CHAPTER 2
HAZARDOUS SUBSTANCE SOURCES

2.1 INTRODUCTION

This chapter describes the multiple sources from which hazardous substances have been released in the Coeur d'Alene River basin.

Sources that have released or continue to release hazardous substances to the Coeur d'Alene River basin include mining and mineral processing operations; waste rock, tailings dumps, and adits at former mine and mill sites; floodplains, river and lake beds and banks containing tailings and mixed tailings and alluvium; and eroding hillsides historically contaminated by smelter emissions. Source materials include waste rock, mill tailings, mixed tailings and alluvium, concentrates, mine drainage waters, smelter emissions, and flue dust. Types of releases include historical disposal of tailings to creeks, rivers, and floodplains, and historical smelter emissions, and ongoing releases of hazardous substances from waste rock and tailings deposits and sites where tailings have come to be located throughout the Coeur d'Alene River basin.

The information presented in this chapter demonstrates the following:

- Hazardous substances, including cadmium, lead, zinc, and other hazardous metals and metalloids, have been and continue to be released as a result of mining and mineral processing operations in the Coeur d'Alene River basin. Releases of hazardous substances to the Coeur d'Alene River basin began in the 1880s and continue to the present. Releases will continue for the foreseeable future absent large-scale remediation or restoration.

- Waste rock, mill tailings, and drainage from underground mine workings are the primary sources of hazardous substances in the Coeur d'Alene River basin (MFG, 1994). Historically, smelter emissions, transported by air pathways, were a primary source of hazardous substances to the hillsides surrounding the Bunker Hill smelter. The predominant secondary sources of hazardous substances are bed, bank, and floodplain sediments and upland soils of the Coeur d'Alene River basin that have been contaminated by releases from the primary sources.

- The many releases of hazardous substances from mines and mineral processing facilities to hillsides, floodplains, and streams of the basin and subsequent transport of wastes from source areas via pathways have resulted in the commingling of hazardous substances from numerous sources, with subsequent distribution of hazardous substances throughout the Coeur d'Alene River basin.

More detailed information on source locations and volumes and area estimates is presented in the Restoration Alternatives Plan for the Coeur d'Alene Basin Natural Resource Damage Assessment (Gearheart et al., 1999). More detailed information on mining and milling history in the Coeur d'Alene River basin is presented in Quivik (1999), and more detailed information on selected mineral processing plants in the Coeur d'Alene River basin, tonnages milled, and characteristics of the milling wastes is presented in Bull (1999).

2.2 HAZARDOUS SUBSTANCES RELEASED

Hazardous substances, as defined in 40 CFR §302.4, Table 302.4 List of Hazardous Substances and Reportable Quantities, include metals and metalloids contained in mining and mineral processing wastes. Hazardous substances that have been released from mining and mineral processing operations in the Coeur d'Alene River basin include:

- antimony and compounds of antimony
- arsenic and compounds of arsenic
- cadmium and compounds of cadmium
- copper and compounds of copper
- lead and compounds of lead
- mercury and compounds of mercury
- silver and compounds of silver
- zinc and compounds of zinc.

The Clean Water Act lists additional hazardous substances at 40 CFR § 116.4 Table 116.4. Hazardous substances listed in Table 116.4 that are and have been released in reportable quantities (Table 117.3) in sediment, runoff, and leachate discharges in the Coeur d'Alene River basin include lead sulfide (galena), lead sulfate, zinc carbonate, zinc chloride, zinc sulfate, arsenic trioxide, cupric chloride, cupric sulfate, ferrous sulfate, nickel hydroxide, nickel chloride, cadmium chloride, and lead chloride (Maest, 2000). In addition, the following compounds listed in Table 116.4 are predicted to precipitate as solids from seeps: antimony trichloride, antimony trifluoride, antimony trioxide, cupric chloride, cupric sulfate, ferrous sulfate, nickel hydroxide, nickel sulfate, cadmium chloride, lead chloride, lead sulfate, and lead carbonate (Maest, 2000).

These substances occur naturally in bedrock, soils, sediments, and waters. However, as a result of mining and ore processing in the basin, the hazardous substances identified above have become highly concentrated in mining and milling wastes, in milling wastes discharged to surface waters, and in smelter emissions, and have been released into the environment.

The injury assessment focused on the hazardous substances cadmium, lead, and zinc. These three substances are prevalent and found in consistently high concentration in wastes, contaminated soils and sediments, and adit and seep drainage throughout the Coeur d'Alene River basin; their concentrations are highly correlated with concentrations of other hazardous substances in mine wastes and contaminated soils and sediments in the Coeur d'Alene River basin; and these substances are known to be toxic to biological resources.

2.3 HISTORICAL RELEASES OF HAZARDOUS SUBSTANCES

Mechanisms by which hazardous substances have been and continue to be released to the Coeur d'Alene River basin include historical disposal of waste rock in dumps adjacent to mine shafts and adits; historical disposal of tailings to creeks, rivers, and floodplains; and historical smelter emissions.

2.3.1 Historical Disposal of Waste Rock and Tailings

What follows is a summary of ore and tailings production histories relevant to releases of hazardous substances to natural resources in the Coeur d'Alene River basin. Mines, mining complexes, and mills are described by the following geographic areas: the South Fork Coeur d'Alene River and its tributaries upstream of Elizabeth Park (excluding Canyon Creek, Ninemile Creek, and Moon Creek) and the South Fork Coeur d'Alene River and its tributaries downstream of Elizabeth Park (excluding Pine Creek) (Figure 2-1), and the mainstem Coeur d'Alene River and the lateral lakes area, Canyon Creek, Ninemile Creek, Moon Creek, and Pine Creek (Figure 2-2).

The ore deposits in the Coeur d'Alene mining region are steeply dipping veins, many of which terminate below ground (Gott and Cathrall, 1980). Mining these subsurface ores involved tunneling and removing the ore from the deposit, leaving underground cavities. Waste rock associated with the removed ore was dumped near mine adits (horizontal entryways) and shafts (vertical entryways). Waste rock dumps are associated with most, if not all, adits and shafts at both producing and nonproducing mines in the Coeur d'Alene River basin (Ridolfi, 1998).

Much of the ore produced in the basin required concentration before smelting. The first mill in the basin, built to process ore from the Bunker Hill Mine, began operations in 1886 (Casner, 1991). Between 1886 and 1997, at least 44 mills are known to have operated in the South Fork Coeur d'Alene River basin. Initially, ores were concentrated by pulverization and gravity separation. Pulverized material was mixed with water and agitated or "jigged." This separated the heavier ores from the lighter host rock. The valuable ores were collected as concentrates, and the waste materials, or jig tailings, were sluiced to dumps or to nearby flowing surface water. Gravity separation was an inefficient recovery process, and jig tailings contained as much as 10% lead or zinc (Long, 1998). Some small operators established operations to reprocess these tailings deposits and extract more lead, zinc, and silver (Quivik, 1999). However, until new technologies such as flotation made the jig tailings profitable sources of mineral wealth, it was more profitable for larger operations to work fresh ore than to re-work tailings (Quivik, 1999).

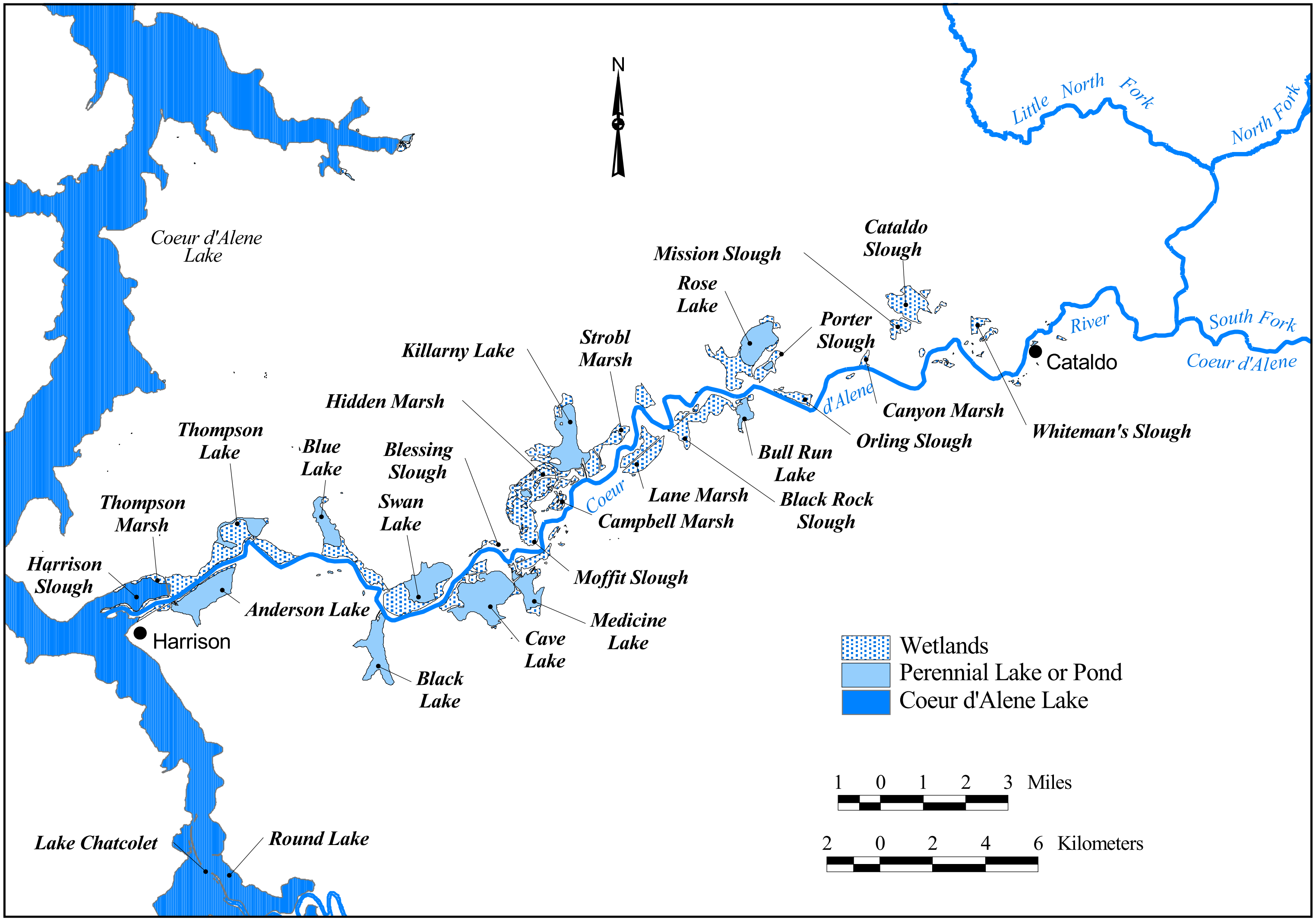

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Figure 2-1. Geographic areas referred to in descriptions of sources of hazardous substances in the mainstem Coeur d'Alene River and the lateral lakes area.

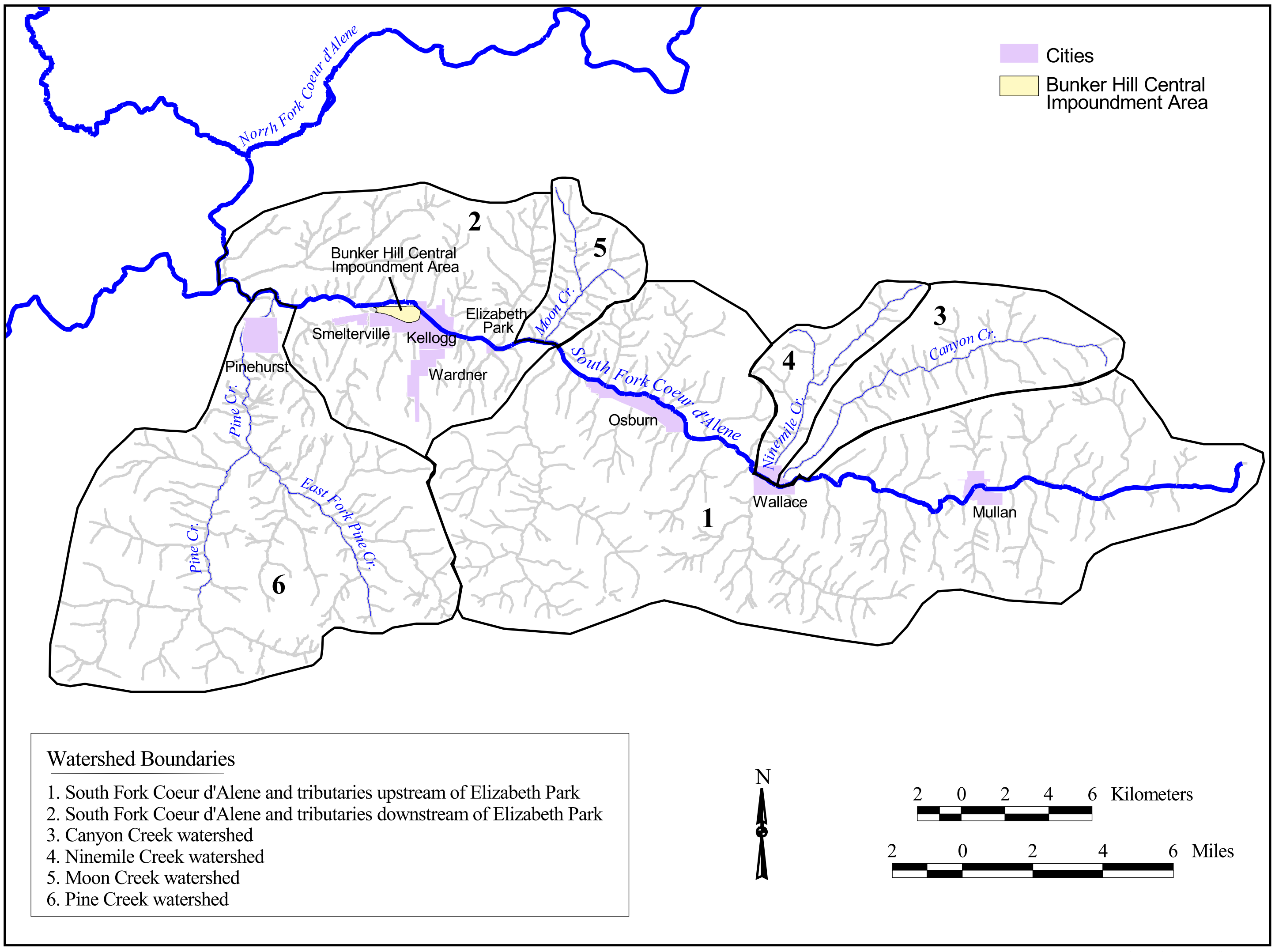

Figure 2-2. Geographic areas used to describe sources of hazardous substances in the South Fork Coeur d'Alene River basin.

In about 1912, flotation milling was introduced to the basin (Casner, 1991). Flotation milling involved finer pulverization of ores and mixing with water, a frothing agent (usually pine oil or cresylic acid), and a collecting agent (usually xanthate) to attract the ore minerals to the froth (Mitchell, 1996). When the mixture was agitated and aerated, metal sulfides adhered to the froth on top and were drawn off as concentrates. The host material settled and was sluiced as tailings to dumps or to nearby flowing surface water. Flotation milling greatly enhanced the efficiency of recovery of minerals, so the remaining tailings had lower concentrations of valuable minerals than did jig tailings. This advancement in technology made it profitable to reprocess old tailings, and companies began re-treating many of the tailings deposited in creeks, dumps, and impoundments in the Coeur d'Alene mining region.

The waste material from the mills contained sulfide and oxide compounds of antimony, bismuth, cadmium, copper, gold, lead, iron, silver, and zinc. The oxide and sulfide forms (when weathered) are leachable and subject to mobilization (MFG, 1992a).

Since milling required large volumes of water, the mills were constructed near sources of surface water. Many were located in steep narrow canyons with little area available for tailings disposal, so tailings were discharged to the streams or sluiced to the South Fork Coeur d'Alene River (Fahey, 1990). Mills along the South Fork Coeur d'Alene River discharged most processing wastes directly to the river. Tailings dumped in the floodplain often subsequently eroded to the stream (Casner, 1991). For over 80 years, from 1886 when milling began in the basin until 1968, when mills were required to impound tailings, the predominant tailings disposal method upstream of Elizabeth Park was discharge to nearby streams (Fahey, 1990; Long, 1998). Downstream of Elizabeth Park, tailings were deposited in the current locations of the Central Impoundment Area (CIA) and Page Pond beginning in 1926 (MFG, 1992a).

In 1901, in response to complaints from downstream landowners, the Mine Owners Association built a plank and pile dam near the village of Osburn to settle tailings on the Osburn flats reach of the South Fork Coeur d'Alene River (Fahey, 1978; Quivik, 1999). The original dam was 1,100 feet wide with a 12 foot head and an anticipated reservoir of 300-400 acres (Quivik, 1999). By 1909, the Osburn impoundment was filled, and tailings were flowing over the spillway. A second line of pilings and planks was added downstream of the original because the first was deteriorating. A series of high flows and floods in 1917 breached the dam. Subsequent flows eroded a deep channel through the tailings that had been impounded behind the dam. The dam was not rebuilt.

In 1902, the Mine Owners Association built a second pile and plank dam across the South Fork Coeur d'Alene River near the mouth of Pine Creek to impound tailings and prevent damage to downstream floodplains. The reservoir created by the dam covered approximately 2,000 acres of the river bottom from the dam upstream as far as Kellogg. By the summer of 1909, tailings had accumulated to the level of the spillway and slimes washed over the dam (Quivik, 1999). The dam washed out during the floods of 1917 and early 1918. It was not repaired.

In 1906, in response to complaints related to flooding and property damage in Wallace caused by tailings deposits near the mouth of Canyon Creek, the companies operating the Frisco, Hecla, Hercules, and Tiger mills formed the Canyon Creek Tailings Association. The association completed construction of a tailings impoundment in lower Canyon Creek in 1907. This dam was also damaged in the 1917 flood and not repaired.

Tailings have been mixed with alluvium and redistributed throughout the South Fork and lower Coeur d'Alene River basins (MFG, 1992a). Jig and flotation tailings were transported downstream from sources and deposited on the floodplains, banks, and beds of the South Fork and lower Coeur d'Alene rivers (MFG, 1992a). In 1903, the first of a series of pollution damage suits was filed by a Shoshone County farmer (Casner, 1991). By the mid-1920s, a visible tailings plume had extended the length of the Coeur d'Alene River, across Coeur d'Alene Lake, and as far as the Spokane River (Casner, 1991).

Estimates of the volume of tailings produced in the Coeur d'Alene River basin range from 110 million tons (through 1990; SAIC, 1993c) to 120 million tons (1884-1997; Long, 1998). SAIC (1993c) estimated that of the 110 million tons of tailings generated, an estimated 64.5 million tons of tailings were discharged to the Coeur d'Alene River or tributaries, 28.8 million tons of tailings remain in dumps and impoundments, and 16.8 million tons of tailings have been returned to underground mine workings as backfill (SAIC, 1993c). Tailings production was estimated by SAIC (1993c) based on ore tonnage, metal production, and the ratio of lead to gangue[1] minerals in the concentrate. Tailings production then was estimated as the difference between ore and concentrate tonnage.

Mill records that contain information on the tonnage and grade of ore milled and the tonnage and grade of concentrates recovered allow for a more precise estimate of the tonnage of tailings produced and the tonnage of metals in the tailings produced. Long (1998), in an open-file report, summarized from individual mill records the total tailings tonnage produced in the Coeur d'Alene mining region from 1886 to 1997, tons of metals contained in the tailings produced, and the percentage of the total tailings production that was disposed to creeks, dumps, and impoundments, or returned to mines as backfill (Table 2-1). Long (1998) estimated that 970,000 tons of lead and over 720,000 tons of zinc have been discharged to surface waters of the basin, and that 220,000 tons of lead and over 320,000 tons of zinc remain in unconfined tailings dumps in the floodplains.

The tailings estimates that follow are based on ore quality and metal recovery by mine. Ores were not necessarily milled in the drainages in which they were produced. Therefore, the estimated tailings produced by each mine were not necessarily disposed of within the reach where the ores were mined. However, the tailings estimates do provide an estimate of total tailings tonnages released in the basin. Between 1884 and the late 1960s, tailings disposal was uncontrolled upstream of Elizabeth Park; therefore, mill locations can be used to estimate the spatial extent of

1. Gangue is the rock surrounding the valuable metals in veins.

Table 2-1
Preliminary Estimate of Mill Tailings Produced in the Coeur d'Alene Mining Region

Disposal Method[a]	Dates	Tailings (tons)	Metals Contained in Tailings (tons)		
			Silver	Lead	Zinc
To creeks	1884-1967	61,900,000	2,400	880,000	>720,000
To dumps	1901-1942	14,600,000	400	220,000	>320,000
Mine backfill	1949-1997	18,000,000	200	39,000	22,000
To impoundments	1928-1997	26,200,000	300	109,000	180,000
Total	1884-1997	120,700,000	3,300	1,248,000	>1,242,000

a. Long (1998) defines dumps as unsecured stockpiles of tailings. Impoundments are secured by dams or other structures. Many impoundments were built over and from older tailings dumps.

Source: Long, 1998.

riparian and riverine resources exposed to primary tailings discharges (MFG, 1992a). Downstream of Elizabeth Park, tailings were deposited in Page Pond beginning in 1926 and the CIA beginning in 1928 (MFG, 1992a).

South Fork Coeur d'Alene River Upstream of Elizabeth Park

In the South Fork drainage upstream of Elizabeth Park (excluding operations on Moon Creek, Ninemile Creek, and Canyon Creek, which are discussed separately), at least 24 mines or mine complexes produced an estimated 47 million tons of ore between 1895 and 1990 (Figure 2-3; Ridolfi, 1998). From this ore, an estimated 1.8 million tons of lead, 790,000 tons of zinc, 170,000 tons of copper, 22,000 tons of silver, 2.5 tons of gold, and 41 million tons of tailings were produced (Mitchell and Bennett, 1983; SAIC, 1993c). Table 2-2 lists the mines of the South Fork drainage upstream of Elizabeth Park, ore production, and estimated tailings production through 1990.

At least 456 adits have been identified in the South Fork drainage upstream of Elizabeth Park, excluding workings on Canyon Creek, Ninemile Creek, and Moon Creek (Hobbs et al., 1965; SAIC, 1993c; Balistrieri et al., 1998; Gearheart et al., 1999; U.S. Forest Service,[2] U.S. BLM[3]).

2. Unpublished list of adits on U.S. Forest Service Land known to drain mine waters. Provided to Ridolfi Engineers by Jim Northrup, Coeur d'Alene National Forest, Supervisor's Office, Coeur d'Alene, ID. December 1999.

3. Unpublished field survey information provided to Ridolfi Engineers by L. Eno, U.S. BLM, Coeur d'Alene District Office, Coeur d'Alene, ID. 1997.

