4.0 PHYSICAL SYSTEM AND MINING IMPACTS

Early mine development was clustered in areas where the mineral belts crossed through the canyons. The initial sources of metals contamination consisted of waste rock dumps adjacent to adits and groundwater drainage discharged from the adits. As mine production increased, ore was hauled to mills which were usually constructed near sources of water. The mills originally produced a mix of fine- and coarse-grained jig tailings. Later refinements in ore processing led to the generation of progressively finer-grained flotation tailings and progressively lower metal concentrations in the mine wastes.

The present day distribution of mining wastes reflects the past mining and milling practices. Large waste rock dumps, which are evident throughout the canyons, are a source of metal contamination. While early jig tailings can be observed mixed in with some of the waste rock dumps, the majority of the jig and flotation tailings were discharged into the stream system near the mills. Over time this material was mixed with the soils and sediment and transported downstream in the canyons, through the South Fork and the Coeur d'Alene River. The floodplains are now considered to be the major source of contamination in the basin. The finer-grained material continues to be transported all the way downstream into the lateral lakes area, Coeur d'Alene Lake and some even into the Spokane River.

Surface water transport has distributed mining wastes throughout much of the alluvium along the South Fork, its tributaries, lateral lakes area, Coeur d'Alene Lake, and the Spokane River. Floodplain contamination differs from the highly visible nature of waste rock piles dumped near the mines. The mining waste in the floodplain is present throughout much of the alluvium and floodplain sediments and extends under roads and towns constructed in the floodplains. This material represents a very large, dispersed source of metal contamination. The metal contamination tends to migrate in surface water and groundwater. Depending on the changing chemistry of the water, metals in the alluvium can be precipitated and/or re-dissolved. Very fine-grained and colloidal material continues to be transported down the Spokane River to the Columbia River.

This section does not attempt to summarize all aspects of the very complex physical system that exists in the basin today. Rather, it presents only the primary aspects that support the evaluation of the nature and extent and fate and transport of metal contamination. Summary information on groundwater, surface water, geology, ore deposits, mining, mine-waste generation, contaminant concentrations and mass loading are presented by watershed in Table 4-1.

4.1 GEOLOGY/GEOCHEMISTRY

The geology, geochemistry, ore deposits and mining practices are all interrelated in the generation and distribution of contamination. As shown in Part 1, Figure 3.2-3, the mineralization (mineral belts) in the mining district tends to cut across many of the canyons that are tributaries of the South and North Forks. The mineral belts trend west-northwest, roughly parallel the valley of the South Fork.

The rock in which veins occur in the basin is bedrock of the Belt Supergroup. It is comprised of six geologic formations. The formations are the Striped Peak, Wallace, St. Regis, Revett, Burke and Prichard.

The formations and their respective geochemistry play a major role in shaping the upper basin topography and acting as hosts for the ore deposits. The presence of carbonate and sulfide minerals in the formations were identified as two of the primary mechanisms that directly affect water chemistry and control the migration of metals. The carbonate and sulfide minerals are subject to natural weathering processes (oxidation and dissolution) which are exacerbated by mining and milling which fractures the host rock and exposes much greater surface areas to oxidation. Metal sulfide oxidation, primarily iron pyrite, creates acidic conditions (lowers pH) which in turn increases the solubility and dissolution of other sulfide minerals. This permits dissolved cadmium, iron, lead, zinc, and other heavy metals to contaminate surface and groundwater. Carbonates can act to increase pH, which tends to precipitate certain heavy metal compounds (secondary minerals). Depending upon pH and other conditions, waters can contain both dissolved and particulate metals. Particulate metals occur as metals adsorbed onto precipitated iron. Under pH conditions observed in surface water in the Basin, cadmium and zinc are in the dissolved phase, while lead has a higher fraction in the particulate phase.

Carbonate minerals, usually ferrous dolomite and less commonly calcite, may be found in all formations, but are common only in the Wallace formation and to a lesser extent in the St. Regis and Striped Peak formations (Hobbs et al. 1965). The presence of the primary minerals is summarized as follows:

- **Prichard Formation:** The sulfide content is typically higher in close proximity to ore deposits or large masses of igneous rocks (i.e. Gem Stock). The formation is comprised of argillite which has little carbonate material.

- **Burke Formation:** Carbonate-rich strata are locally present but constitute only about 1 percent of the total volume. Sulfides are not present in appreciable quantities unless in close proximity to ore deposits or igneous rocks.

- **Revett Formation:** Carbonate-bearing quartzites are locally present but do not constitute a significant percentage of the total volume of quartzite in the formation. Sulfides are not reported unless in close proximity to ore deposits or igneous rocks.

- **St. Regis Formation:** Sulfides are not reported in the St. Regis, unless in close proximity to ore deposits or igneous stocks. The upper portion of the formation contains some carbonate-bearing beds.

- **Wallace Formation:** There are by far more carbonate-bearing rocks in the Wallace than in the other formations of the Belt Supergroup. Both quartzite and argillite layers are frequently carbonate bearing. The carbonate mineral calcite is present, but probably the most abundant carbonate mineral is an iron-rich dolomite, which stands out because of the rusty red or brown stain on weathered surfaces (particularly quartzite). Sulfides are not reported in the Wallace Formation, unless in close proximity to ore deposits or igneous stocks (Hobbs et al. 1965).

