MINE SITE VISIT:

COPPER RANGE COMPANY
WHITE PINE MINE

U.S. Environmental Protection Agency
Office of Solid Waste
401 M Street SW
Washington, DC 20460

4.0 MINE SITE VISIT: COOPER RANGE COMPANY WHITE PINE MINE

4.1 INTRODUCTION

4.1.1 Background

The Environmental Protection Agency (EPA) has initiated several information gathering activities to characterize mining wastes and management practices. As part of these ongoing efforts, EPA is gathering data by conducting visits to mine sites to study waste generation and management practices. As one of several site visits, EPA visited Copper Range Company's White Pine mine in White Pine, Michigan, on May 5 and 6, 1992.

Sites to be visited were selected to represent both an array of mining industry sectors and different regional geographies. All site visits have been conducted pursuant to RCRA Sections 3001 and 3007 information collection authorities. When sites have been on Federal land, EPA has invited representatives of the land management agencies (Forest Service/Bureau of Land Management). State agency representatives and EPA regional personnel have also been invited to participate in each site visit.

For each site, EPA has collected information using a three-step approach: (1) contacting the facility by telephone to get initial information, (2) contacting state regulatory agencies by telephone to get further information, and (3) conducting the actual site visit. Information collected prior to the site visit is then reviewed and confirmed at the site.

The site visit reports describe mining operations, mine waste and material generation and management practices, and regulatory status on a site-specific basis and are based on information gathered from State and Federal agency files, as well as observations made during the site visit. This report focuses on extraction and beneficiation activities at the site and includes only a limited discussion of mineral processing at White Pine. In preparing this report, EPA collected information from a variety of sources, including the Copper Range Company, the Michigan Department of Natural Resources, and other published sources. The following individuals participated in the Copper Range Company site visit on May 5 and 6, 1992:

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4.1.2 General Facility Description

Copper Range Company's White Pine mine is located near White Pine (approximate population 1,200) in Ontonagon County, Michigan, on the Upper Michigan Peninsula. The company's mill and smelter are six miles south of Lake Superior. The facility's tailings impoundments extend north from the mill toward Lake Superior, with the downstream end of one impoundment located 2.5 miles from the lake.

The surface area owned by the Copper Range Company covers approximately 64,000 acres; surface facilities cover approximately 360 acres. The underground mine covers an area of about 25 square miles and extends from the surface to a maximum depth of 2,700 feet. Basic facility operations include underground mining, underground primary crushing, above-ground secondary and tertiary crushing, grinding in rod and ball mills, flotation, filtering, drying, smelting, and electrolytic refining.

The Nonesuch formation, which contains the White Pine ore body, was discovered in 1865 and first mined from 1879 to 1881. More development by the owner, Calumet & Hecla, led to additional mining (operating from 1913 to 1920) and establishment of the White Pine townsite. A drop in copper prices closed the mine in 1920 and led to Copper Range Company's purchase of the property in 1929 at a sheriff's sale (Copper Range Co. Undated).

Several years of testing proved that the previously "worthless" chalcocite, by-passed earlier in favor of native copper, could be mined and milled at a profit. With a $63 million loan from the Reconstruction Finance Corporation, construction of the new "White Pine" project began in March 1952, with the first ore mined a year later. The first copper product was generated in January 1955. In 1977, Copper Range Company was purchased by the Louisiana Land and Exploration Company. The new facility owners built a state-of-the-art refinery, costing $78 million. Construction of the new refinery was completed in 1981 (Copper Range Co. Undated).

Adverse economic conditions in the copper industry led to the gradual shutdown of the White Pine operation; the mine, mill, and most of the smelter closed in 1982. However, the company continued smelter operations to produce copper from scrap material until 1984, when the facility completely shut down (Copper Range Co. Undated).

In 1983, three officers of Copper Range Company began negotiating with Louisiana Land on the possible purchase of the White Pine mine. Echo Bay Mines, Ltd., purchased the White Pine operation in January 1985 and negotiations continued with Echo Bay. The three officers were successful and went on to form the new "Copper Range Company." Operations at the new White Pine began in November 1985 (Copper Range Co. Undated).

In May 1989, Copper Range Company was purchased by Metall Mining Corporation, a Canadian-based international mining company with interests in copper, zinc, lead, gold, and silver (Copper Range Co. Undated). As of January 1, 1992, 88 percent of the mine was owned by Metall and 12 percent by White Pine employees through their Employee Stock Ownership Plan. According to the conditions of the Plan, White Pine employees will eventually hold a maximum of 20 percent ownership of the mine (Skillings' Mining Review 1992).

The high employment mark of 3,140 people at the mine was reached in 1974. Employment at the facility in 1991 was 1,110 and, at the time of the EPA site visit, 1,070 employees worked at the facility (600 of whom work underground). The facility operates 24 hours per day, 7 days per week. Primary mining activities are conducted on all shifts, blasting occurs between shifts, and most support activities are conducted during the day shift.

Between 1955 and 1988, a total of 3.3 billion pounds of copper was produced at the White Pine property. Approximately 46,000 tons of cathode copper and one million ounces of silver were produced in 1989. According to Copper Range Company personnel, a 1988 study found that the mine had approximately 40 years of ore reserves remaining. This estimate, however, is highly dependent on copper prices.

4.1.3 Environmental Setting

Figure 4-1. Location of Copper Range Company's White Pine Mine

(Source: Copper Range Co. Undated)

The Town of White Pine (approximate population 1,200) is located one mile from the mine site. White Pine is about 860 feet above sea level and 260 feet above Lake Superior. Land use in the immediate area is generally limited to mining and residential activity. The location of Copper Range Company's White Pine mine is shown in Figure 4-1 (Copper Range Co. Undated).

According to Copper Range Company personnel, no rare or endangered species are found at the site, although eagles have been spotted flying over the facility. Copper Range Company personnel noted that Peregrine Falcons were reintroduced to the area nine miles south of White Pine. Previously, the State successfully reintroduced Canada Geese on Copper Range Company land, with the involvement of Copper Range Company personnel, equipment, and funds.

The White Pine area experiences a continental to semi-maritime climate, largely dominated by the passage of weather systems from west to east and the modifying influence of Lake Superior. The stabilizing effects of the Lake on air temperatures and prevailing winds provide for cold winters, cool summers, and consistently high humidity throughout the year. The mean annual temperature for White Pine, Michigan, is approximately 40

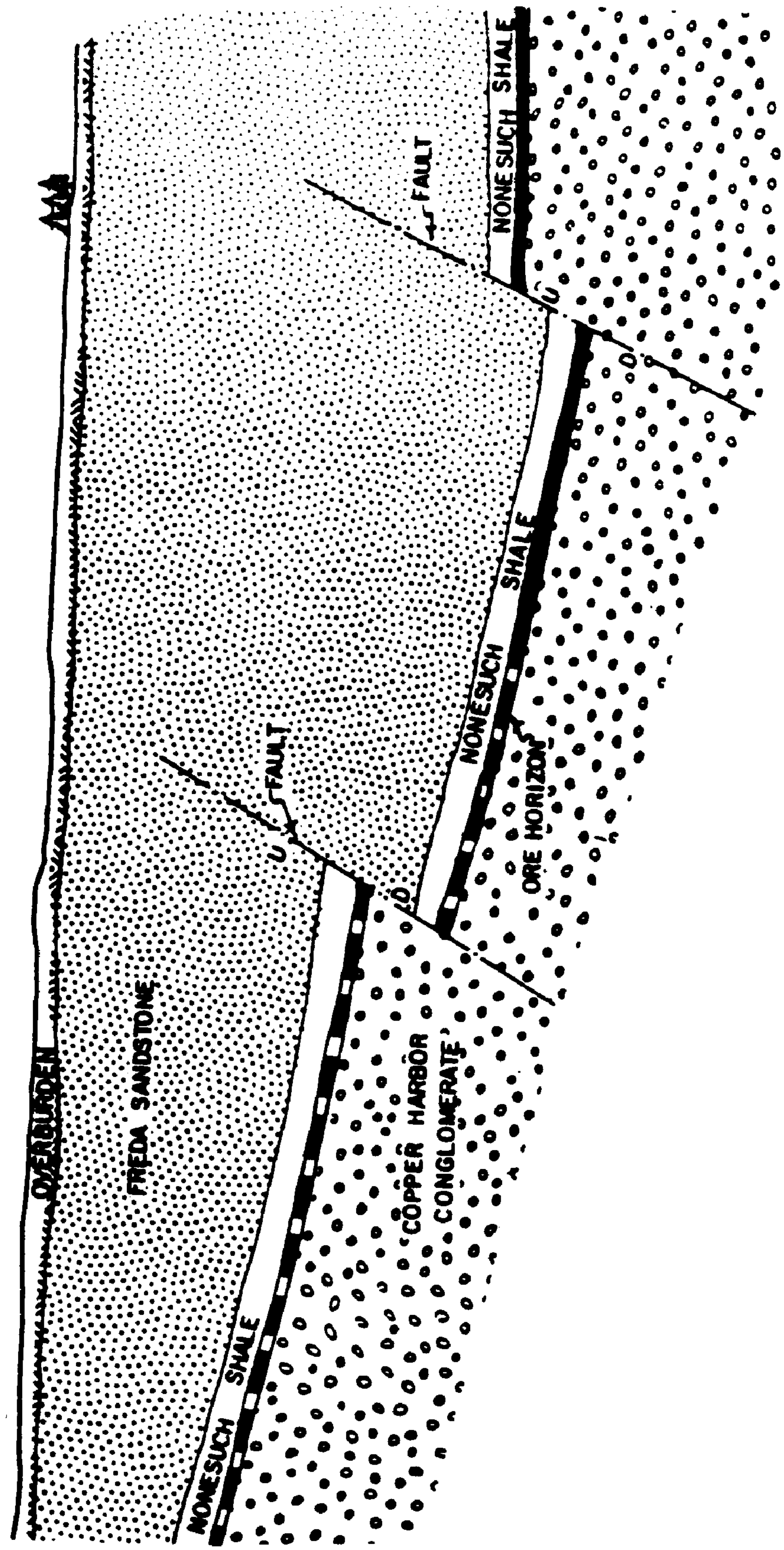
low 80's in the summer. Precipitation is well distributed throughout the year with the non-snow season (May-October) receiving an average of 18.43 inches (58 percent of the annual total rainfall of 32 inches). The annual snowfall at White Pine is 177 inches. The White Pine area averages 142 days with one inch or more of snow on the ground. Peak snow depth occurs in February and March (Copper Range Co. 1978).

