecology), and various other monitoring studies. In addition, Environment Canada and the Provincial Ministry of the Environment have collected water quality data upstream of the Site along the main stem of the Columbia and Pend Oreille Rivers. The following section provides an overview of surface water quality data from the aforementioned data sources.

2.1 METALS

Data sets that include metal concentrations and water quality data in surface water of the UCR, tributaries to the study area, and the Columbia River in Canada are listed in Table 1. The locations of stations listed in Table 1 are shown on Map 1.

2.2 ORGANIC COMPOUNDS

Data for organic chemicals of potential concern (COPCs) within the UCR are limited spatially and temporally (Map 2). One additional surface water sample was collected from Lake Roosevelt just upstream of the City of Grand Coulee drinking water intake in 2001 as part of the UCR expanded site inspection (ESI) and was analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), chlorinated pesticides, and polychlorinated biphenyls (PCBs). Pesticides and herbicides were analyzed in surface water samples collected by the USGS at Northport, Washington, from 1995 through 2000), polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) analyzed by Ecology and USGS in samples collected at Northport in 1992 and 1993 (Serdar et al. 1994), and polybrominated diphenyl ethers (PBDEs) were analyzed in semi-permeable membrane devices (SPMDs) deployed near Marcus Flats in 2005 and 2006 (Johnson et al. 2006).

2.3 CONVENTIONAL ANALYTES

Conventional chemical and physical parameters/analytes measured in the UCR include:

- Alkalinity
- Major ions (sodium, calcium, magnesium, fluoride, chloride, sulfate)
- Conductivity
- Oxidation-reduction potential (ORP)
- pH
- Temperature
- Total suspended solids (TSS)

- Total and dissolved organic carbon (TOC and DOC)
- Dissolved oxygen
- Hardness
- Total dissolved solids (TDS)
- Turbidity.

Data sets were reviewed to identify sample locations where multi-year measurements of these parameters had been made in the UCR. Six locations in the UCR (Map 3) were identified that have multiple years' data for several of the above-listed conventional parameters:

- Northport—Columbia River at Northport (USGS Station 12400520; Ecology's Station 61A070 at river mile [RM] 735.1)
- Kettle Falls—Lake Roosevelt at Kettle Falls (U.S. Bureau of Reclamation [USBR] Site ID FDR005; vertical profile monitoring station)
- Spokane River at Mouth (Ecology Station ID 54A050)
- Lincoln Boat Ramp—Lake Roosevelt near Lincoln Boat Ramp (USBR Site ID FDR008; vertical profile monitoring station)
- Keller Ferry Boat Ramp—Lake Roosevelt near Keller Ferry Boat Ramp (USBR Site ID FDR008; vertical profile monitoring station)
- Logboom—Lake Roosevelt at Logboom u/s FDRW (USBR Site ID FDR010; vertical profile monitoring station).

Additional data for certain conventional parameters (e.g., temperature, pH, dissolved oxygen, alkalinity, TSS, turbidity, hardness) have been collected from the Lake Roosevelt reservoir as part of the Lake Roosevelt Fisheries Evaluation Program (LRFEP) (Lee et al. 2006).

2.4 NUTRIENTS

Nutrients in UCR surface water include ammonia, nitrate, and phosphorus. Nutrients have been monitored at the USGS and Ecology stations near Northport from the 1950s to the present, and at the station in the mouth of the Spokane River from 1990 to 1994. Nutrient data are also available from stations outside the boundaries of the UCR such as the tributary stations listed above, and from the Birchbank and Waneta monitoring stations in British Columbia.

A number of data quality issues were identified during the compilation and evaluation of the historical nutrient data, primarily due to ambiguity in the terminology used for the reported results among studies (e.g., ammonia may be reported as ammonia in USGS data, but as nitrogen in the Ecology data) and in the analytical methods used. Consequently, the evaluation of spatial and temporal trends in nutrient concentrations was not conducted at this time.

3 METALS DATA IN THE UCR AND TRIBUTARIES

Metals/metalloid data in the UCR Site are only available for a subset of the metals on the COPC list, and largely at a single location (Northport, Washington). This section describes available metals and metalloids data for the UCR and its tributaries.

Only data collected since 1995 were used in this analysis; this is when the USGS National Stream Quality Accounting Network (NASQAN) made substantial improvements to sampling methods and analytical methods.[1] Even so, notable improvements in detection limits are also observed beginning in 2001 (discussed below).

3.1 COMPARISON OF METAL CONCENTRATION MEASUREMENTS AT BIRCHBANK, WANETA, AND NORTHPORT

Total metals are monitored at several locations in the Columbia River and Pend Oreille River, a major tributary to the UCR just north of the border, in British Columbia (B.C.). Stations in the main stem of the Columbia River in B.C. include the Columbia River at Birchbank station (Federal ID BC08NE0005/Provincial ID 200003), approximately 10 km (6 miles) upstream of the Trail facility, and the Columbia River at Waneta station (Federal ID BC08NE0001/Provincial ID 200021), located downstream of the smelter. Additional data are available from the Pend Oreille River at Waneta B.C. (Federal ID BC08NE0029/Provincial ID 200021) and further upstream along the Pend Oreille at a station referred to as "Pend Oreille River/at International Boundary" (Federal ID BC08NE0020/Provincial ID E237493) (Table 1; Map 1). The Pend Oreille River enters the Columbia just downstream of the Columbia River Waneta sampling station. It is worth noting that the Pend Oreille River also delivers approximately 24 percent of the average flow passing through the site. Water quality differences between the Columbia and Pend Oreille monitoring stations may influence water quality at Northport.

Box plots of surface water data from the four B.C. locations were developed to compare the statistics of detected total metals concentrations to those measured at Northport, Washington, from 2001 through 2005 (Figures 1 through 5). The box plots are based only on detected metal concentrations so that differences in detection limits do not influence comparisons of metal concentrations between stations. Detection frequencies at the four B.C. sites were very high for all metals evaluated here (mercury data are not available for the B.C. locations). However, at Northport, cadmium and zinc were infrequently detected (detection limits at Northport were higher than those achieved at the B.C. sites). This difference in frequency of detection among the sites due to variable detection limits may result in a upwardly biased central tendency (i.e., mean) at locations where there are fewer detected samples; however, this upward bias means the results should be considered conservative in regard to assessing potential risk. The following summarizes the overall trends by metal.

[1] Personal communication with Steve Cox (2007) regarding the timing of changes to the NASQAN program that affected data quality.

- **Arsenic.** As illustrated within Figure 1, total arsenic concentrations in the Columbia River at Birchbank and Waneta were comparable; while concentrations at the two Pend Oreille River sites are approximately 4 to 5 times greater. At Northport, observed total arsenic concentrations appear to be intermediate between those measured in the Columbia upstream of the border and those measured in the Pend Oreille River (Figure 1).
- **Cadmium.** Total cadmium concentrations in the Columbia River at Waneta are approximately two-fold higher than those measured at Birchbank and the Pend Oreille River (Figure 2). Total cadmium was detected at Northport in only one of 26 samples from 2001 through 2005. The detection limit (0.1 μg/L) was higher than the concentrations measured at the B.C. sites.
- **Copper.** Total copper concentrations are generally, although not substantially, higher in the Columbia River at Waneta than at Birchbank; while total copper concentrations in the Pend Oreille River are higher than those measured in the Columbia at Waneta (Figure 3). Copper concentrations at Northport are similar to those measured in the Pend Oreille River or intermediate between those measured in the Columbia at Waneta and the Pend Oreille River (Figure 3).
- **Lead.** Total lead concentrations were not highly variable between the B.C. sites and Northport, although concentrations are slightly higher in the Pend Oreille River at Waneta than those measured in the Columbia River at Waneta (Figure 4). The range in total lead concentrations at Northport tended to overlap more with the range in concentrations measured in the Pend Oreille River at Waneta (Figure 4). However, overall variability in total lead concentrations was not large (less than a factor of two) among all sampling locations.
- **Zinc.** Overall, total zinc concentrations were higher in the Columbia River at Waneta than upstream at Birchbank, and total zinc concentrations in the Pend Oreille River were intermediate between those measured in the Columbia at Waneta and Birchbank (Figure 5). At Northport, total zinc was infrequently detected at a detection limit of 5 μg/L, which is higher than the majority of detected concentrations at the B.C. sites.

3.2 TIME SERIES COMPARISONS OF METAL CONCENTRATIONS AT NORTHPORT

Summary statistics for total and dissolved metals results from this station are provided in Table 2. Total metals concentrations most frequently detected (i.e., detected in 75 percent or more of the samples analyzed) include arsenic, copper, lead, and nickel. The most frequently detected dissolved metals are barium, calcium, copper, magnesium, potassium, sodium, strontium, and zinc.

Arsenic, cadmium, copper, lead, mercury, and zinc are considered to be representative of the UCR metal COPCs, for the purposes of this discussion. Cadmium, copper, lead, mercury, and zinc are all associated with historic and/or present releases from the Trail facility. Dissolved and total recoverable concentrations of these representative metals in surface water data from Northport (i.e., January 1995 to June 2007) are presented in Table 3. For the purposes of this appendix, only post-2000 data were plotted on Figures 6 through 11. In each figure, closed symbols represent detected concentrations and open symbols represent the detection limit for undetected concentrations. The benchmarks presented include the maximum contaminant level (MCL); the Canadian Council of the Ministers of the Environment, Canadian environmental quality guidelines (CCME, CEQG); the EPA ambient water quality criterion (AWQC, chronic); and the Ecology chronic water quality standards.

Focusing on post-2000 data, these trends in metals concentrations indicate that:

- Elevated detection limits for total cadmium and total zinc constrain data interpretation to data collected after 2001
- Only one metal in dissolved form, cadmium, exceeded chronic AWQC at one sampling event
- Copper exceeded the CCME value (as total copper) once (June 2003)
- Total zinc exceeded the CCME screening value once (June 2003)
- Total lead exceeded the CCME screening value once (December 2005)
- Metal concentrations at Northport are generally most variable in the spring and most stable in the late summer and early fall.

The potential relationships to season and flow were examined by plotting flow data along with measured concentrations; flow data were as reported by Ecology based on a stage-discharge rating curve (Figures 12 through 17). Benchmarks were removed for greater clarity of potential seasonal relationships (Figures 12 through 17).

3.3 METALS DATA FROM LRFEP

Analytical results for surface water samples collected from several locations in the UCR from 1998 to 2000 by LRFEP have recently been published (Scofield and Pavlik-Kunkel 2007). The study and findings of Scofield and Pavlik-Kunkel (2007) are summarized below. Sampling locations are shown on Map 1.

Surface water samples were collected from 11 locations within the reservoir portion of the UCR—Evan's Landing (RM 710); Kettle Falls (RM 701); Gifford (RM 674); Hunters (RM 661); Spokane River Confluence (RM 639); Seven Bays (RM 636); Sanpoil River Confluence (RM 616); Keller Ferry (RM 615); Spring Canyon (RM 600); Porcupine Bay (RM 638); and Sanpoil River (within Sanpoil Arm, RM 617) (Map 1). Samples were collected monthly over the period of January 1998 to March 2000, using a Van Dorn bottle (1998) and depth-integrated water sampler (1999 to 2000) (Scofield and Pavlik-Kunkel 2007). The Van Dorn bottle samples were collected from mid-depth of the photic zone, and 1 m below the photic zone (Scofield and Pavlik-Kunkel 2007). Samples collected with the integrated sampler were collected from the surface to the bottom of the photic zone. Both samplers were weighted with lead weights. As discussed by Scofield and Pavlik-Kunkel (2007), the weights on the samplers may have contributed to sample contamination.

The samples were submitted to the Spokane Tribal Laboratory for total recoverable trace element analysis by inductively coupled atomic emission spectrometry Method 200.7 (arsenic, cadmium, copper, and zinc), graphite furnace atomic absorption Method 200.9, and cold vapor atomic absorption spectrometry, Method 245.1 (mercury) (Scofield and Pavlik-Kunkel 2007).

Summary statistics of the analytical results are provided in Table 4 (Scofield and Pavlik-Kunkel 2007). As shown, frequencies of detection were low for most metals, except lead and iron (Table 4). The authors noted that high reporting limits and the possibility that use of lead weights on sampling equipment affected reported concentrations and impact interpretation of these results.

A synopsis of Scofield and Pavlik-Kunkel's (2007) results is provided below for key trace metals.

- **Arsenic** (n=608). Total arsenic concentrations exceeded the method reporting limit (MRL)[2] in 15 of 608 samples. None of the samples exceeded the AWQC. The authors note that spatial and temporal trends were not distinguishable because of the small number of detected concentrations but that 6 of the 15 measured concentrations occurred in Porcupine Bay, which is located within the Spokane Arm of the river system.
- **Cadmium** (n=608). Total cadmium concentrations exceeded the MRL in only 1 percent (8 of 608) of the samples. These samples were located at or upriver from Seven Bays.
- **Copper** (n=520). Temporal and spatial patterns in total copper concentrations were not evident among the 14 of 520 samples that exceeded the MRL. Measureable copper concentrations occurred from Evans Landing to Spring Canyon. The highest concentrations were reported at Spring Canyon and Keller Ferry.
- **Lead** (n=608). Total lead was detected in 402 of 608 samples located throughout the study area. Because use of a lead weight on the sampling apparatus may have contaminated some of the samples, the authors believe the results are questionable. Consequently, the data are not evaluated further.
- **Mercury** (n=544). Only one of 544 total mercury samples was above the MRL. This sample was located at Spring Canyon.
- **Zinc** (n=608). Total zinc was measured at or above the MRL in 92 of 608 samples located throughout the study area. Log-transformed zinc concentrations at Porcupine Bay were significantly greater (p=0.0079 or less) than those in samples from Evan's Landing, Kettle Falls, Gifford, Hunters, Seven Bays, Spring Canyon, and the Sanpoil River.

[2] Any deviation from the ideal laboratory sample results in a MRL, which is the corrected concentration reportable for that sample under those conditions. The MRL is always equal to or greater than the method detection limit (MDL). Under ideal conditions, the analytical system provides the lowest concentration that can be reported, while minimizing uncertainty due to matrix effects. This concentration is the MDL. MRLs were not reported by Scofield and Pavlik-Kunkel (2007).

3.4 METALS DATA FROM TRIBUTARIES TO THE UCR

Downstream of Northport, several tributaries flow into the UCR, including the Kettle, Colville, Spokane, and Sanpoil rivers. Concentrations of total recoverable metals for these rivers (sampling locations are shown on Map 1) were graphically compared to concentrations found in the UCR at Northport (with the exception of the Colville River, for which no metals data are available for the 1995 to 2007 period). As shown in Figures 18 through 23, metal concentration data for the Kettle, Spokane, and Sanpoil rivers are comparable to concentrations in the UCR at Northport.

4 ORGANIC CHEMICALS

Analysis of organic chemicals in UCR surface water has included analyses of VOCs, SVOCs, pesticides and herbicides, PCBs, PCDDs, PCDFs, and PBDEs, although the distribution of these samples is spatially and temporally limited (see Map 2).

One surface water sample was collected from Lake Roosevelt near the city of Grand Coulee as part of the UCR ESI in 2001. Analytes for the sample included VOCs, SVOCs, pesticides, and PCBs. The results of all organic constituents were below detection limits (USEPA 2003).

Pesticides and herbicides were analyzed in surface water samples collected by the USGS at Northport, Washington, from 1995 to September 2000 (Map 2; USGS 2006). The results are summarized in Table 5. Nearly all of the results were below detection limits with no quality control information.

In 1992, Bortleson et al. (2000) measured dioxin and furan concentrations in the water column (using XAD™ resin columns) and suspended sediment at Northport, and in effluent from the Celgar Pulp Company (located upriver of the Teck Cominco Metals Limited [TCM] facility). Dioxins were detected in each type of sample while furans were detected in the suspended sediment and effluent samples. The 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) congener was not detected in any Northport sample but was detected in the effluent sample.

PCDDs and PCDFs were analyzed in samples collected at Northport in 1992 and 1993 in a joint study by Ecology and USGS (Serdar et al. 1994). This study's focus was on the association of dioxins and furans with suspended particulate matter. However, some analyses were conducted on dissolved samples. The dissolved samples were derived by filtering centrifuged water through XAD™ resin columns. Three PCDDs and 7 PCDFs, including 2,3,7,8-tetrachlorodibenzo-furan (TCDF), were detected in dissolved samples in this study. The authors concluded that there was a significant decrease in 2,3,7,8-TCDD and 2,3,7,8-TCDF concentrations between 1990 to 1993 that coincided with modifications at the Zelstoff Celgar pulp mill. No other data have been found for dioxins in UCR surface water.

Finally, PBDEs were the focus of a statewide study in 2005 and 2006 (Johnson et al. 2006). Samples collected from near Marcus Flats were analyzed for PBDEs as a part of this study. All samples were collected with SPMDs and reported as sample concentration in nanograms per SPMD (Johnson et al. 2006). An SPMD consists of a tubular, layflat, low-density polyethylene (LDPE) membrane containing a thin film of a high-molecular weight lipid surrogate (triolein). The LDPE tubing mimics a biological membrane by allowing selective diffusion of hydrophobic organic compounds into the lipid. SPMDs sequester the dissolved form of a chemical and provide lower detection limits than traditional water sampling techniques. The SPMDs were deployed in the UCR from September 8 to October 6, 2005 (Johnson et al. 2006). PBDEs were detected as PBDE-47, PBDE-99, and total PBDE in the samples collected by this method (Johnson et al. 2006). Concentrations of these three PBDEs in the dissolved phase were estimated using known octanol–water partition coefficients (K_{ows}). Estimated total PBDE concentrations were 16 pg/L in the UCR (Johnson et al. 2006). There are no other surface water data for PBDEs in the UCR.

The Johnson et al. (2006) study also deployed SPMDs in the Spokane River at Ninemile Dam, in the fall of 2005 (September 8 to October 6) and spring of 2006 (March 23 to April 26). Seven PBDE compounds were each detected in both the fall and spring samples (PBDE-47, -49, -66, -99, -100, -153, and -154). Concentrations of the detected PBDEs in the dissolved phase were estimated using known octanol-water partition coefficients (K_{ow}s). Total PBDE concentrations were estimated at 926 pg/L in the fall sample and 146 pg/L in the spring sample. The authors attributed this variation to possible dilution of local source contributions by snowmelt runoff in the upper watershed (Johnson et al. 2006). In comparison to the estimated total PBDE concentration detected in the fall 2005 sample from Marcus Flats mentioned above, the results of the Ninemile Dam samples indicate that the Spokane River may be a significant source of PBDEs to the UCR.

5 CONVENTIONAL WATER QUALITY PARAMETERS

Recent (post-2000) data are available for several conventional water quality parameters in the study area (conductivity, dissolved oxygen, hardness, ORP, pH, temperature, TSS, and turbidity), but there are no data for many other parameters (alkalinity, calcium, chloride, DOC, fluoride, magnesium, sodium, sulfate, TDS, and TOC). Multi-year data for conventional parameters are available from six stations within the UCR Site (Northport, Spokane River at mouth, and the four USBR monitoring stations) (Map 3). Summary statistics of conventional water quality parameter data for the study area sampling locations mentioned above are presented in Table 6.[3]

Recent long-term vertical profile data for conventional parameters between Northport and Grand Coulee Dam are limited to the USBR Kettle Falls, Lincoln Boat Ramp, Keller Ferry Boat Ramp, and Logboom stations. Vertical profile measurements of ORP, pH, conductivity, temperature, and dissolved oxygen from these stations from the period 2002 to 2006 were provided by USBR. These data were generally collected once a month from April to October.

Field measurements of particular interest to the UCR RI/FS include conductivity, temperature, oxygen and total dissolved gas, and pH. Conductivity and temperature are important variables that affect or may be indicative of vertical stratification and mixing. Conductivity is also an indication of major ion content. Oxygen and pH are relevant to water quality, biological process, and metal geochemistry.

5.1 CONDUCTIVITY

Conductivity is a measure of major ion content of surface water. The anion and cation content of surface water reflects that of the source water, including rainfall, runoff, and groundwater infiltration.

Profiles of conductivity measurements collected at the four USBR stations are presented in Figures 24 through 27). The strongest seasonal change in conductivity was observed at the most upstream sampling location, Kettle Falls, although the magnitude of seasonal changes varies from year to year (Figure 24). Vertical stratification in conductivity is also indicated at some downstream stations.

5.2 TEMPERATURE

Temperature conditions of Lake Roosevelt have not substantially changed since the 1970s based on a review of data. Ecology routinely monitors water quality parameters, including water

[3] Available data for lateral distributions of conventional water quality parameters are limited to transect stations dating from April to May 1972 (NPS 1995); because of the age and the limited temporal coverage of those data, they are not discussed here.

temperature, immediately upstream from Lake Roosevelt (Station 61A070 at RM 735.1) and immediately downstream from the reservoir (Station 53A070 at RM 596).

Figure 28 provides an example of temperature conditions in Lake Roosevelt and the changes that occur from the U.S.-Canada border to the Grand Coulee Dam forebay. This information shows approximately a 30- to 40-day shift in the comparable water temperatures between the border and the dam forebay.

Although Lake Roosevelt experiences substantial flows (i.e., commonly 40,000 to 200,000 cfs) and changes in surface elevation, a weak thermal stratification of the water column can occur during the summer when solar radiation heats the surface water (Jaske and Snyder 1967; USFWS 1969). During periods of the weak thermocline, temperatures of the water below the thermocline are commonly in the range of 14 to 19 °C (57 to 66 °F). However, in an exceptionally high flow year, the temperature differential between surface and deeper water has been substantially less (Sylvester 1958). In autumn, the water temperature characteristics change, with longitudinal variation exceeding vertical variation (Riedel 1997). While these studies were conducted prior to the 1973 completion of the flood control dams on the Columbia River in Canada, they provide evidence that Lake Roosevelt can be subject to thermal stratification.

Plots of more recent temperature measurements at four USBR monitoring stations during 2002 to 2006 are presented in Figures 29 through 32. In these plots, the depth values were adjusted to approximate depth using reservoir elevation data from the Columbia River DART database. These figures show that temperature variations over time and with depth at each of these stations can occur. As shown, temperature gradients with depth developed at each of the stations, as early as May at the Keller Ferry and Logboom stations, but disappear by September. When they develop, maximum gradients may extend to less than 10 ft at Kettle Falls (the shallowest of the sites) up to approximately 40 ft (Lincoln Boat Ramp, Keller Ferry) or more.

5.3 pH

Plots of pH measurements at the USBR stations are shown in Figures 33 through 36. In general pH profiles are similar to temperature profiles in most years, although in some months and years, widely different patterns are shown (e.g., Lincoln Boat Ramp, 2002 and 2003, Keller Ferry, 2003). However, overall, there appear to be few seasonal pH patterns that appear consistently from year to year or from station to station. At any given location in the UCR, pH values can vary with depth.

5.4 OXYGEN AND TOTAL DISSOLVED GASES

Low dissolved oxygen is commonly a water quality concern for reservoirs that develop thermal stratification during warmer months of the year. In stratified reservoirs, the subsurface waters below the thermocline (i.e., the hypolimnion) typically develop relatively low dissolved oxygen concentrations as the result of biological oxygen demand coupled with reduced exchange with the surface waters above the thermocline (i.e., the epilimnion). This trend is not observed in the UCR, suggesting that thermal stratification is transient or a true thermocline does not exist (temperature strata may be due to incomplete mixing of different water sources).

However, profile plots of dissolved oxygen concentrations at the USBR station (which are in the main body of the reservoir), as shown in Figures 37 through 40, provide evidence of thermal stratification in Lake Roosevelt during the warmest months (e.g., portions of July and August) of the year. The flow of water through Lake Roosevelt, together with the reservoir's generally low biological productivity, apparently prevents substantially reduced oxygen levels in the hypolimnion, according to the available data.

In contrast, low dissolved oxygen has been frequently reported in surface water near the bottom of the Spokane Arm during summer months. This condition has been attributed to decomposition of summer algal biomass (Stober et al. 1981; Fields et al. 2004; Lee et al. 2003; Pavlik-Kunkel et al. 2005).

Estimates of percent of saturation[4] were calculated for the USBR monitoring stations using the dissolved oxygen concentrations and temperature data reported by the USBR. The calculation was performed based on oxygen solubilities in water taken from Appendix C of Thomann and Mueller (1987), assuming a chlorinity value of zero:

$$[DO]sat. = (0.0044 \times [temperature]^2 - 0.3623 \times temperature + 14.512$$

To account for altitude, a correction factor of 1.05 was added (Horne and Goldman 1983) such that:

$$[DO]sat.\ at\ FDR = (0.0042 \times [temperature]^2 - 0.345 \times temperature + 13.821$$

The results indicate that estimated dissolved oxygen saturation ranges are similar among the four stations: from 82 to 116 percent at the Kettle Falls station, from 65 to 121 percent at the Lincoln Boat Ramp station, from 61 to 116 percent at the Keller Ferry station, and from 68 to 122 percent at the Logboom station (excluding an outlier value of 154 percent that appears erroneous). During spring runoff in the UCR when total dissolved gas levels are high, dissolved oxygen also tends to be at, or greater than, saturation. However, generally during warm periods with thermal stratification and an increased oxygen demand, dissolved oxygen levels can fall below saturation.

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[4] Dissolved oxygen may be measured and reported as an absolute concentration (e.g., mg/L) and/or as a percentage of saturation. The percentage of saturation is important because the capacity of water to dissolve oxygen varies considerably with water temperature. At low temperatures, water will hold more dissolved oxygen at equilibrium (12.8 mg/L at 5°C) than at high temperatures (9.1 mg/L at 20°C).

6 SUMMARY

Surface water quality data collected to date within the UCR have been spatially limited. Notwithstanding these limitations, the preliminary analyses of existing data shown in this appendix are useful for guiding future surface water sampling programs. Additional discussion of surface water quality evaluations are presented in Section 3.2.1 of the BERA work plan.

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FIGURES

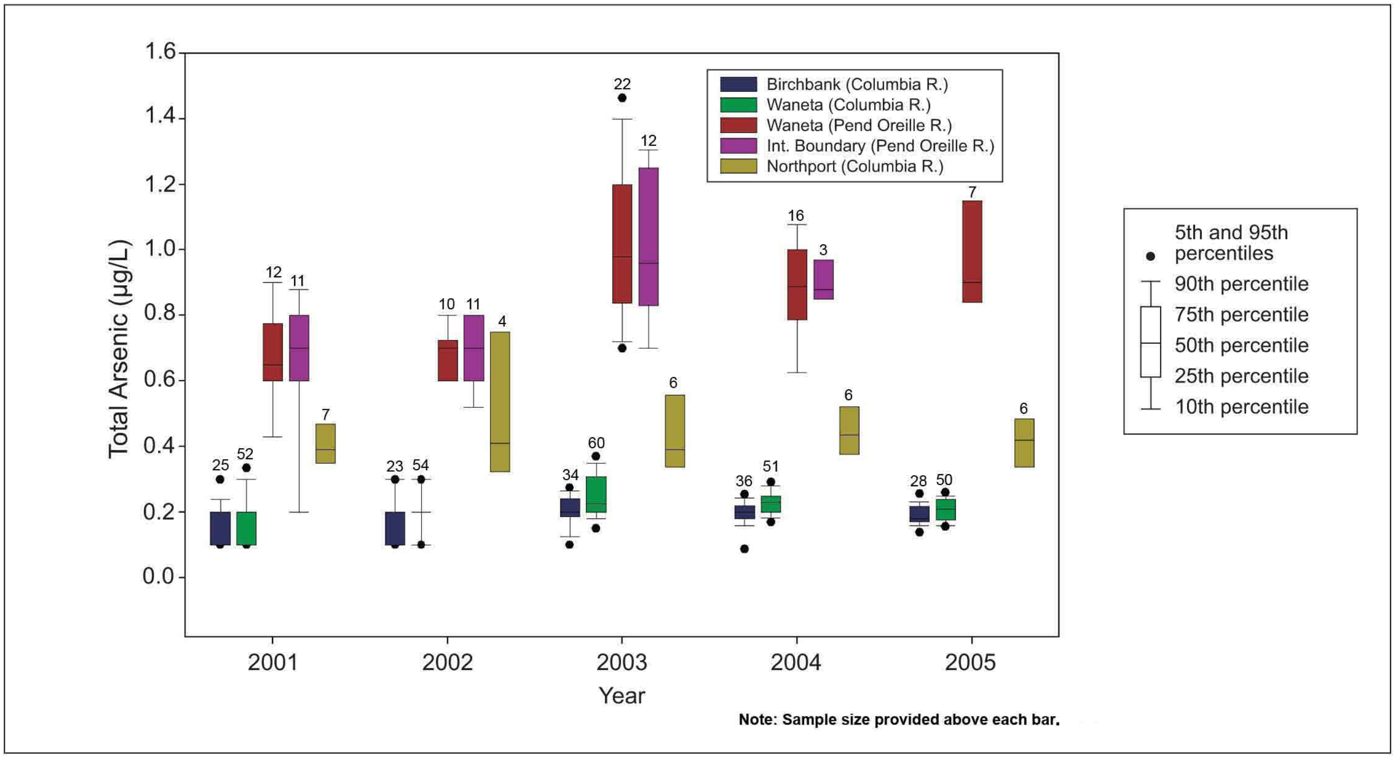

Figure 1. Total Arsenic: Comparison of Surface Water Concentrations at Birchbank, Waneta, the U.S.-Canada Border, and Northport (2001-2005)
Source: Environment Canada (http://waterquality.ec.gc.ca), USGS (http://waterdata.usgs.gov)
Note: Box plots based only on detected concentrations.