- **Striped Peak Formation:** Sulfides are not reported in the Striped Peak Formation, unless in close proximity to ore deposits or igneous stocks (Hobbs et al. 1965). The basal portion of the formation lies within the mining district. It is reported to have some interbedded dolomite.

4.2 ORE DEPOSITS

Ore deposits in the district generally occur as steeply dipping veins in formations of the Belt Supergroup. Most of the veins range in width from a fraction of an inch to 10 feet, and occasionally up to 50 feet wide. In general, the type, grade and location of the deposits do not seem to be affected by depth (Hobbs and Fryklund 1968). Individual ore shoots (i.e., ore-bearing zones within the veins) range in length from a few tens of feet to more than 4,000 feet. Their dip length is usually several times the strike length, and generally they rake steeply in the plane of the vein (Hobbs and Fryklund 1968). Ore minerals are the components of an ore rock that are economically feasible to extract. The primary ore minerals are galena (lead sulfide [PbS]), sphalerite (zinc sulfide [ZnS]), and argentiferous tetrahedrite (an arsenic-antimony sulfide with varying proportions of copper, iron, zinc, and silver). The non-ore minerals associated with mineral deposits consist primarily of quartz (SiO_2) and siderite, an iron carbonate ($FeCO_3$).

There are three general types of vein deposits in the district (Bennett and Venkatakrishnan 1982):

- Deposits in the middle Prichard quartzites (zinc-lead orebodies on Pine Creek)

- Deposits in the Prichard-Burke transition zone (Ninemile Creek and Canyon Creek lead-zinc deposits)

- Deposits in the Revett-St. Regis transition zone (Bunker Hill Mine, Star-Morning Mine, Lucky Friday Mine, and the mines in the Silver Belt)

There is abundant evidence that zones (or halos) of carbonate, primarily disseminated siderite (i.e., iron carbonate), are present around many of the veins of the district. Weathering of these carbonate zones may produce more alkaline stream waters (and probably more alkaline groundwater), with relatively high amounts of iron and lesser amounts of calcium and magnesium. However, alkalinity from carbonate zoning may be buffered by acidic waters generated from sulfide-rich zones around many veins in the district.

Zones of disseminated galena, sphalerite, arsenopyrite, and pyrite are also found around many of the orebodies in the district (White 1998). The weathering of the disseminated sulfides around the veins could produce waters that contain elevated concentrations of metals, at least in areas where there is not sufficient dilution from nonmineralized rock (Stratus 1999).

Throughout the district, most of the ore is associated with quartzite layers in the Belt Supergroup rocks. The Revett quartzite accounts for approximately 75 percent of the ore production; 19 percent is from the quartzite at the Burke-Prichard transition zone; and all current production is from the Revett-St. Regis boundary (White 1998). Table 4-1 identifies the geologic formations and ore minerals that are present in the various canyons.

4.3 MINING PRACTICES

Early in the development of the district, the extracted vein material was hand-sorted to separate rock with no current economic value (waste rock) from ore containing lead and silver. The ore was further separated into ore that could be shipped directly to smelters and ore that would require concentration prior to shipment to the smelter. Mining activity by watershed is summarized in Table 4-1. As shown in the table, all the listed watersheds in the upper basin had producing mines. Recorded ore production figures indicate that the South Fork followed by Canyon Creek and the Upper South Fork were the highest producers. These three watersheds had the highest volume of tailings produced.

An estimated 54.5 to 70 million tons of tailings (see Section 1.0) were discharged to streams from the beginning of ore processing in 1884 until discharge of tailings to streams was discontinued in 1968. The tailings contained an estimated 880,000 tons of lead and more than 720,000 tons of zinc (Long 1998). Table 4.3-1 summarizes the quantities of mill tailings and metals disposed in various settings. In addition to tailings, mining activities generated a large quantity of waste rock. The waste rock was usually dumped near the mine adit. Railroad lines were also constructed using tailings and waste rock as ballast. On the order of 12 million cubic yards are present in CSM 1 and 2, excluding the BHSS. As mining and milling techniques improved, the character of the waste generated in the district changed. Table 4.3-2 briefly summarizes the history of milling and tailings disposal in the basin.

Discharge of metals-impacted water from adits is an ongoing source of metals contamination in the basin. Discharge from 110 adits has been documented within CSM Units 1 and 2, not including the BHSS (Gearheart et al. 1999). The Kellogg Tunnel, located within the BHSS, is the largest single adit source of metals. The discharge from the Kellogg Tunnel is treated for metals removal at the Central Treatment Plant prior to discharge to the South Fork.

When comparing mass loading data presented in Table 4-1, it is evident that ore production or tailings production may not be a good indicator of impacts to surface water. Canyon Creek has an estimated expected (average) dissolved zinc load of 714 pounds per day compared to 89.4 pounds per day in the Upper South Fork while the tailings volumes produced in the two watersheds were fairly comparable. Additional evaluation of individual sources in these watersheds will need to incorporate the position of the source material relative to the floodplain, type of source material present, milling method used and geochemistry of the rock. The metal contamination mixed in the floodplain sediments and alluvium makes a substantial contribution to metal loads downstream from mill sites.

4.4 GROUNDWATER

The character of groundwater flow in the unconfined aquifer system in the basin changes from the mountainous region of the basin down to Coeur d'Alene Lake and then the Spokane River.