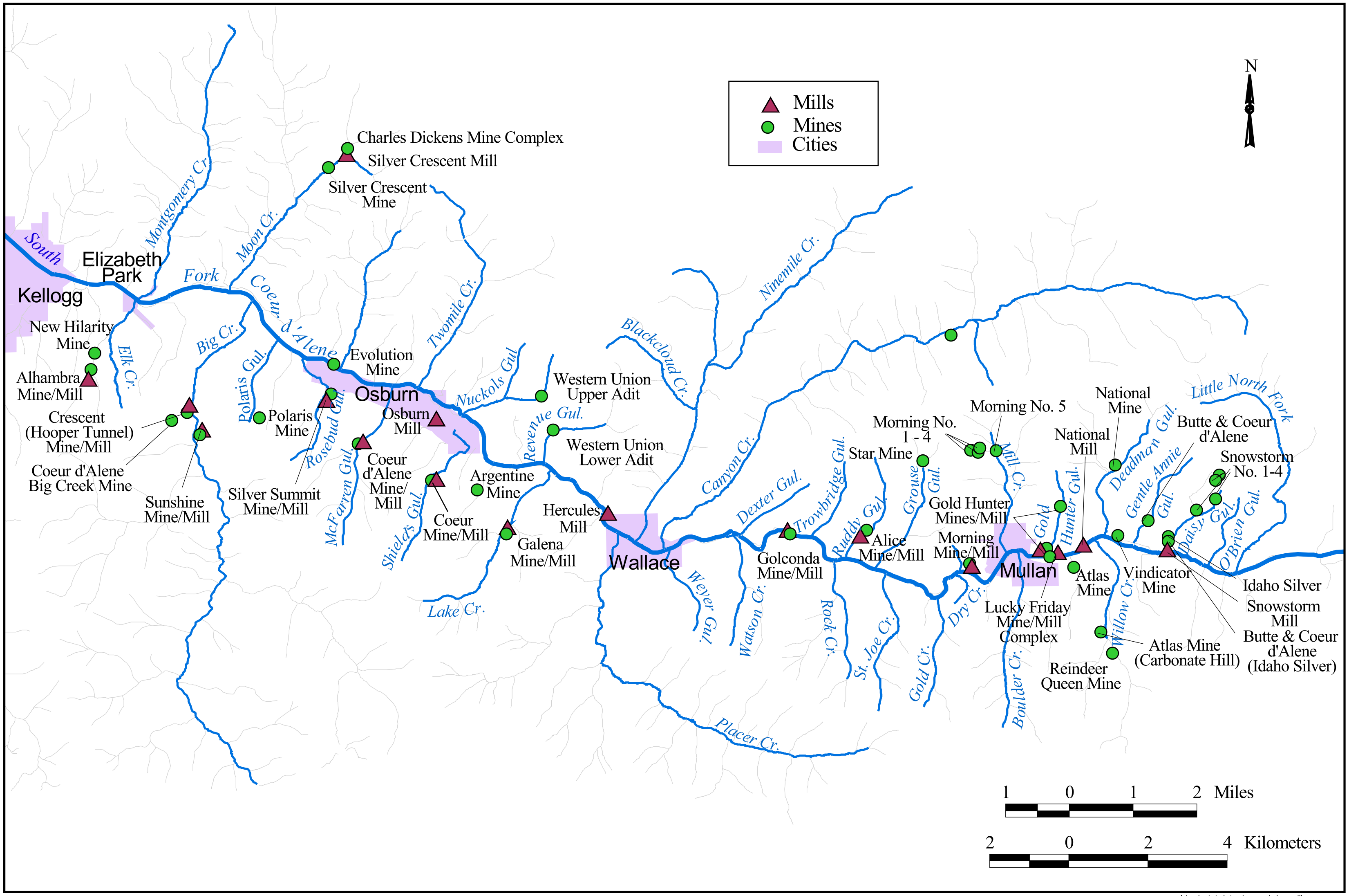

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Figure 2-3. Major mines and mills in the South Fork Coeur d'Alene River basin upstream of Elizabeth Park.
Source: U.S. BLM, 1998.

Table 2-2
South Fork Coeur d'Alene River Mine Production Upstream of Elizabeth Park

Mine	Production Years	Ore Produced (tons)	Mill[a]	Estimated Tailings Produced[b] (tons)
Upstream of Canyon Creek				
Alice	1909-1926	49,419	Alice	45,861
Atlas	1930-1970	6,936	Gold Hunter	6,351
Butte & Coeur d'Alene (Idaho Silver)	1926	35		NA
Golconda	1926-1967	339,228	Golconda	274,299
Gold Hunter	1901-1949	3,260,750	Gold Hunter	3,065,496
Lucky Friday	1938-1990	5,674,668	Lucky Friday, Golconda	4,485,010
Morning	1895-1953	14,136,333	Morning	11,163,230
National	1914-1922	170,008	National	164,316
Reindeer Queen	1910-1916	147		116
Snowstorm	1901-1943	826,580	Snowstorm	706,612
Vindicator	1922-1938	28		NA
Total		***24,464,132***		***19,911,291***
Elizabeth Park to Canyon Creek				
Alhambra	1917-1918	2,200	Crescent	2,059
Argentine	1921-1923	401		393
Big Creek Silver (part of Crescent)	1913-1935	16,847	Crescent	15,608
Coeur d'Alene (Mineral Point)	1919-1952	440,779	Coeur d'Alene (Mineral Point), Hercules (Wallace)	430,984
Coeur (originally Mineral Point)	1969-1990	2,251,910	Coeur	2,195,612
Crescent	1924-1990	962,252	Crescent, Polaris/Silver Summit, Bunker Hill Complex	NA
Evolution	1908-1948	10,474		10,342
Galena	1922-1990	5,895,490	Galena	5,682,193
New Hilarity	1944-1946	879		768
Polaris	1916-1943	320,783	Polaris/Silver Summit	308,203
Rainbow	1958	7,582		7,377

Table 2-2 (cont.)
South Fork Coeur d'Alene River Mine Production Upstream of Elizabeth Park

Mine	Production Years	Ore Produced (tons)	Mill[a]	Estimated Tailings Produced[b] (tons)
Silver Summit (Con Silver)	1948-1982	827,617	Polaris/Silver Summit	795,161
Sunshine	1904-1990	11,453,874	Sunshine	11,004,701
Western Union	1920-1948	11,173		7,838
Total		***22,202,261***		***20,461,239***
Grand Total		***46,666,393***		***40,372,530***

a. Blank cells indicate that most likely there was no mill located on site, and ores were probably shipped elsewhere for milling. No records were found identifying the mill to which the ores were shipped.
b. Estimated tailings produced by each mine were not necessarily disposed within the reach where the ores were mined.
NA = No information available.

Sources: Gage, 1941; Gross, 1982; Mitchell and Bennett, 1983; SAIC, 1993a, 1993b, 1993c; Bennett, unpublished, as cited in Ridolfi, 1998; Quivick, 1999.

Unconfined waste rock piles are found near most, if not all, adits and shafts. At least 56 adits in the South Fork Coeur d'Alene River basin upstream of Elizabeth Park have documented drainage (SAIC, 1993c; U.S. BLM, 1997; USFS, 1997; both as cited in Ridolfi, 1998; Balistrieri et al., 1998; Gearheart et al., 1999).

At least 14 mills operated in the South Fork drainage upstream of Elizabeth Park, excluding mills on Canyon Creek, Ninemile Creek, and Moon Creek (Figure 2-3). Table 2-2 identifies the mills used to process ore from mines in the area. Before 1969, tailings were dumped directly to adjacent streams. Historical discharges of tailings to the South Fork Coeur d'Alene River drainage took place as far upstream as Daisy Gulch. In addition, the tributaries Deadman Gulch, Ruddy Gulch, Lake Creek, McFarren Gulch, and Big Creek, and the mouths of Daisy Gulch, Gold Hunter Gulch, and Rosebud Gulch, were exposed to releases of tailings from milling operations with no tailings containment systems (SAIC, 1993b, 1993c).

Several companies reprocessed tailings that accumulated in the upper South Fork Coeur d'Alene River floodplains. In the early part of the 20th century the Illinois Western Concentrating Company and the Northern Idaho Metals Company both constructed mills between Mullan and Wallace to re-treat tailings deposited in the bed of the South Fork. The Northern Idaho Metals Company built a settling pond between Mullan and Wallace and in the summer of 1917 impounded about 10,000 tons of tailings from the upper South Fork Coeur d'Alene River.

In 1943, Hecla began reprocessing tailings that remained in the former Osburn tailings impoundment area. Tailings were excavated and transported to either Hecla's Osburn Mill (built to re-treat tailings) or Hecla's Gem mill. By end of 1948, Hecla had treated over 3,800,000 tons of Osburn tailings (Quivik, 1999). The Osburn Mill was destroyed by fire in December 1948. In 1946, the Zanetti Brothers also began excavating tailings from the Osburn. In addition, between 1947 and 1952, several companies, including Federal Mining and Smelting Company and the Zanetti Brothers, reworked a tailings deposit near the mouth of Big Creek, reprocessing as much as 99,600 tons in 1949 (Quivik, 1999).

Beginning in the mid-1960s, approximately one-half of the tailings produced from ore mined in the Sunshine (2.4 million tons), Silver Summit (75,000 tons), Coeur (1.1 million tons), and Galena (2.7 million tons) mines were used as sandfill to back-fill underground mine workings at each of these mines (SAIC, 1993c). After 1969, at least 4.9 million tons of tailings were discharged to tailings ponds from Sunshine (1.8 million tons), Silver Summit (13,900 tons), Coeur (1.1 million tons), and Galena (2.0 million tons) mining operations (SAIC, 1993c).

South Fork Coeur d'Alene River Basin Downstream of Elizabeth Park

In the South Fork Coeur d'Alene River basin downstream of Elizabeth Park, excluding Pine Creek (discussed separately), at least 11 mines or mine complexes produced an estimated 48 million tons of ore between 1895 and 1980 (Figure 2-4; Mitchell and Bennett, 1983). From this ore, an estimated 3.2 million tons of lead, 1.4 million tons of zinc, 13,000 tons of copper, 5,000 tons of silver, and 1.4 tons of gold were recovered. Table 2-3 lists ore production through 1980 for the mines of the South Fork drainage downstream of Elizabeth Park.

At least 11 mills, a lead smelter, a zinc electrolytic refinery, and a phosphoric acid plant operated in the South Fork drainage downstream of Elizabeth Park, excluding mills on Pine Creek (Figure 2-4). Historical discharges of tailings to the South Fork Coeur d'Alene River drainage between Elizabeth Park and the North Fork confluence took place as far upstream as Kellogg. In addition, the tributaries Milo Gulch, Deadwood Gulch, Government Gulch, and Humboldt Gulch were exposed to releases of tailings from milling operations (MFG, 1992a). The first mill was constructed in 1886 at Wardner in Milo Gulch. Between 1886 and 1891, this mill processed 117,600 tons of ore and generated 101,020 tons of tailings (Dames & Moore, 1987). Between 1891 and 1909, at least four mills (Old South Mill, South Mill, West Mill, and North Mill) were constructed on the South Fork Coeur d'Alene River near Kellogg downstream of Milo Creek. These mills processed at least 43 million tons of ore and generated approximately 37 million tons of tailings between 1891 and 1981 (Dames & Moore, 1987). Between 1917 and 1981, the lead smelter processed approximately 6.8 million tons of concentrates, 570,000 tons of zinc residue, 300,000 tons of silica and lime, and 1.2 million tons of coal and coke to produce 6.6 million tons of metals, 1.6 million tons of slag, and 16.5 million tons of dust, particulate emissions, and sulfuric acid (Dames & Moore, 1987). The electrolytic zinc plant produced an estimated 3.6 million tons of metals between 1928 and 1936 from 7.3 million tons of concentrate (Dames & Moore, 1987).

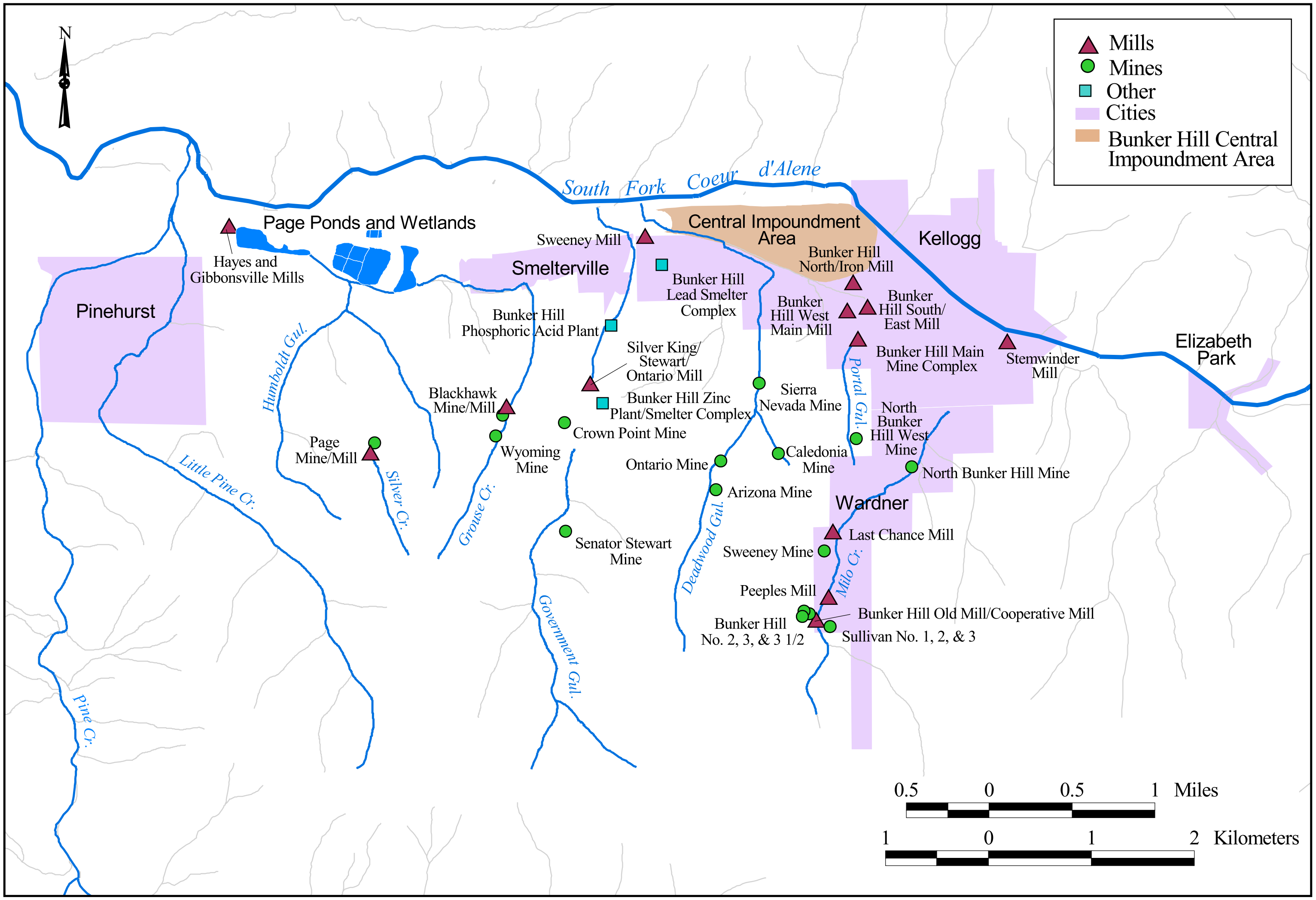

Figure 2-4. Major mines and mills in the South Fork Coeur d'Alene River basin downstream of Elizabeth Park.
Source: U.S. BLM, 1998.

Table 2-3
South Fork Coeur d'Alene River Mine Production Downstream of Elizabeth Park

Mine	Production Years	Ore Produced (tons)	Mill[a]
Arizona	1945-1946	2,321	
Blackhawk	1916-1944	214,126	Page
Bunker Hill	1887-1980	38,483,673	Sweeney, West, South
Caledonia	1909-1942	263,182	
Crown Point	1901-1940	63,098	
Last Chance	1895-1918	2,845,356	On site, Sweeney, Crescent
Ontario	1911-1917	325,502	South
Page	1916-1969	4,307,335	Page
Senator Stewart	1904-1951	1,041,814	
Sierra Nevada	1943-1947	289,450	South[b]
Wyoming	1916-1926	2,774	Page
Total		***47,838,631***	

a. Blank cells indicate that most likely there was no mill located on site, and ores were probably shipped elsewhere for milling. No records were found identifying the mill to which the ores were shipped.
b. Sierra Nevada mine ore milled at the Sierra Nevada mill not included in this production estimate.

Sources: Gross, 1982; Mitchell and Bennett, 1983; Dames & Moore, 1987.

Tailings produced before 1926 were discharged directly to adjacent streams (MFG, 1992a). In approximately 1902, a plank-and-pile dam was constructed near Pinehurst, which increased tailings deposition on Smelterville Flats (Quivik, 1999). Tailings were deposited in Page Pond beginning in 1926 and the CIA beginning in 1928 (MFG, 1992a).

Several companies reprocessed tailings deposited in the floodplain of the South Fork Coeur d'Alene River basin downstream of Elizabeth Park. Between 1904 and 1909, Safford & Safford and the Shoshone Concentrating Company reprocessed tailings on Milo Creek from the creek bed and from the Last Chance Mill, respectively (Quivik, 1999). Mullan Milling reprocessed the Ontario dump at the mouth of Government Gulch. The Ontario dump was estimated to hold 150,000 tons of tailings (Quivik, 1999). Between 1916 and 1929, the Hayes Company re-treated tailings from behind the Pine Creek dam (on the South Fork Coeur d'Alene River near Pine Creek), until the profitable supply was exhausted (Quivik, 1999).

Canyon Creek

In the Canyon Creek drainage, at least 21 mines and mining complexes produced an estimated 36 million tons of ore between 1887 and 1990 (Mitchell and Bennett, 1983; SAIC, 1993c). From this ore, an estimated 2.6 million tons of lead, 1.2 million tons of zinc, 9,000 tons of copper, 5,000 tons of silver, 1 ton of gold, and 27 million tons of tailings were produced (Mitchell and Bennett, 1983; SAIC, 1993c). Table 2-4 lists mines of the Canyon Creek drainage that recorded ore production, the documented ore production for each, and estimated tailings production through 1990.

Table 2-4
Canyon Creek Mine Production

Mine	Production Years	Ore Produced (tons)	Mill[a]	Estimated Tailings Produced[b] (tons)
Ajax	1922-1951	6,235	Bunker Hill Complex	5,020
Ambergris[c]	1919-1934	16,786		14,074
Anchor Group	1937-1951	2,589		2,104
Benton	1955-1956	625		517
Black Bear Fraction	1927-1973	19,727	Amy-Matchless	17,035
Canyon Silver-Formosa	1931-1938/ 1966-1974	24,246	Onsite	20,250
Fairview and Wide West	1945-1950	57,186		50,853
Greenhill-Cleveland	1902-1918	791,447		580,641
Hecla	1898-1944	7,686,967	Hecla, Gem, Standard, Marsh/Blackcloud, Union	6,700,193
Helena-Frisco (Black Bear, Frisco, Gem)	1897-1967	2,676,379	Helena-Frisco, Black Bear, Frisco, Gem	2,144,173
Hercules	1901-1965	3,519,592	Hercules, Hercules (Wallace), Tiger-Poorman, Sherman	2,259,849
Hummingbird	1926-1931	33,449	Hercules (Wallace)	26,125
Marsh	1908-1925	128,805	Marsh/Blackcloud	111,160
Sherman	1927-1972	661,071	Sherman, Hercules (Wallace)	545,387
Sisters	1920-1929	472		68
Standard-Mammoth	1887-1965	3,763,893	Standard-Mammoth	3,232,270
Stanley	1906-1942	1,459		1,443
Star/Morning	1925-1990	12,303,035	Star/Morning, Bunker Hill Complex, Hercules (Wallace), Hecla	9,164,183

Table 2-4 (cont.)
Canyon Creek Mine Production

Mine	Production Years	Ore Produced (tons)	Mill[a]	Estimated Tailings Produced[b] (tons)
Tamarack-Custer[c]	1905-1977	1,973,630	Tamarack-Custer, Hercules (Wallace), Frisco	1,640,484
Tiger-Poorman	1901-1961	1,128,793	Tiger-Poorman, Hercules (Wallace)	915,535
Union	<1905	5,168	Union, Standard, Mammoth	4,225
Total		***34,801,554***		***27,435,589***

a. Blank cells indicate that there was most likely no mill located on site, and ores were probably shipped elsewhere for milling. No records were found identifying the mill to which the ores were shipped.
b. Estimated tailings produced by each mine were not necessarily disposed within the reach where the ores were mined.
c. Mines located in Ninemile Creek drainage, but majority of production was extracted through Canyon Creek drainage (Ridolfi, 1998; SAIC, 1993a). Approximately 30% of the total ore extracted from Tamarack-Custer was extracted through Ninemile Creek between 1912 and 1922, and is included on Table 2-5.

Sources: Mitchell and Bennett, 1983; Fahey, 1990; SAIC, 1993a, 1993b, 1993c; Mitchell, 1996; Bennett, unpublished as cited in Ridolfi, 1998.

At least 138 adits have been identified in the Canyon Creek drainage (Hobbs et al., 1965; Gearheart et al., 1999). Approximately 47 of the adits and the two shafts are entryways to mines known to have produced ore. Waste rock piles are found near most of the adits and shafts. Waste rock from several mines, including the Hecla, the Star, and the Tiger-Poorman, may have been removed for use as construction or fill material (Fahey, 1978; Ridolfi, 1998).Twenty-four adits in the Canyon Creek drainage have documented drainage (Gearheart et al., 1999).

At least 13 mills operated in the Canyon Creek drainage. The locations of the major mills are shown in Figure 2-5. Before 1965, all mills in Canyon Creek released tailings to the stream. Historical releases of tailings to the drainage took place as far upstream as the mill at the Hercules No. 4 adit on Gorge Gulch.

In the early 1900s, small operations reprocessed tailings from the Standard, Gem, Frisco, and upper Mace tailings dumps (Quivik, 1999). The Small Leasing Company was the largest tailings reprocessor in Canyon Creek, re-treating upwards of 500,000 tons of tailings from Canyon Creek deposits between 1938 and 1949, using the Formosa, Golconda, and Hercules mills (Figures 2-3 and 2-5; Quivik, 1999).