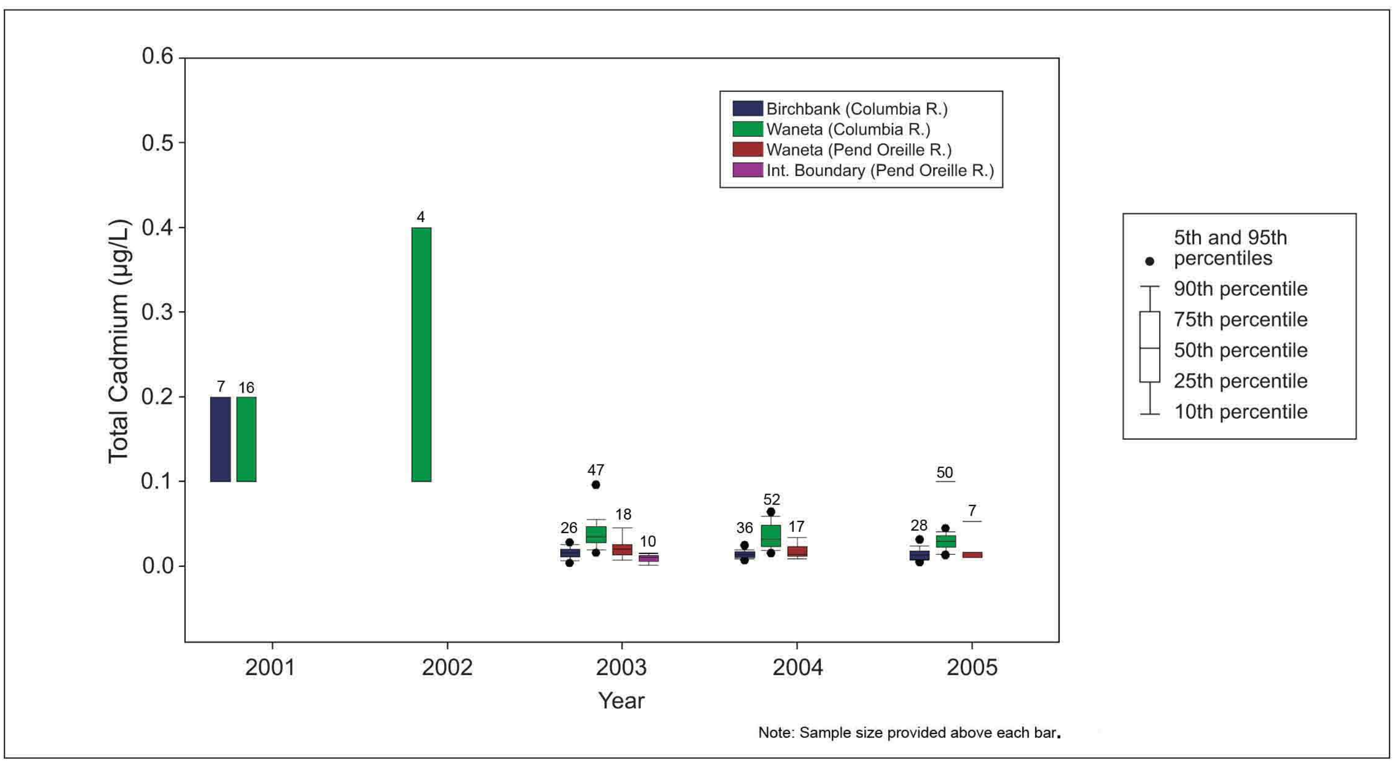

Figure 2. Total Cadmium: Comparison of Surface Water Concentrations at Birchbank, Waneta, and the U.S.-Canada Border (2001-2005)
Source: Environment Canada (http://waterquality.ec.gc.ca), USGS (http://waterdata.usgs.gov)
Note: Box plots based only on detected concentrations. Cadmium was detected in only 1 of 26 samples at Northport from 2001-2005 (detection limit of 0.1 µg/L). Data not available for Pend Oreille in 2001 and 2002.

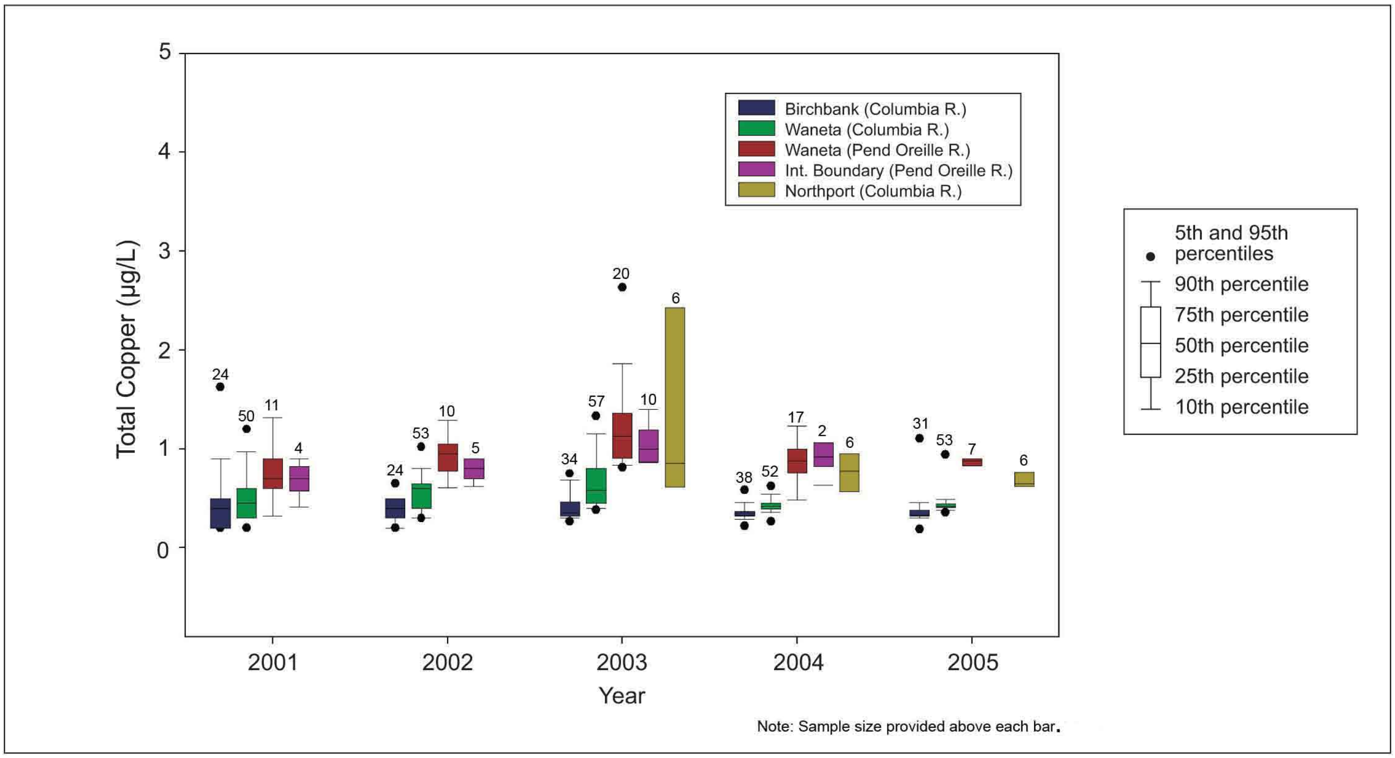

Figure 3. Total Copper: Comparison of Surface Water Concentrations at Birchbank, Waneta, the U.S.-Canada Border, and Northport (2001-2005)
Source: Environment Canada (http://waterquality.ec.gc.ca), USGS (http://waterdata.usgs.gov).
Note: Box plots based only on detected concentrations. Copper was not detected at Northport in 2001 and only twice in 2002 (0.49 and 0.78 µg/L).

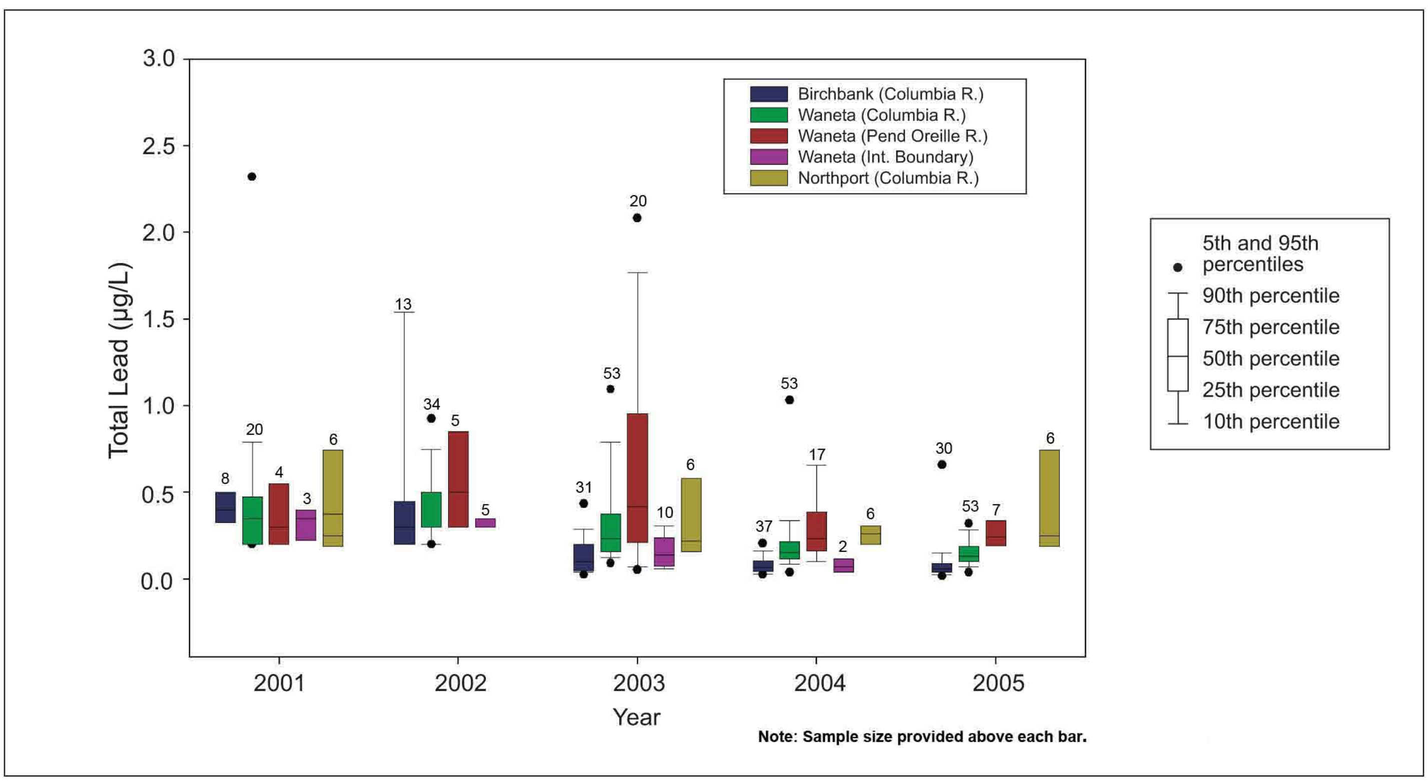

Figure 4. Total Lead: Comparison of Surface Water Concentrations at Birchbank, Waneta, the U.S.-Canada Border, and Northport (2001-2005)
Source: Environment Canada (http://waterquality.ec.gc.ca), USGS (http://waterdata.usgs.gov).
Note: Box plots based only on detected concentrations.

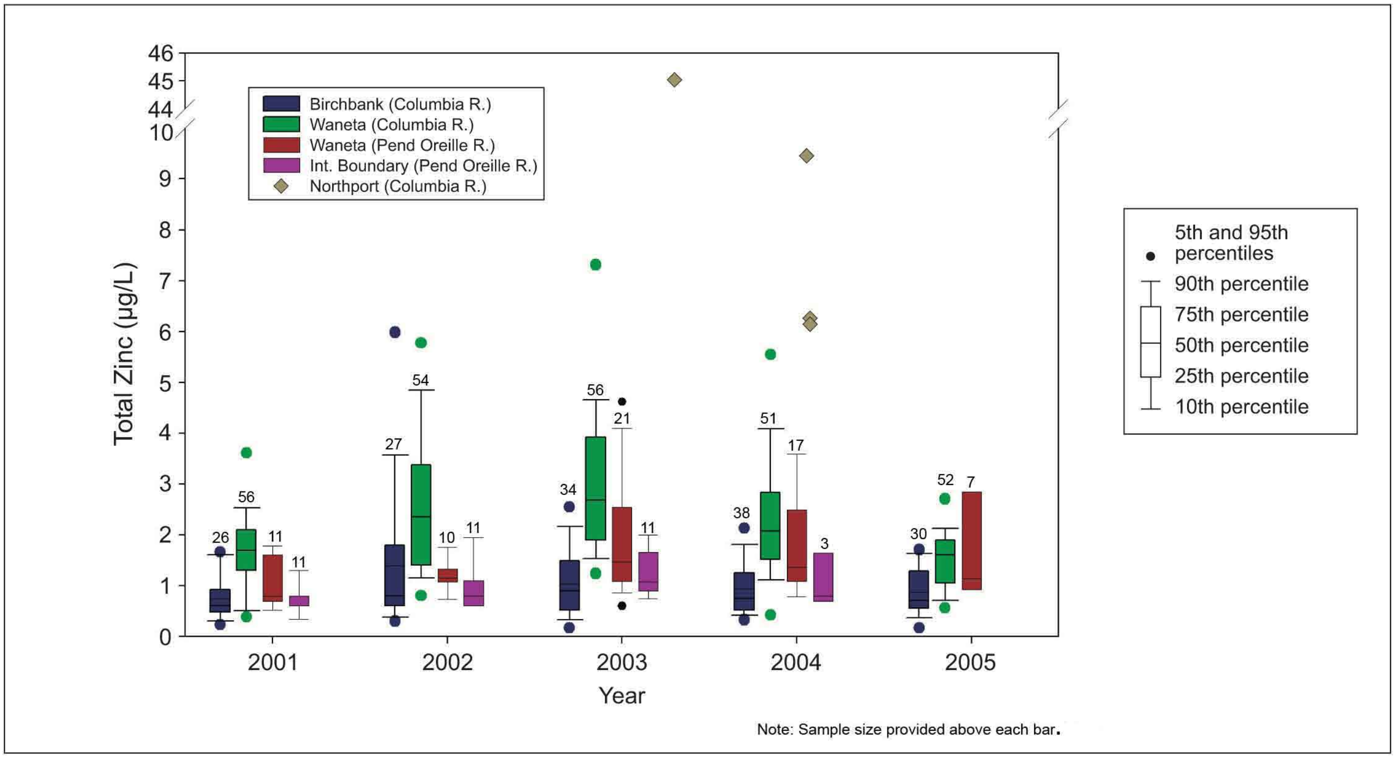

Figure 5. Total Zinc: Comparison of Surface Water Concentrations at Birchbank, Waneta, the U.S.-Canada Border, and Northport (2001-2005)
Source: Environment Canada (http://waterquality.ec.gc.ca), USGS (http://waterdata.usgs.gov).
Note: Zinc was infrequently detected at Northport at a detection limit of 5 µg/L. Detected concentrations are show as individual points. Box plots based only on detected concentrations.

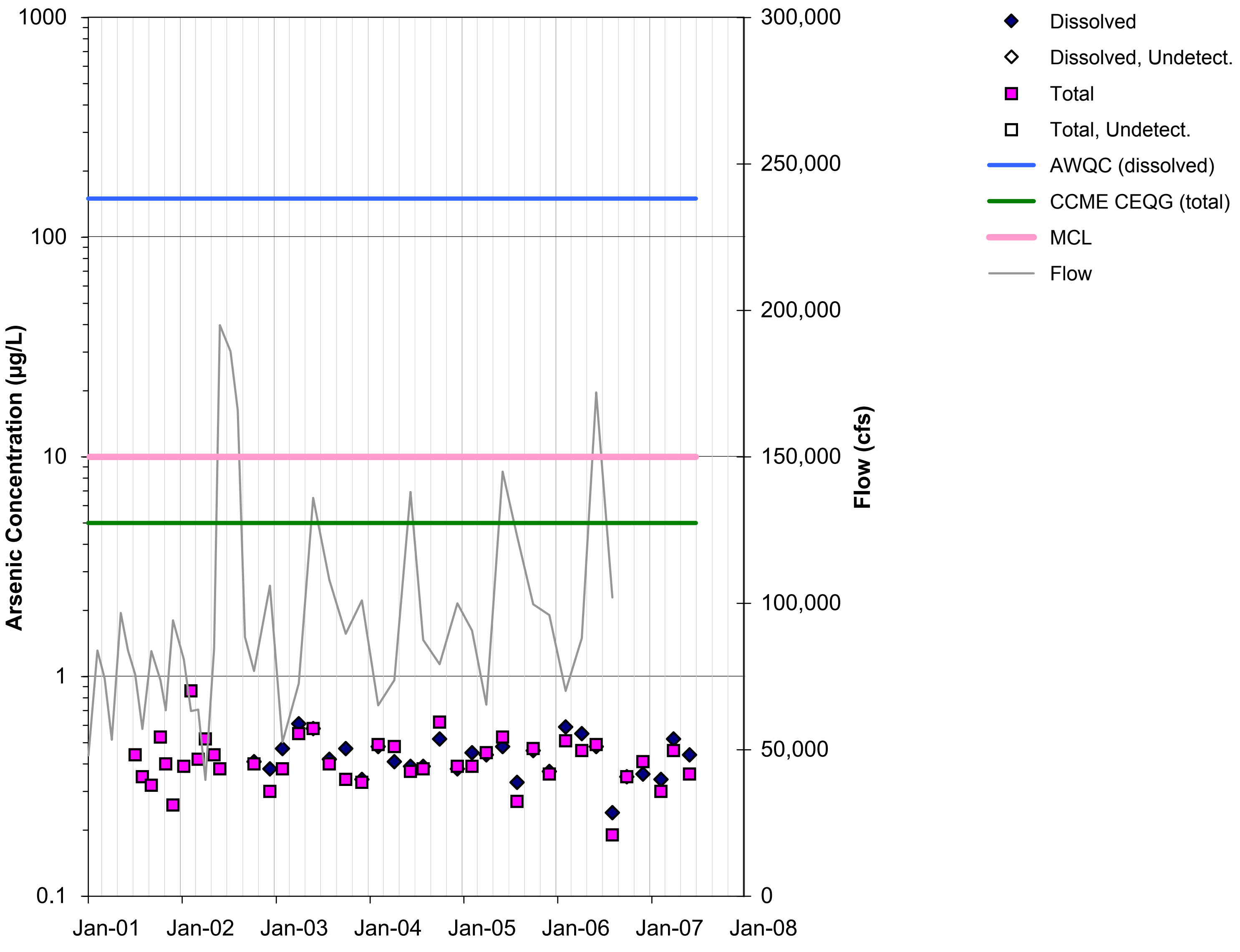

Figure 6. Dissolved and Total Recoverable Arsenic Concentrations in Surface Water Samples Collected at Northport (2001–2007)

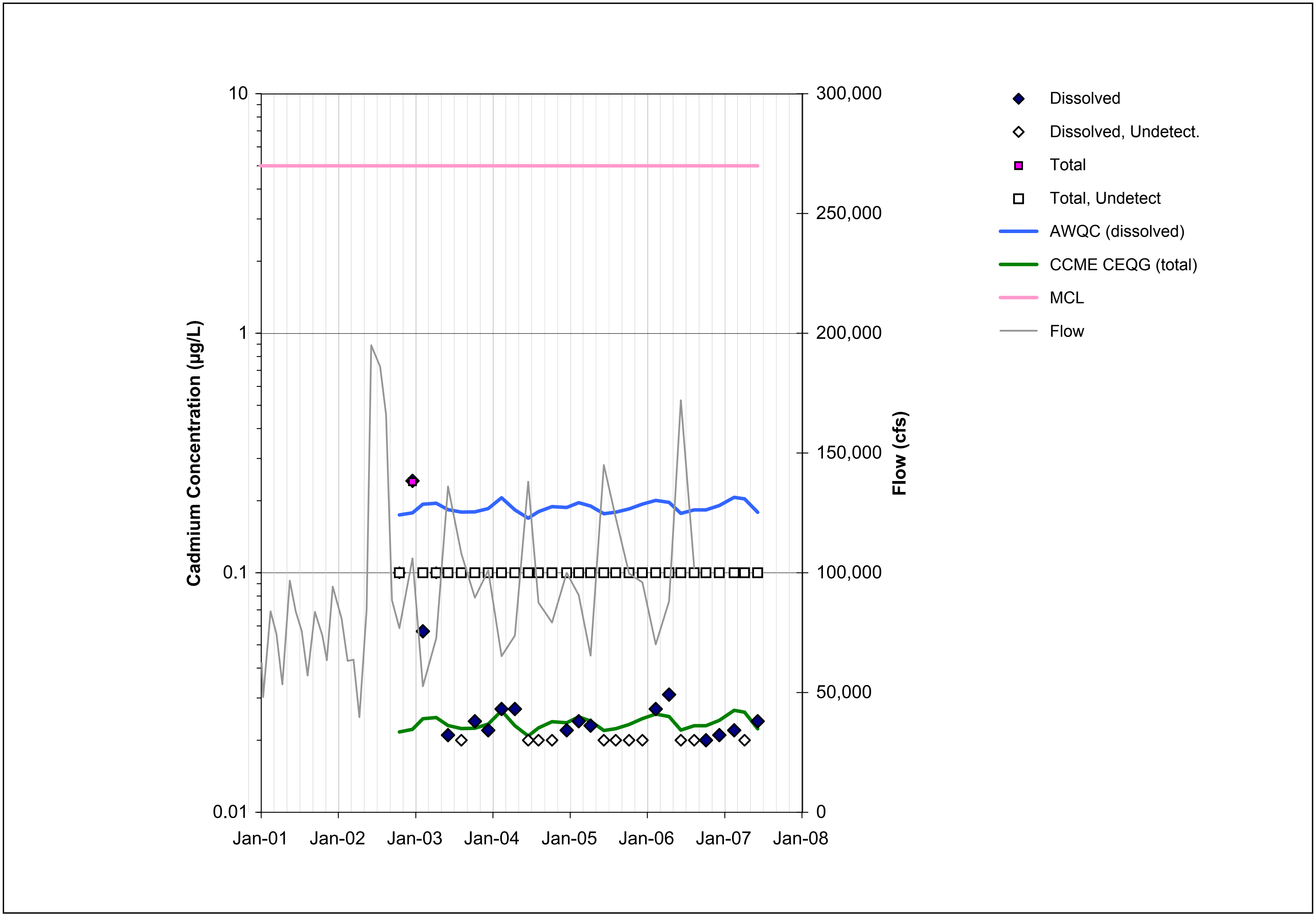

Figure 7. Dissolved and Total Recoverable Cadmium Concentrations in Surface Water Samples Collected at Northport (2001–2007)

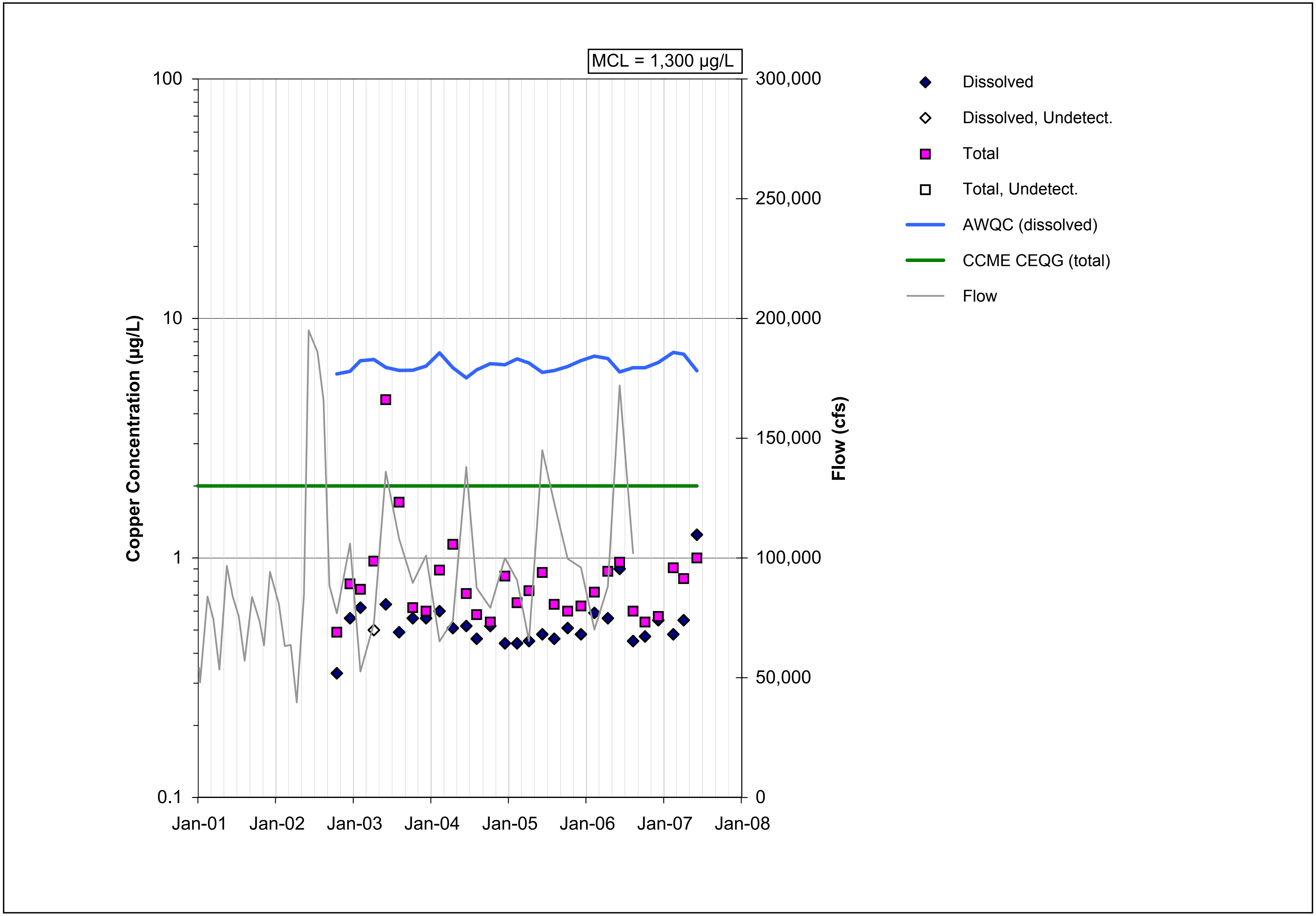

Figure 8. Dissolved and Total Recoverable Copper Concentrations in Surface Water Samples Collected at Northport (2001–2007)

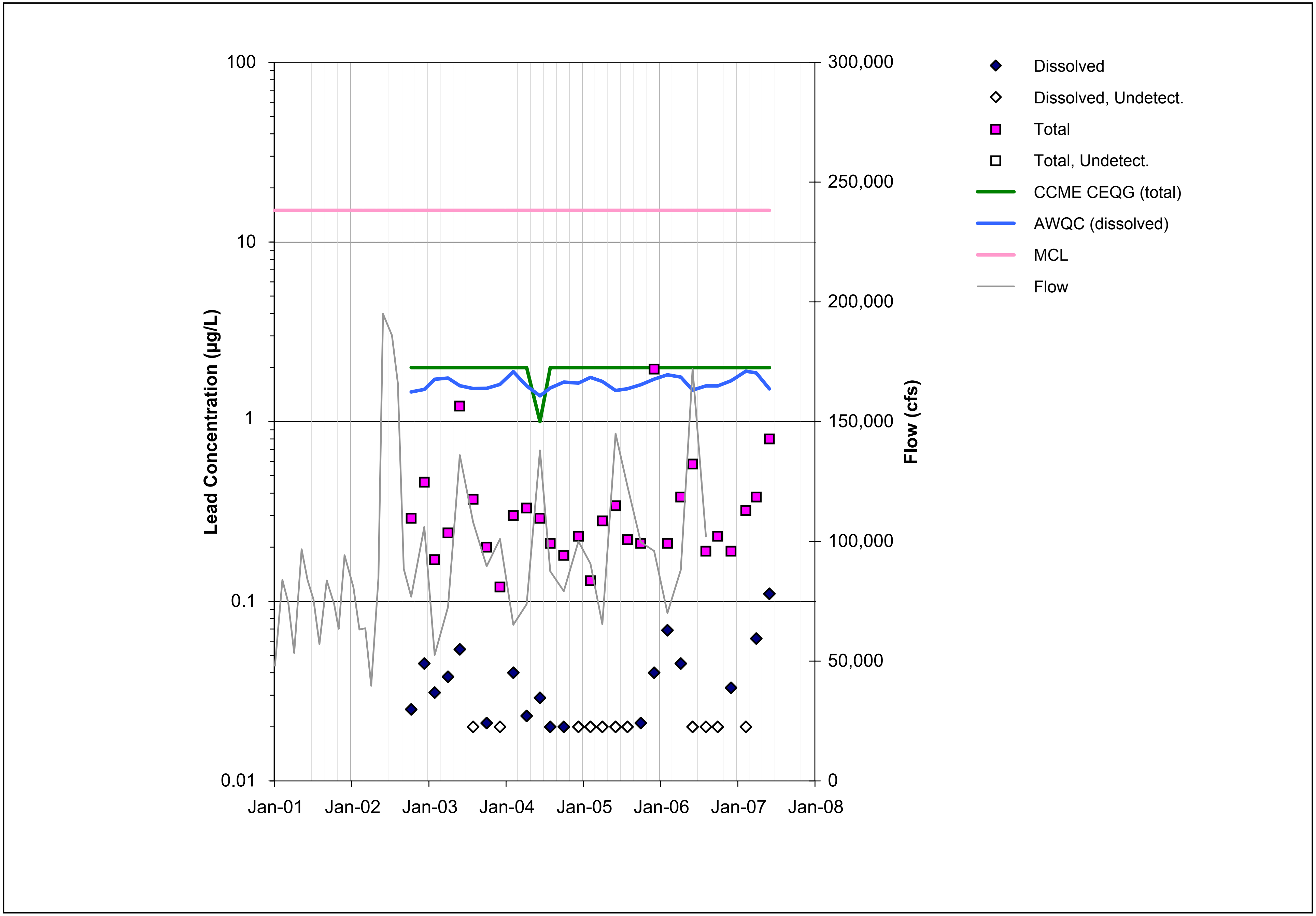

Figure 9. Dissolved and Total Recoverable Lead Concentrations in Surface Water Samples Collected at Northport (2001–2007)