Groundwater flow in the unconfined shallow aquifer system is considered an important pathway in the basin for contaminant migration in the South Fork and its tributaries. Fracture flow in bedrock contributes some recharge to the overlying unconfined aquifer system. However, the contribution of metal contamination from bedrock fractures or faults is expected to be localized to the intersection with mine workings. Currently, there is little information available on fracture flow and contaminant migration. The following discussion of groundwater in the basin focuses on the unconfined water-table aquifer system.

4.4.1 Tributaries to the North and South Forks

Unconfined aquifers in tributaries to the North and South Forks vary greatly in thickness and width. These factors are usually controlled by the depth to bedrock. The source of groundwater recharge to tributary aquifers is a combination of precipitation, snow melt, surface water and, in some cases, mine working discharge. In general, the grain size of aquifer material is coarse but extremely variable. Consequently, the hydraulic conductivity, or the ability of the aquifer to transmit water, is high. Calculated hydraulic conductivity in Canyon Creek ranged from 20 to 200 feet per day. A similar range of hydraulic conductivities is expected in the other tributary aquifers. In the lower portions of some canyons, such as Canyon Creek, two unconfined (or semi-confined) aquifers may be present (the alluvial aquifer and the bedrock aquifer). In such cases, the upper, or shallower aquifer, appears to be the most important for the transport of metal contamination.

Gradients in the tributary aquifers tend to be steep and similar to the topographic gradient. Given the high hydraulic conductivity and the cyclic nature of precipitation, the water table elevations are also highly variable. Subsurface materials that fall between the high and low water table elevations will be subject to cyclic wetting and drying. In sections of the canyons where floodplain source areas have been identified, there will be an increased leaching of metals into groundwater.

Groundwater in the canyons is very interactive with the surface water. Surface water and groundwater interaction is very dependent on the depth to bedrock and width of the floodplain. Many sections of the canyon streams investigated were either losing water to or gaining water from the underlying aquifer. This relationship was studied in detail by the USGS (Barton 2000). Their conclusions confirm that surface water tends to discharge to groundwater where the floodplain widens whereas when the floodplain narrows, groundwater discharges to surface water. Based on surface water mass loading data, this condition appears common in the tributaries. This is discussed further in Section 5.

At the mouth of some tributaries such as Canyon Creek or Ninemile Creek bedrock is very shallow. Where this condition is present, groundwater is forced upward and discharges into surface water. The volume of groundwater discharging to the South Fork is lowered along with the metal mass load. This is offset by an increase in volume and metal mass load in surface water which discharges to the South Fork.

4.4.2 North and South Forks

The North and South Fork valleys are underlain by what appears to be continuous and somewhat uniform two-aquifer system. Information on subsurface conditions in the valleys is limited. Very little information was available on subsurface conditions in the North Fork; however, the presence of alluvium over bedrock is observed in areas of the North Fork, similar to that observed and confirmed by soil borings in areas of the South Fork and its tributaries. As in the tributaries, the upper, or shallow, aquifer appears to be more important in the transport of metal contamination. Therefore, the following discussion focuses on the available information for the South Fork.

Overall the thickness of unconsolidated material overlying bedrock ranges from about 30 feet near Wallace to about 410 feet at Rose Lake. East of Wallace, there appears to be a single unconsolated aquifer present. In general, the water table in the upper aquifer is about 10 feet below the ground surface. As in tributary aquifers there is a zone of subsurface material that is subject to a wetting and drying cycle. Periods of highest recharge in the spring correspond to the shallowest water table conditions.

Groundwater gradients along the South Fork are lower than in the tributaries but transmissivities are high. In the BHSS the upper aquifer hydraulic conductivity ranged from 500 to 11,000 feet per day. The estimated groundwater flow in the upper unconsolated aquifer was about six cubic feet per second. Many sections of the stream system are losing water to or gaining water from the underlying aquifer. The USGS investigation (Barton 2000) documents these conditions in the Osborn Flats area. This condition is expected to occur along many sections of the South Fork.

The wide floodplain observed along many sections of the South Fork, coupled with the large estimated volume of mill tailings known to be mixed with the alluvium, presents a condition of continued metal loading to groundwater and surface water. Based on mass loading data and flow data, metals will continue to be transported by groundwater with a high degree of interaction with surface water. This is discussed further in Section 5.

Available information on groundwater and surface water interactions in the portion of the Spokane River from State Line, Idaho to Spokane, Washington, indicates that water is lost to the aquifer in the upper portion and water is gained by the river in the lower portion. Discharges are highly dependent on in-stream flow and regulation of the river by the Upriver and Post Falls dams.

4.4.3 Main Stem and Lower Coeur d'Alene River

There is little information on groundwater conditions in the Main Stem. It is assumed that conditions are similar to that described for the South Fork. Further west however the character of the aquifer transitions to fine-grained sediment. The aquifer is comprised of mostly silts and clays. Groundwater gradients are very low and groundwater flows slowly. Groundwater is a concern where it discharges to the river from contaminated bank and floodplain sediments. Groundwater will need to be considered in the lateral lakes area as a continuing source of metal contamination to the river.

4.4.4 Coeur d'Alene Lake and Spokane River

Both the Lower Coeur d'Alene River and aquifer system discharge to Coeur d'Alene Lake. Over most of its extent, Coeur d'Alene Lake is a regional groundwater discharge zone. However, at its northernmost end, the lake is a primary source of recharge into the Rathdrum Prairie aquifer.