4.1.3.1 Geology

Except as otherwise noted, the following geological information is excerpted from an *Environmental Assessment of the Operations of the White Pine Copper Division, Copper Range Company* (Copper Range Co. 1978). The copper deposit at the White Pine mine in Ontonagon County, Michigan, is the largest known copper-shale deposit in the United States. It lies within a belt of copper mineralization extending from Mellen, Wisconsin, to the eastern-most edge of the Keweenaw Peninsula, a distance of more than 100 miles. Ontonagon County is underlain by the Middle and Upper Keweenawan rock sequences. All the deposits in the Keweenaw sequences are of Late Precambrian time.

The Middle Keweenawan sequence is comprised of three parts: 1) the lower part, a thin series of interbedded sandstones, shales, and marls; 2) the middle part, composed of volcanic rocks with thin interbedded clastic sediments having a total thickness greater than 30,000 feet; and 3) the upper part (known as the Portage Lake Lava Series), composed of permeable lava flows and conglomerates with a thickness of approximately 20,000 feet.

The Upper Keweenawan sequence overlies the Portage Lake Lava Series. The Upper Keweenawan is divided into three major formations, the Freda Sandstone Formation, the Nonesuch Shale Formation, and the Copper Harbor Conglomerate (See Figure 4-2).


NONESUCH SHALE
FAULT
U
D
NONESUCH SHALE
FAULT
U
D
ORE HORIZON
OVERBURDEN
FREDA SANDSTONE
COPPER HARBOR CONGLOMERATE
NONESUCH SHALE

The Copper Harbor Conglomerate Formation overlies the Portage Lake Lava Series and ranges in thickness from approximately 350 feet in areas south of the White Pine mine to 6,000 feet near the shore of Lake Superior. It contains primarily reddish-brown to grayish-brown, fine- to coarse-grained conglomerate and reddish-brown siltstone, commonly cross-bedded with sandstone. Locally, flows of mafic lava up to several hundred feet thick are interbedded with the clastics.

The Nonesuch Shale and Freda Sandstone Formations overlie the Copper Harbor Conglomerate. In the vicinity of the White Pine mine, the Nonesuch Shale Formation is approximately 600 feet thick and composed of laminated gray to brownish-gray siltstone with minor shale and sandstone and reddish-brown partings. Gray to dark gray siltstone dominates the lower 100 feet, while massive light-gray siltstone to very fine-grained sandstone becomes abundant in the lower-middle and uppermost sections of the formation.

The Freda Sandstone Formation is the upper-most unit of the Keweenawan sequence. The formation is composed of fine arkosic sandstones alternating with red micaceous silty shale. Shale pebble conglomerate horizons occur frequently in the Freda. A conglomerate composed of Huronian iron formation, basalt, and quartzite pebbles, varying from 15 to 150 feet in thickness, occurs in many places as a distinctive horizon several hundred feet up from the base of the formation. Micro-cross-laminations of the fine-grained parts of the formation are a distinctive feature of the Freda. Ripple marks, mud cracks, rain imprints, rill marks, micro-cross-bedding, and angular shale pebble conglomerates attest to shallow water deposition and repeated interruption of sedimentation and exposure to subaerial erosion (Hamblin 1961).

Copper deposits mined at Copper Range Company's White Pine mine are located in the lowermost 18 to 22 feet of the Nonesuch Shale Formation and the uppermost 10 feet of the Copper Harbor Conglomerate Formation. These copper deposits have been locally subdivided into four sections: the Lower Sandstone, the Parting Shale, the Upper Sandstone, and the Upper Shale.

The primary minerals within the White Pine ore body are native copper (Cu), native silver (Ag), and chalcocite (Cu_2S), with minor amounts of bornite (Cu_5FeS_4), chalcopyrite ($CuFeS_2$), and pyrite (FeS_2) also occurring. Native Copper (Cu) is locally abundant primarily in the Lower Sandstone and Parting Shale units and constitutes between 7 and 9 percent of the copper processed at White Pine. It is generally associated with chalcocite as individual grains, but does occur separately in some laminae. It may be as thin as 0.2 millimeter (mm) in sheets 2 to 3 feet long. Native silver (Ag) occurs sporadically and is often associated with native copper. It is either in the form of individual grains, which may be associated with chalcocite only, or in the form of rims on sheets or grains of native copper. Other sulfide minerals including covellite (CuS), greenockite (CdS), sphalerite (ZnS), and galena (PbS) have also been identified at White Pine. A host of other trace elements are also present in the ore body.

Approximately 80 percent of the copper processed at White Pine is chalcocite. Chalcocite is often concentrated in dark-gray laminate shales, occurring most often as finely disseminated grains averaging 2 to 20 microns in diameter in siltstone and 1 mm in diameter shale in sandstone. It also occurs infrequently as 2 and 5 mm oblate ellipsoids in these areas.

4.1.3.2 Hydrology

The following discussion of hydrology in the area of Copper Range Company's White Pine mine is divided into separate Surface Water and Ground Water Sections.

Surface Water

Surface waterbodies associated with Copper Range Company's White Pine mine include Perch Creek, Mineral River, and Lake Superior. Perch Creek receives discharged effluent from the White Pine tailings impoundment system at the facility's NPDES outfall (see Figure 4-3)

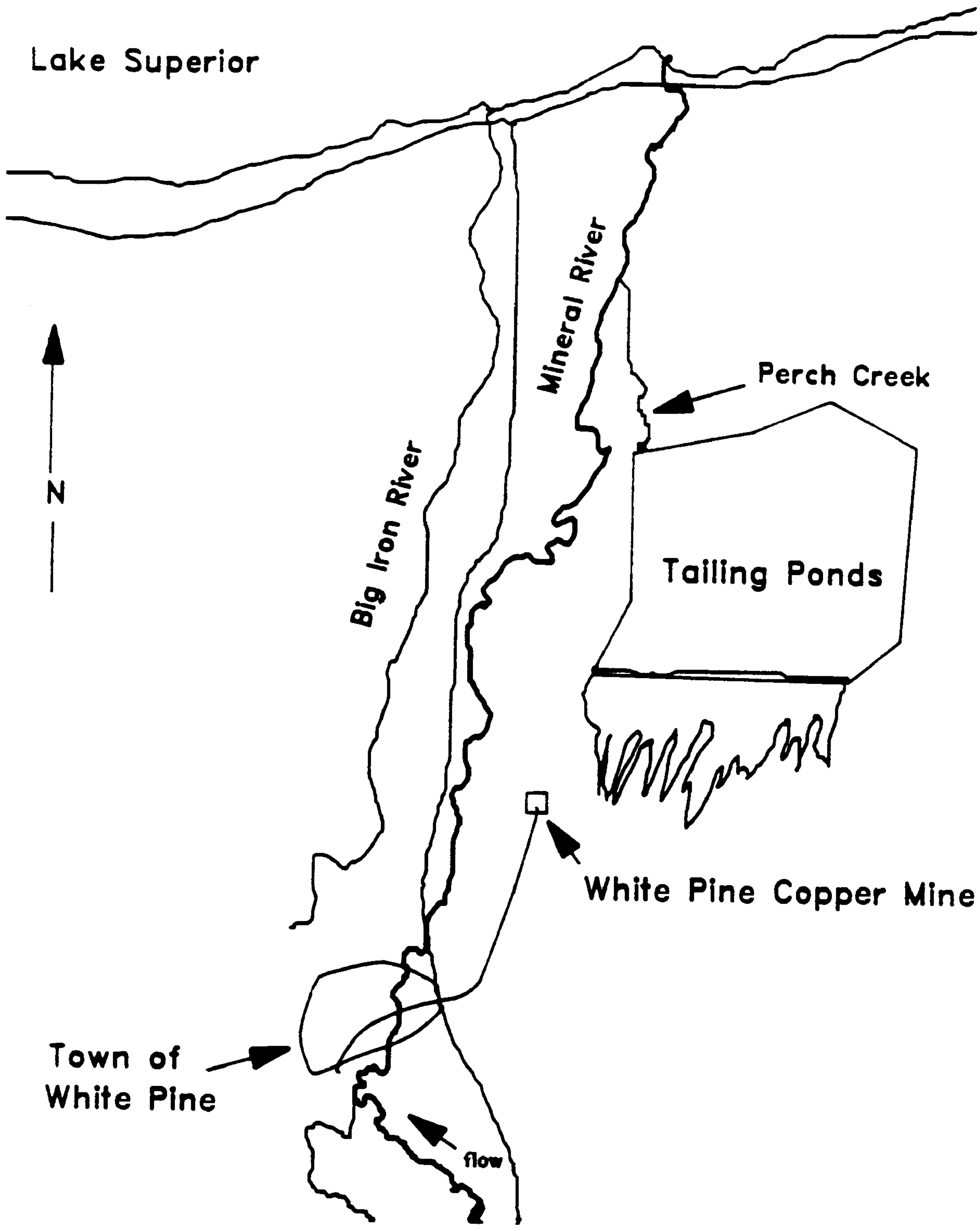


Figure 4-3. Surface Water in the White Pine Area

(Source: MDNR 1989)

. According to Copper Range Company personnel, Perch Creek flow is made up primarily of tailings impoundment effluent. The average flow in Perch Creek is approximately 25 million gallons per day (MGD).

Perch Creek flows north towards Lake Superior and discharges into the Mineral River at a point referred to as the Perch Creek confluence (see Figure 4-3). The Mineral River flows on bedrock and unconsolidated sediment in the vicinity of the White Pine mine, comprised mainly of shale slabs, boulder, and rubble, covered with red clay. The Mineral River flows north and discharges into Lake Superior (MDNR 1989).