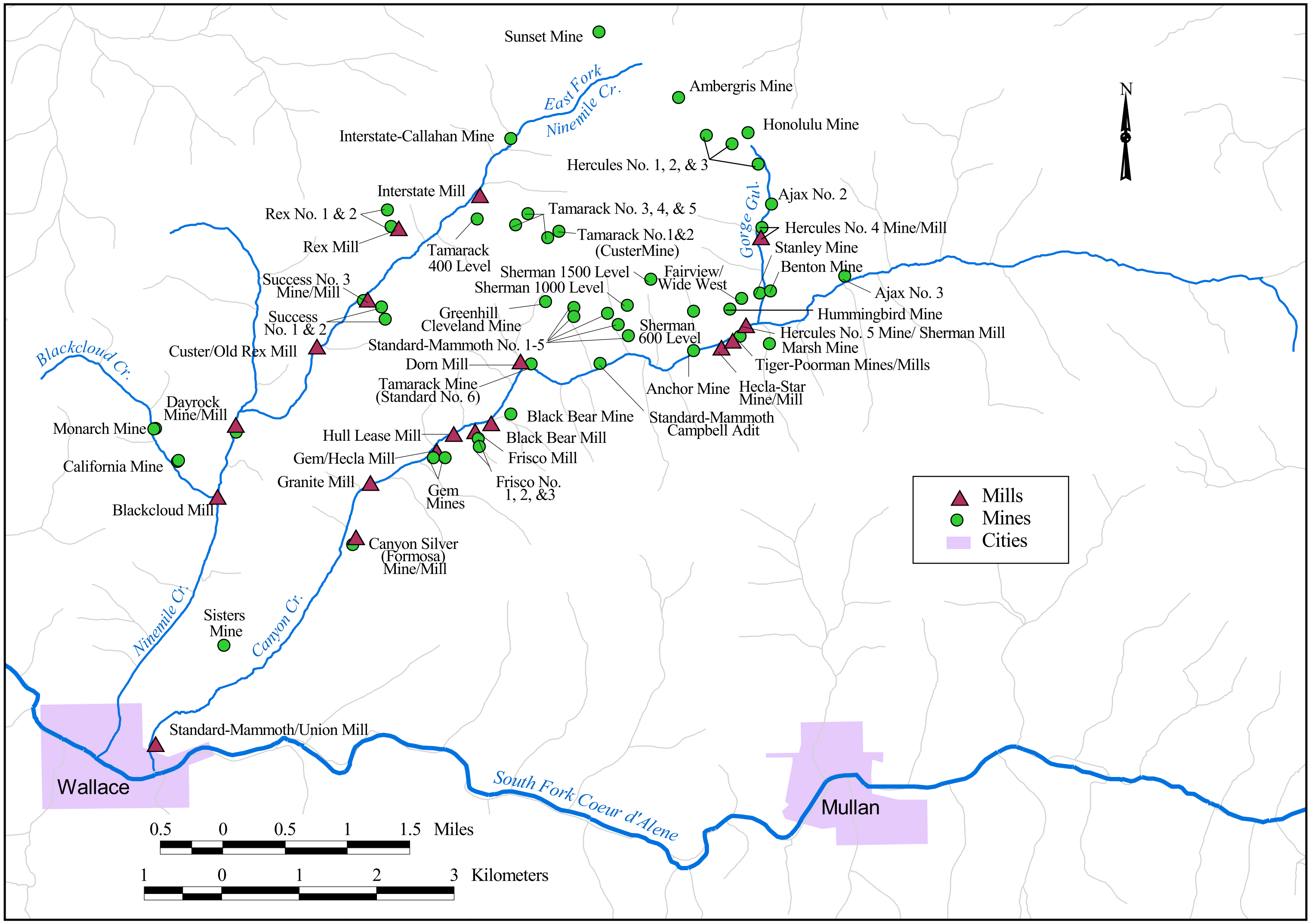

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Figure 2-5. Major mines and mills in the Canyon Creek and Ninemile Creek basins.
Source: U.S. BLM, 1998.

Approximately 50% (2.8 million tons) of the tailings generated by ore from the Star/Morning mine were used as sandfill between 1959 and 1990. In 1965, the Star/Morning Mine tailings ponds 1 and 2 were built in the Canyon Creek floodplain. Between 1970 and 1979, four additional ponds were constructed. The ponds received tailings until 1990 from the Star Mine and later from the Star Phoenix Mine for a total of approximately 3.4 million tons (SAIC, 1993b).

Ninemile Creek

In the Ninemile Creek drainage, eight mines are known to have produced nearly 5 million tons of ore between 1902 and 1977 (Figure 2-5; Mitchell and Bennett, 1983). From this ore, an estimated 330,000 tons of lead, 300,000 tons of zinc, 1,800 tons of copper, 600 tons of silver, 0.17 tons of gold, and 4 million tons of tailings were produced (Mitchell and Bennett, 1983; SAIC, 1993c). Some of the ore mined in the Ninemile Creek drainage was extracted and milled in either the Beaver Creek drainage or the Canyon Creek drainage. Table 2-5 lists the mines of the Ninemile Creek drainage, ore production, and estimated tailings production through 1977.

Table 2-5
Ninemile Creek Mine Production

Mine	Production Years	Ore Produced (tons)	Mill	Estimated Tailings Produced[a] (tons)
California	1902-1925	49,079	Blackcloud/Marsh	41,945
Dayrock	1924-1974	1,276,488	Dayrock, Hercules (Wallace)	1,121,575
Interstate-Callahan[b]	1906-1977	1,423,619	Interstate-Callahan, Galena	1,039,087
Monarch	1904-1942	58,840	Blackcloud/Marsh	52,053
Rex	1905-1949	154,441	Rex, Old Rex (16 to 1)	134,813
Success (Granite)	1905-1952	789,704	Success, Granite	665,798
Sunset[b]	1913-1976	355,032	Golconda	302,863
Tamarack-Custer[c]	1912-1922	845,842	Old Rex (16 to 1), Frisco	703,065
Total		***4,953,045***		***4,061,199***

a. Estimated tailings produced by each mine were not necessarily disposed of within the reach where the ores were mined.
b. Majority of production extracted through Beaver Creek drainage in the 1940s (Ridolfi, 1998).
c. Mine located in Ninemile Creek drainage, but approximately 70% of production was extracted through Canyon Creek drainage and is therefore included in Table 2-4.

Sources: Mitchell and Bennett, 1983; SAIC, 1993c; Ridolfi, 1998.

At least 67 adits have been identified in the Ninemile Creek drainage; most are located in the East Fork of Ninemile Creek (Hobbs et al., 1965; Gearheart et al., 1999). Sixteen of the adits are entryways to mines known to have produced ore. Waste rock piles are probably associated with all of the adits and shafts. At least 12 adits in the Ninemile Creek basin have documented drainage (Gearheart et al., 1999).

At least seven milling facilities operated in the Ninemile Creek basin (Figure 2-5). Before 1965, all mills in Canyon Creek released tailings to the stream. Historical discharges of tailings to the drainage took place at least as far upstream as the Interstate-Callahan mill. Some tailings discharged into Ninemile Creek were later re-treated to extract valuable minerals. In 1916, Interstate-Callahan began re-treating 200,000 to 250,000 tons of tailings it had collected in an impoundment, and the Spokane Metals Recovery Company re-treated tailings from several operations on the East Fork of Ninemile Creek in 1918 (Quivik, 1999). In 1936, the Galena Mill on Lake Creek (Figure 2-3) treated 13,000 tons of lead zinc ore from waste dumps of the Interstate-Callahan mine (Quivik, 1999). During World War II, deposits from the Interstate-Callahan and Rex tailings dumps were re-treated by Callahan Consolidated and the Zanetti Brothers (Quivik, 1999).

Between 1950 and 1974, approximately 400,000 tons of tailings produced by the Dayrock Mine were returned to the mine as sandfill. After 1969, approximately 100,000 tons of tailings from the Dayrock Mine were placed in a tailings pond (SAIC, 1993c).

Moon Creek

In the Moon Creek drainage, eight mines are known to have operated, but most of the recorded ore production was from the Charles Dickens Mine and the Silver Crescent Mine on the East Fork of Moon Creek. The two properties were consolidated in 1937 as the Silver Crescent (SAIC, 1993b). Between 1920 and 1930, the Charles Dickens Mine produced 4,604 tons of ore, yielding 370 tons of lead, 40 tons of zinc, 16 tons of copper, 16,022 ounces of silver, 31 ounces of gold, and 3,803 tons of tailings (Figure 2-3; Table 2-6).

At least six adits and three shafts have been identified in the Moon Creek basin (IGS, 1997). Three of the adits are associated with the Charles Dickens Mine. Adit drainage has been documented in three adits in the basin (USBM, 1995).

The Charles Dickens Mill processed ores from the Charles Dickens Mine, the Silver Dollar Mining Company at Terror Gulch, and Western Union Mine, and also processed custom ores (USBM, 1995). The mill also reprocessed tailings from the Osburn dump. Mill tailings from the Charles Dickens Mill were slurried across the creek and deposited in an area adjacent to the creek and downstream from the mill site. A large tailings impoundment remains (USBM, 1995). A large tailings impoundment recently has been relocated into an on-site repository.

Table 2-6
Moon Creek Mine Production

Mine	Production Years	Ore Produced (tons)	Mill	Estimated Tailings Produced[a] (tons)
Charles Dickens/Silver Crescent	1902-1930	4,604	Charles Dickens	3,803
Total		***4,604***		***3,803***

a. Estimated tailings produced by each mine were not necessarily disposed of within the reach where the ores were mined.

Sources: Mitchell and Bennett, 1983; SAIC, 1993c.

Pine Creek

In the Pine Creek drainage, an estimated 50 mines, nine mills, and 500 patented and unpatented claims operated between 1884 and 1980 (CCJM, 1995). Ore production for mines in the Pine Creek drainage is estimated at 3.2 million tons of ore (Mitchell and Bennett, 1983; Mitchell, 1996) (Figure 2-6; Table 2-7). An estimated 102,000 tons of lead, 210,000 tons of zinc, 900 tons of copper, 140 tons of silver, and 2.5 million tons of tailings were produced (Mitchell and Bennett, 1983; SAIC, 1993c; Mitchell, 1996).

At least 76 adits have been identified in the Pine Creek drainage (Gearheart et al., 1999). Waste rock piles are associated with most of the adits and shafts. The total volume of many of the waste rock dumps has been estimated at over 1.4 million cubic yards (CCJM, 1995; McNary et al., 1995; Mitchell, 1996; Gearheart et al., 1999). At least 22 named adits in the Pine Creek basin have drainage (CCJM, 1995; McNary et al., 1995).

Figure 2-6 identifies the eight major mills that are known to have operated in the Pine Creek drainage. Historical discharges of tailings to the drainage took place as far upstream as the Constitution mill on the East Fork Pine Creek. Other tributaries in the Pine Creek basin that have received tailings from milling operations include Highland Creek, Denver Creek, and Nabob Creek. There is little record of re-treatment of tailings from the banks and bed of Pine Creek (Quivik, 1999).

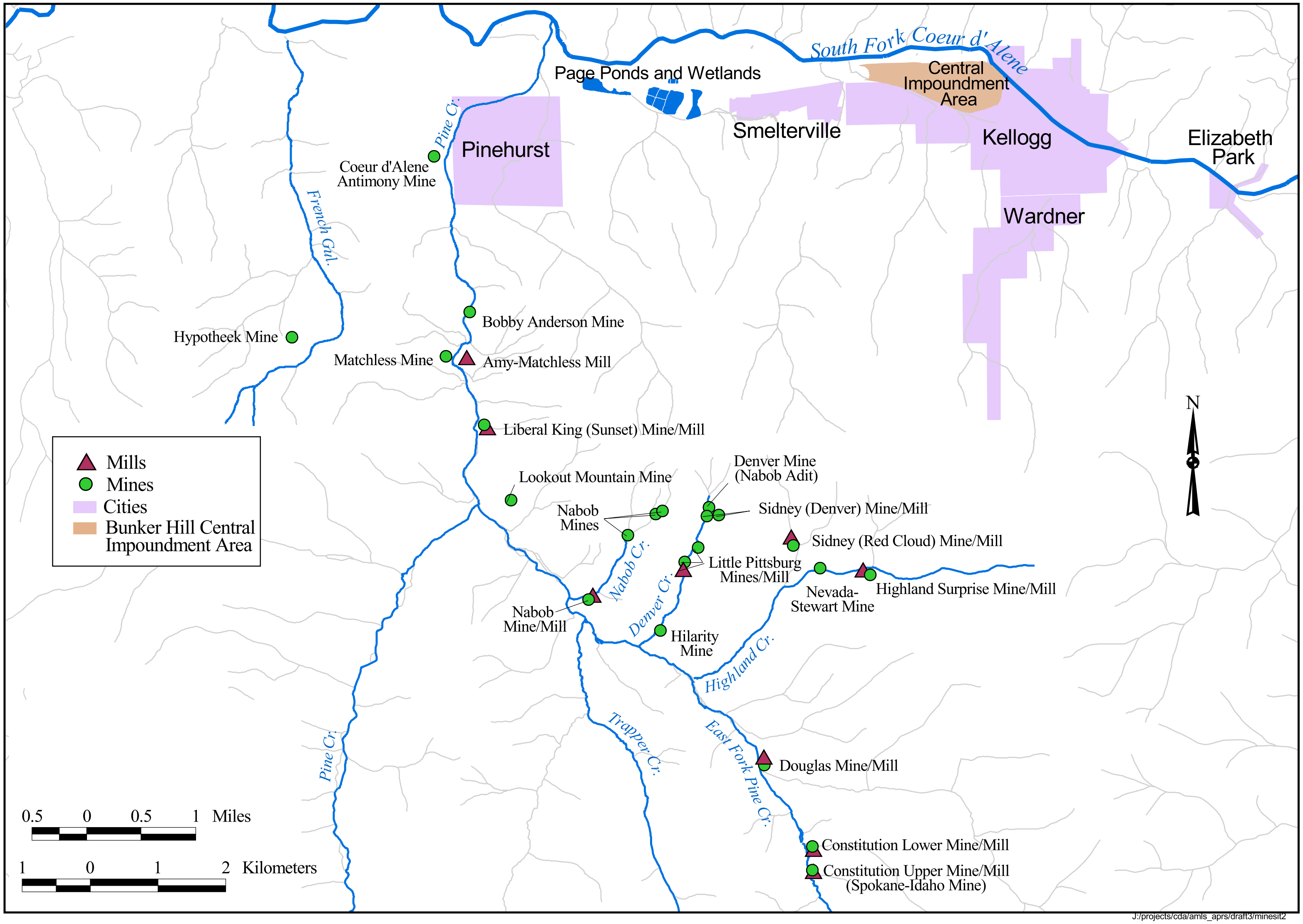

Figure 2-6. Major mines and mills in the Pine Creek basin.
Source: U.S. BLM, 1998.

Table 2-7
Pine Creek Mine Production

Mine	Production Years	Ore Produced (tons)	Mill[a]	Estimated Tailings Produced[b] (tons)
Amy-Matchless	1912-1956	4,569	Amy-Matchless	4,359
Bobby Anderson	1927-1951	523		432
Constitution (Spokane-Idaho)	1915-1968	667,326	Constitution, Amy-Matchless	538,249
Denver	1916-1944	13,000	Bunker Hill Complex, Sullivan, Sidney	8,220
Douglas	1916-1972	167,162	Douglas, Great Falls, Constitution	138,440
Highland Surprise	1904-1971	518,706	Highland Surprise	332,847
Hilarity	1926-1952	3,330		3,103
Hypotheek	1913-1954	88,702	Hypotheek	80,579
Liberal King (Sunset)	1937-1963	256,437	Liberal King (Sunset)	220,006
Little Pittsburgh	1916-1955	320,674	Little Pittsburgh, Great Falls, Nabob	275,624
Lookout Mountain	1922-1952	1,595	Charles Dickens, Liberal King (Sunset), Amy-Matchless	1,149
Nabob	1907-1977	134,069	Nabob, Amy-Matchless	111,759
Sidney (Red Cloud)	1921-1967	1,071,197	Sidney, Galena, Sweeney, Star/Morning, Bunker Hill Complex	816,733
***Total*[c]**		***3,247,290***		***2,531,500***

a. Blank cells indicate that most likely there was no mill located on site, and ores were probably shipped elsewhere for milling. No records were found identifying the mill to which the ores were shipped.
b. Estimated tailings produced by each mine were not necessarily disposed within the reach where the ores were mined.
c. No production records available for the Coeur d'Alene Antimony Mine or the Nevada-Stewart Mine.

Sources: Jones, 1919; Mitchell and Bennett, 1983; SAIC, 1993c; CCJM, 1995; McNary et al., 1995; Mitchell, 1996.

2.3.2 Historical Smelter Emissions

In the early decades of mining in the basin, concentrated ore from the Coeur d'Alene mining region was shipped out of the basin for smelting. Smelting operations in the basin began in 1917 at the Bunker Hill smelter (Bennett, 1982; Casner, 1991). Smelting of sulfide ores produces emissions containing sulfur dioxide and particulate matter consisting of varying amounts of metals and metalloids, depending on the mineralogy of the ore (MFG, 1992a). Smelting of the predominantly galena (PbS) Bunker Hill ores and sulfide ores from other mines resulted in releases of arsenic, cadmium, copper, lead, antimony, selenium, and zinc, among other trace elements, and sulfurous compounds to the atmosphere (Bennett, 1982; CDM et al., 1986). The main sources of hazardous substance emissions were the lead smelter stack and fugitive emissions from the processing and storage areas (CDM et al., 1986). Smelter emissions from the stacks were transported in the air throughout the Coeur d'Alene River valley. Particulates transported in the emissions plume were deposited on the hillsides and valley floor surrounding the smelter (MFG, 1992a).

The smelter emissions content varied over the 63 years of operation, changing with production rates, smelting technology, and emissions control efforts. For most of the operating period, the Bunker Hill smelting complex had few controls on emissions. Table 2-8 presents a brief chronology of construction and technological modifications during the operating history of the smelter complex (Bennett, 1982; Murray, 1982; CDM et al., 1986). Early technological additions to enhance metal recovery, such as the Cottrell electrostatic precipitators installed in 1925 to recover metals from flue dust (Bennett, 1982), probably reduced particulate emissions compared to earlier years. Addition of the sulfuric acid plant in 1954 reduced sulfur dioxide emissions (CDM et al., 1986). Emissions controls were first added to the lead smelter in 1969, when a new baghouse, ventilation system, and scrubbers were installed (Bennett, 1982). In 1970, a new updraft sintering[4] plant and associated sulfuric acid plant replaced the older ore roasting machine (Bennett, 1982; CDM et al., 1986). With addition of the new sintering process, sulfur dioxide emissions were reportedly reduced by 90% (Bennett, 1982). In 1975, scrubbers were installed in the sintering stack, reducing lead smelter main stack emissions by a reported 90% (Bennett, 1982). In 1977, tall stacks (>600 feet) were added to both the zinc and lead smelters in an attempt to disperse contaminants. The stacks reduced ambient air concentrations in the Coeur d'Alene River valley (Bennett, 1982; CDM et al., 1986).

4. Sintering reduced the amount of sulfur in the ore and prepared the lead feed mixture for the blast furnace. Sulfur dioxide and other gases emitted were cleaned in the baghouse and mist precipitator and sent to the sulfuric acid plant. Waste gases from sintering were treated in the baghouse and exhausted through a stack. Sinter is an agglomeration of materials, including oxidized concentrates. Sinter and coke were fed to the blast furnace. Reducing gases and heat were used to produce molten metallic lead and slag. Exhaust gases from the blast furnace were filtered in the main baghouse and discharged from the main stack.

Table 2-8
Chronology of Bunker Hill Smelter Complex Construction and Technological Modifications

1917	Bunker Hill lead smelter began operation. Capacity: 1,000 tons per day (tpd).
1918	Lead smelter enlarged; fourth blast furnace added.
1925	Cottrell electrostatic precipitators added to recover metal-bearing dust from the flue.
1928	Electrolytic zinc plant began operation.
1929	Capacity of lead smelter doubled.
1936	New blast furnace installed; largest lead producing furnace in the United States.
1937	Zinc plant enlarged to 120 tpd.
1941	New plant to recover zinc from lead furnace slag constructed.
1943	Zinc slag fuming plant added to extract zinc from slag.
1945	Electrolytic cadmium plant constructed to extracted cadmium from smelter by-products.
1948	Zinc plant enlarged to 160 tpd.
1952-53	New crushing and grinding equipment added; new charge precipitation and bedding (ore preparation) plant; new pelletizing plant. Increased smelter capacity.
1954	Sulfuric acid plant added to zinc plant.
1957	New blast furnace installed.
1958	New stack built at smelter.
1960	Phosphoric acid plant and fertilizer plant constructed.
1964	Fire destroyed precipitation plant and baghouse.
1966	New furnace feed system added. Lead smelter capacity increased to 100,000 tpd.
1967	Zinc plant enlarged to 310 tpd.
1968	Second sulfuric acid plant added to zinc plant.
1969	New baghouse, ventilation system, and vent with scrubbers added to lead smelter.
1970	New sintering plant and sulfuric acid plant replaced the ore roasting operation.
1972	Blast furnace extended to accommodate increased production.
1973	Fire destroyed parts of main baghouse. Study of lead smelter stack and fugitive emissions conducted.
1974	Baghouse repaired.
1975	Scrubbers installed in the sintering plant.
1977	A 610 foot stack built at zinc plant; 715 foot stack built at lead smelter.
1978	Electrolytic silver refinery constructed.
1981	Smelter complex closed.

Sources: Bennett, 1982; Murray, 1982; CDM et al., 1986.

Between 1917 and 1963, the lead smelter processed 4.3 million tons of concentrate and 323,000 tons of zinc residue to produce 2.9 million tons of lead and 311,000 tons of zinc (Dames & Moore, 1987). No emissions data are available for the years between 1917 and 1955. However, from 1955 to 1964, average emissions of lead from the main lead smelter stack were estimated to be 9.2 tons per month (IDHW, 1976, as cited by Ragaini et al., 1977).

Plant production rates increased in the late 1960s and early 1970s with the addition of a new furnace feed system, enlargement of the zinc plant, replacement of the older downdraft ore roasting operation by an updraft sintering process, and extension of the blast furnace (Bennett, 1982; CDM et al., 1986). Stack emission rates for lead measured by the Bunker Hill Co. and Gulf Resources and Chemical Company (who purchased the smelter complex in 1968) increased in the late 1960s and early 1970s from historical levels of approximately 10 tons per month to approximately 15 tons per month (CDM et al., 1986). The enlargement of the blast furnace in 1972 increased lead emissions from the main stack to approximately 20 tons per month (measured by Gulf Resources and Chemical Company, reported in CDM et al., 1986). The Shoshone Lead Health Project (IDHW, 1976, as cited by Ragaini et al., 1977) estimated that emissions between 1965 and 1973 averaged 11.7 metric tons per month.