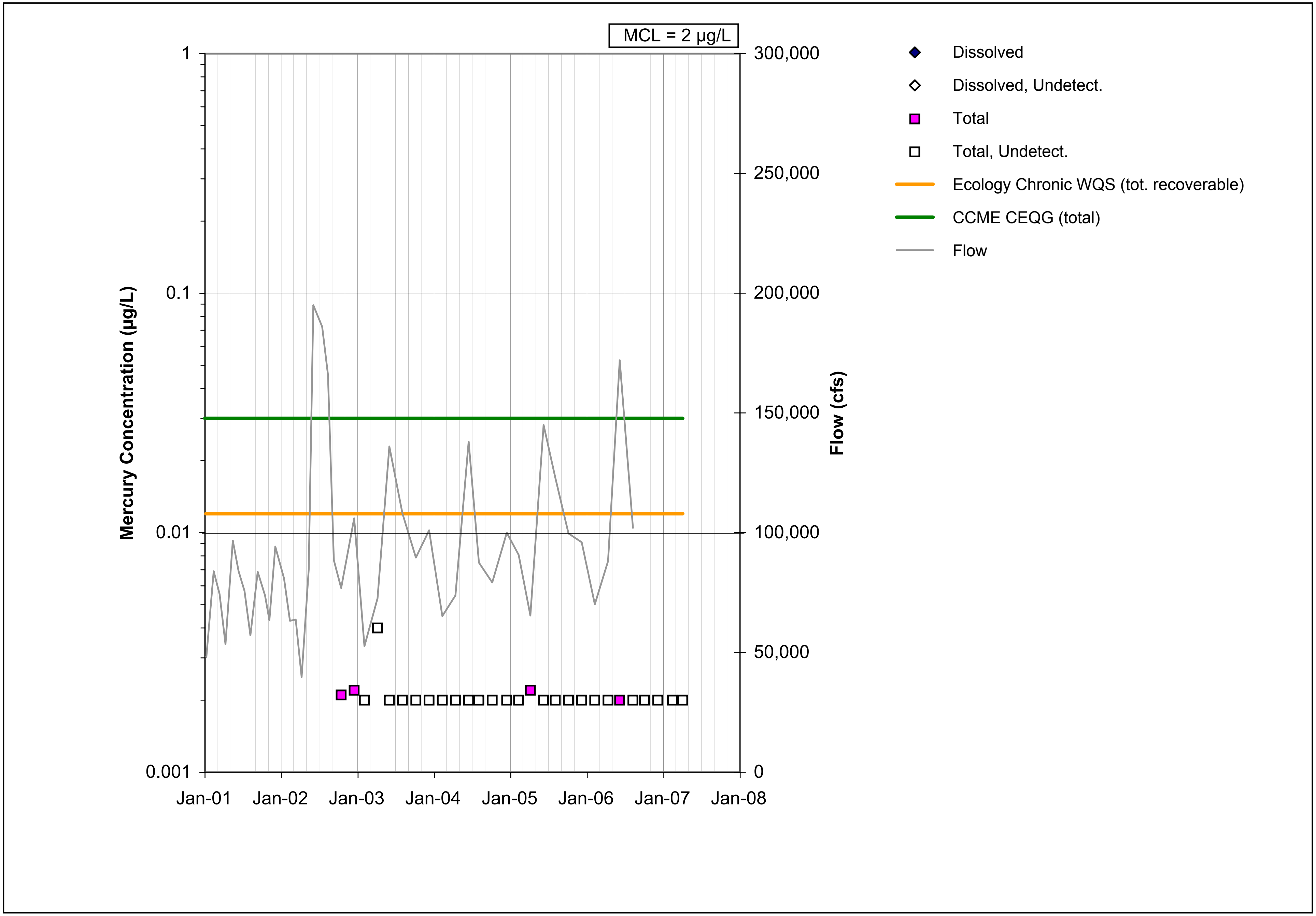

Figure 10. Dissolved and Total Recoverable Mercury Concentrations in Surface Water Samples Collected at Northport (2001–2007)

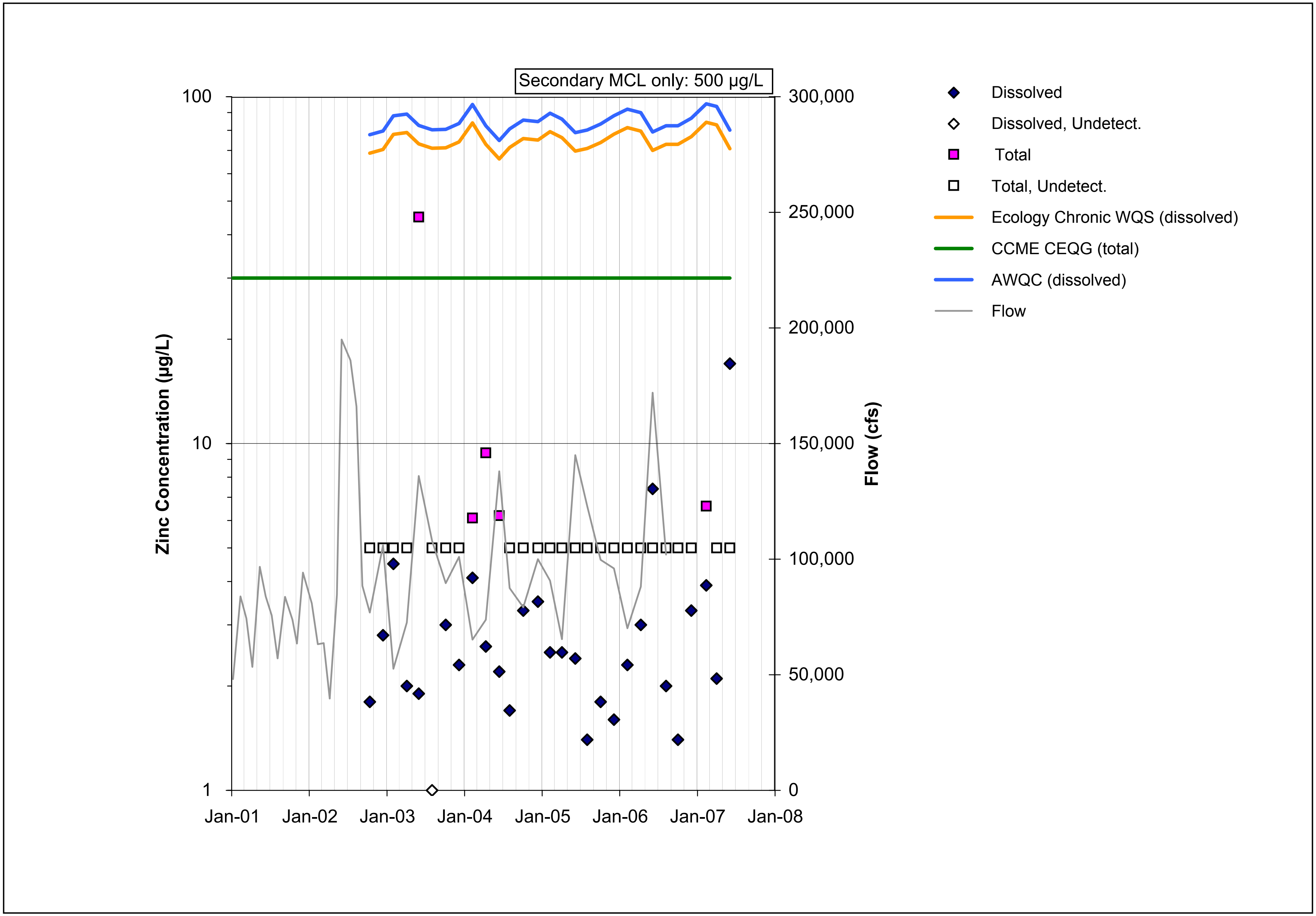

Figure 11. Dissolved and Total Recoverable Zinc Concentrations in Surface Water Samples Collected at Northport (2001–2007)

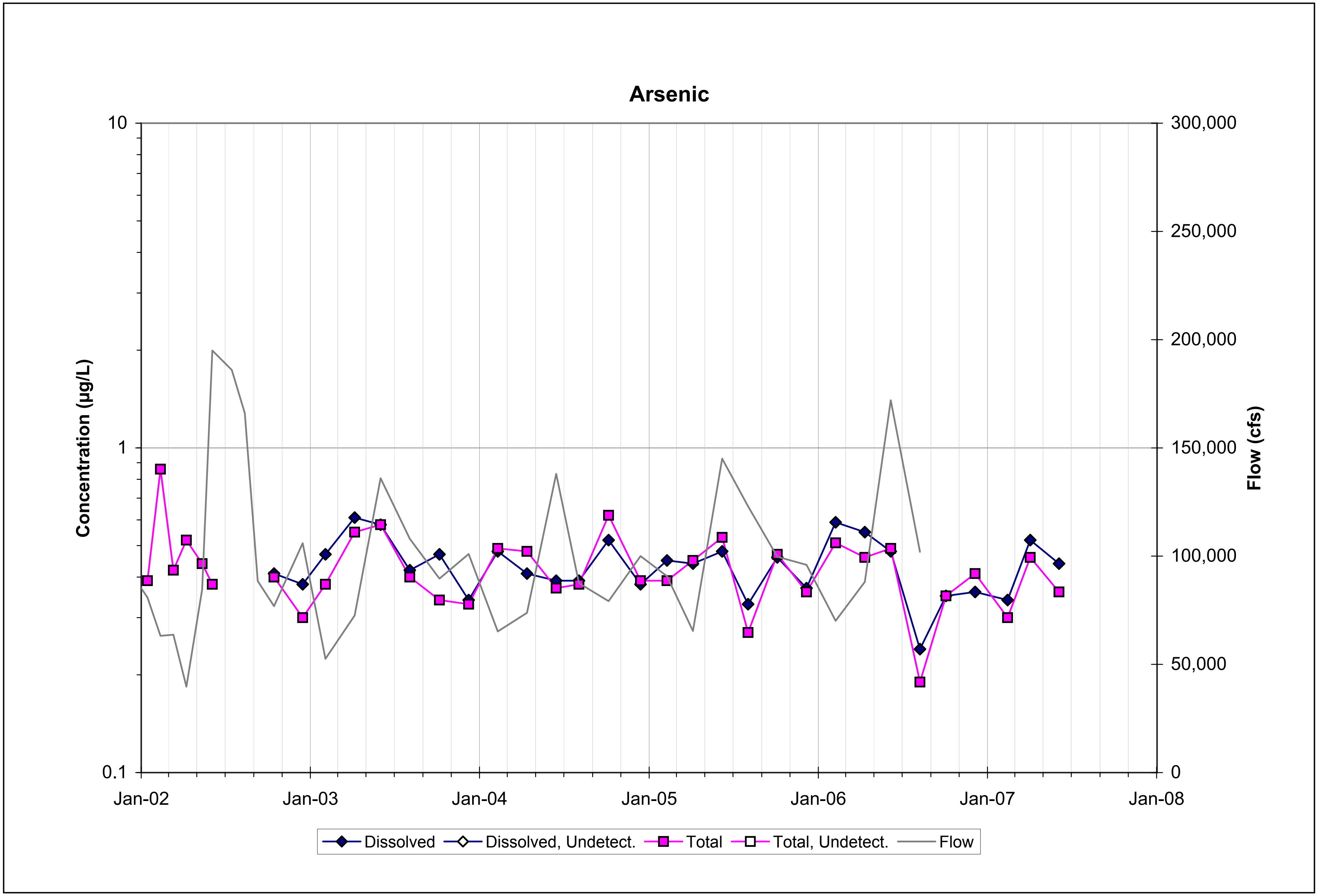

Figure 12. Dissolved and Total Recoverable Arsenic Concentrations in Surface Water Samples Collected at Northport (2002–2007)

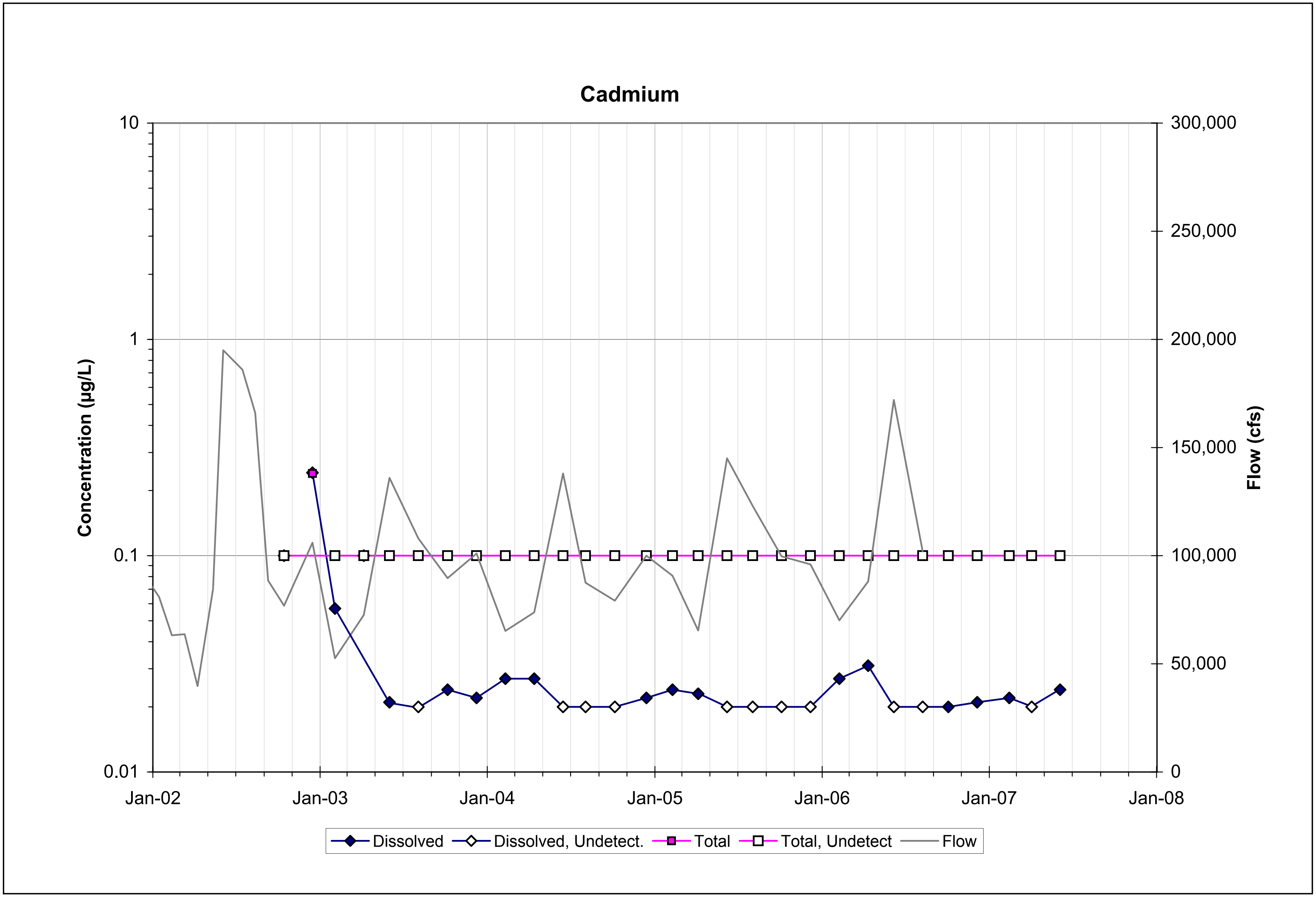

Figure 13. Dissolved and Total Recoverable Cadmium Concentrations in Surface Water Samples Collected at Northport (2002–2007)

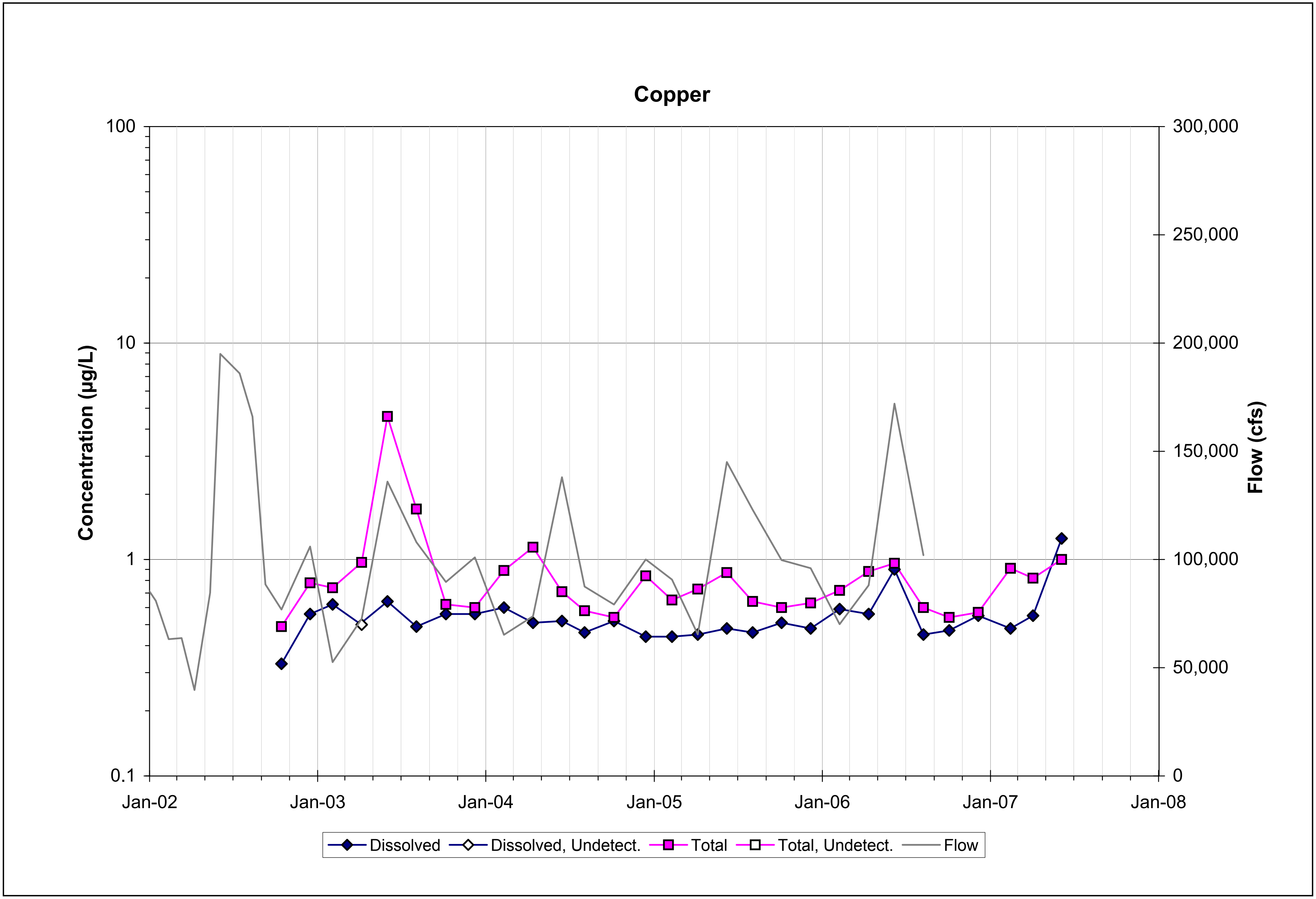

Figure 14. Dissolved and Total Recoverable Copper Concentrations in Surface Water Samples Collected at Northport (2002–2007)

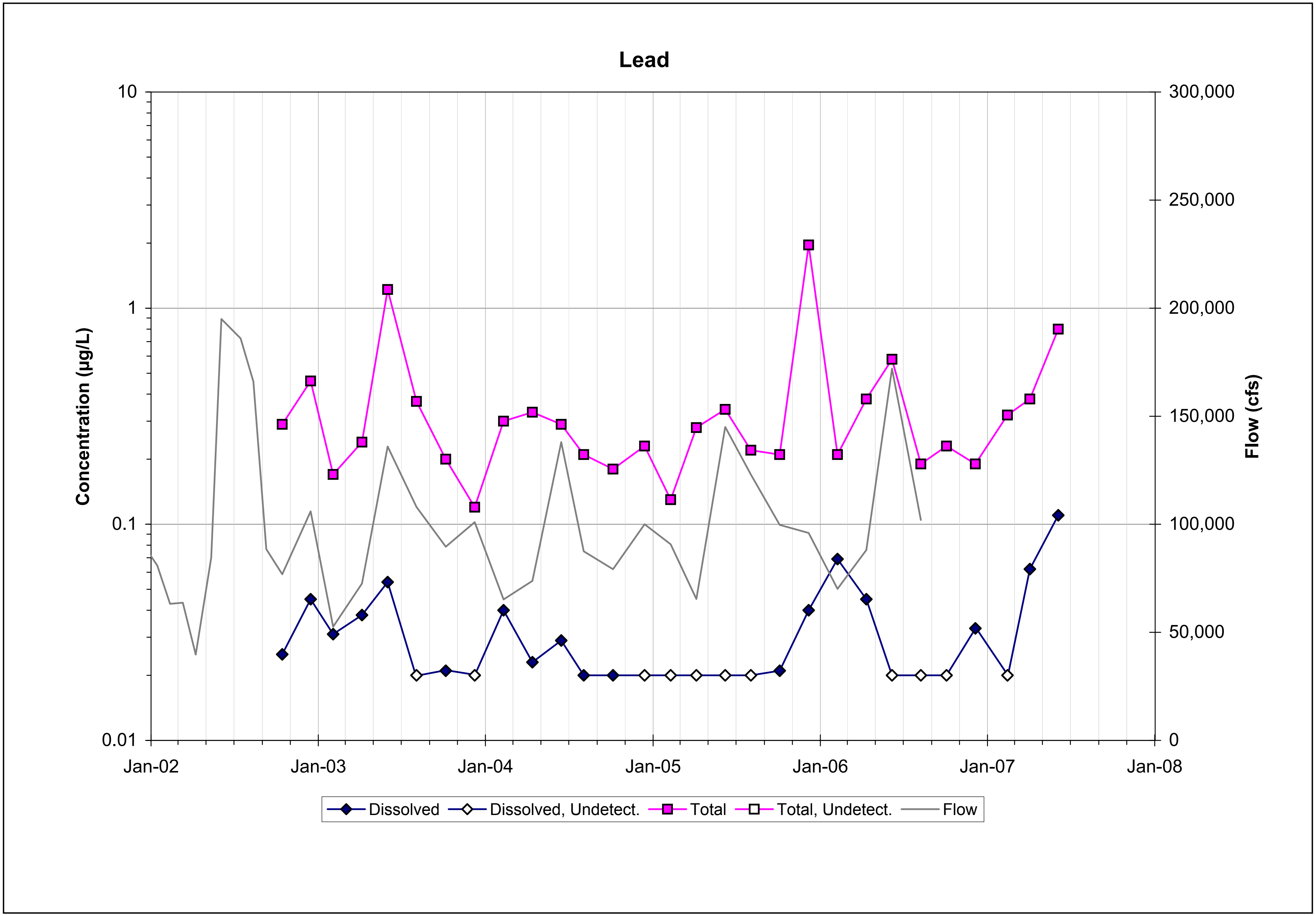

Figure 15. Dissolved and Total Recoverable Lead Concentrations in Surface Water Samples Collected at Northport (2002–2007)

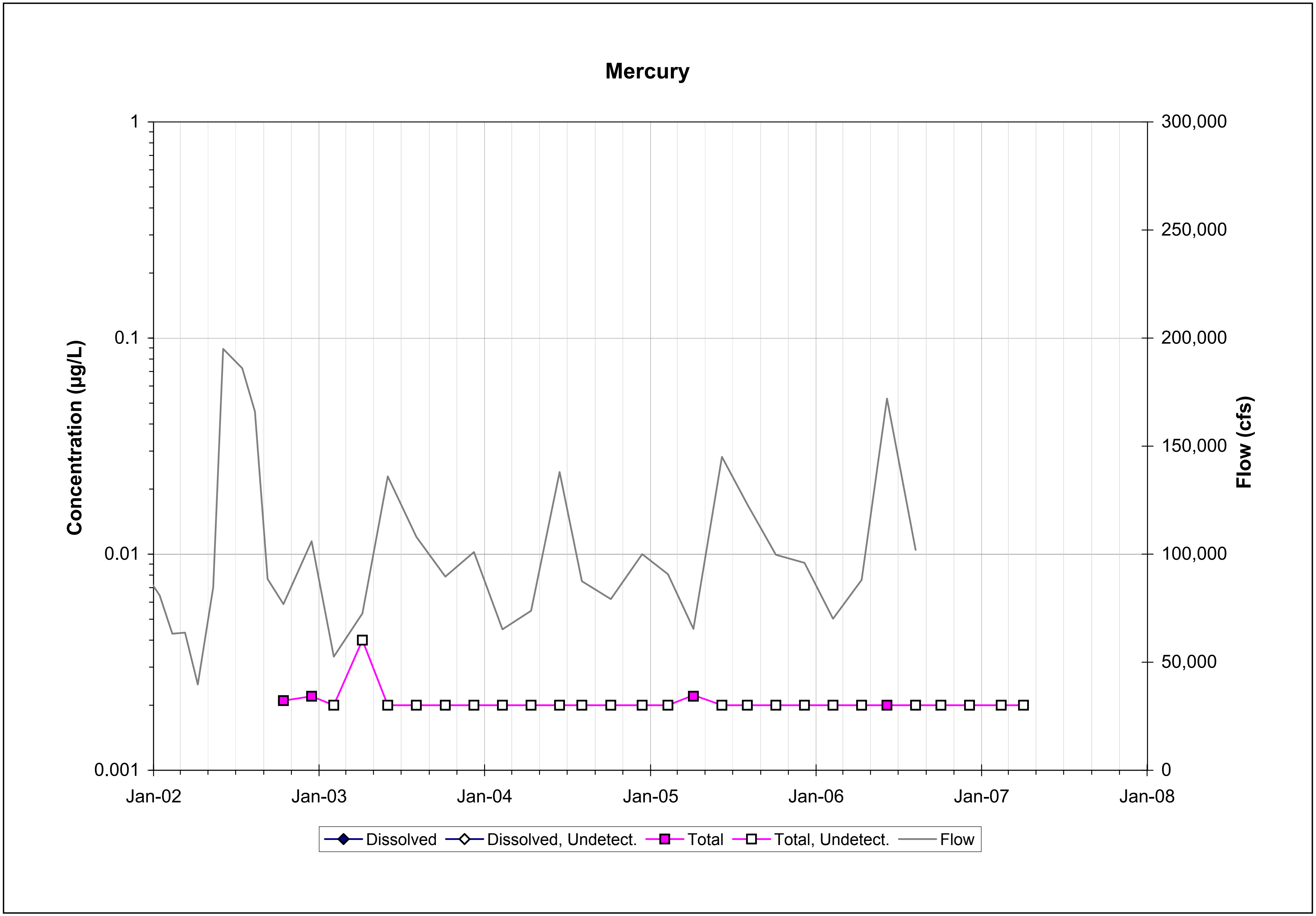

Figure 16. Dissolved and Total Recoverable Mercury Concentrations in Surface Water Samples Collected at Northport (2002–2007)