The Mineral River experiences low-flow conditions in summer and winter upstream of the Perch Creek confluence. During these times, flow in the Mineral River downstream of the Perch Creek confluence is primarily tailings impoundment effluent from the White Pine mine. Elevated total dissolved solids (TDS) and chlorides are found in the Mineral River below the Perch Creek confluence due to calcium, magnesium, and sodium imparted by Perch Creek into the River (MDNR 1989).

Ground Water

According to the Michigan Department of Natural Resources (MDNR), ground water supplies are not abundant on the Upper Michigan Peninsula. The quantity and quality of water vary from one area to another. Wells yielding large supplies (several hundred gallons per minute or more) are rarely found on the peninsula. In some areas of the peninsula, it is almost impossible to obtain even the small supply needed for domestic use (MDNR 1969).

Glacial material is not considered a reliable source of water over much of Ontonagon County. Approximately 60 percent of the wells in the County are drilled into bedrock. Drilling into bedrock, however, does not ensure a satisfactory supply; according to MDNR, inadequate supplies or saline water are common problems. Ground water generally occurs in fractures with yield depending on the number and size of fractures penetrated. The first 50 feet of bedrock typically yield a moderate supply. At greater depths, open fractures are rare, and yields are smaller and have an increasing chance of contacting saline water (MDNR 1969).

Freda Sandstones and Nonesuch Shale underlie the glacial drift in most of the northern third of Ontonagon County. The sandstone beds yield fresh water to many shallow wells, but the deeper sandstone wells generally yield water too high in chlorides for domestic use. Near Lake Superior, most bedrock wells more than 75 feet deep yield saline water; farther south, most wells less than 150 feet deep yield fresh water. Many of the wells yield water containing iron. Most wells yield enough water for a domestic water supply, but in some instances drilling more than one well is necessary to obtain a satisfactory supply (MDNR 1969).

The Freda Sandstone formation is classified as a Class II aquifer by the U.S. EPA. This classification designates the aquifer as a current and potential source of drinking water and as having other beneficial uses. According to Copper Range Company personnel, the depth from the surface to the Freda Sandstone formation aquifer at the White Pine mine site ranges from less than 20 feet to 75 feet. The thickness of the aquifer ranges between 6 and 25 feet. The principle use of the aquifer is as a source of private drinking water. Although there are no drinking water wells on the Copper Range Company property, both drinking water and public water system wells are located within 1/4-mile of the site.

4.2 FACILITY OPERATIONS

4.2.1 Mining Operations

Mining at the Copper Range Company White Pine facility is conducted underground using standard room-and-pillar extraction techniques. The underground mine currently covers 25 square miles (5 miles by 5 miles). The mine extends down from the portal at the plant site to active mining at depths ranging from 1,500 - 2,700 feet. At the time of the site visit, mining occurred in two general areas of the mine (the Northeast and Southwest Areas). Within these areas, mining is performed in discrete sections; active sections in the Northeast Area include sections 21, 22, 23, 24, 25, 31, and 32, while active sections in the Southwest Area include 91, 93, 96, 97, and 99 (see Figure 4-4)

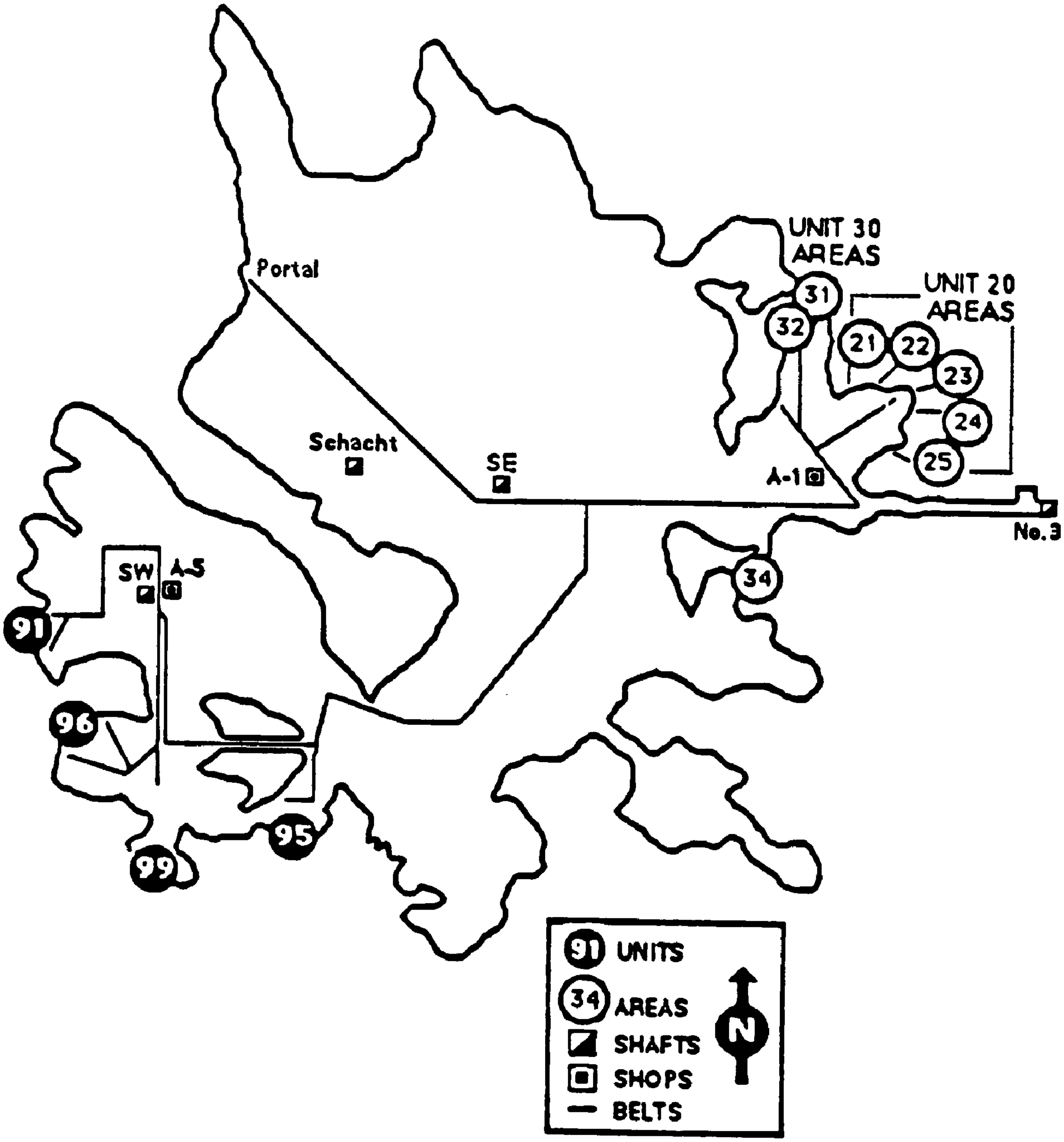


Figure 4-4. Map of White Pine Mine

(Source: Copper Range Co. Undated)

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The Southwest mine area has a 2,200-foot deep shaft used for personnel and materials transport, as well as ventilation. The Northeast mine area has a 440-foot deep shaft, located approximately 15,000 feet from active mining sections (Skillings' Mining Review 1992).

Mine ore is extracted from rooms about 20 to 28 feet wide and 8 to 17 feet high. In room-and-pillar mining, the rooms are mined on a regular pattern, separated from each other by pillars of un-mined ore (the width of pillars at the White Pine mine was not determined). All mining in a section of the White Pine mine is conducted on one level. Connecting roads between rooms and sections of the mine are generally 25 feet wide and 11 feet high.

The Copper Range Company mining cycle includes: bolting, drilling, powdering, blasting, loading, hauling, crushing, and conveying (Copper Range Co. Undated). These activities are discussed in greater detail below.

Bolts are installed to stabilize walls and ceilings in a technique known as roof bolting. In roof bolting, holes are drilled into the roof at regular intervals and steel bolts with resin capsules are inserted into the holes. The resin then solidifies to form a bond between the bolt and rock to secure the roof (Copper Range Co. Undated).

Holes measuring 1 3/4 feet in diameter are drilled 12 to 15 feet into the ore column "face" with a drilling machine. The number of holes depends on the size of the room, and blast patterns vary, depending on location. The drilled holes are then loaded with explosives, and are blasted at the end of each shift (Copper Range Co. Undated). Copper Range Company blasts exclusively with ammonium nitrate fuel oil (ANFO). Each blast breaks about 350 tons of ore, with a total of 17,000 tons of ore removed from the mine daily.

Broken ore is scooped or mucked into trucks or carried directly by trams to portable primary (Stamler) crushers, which reduce the ore size to less than 12 inches (Copper Range Co. Undated). Crushed ore is then automatically deposited on conveyors for transport to the surface. As ore is conveyed to the surface, it is transferred (at Transfer Point #1) to one of two concrete coarse ore bins.

Overall, the mine workings at the White Pine mine were generally dry at the time of the EPA site visit. When blasting occurs, mine water flows are released and accumulate in the blast area. Portable suction pumps are used to collect this mine water and transport it to local underground sumps. Water used for dust control during blasting is also pumped to these sumps. From the local sumps, water flows into one of three central underground mine water sumps. From these central sumps, mine water is pumped to the surface and into the tailings management system.

Backfilling is not practiced at White Pine and there is no waste rock. All mined material is considered to be ore and is crushed and beneficiated. White Pine ore grade averages between 1 and 1.1 percent copper. According to Copper Range Company personnel, at the time of the site visit the facility was mining lower than average grade ore because it is easier to access.

4.2.2 Beneficiation Operations

The objective of beneficiation operations is to produce a high grade copper concentrate that can be smelted. Mined ore is crushed, ground in rod and ball mills, and floated to recover the copper minerals contained in the ore (Copper Range Co. Undated).

From 17,000 tons per day of ore extracted from the mine, the mill produces approximately 500 tons of concentrate per day, which assays at 30 percent copper. About 87 to 89 percent of the copper in the ore is recovered in the mill. The mill product is then filtered and dried prior to smelting (Copper Range Co. Undated).