In 1973, two of seven baghouse filter units at the lead smelter main stack were destroyed in a fire (CDM et al., 1986). A third unit was shut down for routine maintenance and remained inoperable for about six months (CDM et al., 1986). The baghouse was repaired in 1974, but in the interim, emissions control was severely reduced. Total particulate emissions of approximately 15 to 160 tons per month containing 50 to 70% lead were reported from the lead smelter main stack through November 1974; in February and March 1974, monthly total particulate emissions were approximately 150 tons (TerraGraphics, 1990). Between January and September 1974, more than 4,000 pounds (2 tons) of arsenic, 70,000 pounds (35 tons) of cadmium, 700,000 pounds (350 tons) of lead, 5,000 pounds (2.5 tons) of mercury, and 123,000 pounds (61.5 tons) of zinc were released from the stack (CDM et al., 1986). The increased emissions caused a distinct increase in atmospheric lead concentrations. The effect of the increase was immediately apparent as epidemic lead poisoning among area children (IDHW, 1976, as cited by Ragaini et al., 1977). A public health study conducted in 1974 identified smelter emissions as the major source of contamination and excess absorption in children (IDHW, 1976, as cited by Ragaini et al., 1977; TerraGraphics, 1990).

After the construction of the tall stacks at the zinc plant and lead smelter in 1977, quarterly average ambient air lead concentrations measured at the Kellogg Medical Center, Silver King School, Smelterville City Hall, Kellogg City Hall, Pinehurst School, and Osburn Radio Station decreased. The decrease in ambient air concentrations was partially caused by release of emissions at greater height for longer-distance dispersal, but also partially caused by the increased draft of the taller stacks (MFG, 1992a). Gaseous and particulate wastes that previously were not captured in the draft had escaped as fugitive emissions and contributed to the greatly elevated concentrations measured at sampling stations near the smelter complex. The increased draft allowed capture of more of the process wastes (CDM et al., 1986). Following smelter closure in late 1981, airborne lead concentrations decreased by a factor of 10.

Using emissions data collected by the Bunker Hill Co. and Gulf Resources and Chemical Co. data on emissions from the lead smelter main stack, CDM et al. (1986) estimated arsenic, cadmium, lead, mercury, and zinc emissions from the lead smelter main stack from 1965 through 1981. More than 70,000 pounds of arsenic (35 tons), 570,000 pounds of cadmium (280 tons), 6,000,000 pounds of lead (3,000 tons), 29,000 pounds of mercury (15 tons), and 860,000 pounds of zinc (430 tons) were emitted between 1965 and 1981. The estimates were based on lead smelter main stack data only, and do not include fugitive emissions, which were estimated to total more than stack emissions (CDM et al., 1986).

Emissions data collected during the period of smelter operation and ambient air concentrations data collected during and after the period of smelter operation confirm that the smelters were a source of hazardous substances to the Coeur d'Alene River environment (Figure 2-7). Additional sampling of environmental media during the 1970s by the Bunker Hill Co. and during the 1980s as part of the remedial investigation and feasibility studies (TerraGraphics, 1990) confirmed that soil resources of the Coeur d'Alene River basin (in addition to humans; JEG et al., 1989) were exposed to the hazardous substances and that the smelter complex was the source of the hazardous substances.

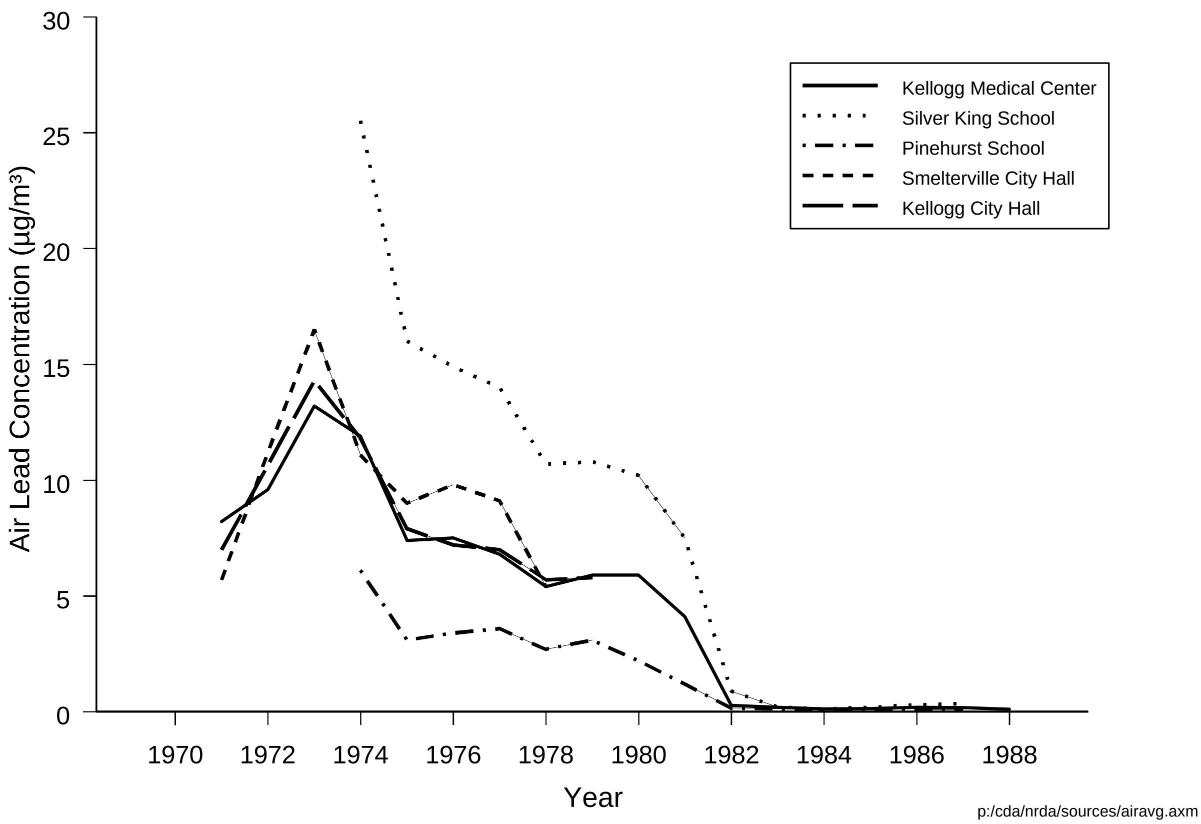

Figure 2-7. Ambient air concentrations of lead (mean annual) measured in the populated areas of the Bunker Hill Superfund site.
Data source: U.S. EPA (1989) as cited in TerraGraphics (1990).

2.4 ONGOING RELEASE MECHANISMS

Releases from source materials are ongoing. Source materials include abandoned tailings dumps and former tailings impoundments; mixed tailings and alluvium deposited in floodplains, stream beds, lake beds, and fill areas; waste rock piles; adit and seep drainage; and soils historically contaminated by smelter emissions.

Mechanisms of releases from waste rock and tailings dumps include water and wind erosion and leaching by acid water. Mechanisms of releases from tailings and mixed tailings and alluvium in the floodplain, beds, and banks include remobilization by seasonal high water, bank sloughing, and entrainment of bed sediments and inundated floodplain sediments in surface water. In addition, seasonal changes in redox chemistry cause releases of soluble metals from floodplain tailings deposits to groundwater and surface water.

Waste rock may contain elevated concentrations of hazardous substances that may be released to the environment by wind or water erosion or leaching. Some of the waste rock in the basin contains pyrite (FeS_2) or other sulfide minerals, which, upon weathering, release acid that drains from the dumps and may leach metals from the waste rock. In addition, groundwater flowing through underground mine workings may oxidize exposed pyrite and form acid mine drainage. Where surface water or groundwater contacts sulfide minerals in an oxidizing environment, such as in underground mine workings, surface waste rock piles, and floodplain tailings deposits, acid mine drainage and metal-bearing leachate may form. Where this occurs, the materials generating the acidic metal-bearing leachate continue to serve as sources of hazardous substances (Balistrieri et al., 1998).

Soils near the former Bunker Hill smelter remain devegetated and contain elevated concentrations of hazardous substances deposited from smelter emissions (Brown et al., 1998). Erosion of these soils to surface waters is an ongoing source of hazardous substances (MFG, 1992a).

This section describes the principal sources of hazardous substances in the basin, which are:

- historical releases from mines and mills, particularly tailings disposal, and re-releases from tailings mixed in bed, bank, and floodplain sediments
- waste rock dumps associated with both producing and nonproducing mines
- metal-bearing leachate draining from adits, waste rock dumps, and tailings dumps
- historical smelter emissions.

2.4.1 Tailings and Mixed Tailings, Waste Rock, and Alluvium/Soils/Sediments

Tailings historically were released by numerous mills to flowing surface waters and floodplains of the Coeur d'Alene River basin and allowed to wash downstream. An estimated 61.7 to 64.5 million tons of tailings were released to surface waters of the Coeur d'Alene River basin (Long, 1998; SAIC, 1993c). Tailings discharged to creeks and the South Fork Coeur d'Alene River from 1886 through 1968 were transported downstream by natural fluvial processes. Through natural processes the tailings became mixed with native alluvium, deposited on the floodplain and in the bed and banks of streams and lakes, remobilized by seasonal high water and floods, and redeposited. Uncontained tailings deposits and mixed tailings and alluvium remain throughout the South Fork (Figure 2-8) and mainstem Coeur d'Alene River basin and now constitute an ongoing source of hazardous substance releases throughout the basin. Tailings and mixed tailings and alluvium contain elevated concentrations of hazardous substances, are subject to erosion, leaching, and transport via surface and groundwater, and constitute an ongoing source of hazardous substances to surface water, groundwater, soils, and biota.

This section summarizes information on historical releases from mills of the Coeur d'Alene River basin, locations of former tailings impoundments, and areas where residual tailings and mixed tailings and alluvium have come to be located in floodplain, bed, and bank deposits. More detailed descriptions are presented in Ridolfi (1998), Bull (1999), Gearheart et al. (1999), and Quivik (1999). In addition, ongoing work by the U.S. EPA and its subcontractors CH2M Hill and URS Greiner Woodward Clyde will provide additional data on waste types, locations, and volumes.

Waste rock dumps consist of material extracted to reach the ore but discarded before the ore beneficiation process. Waste rock dumps are associated with most of the producing and nonproducing mines in the basin and are typically located near mine adits and shafts (Figure 2-9). Waste rock piles throughout the upper Coeur d'Alene River basin are subject to surface erosion and leaching. The U.S. Geological Survey (Hobbs et al., 1965), U.S. DOI Bureau of Land Management (McNary et al., 1995; mine site inventory mapping), USDA Forest Service (USFS, 1997, as cited in Ridolfi, 1998), SAIC (1993c), Idaho Geological Society (IGS, 1997), U.S. Bureau of Mines (USBM, 1995), and others have identified at least 670 adits and 22 shafts, and waste rock dumps are associated with most of them. Volumes of waste rock have been estimated for the Moon Creek drainage (USBM, 1995), Pine Creek drainage (CCJM, 1995; D. Fortier, U.S. BLM Coeur d'Alene Field Office, personal communication), and the South Fork Coeur d'Alene River basin (Gearheart et al., 1999). U.S. EPA is currently conducting studies to further characterize waste volumes and concentrations of hazardous substances in source areas as part of the Coeur d'Alene Basinwide Remedial Investigation. In addition, waste rock and tailings removals by U.S. BLM are currently in progress in the Pine Creek drainage.

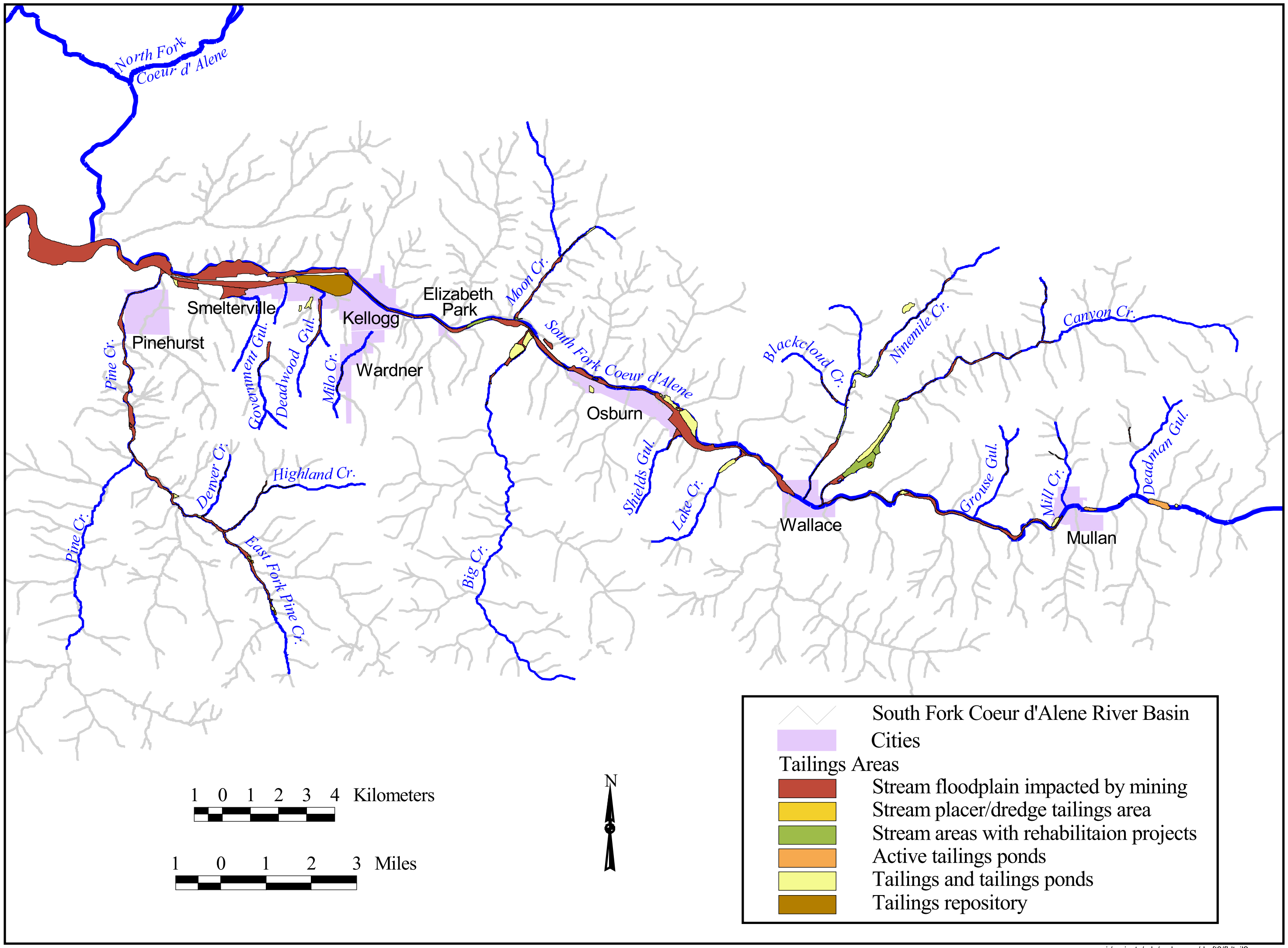

Figure 2-8. Estimated tailings distribution in South Fork Coeur d'Alene River basin.
Source: U.S. BLM, 1999.

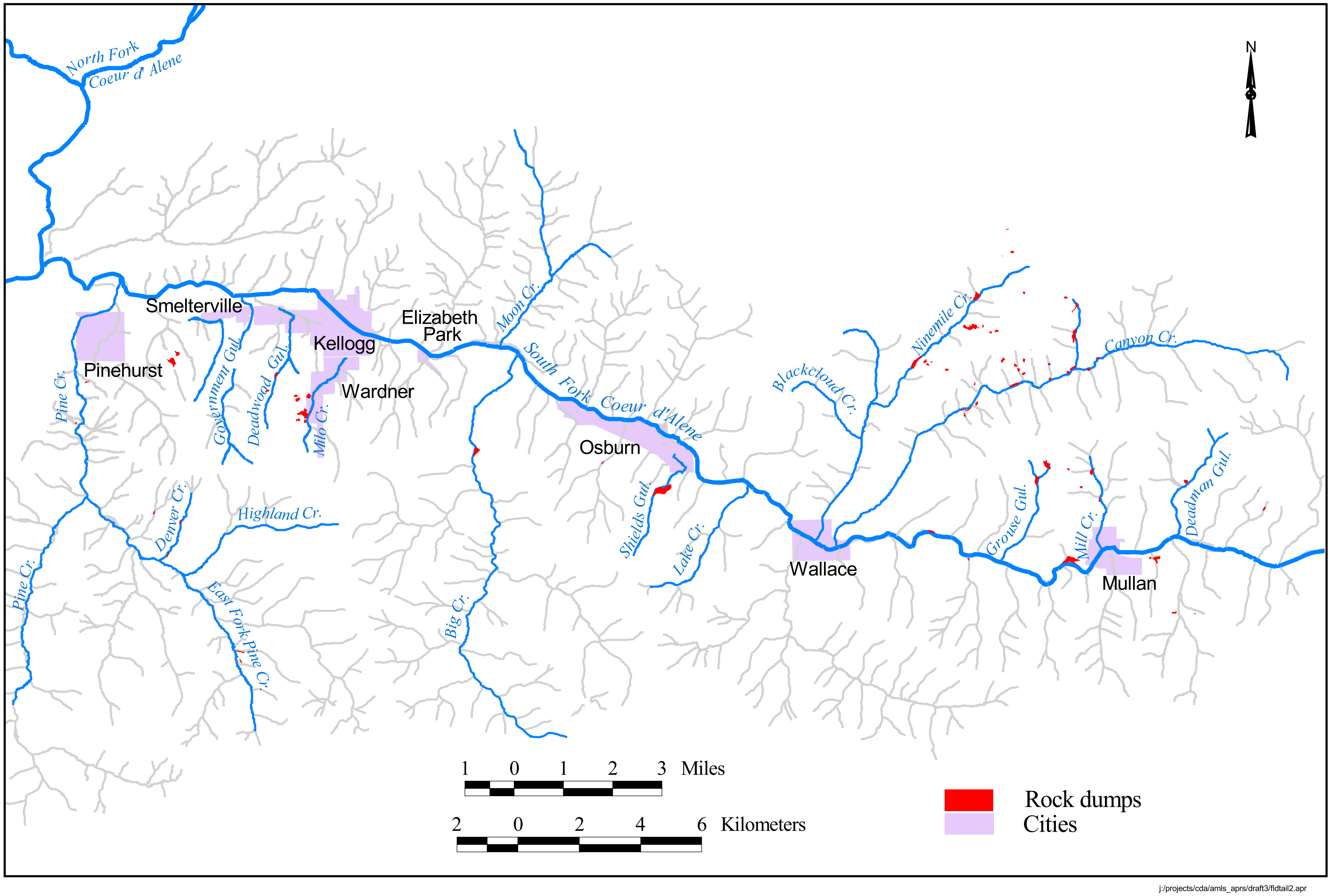

Figure 2-9. Estimated major waste rock distribution in South Fork Coeur d'Alene River basin.
Source: U.S. BLM, 1999.

South Fork Coeur d'Alene River Upstream of Elizabeth Park

The mill located farthest upstream in the basin was the Snowstorm Mill, at the mouth of Daisy Gulch (Figure 2-3). Residual tailings may be present in the floodplains and bed of the South Fork Coeur d'Alene River from there downstream to Mullan (Ridolfi, 1998). At the Lucky Friday Mine, tailings ponds constructed in and after 1969 across the river from the mouth of Gentle Annie Gulch, near Gold Hunter Gulch, and near Mullan may have been built over tailings previously deposited in the floodplain (Ridolfi, 1998). Between Mullan and Wallace, residual tailings from mills within the reach plus wastes from mills upstream of the reach remain. The uncontained tailings pond at the Golconda Mill, located in the South Fork floodplain, may also have been constructed over previously deposited tailings.

Downstream of Wallace, residual tailings are known to be present in the floodplain. An estimated 1.9 to 4.6 million cubic yards of tailings and tailings-contaminated sediments are present in the banks, beds, and floodplains of the South Fork Coeur d'Alene River basin, upstream of Elizabeth Park (Gearheart et al., 1999). An estimated 7.3 to 7.7 million cubic yards are contained in tailings piles and impoundments, including the Daisy Gulch tailings ponds, the Lucky Friday mine active and inactive tailings ponds, tailings at the National millsite, the Golconda tailings, the Osburn tailings ponds, the Sunshine Tailings ponds, the Silver Crescent tailings, and the tailings near Osburn. An estimated 230,000 to 1.2 million cubic yards of tailings remain at former millsites in the upper South Fork Coeur d'Alene basin (Gearheart et al., 1999).

Gearheart et al. (1999) estimated that there are at least 3.2 million cubic yards of waste rock covering 58 acres of the South Fork Coeur d'Alene River basin upstream of Elizabeth Park (excluding Canyon and Ninemile creeks). Waste rock piles at the Caladay Mine in Daly Gulch, the Coeur d'Alene Mine in McFarren Gulch, the Morning # 6 adit near Mullan, and the Rock Creek mine in Rock Creek are located in the creek (SAIC, 1993c; D. Fortier, U.S. BLM, pers. com., December 1999). At each of these sites, the creek flows through a culvert under the waste rock, and at the Coeur d'Alene Mine, water exiting the culvert flows along the toe of the waste rock (SAIC, 1993c). At the Golconda Mine, waste rock was placed in the floodplain of the South Fork Coeur d'Alene River, and is subject to erosion during high flows (SAIC, 1993a; 1993c).

Concentrations of metals have been measured in tailings and floodplains at several locations in the South Fork Coeur d'Alene River basin upstream of Elizabeth Park (Table 2-9). Concentrations were greatest in tailings samples collected near Wallace. Concentrations up to 169 mg cadmium/kg, 58,000 mg lead/kg, and 28,000 mg zinc/kg were measured (Ecology and Environment, 1995). Copper concentrations in sampled tailings impoundments ranged from 198 to 560 mg/kg (Gross, 1982). Arsenic concentrations in sampled tailings impoundments ranged from 30.8 to 1,200 mg/kg (Ecology and Environment, 1995).