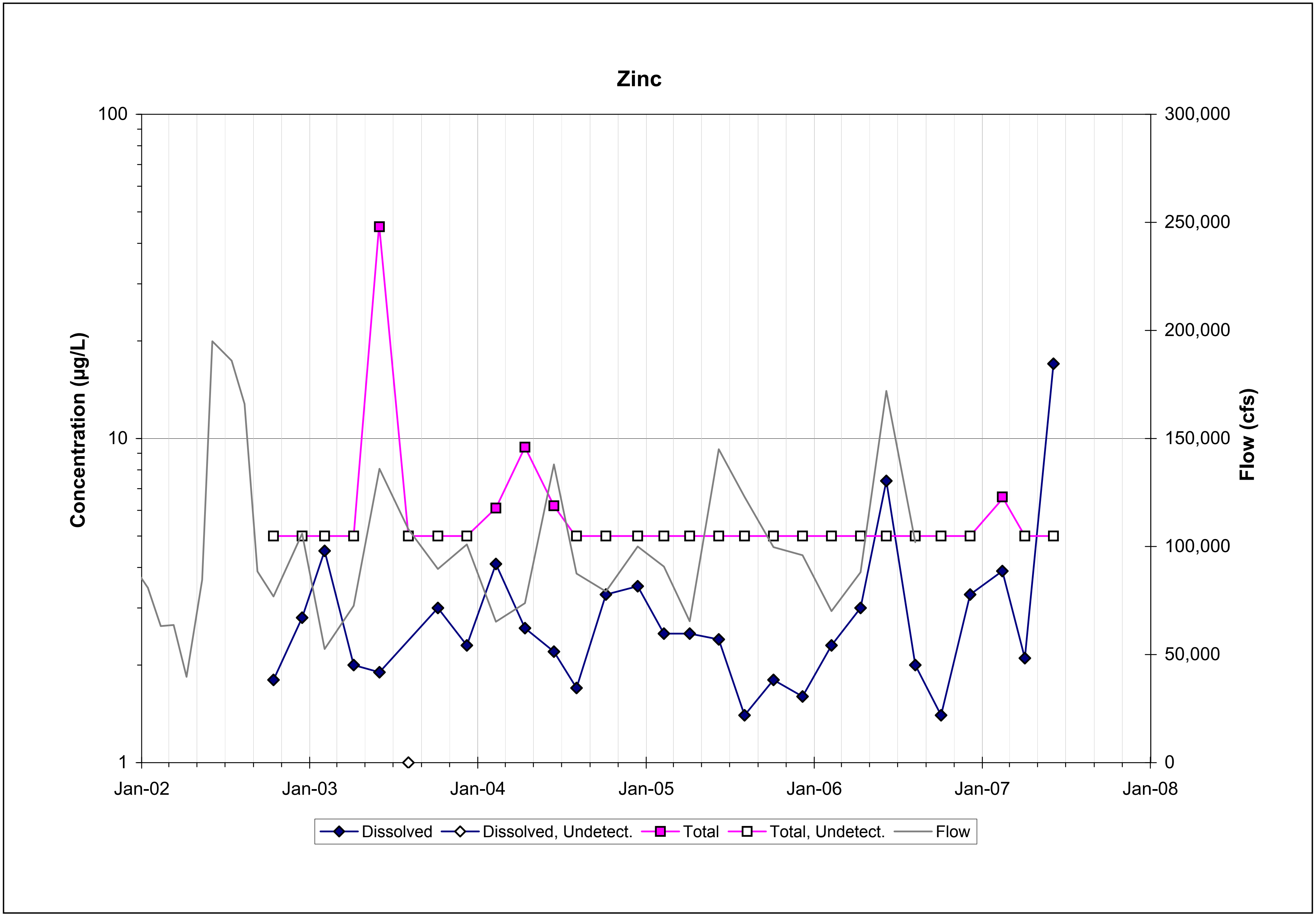

Figure 17. Dissolved and Total Recoverable Zinc Concentrations
in Surface Water Samples Collected at Northport (2002–2007)

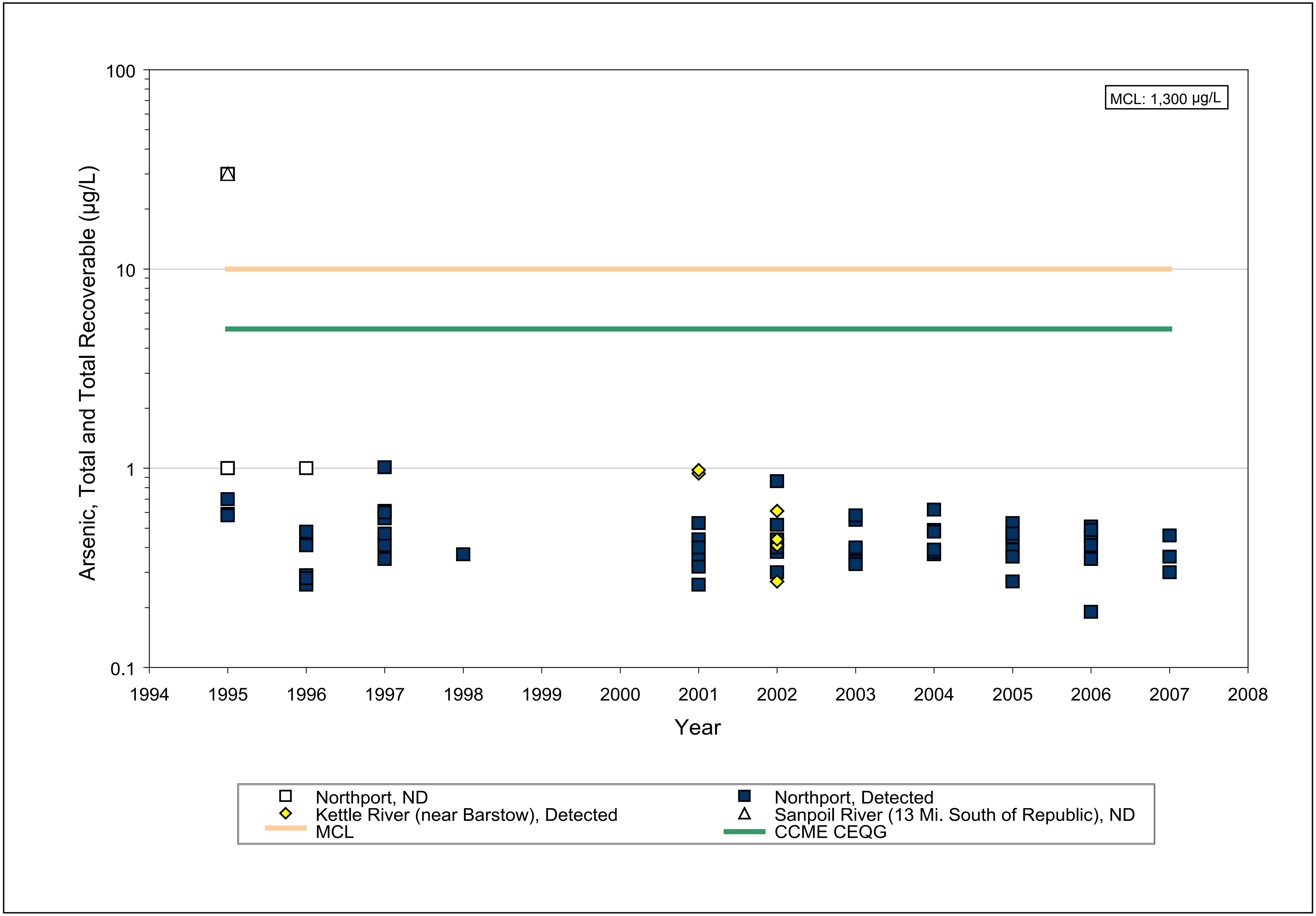

Figure 18. Available Total and Total Recoverable Arsenic Concentrations, Northport and Major Tributaries (1995–2007)

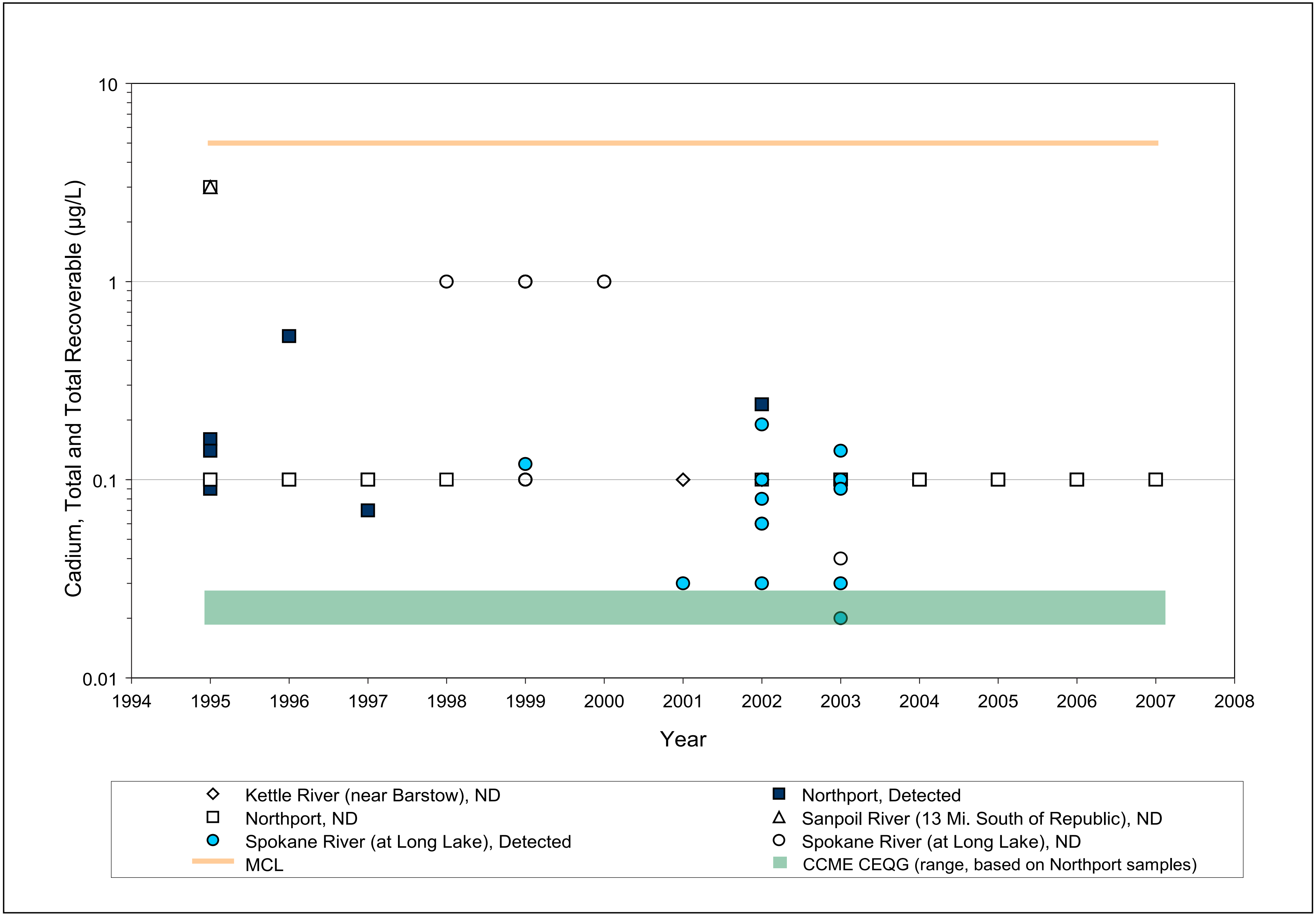

Figure 19. Available Total and Total Recoverable Cadmium Concentrations, Northport and Major Tributaries (1995–2007)

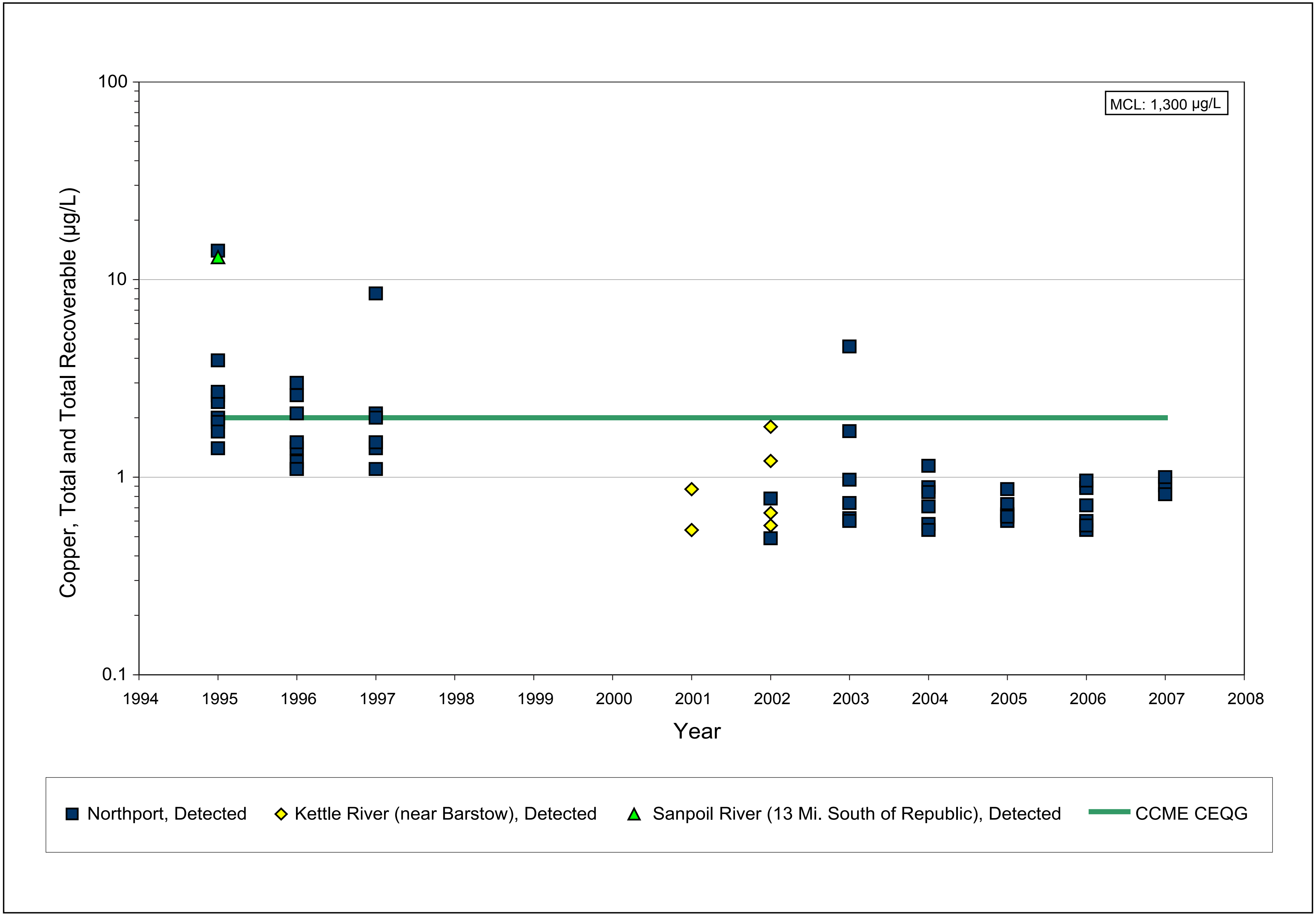

Figure 20. Available Total and Total Recoverable Copper Concentrations, Northport and Major Tributaries (1995–2007)

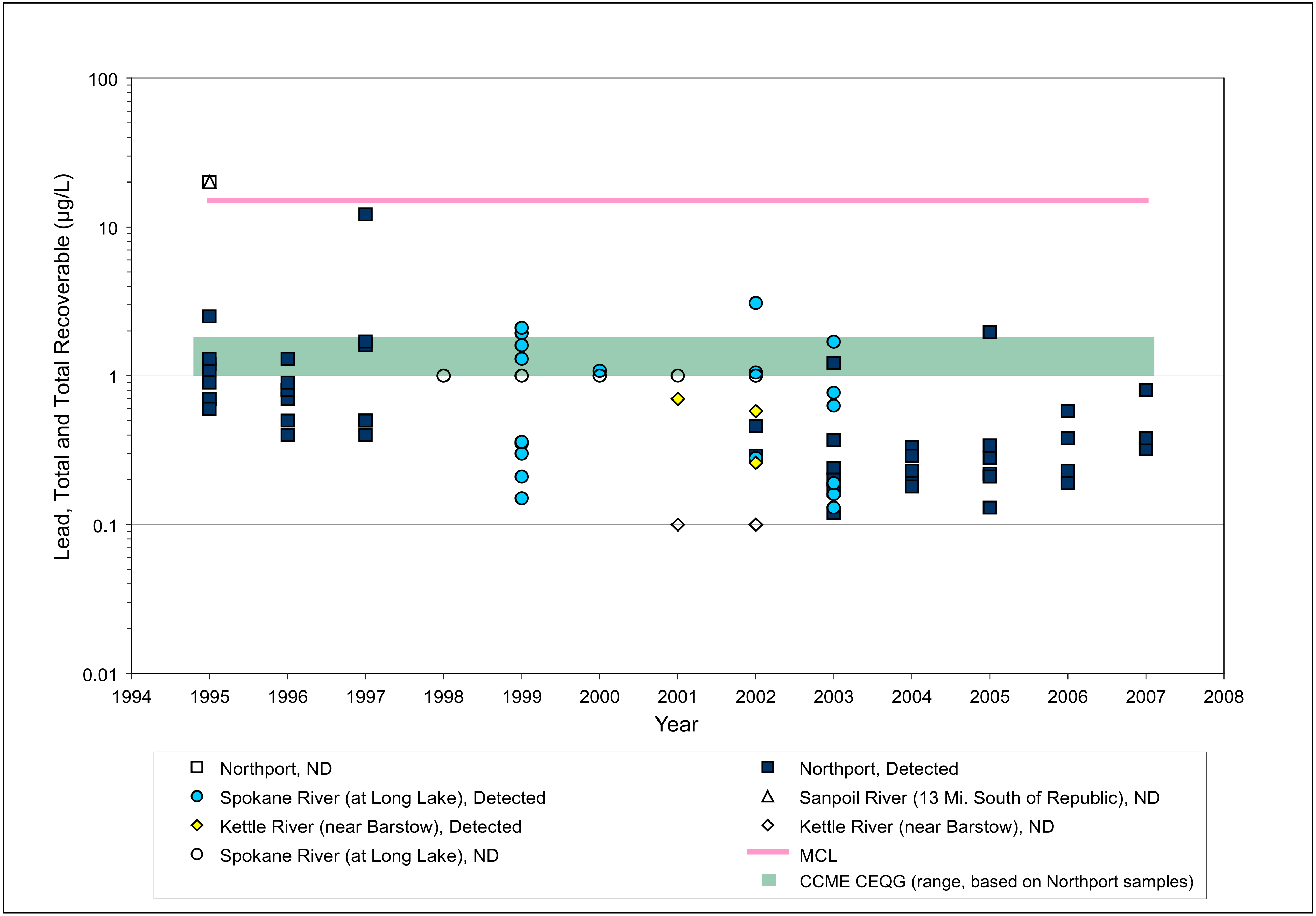

Figure 21. Available Total and Total Recoverable Lead Concentrations, Northport and Major Tributaries (1995–2007)

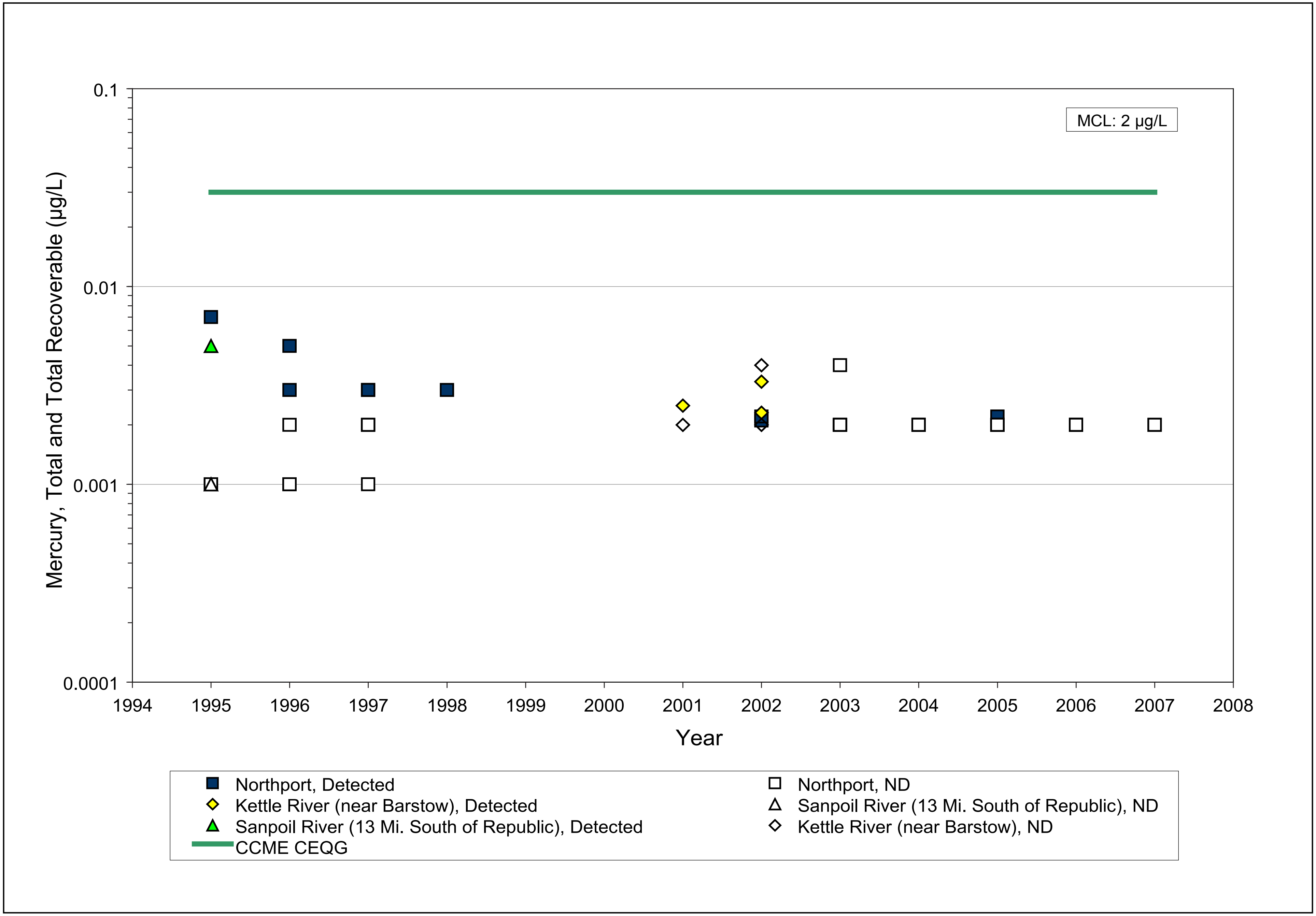

Figure 22. Available Total and Total Recoverable Mercury Concentrations, Northport and Major Tributaries (1995–2007)

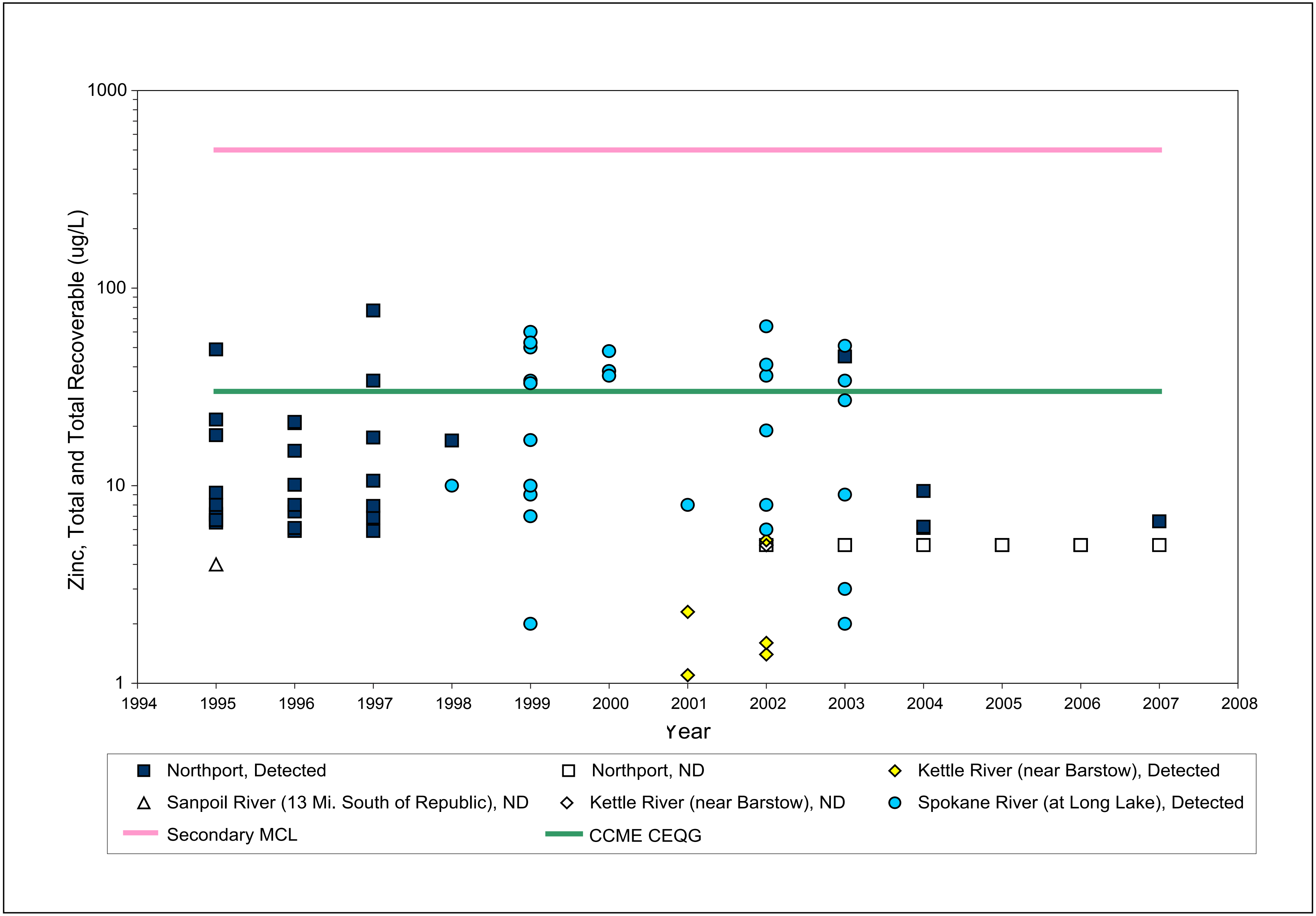

Figure 23. Available Total and Total Recoverable Zinc Concentrations, Northport and Major Tributaries (1995–2007)