4.2.2.1 Crushing and Grinding

At the surface, ore is received into two-1,500 live ton capacity coarse ore storage bins and withdrawn over double deck scalping screens. Greater than 3 inch size rock is crushed by two-7 foot Symons standard cone crushers. Scalping screen undersize is sent directly to fine ore storage, while the intermediate product is conveyed to four-1,000 live ton Shorthead crusher feed bins. Shorthead feed is processed through four parallel screening and crushing lines to make a final nominal crusher product size of 5/8 inch. Each bin has a capacity of 1,500 tons of ore. The crushing plant is equipped with one wet and one "Rotoclone N" dust collector.

Crusher product is conveyed and distributed to one of seven fine ore bins which feed the grinding circuit. There are three grinding sections consisting of two parallel lines per section and a fourth section with a single larger capacity set of mills. Rock is withdrawn from beneath the fine ore storage bins, conveyed to the rod mill feed chute and mixed with fresh water and a portion of the required flotation reagent. Each grinding line consists of an open circuit rod mill in series with a ball mill in closed circuit with cyclone classifiers.

A portion of the xanthate collector, necessary for flotation, is added to the ore in the ball mills. The discharge from each ball mill is fed through a primary hydrocyclone, where the overflow (undersize) material (5 percent greater than 100 mesh) is sent to primary flotation, while the underflow (oversize) material returns to the ball mill for further grinding.

4.2.2.2 Flotation

Flotation at Copper Range Company is accomplished in four stages. (Specific information concerning flotation cell sizes and capacities was not collected during the site visit.) A detailed flow diagram of the White Pine flotation circuit is shown in Figure 4-5.

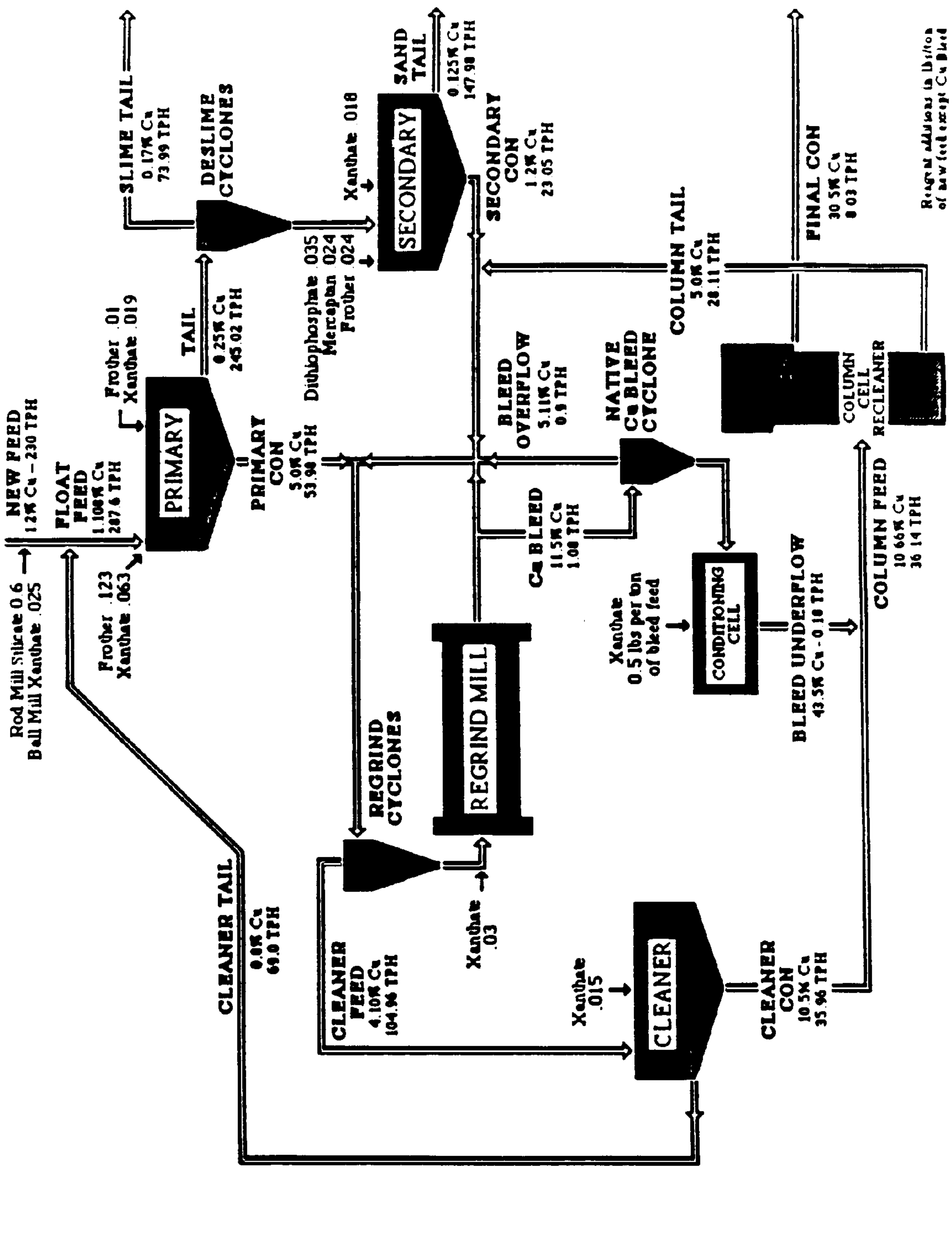
Rod Mill Silicate 0.6
Ball Mill Xanthate .025
NEW FEED 1.2% Cu - 230 TPH
FLOAT FEED 1.106% Cu 287.6 TPH
Frother .123
Xanthate .063
Frother .01
Xanthate .019
PRIMARY
PRIMARY CON 5.0% Cu 53.98 TPH
TAIL 0.25% Cu 245.02 TPH
DESLIME CYCLONES
SLIME TAIL 0.17% Cu 73.99 TPH
Dithiophosphate .035
Mercaptan .024
Frother .024
Xanthate .018
SECONDARY
SAND TAIL 0.125% Cu 147.98 TPH
SECONDARY CON 1.2% Cu 23.05 TPH
BLEED OVERFLOW 5.11% Cu 0.9 TPH
NATIVE Cu BLEED CYCLONE
Cu BLEED 11.5% Cu 1.08 TPH
COLUMN TAIL 5.0% Cu 28.11 TPH
FINAL CON 30.5% Cu 8.03 TPH
COLUMN CELL RECLEANER
REGRIND CYCLONES
REGRIND MILL
Xanthate 0.5 lbs per ton of bleed feed
CONDITIONING CELL
BLEED UNDERFLOW 43.5% Cu - 0.18 TPH
COLUMN FEED 10.66% Cu 36.14 TPH
CLEANER TAIL 0.6% Cu 69.0 TPH
CLEANER FEED 4.10% Cu 104.96 TPH
Xanthate .03
Xanthate .015
CLEANER
CLEANER CON 10.5% Cu 35.96 TPH

Table 4-1. Purpose and 1992 Application Rates of Flotation Reagent Classes

Reagent Class	Purpose	1992 Application Rate (pounds/ton)
Frothers	Promote the formation of froth having the desired characteristics (stiffness or fragility) and having little or no collecting property.	0.1085
Primary Collectors and Promoters	Selectively coat the particles to be floated with a water-repellant surface that will adhere to air bubbles.	0.1982 0.0194

(Source: U.S. EPA Field Notes; Cummins and Given 1973)

Table 4-2. 1991 Annual Reagent Consumption and 1992 Application Rates at Copper Range Company's White Pine Mine

Reagent	1991 Annual Consumption (tons/year)	1992 Application Rate (lbs/ton)
Xanthate	987,865	0.1821
Test Collectors	87,812	0.0160
n-Dodecyl Mercaptan	158,592	0.0273
Flocculants	62,248	0.0061
Defoamers	7,614	0.0153

(Source: U.S. EPA Field Notes)

Reagent functions include frothers and collectors/promoters. The specific purpose of each class of reagent used at White Pine, as well as their collective 1992 application rates, are presented in Table 4-1. A complete list of all flotation reagents used at White Pine, along with their individual application rates, are listed in Table 4-2. Lime is also added to the ore at a rate of 0.0001 pounds per ton (25 tons per month) to buffer the rotary kiln dryer scrubber water, which is discharged to the concentrate thickeners (see below) and is characterized by low pH (the actual initial and final scrubber water pH were not determined).

Primary rougher flotation at Copper Range Company is a standard froth flotation system, using mechanical cells. Primary rougher flotation overflow is fed to the concentrate regrind mill, while the tails are sent to a desliming cyclone. The overflow from the desliming cyclone is discharged as slime tails, and the coarse sand underflow is sent to secondary scavenger flotation.

Secondary flotation at White Pine is also standard froth flotation. Secondary flotation cell overflow is fed to the regrind cyclone, while the underflow is discharged as sand tails.

Overflow from the regrind cyclone flows to the first stage of cleaner flotation. Underflow from the cyclone is fed to a regrind mill for additional size reduction. Reground ore is either discharged to a native copper bleed cyclone or to the secondary flotation circuit.

Copper Range Company operates four Deister column flotation cells (recleaners). Tails from column flotation are returned to the regrind system for additional size reduction. Final concentrate from recleaning flotation is sent, along with concentrate from the copper bleed flotation system, to thickeners. Tails from copper bleed flotation are fed to the column cells. Copper Range Company's final flotation concentrate is about 30 percent copper (Copper Range Co. Undated; MDNR 1992b). Final mill tailings are analyzed for copper content to assess mill performance and are discharged via a pumphouse to the tailings management system (see tailings discussion in Section 4.3.1.1 of this report). Copper Range Company's White Pine mine generates an average of 15,300 tons of tailings per day (approximately 5.6 million tons per year).

4.2.2.3 Concentrate Thickening

Copper Range Company operates two (one primary, one secondary) concrete concentrate settling ponds/thickeners in series, each measuring 100 feet in diameter (the depth and capacity of the thickeners were not determined). Overflow water from the thickeners is used as makeup water for the mill. Underflow from the thickeners is sent to the filter building.