Table 2-9
Mean (minimum-maximum) Concentrations of Metals in South Fork Coeur d'Alene River Basin Tailings, Sediments, and Soils Upstream of Elizabeth Park

Site	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Big Creek	Soil	1[a]	—	300	320
Elk Creek Pond	Soil	1[b]	0.4	8,520	1,860
	Sediment	1[b]	16.8	5,720	5,400
Elizabeth Park (upstream)	Soil	1[b]	56.6	40,800	9,470
Evolution	Tailings	2[c]	11.8 (2.45-21.2)	2,630 (420-4,840)	1,146 (151-2,140)
	Soil	1[c]	90	31,000	14,500
	Sediment	3[c]	84 (30-112)	16,583 (5,240-35,300)	9,317 (4,850-16,700)
Galena	Tailings	16[d]	<0.5 (<0.5-2.13)	308 (94-2,750)	47 (22-78)
Gene Day Park	Soil	6[c]	3.9 (0.7-6.3)	347 (175-558)	423 (151-1,050)
	Sediment	2[c]	14.8 (8.3-21.3)	614 (369-858)	515 (314-716)
Golconda	Soil	1[e]	100	45,800	20,700
	Tailings	2[e]	1.8 (1.0-2.6)	639 (353-924)	158 (28-287)
Lucky Friday	Tailings	6[d]	17.7 (9-39)	4,800 (1,500-14,000)	2,333 (1,500-4,500)
Mullan	Sediment	4[f]	1.4 (0.1)	203 (16)	827 (478)
		8[g]	1.3 (0.5-3.7)	202 (50-596)	200 (54-568)
Osburn	Soil	1[h]	160	56,800	22,000
	Soil	1[h]	—	890	804
	Sediment	1[b]	22.2	7,030	3,280
		4-5[i]	9.7 (6.2)	3,580 (1,275)	2,865 (1,594)
Silver Summit	Tailings	3[d]	2.3 (1.8-2.6)	157 (130-180)	63 (<50-73)
Silverton	Tailings	5[c]	65.9 (22.7-90.2)	29,180 (17,200-44,400)	9,516 (5,310-11,700)
	Sediment	1[c]	34.2	9,640	5,770
South Fork CdA Floodplains between Elizabeth Park and Wallace	Soil	13[j]	28.7 (6.3-52.5)	10,191 (1,300-25,600)	4,091 (1,420-8,570)

Table 2-9 (cont.)
Mean (minimum-maximum) Concentrations of Metals in South Fork Coeur d'Alene River Basin Tailings, Sediments, and Soils Upstream of Elizabeth Park

Site	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Wallace	Tailings	2[c]	108 (48.6-169)	54,350 (50,700-58,000)	17,330 (6,660-28,000)
	Sediment	5[c]	14.0 (7.2-19.4)	2,281 (893-3,020)	6,206 (22-17,900)
		4-5[i]	4.8 (1.9)	1,333 (557)	3,273 (1,993)
	Soil	1[a]	—	2,200	3,000

a. Soils collected from surface (Ragaini et al., 1977).
b. Sediments collected from stream channel; soils collected from floodplain banks (Ridolfi, 1991).
c. Ecology and Environment, 1995.
d. Gross, 1982.
e. Tailings collected from impoundment and soil collected from the South Fork Coeur d'Alene River bank (Hudson, 1998).
f. Sediments collected from the South Fork CdA River. Values in parentheses are standard error of the mean; minimum and maximum values were not provided (Farag et al., 1998).
g. Sediments collected from the South Fork CdA River (Reece et al., 1978).
h. Value reported is maximum value measured in the floodplain at Osburn Flats (MFG, 1996, as cited in Ridolfi, 1998).
i. Sediments collected from the South Fork CdA River. Values in parentheses are standard deviations (Woodward et al., 1997).
j. Hagler Bailly Consulting, 1995.

South Fork Coeur d'Alene River Downstream of Elizabeth Park

An estimated 24.6 million cubic yards of tailings are contained in the CIA, and an estimated 2.1 million cubic yards of tailings are contained in Page Pond (Gearheart et al., 1999) (Figure 2-4). Tailings from mills upstream and within the reach have been mixed with alluvium and are present in the floodplains at depths of up to 10 feet (MFG, 1992a). Tailings deposition throughout Smelterville Flats was promoted by the plank-and-pile dam and associated settling pond constructed at Pinehurst Narrows (MFG, 1992a; Quivik, 1999). An estimated 1.7 to 7.8 million cubic yards of tailings and tailings-contaminated sediment remain in the beds, banks, and historical floodplains of the South Fork Coeur d'Alene River downstream of Elizabeth Park and in the Page swamps (Gearheart et al., 1999). An estimated 7,900 to 39,000 cubic yards of tailings remain near former millsites (Gearheart et al., 1999).

An estimated 1.1 million cubic yards of waste rock covering 21 acres remain in the South Fork Coeur d'Alene River basin downstream of Elizabeth Park (Gearheart et al., 1999). The largest waste rock dumps are located in Silver Creek (260,000 yd^3), Deadwood Gulch (250,000 yd^3), and Milo Gulch (200,000 yd^3) (MFG, 1992a).

Concentrations of metals have been measured in tailings at several locations in the South Fork Coeur d'Alene River basin downstream of Elizabeth Park (Table 2-10). Maximum concentrations were measured in CIA pond sludge (5,680 mg cadmium/kg; 237,000 mg zinc/kg) and in CIA jig tailings (56,100 mg lead/kg) (MFG, 1992a). Concentrations of arsenic were measured up to 504 mg/kg at Smelterville flats, 202 mg/kg in Page Pond, and 692 mg/kg in the CIA (MFG, 1992a). Concentrations measured in sediments ranged from 0.6 to 140 mg cadmium/kg, 82 to 39,300 mg lead/kg, and 118 to 22,000 mg zinc/kg.

Concentrations of hazardous substances in samples of waste rock from the Bunker Hill Mine dumps up to 45.7 mg/kg cadmium (Silver Creek), 19,400 mg/kg lead (Magnet Gulch), and 8,070 mg/kg zinc were measured (Silver Creek) (MFG, 1992a). Arsenic concentrations up to 3,080 mg/kg were measured at a waste rock dump in the Little Pine Creek drainage (MFG, 1992a).

Soil sampling conducted as part of the Bunker Hill Superfund Site Remedial Investigation on the unpopulated hillsides surrounding the Bunker Hill smelter complex showed that the most elevated soil concentrations of hazardous substances were nearest the smelter complex, but contaminant concentrations did not consistently decrease with distance for all metals (MFG, 1992a). Concentrations measured in hillside soils ranged from 7.8 to 245 mg cadmium/kg, 82 to 13,700 mg lead/kg, and 310 to 16,100 mg zinc/kg.

Mainstem Coeur d'Alene River, Lateral Lakes, and Coeur d'Alene Lake

Tailings discharged to the South Fork Coeur d'Alene River have been transported by natural fluvial processes downstream to the mainstem Coeur d'Alene River and lateral lakes area, and into Coeur d'Alene Lake. Waste materials released from numerous sources were commingled, mixed with native alluvium, and, during seasonal high water, deposited in the floodplains of the Coeur d'Alene River, and on the beds and banks of the river, the lateral lakes, and Coeur d'Alene Lake.

Horowitz et al. (1993) estimated that 75 million metric tons (82.7 million tons) of sediments enriched in trace elements have been transported the length of the Coeur d'Alene River and deposited on the bed of Coeur d'Alene Lake. Sediment sampling in the river bed has indicated elevated concentrations of metals in the river bed to depths ranging up to 23 feet near Cataldo (URSG and CH2M Hill, 1998). Gearheart et al. (1999) estimated volumes of tailings-contaminated sediment containing greater than 1,000 ppm lead in the mainstem Coeur d'Alene River channel (21.4 million cubic yards), the banks and levees (1.5 million cubic yards), the floodplain (25.7 million cubic yards), palustrine wetlands (5.9 million cubic yards), and in lateral lake beds (6 million cubic yards). They estimated the volume of tailings-contaminated sediment in Coeur d'Alene Lake to be 43.8 million cubic yards. These contaminated sediments are a secondary source of hazardous substances to groundwater, surface water, and biological resources of the lower Coeur d'Alene River basin.

Table 2-10
Mean (minimum-maximum) Concentrations of Metals in South Fork Coeur d'Alene River Basin Tailings, Sediments, and Soils Downstream of Elizabeth Park

Site	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Bunker Creek	Sediment	2[a]	34 (26-42)	1,000 (500-1,500)	9,250 (2,500-16,000)
Bunker Hill Complex	Soil	117[b]	19.0 (1.0-181)	1,606 (15.9-15,600)	1,028 (160-16,100)
CIA	Tailings (flotation)	NA[a]	(6.1-40.0)	(353-7,760)	(624-7,990)
	Tailings (jig)	NA[a]	(11.9-135)	(258-56,100)	(540-24,700)
	Sludge	1[a]	5,680	2,670	237,000
	Soil	9[a]	40.4 (NA)	4,513 (NA)	10,500 (NA)
Government Gulch	Sediment	2[a]	41 (18-63)	1,950 (1,900-2,000)	3,150 (2,500-3,800)
Grouse Creek	Sediment	2[a]	5.6 (5.2-6.0)	783 (475-1,090)	636 (619-652)
Kellogg	Sediment	32[c]	36.3 (27.0-43.3)	4,797 (1,670-11,400)	3,912 (2,080-7,550)
		4-5[d]	4.7 (1.2)	2,692 (978)	961 (189)
	Soil	16[e]	12.9 (0.5-87.0)	2,766 (72-21,000)	1,400 (87-9,200)
		5[f]	59.7 (32-82)	3,174 (170-6,700)	2,174 (200-5,700)
	Tailings	1[f]	37	7,900	7,500
		39[g]	—	3,592 (600-6,300)	4,262 (2,000-13,000)
Page Pond	Tailings	3[a]	38.7 (NA)	4,350 (NA)	4,260 (NA)
	Soil	12[h]	38.7 (21.0-48.0)	4,350 (2,560-6,550)	4,260 (2,950-6,120)
Page Swamp	Soil	18[i]	—	9,350 (182-26,800)	—
Pinehurst	Sediment	4[j]	83.0 (24.9)	4,757 (295)	8,130 (2,538)
		8[k]	38.3 (0.6-140)	8,162 (82-39,300)	5,151 (118-22,000)
		4-5[d]	60 (63)	5,400 (1,069)	5,048 (3,389)
	Soil	1[f]	18	1,000	940
Sewage Treatment Plant	Soil	16[h]	69.3 (35.0-121)	19,800 (11,600-32,700)	8,120 (4,510-12,000)
Shoshone County Airport	Soil	24[h]	49.0 (18.4-133)	15,500 (11,100-28,200)	6,050 (2,860-13,100)
	Soil	12[h]	27.8 (21.0-36.0)	5,340 (3,970-6,310)	2,910 (2,070-4,560)

Table 2-10 (cont.)
Mean (minimum-maximum) Concentrations of Metals in South Fork Coeur d'Alene River Basin Tailings, Sediments, and Soils Downstream of Elizabeth Park

Site	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Smelter Complex	Soil (material)	47[a]	6,711 (10-127,000)	107,323 (1,210-416,000)	80,557 (593-432,000)
	Soil (residual material)	116[a]	1,391 (2.6-19,900)	39,138 (104-399,000)	32,448 (123-329,000)
	Soil (hillside)	47[a]	39.3 (7.8-245)	3,023 (81.9-13,700)	2,195 (310-16,100)
	Soil (subsurface)	151[a]	237 (<0.4-8,930)	26,090 (<5-651,000)	7,674 (46-77,100)
Smelterville	Soil	16[l]	50.2 (18.1-95.7)	14,190 (3,860-22,100)	6,650 (2,130-14,200)
		3[f]	82.7 (25-140)	6,233 (3,2007,900)	6,057 (870-13,000)
	Sediment	3[m]	27.2 (18.6-43.0)	62,500 (55,000-69,500)	10,233 (8,800-12,700)
	Tailings	6[a]	81.7 (3.3-312)	18,444 (42-48,200)	8,892 (180-33,500)
		2[f]	26	1,995 (290-3,700)	17,700 (3,200-29,000)
South Fork CdA River Mouth	Sediment	1[m]	64	1,100	4,700

a. MFG, 1992a.
b. Soils collected from 0 to 12 inches around the Bunker Hill complex area (Dames & Moore, 1990).
c. Sediments collected from the South Fork Coeur d'Alene River (Reece et al., 1978).
d. Sediments collected from the South Fork Coeur d'Alene River. Values in parentheses are standard deviations (Woodward et al., 1997).
e. Soils collected from river bank and floodplain areas (Horowitz, 1995).
f. Ragaini et al., 1977.
g. Tailings collected from surface, 5 ft, and 10 ft levels from a "classical tailings pile" approximately 4 miles west of Kellogg (Galbraith, 1971).
h. Soils collected from fugitive dust source barren areas (CH2M Hill, 1989).
i. Soils collected from 0-6 inches in West and East Page Swamp (Mullins and Burch, 1993).
j. Sediments collected from the South Fork CdA River. Values in parentheses are standard error of the mean; minimum and maximum values were not provided (Farag et al., 1998).
k. Ecology and Environment, 1995.
l. Soils collected from South Fork CdA River floodplain (Hagler Bailly Consulting, 1995).
m. Sediments collected from river bank (USGS, unpublished).[5]

5. Unpublished sampling data collected in August 1989 and June 1991 by USGS, Water Resources Division, Doraville, GA.

Table 2-11 presents example concentrations of hazardous substances measured in floodplain, lake bed, and river bed and bank sediments of the lower Coeur d'Alene River basin. Concentrations of hazardous substances up to 202 mg cadmium/kg were measured in soil collected near Rose Lake, 37,400 mg lead/kg in Killarney Lake sediments; and 34,150 mg zinc/kg in Killarney Lake sediments (USGS, unpublished;[6] Bender, 1991; Horowitz, 1995; URSG and CH2M Hill, 1998).

In addition to natural fluvial transport and deposition, tailings have been dredged from the river bed and impounded in the floodplain of the mainstem Coeur d'Alene River. In the early 1930s, the Mine Owners Association installed a dredge system to excavate tailings from the Coeur d'Alene River near Cataldo (Casner, 1991). Tailings were dredged from the river channel and piped to a disposal area at Mission Flats. Dikes made of dredged tailings were constructed around the tailings to form an impoundment for tailings deposition and drying. By 1951, the dredge spoils covered over 2,000 acres to a depth of as much as 25 to 30 feet (Casner, 1991). Dredging continued into the 1960s. An estimated 34.5 million tons of mixed alluvium and tailings were excavated between 1933 and 1967 (SVNRT, 1998, as cited in Ridolfi 1998). In the mid-1960s, the Idaho Department of Transportation purchased more than 1 million tons of dredge spoils to use in constructing the I-90 road bed (Casner, 1991). Table 2-11 presents ranges of concentrations measured in dredge spoils at Cataldo Mission Flats. Concentrations of lead in Mission Flats ranged up to 13,100 mg/kg and zinc ranged up to 16,000 mg/kg (Table 2-11; Galbraith et al., 1972).

Tailings were also used in constructing portions of the Union Pacific Railroad in 1887. The rail corridor generally follows the Coeur d'Alene River and includes 35 river and creek crossings. It also crosses portions of Coeur d'Alene Lake, Harrison Marsh, Anderson Lake, Black Lake, Cave Lake, Medicine Lake, Lane Marsh, Black Rock Slough, and Bull Run Lake (MFG, 1996; Ridolfi, 1998). The rail embankments and ballast material were constructed of tailings and other mine waste products (MFG, 1996). The Union Pacific Railroad is now discontinued (MFG, 1996).

Subsequent flooding has damaged the ballast and washed contaminated materials into the floodplain.[6] The rail corridor has served as a source of hazardous substances to surface water, groundwater, sediment, and biological resources of the lower Coeur d'Alene River basin. In addition, the railroad corridor in the lower basin has been contaminated in places by deposition of river-transported tailings during high flow.

6. Unpublished data collected by NRDA field personnel during field investigations in March 1997. As cited in Ridolfi, 1998. Available from Ridolfi Engineers, Seattle, WA.

Table 2-11
Mean (minimum-maximum) Metals Concentrations in Tailings, Sediments, and Soils in Lower Coeur d'Alene River Basin

Site	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Anderson Lake	Sediment	24[a]	11.6 (0.3-53.9)	1,105 (20-3,860)	1,244 (73-6,520)
		3[b]	48 (42-56)	2,650 (1,750-3,350)	2,983 (2,150-3,550)
		1[c]	9.7	2,492	2,180
Bare Marsh	Sediment	25[a]	10.0 (0.8-46.0)	1,433 (71-7,020)	1,166 (64-6,180)
	Soil	1[d]	13.0	2,100	—
Black Lake	Soil	39[e]	11.5 (0.5-48.0)	2,280 (32-11,000)	1,463 (80-7,300)
	Sediment	24[a]	10.2 (1.5-33.0)	1,075 (174-4,720)	935 (185-2,760)
		4[b]	21.8 (11-29)	1,935 (490-4,700)	2,250 (1,750-2,600)
Black Rock Slough	Sediment	24[a]	17.9 (0.3-39.3)	3,447 (63-7,630)	2,272 (49-6,620)
Blessing Slough	Sediment	24[a]	19.7 (0.1-46.9)	3,801 (36-9,190)	1,584 (49-3,530)
		3[f]	—	3,499 (3,223-3,996)	—
	Soil	2[d]	7.8 (4.5-11.0)	720 (560-880)	—
Blue Lake	Sediment	24[a]	24.0 (1.5-56.5)	3,445 (31-7,860)	2,435 (97-4,460)
		4[b]	45.5 (25-83)	2,988 (950-4,200)	3,788 (2,000-6,800)
		3[f]	—	2,576 (2,447-2,688)	—
Bull Run Lake	Sediment	24[a]	21.3 (9.0-46.1)	5,060 (1,070-15,400)	2,834 (1,260-5,720)
Campbell Marsh	Sediment	25[a]	21.9 (2.7-37.4)	4,674 (312-8,890)	2,381 (239-4,330)
	Soil	13[d]	16.2 (3.2-29.0)	2,582 (26-7,500)	—
Cataldo	Soil	32[e]	8.6 (0.5-21.0)	1,817 (54-4,900)	1,189 (80-6,200)
		9[g]	22.2 (4.8-33.1)	3,742 (182-5,720)	2,361 (370-4,270)
		26[h]	18.0 (0.1-158)	3,204 (15-9,600)	2,037 (22-6,830)
	Sediment	4[i]	14.5 (2.4)	2,390 (138)	2,543 (108)
		12[j]	16.7 (7.4-22.6)	3,352 (2,610-4,180)	3,069 (1,960-3,860)
		1[c]	4.8	2,310	1,350
		4[k]	10.5 (8.4-12.9)	2,800 (2,000-3,800)	10,075 (6,500-19,000)
		33[h]	16.9 (0.02-75.3)	1,942 (12-4,640)	1,755 (44-3,780)
Cataldo Boat Ramp	Soil	1[l]	18.5	6,030	5,510
	Sediment	1[l]	3.5	1,380	13,700

Table 2-11 (cont.)
Mean (minimum-maximum) Metals Concentrations
in Tailings, Sediments, and Soils in Lower Coeur d'Alene River Basin

Site	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Cataldo Mission	Soil	1[l]	6.9	1,110	1,580
	Tailings (0-1 feet)	6[m]	—	4,217 (2,800-5,500)	3,183 (2,400-4,000)
	Tailings (2-3.5 feet)	42[m]	—	5,069 (300-13,100)	4,229 (400-16,000)
	Tailings (4-6.5 feet)	17[m]	—	626 (50-4,300)	741 (200-3,100)
	Tailings (7-11.5 feet)	10[m]	—	128 (50-500)	380 (300-600)
Cataldo Slough	Sediment	18[a]	25.5 (0.7-67.8)	2,365 (83-5,650)	2,797 (132-11,700)
Cave Lake	Sediment	22[a]	10.2 (0.9-28.1)	1,391 (36-7,490)	1,043 (48-4,450)
		3[b]	36 (29-45)	2,950 (2,300-3,850)	2,950 (2,750-3,300)
		6[h]	16.2 (0.2-39.1)	3,088 (12-9,360)	1,974 (40-5,280)
CdA River	Soil	44[n]	11.3 (0.3-31.8)	2,223 (20-8,030)	1,234 (55-8,850)
		49[o]	3.7 (0.5-23.8)	241 (18-1,565)	202 (39-865)
	Sediment	10[p]	—	1,997 (587-4,460)	—
		3[f]	—	2,853 (2,447-3,489)	—
		9[d]	—	2,521 (1,775-3,475)	—
CdA River Delta	Sediment	107[q]	43 (16-75)	3,700 (3,000-6,300)	3,800 (3,200-4,700)
		9[j]	33.2 (5.8-50.7)	3,374 (2,460-4,320)	3,007 (2,250-3,480)
		2[c]	25.5 (8-43)	3,929 (3,700-4,158)	3,740 (3,680-3,800)
		7[r]	—	—	3,103 (635-6,760)
CdA River near Black Lake	Sediment	4[i]	27.0 (2.7)	3,850 (442)	4,475 (474)
		4[k]	53.8 (21-145)	6,123 (3,310-12,700)	4,470 (3,070-7,350)
		28[h]	21.3 (0.02-70.6)	5,842 (18.4-35,600)	3,564 (50-10,700)
	Soil	18[h]	4.6 (0.02-17.3)	1,188 (6-6,530)	628 (31-2,730)
CdA River near Blue Lake	Sediment	7[k]	40 (19-107)	4,420 (2,150-6,870)	4,568 (3,040-5,580)
CdA River near Killarney Lake	Sediment	4[i]	24.8 (4.2)	2,175 (293)	3,290 (333)
	Soil	25[h]	6.7 (0.1-24.0)	1,949 (7-9,910)	1,064 (17-4,590)

Table 2-11 (cont.)
Mean (minimum-maximum) Metals Concentrations
in Tailings, Sediments, and Soils in Lower Coeur d'Alene River Basin

Site	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
CdA River near Rose Lake	Sediment	4[i]	33.0 (2.7)	6,810 (1,469)	6,790 (858)
		1[c]	7.2	3,870	7,300
CdA River near Thompson Lake	Sediment	2[j]	17.4 (16.5-18.0)	3,677 (2,710-4,740)	3,245 (1,730-6,650)
		1[c]	8.3	3,992	4,220
		5[k]	90 (9-208)	14,492 (4,880-28,600)	7,024 (3,400-11,830)
		3[f]	—	3,177 (2,281-4,405)	—
Dudley	Soil	9[g]	32.2 (19.7-56.6)	4,462 (2,010-6,870)	3,038 (1,830-5,430)
		10[h]	4.0 (0.1-9.2)	767 (20-2,810)	491 (86-1,230)
Harrison	Soils	5[e]	5.5 (0.5-18.0)	1,423 (140-3,500)	734 (150-2,200)
		21[h]	16.0 (0.03-72.1)	2,846 (21-17,500)	2,204 (45-10,700)
	Sediment	4[i]	25.5 (1.9)	3,363 (267)	3,895 (276)
		5[k]	4.7 (<0.5-10)	2,016 (42-5,280)	965 (111-2,270)
		28[h]	18.7 (0.03-79.5)	4,544 (11-19,900)	2,938 (48-11,500)
Harrison Marsh	Sediment	13[a]	38.1 (19.7-63.3)	4,129 (1,540-7,000)	3,959 (2,870-5,170)
Harrison Slough	Sediment	24[a]	32.3 (11.6-96.4)	4,515 (3,030-8,660)	3,425 (1,700-7,040)
Hidden Marsh	Sediment	19[a]	20.5 (0.8-77.3)	2,763 (72-6,340)	1,493 (95-2,920)
Killarney Lake	Sediment	23[a]	36.1 (11.1-76.2)	5,002 (1,890-9,680)	3,550 (1,020-5,860)
		3[b]	78.3 (50-130)	3,700 (2,550-4,600)	4,483 (4,000-5,200)
		90[s]	42.5 (<1-146)	4,893 (<2-37,400)	6,587 (100-34,150)
		3[f]	—	4,522 (3,207-5,502)	—
		10[h]	25.0 (0.02-55.8)	3,886 (48-12,800)	3,504 (134-8,710)
	Soil	7[g]	17.8 (0.2-36.3)	4,704 (434-11,600)	2,442 (589-3,980)
CdA Lake	Sediment (surface)	150[t]	62 (<0.5-157)	1,900 (14-7,700)	3,600 (63-9,100)
	Sediment (core)	12[t]	25 (<0.1-137)	3,200 (12-27,500)	2,400 (59-14,000)
CdA Lake Northwest Shore	Sediment (lower)	9[u]	0.7 (0.2-1.8)	34.9 (4.1-123)	363.6 (118-756)
	Sediment (upper)	9[u]	0.6 (0.2-1.5)	59.7 (10.2-326)	289.3 (54.5-542)
CdA Lake-North	Sediment	5[c]	7.4 (6.6-8.2)	3,315 (1,146-5,732)	4,466 (2,740-5,360)
		15[q]	—	—	3,723 (588-7,320)
CdA Lake-South	Sediment	1[c]	9.9	367	1,310
Lane	Soil	26[e]	16.0 (0.8-34.0)	2,886 (70-5,100)	2,030 (125-5,100)