A large number of hydrogeologic investigations and studies have occurred in the upper reaches of the river basin above Long Lake where extensive and highly productive glacial outwash aquifer system (the Spokane Valley/Rathdrum Prairie Aquifer) is present. This aquifer is the major source of drinking water for the cities of Spokane, Post Falls and Coeur d'Alene, and for residents within the Spokane Valley area.

Little information is available on metal transport in groundwater around the lake and along the upper portion of the Spokane river. However, groundwater is not expected to be a major pathway for metal migration in these areas.

4.5 SURFACE WATER AND SEDIMENT TRANSPORT

The physical processes of rain falling on soil, runoff from snowmelt or precipitation, channel bank and bed erosion, or mass movement incorporates sediment into streams of water. Water in streams transports, deposits, and sorts the delivered sediment based on the stream energy, discharge, and size and quantity of sediment. Sediment is generally incorporated and transported as suspended load (smaller particles that travel in the flowing water) or bedload (larger particles that travel along the bottom of the channel) during the high-flow stream discharges during spring and summer snowmelt. The quantity of the sediment transported typically increases as stream discharge increases, as does the particle size moved. Even during low-flow conditions, some sediment transport occurs as very fine particles that are kept in suspension by moving water.

The primary physical mechanism responsible for the transport of metal contamination in the basin is surface water flow coupled with sediment mobilization and transport. The CSMs encompass approximately 1,500 square miles with 810 miles of mapped stream channel in the Coeur d'Alene River basin. The drainage density ranges from approximately 0.4 to 1.0 mile per square mile. This density is relatively constant throughout the basin. Contaminated sediments transported in the Coeur d'Alene River basin are derived from bank erosion, channel migration, bed material remobilization, and sediments from debris deposits adjacent to stream channels. Summary information on surface water and sediment is presented in Tables 4-1 and 4.5-1.

In the upper Coeur d'Alene River tributaries (e.g., Canyon Creek), high gradients (slope) and often confined channels limited the capacity to store sediment; therefore, these areas produce occurs much of the sediment transported by the overall system. Some sediment storage occurs in areas in the upper basin where there were developed floodplains (i.e. Woodland Park) in contact with the stream channel.

In the South Fork, lower gradients allow for more sediment to be stored (e.g., Osburn flats) than in the tributaries. In areas where the channel has not been channelized or banks protected, the channels often displayed a meandering and braided channel form. These braided channels may deposit sediment in one area while incorporating sediment from another area. As with the tributaries, the quantity of sediment transported, as well as the particle size, increases at larger stream discharges but some sediment transport was found to occur at low discharges. Sediment sources in the South Fork are from bank erosion, channel migration, channel bed material remobilization, and sediment from the upper watersheds and tributary streams.

In the Lower Coeur d'Alene River, which consists of a broad floodplain with numerous lakes and wetlands adjacent to the channel, the gradient of the channel is very low. The many wetlands, lakes and broad floodplains in this section of the river provide abundant storage for storm water. These areas store water during large discharges and mute peak discharges at downstream locations. Due to the low gradient, this section of the river does not transport appreciable quantities of gravel; however, sand, silt, and clay-sized particles are transported. Storage of sediment occurs in the broad floodplain, wetland, and lakes adjacent to the channel. The quantity of sediment transported increases at higher discharges, with some sediment load transported at even lower discharges. Sediment sources in the Lower Coeur d'Alene River include bank erosion, channel bed remobilization and sediment from the upper watersheds, tributary channels, and the South Fork. Channel migration does not appear to be a significant source of sediment as the channel alignment has been relatively constant since development has limited channel migration. Prior to development, the channel did migrate.