4.2.2.4 Filtering and Drying

In the filter building, two rotary drum vacuum filters are used to produce a concentrate filter cake (at the time of the site visit, only one of the two filters was operating). The concentrate filter cake leaving the filter building has been dewatered to contain 20 - 22 percent moisture (MDNR 1992b).

From the filter building, the concentrate is placed on conveyors, fluxed with limestone and mixed with concentrates from other mines (application rates and total quantities used were not collected) and sent to a gas-fired rotary kiln dryer, equipped with a wet scrubber system. The scrubber water, characterized by low pH, is sent back to the concentrate thickeners. Fluxes used at the White Pine facility include limestone and precipitated dust from the facility's electrostatic precipitator (identified by Copper Range Company personnel as an unspecified recycled material). Limestone is stored in on-site piles under a shed roof. The kiln dryer reduces the moisture content of the concentrate to approximately 10 to 13 percent.

In the past, pyrite was added to high silicate White Pine ore to provide a source of sulfur (needed for smelting). Today, sufficient sulfur content in the smelter feed is obtained in ore concentrate received from other mines and mills (such as Phelps Dodge's Morenci operation), which is co-smelted with White Pine ore. The quantity of concentrate from other operations that is smelted by Copper Range Company varies on a daily basis.

4.2.3 Smelting and Refining

The effluent from the kiln dryer is fed into a reverbatory furnace, where it melts and separates into slag and matte. The liquid slag is skimmed off through tap holes while the matte, now 65 percent copper, is drawn off and charged into a converter furnace (Copper Range Co. Undated).

In the converter furnace, low pressure air is added to produce a 99 percent pure blister copper. A fire-refining furnace eliminates the remaining removable impurities, leaving 99.7 percent pure copper that is ready for casting. The copper is cast into anodes measuring 37 inches by 36 inches by 1.5 inches, and weighing over 600 pounds (Copper Range Co. Undated). Smelter stack emissions monitoring, including sulfur dioxide (SO_2) and arsenic, is discussed in Section 4.4 of this report.

Anodes go to an electrolytic refinery, where they are placed in cells containing electrolytic solution. Anodes are alternated in the cells with stainless steel blanks, which are the cathodes. When electrical current is sent through the system, copper is plated on the blanks, and the impurities sink to the bottoms of the cells. When the blanks are plated with copper on both sides, they are removed from the cells and stripped of copper. This final product, called cathode, weighs 90 pounds and measures 38 inches by 38 inches by three-sixteenth (3/16) inch. It is ready for shipment to market. Annual target cathode production output is approximately 120 million pounds (Copper Range Co. Undated).

Silver also occurs in the ore body as an important byproduct. It is collected in the slime at the bottom of the electrolytic cells and shipped for additional processing for silver recovery (Copper Range Co. Undated). The site team did not visit the smelting and refining portions of the site and information related to stack height, emission rates, and emission controls was not obtained.

4.2.4 Other Areas

4.2.4.1 Assay Laboratory

Copper Range Company operates a full, on-site wet laboratory located near the filter building. The laboratory analyzes samples from the mill, smelter, electrolytic refinery, and tailings.

4.2.4.2 Fuel Oil Storage Areas

Upon receipt at the facility, fuel oil and antifreeze (contained in 55-gallon drums) are stored in a central outdoor area. The drums are elevated above ground with no secondary containment. In facility shops and process areas, fuel oil, as well as lubricants and solvents, are stored (prior to use) without secondary containment. In some cases, drums of these materials are elevated above ground.

4.2.4.3 Power Plant

Copper Range Company has an on-site power plant, which is operated by 20 employees (including four wastewater treatment plant operators). The plant has three turbines with a nominal total capacity of 55 megawatts (MgW) (average peak load of 53 MgW). Two stoker-fired boilers feed two turbines (20 MgW capacity each). Waste heat recovered from the smelter feeds the third turbine (15 MgW capacity).

The boilers can be fired with coal, natural gas, or oil, depending on relative fuel prices. Natural gas has been used since February 1, 1992. When coal is used, low sulfur coal (less than 1.5 percent) is stockpiled in an outside storage area with very little surge capacity (most coal is delivered on a daily basis). Information was not obtained concerning power plant emissions or controls.

4.2.4.4 Shops

Maintenance and repair of surface department equipment is conducted in an on-site surface shop. Major repairs of mine equipment are also performed in surface shops. However, most mine equipment repairs are conducted in underground shops.

4.2.4.5 Underground Storage Tanks

At the time of the site visit, Copper Range Company had 15 State-permitted underground storage tanks at the White Pine site (several additional tanks had recently been removed). Only one of these tanks, a 20,000 gallon gasoline tank, was being used. This tank was inspected daily for leaks. An additional underground tank was currently empty, but can be used to store heating oil. The remaining 13 tanks, ranging in size up to 20,000 gallons, were empty and permanently inactive. All of the inactive tanks were previously used to store petroleum products.

4.2.4.6 Warehouse

Two on-site warehouses provide supplies to the mine and surface departments from a stock of 27,000 separate items. All chemicals, including flotation reagents, are delivered to a reagent storage area in the warehouse prior to being sent to specific areas for use.

4.2.4.7 Wastewater Treatment Systems

Copper Range Company operates two wastewater treatment plants. The main plant (located about 0.5 miles northwest of the smelter building) provides wastewater treatment for the town of White Pine, as well as most of the mine site. Treatment at this plant includes primary and secondary (i.e., biological) treatment. The main plant effluent is pumped to the tailings pumphouse and mixed with mill tailings. The lime in the tailings provides for additional phosphorous removal. Copper Range Company's smaller wastewater treatment plant (located at the southeast shaft) uses aeration treatment.

Effluent from both treatment plants is discharged to Copper Range Company's tailings management system via outfall 00A (see NPDES Permit discussion in Section 4.4.2.1 of this report). The average flow from these systems is approximately 0.004 MGD. Sewage sludges are sent to drying beds and are eventually used to promote revegetation of tailings impoundments areas.

4.2.4.8 Potable Water System

Copper Range Company pumps all of its fresh water (for potable and process uses) from Lake Superior. The water pump station is located at the Lake, 6 miles away from the mill site. The total fresh water volume pumped from the Lake to the facility averages approximately 20 MGD.

Of the 20 MGD input, an average of 0.3 MGD (1 MGD maximum) is sent to Copper Range Company's potable water plant. This plant supplies both the facility and the town of White Pine with potable water. Alum, soda ash, fluorine (in the form of fluosilicic acid), and chlorine are added to the pumped water, which is then filtered in three sand beds.

Complete volatile/semivolatile analyses are performed quarterly on treated potable water. According to Copper Range Company personnel, only chlorodibromomethane, chloroform, and dichlorobromomethane

Table 4-3. Results of Sampling for Constituents in Potable Water and Applicable MCLs

Compound	**7/24/91 ppm**	**12/12/91 ppm**	**3/23/92 ppm**
Chlorodibromomethane	0.0017	0.0005	0.0503
Chloroform	0.0237	0.0125	0.0177
Dichlorobromomethane	0.0068	0.0032	0.0023
Total Trichloromethanes*	0.322	0.0162	0.0703

* There are no MCLs for the individual compounds listed above. However, the MCL for total trihalomethanes is 0.1 ppm.

(Source: U.S. EPA Field Notes)

have been found in samples. These are thought to be byproducts of the chlorination and fluorination processes. Table 4-3 provides the results of the most recent analyses for these constituents.

Water pumped from Lake Superior to be used in facility processes is sent to a concrete-lined spray pond (3,800,000 gallon capacity) and combined with non-contact cooling water from the power plant. According to Copper Range Company personnel, no further treatment, with the exception of occasional chlorine addition, is employed prior to use in facility processes.

4.3 WASTE AND MATERIALS MANAGEMENT

A number of extraction and beneficiation wastes and materials are generated at the site and are managed in the facility's tailings impoundment system. Mineral processing wastes are also generated on-site. In addition, other wastes are generated on-site that are not uniquely related to mineral extraction, beneficiation, and processing. The hazardous portion of these wastes are typically shipped off-site for disposal. Nonhazardous wastes, such as tires and refuse, are managed both on- and off-site.

This section emphasizes management of extraction and beneficiation wastes and materials, and the units in which they are managed, as well as areas where processing wastes and materials are commingled with those from extraction and beneficiation. Although processing is generally beyond the scope of this report, limited information on these wastes and materials will be discussed below in order to characterize the material balance throughout the facility.

4.3.1 Extraction and Beneficiation Wastes and Materials

4.3.1.1 Tailings

Tailings samples are collected and analyzed daily in the on-site assay laboratory. These samples are primarily analyzed for copper and silver to assess mill performance. The results of analyses conducted immediately prior to the EPA site visit are summarized in Table 4-4 below.

Table 4-4. Results of Tailings Analyses (May 3 and 4, 1992)

Date	Percent Copper	Troy Oz. Silver/ Short Ton	Date	Percent Copper	Troy Oz. Silver/ Short Ton
May 3, 1992	0.166	0.031	May 4, 1992	0.147	0.027
	0.153			0.154	
	0.159			0.164	

(Source: U.S. EPA Field Notes)

Other tailings components may include sandstone, shale, trace metals and trace flotation reagents. Copper Range Company monitors the final effluent discharge from the tailings impoundment treatment system (outfall 001) and intermediate internal outfalls (00A and 00B) as required by their NPDES Permit.

In 1991, Copper Range Company's White Pine facility generated 5,583,483 tons of tailings in 1991. Tailings from the mill are discharged to a tailings pumphouse via two separate (sand and slime) launders. Lime additions in the mill increase precipitation and settling of solids in the tailings impoundment treatment system. Approximately one-tenth of a pound of lime per ton of tailings was added in 1991, resulting in a total addition of 604,000 pounds during the year.

At the pumphouse, sand and slime tailings flow to separate sump areas. The discharges from these areas normally are combined and pumped to the impoundment system via one of two steel pipelines. A launder and damper gate system within the pumphouse allows for separation of the sand tailings. They are then hydrocycloned in the sand plant portion of the pumphouse and pumped to North 2 impoundment via pipeline for use in construction of the core of the dam.