Table 2-11 (cont.)
Mean (minimum-maximum) Metals Concentrations in Tailings, Sediments, and Soils in Lower Coeur d'Alene River Basin

Site	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Lane Marsh	Sediment	24[a]	16.5 (3.0-31.6)	3,442 (338-7,550)	1,821 (374-3,890)
		3[d]	8.5 (6.0-12.0)	2,067 (1,200-3,100)	—
Medicine Lake	Sediment	24[a]	23.8 (3.4-80.6)	3,187 (228-19,900)	2,349 (397-10,400)
		2[b]	37 (30-44)	2,825 (2,650-3,000)	2,750 (2,550-2,950)
		9[h]	27.9 (0.2-83.3)	5,755 (30-25,800)	3,835 (130-12,500)
Medimont	Sediment	28[h]	24.1 (0.1-114.0)	5,507 (17-32,900)	3,885 (45-15,400)
	Soil	30[e]	8.7 (0.5-31.0)	1,641 (29-4,900)	1,342 (75-5,100)
		1[l]	105	19,200	7,400
		24[h]	5.8 (0.05-23.8)	2,218 (18-14,500)	1,149 (30-4,510)
Mission Slough	Sediment	13[a]	22.7 (4.0-45.3)	2,928 (501-5,110)	2,258 (456-4,530)
Moffit Slough	Sediment	24[a]	14.9 (0.5-44.1)	2,851 (32-16,200)	1,665 (43-6,030)
	Soil	5[d]	17.0 (6.1-38.0)	3,022 (210-5,400)	—
Orling Slough	Sediment	24[a]	14.2 (4.8-23.1)	4,207 (426-9,680)	1,679 (723-2,410)
Porter Slough	Sediment	24[a]	14.0 (0.6-31.0)	2,621 (88-8,230)	1,526 (63-3,960)
Rose Lake	Soil	37[e]	13.7 (0.5-202.0)	1,624 (47-6,600)	1,294 (93-6,800)
		10[d]	—	2,890 (249-8,655)	—
	Sediment	20[a]	18.6 (1.2-38.6)	3,227 (32-8,870)	2,188 (56-6,090)
		3[b]	10.3 (2-15)	1,817 (100-3200)	1,413 (240-2,100)
		9[h]	0.4 (0.02-2.4)	120 (17-350)	201 (69-385)
Strobl Marsh	Sediment	24[a]	26.1 (6.8-58.8)	5,826 (3,970-11,100)	3,012 (815-5,520)
		4[d]	11.3 (2.8-22.0)	1,860 (130-4,400)	—
Swan Lake	Sediment	18[a]	32.4 (2.7-72.0)	3,965 (213-8,350)	3,258 (241-5,780)
		4[b]	31.8 (19-57)	3,263 (1,800-3,900)	3,025 (1,900-4,650)
		3[f]	—	3,814 (3,305-4,145)	—
Thompson Lake	Sediment	24[a]	27.2 (1.7-85.2)	3,723 (324-8,880)	3,009 (163-7,330)
		2[b]	27 (23-31)	3,150 (2,600-3,700)	2,950 (2,900-3,000)
		1[c]	8.9	3,386	2,560
	Soil	1[g]	8.5	2,730	1,075
		8[d]	—	3,133 (34-6,570)	—
		3[d]	12.3 (9.8-14.0)	1,863 (990-2,300)	—
Thompson Marsh	Sediment	24[a]	7.6 (0.3-19.9)	1,812 (99.4-12,200)	878 (83-2,450)

Table 2-11 (cont.)
Mean (minimum-maximum) Metals Concentrations
in Tailings, Sediments, and Soils in Lower Coeur d'Alene River Basin

Site	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)

a. Sediments collected from lacustrine and palustrine areas (Campbell et al., 1999).
b. Sediments collected from 1 to 9 m in lake inlets and open water (Bauer, 1974; data also presented in Rabe and Bauer, 1977, and Funk et al., 1975).
c. Hornig et al., 1988 (wet weight measurement).
d. Neufeld, 1987.
e. Soils collected from river bank and floodplain areas (Horowitz, 1995).
f. Krieger, 1990.
g. Soil samples collected from islands and river bank (Roy F. Weston, 1989).
h. Soils collected from floodplains and sediments collected from Coeur d'Alene River and lateral lakes (URSG and CH2M Hill, 1998).
i. Sediments collected from the Coeur d'Alene River. Values in parentheses are standard error of the mean; minimum and maximum values were not provided (Farag et al., 1998).
j. Sediments collected from the Coeur d'Alene River (Reece et al., 1978).
k. Sediment samples collected from river bank (USGS, unpublished[7]).
i. Sediments collected from stream channel; soils collected from floodplain banks (Ridolfi, 1991).
m. Tailings core samples collected from Cataldo Mission Flats area (Galbraith, 1971; Galbraith et al., 1972).
n. Soils collected from floodplain areas (Hagler Bailly Consulting, 1995).
o. Soils collected at 0-5 cm in Kootenai County (Keely, 1979).
p. Audet, 1997.
q. Sediments collected from the river delta area (Maxfield et al., 1974).
r. Sediments collected from Coeur d'Alene Lake between 2 and >20 m (Winner, 1972).
s. Sediments collected from three locations in Killarney Lake (Bender, 1991).
t. Horowitz et al., 1992, 1993, 1995.
u. Sediments collected from littoral/water interface and 1m above the water level (Cernera et al., 1998).

Concentrations of metals measured in the discontinued railroad right of ways (ROW) are presented in Tables 2-12 and 2-13. Table 2-12 presents cadmium, lead, and zinc concentrations in samples collected from the zero to 18 in. depth from locations in both the lower and upper basins (U.S. EPA, 1999). Samples were collected from the mainline and from sidings (where the track divides to allow for loading/unloading or passing). Samples were also collected from the ROW to the north and south of the tracks. Cadmium concentrations north and south of the mainline ranged from 0.5 to 99.4 mg/kg, lead concentrations ranged from 151 to 33,700 mg/kg, and zinc concentrations ranged from 114 to 15,300 mg/kg. Table 2-13 presents lead concentrations in samples collected from the 0 to 6, 6 to 12, and 12 to 18 in. depths at locations along the railroad within the Bunker Hill Superfund Site.

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7. Unpublished sampling data collected in August 1989 and June 1991 by USGS, Water Resources Division, Doraville, GA.

Table 2-12
Concentrations of Cadmium, Lead, and Zinc (mg/kg) in Railroad Right of Way[a]

Location	Mile	Cadmium		Lead		Zinc	
		Mainline	Siding	Mainline	Siding	Mainline	Siding
Springston Siding #1	33.5	22.6	9.4	14,400	7,500	3,090	1,560
~0.5 miles east of Medimont	42	18.6	—	4,390	—	1,890	—
Dudley Siding	52	26.1	17.6	8,060	4,100	3,640	2,080
~1 mile east of Cataldo	58.5	34.1	—	11,500	—	5,540	—
~0.75 miles west of Enaville	62	30.9	—	8350	—	4,700	—
Siding west of Enaville	62.5	30.6	17.1	7,050	6,160	4,730	2,580
Sunshine Mine siding at Shont	72.8	190	82.4	58,800	36,700	8,4700	8,680
Silverton area east of Osburn	78	102	—	30,400	—	13,800	—
Morning Mine area	5	68.3	—	17,100	—	11,500	—

a. Samples were collected from the surface to 18 inches.

Source: U.S. EPA, 1999.

Table 2-13
Concentrations of Lead (mg/kg) Collected from Railroad Right of Way within the Bunker Hill Superfund Site

Sample Location	Sample Size	Sample Depth		
		0-6 in.	6-12 in.	12-18 in.
Eastern Site Boundary to Elizabeth Park	3	1,470-28,200	1,410-25,900	1,590-17,900
Elizabeth Park to Ross Ranch	42	1,150-56,000	560-52,900	408-67,400
Ross Ranch to Kellogg Depot	47	3,450-64,300	2,540-42,900	3,350-70,500
Kellogg Depot to Silver Mountain	39	690-80,800	3,170-64,900	1,320-55,000
Silver Mountain to Smelterville	78	867-84,600	1,850-81,600	1,560-67,500
Smelterville to Page Swamp	73	800-30,200	730-37,100	488-37,500
Page Swamp to Pine Creek	108	628-47,200	1,290-57,700	986-89,800
Pine Creek to South Fork Coeur d’Alene River	33	500-19,200	120-23,000	95-23,700
South Fork Coeur d’Alene River to Western Site Boundary	37	251-15,600	56-26,200	58-36,700

Source: MFG, 1996.

Canyon Creek

In the Canyon Creek drainage, the largest unconfined deposits of jig and flotation tailings and mixed tailings and alluvium are in the lower reaches where the creek gradient diminishes and the valley widens (Figure 2-8). The lower reach of the creek was impounded in the early part of the twentieth century to settle tailings, and more than 400,000 cubic yards (230,000 cubic yards tailings; 134,000 cubic yards reworked tailings and alluvium; 45,000 cubic yards railroad embankment; 13,000 cubic yards Formosa slimes) of tailings and alluvium accumulated (U.S. EPA, 1995). Approximately 532,300 cubic yards of mixed tailings and alluvium have been moved from the lower Canyon Creek floodplain to a repository near the southeastern edge of the floodplain in the Woodland Park area (SVNRT, 1998, as cited in Ridolfi, 1998 and in Gearheart et al., 1999). As a result of former tailings disposal practices, residual jig and flotation tailings are present in the floodplain upstream of the former impoundment area as well. In addition to unconfined tailings deposits in the drainage, the Star Mine tailings ponds are located in the Canyon Creek floodplain upstream of Woodland Park. The six ponds received tailings from 1965 to 1990. The ponds cover 62 acres and are estimated to hold 3.4 million tons of tailings (2.1 million cubic yards) (SAIC 1993a; 1993b; Gearheart et al., 1999).

An estimated 139 acres of floodplain have been remediated, but an estimated 83 acres of contaminated floodplain remain (Gearheart et al., 1999). The volume of tailings-contaminated floodplain materials remaining in the Canyon Creek and Gorge Gulch floodplains, beds, and banks is estimated to be between 134,000 and 669,000 cubic yards (Gearheart et al., 1999). An estimated 39,000 to 166,000 cubic yards of tailings-contaminated material remains near former millsites (Gearheart et al., 1999).

Waste rock is believed to be located near all adits and shafts in the basin. Gearheart et al. (1999) estimated that waste rock dumps in the Canyon Creek drainage contain 3.1 million cubic yards of waste rock and cover 75 acres. Waste rock piles at the Ajax Mine, the Hercules Mine (No. 4 adit in Gorge Gulch), the Gertie Mine, and the Tamarack-Custer #7 (also called the Standard #6) are subject to erosion by the creek (SAIC, 1993a; MFG, 1994). The waste rock pile at the Hercules No. 3 adit in Gorge Gulch is located in the creek, and the creek flows through it (Ridolfi, 1998).

Concentrations of cadmium, lead, and zinc in samples collected during the early 1990s site characterization of lower Canyon Creek are presented in Table 2-14. Concentrations of metals in tailings and alluvium were reported for three reaches: (1) the Formosa reach, from the upstream end of the Star Tailings Ponds to approximately 1,000 feet upstream of the Canyon Silver-Formosa Mine; (2) the Upper Ponds reach, from Star Tailings Ponds No. 1 to No. 4; and (3) the Woodland Park reach, from the downstream end of the Star Tailings Pond No. 2 to the old tailings dam, approximately 1,200 feet downstream of Star Tailings Pond No. 6 (U.S. EPA, 1995).

Table 2-14
Mean (minimum-maximum) Concentrations of Metals in Tailings, Sediments, and Soils in the Canyon Creek Basin

Reach	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Canyon Creek	Soils	6[a]	22.6 (4.9-44.8)	18,293 (5,460-42,200)	3,838 (590-7,450)
		18[b]	—	16,389 (500-38,000)	6,133 (500-44,000)
	Sediment	4[c]	49.3 (6.5)	9,187 (522)	8,543 (931)
		13[b]	—	3,053 (400-63,000)	2,100 (1,100-3,300)
Formosa	Railroad embankment	14[d]	54 (9.2-142)	20,599 (352-43,600)	4,013 (387-13,100)
	Reworked tailings/ alluvium	3[d]	38 (24.4-45.2)	12,633 (11,200-14,600)	2,863 (2,090-4,360)
	Alluvium	6[d]	26 (8.4-60)	2,284 (240-7,720)	606 (258-1,440)
	Tailings	6[d]	464 (9.6-1,850)	45,183 (15,300-83,600)	13,906 (876-55,200)
Frisco	Soil	1[e]	40.5	76,300	7,040
	Tailings	NA[f]	—	(2,420-93,200)	(467-46,400)
Tamarack	Tailings	1[g]	53.6	54,800	8,650
	Soil	1[g]	345	47,200	53,200
	Sediment	3[g]	58.9 (21.3-105)	11,040 (3,990-22,600)	11,163 (6,090-15,800)
Upper Pond	Railroad embankment	6[d]	41 (15.6-94)	51,117 (900-137,000)	5,381 (576-13,900)
	Tailings	2[d]	66 (27.2-104)	25,950 (22,500-29,400)	7,410 (3,620-11,200)
	Alluvium	1[d]	15.6	235	672

Table 2-14 (cont.)
Mean (minimum-maximum) Concentrations of Metals in Tailings, Sediments, and Soils in the Canyon Creek Basin

Reach	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Woodland Park	Reworked tailings/ alluvium	14[d]	29 (7.2-72.2)	16,194 (7,720-40,400)	5,380 (225-16,000)
	Jig tailings	14[d]	52 (<2-214)	78,986 (20,600-243,000)	7,139 (46.8-28,300)
	Railroad embankment	9[d]	162 (3.2-860)	34,810 (109-123,000)	17,352 (157-95,200)
	Alluvium	58[d]	55 (<2.0-1,320)	4,661 (159-20,800)	2,404 (52.4-10,400)
	Tailings	46[d]	54 (4-518)	47,750 (5,120-136,000)	7,784 (876-74,600)
	Soil	2[e]	19.2 (8.4-30)	68,200 (64,900-71,500)	5,255 (3,290-7,220)
	Sediment	1[e]	456	26,200	26,300

a. Soils collected from the floodplain (Hagler Bailly Consulting, 1995).
b. Soils and sediments collected from Canyon Creek valley bottom (Galbraith, 1971).
c. Sediments collected from stream channel (Farag et al., 1998; values in parentheses are standard error of the mean; minimum and maximum values were not provided).
d. U.S. EPA, 1995.
e. Sediments collected from stream channel; soils collected from floodplain banks (Ridolfi, 1991).
f. SVNRT, 1996, as cited in Ridolfi, 1998.
g. Ecology and Environment, 1995.

Concentrations of metals in tailings and alluvium ranged from <2 to 1,850 mg cadmium/kg, 159 to 243,000 mg lead/kg, and 46.8 to 74,600 mg zinc/kg (Table 2-14; U.S. EPA, 1995). Concentrations of metals measured in the discontinued railroad embankment ranged from 3.2 to 860 mg cadmium/kg, 109 to 137,000 mg lead/kg, and 157 to 95,200 mg zinc/kg (Table 2-14; U.S. EPA, 1995). Concentrations of metals in soils and sediments ranged from 4.9 to 456 mg cadmium/kg, 500 to 76,300 mg lead/kg, and 500 to 53,200 mg zinc/kg. Some of this material has recently been moved to a repository.

Ninemile Creek

Tailings deposits in the Ninemile Creek drainage include a large mixed-jig and flotation tailings pile at the Interstate-Callahan Mill (66,000 to 80,000 cubic yards), a tailings pond at the Rex Mill (84,000 cubic yards, plus an additional 9,000 cubic yards near the mill site), and a tailings pile at the Success Mill (200,000 cubic yards, plus an additional 200 to 1,700 cubic yards near the millsite) (Figures 2-5 and 2-8) (SAIC, 1993a, 1993b; Gearheart et al., 1999).

The tailings pile at the Interstate-Callahan Mill was historically in direct contact with Ninemile Creek. In 1992 and 1993, the Hecla Mining Company attempted to isolate the tailings from the creek, but zinc loadings still increase through the reach in which the mill site is located (Ridolfi, 1998). Surface water collects seasonally on the pond, infiltrates, and discharges from a seep at the toe of the tailings dam (Ridolfi, 1998). The waste rock and tailings pile at the Success Mill also were historically in contact with the creek and were actively eroding. In 1993, the U.S. EPA conducted a reclamation project to isolate the tailings from the creek (Ridolfi, 1998).

On the mainstem of Ninemile Creek, tailings discharged from the Dayrock Mill probably remain in the floodplain near the mill (Gross, 1982), and tailings produced at the mill at Blackcloud may also be present (Ridolfi, 1998). Volume estimates for these tailings deposits are 11,000 cubic yards (Dayrock) and 7,000 cubic yards (Blackcloud). The Dayrock impoundment is estimated to contain 134,000 to 269,000 cubic yards of tailings (Gearheart et al., 1999).

In addition to these discrete tailings deposits, historical tailings disposal to the creek and erosion of tailings in contact with the creek have distributed hazardous substances throughout the East Fork and mainstem of Ninemile Creek. In 1994, the Silver Valley Natural Resource Trustees, Idaho Division of Environmental Quality, U.S. DOI Bureau of Land Management, and Hecla Mining Company removed some of the mixed tailings and alluvium from the lower East Fork of Ninemile Creek, but an estimated 195,000 cubic yards of mixed tailings and alluvium remain in the floodplain elsewhere in the drainage (Gearheart et al., 1999).

Measured concentrations of cadmium in floodplain materials range from 0.2 to 106.5 mg/kg, lead from 3,840 to 100,000 mg/kg, and zinc from 390 to 19,700 mg/kg (Table 2-15). Copper concentrations in the Interstate-Callahan tailings impoundment ranged from 40 to 168 mg/kg (Gross, 1982). Gearheart et al. (1999) estimated that waste rock dumps in the Ninemile Creek drainage contain 2.5 million cubic yards of waste rock and cover approximately 53 acres.

Table 2-15
Mean (minimum-maximum) Concentrations of Metals in Ninemile Creek Basin Tailings, Sediments, and Soils

Site	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
East Fork Ninemile Creek	Soils	NA[a]	—	(14,700-100,000)	(963-3,230)
Ninemile Creek	Soils	5[b]	8.8 (0.2-12.7)	27,280 (14,500-59,600)	2,580 (1,540-3,720)
		NA[a]	—	(12,600-72,000)	(1,050-10,600)
	Sediment	4[c]	106.5 (33.3)	4,503 (25)	19,700 (4,699)
Interstate-Callahan	Tailings	3[d]	3.8 (2.1-6.9)	5,703 (3,840-7,070)	980 (390-1,400)
Success	Tailings	1[e]	10.9	8,010	2,430

a. Values reported for ranges of concentrations from soil test pits (SVNRT, 1994, as cited in Ridolfi, 1998).
b. Soils collected from the floodplain (Hagler Bailly Consulting, 1995).
c. Sediments collected from stream channel (Farag et al., 1998; values in parentheses are standard error of the mean; minimum and maximum values were not provided).
d. Gross, 1982.
e. Ecology and Environment, 1993, as cited in Ridolfi, 1998.

Moon Creek

In the Moon Creek drainage, south of the former Charles Dickens Mill and in the Moon Creek floodplain (Figures 2-3 and 2-8), an estimated 40,000 to 42,600 cubic yards of tailings remain, covering approximately 5 acres (Gross, 1982; USBM, 1995; Ridolfi, 1996, as cited in Ridolfi, 1998). Moon Creek bisects the tailings and is in direct contact with them throughout the length of the tailings impoundment. Soils surrounding the mill comprise 6 to 8 feet of jig tailings, waste rock, wood, and other debris mixed with alluvium (Ridolfi, 1998). Mine wastes have been transported from the Silver Crescent and Charles Dickens mine sites throughout the floodplain and the channel of the East Fork and possibly the main stem of Moon Creek.[8]

Concentrations of metals in the Silver Crescent Mill and Charles Dickens Mine Complex tailings range from 0.5 to 120 mg cadmium/kg, 2 to 47,300 mg lead/kg, and 1 to 17,000 mg zinc/kg (Table 2-16). In Moon Creek tailings, copper ranged from 1 to 840 mg/kg, antimony ranged from 5 to 330 mg/kg, arsenic ranged from 5 to 1,300 mg/kg, and mercury ranged from 0.016 to 19 mg/kg (Gross, 1982; USBM, 1995).

8. Unpublished data collected by NRDA field personnel during field investigations in October 1996. As cited in Ridolfi, 1998. Available from Ridolfi Engineers, Seattle, WA.

Table 2-16
Mean (minimum-maximum) Concentrations of Metals in Moon Creek Basin Tailings, Sediments, and Soils

Site	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Charles Dickens/ Silver Crescent	Tailings	312[a]	23.1 (0.5-120)	5,657 (2-47,300)	4,217 (1-17,000)
		6[b]	42.6 (5.2-91.3)	14,967 (1,080-29,180)	4,088 (1,710-8,050)

a. USBM, 1995.
b. Gross, 1982.

Pine Creek

Tailings deposits in the Pine Creek drainage include dumps associated with the Constitution Mill, the Little Pittsburgh (Mascot) Mill, the Nabob Mill, the Liberal King (Sunset) Mill, the Douglas Mill, and the Amy Matchless Mill (Figures 2-6 and 2-8).