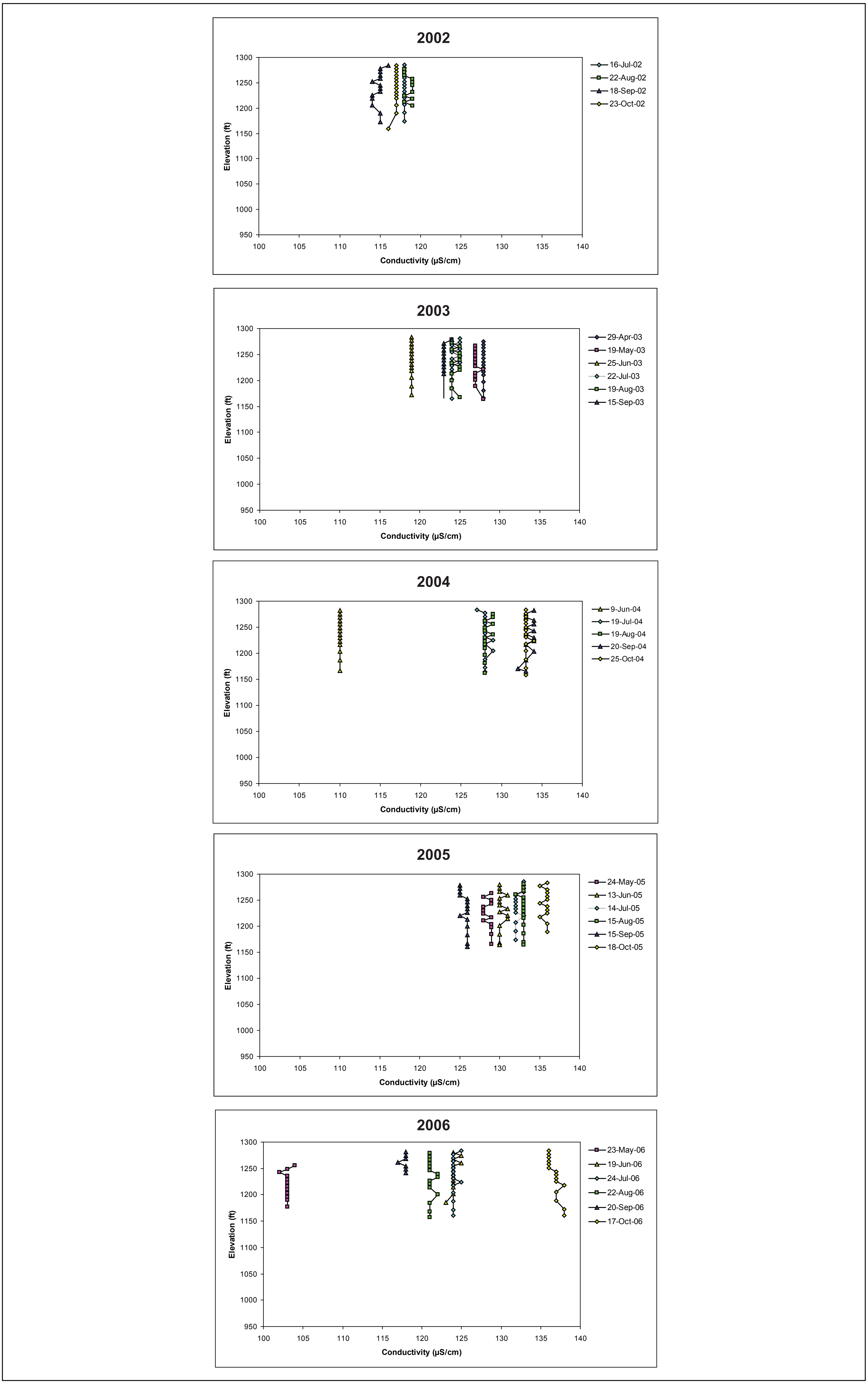

Figure 24. Conductivity Profiles from USBR Kettle Falls Station, 2002–2006

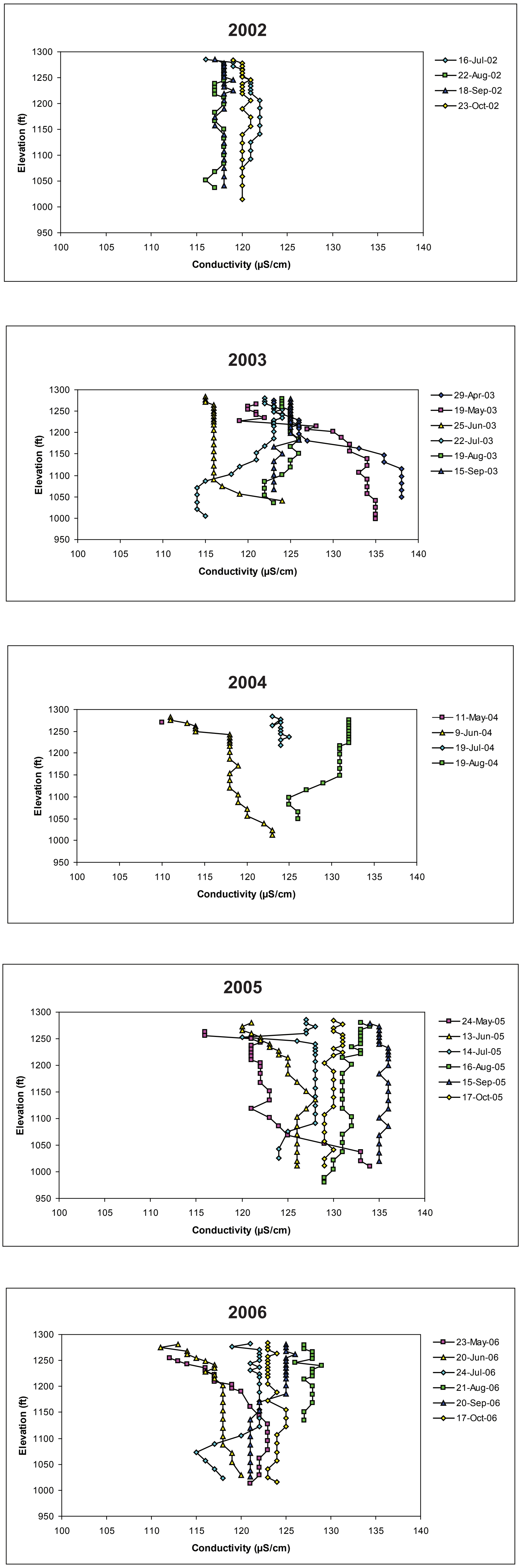

Figure 25. Conductivity Profiles from USBR Lincoln Boat Ramp Station, 2002–2006

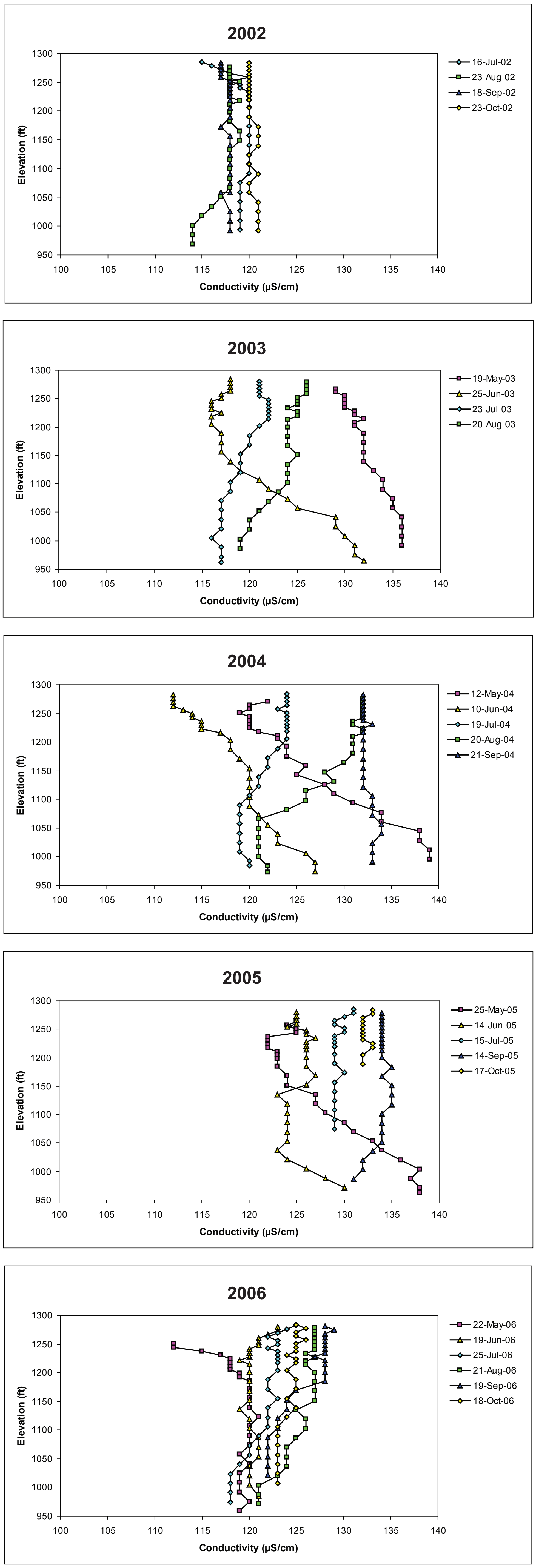

Figure 26. Conductivity Profiles from USBR Keller Ferry Station, 2002–2006

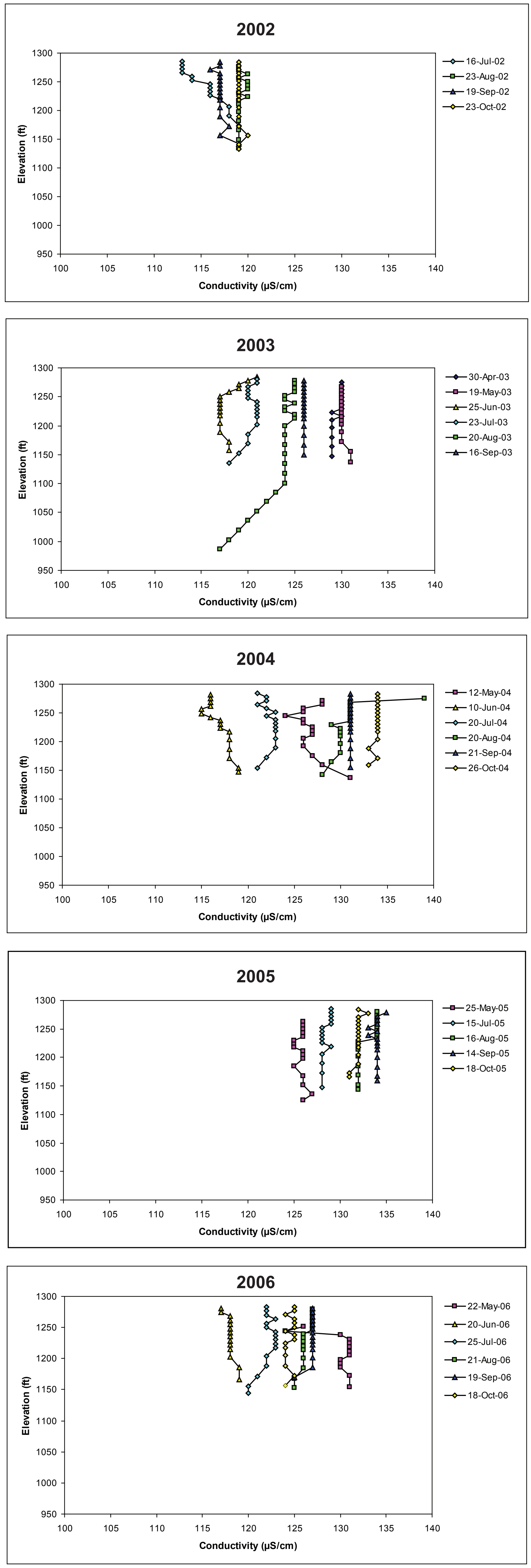

Figure 27. Conductivity Profiles from USBR Logboom Station, 2002–2006

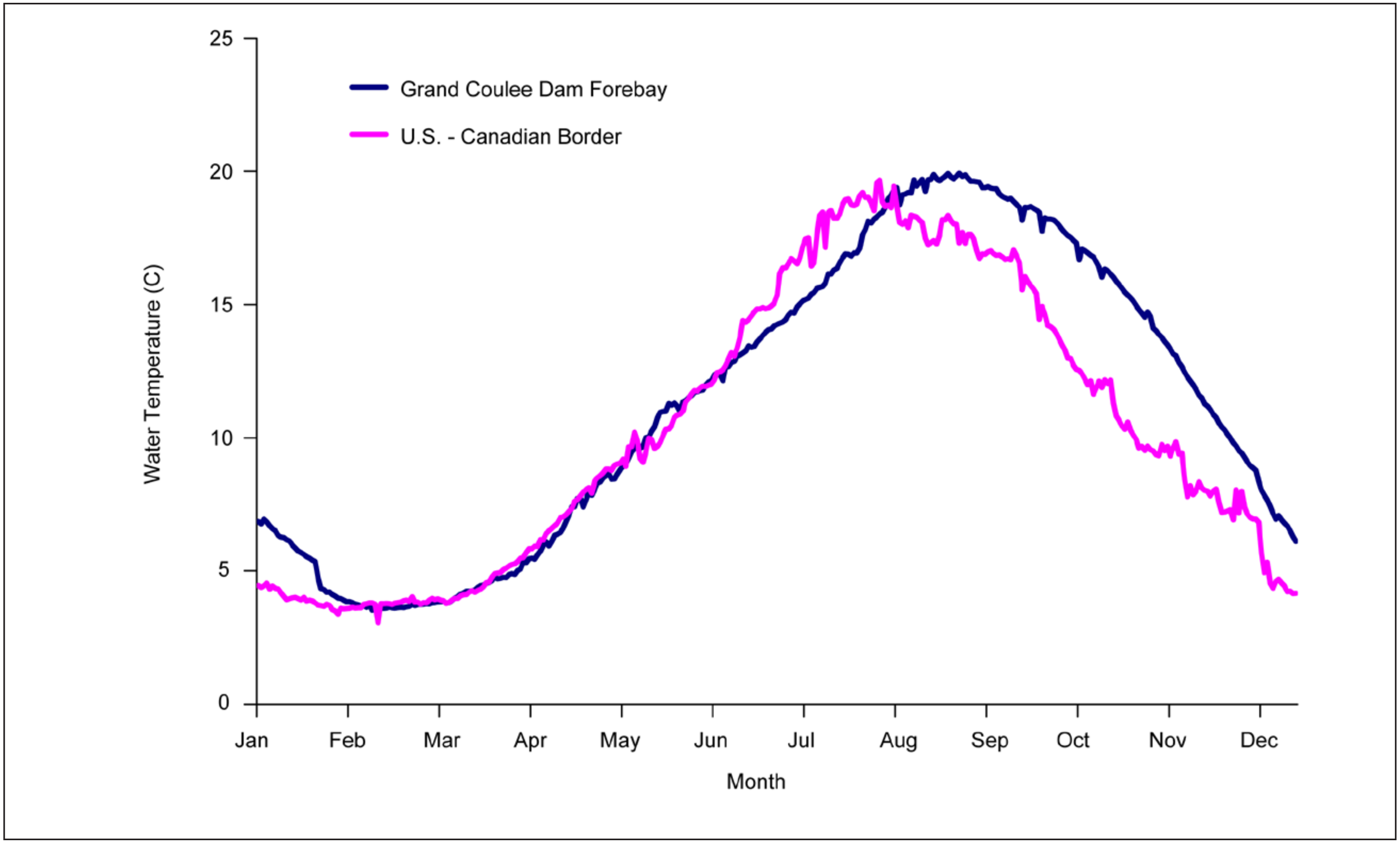

Figure 28. Daily Average Water Temperature at the U.S.-Canada Border and Grand Coulee Dam Forebay, 1998-2003
Data Sources: U.S. Army Corps DART (Data Access in Real Time)
http://www.cqs.washington.edu/dart/dart.html (September 2006).
Grand Coulee Dam Forebay: Collected by U.S. Army Corps of Engineers, Water Management Division Year-Round Automated Station, RM 596.6 Lat 47°57'24"; Long 118°58'35"; Sensor Depth 15 ft.
U.S.-Canada Border Boundary: U.S. Army Corps of Engineers, Water Management Division CIBW: Year-Round Automated Station, RM 746 Lat 48°58'16.9"; Long 117°38'44.9"; Sensor Depth 15 ft.
Note: Temperature measurements collected in the forebay are taken at a specific elevation and do not represent the entire water column.