As shown in Figure 4-6

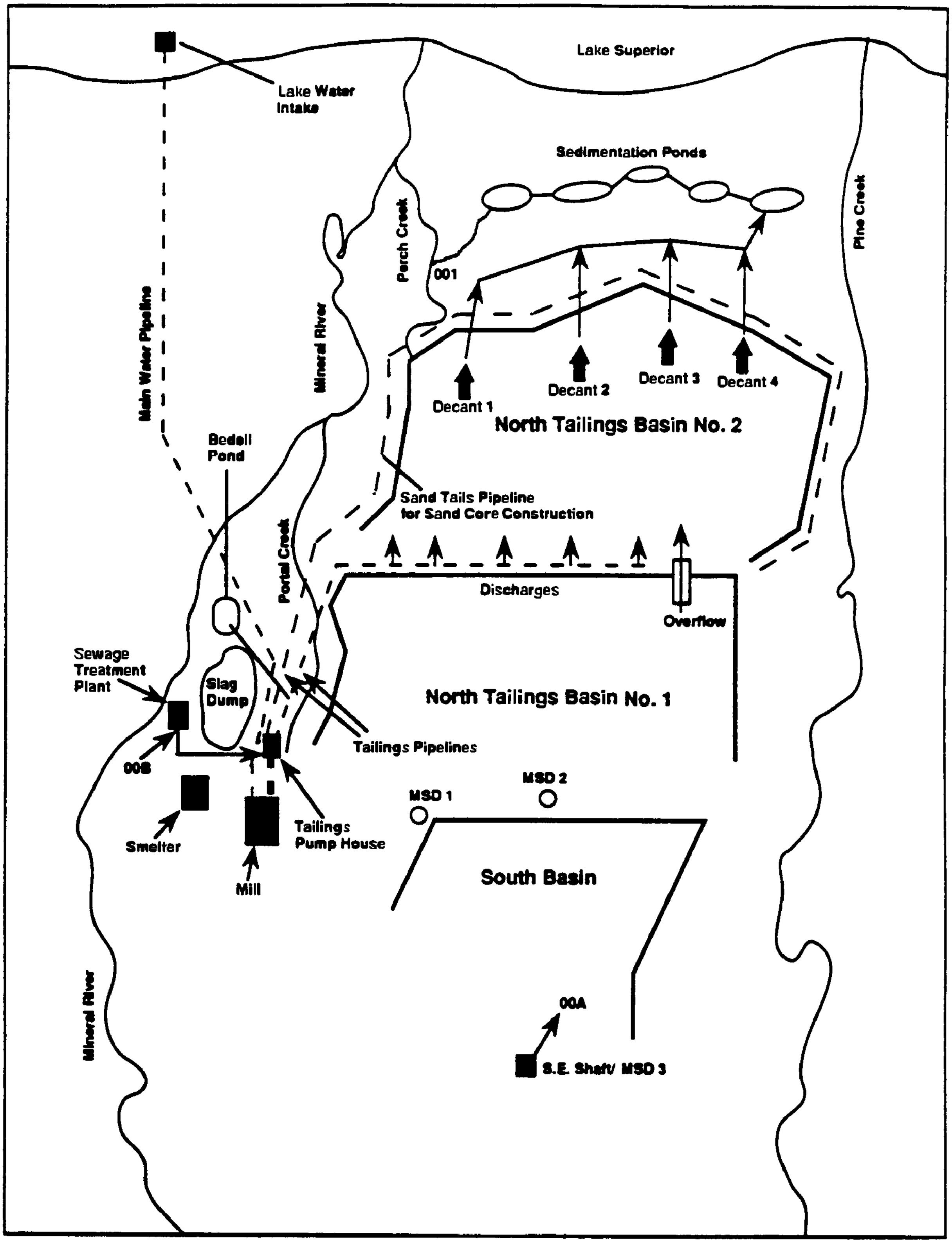

Figure 4-6. Map of Tailings System

(Source: U.S. EPA Field Notes)

, three tailings impoundments are located at Copper Range Company's White Pine mine: North 1 (1,850 acres), North 2 (2,450 acres), and the South Basin (1,300 acres). (Details about the height, capacities, and current tailings storage volumes of the facility's tailings impoundments were not determined.) The North 2 tailings dams (upstream and downstream) are constructed of clay with a central core of hydrocycloned sand tailings from the mill. The North 1 and South Basin dams, which were built by the facility for future tailings disposal, are constructed entirely of clay.

Tailings have been pumped to North 2 since October 1971. At the time of the site visit, it was estimated that North 2 had capacity for two more years of operation until the planned construction of an additional lift to the berm (see below). Tailings from the pumphouse flow to North 2 in steel pipes with no secondary containment. From the pipeline, tailings are discharged to the impoundment through one of five spigots (see Figure 4-6). The spigots are evenly spaced along the upstream dam of the impoundment. At the time of the EPA site visit, only the third spigot (central) was active. Copper Range Company also plans to utilize the first spigot (closest to plant) for tailings discharge when mill production increases. In addition to tailings, water collected in plant drains (including water from the mechanical shops, paint shops, and "spartan" steam cleaning) and sanitary wastewater from both facility water treatment plants are discharged to North 2. At the time of the EPA site visit, the surface of the impoundment was completely covered with water. The site visit team also noted the presence of standing trees in the North 2 impoundment.

Four decant towers, identified in Figure 4-6, are located in North 2 (evenly spaced near the downstream dam). These towers are used to decant clarified effluent from North 2 through a spillway and into the first of a series of five clay-lined basins (or polishing ponds) (see Figure 4-6). Water residence time in North 2 is 117 days. These ponds are among a number of old borrow pits that were originally used to obtain clay during initial construction of the impoundment dams. These ponds are not dredged by the facility.

Construction of the North 2 dam includes a french drain system to remove precipitation that enters the central sand core of the impoundment. These drains, along with runoff from the outside slopes of

North 2, discharge into a series of clay-lined ditches (spillways), which completely surround North 2 (except for the barrier between North 1 and North 2). The site visit team observed discharges from virtually all of the drainage pipes, which are spaced at intervals of 125 feet along the ditches. The drainage ditches flow into the polishing pond system.

No tailings water is reclaimed at White Pine. Rather, water is channeled through the polishing (sedimentation) ponds to provide final settling prior to discharge. No chemicals are added to the water in the ponds. The discharge from the last polishing pond passes over a concrete weir and rip-rap into Perch Creek (designated as NPDES outfall 001). Perch Creek flows into the Mineral River, which flows into Lake Superior. In the past, polymers were added to the decant pipe discharge to the spillway to promote settling and precipitation in the polishing pond system. However, this practice has been discontinued.

The average effluent discharge from outfall 001 during 1991 was 24 MGD. Freezing does not occur at outfall 001 due to the constant flow from the tailings system. The effluent discharge from outfall 001 accounts for essentially all of the flow in Perch Creek. Monitoring requirements and data for outfall 001 are described in Section 4.4.2 of this report.

At the time of the EPA site visit, Copper Range Company was experiencing a minor leakage of non-clarified tailings into the spillway system as a result of a malfunction in the bladder system of one of the decant towers. This malfunction caused concern that an increase in solids might clog the tailings decant system. Copper Range Company closed off the affected area of the spillway and has repaired the decant tower. According to Copper Range Company personnel, no change in the composition of outfall 001 effluent was experienced.

Prior to October 1971, North 1 was used for tailings disposal. The North 1 impoundment currently receives water directly from Mine Sump Nos. 1 and 2, indirectly from Sump No. 3 after prior settling in the South Basin, and direct precipitation. In the northeast corner of the unit, North 1 overflows to North 2. Water residence time in North 1 is 17 days. The EPA site visit team observed that North 1 was approximately one-third full (centered around the overflow area).

The North 1 impoundment dam is constructed entirely of clay. Therefore, according to Copper Range Company personnel, no seepage enters the confining berms. Sheet storm water runoff from the outer slopes of the west berm enters Portal Creek located immediately west of the unit. Sheet storm water runoff from the east berm enters Pine Creek located immediately east of the impoundment.

The South Basin currently receives mine water from Mine Sump No. 3, as well as direct precipitation. Water flows by gravity through the South Basin and then via pipe to North 1. Copper Range Company does not control runoff from the outside slopes of the South Basin. The EPA site visit team did not visit the South Basin.

According to Copper Range Company personnel, no reclamation is required for the tailings impoundments at White Pine. However, Copper Range Company has voluntarily seeded the outside slopes of the tailings impoundment(s) as well as the borrow pit areas, both for the control of erosion from natural elements and to provide cover and food for wildlife species which populate or migrate to the area. Substantial vegetation growth was noted by the EPA site visit team. Parts of the outside slopes of the North 2 impoundment have also been reseeded and lower areas of the slopes appear to be well vegetated.

Copper Range Company applied to the Michigan Department of Natural Resources (MDNR) for permission to add an additional lift to the North 2 dam under the State's Dam Construction Act. Specifically, the application calls for the addition of 200,000 cubic yards of clay to raise the dam three feet in height. The approval process involves only dam safety considerations. Copper Range Company also recently applied to MDNR to undertake additional construction work on the facility's South Basin in anticipation of future use.

Copper Range Company is not required to monitor ground water at the site.

4.3.1.2 Mine Water

As shown in Figure 4-6, Mine Sump Discharge (MSD) Nos. 1 and 2 discharge to the North 1 tailings basin (and subsequently North 2). MSD No. 3 discharges to the South Basin and thence by gravity flow, via pipeline, to North 1. The volumes of mine water generated were not determined. Analysis of mine water discharged to the impoundment system is performed on samples taken at the three sumps in the mine and/or at the MSD discharge pipes within the impoundment. According to Copper Range Company personnel, elevated total dissolved solids (TDS) levels detected in outfall 001 are caused by mine water since elevated TDS levels are characteristic of the connate water found in the Nonesuch formation, where mining is occurring.