Tailings associated with the Amy Matchless and Liberal King mines, and tailings believed to be associated with the Little Pittsburgh Mill at the mouth of Denver Creek, were removed by U.S. BLM in 1996 and 1997 (CCJM, 1998). These tailings, totaling about 23,075 cubic yards, were initially moved to a temporary storage area (TSA) near the upper Constitution Mill (CCJM, 1998). In 1998, they were removed to the CIA (Fortier, U.S. BLM Coeur d'Alene Field Office, personal communication, June, 2000). In 1998, another 420 cubic yards were removed from the Amy Matchless site to the CIA, completing the planned U.S. BLM removals from the site (D. Fortier, U.S. BLM Coeur d'Alene Field Office, personal communication, June, 2000).

Approximately 4,800 to 9,000 cubic yards of tailings were estimated to remain below the Liberal King (Sunset) Mill (Gross, 1982; CCJM, 1995). The floodplain tailings were removed by the U.S. BLM in 1997 (CCJM, 1998). Approximately 8,700 cubic yards of tailings and 660 cubic yards of the alluvium beneath the tailings were removed to the TSA. In 1998, approximately 20 cubic yards of tailings material were removed directly to the CIA (D. Fortier, U.S. BLM Coeur d'Alene Field Office, personal communication, June, 2000). In 1999, U.S. BLM removed approximately 1,800 cubic yards of tailings material from the rock dump and hillsides near and below the mill, to the CIA (D. Fortier, U.S. BLM Coeur d'Alene Field Office, personal communication, June, 2000).

An impoundment in the East Fork of Pine Creek near the confluence with Denver Creek was estimated to contain approximately 1,000 to 1,880 cubic yards of tailings believed to have been discharged from the Little Pittsburg Mill (Gross, 1982; CCJM, 1995; McNary et al., 1995). In 1996, that estimate was revised to 7,900 cubic yards. Of that amount, 5,200 cubic yards (4,300 cubic yards of tailings and 660 cubic yards of alluvium) were located on public lands and were moved to the TSA in 1996 and 1997 (CCJM, 1998; D. Fortier, U.S. BLM Coeur d'Alene Field Office, personal communication, June, 2000).

An estimated 31,000 to 46,000 cubic yards of tailings are located at the Douglas Mine site (Gross, 1982; McNary et al., 1995). The U.S. EPA removed 24,762 cubic yards of tailings from near the road in 1996 and covered them in 1997 (U.S. EPA, 1998). In 1998, U.S. BLM removed tailings and mill wastes from mill areas at the Liberal King (99 cubic yards), the Upper Constitution (361 cubic yards), and the Red Cloud/Sidney (688 cubic yards) (D. Fortier, U.S. BLM Coeur d'Alene Field Office, personal communication, June, 2000).

Tailings associated with other sites in the Pine Creek drainage have not been removed. Approximately 40,000 to 45,000 cubic yards of tailings remain near the Nabob Mill (CCJM, 1995; McNary et al., 1995; Gearheart et al., 1999). In 1995, the mine operator seeded and placed soil cover materials over the tailings, but success of the revegetation is limited (CCJM, 1998). At the Constitution Mine site, two tailing dumps are estimated to contain 25,900 and 35,900 cubic yards (Gross, 1982; CCJM, 1995; McNary et al., 1995); these tailings have not been removed (CCJM, 1998). According to Gross (1982), tailing ponds at the Constitution site could be eroded by surface streams and wind. Gearheart et al. (1999) estimated that the total volume of tailings remaining in piles and impoundments is 79,700 cubic yards, and the total volume of tailings remaining at 10 former mines and millsites is 29,000 to 126,000 cubic yards.

Other smaller tailing deposits exist throughout the basin, and many tailing deposits are near or in contact with streams in the Pine Creek basin (McNary et al., 1995). In addition to the discrete tailings deposits, the discharge of tailings to the Pine Creek drainage has resulted in the distribution of tailings and mixed tailings and alluvium throughout reaches of the East Fork and mainstem Pine Creek, and tributaries to the East Fork (Highland, Denver, Red Cloud, and Nabob creeks), downstream of mills. An estimated 346,000 to 1.4 million cubic yards of tailings-contaminated materials may remain in the beds and banks of Pine Creek, East Fork Pine Creek, Highland Creek, Red Cloud Creek, and Denver Creek (Gearheart et al., 1999). In 1999, U.S. BLM removed the major discrete tailings deposits from public lands in Highland Creek. Approximately 8,100 cubic yards of tailings were removed and placed on the CIA (D. Fortier, U.S. BLM Coeur d'Alene Field Office, personal communication, June, 2000).

More than 1.4 million cubic yards of waste rock are associated with the producing and nonproducing mines in the Pine Creek basin (CCJM, 1995; McNary et al., 1995; Gearheart et al., 1999). The largest waste rock dumps inventoried are associated with the Sidney (95,000 yd^3 on Denver Creek, plus a 2 acre dump of undetermined volume in Red Cloud Creek), Lookout Mountain (50,000 yd^3), Nabob (48,000 yd^3), Highland Surprise (45,000-85,000 yd^3), Douglas (35,000 yd^3), Crystalite (25,000 yd^3), and Constitution (21,000 yd^3) mines (CCJM, 1995; McNary et al., 1995). Smaller waste rock piles are associated with the Blue Eagle Group (1,000 yd^3), Little Pittsburg (1,000 2,000 yd^3), Nevada Stewart (1,000 yd^3), Silver Hill (700 yd^3), and Sullivan (600 yd^3) (CCJM, 1995; McNary et al., 1995). The waste rock dumps are typically located near mine adits and shafts.

Other waste rock sources are near or in direct contact with streams in the basin (McNary et al., 1995). At the Crystalite claim at the Nabob Mine, an ore bin at the south end of the waste dump has been undercut by Nabob Creek. At the Little Pittsburg Mine, surface structures are within the active channel of Denver Creek and one adit is flooded and filled with stream sediment. Mascot Mining recently regraded the Hilarity Mine rock dumps in Denver Creek (D. Fortier, U.S. BLM Coeur d'Alene Field Office, personal communication, June, 2000). High flows in Highland Creek have eroded the base of a Highland Surprise mine dump. Dry Creek flows through a waste dump associated with the Blue Eagle Group. A small tributary to the East Fork Pine Creek erodes at least three of the waste dumps associated with the Pine Claim (SAIC, 1993a; CCJM, 1995; McNary et al., 1995). In winter 1999 and spring 2000, U.S. BLM regraded the Sidney rock dump and reconstructed Red Cloud Creek to reduce erosion of the rock dump to the stream (D. Fortier, U.S. BLM Coeur d'Alene Field Office, personal communication, June, 2000).

Table 2-17 lists concentrations of metals measured in waste rock dumps in the Pine Creek basin. Cadmium concentrations ranged from <1 mg/kg at most sites to 140 mg/kg at the Douglas mine site. Lead ranged from 13 mg/kg at the Blue Eagle Group to 53,300 mg/kg at the Crystalite claim. Zinc ranged from 16 mg/kg at the Blue Eagle Group to 46,400 mg/kg at the Crystalite claim. Ranges of other contaminant concentrations measured in waste rock dumps include those for antimony (<10-160 mg/kg), arsenic (<10-3,400 mg/kg), copper (<10-580 mg/kg), and mercury (<0.01-20.6 mg/kg) (McNary et al., 1995).

Table 2-17
Mean (minimum-maximum) Concentrations of Metals in Pine Creek Basin Tailings, Sediments, and Soils

Site	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Amy-Matchless	Tailings	6[a]	31.2 (<0.1-122)	4,266 (973-8,260)	5,569 (660-16,900)
		7[b]	87.5 (0.22-392)	1,948 (63.3-4,790)	10,604 (137-23,700)
	Sediment	2[a]	1.4 (1.1-1.7)	524 (310-738)	393 (270-516)
		1[c]	<1.0	285	352
		3[b]	1.7 (1.1-2.4)	310 (299-324)	362 (279-427)
	Soil	1[a]	4.0	825	1,030
Blue Eagle Group	Waste rock	2[c]	<1	15 (13-17)	31 (16-45)
Bobby Anderson	Sediment	1[c]	<1	237	310
Constitution	Tailings	26[c]	33.0 (4-112)	4,487 (85-11,900)	8,495 (870-29,800)
		3[a]	16.7 (9.5-30.7)	2,740 (1,300-4,930)	5,410 (3,460-8,990)
		6[d]	15.8 (9.8-22.9)	3,618 (1,130-5,910)	4,312 (2,270-6,850)
	Sediment	4[a]	9.2 (<1-18.2)	3,517 (9-5,510)	3,498 (22-6,930)
		3[c]	9.9 (1.6-19.1)	3,503 (1,110-4,710)	3,232 (807-5,020)
	Waste rock	2[c]	4 (<1-7)	512 (314-710)	790 (340-1,240)
Crystalite Claim	Waste rock	5[c]	34 (<1-110)	24,780 (6,300-53,300)	12,958 (690-46,400)

Table 2-17 (cont.)
Mean (minimum-maximum) Concentrations of Metals in Pine Creek Basin Tailings, Sediments, and Soils

Site	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Denver	Tailings	2[c]	21.5 (17-26)	3,800 (2,700-4,900)	3,350 (2,400-4,300)
		3[a]	11.6 (<0.1-34.7)	3,242 (847-4,710)	6,073 (408-16,800)
	Sediment	6[a]	3.7 (<1-15.5)	1,188 (426-3,260)	1,199 (770-2,610)
Douglas	Tailings	21[c]	16.8 (<1-66)	2,666 (120-5,300)	4,935 (280-11,900)
		3[d]	16.6 (9.5-21.7)	1,953 (1,090-2,570)	4,643 (3,040-7,340)
	Sediment	2[c]	1.3 (<1-1.6)	419 (376-462)	550 (468-632)
	Waste rock	7[c]	28 (<1-140)	7,574 (620-33,800)	11,131 (220-59,700)
Douglas/Sherman	Waste rock	2[c]	<1	841 (82-1,600)	155 (120-190)
Fourth of July	Sediment	1[c]	<1	269	511
Highland Surprise	Sediment	5[a]	7.2 (<1-13.7)	2,564 (72-6,680)	2,284 (161-3,790)
		1[c]	20.9	3,690	5,730
	Waste rock	25[c]	20 (<1-95)	5,343 (59-51,900)	6,920 (110-34,100)
Hilarity	Sediment	3[c]	5.5 (3.1-6.4)	1,500 (621-1,930)	2,180 (1,470-2,430)
Liberal King	Tailings	3[a]	14.5 (<0.1-43.3)	1,251 (331-2,880)	784 (113-1,460)
	Sediment	2[a]	1.4 (1.1-1.7)	258 (211-304)	364 (357-370)
		1[c]	<1	246	469
	Soil	5[a]	2.0 (<1-3.0)	1,353 (140-4,320)	405 (65-657)
Little Pittsburg	Sediment	1[c]	10.7	4,850	4,595
	Waste rock	5[c]	25 (<1-66)	4,778 (190-11,800)	7,271 (57-17,800)
Lookout Mountain	Sediment	1[c]	2.7	476	957
	Waste rock	7[c]	<1	2,825 (76-9,300)	86 (41-180)
Lynch Gulch	Waste rock	1[c]	<1	65	26
Nabob	Tailings	56[c]	33.9 (<1-400)	5,777 (590-61,700)	4,446 (110-74,300)
		2[a]	45.6 (8.5-82.6)	7,325 (6,960-7,690)	2,890 (1,370-4,410)
	Sediment	4[a]	4.6 (<1-10.1)	628 (241-1,190)	1,116 (596-1,780)
	Soil	4[a]	1.0 (<1-1.3)	1,412 (183-2,790)	579 (254-894)
	Waste rock	3[c]	4.3 (<1-7.0)	16,633 (1,800-28,800)	1,587 (260-2,600)
Nevada Stewart	Sediment	1[c]	10.1	2,460	4,370
	Waste rock	3[c]	<1 (<1-1)	6,400 (1,000-11,800)	230 (130-420)
Owl Prospect	Sediment	1[c]	<1	53	180
Pine Creek	Sediment	4[e]	2.3 (0.8)	264 (79)	469 (139)
Sidney	Sediment	3[a]	8.8 (<1-14.4)	1,151 (192-1,940)	1,976 (388-3,580)
		1[c]	15.9	3,780	5,170
	Waste rock	16[c]	15 (<1-40)	2,781 (37-11,000)	4,341 (74-11,800)
Silver Hill	Waste rock	1[c]	<1	43	54

Table 2-17 (cont.)
Mean (minimum-maximum) Concentrations of Metals in Pine Creek Basin Tailings, Sediments, and Soils

Site	Type	Sample Size	Cadmium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Star Antimony	Sediment	2[c]	4.7 (3.1-6.2)	833 (774-891)	2,100 (1,610-2,590)
Sullivan	Waste rock	2[c]	<1	84 (17-150)	154 (58-250)

a. CCJM, 1995.
b. Ecology and Environment, 1995.
c. McNary et al., 1995.
d. Gross, 1982.
e. Farag et al., 1998 (values in parentheses are standard error of the mean; minimum and maximum values were not provided).

Concentrations of metals in Pine Creek basin tailings have been measured at the Nabob, Denver, Douglas, Constitution, Liberal King, and Amy-Matchless operations (Table 2-17). Concentrations of cadmium (400 mg/kg), lead (61,700 mg/kg), and zinc (74,300 mg/kg) were greatest at the Nabob site (Table 2-17). In Pine Creek tailings, copper ranged from below detection to 4,940 mg/kg, antimony ranged from <10 to 920 mg/kg, arsenic ranged from <10 to 1,400 mg/kg, mercury ranged from 0.024 to 45.5 mg/kg, nickel ranged from below detection to 47.3 mg/kg, and silver ranged from 0.27 to 56.1 mg/kg (Gross, 1982; CCJM, 1995; Ecology and Environment, 1995; McNary et al., 1995).

Concentrations of metals in soils and sediments ranged from <0.01 to 20.9 mg cadmium/kg, 9 to 6,680 mg lead/kg, and 22 to 6,930 mg zinc/kg.

2.4.2 Summary of Tailings and Mixed Tailings, Waste Rock, and Alluvium/Soils/ Sediments

- At least 44 former mills historically produced an estimated 110 to 120 million tons of tailings; an estimated 103 million tons of tailings were discharged to creeks, unsecured dumps, and impoundments; and an estimated 75 million metric tons (82.7 million tons) of trace-element enriched sediments have been deposited in the bed of Coeur d'Alene Lake.

- Disposal practices included direct disposal to surface waters, disposal on floodplains, and impoundment of tailings in the floodplains.

- Tailings and mixed tailings and alluvium (soils and sediments) contain elevated concentrations of hazardous substances. Concentrations measured in tailings, soils, and sediment samples collected throughout the basin by numerous investigators over many years indicate that the contamination is pervasive in the basin, concentrations of hazardous substances are consistently elevated, and the concentrations are sufficiently elevated that these materials serve as sources of releases of hazardous substances.

- The hazardous substances released from the many sources in the Coeur d'Alene River basin are inextricably commingled in the environment. Transport and mixing via natural fluvial processes resulted in downstream movement of hazardous substances, and deposition of inextricably commingled wastes in sediments in floodplains, beds, and banks throughout the Coeur d'Alene River basin.

- Waste rock dumps are known or believed to be associated with most adits and shafts.

- Waste rock dumps may contain elevated concentrations of hazardous substances, may be acid generating, and may serve as sources of hazardous substances to surface water, groundwater, soil, and biological resources.

2.4.3 Drainage from Adits and Seeps

In the South Fork Coeur d'Alene River basin, mining activities resulted in many miles of underground workings, interconnecting mines, interconnecting drainages, and connectivity at multiple levels. Some of the underground workings have been backfilled with tailings. Shafts, adits, and underground workings expose minerals in the remaining ore and backfilled tailings to oxygen and groundwater, which can form acid mine drainage, or metal-laden leachate. Discharge of mine drainage containing elevated concentrations of metals is an ongoing source of hazardous substances to surface waters. At least 115 adits are known to discharge mine drainage in the South Fork Coeur d'Alene River basin (Gearheart et al., 1999).

Seeps, which are surface expressions of groundwater, are commonly found at the bases of waste rock piles and along creek banks, including banks covered by tailings and mixed tailings and alluvium. Seeps typically result from infiltration of rainfall, snowmelt, or mine drainage. Releases from seeps typically flow to streams. Seep water emerging from waste rock, tailings, or mixed tailings and alluvium deposits often contains greatly elevated concentrations of hazardous substances leached from waste deposits.

The following sections present evidence of hazardous substance releases from underground mine workings as adit discharge, and from seeps emerging from waste deposits.

South Fork Coeur d'Alene River Upstream of Elizabeth Park

Fifty-six adits in the South Fork drainage upstream of Elizabeth Park, excluding the Canyon Creek, Ninemile Creek, and Moon Creek drainages, are known to discharge mine drainage (Gearheart et al., 1999). Available water quality data from Osburn Flats seeps and four adits, the

Snowstorm No. 3, the Morning No. 5, the Morning No. 6, and the Silver Dollar, are presented in Table 2-18.

Table 2-18
Concentrations of Dissolved Hazardous Substances in Adit and Seep Discharge, South Fork Coeur d'Alene River Basin Upstream of Elizabeth Park

Site	Type	Date	Flow (cfs)	pH	Cond. (μS/cm)	Hard. (mg/L)	Cd (μg/L)	Pb (μg/L)	Zn (μg/L)
Crescent Mine (Hooper Tunnel)	Adit	Aug. 1996[a]	0.04	6.64	501	278	0.91	3.8	142
		Jun. 1997[a]	0.08	7.15	377	192	1.3	27	238
Morning No. 5	Adit	Aug. 1996[a]	0.06	7.03	381	220	0.59	0.67	401
		Jun. 1997[a]	0.09	7.57	363	196	45	4.1	4,270
Morning No. 6	Adit	May 1991[b]	0.60	8.26	980	—	0.7	<3	<20
		Oct. 1991[c]	0.92	7.74	1481	—	0.4	<1	<12
Osburn Flats	Seep	Mar. 1997[d]	—	—	—	—	—	—	8,370
		Jun. 1997[a]	0.06	6.62	201	99	38	1.8	4,720
Silver Dollar	Adit	Aug. 1996[a]	0.01	7.63	370	234	0.02	0.45	11
		Jun. 1997[a]	0.02	7.72	374	240	0.02	0.05	19
Snowstorm No. 3	Adit	Jun. 1997[a]	12.00	6.97	26	11.3	0.04	0.2	13
Sunshine	Outfall	May 1991[b]	3.50	6.16	44	—	2.1	<3	<20
		Oct. 1991[c]	4.02	7.26	14.22	—	1.6	<1	240

a. Balistrieri et al., 1998.
b. MFG, 1991.
c. MFG, 1992b.
d. SVNRT, 1997, as cited in Ridolfi, 1998.

The Snowstorm No. 3 discharges to Daisy Gulch, which drains to the South Fork Coeur d'Alene River. Ores from the Snowstorm Mine contained mainly copper, and drainage from the adit contains elevated concentrations of copper (Balistrieri et al., 1998; copper data not shown in Table 2-18). The Morning No. 5 drains to Mill Creek, which flows to the South Fork Coeur d'Alene River. The Morning Mine ore was rich in lead and zinc, and drainage from the Morning No. 5 adit contains elevated concentrations of lead and zinc (Balistrieri et al., 1998). Drainage from the Morning No. 6 flows through a biological treatment system that retains metals to some degree and then discharges into the South Fork (SAIC, 1993b). The data presented in Table 2-18 confirm that adits are a source of hazardous substances released from underground mine workings in the South Fork Coeur d'Alene River basin.

Seeps from waste rock piles and tailings and mixed tailings and alluvium are known to occur along the South Fork Coeur d'Alene River upstream of Elizabeth Park. Information regarding seep locations, discharge, and water quality is limited. Table 2-18 presents seep water quality data collected from the Osburn Flats tailings deposits in March and June 1997 (SVNRT, 1997, as cited in Ridolfi, 1998; Balistrieri et al., 1998). These data confirm that the Osborn Flats seeps are a source of hazardous substances to the South Fork Coeur d'Alene River.

South Fork Coeur d'Alene River Downstream of Elizabeth Park

Seeps from waste rock piles and tailings and mixed tailings and alluvium are known to occur along the South Fork Coeur d'Alene River downstream of Elizabeth Park. Information regarding adit and seep locations, discharge, and water quality is limited. Table 2-19 presents seep water quality data collected from two seeps near the CIA and from the Kellogg Tunnel discharge, which is treated at the Central Treatment Plant near the CIA before discharging to the South Fork Coeur d'Alene River (MFG, 1992a).

Table 2-19
Concentrations of Dissolved Hazardous Substances in Adit and Seep Discharge, South Fork Coeur d'Alene River Basin Downstream of Elizabeth Park

Site	Type	Date	Flow (cfs)	pH	Cond. (µS)	Hard. (mg/L)	Cd (µg/L)	Pb (µg/L)	Zn (µg/L)
CIA Tailings Pond	Seep	— [a]				—	<4-9	<5-25	4,940-25,700
	Seep (upper)	Nov. 1996[b]	0.11	5.69	783	400	33	123	20,150
	Seep (lower)	Nov. 1996[b]	1.71	6.05	639	338	32	35	10,080
Kellogg Tunnel[b]	Adit	Jun. 1997[b]	1.5-3.12	2.72	4,140	1,432	1,570	825	615,000

a. MFG, 1992a.
b. Balistrieri et al., 1998 (concentrations before water is treated).

Canyon Creek

In the Canyon Creek drainage, 24 adits discharge mine waters to surface water (Gearheart et al., 1999); others may also discharge. Water quality data for six of the more well-sampled adits are presented in Table 2-20; additional adit water quality data are presented in Gearheart et al. (1999).

Table 2-20
Concentrations of Dissolved Hazardous Substances in Adit and Seep Discharge, Canyon Creek Drainage

Site	Type	Date	Flow (cfs)	pH	Cond. (µS/cm)	Hard. (mg/L)	Cd (µg/L)	Pb (µg/L)	Zn (µg/L)
Black Bear	Adit	Nov. 1997[a]	1.13	—	—	45	0.5	2.2	89
Canyon Silver-Formosa	Adit	May 1998[a]	—	—	—	249	0.3	1.5	206
Hercules No. 5	Adit	May 1991[b]	2.8	6.21	219	—	64	308	6,550
		Oct. 1991[c]	0.79	7.88	260	—	0.3	<1	<12
		Aug. 1996[d]	2.6	7.75	221	130	0.65	0.54	103
		Jun. 1997[d]	3.0	7.58	220	118	32	223	2,510
		Nov. 1997[a]	1.4	7.86	—	111	3.2	2.1	277
		May 1998[a]	1.9	7.27	—	112	26	81.9	2,120
Hidden Treasure	Adit	May 1998[a]	1.44	6.97	—	81	1.5	0.2	363
Tamarack No. 7	Adit	May 1991[b]	3.2	7.01	168	—	5.1	<3	1,720
		Oct. 1991[c]	1.6	6.84	207	—	1.4	<1	501
		Aug. 1996[d]	—	7.51	205	115	2	0.1	632
		Jun. 1997[d]	2.0	7.50	216	122	16	0.2	2,800
		Nov. 1997[a]	0.01	—	—	113	1.3	0.1	586
		May 1998[a]	—	7.11	—	121	16.6	<0.5	2,790
Gem No. 3	Adit	May 1991[b]	0.2	6.95	405	—	9.1	3	17,150
		Oct. 1991[c]	0.25	6.76	382	—	7.5	<1	14,100
		Aug. 1996[d]	—	6.98	376	178	9.6	0.1	16,300
		Jun. 1997[d]	1.0	7.10	375	185	17	0.7	18,030
		May 1998[a]	0.6	6.93	—	163	10.8	<0.5	13,200
Railroad Track	Spring	May 1994[e]	—				179	1,031	27,200
Star Phoenix	Outfall	May 1991[b]	1.10	—	—	—	5.6	14	1,420
		Oct. 1991[c]	0.94	6.96	180	—	6.4	11	1,160

a. CH2M Hill and URSGWC, 1998.
b. MFG, 1991.
c. MFG, 1992b.
d. Balistrieri et al., 1998.
e. U.S. EPA, 1995.