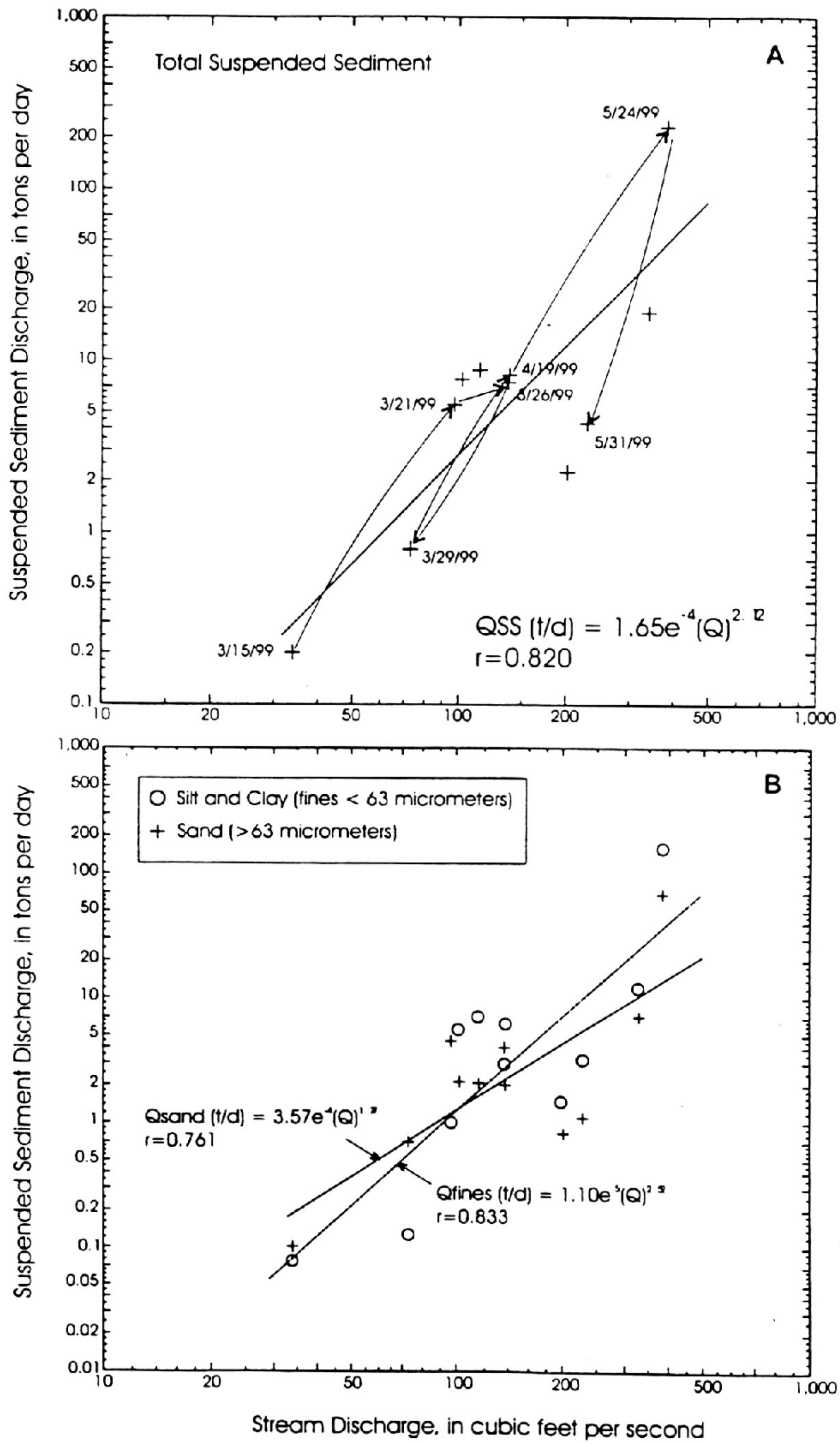
Little sediment is transported through Coeur d'Alene Lake except during high-flow events. The majority of sediment entering the lake is deposited as deltas at the mouth of each tributary. Most of the fine material carried in by the Coeur d'Alene River is deposited in the lake before the water exits via the Spokane River.

Free-flowing segments of the Spokane are noted for their lack of fine sediments and the river's "armored" gravel and cobble-dominated bed surface. Fine-grained, metals-laden sediments that may be deposited within the interstitial spaces of the tightly packed armored substrate of the riverbed throughout its shallow reaches are not readily accessible, nor are they believed to represent significant quantities potentially available for remedial considerations. Fine sediments do, though, locally accumulate in lower energy eddies along the shorelines, as bars and beaches within the braided segment of the river near Stateline, in backwater pockets, and in reservoirs created by the dams along the river. Upstream of Hangman Creek, a limited amount of sediment accumulates in the river channel because relatively little sustained fine-grained load is transported into, or is residing in the river. Below the confluence with Hangman Creek, substantial suspended sediment mass is introduced and fine-grained pronounced sediment accumulates behind down-river dams, particularly Long Lake.

The discharge of fine-grained particles is typically controlled by the available supply of such particles and the supply is often less than the stream can transport (Colby 1956). These fine-grained sediments move downstream with the same velocity as the water transporting them. In contrast to fine-grained sediments, the supply of coarse-grained sediments in streams is generally greater than the stream can transport. Thus, the discharge of coarse-grained sediments is typically controlled by the ability of the stream to transport them (Guy 1970). Bedload material may move only occasionally (e.g. during seasonal high flows or flood events) and is generally stable.

As mentioned above, increased stream discharge typically results in increased quantities of suspended sediment because of the increased energy available for sediment mobilization. Accordingly, varying quantities of sediment are transported depending on the stream discharge rate. To estimate the quantity of sediment transported at varying stream discharge rates, stream discharges verses sediment loads were plotted on log-log paper and a regression curve was fit to the data relating sediment load to stream discharge by Clark and Woods (2000). An example of such a sediment-rating curve is shown in Figure 4.5-1 for Canyon Creek above the mouth at Wallace. Figure 4.5-1 contains regression lines for the total sand-sized (>63 μm) and fine-sized (<63 μm) suspended sediments as a function of the discharge rate in cubic feet per second. Similar sediment rating curves were developed for a total of eight locations.

The sediment rating curves were used to estimate the suspended and bedload sediment loads transported (Table 4.5-1) under varying flow regimes for the seven locations for which data were available. The discharge rates selected represent the 10th and 90th percentiles and the estimated expected (average) discharges. The estimated expected discharges are those values calculated using statistical methods described in Part 1, Section 5.4.2, and in a separate technical memorandum developed in support of the RI/FS (URS 2001). The 10th and 90th percentile discharges were TMDL discharges when available. That is, the discharges of the 10th and 90th percentile were used as presented in the TMDL technical support document of August 2000 (USEPA). The findings of sediment erosion and stream transport are discussed further in Section 5.