4.3.2 Smelter Slag and Reverbatory Bricks

Although slag and bricks are generally beyond the scope of this report, they are briefly discussed here because runoff from piles of slag and brick storage areas is commingled with extraction and beneficiation wastes. Copper Range Company generated 207,843 tons of reverbatory furnace slag in 1991. Today, Copper Range Company operates a slag dump (constructed in 1953) located adjacent (just to the north) of the smelter. Historically, during the 1970's, the majority of the dump slag was crushed and underwent beneficiation (separation of copper-bearing slag from the waste slag) via a heavy media flotation process plant located within the slag dump. The residual from the plant (tailings) was graded and stockpiled at the north end of the dump. Periodically—during low mine production periods—copper-bearing slag is now processed in the mill to recover the copper. Piles of refractory bricks, from normal repair activity, are presently stored on the southern portion of the slag dump. These bricks are crushed at the site and recycled via the mill to recover the copper content. The piles of stored brick are covered with tarps. Scrap tires tied to lanyards are utilized to secure the tarps. Runoff from the slag dump flows to North 1 via the Bedell Pond.

4.3.3 Site Runoff

In general, all site runoff is collected and ultimately sent to the tailings pumphouse (with the exception of sheet storm water runoff from the outside slopes of the North 1 impoundment along Portal Creek to the west and Pine Creek to the east and the South Basin, as discussed above). Site runoff can be stored temporarily in a 50 million gallon reservoir (referred to as the Bedell Pond) prior to discharge to the tailings impoundment (see Figure 4-6).

4.3.4 Other Wastes and Materials

4.3.4.1 Laboratory

Analyses at the on-site lab generate a number of materials. A summary of them and their management is presented below:

- Electrolyte - recycled to the plant.
- Liquid samples (including tailings) - placed in barrels and disposed of off-site as hazardous waste by an outside firm. In 1991, 78 containers containing 9,864 kg of laboratory wastes were generated.
- Ceramics/crucibles - placed in barrels and disposed of off-site by an outside firm (no quantities available).

4.3.4.2 Sanitary Wastewater

Effluent from the sanitary wastewater treatment system located at the S.E. shaft dry is discharged through NPDES internal outfall 00A to the tailings management system (typical flows range from 0.003 to 0.005 MGD). Sewage treatment plant effluent from the main plant (NPDES internal outfall 00B), which also services the community of White Pine, is pumped to the tailings pumphouse and thence to the tailings management system.

4.3.4.3 Power Plant Wastes

Runoff from the coal storage pile, along with all plant runoff, is managed through the tailings impoundment system. Ash from the plant is sluiced with water from the spray pond and discharged to the tailings system. Approximately 216 gallons per day of ash sluice water (containing 30 percent solids) is generated at White Pine. The plant's boilers are equipped with wet scrubbers for dust control. Collected scrubber waste is combined with dust collected from the smelter flue and sent to the rotary kiln dryer (along with the fluxed feed from the filter plant).

4.3.4.4 Waste Oil

A 10,000-gallon aboveground tank is used to store vehicle and hydraulic waste oil. The tank is surrounded by a clay containment "moat." When the tank is filled, waste oil is manifested and shipped off-site by Oil Services, Inc., (Eveleth, Minnesota) for recycling and reuse in asphalt plants. In 1991, there were three pick-ups, totaling approximately 98,210 lbs (13,095 gallons) of used oil.

4.3.4.5 Refuse

Nonhazardous solid waste generated at Copper Range Company is classified in one of two categories: garbage (3,016 cubic yards generated in 1991) or inerts (3,741 cubic yards generated in 1991). Garbage includes lunchroom scraps, paper, cardboard, metal containers, glass, rags, and other rubbish. Inert materials include broken concrete, bricks, masonry, rocks, and uncontaminated soils. Both inerts and garbage are sent to a State Type II private landfill, identified as the K&W landfill, in Ontonagon, Michigan. It is not known why the facility manages these wastes separately prior to disposal.

Garbage is accumulated in designated areas and stored for pickup in containers by an outside firm. Inerts are temporarily managed in a large area adjacent to the facility road from the mill to the tailings impoundments. Throughout this storage area, the EPA site visit team noted stained soils and the presence of empty drums. In addition, explosives and caps are stored in tractor trailers in the inert storage area.

Scrap steel, wood pallets and other wooden items, and empty 55-gallon drums (which did not contain hazardous materials) are disposed of in an area identified by Copper Range Company as the "boneyard." These items are accumulated in the boneyard for future reuse, recycle, resale, or other management. According to Copper Range Company personnel, empty drums are managed according to the empty container requirements specified in 40 CFR Part 261.7.

4.3.4.6 Spent Solvents

In 1991, 172 containers containing 9,864 kilograms of spent solvent were disposed of off-site as hazardous wastes. Copper Range Company holds an EPA Hazardous Waste Generator permit (Permit No. MID086176658). A non-chlorinated solvent, "140 Stoddard," is the most commonly used solvent at Copper Range Company. Copper Range Company personnel indicated that an additional 10 containers (1,562 kg) of hazardous petroleum naphtha were also disposed of off-site. All shipments of hazardous waste are manifested. The EPA site visit team noted the presence of "Safety Kleen" solvent collection/storage containers throughout shop areas at the facility.

4.3.4.7 Batteries

Spent batteries are temporarily stored in the boneyard prior to pick-up by the original vendor. No information was available concerning the quantity of spent batteries generated at White Pine or the management of battery acids.

4.3.4.8 Scrap Tires

Copper Range Company has been involved in the recapping of tires since the early 1950's. Copper Range Company attempts to reuse tire casings to the greatest extent possible and has modified a number of vehicles to accept heavier ply tires to maximize recapping potential. To date, there are tires in use at White Pine that have been recapped over 20 times. On average, 1600x25 size tires are recapped five times and 1800x25 size tires are recapped eight times. On average, larger tires cannot be recapped as many times as smaller tires. Copper Range Company also works with rubber manufacturers on increasing recap life through the improvement of rubber compounds (Copper Range Co. 1992d).

Copper Range Company has also made improvements to extend the original tread life of its tires. Early tests have shown that tread life can be increased by 40 percent by installing cores in the tires of larger equipment. The use of cores also reduces waste, as only the damaged part must be removed, rather than an entire core or tire (Copper Range Co. 1992d).

Scrap tires are disposed of in a tire storage area permitted by the MDNR (it is not known if the area is lined). The tires managed in the area are equally proportioned between surface truck tires and mine equipment tires. The exact size and number of scrap tires in the tire storage area were not determined. The Copper Range Company is currently looking for a vendor to shred these scrap tires.

Recently, Copper Range Company began salvaging scrap tires from the pile. Eight tires have been removed from the scrap pile and sent for repairs. These tires are then run with tire cores in them. According to Copper Range Company, additional tires will be removed and reclaimed as time and resources allow (Copper Range Co. 1992d).

4.3.4.9 Asbestos

Copper Range Company personnel indicated that asbestos is found in buildings at the White Pine facility. An "Asbestos Team" (four employees) removes asbestos from locations at the site on an unspecified schedule. Asbestos materials are placed in bags, which are stored in a covered area adjacent to the hazardous waste storage area (no additional information was available concerning the hazardous waste storage area). When 100 bags have accumulated, the bags are shipped off-site to the permitted K&W landfill. The total quantity of asbestos material shipped off-site was not obtained.

4.3.4.10 Polychlorinated Biphenyls (PCBs)

Copper Range Company has eight electrical transformers containing PCBs located in the underground mine workings and a total of 49 PCB transformers located within the surface facilities. General PCB inspections are conducted on a quarterly basis. In addition, Copper Range Company conducted a PCB audit in the first quarter of 1990. This audit inspected all underground and surface operations. For units with the potential for PCB leaks, daily inspection and repair plans were developed. The EPA site visit team observed one power plant transformer containing PCBs. The transformer had secondary containment (i.e., it was surrounded by berms), and daily transformer inspection records were maintained.

4.4 REGULATORY REQUIREMENTS AND COMPLIANCE

A number of Michigan State agencies are responsible for regulating various aspects of Copper Range Company's White Pine operations. These agencies, the permits/authorizations issued to Copper Range Company, and the major permit requirements, are described below.

4.4.1 Mining Regulatory Requirements

The Michigan Mining Act does not regulate metals mining. Therefore, Copper Range Company is not required to develop or submit an operating/closure plan. There are no State requirements for tailings impoundment reclamation or bonding.

4.4.2 Surface Water Permits and Monitoring

4.4.2.1 NPDES Permit

NPDES permit No. MI0006114 was issued to Copper Range Company on January 1, 1991, by the Michigan Department of Natural Resources. The Copper Range Company NPDES permit addresses two discharges, outfalls 001 and 002. The limits for metals, total suspended solids (TSS), and pH are based on the effluent guidelines for the Ore Mining and Dressing Category (40 CFR Part 440). (It is unclear whether the permit limits are based on effluent guidelines for mine drainage and/or mill discharges.) For other parameters, limits are based on the State permit writer's best professional judgment. These limits are shown in Table 4-5.

As part of its 1990 NPDES permit renewal process, Copper Range Company was required to conduct biomonitoring (quarterly tests on two species using effluent from outfall 001), a Lake Superior mixing zone study, and as part of a Lake-wide initiative, examine new approaches to reducing their TDS/chlorides loadings to the Lake. These reports were submitted to the State in April 1992 and are discussed in greater detail in Sections 4.4.2.2 through 4.4.2.4 of this report (MDNR 1990).

Table 4-5. Monitoring Data for Outfall 001 (January - March 1992)

Parameter		Permit Limits	January 1992	February 1992	March 1992
Flow (MGD)	Monthly Avg	(report)	23.4	18.9	28
	Daily Max	51.1	27.3	21.3	30.6
pH (s.u.)	Range	6.5-9.0	7.4-7.6	7.4-7.5	7.1-7.6
TDS (mg/l)	Monthly Avg	(report)	1,900	1,650	2,000
	Daily Max	(report)	2,000	1,800	2,000
TSS (mg/l)	Monthly Avg	20	14	7	6
	Daily Max	30	18	10	12
Cadmium (µg/l)	Monthly Avg	50	0.6	0.6	0.7
	Daily Max	100	0.7	0.7	0.8
Copper (µg/l)	Monthly Avg	150	10	ND	25
	Daily Max	300	10	ND	40
Lead (µg/l)	Monthly Avg	300	ND	2	ND
	Daily Max	600	ND	3	ND
Zinc (µg/l)	Monthly Avg	500	5	ND	5
	Daily Max	1000	10	ND	10
Mercury (µg/l)	Monthly Avg	(report)	ND	ND	ND
	Daily Max	(report)	ND	ND	ND
Chloride (mg/l)	Monthly Avg	(report)	1,140	916	1,035
	Daily Max	(report)	1,215	917	1,114

ND = Not Detected

(Source: Copper Range Co. 1992e)

Outfall 001 is the discharge of effluent from the final clay polishing pond in the tailings water system into Perch Creek. The facility's permit requires monitoring for pH, chloride, metals, hardness, flow, TDS, and TSS. Sampling is conducted weekly for flow and pH and two times per month for all other parameters, with the results of monitoring submitted to the State on a monthly basis. Facility personnel indicated that a trace metals study was also conducted in the early 1980's (no additional details about the study were available).