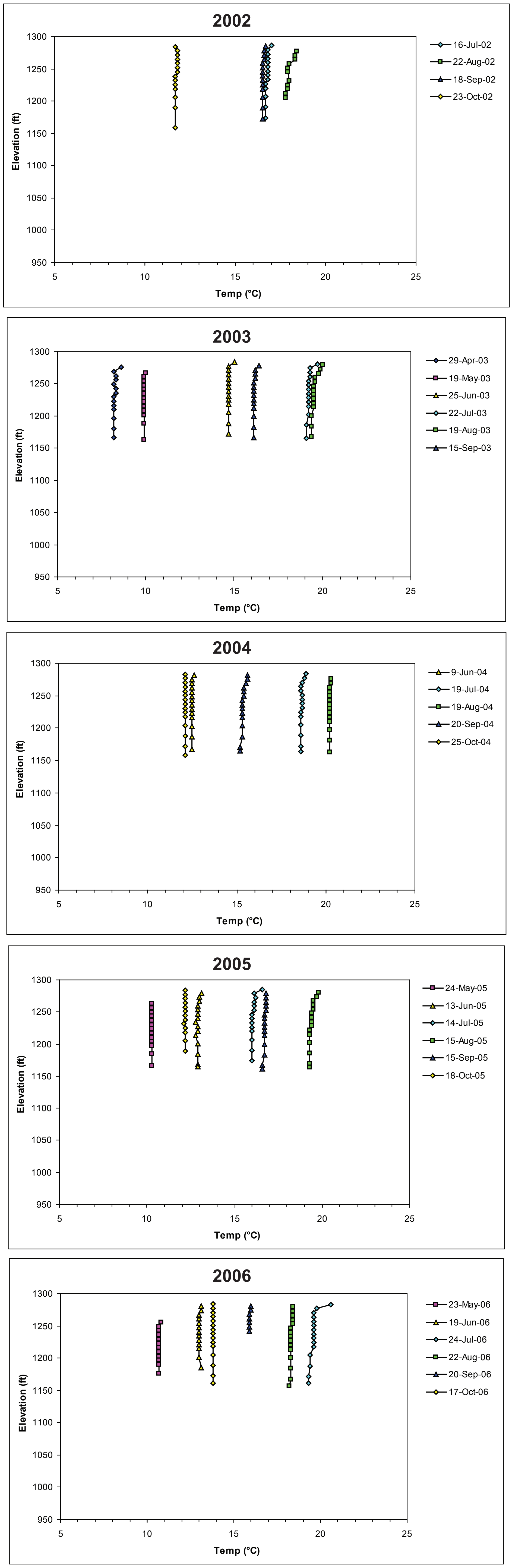

Figure 29. Temperature Profiles from USBR Kettle Falls Station, 2002–2006

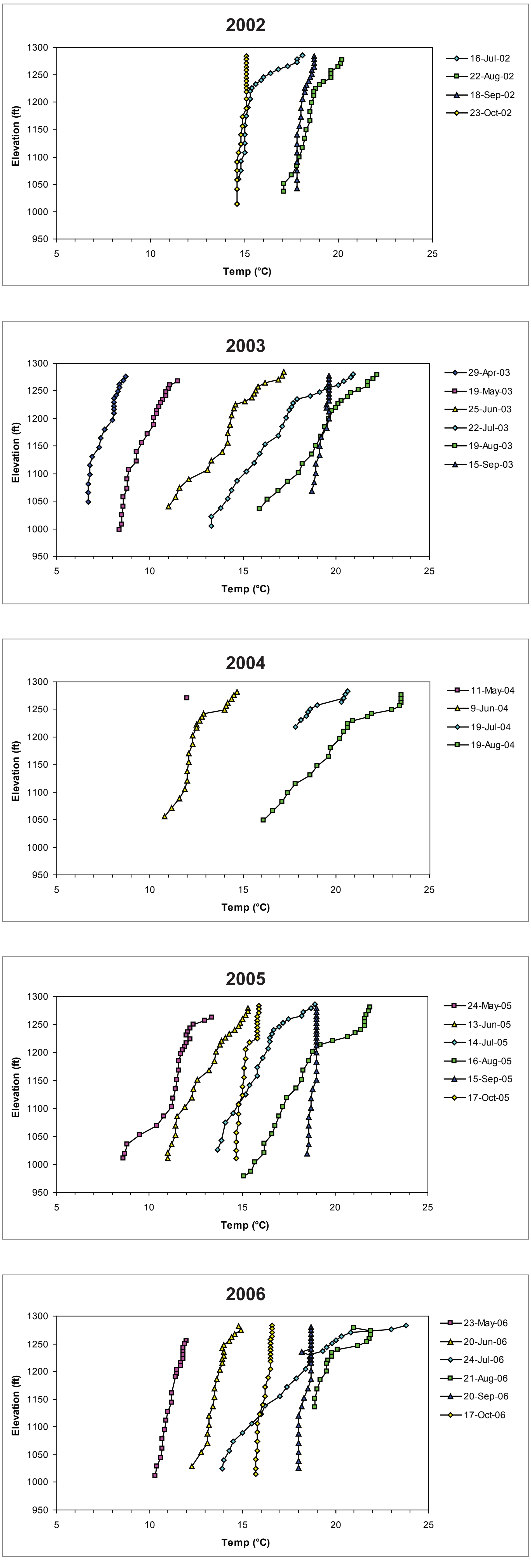

Figure 30. Temperature Profiles from USBR Lincoln Boat Ramp Station, 2002–2006

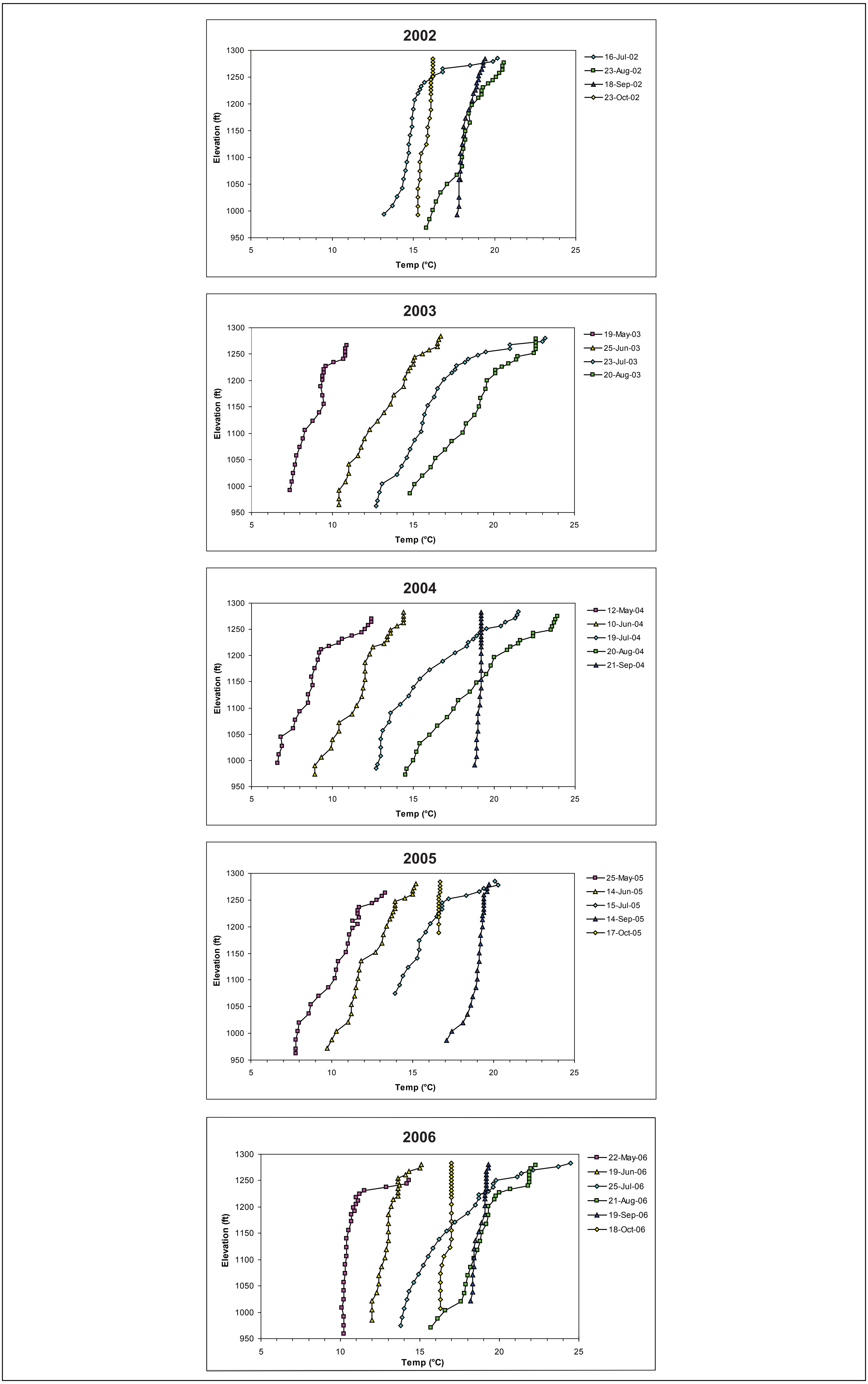

Figure 31. Temperature Profiles from USBR Keller Ferry Station, 2002–2006

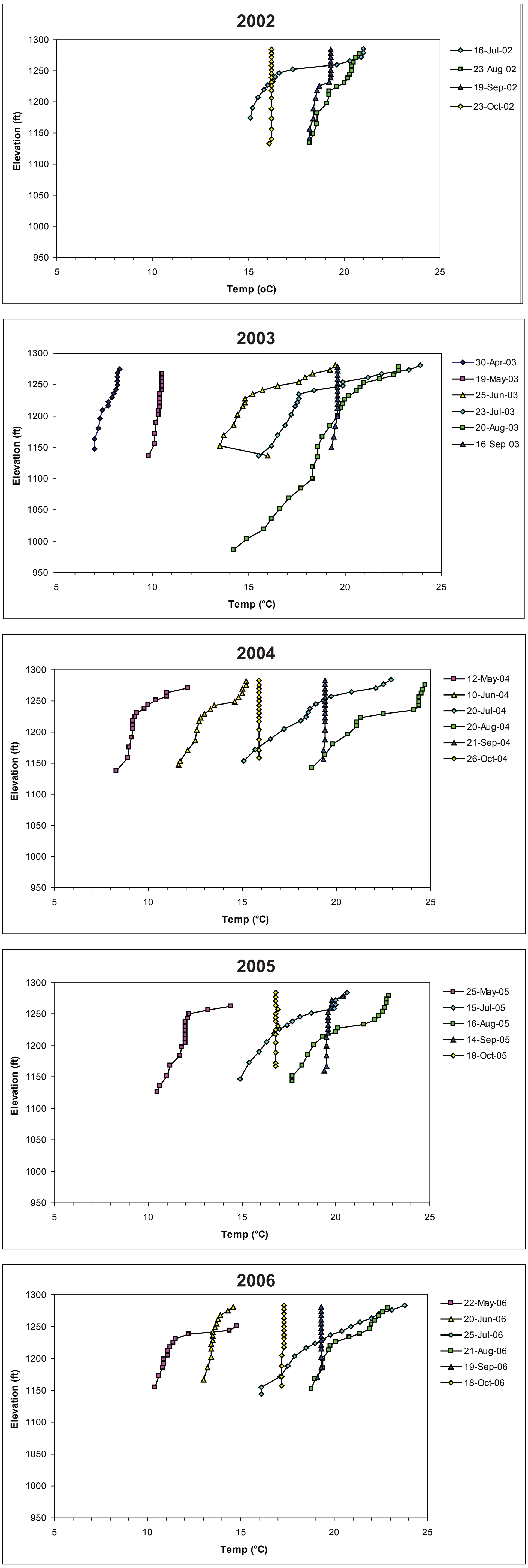

Figure 32. Temperature Profiles from USBR Logboom Station, 2002–2006

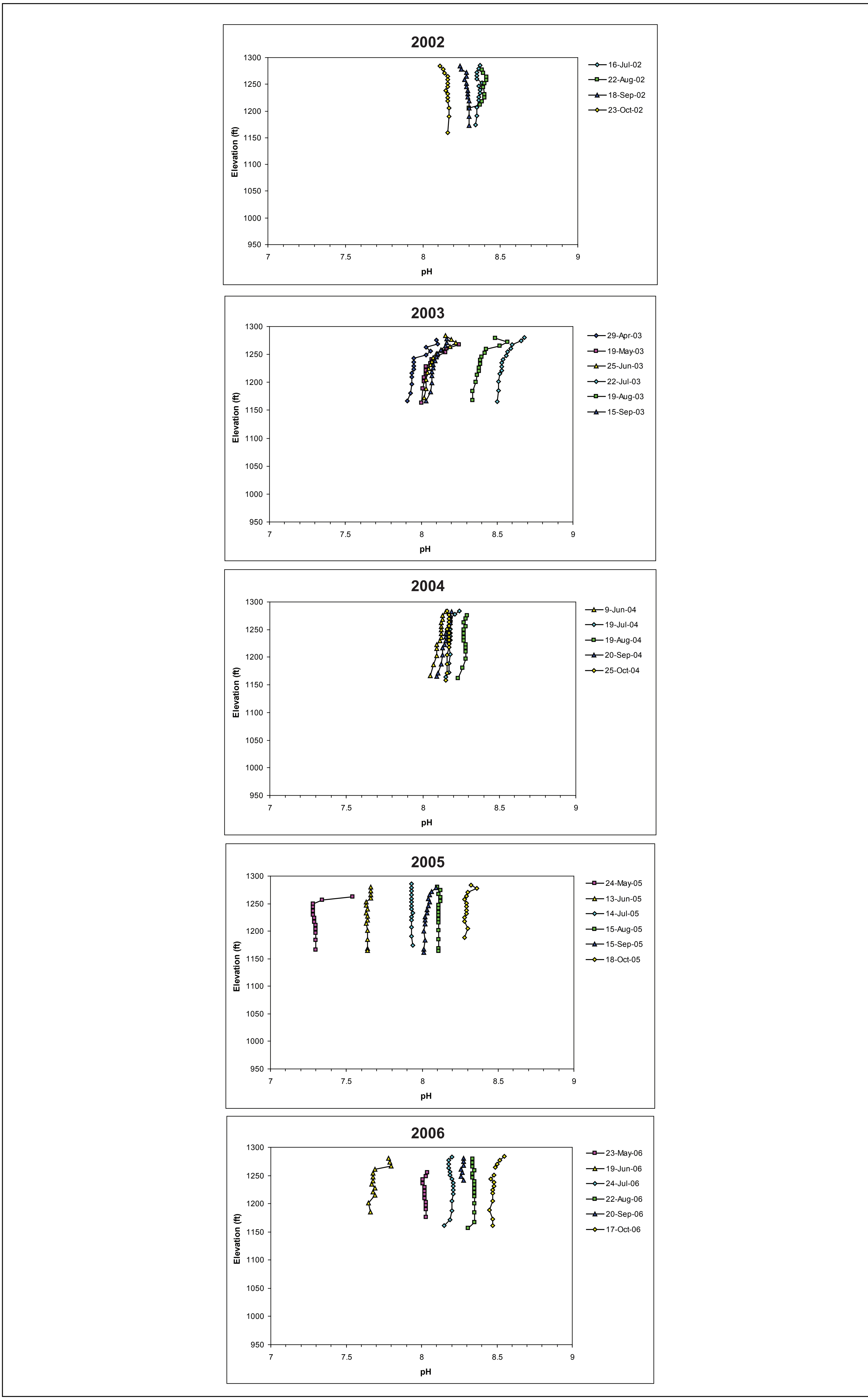

Figure 33. pH Profiles from USBR Kettle Falls Station, 2002–2006

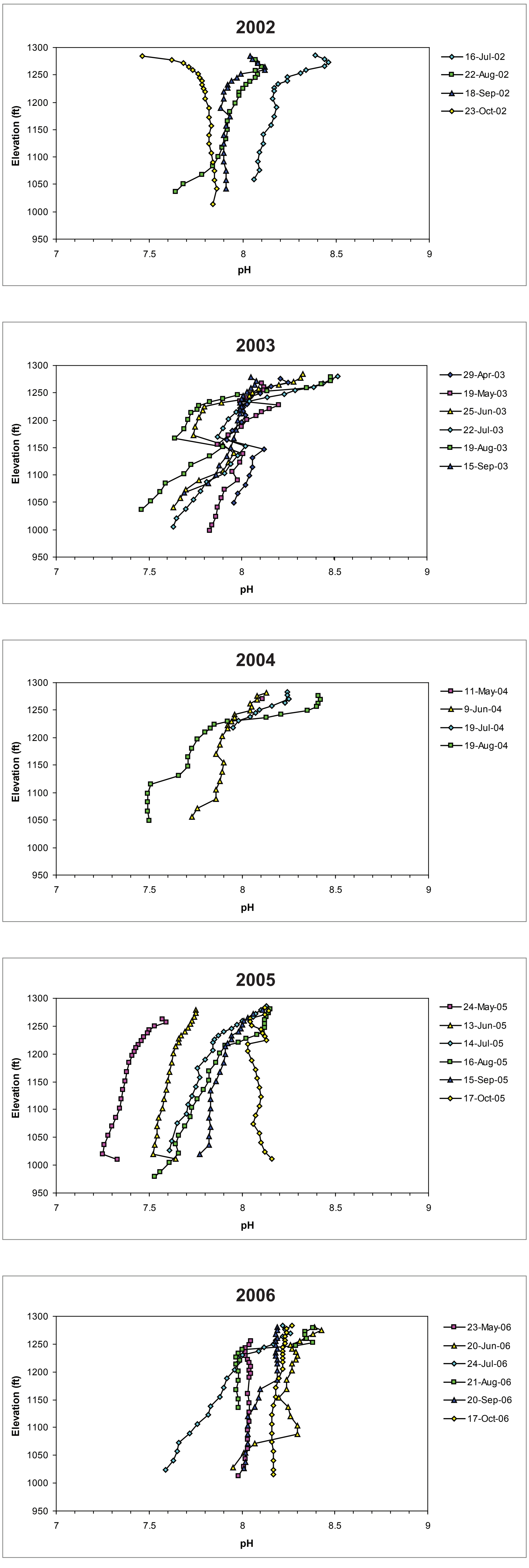

Figure 34. pH Profiles from USBR Lincoln Boat Ramp Station, 2002–2006

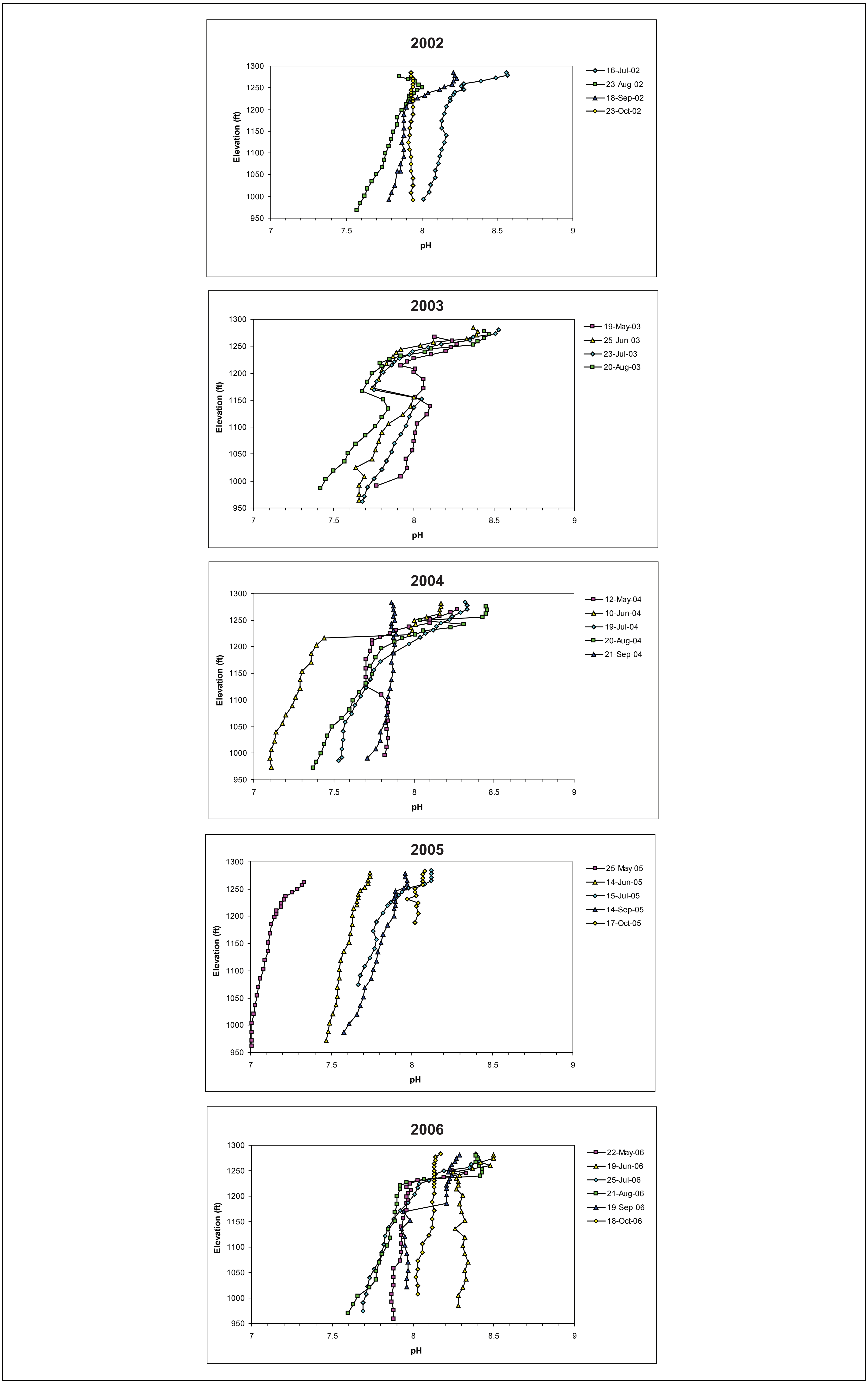

Figure 35. pH Profiles from USBR Keller Ferry Station, 2002–2006

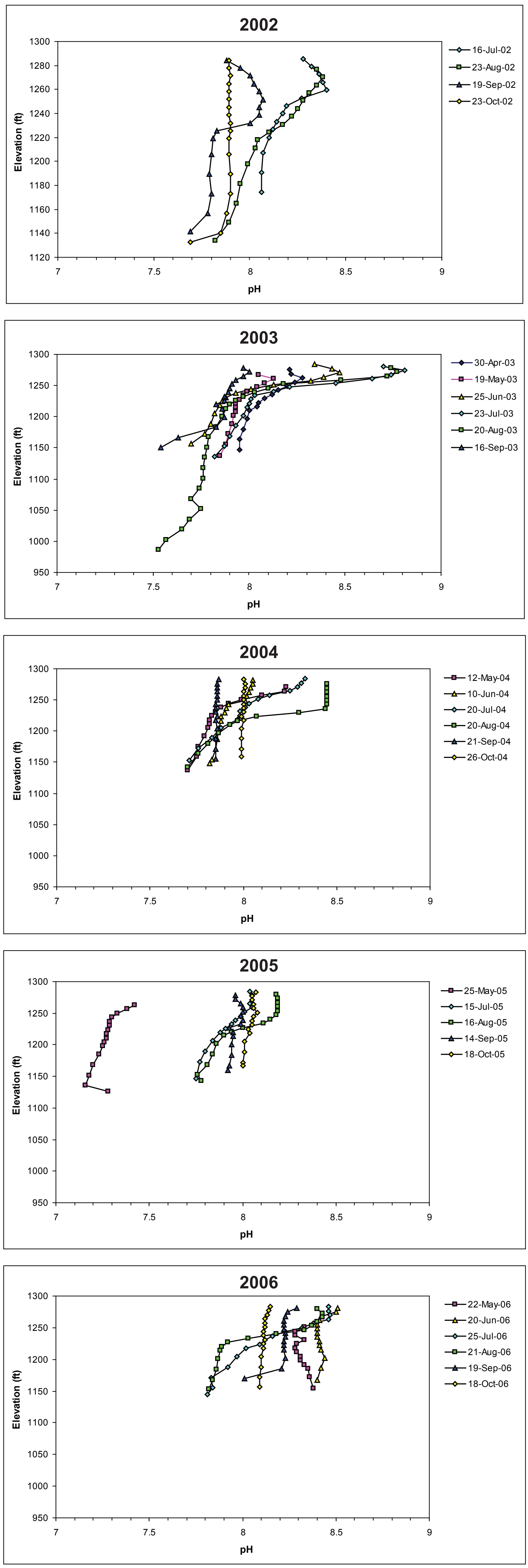

Figure 36. pH Profiles from USBR Logboom Station, 2002–2006

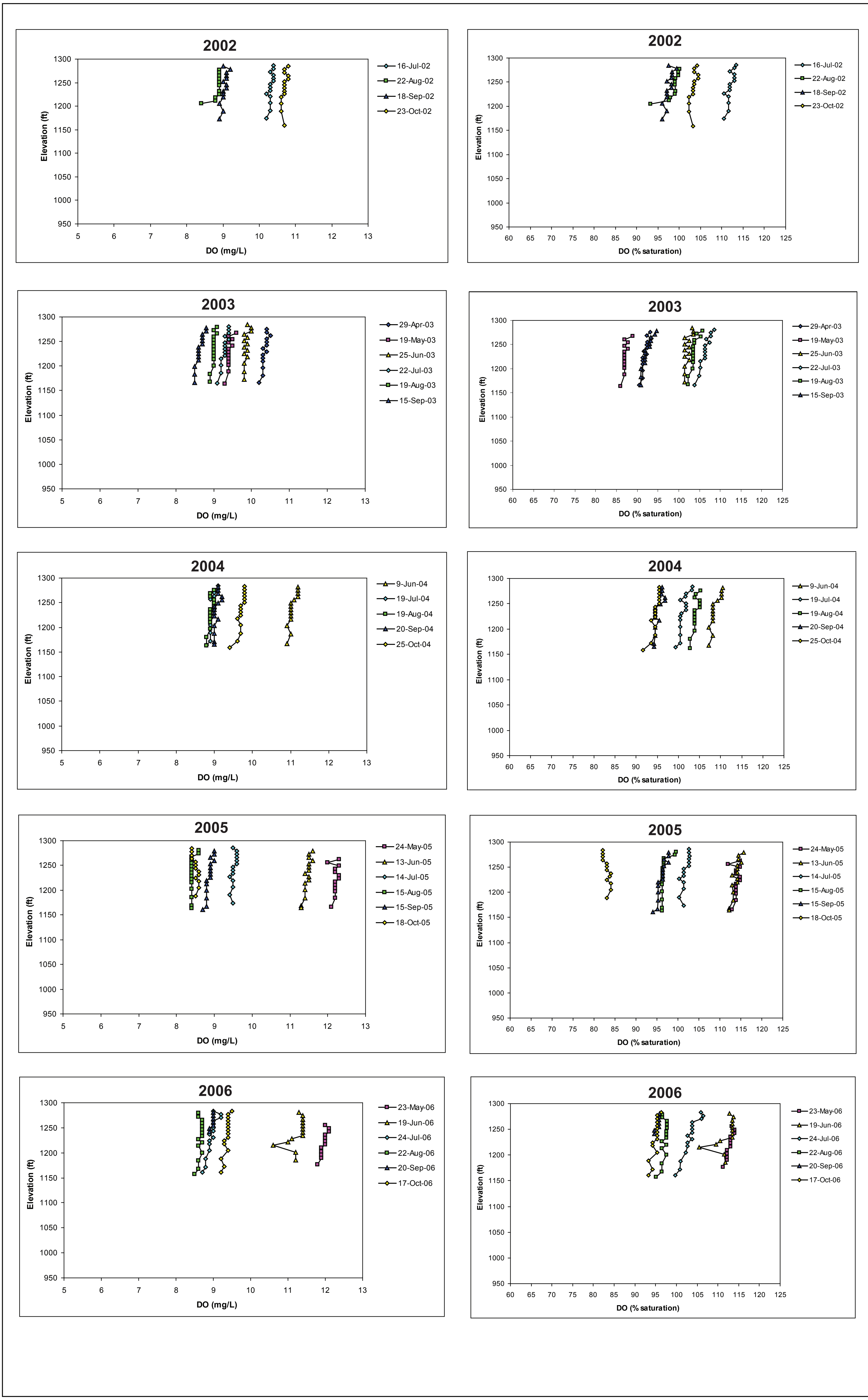

Figure 37. Dissolved Oxygen Profiles from USBR Kettle Falls Station, 2002–2006

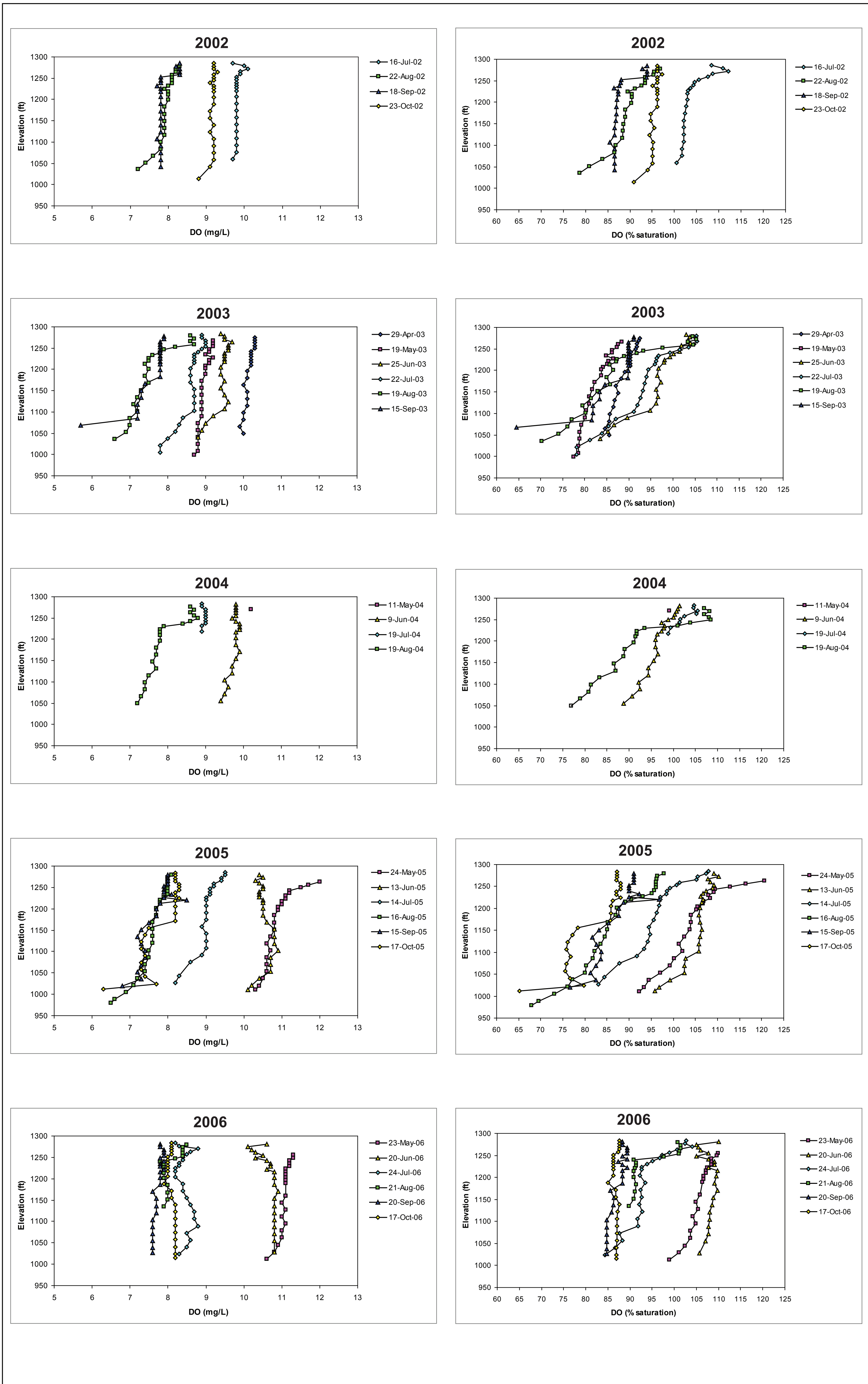

Figure 38. Dissolved Oxygen Profiles from USBR Lincoln Boat Ramp Station, 2002–2006

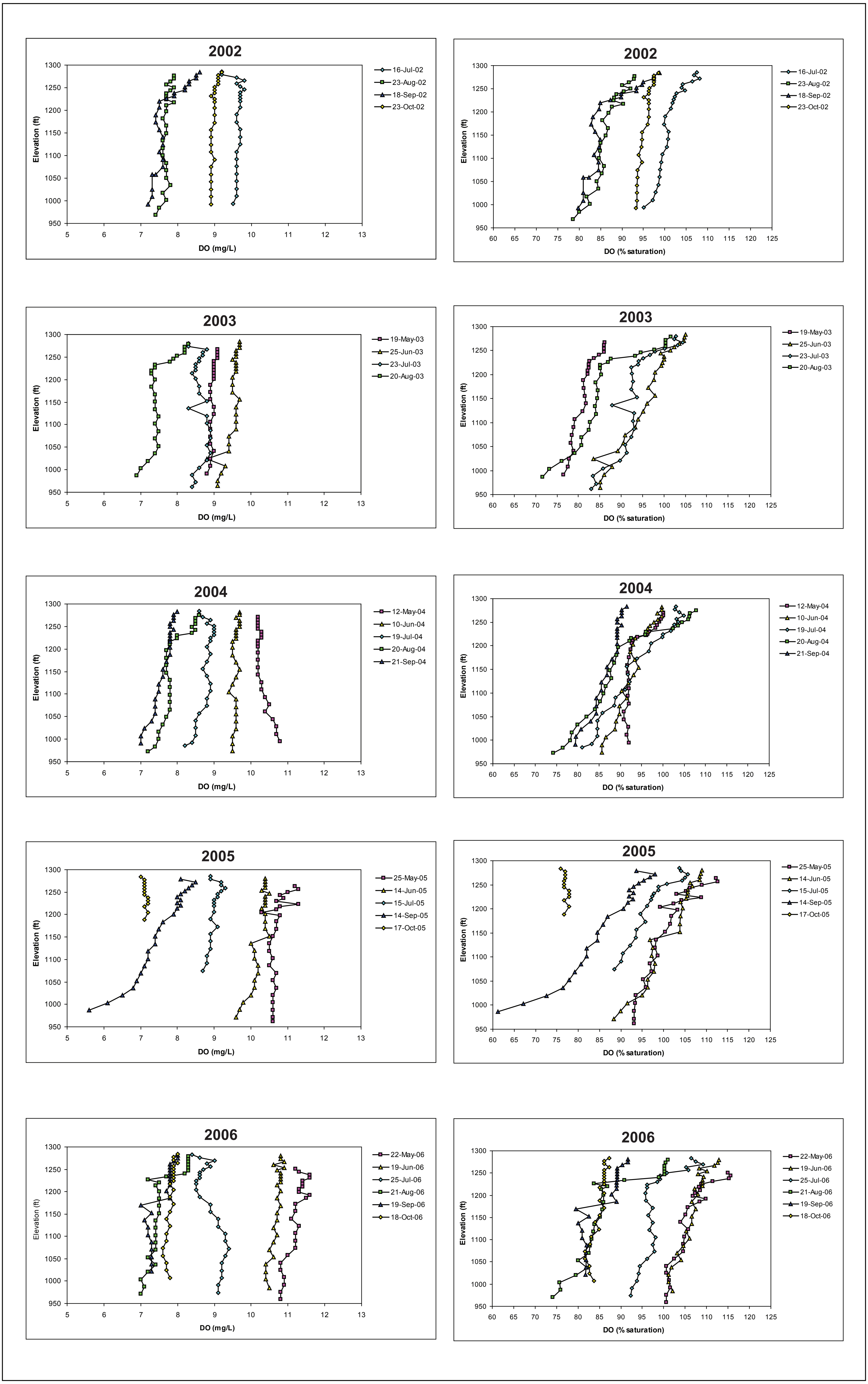

Figure 39. Dissolved Oxygen Profiles from USBR Keller Ferry Station, 2002–2006

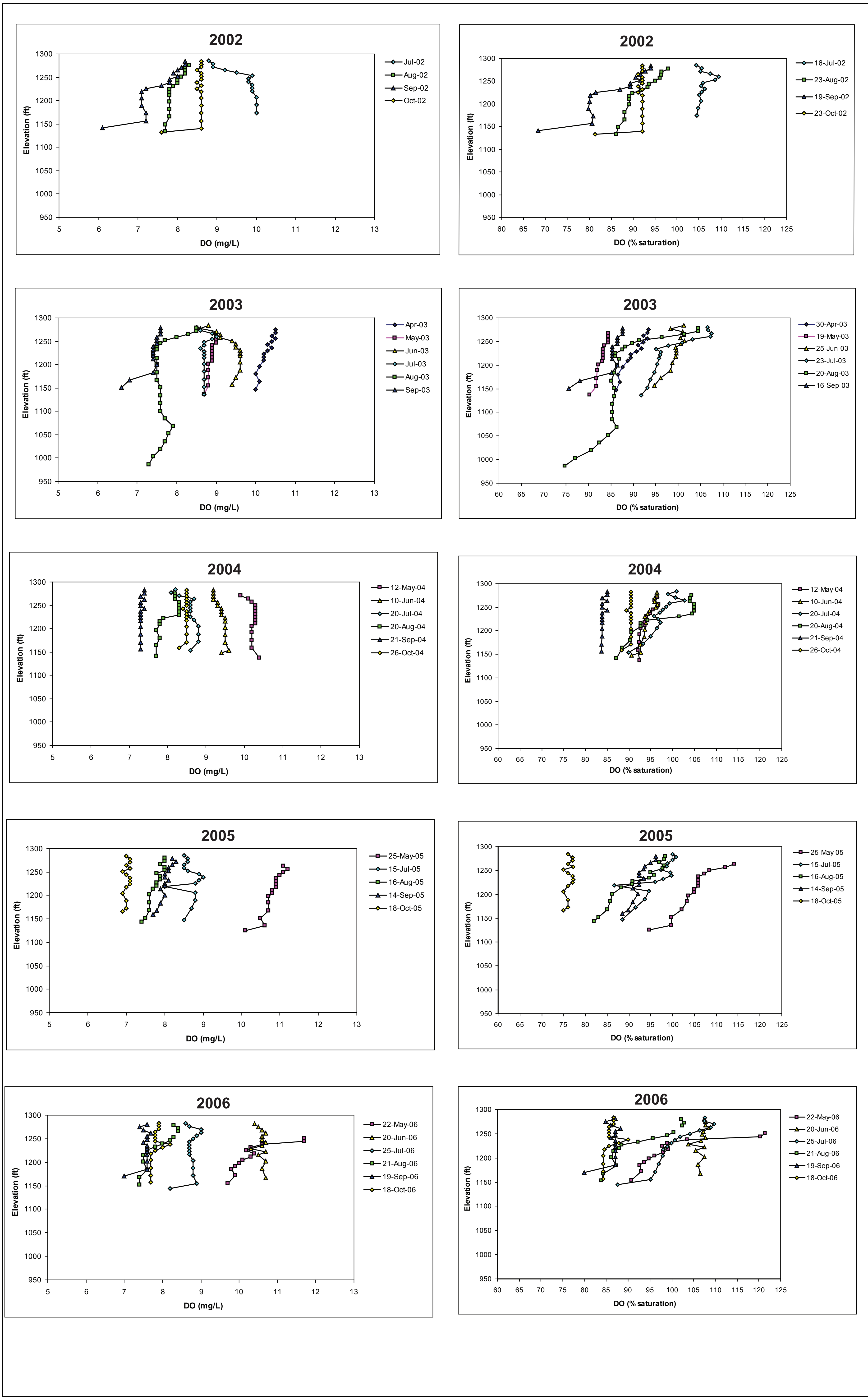

Figure 40. Dissolved Oxygen Profiles from USBR Logboom Station, 2002–2006

MAPS

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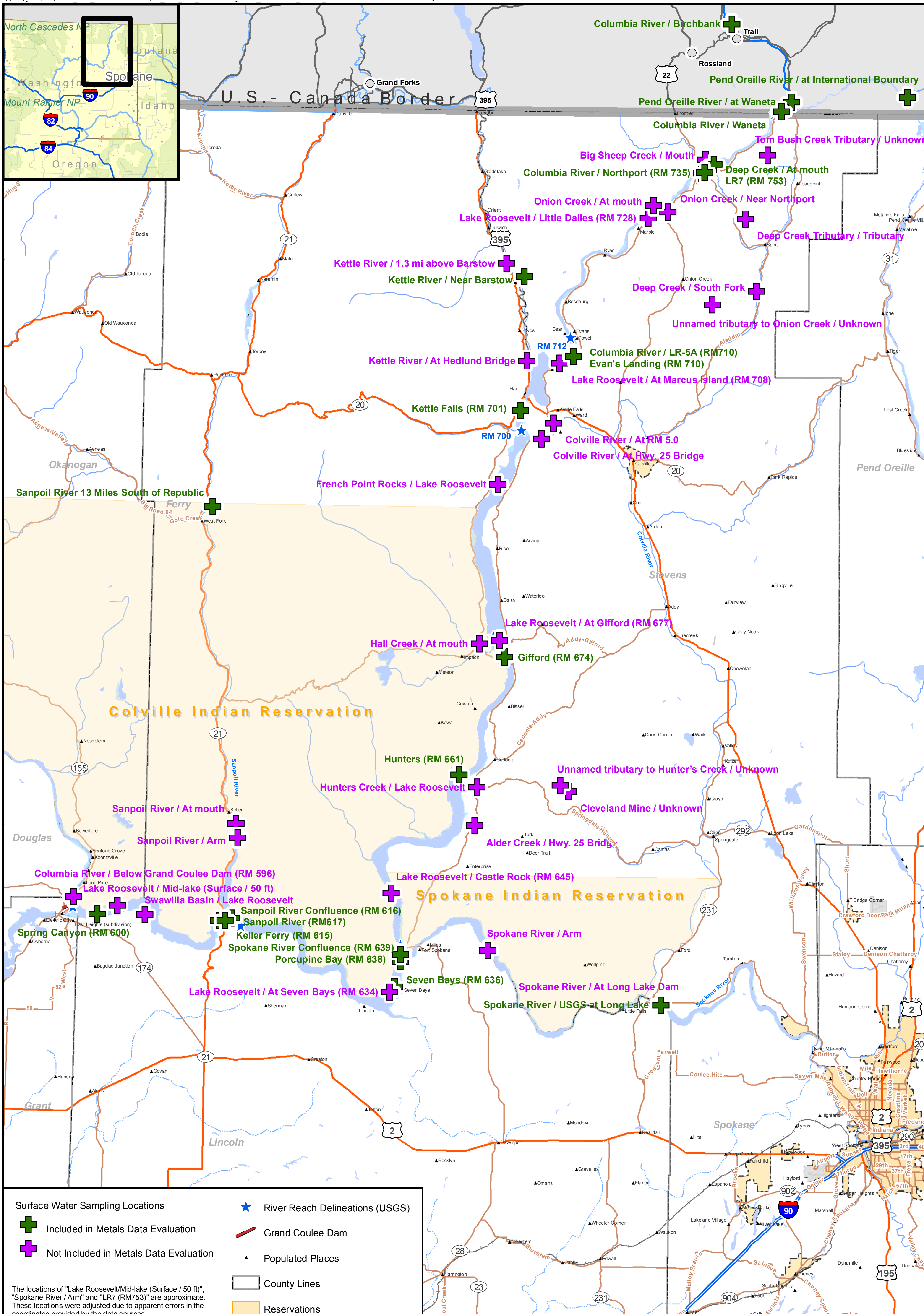
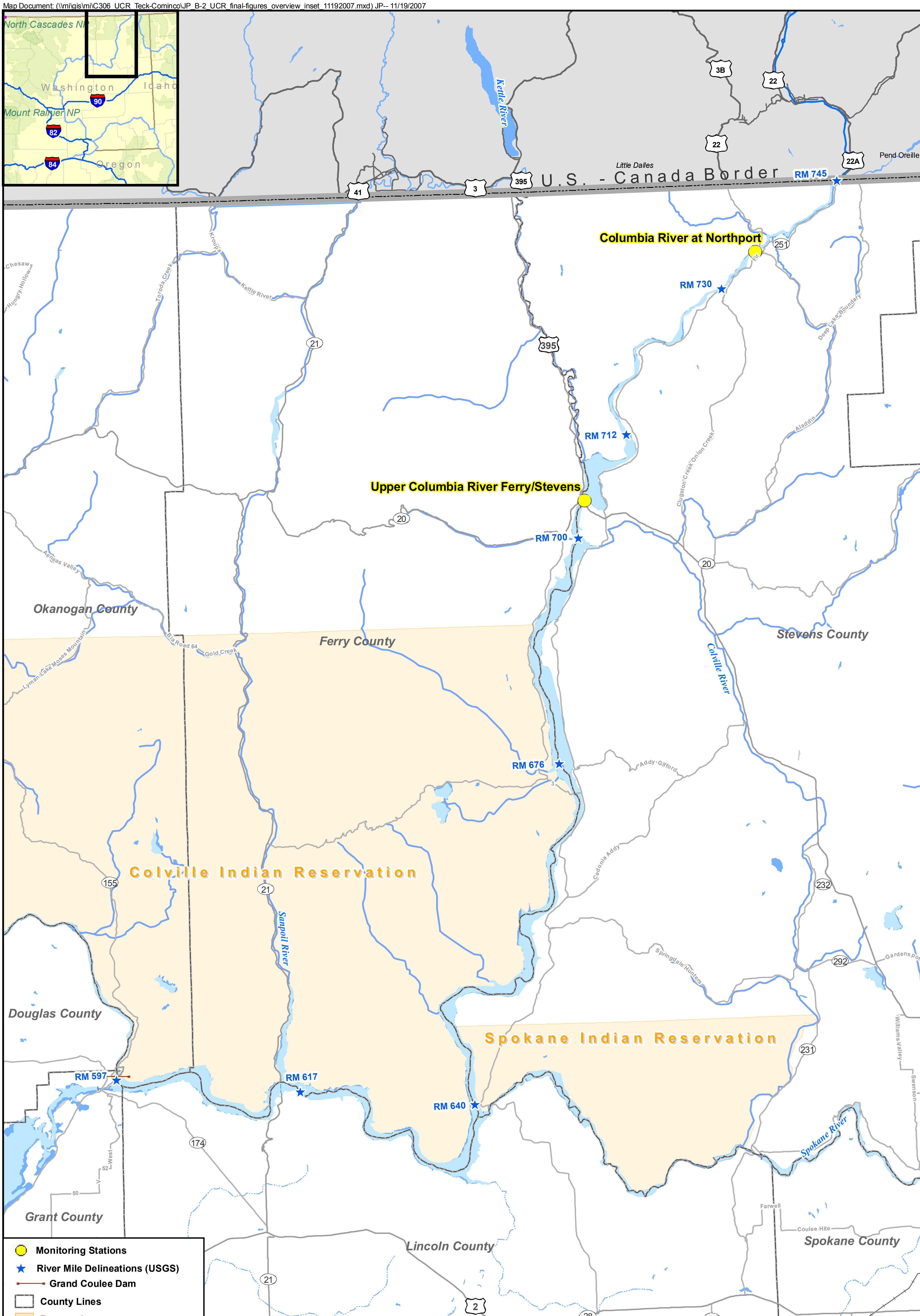