Source: Clark and Woods 2000

EPA REGION 10

027-RI-CO-102Q
Coeur d'Alene Basin RI/FS
RI REPORT

Doc. Control:4162500.6615.05.a
Generation: 1

RI700
110200

Figure 4.5-1
Sediment Transport Curves for Total Suspended Sediment, Suspended Sediment and Clay, and Suspended Sand at Canyon Creek Above the Mouth at Wallace, Water Years 1999 and 2000

Table 4-1
Summary of Hydrology, Hydrogeology, Mine Production, Surface Water Concentrations, and Mass Loading

Watershed	Area (square miles)	Mapped Main Channel Length (miles)	Baseflow (cfs)	Annual Average Discharge (cfs)	Estimated Expected (Average) Discharge[b] (cfs)	Max. Mean Daily Discharge (cfs)	Identified Aquifers	Hydraulic Conductivity (ft/day)
North Fork and Tributaries								
Prichard Creek (PR14)	97.8	45	15 to 20	225	534 (cv = 2.88)	1,750	Bedrock; Shallow Alluvial	NA
Beaver Creek (all locations)	44.1	12	5 to 10	100	Not Available	790	Bedrock; Shallow Alluvial	NA
North Fork CdA River (NF50)	62	28	200 to 250	1,900	1,660 (cv = 1.68)	50,000	Bedrock; Shallow Alluvial	NA
South Fork and Tributaries								
Upper South Fork (SF228)	50	13.3	30 to 40	133	114.6 (cv = 1.32)	2,450	Shallow Alluvial	NA
Canyon Creek (CC287/288)	21.9	11.7	3 to 5	60	53.4 (cv = 1.15)	1,320	Bedrock; Shallow Alluvial	20 to 200
Ninemile Creek (NM305)	11.6	9.5	3 to 5	18.7	19.8 (cv = 1.31)	540	Bedrock; Shallow Alluvial	90 to 120
Big Creek (BC260)	29.9	12.8	5 to 10	88.6	Not Available	1,800	Bedrock; Shallow Alluvial	NA
Moon Creek (MC262)	9	3.8	1 to 2	9	13.2 (cv = 2.11)	56	Bedrock; Shallow Alluvial	NA
Pine Creek (PC305)	79.6	10.2	20 to 30	190	215 (cv = 2.94)	4,650	Bedrock; Shallow Alluvial	NA
South Fork CdA River (Pinehurst) (SF271)	97	18.9	90 to 100	540	533 (cv = 1.37)	9,000	Confined alluvial sediments (lower); unconfined alluvial sediments (upper)	500 to 11,000 (upper aquifer)
Coeur d'Alene River								
Coeur d'Alene River (Harrison) (LC60)	43.7	35.7	500	2,630	2,810 (cv = 1.42)	66,793	Bedrock; Shallow Alluvial	NA
Coeur d'Alene Lake								
Coeur d'Alene Lake (Post Falls) (SR50)	70	NA	1,400	6,270	7,530 (cv = 1.62)	NA	Rathdrum Prairie	NA
Spokane River								
Spokane River (Long Lake) (SR85)	34.7	110	NA	7,810	8,120 (cv = 0.845)	NA	Rathdrum Prairie	NA

Table 4-1 (Continued)
Summary of Hydrology, Hydrogeology, Mine Production Surface Water Concentrations, and Mass Loading

Watershed	Transmissivity (gpd/foot)	Number of BLM Source Areas	Number of Producing Mines	Number of Mills	Ore Produced (tons)	Tailings Produced (tons)	Prevalent Geologic Formations
North Fork and Tributaries							
Prichard Creek (PR14)	NA	58	9	10	636,000	497,000	Prichard
Beaver Creek (all locations)	NA	74	12	1	2,138,000	1,974,000	Prichard; Wallace; Burke; Revett
North Fork CdA River (NF50)	NA	3	0	0	0	0	Prichard; Burke; Revett; St. Regis; Wallace
South Fork and Tributaries							
Upper South Fork (SF288)	NA	229	11	6	24,464,000	19,911,000	St. Regis; Wallace
Canyon Creek (CC287/288)	1,900 to 13,000	125	21	12	34,800,000	27,436,000	Prichard; Burke
Ninemile Creek (NM305)	NA	70	8	7	4,960,000	4,060,000	St. Regis; Revett; Wallace
Big Creek (BC260)	NA	71	4	2	12,435,000	11,022,000	St. Regis; Revett; Wallace
Moon Creek (MC262)	NA	14	2	1	4,600	3,800	Prichard; Burke
Pine Creek (PC305)	NA	131	14	10	3,160,000	1,634,000	Prichard
South Fork CdA River (Pinehurst) (SF271)	NA	294	25	4	44,405,000 (upstream of Elizabeth Park); 47,839,000 (downstream of Elizabeth Park)	40,922,000 (upstream of Elizabeth Park)	Prichard; Burke; Revett; St. Regis
Coeur d'Alene River							
Coeur d'Alene River (Harrison) (LC60)	NA	0	0	0	0	0	NA
Coeur d'Alene Lake							
Coeur d'Alene Lake (Post Falls) (SR50)	NA	0	0	0	0	0	NA
Spokane River							
Spokane River (Long Lake) (SR85)	NA	0	0	0	0	0	NA

Table 4-1 (Continued)
Summary of Hydrology, Hydrogeology, Mine Production Surface Water Concentrations, and Mass Loading