The Hercules No. 5, Tamarack No. 7, and Gem No. 3 are the most well characterized adits in the Canyon Creek Basin (MFG, 1991, 1992b; Balistrieri et al., 1998; CH2M Hill and URSGWC, 1998). The Hercules No. 5 drains the Hercules and Hummingbird underground workings, and possibly the Union and the Sherman workings as well (SAIC, 1993c). Approximately 25% of the Hercules No. 5 adit discharge enters Gorge Gulch directly, and approximately 75% of the flow infiltrates the waste rock pile and discharges to Gorge Gulch as seepage (SAIC, 1993a). The Tamarack No. 7 drains the Tamarack-Custer, the Standard-Mammoth, and most likely the

Greenhill-Cleveland underground workings (SAIC, 1993c; Ridolfi, 1998). Discharge flows to Canyon Creek through a pipe (Ecology and Environment, 1995). The Gem No. 3 drains the Gem, Black Bear, and Frisco (Helena-Frisco) workings (SAIC, 1993c; Ridolfi, 1998). Discharge from the Gem No. 3 also flows to Canyon Creek through a pipe (SAIC, 1993a).

Concentrations in Hercules No. 5 and Tamarack No. 7 water are substantially more elevated during high flow than during low flow at each adit, most likely because an increased volume of groundwater is in contact then with mine workings. Concentrations in adit discharge from the Gem No. 3 are consistently elevated during both low flow and high flow. The data presented in Table 2-20 confirm these adits as sources of hazardous substances during both high flow and low flow.

At least seven seeps from waste rock piles have been identified in the Canyon Creek drainage. Among the seven are seeps associated with waste rock piles at the Hercules No. 3 and No. 5 adits, the Star Mine Tailings ponds, and the Woodland Park floodplain. Additional seeps may exist.

Concentrations of total zinc measured in seeps from the lower Canyon Creek floodplain in October 1991, September 1993, and May 1994 range from 29,867 µg/L to 35,400 µg/L (MFG, 1992b; Houck and Mink, 1994; U.S. EPA, 1995). In October 1991, MFG (1992b) measured dissolved zinc at 3,830 µg/L. Concentrations of total and dissolved cadmium measured in a seep from the lower Canyon Creek floodplain in October 1991 were 396 µg/L and 390 µg/L, and concentrations of total and dissolved lead were 1,590 µg/L and 1,480 µg/L. Concentrations of total zinc measured in seeps from the Star Tailings Ponds NPDES-permitted discharge in 1991 ranged from 1,230 µg/L during low flow to 1,360 µg/L during high flow (MFG, 1991, 1992b). In May 1998, total and dissolved concentrations of zinc measured in seeps from the Star Tailings Ponds were 9,720 µg/L and 9,370 µg/L, respectively (CH2M Hill and URSGWC, 1998).

These concentrations confirm that seep discharge from tailings and mixed tailings and alluvium are sources of hazardous substances to Canyon Creek.

Ninemile Creek

In the Ninemile Creek drainage, 12 adits are known to discharge mine water to surface water (Gearheart et al., 1999). Other draining adits may exist. Water quality data are available for four draining adits: the Interstate No. 4, the Rex No. 2, the Success No. 3, and the Sunset (Table 2-21).

The Interstate No. 4 drainage flows from the adit through a waste rock pile, and discharges to the East Fork of Ninemile Creek as seepage (SAIC, 1993b). The drainage from the Rex No. 2 discharges to a tributary gulch via a culvert and decant pond on the tailings pond surface (SAIC, 1993b). The gulch discharges to the East Fork of Ninemile Creek. Historically, drainage from the Success No. 3 infiltrated the tailings pile and entered the creek as seepage (SAIC, 1993b). Since 1993, adit drainage has been diverted around the tailings pile and enters the creek upstream and downstream of the tailings pile (IDEQ, 1994, as cited in Ridolfi, 1998).

Table 2-21
Concentrations of Dissolved Hazardous Substances in Adit Discharge, Ninemile Creek

Site	Type	Date	Flow (cfs)	pH	Cond. (µS/cm)	Hard. (mg/L)	Cd (µg/L)	Pb (µg/L)	Zn (µg/L)
Interstate-Callahan	Adit (No. 4)	Oct. 1991[a]	—	—	—	—	0.3	<0.1	73
		Aug. 1996[b]	0.07	7.33	204	110	0.14	0.03	39
		Jun. 1997[b]	0.14	7.50	158	88	0.04	0.05	26
		Nov. 1997[c]	0.04	—	—	112	0.06	0.14	25
		May 1998[c]	0.03	7.44	—	86	0.04	0.11	8
	Seep	Nov. 1996[b]	0.002	4.8	679	144	650	225	172,000
		Jun. 1997[b]	0.007	4.6	674	121	680	386	179,500
Rex	Adit (No. 2)	Aug. 1996[b]	0.01	7.10	150	70	5.5	42	1,210
		Jun. 1997[b]	0.02	7.29	119	50	11	197	2,350
		Nov. 1997[c]	0.03	—	—	67	6.2	45	1,350
		May 1998[c]	0.01	6.63	—	51	12	110	2,550
	Seep	Nov. 1996[b]	0.02	6.17	368	163	36	5.3	13,100
		Jun. 1997[b]	0.06	6.66	450	185	8.8	0.72	20,750
Success	Adit (No. 3)	Aug. 1996[b]	0.01	6.89	578	256	280	2.8	50,700
		Jun. 1997[b]	0.04	7.34	538	239	357	44	57,400
		May 1998[c]	0.01	6.37	—	231	376	7	73,500
	Seep (upper)	Nov. 1996[b]	0.01	4.85	157	43	117	215	20,200
		Jun. 1997[b]	0.003	7.13	56	15	26	112	3,760
	Seep (lower)	Nov. 1996[b]	0.002	6.11	184	55	140	930	24,200
		Jun. 1997[b]	0.04	6.29	120	34	82	515	13,600
Sunset	Adit	Nov. 1997[c]	—	—	—	50	150	93	24,300

a. MFG, 1992b.
b. Balistrieri et al., 1998. Cd, Pb, and Zn concentrations in August 1996 Interstate No. 4 samples are the mean of duplicate samples. Cd, Pb, and Zn concentrations in June 1997 Success No. 3 samples are the mean of triplicate samples.
c. CH2M Hill and URSGWC, 1998.

Five seeps from tailings and waste rock dumps have been identified in the Ninemile Creek watershed. Seeps have been identified emerging from Interstate-Callahan waste rock, Interstate-Callahan tailings, Tamarack waste rock, Rex tailings, and Success tailings. Other seeps may exist.

Table 2-21 presents high and low flow concentrations of hazardous substances measured in seep discharge at four locations. Each of the four seeps discharges substantial concentrations of cadmium, lead, and zinc to the East Fork of Ninemile Creek. In particular, concentrations of dissolved zinc in seep discharge from the Interstate-Callahan tailings exceed 170,000 µg/L and are relatively constant during high flow and low flow (Table 2-21). The total zinc load from the Interstate-Callahan tailings seeps to the East Fork of Ninemile Creek is estimated to range from 0.93 lb/day to 8.6 lb/day.

The concentrations presented in Table 2-21 confirm that adit discharge and seep discharge from tailings are sources of hazardous substances to Ninemile Creek.

Moon Creek

In the Moon Creek drainage, three adits — the Silver Crescent adit and two Charles Dickens Mine adits — drain to surface water resources. Two seeps believed to drain the Charles Dickens Mine and contaminated soil and jig tailings from the Charles Dickens Mine emerge from the bank of the East Fork of Moon Creek. Dissolved metals concentrations measured in seep and adit discharge in the Moon Creek basin range from 0.21 to 224 µg cadmium/L, 0.7 to 500 µg lead/L, and 46 to 28,854 µg zinc/L (Table 2-22; USBM, 1995). Maximum concentrations of metals measured in tailings pore water were 864 µg cadmium/L, 2,400 µg lead/L, and 175,000 µg zinc/L (Table 2-22; USBM, 1995).

Table 2-22
Concentrations of Dissolved Hazardous Substances in Moon Creek Basin Seep and Adit Discharge

Site	Type	Date	Flow (cfs)	pH	Cond. (µS/cm)	Hard. (mg/L)	Cd (µg/L)	Pb (µg/L)	Zn (µg/L)
Charles Dickens/ Silver Crescent	Seep (road)	Jan. 1993	—	6.75	—	47.3	1.88	1.6	973
		Mar. 1993	—	6.79	—	34.7	3.45	3.6	793
	Seep (confluence)	Apr. 1993	—	3.67	—	192.8	224	318	28,854
		May 1993	—	3.11	—	164.0	179	389	27,800
		Jun. 1993	—	3.29	—	144.3	136	500	20,130
		Aug. 1993	—	3.05	—	93.2	77	300	1,110
		Oct. 1993	—	2.86	—	115.8	68	300	9,020
		Dec. 1993	—	3.29	—	79.0	58.7	220	7,700
	Seep (tailings)	Mar. 1993	—	4.60	—	70.0	19.8	64.0	5,220
	Adit	Mar. 1993	—	7.57	—	271.8	0.21	0.7	46
	Pore water (tailings)[a]	Jun. 1993	—	—	—	592	805	1,490	104,980
		Jul. 1993	—	5.1-6.5	1804	610	775	1,675	91,640
		Aug. 1993	—	4.6-6.0	1,805	597	953	1,690	97,600

a. Mean of four samples.

Source: USBM, 1995.

Pine Creek

Of the more than 50 known adits associated with producing and nonproducing mines in the Pine Creek basin, at least 22 are known to drain to surface water resources water (Gearheart et al., 1999). Table 2-23 presents concentrations of the hazardous substances cadmium, lead, and zinc measured in draining adits, seeps, and springs in the Pine Creek basin. Dissolved metal concentrations measured in seep and adit discharge on the Pine Creek basin range from below detection to 423 µg cadmium/L, below detection to 2,560 µg lead/L, and below detection to 167,000 µg zinc/L.

Table 2-23
Concentrations of Dissolved Hazardous Substances
in Pine Creek Basin Adit, Seep, and Spring Discharge

Site	Type	Date	Flow (cfs)	pH	Cond. (µS/cm)	Hard. (mg/L)	Cd (µg/L)	Pb (µg/L)	Zn (µg/L)
Amy-Matchless	Adit	Jul. 1994[a]	—	7.2	520	247	<0.3	<1.0	90
		Nov. 1997[b]	0.001	—	—	270	0.5	0.1	349
		May 1998[b]	0.01	6.7	—	325	0.2	<0.5	192
Constitution	Adit	Jun. 1993[c]	—	—	—	31	ND	6.87	406
		Aug. 1993[c]	—	6.8	80	45	3.7	8.63	1,030
		Jul. 1994[a]	—	7.6	243	45	3.1	15.9	606
		Nov. 1997[b]	0.10	—	—	15	0.9	3.9	214
		May 1998[b]	0.06	7.1	—	9.6	<0.4	2.9	116
	Seep	Jul. 1994[a]	—	6.5	60	23	3.6	3.0	1,300
	Spring	Jul. 1994[a]	—	6.3	28	12	<0.3	67.9	111
Denver	Seep	Jul. 1994[a]	—	6.8	127	40	12.0	8.6	3,690
	Spring	Jun. 1993[c]	—	7.9	310	126	ND	ND	ND
		Aug. 1993[c]	—	7.6	260	126	ND	—	24
Highland Surprise	Adit	Jun. 1993[c]	—	7.5	510	—	9.0	11.1	5,790
		Aug. 1993[c]	—	7.5	380	219	ND	ND	2,650
		Jul. 1994[a]	—	7.6	379	193	2.9	4.2	1,690
		Nov. 1997[b]	0.04	—	—	197	0.83	0.17	1,250
		May 1998[b]	0.04	7.8	—	196	0.6	<0.1	2,010
	Seep	Jun. 1993[c]	—	7.5	150	49	ND	—	521
		Aug. 1993[c]	—	8.4	400	217	2.5	1.9	2,070
		Jul. 1994[a]	—	6.8	223	86	37.1	57	12,500
	Spring	Jun. 1993[c]	—	7.1	210	74	32.7	39.8	12,900
		Aug. 1993[c]	—	7.5	230	106	36.1	344	14,100
Hilarity	Adit	Jun. 1993[c]	—	7.4	360	157	6.9	4.89	5,290
		Aug. 1993[c]	—	8.0	430	215	—	—	—
	Seep	Jun. 1993[c]	—	—	—	79.4	21.2	104	8,910
		Aug. 1993[c]	—	6.2	130	57.2	12	7.3	5,130
	Spring	Jun. 1993[c]	—	7.3	40	10.9	ND	1.7	8.8
		Aug. 1993[c]	—	8.0	20	7.1	ND	ND	92.9

Table 2-23 (cont.)
Concentrations of Dissolved Hazardous Substances in Pine Creek Basin Adit, Seep, and Spring Discharge

Site	Type	Date	Flow (cfs)	pH	Cond. (µS/cm)	Hard. (mg/L)	Cd (µg/L)	Pb (µg/L)	Zn (µg/L)
Liberal King	Adit	Jul. 1994[a]	—	8.7	720	357	<0.3	<1.0	73
		Nov. 1997[b]	0.01	—	—	335	0.1	0.9	37
		May 1998[b]	0.002	8.0	—	319	0.1	<0.5	39
	Seep	Jul. 1994[a]	—	6.9	703	340	6.6	2.4	1,430
Little Pittsburg	Adit (upper)	Jun. 1993[c]	—	3.9	620	128	92.7	686	22,100
		Aug. 1993[c]	—	3.3	1,220	472	226	2,560	73,600
		May 1998[b]	0.0004	3.4	—	250	187	2,150	62,300
	Adit (lower)	Jun. 1993[c]	—	7.2	760	449	161	2.5	63,300
		Aug. 1993[c]	—	7.4	800	444	—	—	—
		Nov. 1997[b]	0.005	—	—	178	24.7	1.0	13,300
		May 1998[b]	0.007	6.7	—	271	107	0.4	63,600
	Seep	Jun. 1993[c]	—	7.7	40	11.4	ND	5.14	198
		Aug. 1993[c]	—	6.8	50	22.6	2.7	—	918
	Spring 1	Jun. 1993[c]	—	6.6	60	20.4	ND	1.5	777
		Aug. 1993[c]	—	7.3	110	49.5	8.1	ND	3,380
	Spring 2	Jun. 1993[c]	—	6.5	560	229	ND	11.7	1,010
		Aug. 1993[c]	—	6.3	390	188	—	—	1,030
Lookout Mountain	Adit	Jun. 1993[c]	—	7.8	470	176	ND	ND	39
		Aug. 1993[c]	—	7.2	345	180	ND	ND	61
		Nov. 1997[b]	0.03	—	—	182	1.4	0.4	57
		May 1998[b]	0.03	8.3	—	172	0.8	<0.8	39
	Seep	Jun. 1993[c]	—	8.0	230	80.8	ND	1.6	17
		Aug. 1993[c]	—	7.7	290	—	ND	ND	28.3
	Spring	Jun. 1993[c]	—	7.1	140	65.9	ND	ND	6.5
		Aug. 1993[c]	—	7.0	240	—	ND	ND	6.5
Lynch-Nabob	Adit	Nov. 1997[b]	0.001	—	—	128	30.5	640	11,100
Lynch-Pine	Adit	Jun. 1993[c]	—	4.8	210	105	67.9	1,020	15,200
		Aug. 1993[c]	—	6.0	340	149	61.8	822	16,300
Nabob	Adit	Jun. 1993[c]	—	7.7	840	433	14	ND	7,190
		Aug. 1993[c]	—	8.3	570	305	ND	1.5	683
		Jul. 1994[a]	—	8.8	541	298	5.6	119	3,530
		Nov. 1997[b]	0.07	—	—	597	7.4	0.1	10,100
		May 1998[b]	0.06	7.3	—	535	8.0	<0.2	8,310
Nevada-Stewart	Adit	Jun. 1993[c]	—	6.8	1,030	485	ND	5.73	10,100
		Aug. 1993[c]	—	6.9	930	653	1.0	1.4	9,950
		Nov. 1997[b]	0.11	—	—	508	0.44	0.31	10,700
		May 1998[b]	0.04	7.4	—	470	<0.5	<1.1	8,720
	Spring	Jun. 1993[c]	—	7.1	430	168	4.1	3.1	3,640
		Aug. 1993[c]	—	7.1	310	154	3.2	1.3	2,760

Table 2-23 (cont.)
Concentrations of Dissolved Hazardous Substances in Pine Creek Basin Adit, Seep, and Spring Discharge

Site	Type	Date	Flow (cfs)	pH	Cond. (µS/cm)	Hard. (mg/L)	Cd (µg/L)	Pb (µg/L)	Zn (µg/L)
Owl Prospect	Adit	Jun. 1993[c]	—	6.9	280	168	ND	9.63	470
		Aug. 1993[c]	—	7.0	250	129	ND	7.93	389
Sidney	Adit (Red Cloud)	Jun. 1993[c]	—	7.1	920	465	423	349	167,000
		Aug. 1993[c]	—	7.9	340	170	24.3	16.9	8,450
		Nov. 1997[b]	0.003	—	—	155	10.8	19.3	4,850
		May 1998[b]	0.01	7.1	—	224	135	20	<9
	Adit (Sidney)	Jun. 1993[c]	—	7.3	80	25	11.0	93.8	3,540
		Aug. 1993[c]	—	6.5	580	313	46.6	7.43	26,200
		Jul. 1994[a]	—	8.2	340	160	19.0	22.6	5,110
S F Fraction	Adit	Jun. 1993[c]	—	7.7	120	50.3	ND	7.9	14

a. CCJM, 1995.
b. CH2M Hill and URSGWC, 1998.
c. McNary et al., 1995.

ND: not detected.

2.5 SUMMARY

Information presented in this chapter confirms that hazardous substances have been and continue to be released from sources related to historical mining, milling, and smelting in the Coeur d'Alene River basin. The data presented in this chapter are not an exhaustive compilation of source areas and concentrations. Characterization of source areas and of the dynamics of releases is ongoing in the Coeur d'Alene River basin. However, the data presented in this chapter reflect the consistent finding that mining and mineral processing sources are the primary sources of hazardous substances to resources of the basin.

The types of materials containing elevated concentrations of hazardous substances (surface water, adit and seep drainage, tailings, soils, and sediments) and the location of materials that contain elevated concentrations (i.e., associated with or downgradient of mining operations) are consistent with the conclusion that wastes released from mining and mineral processing operations were the original sources of hazardous substance releases in the basin. The consistently elevated concentrations of hazardous substances in floodplain soils and sediments throughout the basin confirm that the floodplains, beds, and banks where hazardous substances have come to be located now are ongoing sources of hazardous substances.

In summary, the data presented in this chapter confirm that hazardous substances in wastes from mining and mineral processing operations are released from numerous source areas in the Coeur d'Alene River basin. The areas include adits, seeps, and waste rock and tailings dumps, contaminated upland soils that are eroded and remobilized by wind and water, and tailings and mixed tailings and alluvium that are distributed throughout the floodplains of the Coeur d'Alene River basin.

While sources such as certain adits, waste rock piles, and confined tailings dumps remain relatively discrete sources, tailings historically discharged to creeks, transported by surface waters, and deposited in floodplain, bed, or bank sediments have become intermixed and commingled. Tailings and mixed tailings and alluvium released from a single source have been differentially transported, mixed, deposited, and reworked by flooding and seasonal high water. As a result of the mobilization, remobilization, and mixing of releases from numerous sources, and sorting by energy and gravity in the transport by surface water pathways, tailings have lost the original geochemical identities or ratios of elements that might have characterized the waste upon release from the mill. Moreover, since many of the mills processed ores from numerous mines, even confined tailings dumps may not contain deposits of distinguishable source. Similarly, upland soils historically contaminated by smelter emissions, fugitive dust emissions, waste storage, or windblown tailings also become a part of the inextricably commingled waste released to the South Fork Coeur d'Alene River. Erosion and release to surface water have resulted in mixing and commingling with sediments and tailings from upstream sources.

Many of the adits that currently discharge water are draining the interconnected workings of numerous mines. Where one adit drains a series of interconnected mines, the source of metals contained in the drainage, or of the acid that leaches the ore remaining in the underground workings, cannot be traced. In such cases, the original source of much of the hazardous substances discharged in mine drainage cannot be apportioned among mines. Once mine drainage discharges to surface waters or infiltrates shallow groundwater, it becomes mixed with surface or groundwater. As with the mixing of tailings, discharges from numerous adits, seeps, and groundwater in contaminated floodplain deposits become mixed and inseparable in the surface water resource.

Releases from sources located throughout the basin are ongoing. Contaminated groundwater continues to be released from adits, seeps continue to discharge leachate from waste rock dumps and tailings deposits, and contaminated materials in the floodplains and uplands continue to be eroded and released to surface water. Tailings and mixed tailings in the floodplains, beds, and banks are continually reworked by natural processes, resuspended, and redeposited. During high flows, hazardous substances in floodplain, bed, and bank sediments are re-released to the surface water column, transported, and redeposited. Natural fluvial and hydraulic processes that would, absent the release of hazardous substances from mining and mineral processing operations, function to maintain the structure and function of the Coeur d'Alene River basin watershed and aquatic and riparian ecosystems, instead function as pathways of hazardous substance transport and re-release.

Ongoing releases of hazardous substances from point and diffuse sources occur throughout the basin. Releases occur at spatial and temporal scales ranging from periodic releases of hazardous substances by movements of large amounts of sediments during seasonal high water, to episodic small-scale erosive events, to steady discharge of metal leachate from adits. Releases occur from near the headwaters of the South Fork Coeur d'Alene River, including numerous tributaries, throughout the length of the South Fork and mainstem Coeur d'Alene river valleys, and in Coeur d'Alene Lake.

Finally, releases from the sources described are mobile in the environment. Releases from sources to pathway resources result in the transport of hazardous substances and the exposure of natural resource. Transport and exposure pathways are described in Chapter 3.

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