Integral Parametrix

Map 1. **Surface Water Metals Sampling Locations in the Study Area and Vicinity**

Upper Columbia River, WA

Map Document: (\\mi\gis\mi\C306_UCR_Teck-Cominco\JP_B-2_UCR_final-figures_overview_inset_11192007.mxd) JP-- 11/19/2007



Integral Parametrix

Km: 0 5 10

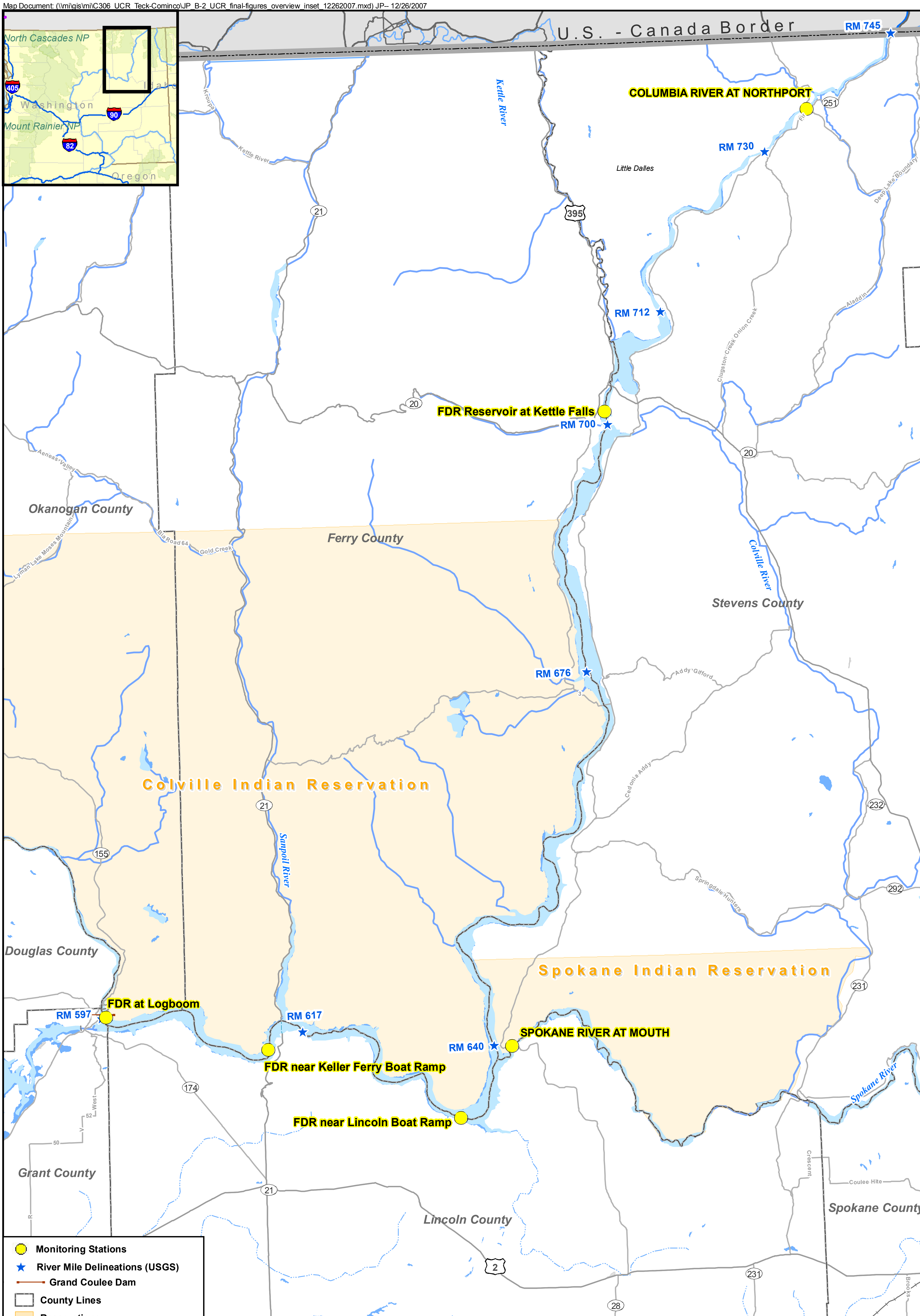
Miles: 0 5 10

N

Map 2. **Surface Water Organic Compounds Sampling Locations in the Study Area**

Upper Columbia River, WA

Map Document: (\\mi\gis\mi\C306_UCR_Teck-Cominco\JP_B-2_UCR_final-figures_overview_inset_12262007.mxd) JP-- 12/26/2007



Integral Parametrix

Km: 0 5 10

Miles: 0 5 10

N

Map 3. **Surface Water Conventional Parameters Sampling Locations in the Study Area**

Upper Columbia River, WA

TABLES

Table 1. Summary of Surface Water Quality Data Sets in the Study Area and Vicinity

Water Body	Sample Location	Date(s)	Source
Upstream of Upper Columbia River (North of Border)			
Columbia River	Birchbank	1983-2006	Env. Canada
	Waneta	1979-2005	Env. Canada
Pend Oreille River	International Boundary	1997-2004	Env. Canada
	Waneta	1979-2007	Env. Canada
Upper Columbia River			
Columbia River/Lake Roosevelt	Northport (RM 735)	1951-2005	EIM, NWIS
	LR-5A (RM 710)	2004	Paulson et al. (2006)
	LR7 (RM 753)	2004	Paulson et al. (2006)
	Little Dalles (RM 728)	1989	Johnson (1991)
	Castle Rock (RM 645)	1989	Johnson (1991)
	At Marcus Island (RM 708)	1986	Johnson et al. (1988)
	Colville River At Mouth, Hwy. 25 Bridge	1986	Johnson et al. (1988)
	At Gifford (RM 677)	1986	Johnson et al. (1988)
	At Seven Bays (RM 634)	1986	Johnson et al. (1988)
	Mid-lake (surface)	1980	STORET
	Mid-lake (50 ft)	1980	STORET
	French Point Rocks	1989	Johnson (1991)
	Spokane River at Mouth	1991	NPS (1995)
	Sanpoil River Near Mouth	1986	NPS (1995)
	Swawilla Basin	1989	Johnson (1991)
	Lake Roosevelt at Grand Coulee	2001	USEPA (2003)
	Sanpoil River (RM 617)	1998-2000	Scofield and Pavlik-Kunkel (2007)
	Porcupine Bay (RM 638)	1998-2000	Scofield and Pavlik-Kunkel (2007)
	Spring Canyon (RM 600)	1998-2000	Scofield and Pavlik-Kunkel (2007)
	Keller Ferry (RM 615)	1998-2000	Scofield and Pavlik-Kunkel (2007)
	Sanpoil River Confluence (RM 616)	1998-2000	Scofield and Pavlik-Kunkel (2007)
	Seven Bays (RM 636)	1998-2000	Scofield and Pavlik-Kunkel (2007)
	Spokane River Confluence (RM 639)	1998-2000	Scofield and Pavlik-Kunkel (2007)

Table 1. Summary of Surface Water Quality Data Sets in the Study Area and Vicinity

Water Body	Sample Location	Date(s)	Source
Columbia River/Lake Roosevelt	Hunters (RM 661)	1998-2000	Scofield and Pavlik-Kunkel (2007)
(continued)	Gifford (RM 674)	1998-2000	Scofield and Pavlik-Kunkel (2007)
	Kettle Falls (RM 701)	1998-2000	Scofield and Pavlik-Kunkel (2007)
	Evan's Landing (RM 710)	1998-2000	Scofield and Pavlik-Kunkel (2007)
Downstream of Upper Columbia River (Below Grand Coulee Dam)			
Columbia River	Below Grand Coulee Dam (RM 596)	1986	Johnson et al. (1988)
Tributaries to Upper Columbia River			
Alder Creek	Hwy. 25 Bridge	1986	Johnson et al. (1988)
Big Sheep Creek	At mouth	1986	Johnson et al. (1988)
Cleveland Mine	Unknown	1999	EIM
Colville River	At RM 5.0	1986	Johnson et al. (1988)
	At Hwy 25 Bridge	1986	Johnson et al. (1988)
	At Kettle Falls	1960-1972	NPS (1995)
Deep Creek	At mouth	1986	Johnson et al. (1988)
	South Fork	2001	USEPA (2002)
Deep Creek Tributary	Tributary	2001	USEPA (2002)
Hall Creek	At mouth	1986	Johnson et al. (1988)
Hunters Creek	Lake Roosevelt	1986	Johnson et al. (1988)
Kettle River	At Hedlund Bridge	1986	Johnson et al. (1988)
	1.3 mi above Barstow	1986	Johnson et al. (1988)
	Near Barstow	1971-2005	EIM
Onion Creek	Near Northport	1990-95	EIM
	At mouth	1986	Johnson et al. (1988)
Sanpoil River	At mouth	1986	EIM; Johnson et al. (1988)
	Near mouth	1980-1981	NPS (1995)
	Arm	1989	EIM; Johnson 1991
	13 Mi. South of Republic	1990-95	EIM

Table 1. Summary of Surface Water Quality Data Sets in the Study Area and Vicinity

Water Body	Sample Location	Date(s)	Source
Spokane River	At Long Lake Dam	1986	Johnson et al. (1988)
	Arm	1989	Johnson (1991)
	Below Long Lake Dam	1972-1973	NPS (1995)
	USGS at Long Lake	1998-2003	NWIS
Tom Bush Creek Tributary	Unknown	2001	USEPA (2002)
Unnamed tributary to Hunter’s Creek	Unknown	2001	USEPA (2002)
Unnamed tributary to Onion Creek	Unknown	2001	USEPA (2002)

Notes:
RM = River mile
EIM = Ecology Environmental Information Management System (www.ecy.wa.gov/EIM)
Env. Canada = Environment Canada Water Quality Database (http://waterquality.ec.gc.ca/waterqualityweb/searchtext.aspx)
NWIS = National Water Information System (http://nwis.waterdata.usgs.gov/wa/nwis/)
STORET = USEPA Storage and Retreival Database (http://www.epa.gov/storet/index.html)

Table 2. Summary Statistics for Total and Dissolved Metals Concentrations Measured at Northport [a,b]

Analyte	Sample Date Range	Units	N	N Detected	Frequency of Detection	Detected Results						Detected and Undetected Results[c]					
						Min	Max	Mean	Median	25th Percentile	75th Percentile	Min	Max	Mean	Median	25th Percentile	75th Percentile
Total																	
Arsenic	10/9/1974 - 6/4/2007	µg/L	95	75	79%	0.19	3.0	0.62	0.47	0.375	0.78	0.19	30 *U*	3.14	0.55	0.39	1.0
Barium	10/7/1977 - 7/15/1982	µg/L	12	4.0	33%	100	200	175	200	175	200	100	200	125	100	100	125
Cadmium	10/9/1974 - 6/4/2007	µg/L	76	8.0	11%	0.04	0.53	0.17	0.12	0.085	0.18	0.04	20 *U*	3.2	0.1	0.1	1.25
Chromium	1/14/1975 - 6/4/2007	µg/L	75	12	16%	0.17	20	5.316	0.685	0.2925	10	0.17	20	4.3	0.5	0.5	5.0
Cobalt	10/9/1974 - 7/15/1982	µg/L	16	0.0	0%	--	--	--	--	--	--	1.0 *U*	100 *U*	75	100	75.5	100
Copper	10/9/1974 - 6/4/2007	µg/L	83	73	88%	0.49	80	6.6	1.5	0.84	4.58	0.49	80	8.0	2.0	0.885	17
Iron	10/9/1974 - 7/15/1982	µg/L	27	27	100%	20	590	206	160	75	255	20	590	206	160	75	255
Lead	10/9/1974 - 6/4/2007	µg/L	72	55	76%	0.12	12.1	0.8	0.5	0.26	0.8	0.12	200 *U*	32.9	0.7	0.315	4.9
Manganese	10/9/1974 - 7/15/1982	µg/L	27	14	52%	10	80	26	20	20	30	10	80	18	10	10	20
Mercury	10/9/1974 - 6/4/2007	µg/L	91	27	30%	0.001	0.3	0.065	0.003	0.002	0.1	0.001	0.5 *U*	0.093	0.002	0.002	0.1
Nickel	5/13/1982 - 6/4/2007	µg/L	34	29	85%	0.46	0.95	0.68	0.66	0.58	0.77	0.46	10 *U*	1.0	0.68	0.595	0.9
Selenium	10/9/1974 - 7/15/1982	µg/L	24	0.0	0%	--	--	--	--	--	--	1.0 *U*	1.0 *U*	1.0	1.0	1.0	1.0
Silver	10/7/1977 - 6/4/2007	µg/L	40	5.0	13%	1.0	4.0	2.0	2.0	1.0	3.0	0.1 *U*	20 *U*	1.0	0.1	0.1	1.0
Zinc	10/9/1974 - 6/4/2007	µg/L	89	63	71%	4.2	160	39	21	7.3	60	4.2	160	29	8.0	5.0	50
Dissolved																	
Aluminum	11/9/1982 - 6/13/2000	µg/L	96	71	74%	3.0	30	11	10	7.0	13	3.0	30	11	10	9.2	12
Antimony	11/27/1995 - 6/13/2000	µg/L	44	0.0	0%	--	--	--	--	--	--	1.0 *U*	1.0 *U*	1.0	1.0	1.0	1.0
Arsenic	1/25/1961 - 6/4/2007	µg/L	149	59	40%	0.2	10	1.0	1.0	0.4	1.0	0.2	10	1.0	1.0	1.0	1.0
Barium	10/7/1977 - 6/13/2000	µg/L	111	107	96%	20	200	34	33	28.5	36	20	200	37	33	29	37
Beryllium	11/9/1982 - 6/13/2000	µg/L	80	1.0	1%	0.9	0.9	0.9	0.9	0.9	0.9	0.5 *U*	1.0 *U*	1.0	1.0	0.5	1.0
Boron	12/19/1960 - 9/27/2000	µg/L	61	14	23%	4.5	60	19	15	7.0	20	4.0 *U*	60	13	16	4.5	16
Cadmium	4/1/1975 - 6/4/2007	µg/L	144	43	30%	0.0	21	2.3	0.0	0.0	0.2	0.0	21	1.0	1.0	0.0	1.0
Calcium	11/15/1951 - 9/27/2000	mg/L	359	359	100%	15	28	21	20	19	23	15	28	21	20	19	23
Chromium	1/25/1961 - 6/4/2007	µg/L	120	36	30%	0.3	30	3.3	0.8	0.4	1.3	0.3 *U*	30	3.0	1.0	0.8	1.0
Cobalt	1/25/1979 - 6/13/2000	µg/L	106	1.0	1%	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0 *U*	2.0	3.0	1.0	3.0
Copper	1/25/1961 - 6/4/2007	µg/L	133	105	79%	0.3	190	6.5	1.3	0.6	4.0	0.3	190	5.0	1.0	0.8	2.2
Iron	10/9/1974 - 9/27/2000	µg/L	127	79	62%	3.0	400	18	9.0	5.0	13	3.0	400	14	10	5.0	10
Lead	5/22/1985 - 6/4/2007	µg/L	119	54	45%	0.0	16	1.1	0.1	0.0	1.0	0.0	16	1.0	1.0	0.1	1.0
Lithium	11/9/1982 - 9/27/2000	µg/L	104	16	15%	2.0	20	7.0	6.0	4.8	8.3	2.0	20	5.0	4.0	4.0	4.0
Magnesium	11/15/1951 - 9/27/2000	mg/L	359	359	100%	2.9	7.4	4.5	4.5	4.1	4.9	2.9	7.4	4.5	4.5	4.1	4.9
Manganese	10/9/1974 - 6/13/2000	µg/L	105	62	59%	1.0	80	4.0	2.0	1.0	3.0	1.0	80	4.1	1.6	1.0	3.0
Mercury	10/9/1974 - 9/3/1991	µg/L	63	25	40%	0.1	18	1.2	0.2	0.1	0.3	0.1	18	0.6	0.1	0.1	0.5
Molybdenum	11/9/1982 - 6/13/2000	µg/L	96	1.0	1%	10	10	10	10	10	10	1.0 *U*	10	6.0	10	1.0	10
Nickel	10/2/1981 - 6/4/2007	µg/L	141	63	45%	0.3	3.0	0.9	0.6	0.5	1.0	0.3	3.0	1.0	1.0	0.7	1.0
Potassium	12/19/1960 - 9/27/2000	mg/L	357	357	100%	0.1	1.7	0.8	0.7	0.6	0.8	0.1	1.7	0.8	0.7	0.6	0.8
Selenium	10/9/1974 - 9/27/2000	µg/L	131	0.0	0%	--	--	--	--	--	--	1.0 *U*	2.0 *U*	1.0	1.0	1.0	1.0
Silver	10/2/1981 - 6/4/2007	µg/L	127	5.0	4%	0.1	1.0	1.0	1.0	1.0	1.0	0.0 *U*	1.0	1.0	1.0	1.0	1.0
Sodium	11/1/1960 - 9/27/2000	mg/L	371	371	100%	0.9	4.5	1.8	1.8	1.5	2.1	0.9	4.5	1.8	1.8	1.5	2.1
Strontium	11/9/1982 - 9/27/2000	µg/L	107	107	100%	65	120	90	90	83	98	65	120	90	90	83	98
Vanadium	11/9/1982 - 9/27/2000	µg/L	107	0.0	0%	--	--	--	--	--	--	6.0 *U*	10 *U*	7.0	6.0	6.0	8.0
Zinc	11/21/1961 - 6/4/2007	µg/L	162	154	95%	1.1	200	16	4.2	2.5	20	1.0 *U*	200	16	4.4	2.5	20

Notes:
Data presented in the table has been evaluated over a dataset which excludes valueds of "0" for some analytes.
mg/L = milligrams per liter
µg/L = micrograms per liter
N = Number of Samples.
U = Undetected at the detection limit value shown.
[a] Northport: Columbia River at Northport (USGS Station 12400520; Ecology's Station 61A070 at RM 735.1).
[b] Summary statistics shown were compiled from statistics provided in Scofield and Pavlik-Kunkel (2007). Frequency of detection was calculated based on statistics provided. For this table, values < 10 were rounded to the nearest one-tenth (i.e., one decimal place), and values >10 were rounded to the nearest whole value (i.e., no decimal places).
[c] Statistics provided include estimated concentrations which were calculated by dividing the minimum reporting limit (MRL) in half (Scofield and Pavlik-Kunkel 2007).

Table 3. Dissolved and Total Concentrations of Indicator Metals in Surface Water Samples from Northport (1995-2007)

			Arsenic				Cadmium				Copper				Lead				Mercury				Zinc			
Location ID	Sample Date	Sample ID	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L
61A070	1/10/1995	37006_1995110_W				30	0.088 J			3 U	1.68		14 J		0.244			20 U				0.001 U	3.7 J		7.1 J	
61A070	2/7/1995	34067_199527_W				30																				
61A070	2/7/1995	37023_199527_W								0.1 U			2.6				0.9 J								9.2 J	
61A070	3/7/1995	37042_199537_W				30	0.078 J			0.1 U	1.41		2		0.057 J		0.7 J					0.001 U	2.8 J		6.7 J	
61A070	4/4/1995	37061_199544_W			0.59 J				0.09 J				2				0.7				0.007 J				6.5 J	
61A070	5/3/1995	37080_199553_W			0.7 J				0.16 J				2.4				1.2					0.001 U			7.2 J	
61A070	6/6/1995	36261_199566_W			0.579 J					0.1 U			3.9				2.5					0.001 U			18 J	
61A070	7/11/1995	36280_1995711_W							0.14 J				2.7				1.1 J				0.001 J				21.6 J	
61A070	8/8/1995	37099_199588_W								0.1 U			1.9				0.7 J					0.001 U			48.9	
61A070	9/6/1995	36338_199596_W				1	0.083 J				1.47				0.585							0.001 U	3.7 J			
12400520	9/27/1995	1995927SW	1					1 U			1					1 U							6			
61A070	10/3/1995	37121_1995103_W					0.079			0.1 U	1.19		1.7		0.13		1.3					0.001 U	3		6.7 J	
61A070	11/7/1995	37138_1995117_W				1				0.1 U			1.4				0.6					0.001 U			8 J	
12400520	11/27/1995	19951127SW						1 U			1					1 U							4			
61A070	12/5/1995	34092_1995125_W				1	0.048				0.934				0.069								5.2			
61A070	1/9/1996	37175_199619_W				1				0.1 U			3				1.3 J				0.001	0.001			20.7	
12400520	1/16/1996	1996116SW		1 U				1 U			1					1 U							4			
61A070	2/6/1996	37188_199626_W						0.02 U			1.02				0.11							0.001 U	4.2 J			
12400520	2/14/1996	1996214SW		1 U				1 U				1 U				1 U							6			
61A070	3/5/1996	37205_199635_W			0.41					0.1 U			2.1 J				0.7								15 J	
12400520	3/6/1996	199636SW		1 U				1 U			2					1 U							2			
12400520	3/19/1996	1996319SW		1 U				1 U			2					1 U							3			
12400520	4/3/1996	199643SW		1 U				1 U			1					1 U							2			
61A070	4/10/1996	37224_1996410_W					0.058				1.16				0.092							0.001 U	3.5			
12400520	4/17/1996	1996417SW		1 U				1 U			1					1 U							2			
12400520	5/7/1996	199657SW		1 U				1 U			2					1 U							2			
61A070	5/7/1996	37243_199657_W								0.1 U			2.6				0.8								21 J	
12400520	5/22/1996	1996522SW	1					1 U			1					1 U							4			
12400520	6/3/1996	199663SW		1 U				1 U			2					1 U							6			
61A070	6/4/1996	36433_199664_W					0.03				1				0.11						0.003		2.5			
12400520	6/19/1996	1996619SW		1 U				1 U			2					1 U							3			
61A070	7/9/1996	37527_199679_W			0.48				0.53				1.4				0.8					0.001 U			5.9	
12400520	7/10/1996	1996710SW		1 U				1 U			1					1 U							8			
12400520	7/23/1996	1996723SW		1 U				1 U			2					1 U							2			
61A070	8/6/1996	34112_199686_W					0.044				0.797				0.059								2.6			
12400520	8/14/1996	1996814SW		1 U				1 U			1					1 U							5			
61A070	9/4/1996	37545_199694_W			0.26					0.1 U			1.5 J				0.8 J				0.005				7.4 J	
12400520	9/24/1996	1996924SW		1 U				1 U				1 U				1 U							3			
61A070	10/9/1996	37282_1996109_W			0.29		0.037			0.1 U	0.786		1.2 J		0.046		0.4					0.002 U	1.8 J		6.1 J	
12400520	10/22/1996	19961022SW		1 U				1 U				1 U				1 U							4			
61A070	11/6/1996	34129_1996116_W			0.29																					
61A070	11/6/1996	37301_1996116_W								0.1 U			1.1 J				0.5					0.001 U			10.1 J	
12400520	12/4/1996	1996124SW		1 U				1 U				1 U				1 U							3			
61A070	12/4/1996	37320_1996124_W			0.28		0.051			0.1 U	0.716		1.1		0.22		0.9					0.001 U	2.9		8 J	
12400520	1/13/1997	1997113SW		1 U				1 U				1 U				1 U							2			
61A070	2/5/1997	37338_199725_W			0.41			0.03 U		0.1 U	0.789		2.1		0.087		0.5					0.001 U	3.1		34 J	
61A070	3/5/1997	34153_199735_W			0.47																					
61A070	3/5/1997	37357_199735_W							0.07				1.4				0.5								6.9	
12400520	3/11/1997	1997311SW		1 U				1 U				1 U				1 U							3			
12400520	4/8/1997	199748SW		1 U				1 U			1.1					1 U							2.9			
61A070	4/9/1997	37702_199749_W			0.56		0.05			0.1 U	0.84		2		0.15		1.6					0.002 U	3.97		10.6	
12400520	4/30/1997	1997430SW		1 U				1 U			1.3					1 U							2.4			
61A070	5/7/1997	37376_199757_W			0.61					0.1 U			1.5				1.7				0.003 J				7.9 J	

Table 3. Dissolved and Total Concentrations of Indicator Metals in Surface Water Samples from Northport (1995-2007)