Watershed	Principal Ore Minerals	Sulfide Minerals (%)	Carbonate Minerals (%)	Sediment Yield Water Year 1999 (tons)	Estimated Expected (Average) Dissolved Cadmium Concentration (µg/L)[b]
North Fork and Tributaries					
Prichard Creek (PR14)	Galena	Minimal	Minimal	NA	**0.42** (cv = 0.686)
Beaver Creek (all locations)	Galena (Ag,Pb); Sphalerite (Zn)	Pyrite; Pyrrhotite (3-5)	Siderite; ankerite (3-5)	NA	**3.7** (calculated average)
North Fork CdA River (NF50)	Minimal	Minimal	Minimal	25,400	NA
South Fork and Tributaries					
Upper South Fork (SF288)	Galene; sphalerite; tetrahedrite; chalcopyrite	Pyrite; Pyrrhotite (2-3)	Siderite; barite; calcite; magnetite (high relative to other watersheds)	2,400	**1.07** (cv = 0.455)
Canyon Creek (CC287/288)	Galena; sphalerite	Pyrite; galena	Siderite	1,358	**17.6** (cv = 1.05)
Ninemile Creek (NM305)	Galena; sphalerite	Pyrite (3-5)	Minimal	397	**22** (cv = 0.48)
Big Creek (BC260)	Galena; tetrahedrite; sphalerite; chalcopyrite	Arseno-pyrite; pyrite	Ankerite; siderite	1,443	**1** (max. detected)
Moon Creek (MC262)	Galena; sphalerite	Pyrite; Pyrrhotite	?	NA	**0.68** (cv = 0.33)
Pine Creek (PC305)	Galena; sphalerite	Pyrite	Ankerite	2,923	**0.538** (cv = 2.68)
South Fork CdA River (Pinehurst) (SF271)	Galena; siderite	Pyrite	?	21,930	**9.08** (cv = 0.629)
Coeur d'Alene River					
Coeur d'Alene River (Harrison) (LC60)	NA	NA	NA	50,150	**1.92** (cv = 0.371)
Coeur d'Alene Lake					
Coeur d'Alene Lake (Post Falls) (SR50)	NA	NA	NA	NA	NA
Spokane River					
Spokane River (Long Lake) (SR85)	NA	NA	NA	NA	NA

Table 4-1 (Continued)
Summary of Hydrology, Hydrogeology, Mine Production Surface Water Concentrations, and Mass Loading

Watershed	Estimated Expected (Average) Total Lead Concentration (µg/L)[b]	Estimated Expected (Average) Dissolved Zinc Concentration (µg/L)[b]	Estimated Expected (Average) Dissolved Cadmium Mass Loading (lbs/day)[b]	Estimated Expected (Average) Total Lead Mass Loading (lbs/day)[b]	Estimated Expected (Average) Dissolved Zinc Mass Loading (lbs/day)[b]
North Fork and Tributaries					
Prichard Creek (PR14)	3.54 (cv = 2.02)	31.2(cv = 0.30)	0.874 (cv = 2.34)	42.7 (cv = 28.9)	83.6 (cv = 2.8)
Beaver Creek (all locations)	3.4 (calculated average)	**621** (calculated average)	Not Available	< 1 (measured)	24 (measured)
North Fork CdA River (NF50)	2.13 (cv = 2.1)	10.1 (cv = 0.94)	Not Available	**98** (cv = 11.6)	239 (cv = 3.11)
South Fork and Tributaries					
Upper South Fork (SF288)	9.21 (cv = 0.902)	**188** (cv = 0.741)	0.504 (cv = 1.05)	**8.22** (cv = 3.9)	**89.4** (cv = 1.23)
Canyon Creek (CC287/288)	**194** (cv = 1.72)	**2420** (cv = 1.09)	**5.6** (cv = 0.75)	**292** (cv = 8.89)	**714** (cv = 0.84)
Ninemile Creek (NM305)	**92.1** (cv = 0.802)	**3410** (cv = 0.47)	**1.6** (cv = 0.86)	**13.1** (cv = 2.63)	**276** (cv = 0.92)
Big Creek (BC260)	**28** (max. detected)	6.9 (max. detected)	Not detected to 0.03	1.7 to 91.1 (measured)	0.9 to 4.7 (measured)
Moon Creek (MC262)	3.7 (cv = 1.2)	**121** (cv = 0.39)	0.047 (cv = 2.24)	0.42 (cv = 6.00)	9.9 (cv = 3.06)
Pine Creek (PC305)	4.56 (cv = 1.3)	**112** (cv = 0.45)	**5.4** (cv = 96.4)	**12.3** (cv = 19.9)	**90.2** (cv = 2.93)
South Fork CdA River (Pinehurst) (SF271)	**55.7** (cv = 1.34)	**1,430** (cv = 0.633)	**20.9** (cv = 0.873)	**369** (cv = 5.53)	**2,920** (cv = 0.644)
Coeur d'Alene River					
Coeur d'Alene River (Harrison) (LC60)	**51.6** (cv = 1.08)	**344** (cv = 0.475)	**29** (cv = 1.39)	**1,510** (cv = 4.11)	**4190** (cv = 1.02)
Coeur d'Alene Lake					
Coeur d'Alene Lake (Post Falls) (SR50)	2.12 (cv = 0.865)	**57.6** (cv = 0.476)	NA	156 (cv = 3.86)	3,640 (cv = 3.67)
Spokane River					
Spokane River (Long Lake) (SR85)	1.45 (cv = 0.498)	**27.3** (cv = 1.74)	NA	110 (cv = 0.99)	2210 (cv = 3.12)

[a]Estimated expected value (average discharge) is a calculated value based on a regression line fit to the data while the average annual discharge is based on the period of record and taking an average.

Table 4-1 (Continued)
Summary of Hydrology, Hydrogeology, Mine Production Surface Water Concentrations, and Mass Loading

[b]Estimated expected values for discharge, concentration and mass loading are for the following sampling locations: PR14, NF50, SF228, CC287/288, NM305, BC260, MC262, PC305, SF271, LC60, SR50, and SR85.

Notes:
Information summarized in this table was previously presented in Parts 1 through 6.
cv - coefficient of variation. The coefficient of variation is a measure of the variability (or uncertainty) of an estimated value. The greater the coefficient of variability, the greater the uncertainty of the estimated value.
NA - not available
Bold - Indicates screening level or TMDL exceedances.
cfs - cubic feet per second
µg/L - microgram per liter
lbs/day - pound per day

Table 4.3-1
Preliminary Estimate of Mill Tailings Produced in the Coeur d'Alene Mining District

Disposal Method[a]	Dates	Tailings (ton)	Metals Contained in Tailings (ton)		
			Silver	Lead	Zinc
To creeks	1884-1967	70,000,000	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)

Table 4.3-2
History of Tailings Disposal Practices in the Coeur d'Alene Basin

Date	Milestone
1886	Processing of ore initiated using jigging.
1891	Six mills operating, with a total capacity of 2,000 tons per day
1901-1904	Construction of plank dams on Canyon Creek near Woodland Park and on the South Fork near Osburn and Pinehurst to control tailings movement. Large volumes of tailings accumulate behind the dams.
1905	Jig tailings from the Morning mill contained about 8% lead and 7% zinc.
1900-1915	Recovery of zinc initiated during this period. Previously, zinc was not recovered, and mills primarily processed low-zinc ores.
1906	Total milling capacity in the basin was 7,000 tons per day
1910	Flotation introduced in the basin at the Morning mill. Increased metals recoveries were achieved using flotation. Flotation tailings were finer grained than jig tailings and were transported greater distances by streams.
1917	Plank dams at Woodland Park and Osburn breached by flood waters.
1918	Flotation had been adopted at most mills by this time.
mid-1920s	Tailings observed in Spokane River.
1925	Flotation tailings from the Morning mill contain <1% each of lead and zinc.
1926-1928	Bunker Hill mills begin placing tailings at Page Pond and the present-day location of the Central Impoundment Area.
1932	Dredging operations initiated in Lower Coeur d'Alene below Cataldo. Dredging continued until 1967. Dredge spoils were placed at Mission Flats.
1933	Plank dam near Pinehurst breached by flood waters.
1940-1942	Addition of 12 new mills with a combined capacity of 2,000 tons per day. Total milling capacity in the basin was 12,000 tons per day.
1940s	Reprocessing of a portion of the tailings that had accumulated behind the Osburn and Woodland Park plank dams.
Late 1950s	Reuse of tailings as stope fill initiated.
1960s	Start of I-90 construction. Tailings from Mission Flats and Bunker Hill tailings pond used in embankment construction.
1968 to present	All tailings impounded or used as stope fill.

Table 4.5-1
Estimated Sediment Loads at the Estimated 10th and 90th Percentile Discharges and Estimated Expected (Average) Discharge

Sampling Location	Discharge (cfs)	Suspended Sand Discharge (tons/day)	Suspended Fines (<63 µm) Discharge (tons/day)	Total Suspended Sediment Discharge (tons/day)	Total Bedload Sediment Discharge (tons/day)
Canyon Creek (Above Mouth Near Wallace)					
10th Percentile	11	0.0249	0.00463	0.0266	0.000273
Estimated Expected Discharge	53	0.402	0.244	1	0.0163
90th Percentile	149	2.51	3.29	6.68	0.240
Ninemile Creek (Above Mouth Near Wallace)					
10th Percentile	3	0.000293	0.0000591	0.000284	0.00000463
Estimated Expected Discharge	19.8	0.0812	0.0445	0.119	0.00984
90th Percentile	41	0.710	0.572	1.22	0.189
South Fork (at Silverton)					
10th Percentile	48	0.00952	0.0966	0.139	0.00623
Estimated Expected Discharge	230	0.841	2.64	4.38	0.29
90th Percentile	649	16.3	23.5	42.9	3.68
Pine Creek (Below Amy Gulch Near Pinehurst)					
10th Percentile	29	0.0000994	0.0000232	0.000113	0.00227
Estimated Expected Discharge	215	0.129	0.0806	0.228	0.772
90th Percentile	387	1.06	0.882	2.13	4.27
South Fork (Near Pinehurst)					
10th Percentile	97	0.0568	0.0489	0.0891	0.0114
Estimated Expected Discharge	533	4.61	4.25	7.60	1.14
90th Percentile	1290	45.1	43.1	76.4	12.3
North Fork (at Enaville)					
10th Percentile	253	0.000771	0.000924	0.00154	0.0000411
Estimated Expected Discharge	1660	0.579	1.15	1.71	0.0954
90th Percentile	5090	29.9	80.6	111	9.65
Coeur d'Alene River (Near Harrison)					
10th Percentile	348	0.000111	0.314	0.112	--
Estimated Expected Discharge	2810	1.00	55.7	35	--
90th Percentile	6870	49.5	511	410	--

Note: cfs - cubic feet per second