			Arsenic				Cadmium				Copper				Lead				Mercury				Zinc			
Location ID	Sample Date	Sample ID	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L
12400520	5/20/1997	1997520SW		1 U				1 U			1.9					1 U							2.4			
12400520	6/3/1997	199763SW		1 U				1 U			1.3					1 U							6.1			
61A070	6/4/1997	37741_199764_W			1.01		0.025		0.1		1.09		8.5		0.322		12.1				0.003		1.8		77 J	
12400520	6/17/1997	1997617SW		1 U				1 U			1.2					1 U							3.2			
12400520	6/30/1997	1997630SW		1 U				1 U			1.3					1 U							2.1			
61A070	7/9/1997	34181_199779_W			0.6																					
61A070	7/9/1997	37395_199779_W								0.1 U			1.5				0.5								5.9 J	
12400520	7/15/1997	1997715SW		1 U				1 U				1 U				1 U							1.6			
61A070	8/6/1997	36474_199786_W			0.35		0.025			0.1 U	0.721		1.1		0.05		0.4				0.002		2.56		17.5 J	
12400520	8/20/1997	1997820SW		1 U				1 U				1 U				1 U							3.2			
61A070	9/10/1997	37800_1997910_W																				0.002 U				
12400520	10/7/1997	1997107SW		1 U				1 U				1 U				1 U							1.4			
12400520	11/18/1997	19971118SW		1 U				1 U			2.2					1 U							1.4			
12400520	1/21/1998	1998121SW		1 U				1 U				1 U				1 U							2.4			
61A070	3/3/1998	98106163_199833_W			0.37		0.067			0.1 U	0.626				0.045						0.003		3.08		16.9 J	
12400520	3/4/1998	199834SW		1 U				1 U				1 U				1 U							1.7			
12400520	4/1/1998	199841SW		1 U				1 U			1.1					1 U							7.5			
12400520	4/29/1998	1998429SW		1 U				1 U				1 U				1 U							12.1			
12400520	5/27/1998	1998527SW		1 U				1 U				1 U				1 U							5.1			
12400520	6/24/1998	1998624SW		1 U				1 U				1 U				1 U							4.9			
12400520	7/21/1998	1998721SW		1 U				1 U				1 U				1 U							1.1			
12400520	9/22/1998	1998922SW		1 U				1 U				1 U				1 U							1.5			
12400520	11/23/1998	19981123SW	1																							
12400520	1/5/1999	199915SW		1 U																						
12400520	2/24/1999	1999224SW		1 U																						
12400520	4/5/1999	199945SW		1 U																						
12400520	5/5/1999	199955SW		1 U				1 U				1 U				1 U							1.8			
12400520	6/8/1999	199968SW		1 U				1 U				1 U				1 U							1.6			
12400520	6/30/1999	1999630SW		1 U				1 U				1 U				1 U							2.6			
12400520	7/21/1999	1999721SW		1 U				1 U				1 U				1 U							1.2			
12400520	8/18/1999	1999818SW		1 U																						
12400520	9/21/1999	1999921SW		1 U																						
12400520	11/17/1999	19991117SW		2 U																						
12400520	12/28/1999	19991228SW		2 U																						
12400520	2/8/2000	200028SW		2 U																						
12400520	3/15/2000	2000315SW		2 U																						
12400520	4/12/2000	2000412SW	1 J					1 U				1 U				1 U								2.1 U		
12400520	5/9/2000	200059SW		2 U				1 U				1 U				1 U								4.7 U		
12400520	6/13/2000	2000613SW		2 U				1 U				1 U				1 U								3.2 U		
12400520	8/22/2000	2000822SW		2 U																						
12400520	9/27/2000	2000927SW		2 U																						
61A070	7/9/2001	1286057_200179_W			0.44																					
61A070	8/6/2001	1368080_200186_W			0.35																					
61A070	9/10/2001	1408080_2001910_W			0.32																					
61A070	10/15/2001	1468155_20011015_W			0.53																					
61A070	11/5/2001	1498100_2001115_W			0.4																					
61A070	12/3/2001	2018080_2001123_W			0.26																					
61A070	1/14/2002	2068080_2002114_W			0.39																					
61A070	2/11/2002	2118105_2002211_W			0.86																					
61A070	3/11/2002	2158155_2002311_W			0.42																					
61A070	4/8/2002	2178180_200248_W			0.52																					
61A070	5/12/2002	2228080_2002512_W			0.44																					
61A070	6/3/2002	2268155_200263_W			0.38																					

Table 3. Dissolved and Total Concentrations of Indicator Metals in Surface Water Samples from Northport (1995-2007)

			Arsenic				Cadmium				Copper				Lead				Mercury				Zinc			
Location ID	Sample Date	Sample ID	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L	Dissolved µg/L	Dissolved, Undetect. µg/L	Total µg/L	Total, Undetect. µg/L
61A070	10/14/2002	131502_20021014_W	0.41		0.4			0.1 U		0.1 U	0.33		0.49		0.025		0.29				0.0021		1.8			5 U
61A070	12/15/2002	131727_20021215_W	0.38		0.3		0.242		0.24		0.56		0.78		0.045		0.46				0.0022		2.8			5 U
61A070	2/2/2003	131817_200322_W	0.47		0.38		0.057			0.1 U	0.62		0.74		0.031		0.17					0.002 U	4.5			5 U
61A070	4/6/2003	132021_200346_W	0.61		0.55			0.1 U		0.1 U		0.5 U	0.97 J		0.038		0.24					0.004 U	2			5 U
61A070	6/1/2003	132265_200361_W	0.58		0.58		0.021			0.1 U	0.64		4.58		0.054		1.22					0.002 U	1.9		45	
61A070	8/3/2003	132444_200383_W	0.42		0.4			0.02 U		0.1 U	0.49		1.71			0.02 U	0.37					0.002 U		1 U		5 U
61A070	10/6/2003	132608_2003106_W	0.47		0.34		0.024			0.1 U	0.56		0.62		0.021		0.2					0.002 UJ	3			5 U
61A070	12/8/2003	132787_2003128_W	0.34		0.33		0.022			0.1 U	0.56		0.6			0.02 U	0.12					0.002 U	2.3			5 U
61A070	2/9/2004	132964_200429_W	0.48		0.49		0.027			0.1 U	0.6		0.89		0.04		0.3					0.002 U	4.1		6.1	
61A070	4/12/2004	133180_2004412_W	0.41		0.48		0.027			0.1 U	0.51		1.14		0.023		0.33					0.002 U	2.6		9.4	
61A070	6/14/2004	133381_2004614_W	0.39		0.37			0.02 U		0.1 U	0.52		0.71		0.029		0.29					0.002 U	2.2		6.2	
61A070	8/2/2004	133513_200482_W	0.39		0.38			0.02 U		0.1 U	0.46		0.58		0.02		0.21					0.002 U	1.7			5 U
61A070	10/5/2004	133742_2004105_W	0.52		0.62			0.02 U		0.1 U	0.52		0.54		0.02		0.18 J					0.002 U	3.3			5 U
61A070	12/13/2004	133949_20041213_W	0.38		0.39 J		0.022			0.1 U	0.44		0.84 J			0.02 U	0.23					0.002 U	3.5			5 U
61A070	2/8/2005	134150_200528_W	0.45		0.39		0.024			0.1 U	0.44		0.65			0.02 U	0.13					0.002 U	2.5			5 U
61A070	4/5/2005	134304_200545_W	0.44		0.45 J		0.023			0.1 U	0.45		0.73			0.02 U	0.28				0.0022		2.5			5 U
61A070	6/7/2005	134560_200567_W	0.48		0.53			0.02 U		0.1 U	0.48		0.87 J			0.02 U	0.34 J					0.002 U	2.4			5 U
61A070	8/2/2005	134740_200582_W	0.33		0.27			0.02 U		0.1 U	0.46		0.64			0.02 U	0.22					0.002 U	1.4			5 U
61A070	10/4/2005	134956_2005104_W	0.46		0.47			0.02 U		0.1 U	0.51		0.6		0.021		0.21					0.002 U	1.8			5 U
61A070	12/6/2005	135222_2005126_W	0.37		0.36			0.02 U		0.1 U	0.48		0.63		0.04		1.96					0.002 U	1.6			5 U
61A070	2/7/2006	135406_200627_W	0.59		0.51		0.027			0.1 U	0.59		0.72		0.069		0.21					0.002 U	2.3			5 U
61A070	4/11/2006	135621_2006411_W	0.55		0.46		0.031			0.1 U	0.56		0.88		0.045		0.38					0.002 U	3			5 U
61A070	6/6/2006	135834_200666_W	0.48		0.49			0.02 U		0.1 U	0.9		0.96			0.02 U	0.58				0.002		7.4			5 U
61A070	8/8/2006	136043_200688_W	0.24		0.19			0.02 U		0.1 U	0.45		0.6			0.02 U	0.19					0.002 U	2			5 U
61A070	10/3/2006	136258_2006103_W	0.35		0.35		0.02			0.1 U	0.47		0.54			0.02 U	0.23					0.002 U	1.4			5 U
61A070	12/5/2006	136491_2006125_W	0.36		0.41		0.021			0.1 U	0.55		0.57		0.033		0.19					0.002 U	3.3			5 U
61A070	2/13/2007	136818_2007213_W	0.34		0.3		0.022			0.1 U	0.48		0.91			0.02 U	0.32					0.002 U	3.9		6.6	
61A070	4/3/2007	136990_200743_W	0.52		0.46			0.02 U		0.1 U	0.55		0.82		0.062		0.38					0.002 U	2.1			5 U
61A070	6/4/2007	137256_200764_W	0.44		0.36		0.024			0.1 U	1.25		1		0.11		0.8					0.002 U	17			5 U

Notes:

Location ID 61A070 denotes data from Ecology monitoring station at Northport; Location ID 12400520 denotes data from USGS monitoring station at Norhtport.

J = Analyte was detected below the sample minimum reporting limit, the value shown is estimated.

U = Undetected at the detection limit value shown.

µg/L = micrograms per liter

Table 4. LRFEP Summary Statistics for Metals Concentrations (µg/L)[a]

Analyte	N	N Detected	FOD	Detected Results						Detected and Undetected Results[b]				
				Min	Max	Mean	Median	SD	CV	Min	Max	Mean	Median	SD
Aluminum	608	243 [c]	40%	na	na	na	na	na	na	5.0	6,000	69	30.0	261
Antimony	520	0 [c]	0%	na	na	na	na	na	na	10	25	23	25	4.3
Arsenic	608	15	2.5%	1	98	45	57	33	74	0.5	98	22	25	10
Barium	520	520 [c]	100%	na	na	na	na	na	na	15	152	31	29	12
Beryllium	520	0 [c]	0%	na	na	na	na	na	na	0.5	2.0	0.5	0.5	0.1
Cadmium	608	8	1.3%	5	7	5.9	5.5	1	17	2.0	7.0	2.6	2.5	0.6
Calcium	608	608 [c]	100%	na	na	na	na	na	na	6,730	33,800	17,862	18,000	2,566
Chromium	520	0 [c]	0%	na	na	na	na	na	na	2.0	3.5	3.3	3.5	0.5
Cobalt	520	0 [c]	0%	na	na	na	na	na	na	2.0	7.0	3.3	3.5	0.5
Copper	520	14	2.7%	4	28	9.1	8	6.2	68	2.0	28	3.5	3.5	1.4
Iron	608	578 [c]	95.0%	na	na	na	na	na	na	5.0	1,260	57	34	92
Lead	608	402	66.1%	1	182	5.6	4	11	188	0.5	182	3.9	2.0	8.8
Magnesium	608	608 [c]	100%	na	na	na	na	na	na	2,230	8,860	4,376	4,200	873
Manganese	608	407 [c]	67.0%	na	na	na	na	na	na	0.5	88	5.8	4.0	8.1
Mercury	545	1	0.2%	1.2	1.2	1.2	1.2	--	--	0.1	1.2	0.1	0.1	0.0
Nickel	520	5 [c]	1.0%	na	na	na	na	na	na	5.0	29	7.4	7.5	1.9
Potassium	608	225 [c]	37.0%	na	na	na	na	na	na	425	1,860	631	450	306
Selenium	519	5 [c]	1.0%	na	na	na	na	na	na	25	98	39	40	6.6
Silica	608	608 [c]	100%	na	na	na	na	na	na	1,500	8,530	2,841	2,550	1,024
Silver	520	0 [c]	0%	na	na	na	na	na	na	2.5	5.0	4.7	5.0	0.8
Sodium	608	608 [c]	100%	na	na	na	na	na	na	1,070	5,730	2,083	1,945	658
Zinc	608	92	15.1%	5	84	22.5	14.5	16.1	72	2.5	84	7.9	5.0	9.1

Notes:
CV = coefficient of variation
FOD = frequency of detection
µg/L = micrograms per liter
N = number of samples
na = Data not provided in Scofield and Pavlik-Kunkel (2007).
SD = standard deviation

[a] Summary statistics shown were compiled from statistics provided in Scofield and Pavlik-Kunkel (2007). Frequency of detection was calculated based on statistics provided. For this table, values < 10 were rounded to the nearest one-tenth (i.e., one decimal place), and values >10 were rounded to the nearest whole value (i.e., no decimal places).
[b] Statistics provided include estimated concentrations which were calculated by dividing the minimum reporting limit (MRL) in half (Scofield and Pavlik-Kunkel 2007).
[c] Approximate; N detected was calculated based on information on the number of results below the MRLs, provided in Scofield and Pavlik-Kunkel (2007).

Table 5. Summary Statistics for Organic Analytical Results from USGS Sampling at Northport[a] (1995-2000)

Analyte	Sample Date Range	Units	N	N Detected	Frequency of Detection	Detected Results Min	Detected Results Max	Detected Results Mean	Detected Results Median	Detected Results 25th Percentile	Detected Results 75th Percentile	Detected and Undetected Results Min	Detected and Undetected Results Max	Detected and Undetected Results Mean	Detected and Undetected Results Median	Detected and Undetected Results 25th Percentile	Detected and Undetected Results 75th Percentile
Herbicides																	
Acetochlor	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.002 U	0.004 U	0.002	0.002	0.002	0.002
Alachlor	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.002 U	0.002 U	0.002	0.002	0.002	0.002
Benfluralin	11/27/1995 - 9/27/2000	ug/L	55	1	2%	0.004	0.004	0.004	0.004	0.004	0.004	0.002 U	0.01 U	0.002	0.002	0.002	0.002
Butylate	11/27/1995 - 9/27/2000	ug/L	55	1	2%	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Cyanazine	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.004 U	0.018 U	0.004	0.004	0.004	0.004
Dimethyl tetrachloroterephthalate	1/16/1996 - 9/27/2000	ug/L	54	6	11%	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.003 U	0.002	0.002	0.002	0.002
Ethalfluralin	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.004 U	0.009 U	0.004	0.004	0.004	0.004
Metolachlor	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.002 U	0.013 U	0.002	0.002	0.002	0.002
Metribuzin	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.004 U	0.006 U	0.004	0.004	0.004	0.004
Napropamide	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.003 U	0.007 U	0.003	0.003	0.003	0.003
Pebulate	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.002 U	0.004 U	0.004	0.004	0.004	0.004
Pendimethalin	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.004 U	0.01 U	0.004	0.004	0.004	0.004
Prometon	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.01 U	0.02 U	0.02	0.02	0.02	0.02
Simazine	11/27/1995 - 9/27/2000	ug/L	55	2	4%	0.002	0.003	0.0025	0.0025	0.00225	0.00275	0.002	0.011 U	0.005	0.005	0.005	0.005
Thiobencarb	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.002 U	0.005 U	0.002	0.002	0.002	0.002
Triallate	11/27/1995 - 9/27/2000	ug/L	55	2	4%	0.002	0.002	0.002	0.002	0.002	0.002	0.001 U	0.002	0.001	0.001	0.001	0.001
Trifluralin	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.002 U	0.009 U	0.002	0.002	0.002	0.002
Pesticides																	
2,6-Diethylaniline	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.002 U	0.003 U	0.003	0.003	0.003	0.003
2-Chloro-4-isopropylamino-6-amino-s-triazine	11/27/1995 - 9/27/2000	ug/L	55	1	2%	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.006 U	0.002	0.002	0.002	0.002
4,4'-DDE	11/27/1995 - 9/27/2000	ug/L	55	6	11%	0.001	0.002	0.002	0.002	0.00125	0.002	0.001	0.006 U	0.005	0.006	0.006	0.006
alpha-HCH	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.002 U	0.005 U	0.002	0.002	0.002	0.002
Atrazine	11/27/1995 - 9/27/2000	ug/L	55	6	11%	0.002	0.004	0.003	0.002	0.002	0.00275	0.001 U	0.008 U	0.001	0.001	0.001	0.001
Azinphos-methyl	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.001 U	0.05 U	0.002	0.001	0.001	0.001
Carbaryl	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.003 U	0.041 U	0.004	0.003	0.003	0.003
Carbofuran	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.003 U	0.02 U	0.003	0.003	0.003	0.003
Chlorpyrifos	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.004 U	0.005 U	0.004	0.004	0.004	0.004
cis-Permethrin	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.005 U	0.006 U	0.005	0.005	0.005	0.005
Diazinon	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.002 U	0.005 U	0.002	0.002	0.002	0.002
Dieldrin	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.001 U	0.005 U	0.001	0.001	0.001	0.001
Disulfoton	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.02 U	0.02 U	0.02	0.02	0.02	0.02
Ethoprop	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.003 U	0.005 U	0.003	0.003	0.003	0.003
Ethyl di-n-prophylthiolcarbamate	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.002 U	0.002 U	0.002	0.002	0.002	0.002
Fonofos	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.003 U	0.003 U	0.003	0.003	0.003	0.003
gamma-BHC (Lindane)	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.004 U	0.004 U	0.004	0.004	0.004	0.004
Linuron	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.002 U	0.035 U	0.003	0.002	0.002	0.002
Malathion	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.005 U	0.027 U	0.005	0.005	0.005	0.005
Methyl parathion	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.006 U	0.006 U	0.006	0.006	0.006	0.006
Molinate	11/27/1995 - 9/27/2000	ug/L	55	1	2%	0.011	0.011	0.011	0.011	0.011	0.011	0.002 U	0.011	0.004	0.004	0.004	0.004
Parathion	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.004 U	0.007 U	0.004	0.004	0.004	0.004
Phorate	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.002 U	0.011 U	0.002	0.002	0.002	0.002
Propachlor	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.007 U	0.01 U	0.007	0.007	0.007	0.007
Propanil	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.004 U	0.011 U	0.004	0.004	0.004	0.004
Propargite	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.01 U	0.05 U	0.01	0.01	0.01	0.01

Table 5. Summary Statistics for Organic Analytical Results from USGS Sampling at Northport[a] (1995-2000)

						Detected Results						Detected and Undetected Results					
Analyte	Sample Date Range	Units	N	N Detected	Frequency of Detection	Min	Max	Mean	Median	25th Percentile	75th Percentile	Min	Max	Mean	Median	25th Percentile	75th Percentile
Pesticides (cont'd)																	
Propyzamide	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.003 U	0.004 U	0.003	0.003	0.003	0.003
Tebuthiuron	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.01 U	0.02 U	0.01	0.01	0.01	0.01
Terbacil	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.007 U	0.034 U	0.007	0.007	0.007	0.007
Terbufos	11/27/1995 - 9/27/2000	ug/L	55	0	0%	--	--	--	--	--	--	0.01 U	0.02 U	0.01	0.01	0.01	0.01

Notes:
Data presented in the table has been evaluated over a dataset which excludes 0 values for some analytes.
-- = not applicable
µg/L = micrograms per liter
N = number of samples
U = Compound not detected at or above the reported concentration.

[a] Northport: Columbia River at Northport (USGS Station 12400520).

Table 6. Summary Statistics for Conventional Parameters Analyzed within the Study Area [a]

	Columbia River Stations					
	Columbia River at Northport	FDR Reservoir at Kettle Falls[b]	Spokane River at Mouth	FDR Reservoir at Lincoln Boat Ramp[b]	FDR Reservoir at Keller Ferry[b]	FDR Reservoir at Log Boom[b]
Station ID:	12400520 (USGS) 61A070 (ECY)	FDR005 (USBR)	54A050 (ECY)	FDR008 (USBR)	FDR008 (USBR)	FDR010 (USBR)
Alkalinity (mg/L as $CaCO_3$)						
Date Range	1970-1980	-	-	-	-	-
Count	108	-	-	-	-	-
Minimum	39.0	-	-	-	-	-
Maximum	75.0	-	-	-	-	-
Median	60.0	-	-	-	-	-
25th Percentile	54.75	-	-	-	-	-
75th Percentile	65	-	-	-	-	-
Calcium (Dissolved, mg/L)						
Date Range	1951-2000	-	-	-	-	-
Count	359	-	-	-	-	-
Number of detected results	359	-	-	-	-	-
Minimum	15	-	-	-	-	-
Maximum	28	-	-	-	-	-
Median	20.0	-	-	-	-	-
25th Percentile	19.0	-	-	-	-	-
75th Percentile	23.0	-	-	-	-	-
Chloride (Dissolved, mg/L)						
Date Range	1951-2000	-	-	-	-	-
Count	351	-	-	-	-	-
Number of detected results	350	-	-	-	-	-
Minimum	0.1	-	-	-	-	-
Maximum	2.5	-	-	-	-	-
Median	0.8	-	-	-	-	-
25th Percentile	0.6	-	-	-	-	-
75th Percentile	1	-	-	-	-	-
Conductivity (µS/cm)						
Date Range	1951-2007	2002-2006	1990-1994	2002-2006	2002-2006	2002-2006
Count	1192	371	45	572	590	434
Minimum	13	102	65	110	112	113
Maximum	257	138	203	138	139	139
Median	144	125	129	123	123	126
25th Percentile	134	119	102	120	120	120
75th Percentile	158	130	148	128	128	130

Table 6. Summary Statistics for Conventional Parameters Analyzed within the Study Area [a]

	Columbia River Stations					
	Columbia River at Northport	FDR Reservoir at Kettle Falls[b]	Spokane River at Mouth	FDR Reservoir at Lincoln Boat Ramp[b]	FDR Reservoir at Keller Ferry[b]	FDR Reservoir at Log Boom[b]
Station ID:	12400520 (USGS) 61A070 (ECY)	FDR005 (USBR)	54A050 (ECY)	FDR008 (USBR)	FDR008 (USBR)	FDR010 (USBR)
Dissolved Organic Carbon (DOC, mg/L)						
Date Range	1978-2000	-	-	-	-	-
Count	66	-	-	-	-	-
Minimum	0.9	-	-	-	-	-
Maximum	10.0	-	-	-	-	-
Median	1.4	-	-	-	-	-
25th Percentile	1.1	-	-	-	-	-
75th Percentile	1.6	-	-	-	-	-
Dissolved Oxygen (DO, mg/L)						
Date Range	1962-2007	2002-2006	1990-1994	2002-2006	2002-2006	2002-2006
Count	541	371	45	572	590	434
Minimum	5.0	8.4	7.8	5.5	5.6	6.1
Maximum	14.8	12.3	14.1	12	11.6	11.7
Median	11.8	9.3	10.2	8.6	8.9	8.5
25th Percentile	10.6	8.9	8.9	7.9	7.8	7.7
75th Percentile	12.7	10.4	12.0	9.8	9.6	9.2
Fluoride, dissolved (mg/L)						
Date Range	1952-2000	-	-	-	-	-
Count	339	-	-	-	-	-
Number of detected results	272	-	-	-	-	-
Minimum	0.1 U	-	-	-	-	-
Maximum	0.6	-	-	-	-	-
Median	0.1	-	-	-	-	-
25th Percentile	0.1	-	-	-	-	-
75th Percentile	0.2	-	-	-	-	-
Hardness (mg/L as $CaCO_3$)						
Date Range	1951-2007	-	1990-1991	-	-	-
Count	861	-	6	-	-	-
Minimum	24.0	-	29	-	-	-
Maximum	130	-	74	-	-	-
Median	71.0	-	46	-	-	-
25th Percentile	65.4	-	37	-	-	-
75th Percentile	78.0	-	49.8	-	-	-

Table 6. Summary Statistics for Conventional Parameters Analyzed within the Study Area [a]

	Columbia River Stations					
	Columbia River at Northport	FDR Reservoir at Kettle Falls[b]	Spokane River at Mouth	FDR Reservoir at Lincoln Boat Ramp[b]	FDR Reservoir at Keller Ferry[b]	FDR Reservoir at Log Boom[b]
Station ID:	12400520 (USGS) 61A070 (ECY)	FDR005 (USBR)	54A050 (ECY)	FDR008 (USBR)	FDR008 (USBR)	FDR010 (USBR)
Magnesium (dissolved, mg/L)						
Date Range	1951-2000	-	-	-	-	-
Count	359	-	-	-	-	-
Number of detected results	359	-	-	-	-	-
Minimum	2.9	-	-	-	-	-
Maximum	7.4	-	-	-	-	-
Median	4.5	-	-	-	-	-
25th Percentile	4.1	-	-	-	-	-
75th Percentile	4.9	-	-	-	-	-
ORP (mV)						
Date Range	-	2002-2006	-	2002-2006	2002-2006	2002-2006
Count	-	353	-	550	565	394
Minimum	-	-144	-	-35	34	-91
Maximum	-	322	-	381	398	290
Median	-	216	-	219	231	224
25th Percentile	-	125	-	116	144	134
75th Percentile	-	255	-	248	254	257
pH (standard units)						
Date Range	1948-2007	2002-2006	1990-1994	2002-2006	2002-2006	2002-2006
Count	1106	371	45	572	590	434
Minimum	6.8	7.3	7.3	7.3	7.0	7.2
Maximum	13.0	8.7	8.7	8.5	8.6	8.8
Median	7.8	8.2	8.0	8.0	7.9	8.0
25th Percentile	7.6	8.0	7.8	7.8	7.8	7.9
75th Percentile	8.0	8.3	8.3	8.1	8.1	8.2
Sodium (Dissolved, mg/L)						
Date Range	1960-2000	-	-	-	-	-
Count	371	-	-	-	-	-
Number of detected results	371	-	-	-	-	-
Minimum	0.9	-	-	-	-	-
Maximum	4.5	-	-	-	-	-
Median	1.8	-	-	-	-	-
25th Percentile	1.5	-	-	-	-	-
75th Percentile	2.1	-	-	-	-	-

Table 6. Summary Statistics for Conventional Parameters Analyzed within the Study Area [a]

	Columbia River Stations					
	Columbia River at Northport	FDR Reservoir at Kettle Falls[b]	Spokane River at Mouth	FDR Reservoir at Lincoln Boat Ramp[b]	FDR Reservoir at Keller Ferry[b]	FDR Reservoir at Log Boom[b]
Station ID:	12400520 (USGS) 61A070 (ECY)	FDR005 (USBR)	54A050 (ECY)	FDR008 (USBR)	FDR008 (USBR)	FDR010 (USBR)
Sulfate (Dissolved, mg/L)						
Date Range	1951-2000	-	-	-	-	-
Count	361	-	-	-	-	-
Number of detected results	360	-	-	-	-	-
Minimum	1.6	-	-	-	-	-
Maximum	23.0	-	-	-	-	-
Median	12.0	-	-	-	-	-
25th Percentile	9.1	-	-	-	-	-
75th Percentile	15.0	-	-	-	-	-
Temperature (° Celsius)						
Date Range	1967-2007	2002-2006	1990-1994	2002-2006	2002-2006	2002-2006
Count	658	371	45	572	590	434
Minimum	0.0	8.2	0.9	6.7	6.6	7
Maximum	20.1	20.6	25.3	23.8	24.5	24.7
Median	8.7	16	11.6	16.2	16.1	17.7
25th Percentile	4.3	12.2	5.4	13.8	12.9	14.9
75th Percentile	14.6	18.4	19.4	18.7	18.9	19.6
Total Dissolved Solids (TDS, mg/L)						
Date Range	1960-2000	-	-	-	-	-
Count	347	-	-	-	-	-
Minimum	61.0	-	-	-	-	-
Maximum	158.0	-	-	-	-	-
Median	84.0	-	-	-	-	-
25th Percentile	77.5	-	-	-	-	-
75th Percentile	92.0	-	-	-	-	-
Total Organic Carbon (TOC, mg/L)						
Date Range	1974-1981	-	-	-	-	-
Count	454	-	-	-	-	-
Number of detected results	435	-	-	-	-	-
Minimum	0.5	-	-	-	-	-
Maximum	6.7	-	-	-	-	-
Median	2.0	-	-	-	-	-
25th Percentile	1.4	-	-	-	-	-
75th Percentile	2.7	-	-	-	-	-

Table 6. Summary Statistics for Conventional Parameters Analyzed within the Study Area [a]

	Columbia River Stations					
	Columbia River at Northport	FDR Reservoir at Kettle Falls[b]	Spokane River at Mouth	FDR Reservoir at Lincoln Boat Ramp[b]	FDR Reservoir at Keller Ferry[b]	FDR Reservoir at Log Boom[b]
Station ID:	12400520 (USGS) 61A070 (ECY)	FDR005 (USBR)	54A050 (ECY)	FDR008 (USBR)	FDR008 (USBR)	FDR010 (USBR)
Total Suspended Solids (TSS, mg/L)						
Date Range	1974-2007	-	-	-	-	-
Count	454	-	-	-	-	-
Number of detected results	435	-	-	-	-	-
Minimum	0.5 U	-	-	-	-	-
Maximum	43.0	-	-	-	-	-
Median	3.0	-	-	-	-	-
25th Percentile	2.0	-	-	-	-	-
75th Percentile	5.0	-	-	-	-	-
Turbidity (NTU)						
Date Range	1978-2007	-	1990-1994	-	-	-
Count	382	-	45	-	-	-
Number of detected results	371	-	41	-	-	-
Minimum	0.2	-	0.5	-	-	-
Maximum	11.0	-	11	-	-	-
Median	1.0	-	1.1	-	-	-
25th Percentile	0.6	-	0.8	-	-	-
75th Percentile	1.4	-	1.6	-	-	-

Notes:
$CaCO_3$ = calcium carbonate.
mg/L = milligrams per liter
mV = millivolts
µS/cm = microsiemens per centimeter
NTU = nephelometric turbidity unit
ORP = oxidation-reduction potential
U = The analyte was not detected at or above the reported concentration.

[a] All statistical evaluations have been performed on both detected and non-detected values, and excludes values of "0" reported for some non-field measurements.
[b] Data from these stations (U.S. Bureau of Reclamation) represent vertical profile measurements.