Table 4-5 summarizes monitoring conducted by Copper Range Company at outfall 001 during January through March 1992.

Outfall 002 represents the discharge from the 3-Shaft sewage treatment plant. While Copper Range Company retains the permit for this outfall, the system is currently inactive, and no discharge actually occurs. Discharge monitoring reports for outfall 002 for the period January through March 1992 indicated no discharge during the period.

The NPDES permit also requires monitoring at two internal outfalls, designated as outfalls 00B (sewage treatment effluent from the main sewage treatment plant to the tailings pumphouse) and 00A (from Southeast Shaft sewage treatment plan to the South Basin).

Wastewater discharged from these outfalls eventually flows into the facility's tailings impoundment system. Specifically, outfall 00A is the discharge from the main wastewater treatment plant located north of the mill (includes sanitary wastewater from the town of White Pine) and outfall 00B is the discharge from Mine Water Sump No. 3 to the South Basin. Monitoring data for outfalls 00A and 00B for the period of January

Table 4-6. Monitoring Data for Outfall 00A (January - March 1992)

Parameter		Permit Limit	January 1992	February 1992	March 1992
Flow (MGD)	Monthly Avg	(report)	0.004	0.004	0.003
	Daily Max	0.03	0.005	0.004	0.004
TSS (mg/l)	Monthly Avg	(report)	41	57	36
	Daily Max	(report)	58	86	44
BOD (mg/l)	Monthly Avg	(report)	117	109	75
	Daily Max	(report)	180	170	101

(Source: MDNR 1990)

Table 4-7. Monitoring Data for Outfall 00B (January - March 1992)

Parameter		Permit Limit	January 1992	February 1992	March 1992
Flow (MGD)	Monthly Avg	(report)	0.259	0.242	0.368
	Daily Max	0.9	0.265	0.385	0.508
TSS (mg/l)	Monthly Avg	(report)	13	13	22
	Daily Max	(report)	18	19	28
BOD (mg/l)	Monthly Avg	(report)	16	14	13
	Daily Max	(report)	26	16	15

(Source: MDNR 1990)

through March 1992 are summarized in Tables 4-6 and 4-7.

4.4.2.2 Lake Superior Mixing Zone Study

As part of the NPDES permit reapplication process, Copper Range Company was required to conduct a 1991 study to describe the dimensions and temporal behavior of the plume of the Mineral River discharge into Lake Superior, which is dominated by the effluent from Copper Range Company's White Pine mine. The results of the study were to be used to determine the need for limitations on dissolved solids, metals, and other pollutants in the discharge from outfall 001. The Copper Range Company study characterized the Mineral River discharge as having TDS concentrations between 2,000 and 3,000 mg/l and chloride concentrations between 1,000 and 2,500 mg/l. Flow and constituent concentrations varied both on a seasonal and daily basis (Copper Range Co. 1992a).

The nearshore area of the lake is dominated by a large bedrock outcrop, just west of the mouth of the Mineral River. The outcrop, as well as associated boulders and cobble, were found to influence the deposition of sand in flats and bars beginning at Gull Point and extending eastward to the Mineral River mouth. The sand shifts radically, periodically covering and exposing areas of bedrock and cobble. The dynamic nature of the bottom is controlled by wind and wave conditions. According to Copper Range Company, the precise configuration of nearshore sand bars influences the initial direction of the Mineral River discharge as it enters the lake (Copper Range Co. 1992a).

According to Copper Range Company, the Mineral River plume generally extends toward the northeast from the mouth for a distance of 500 to 4,000 feet, under the influence of steady eastward currents and longshore drift. The plume is dense and typically sinks to the bottom. Copper Range Company stated that incompletely diluted effluent is often confined to a layer within one foot of the bottom. The plume does, however, occasionally extend vertically throughout the water column within about 500 feet of the mouth, when localized onshore winds pile water up along the shore (Copper Range Co. 1992a).

According to Copper Range Company, most of the water column is generally free of the plume's influence, and the plume does not block the longshore migration of fish populations. In addition, according to Copper Range Company, the concentrations of chlorides in the plume are not toxic to fish (Copper Range Co. 1992a). (EPA chronic and acute water quality criteria for chloride are 230 mg/l and 860 mg/l, respectively.)

4.4.2.3 Environmental Assessment of the Effects of Chloride and TDS Discharge on Lake Superior

As part of the NPDES permit reapplication process, Copper Range Company was required to conduct a 1991 study to assess the local and long-term effects on Lake Superior of the discharge from Copper Range Company's White Pine mine. The Copper Range Company study concluded that the Mineral River discharge was not causing any measurable effects, either locally or over the entire lake. Copper Range Company made this conclusion based on the lack of impact on the benthic community, the insignificant magnitude of any future chloride increase in the lake attributable to mine discharges, and the absence of any detectable effects on local water intakes (from Silver City to Ontonagon) (Copper Range Co. 1992b).

According to Copper Range Company, chloride concentrations in Lake Superior have been constant (at about 1.2 mg/l) from 1885 to the time of the study (1992). The Copper Range Company stated that by far, the largest and most widespread sources of chloride loading to the lake are natural tributary inputs and atmospheric deposition, which combine to contribute an estimated 74 percent of the total loading. Point sources, among them the White Pine mine, were found by Copper Range Company to account for 26 percent (estimated) of the total chloride loading (Copper Range Co. 1992b). As shown in Table 4-5, chloride concentrations in the 20 MGD mine discharge averaged about 1,000 mg/l from January through March 1992.

4.4.2.4 Biomonitoring Testing

The Mineral River supports a fish and macroinvertebrate community year-round. These communities are limited by yearly extremes in hydrologic fluctuations, primarily the seasonal low flows. A June 1989 investigation by the Michigan Department of Natural Resources' Surface Water Quality Division found a diverse fish community both upstream and downstream of the Perch Creek confluence with the Mineral River (i.e., where the White Pine mine discharge enters the River). While the MDNR described the overall macroinvertebrate abundance and diversity as low, the macroinvertebrate community was much reduced downstream of the confluence as compared to the community upstream (MDNR 1989).

The reduction in macroinvertebrates downstream of the confluence may not be solely attributable to the effluent introduced via Perch Creek. Major physical and natural stream quality differences (i.e., slope, elevation, water velocities) exist along the Mineral River in the White Pine area. Below the Perch Creek confluence, the River is more susceptible to flow fluctuations and scouring during periods of high precipitation and runoff. These natural extremes in combination with heavy natural clay deposits on all stream substrates are thought be responsible for reducing the diversity of macroinvertebrates in the Mineral River (MDNR 1989).

As part of the NPDES permit reapplication process, Copper Range Company was required to perform acute and chronic biomonitoring on samples of the discharge from outfall 001. Cerodaphnia dubia (Cerodaphnia) and Pimephales promelas (fathead minnows) were selected as the test organisms for the sampling and analysis that were performed in April, June, August, and October 1991. The results of Copper Range Company's biomonitoring are summarized in Table 4-8.

Table 4-8. Results of Copper Range Company Biomonitoring Testing (April - October 1991)

Report Date	Cerodaphnia dubia 96-hour LC50	Cerodaphnia dubia 7-day NOEC	Pimephales promelas 96-hour LC50	Pimephales promelas 7-day NOEC
April 1991	100 percent effluent (no acute toxicity)	100 percent effluent (no chronic toxicity)	100 percent effluent (no acute toxicity)	100 percent effluent (no chronic toxicity)
June 1991	100 percent effluent (no acute toxicity)	100 percent effluent (no chronic toxicity)	100 percent effluent (no acute toxicity)	100 percent effluent (no chronic toxicity)
August 1991	Acute toxicity at 62 percent effluent	Chronic toxicity at 25 percent effluent (survival) and 12.5 percent effluent (reproduction)	100 percent effluent (no acute toxicity)	100 percent effluent (survival) and Chronic toxicity at 50 percent effluent (reproduction)
October 1991	Not Valid	Not Valid	100 percent effluent (no acute toxicity)	100 percent effluent (no chronic toxicity)

The LC50 represents the highest concentration of effluent (diluted with water) at which less than 50 percent organism mortality is observed. The no observed effect concentration (NOEC) represents the concentration of effluent (diluted with water) in which no chronic toxicity is observed (i.e., there were no observed differences between the test sample and the control sample).

Table 4-8 indicates that, during August 1991 sampling, acute and chronic toxicity were observed in diluted effluent from outfall 001.

4.4.3 Ground Water Monitoring

Based on Michigan State law, Copper Range Company is not required to conduct ground water monitoring in any area at the site, including the tailings impoundments. It should be noted that the uppermost aquifer (25 feet) underlying the facility recharges Lake Superior.

4.4.4 Air Permits and Monitoring

The Minnesota Air Pollution Control Commission has issued permits for air use equipment operating within the facility's Power Plant, Rotary Kiln Concentrate Dryer, Electrolytic Refinery and Nickel Sulfate Plant.

Although the smelter stack is the primary emission source at the site, the smelter facility was specifically "grandfathered" from the permit process under State law. The only requirements are that the opacity of emissions at the site must be less than 20 percent and particulate emissions must not exceed limitations specified by State law.

In 1969, Copper Range Company began conducting voluntary continuous monitoring for ambient sulfur dioxide (SO_2) and particulates at four locations (1 mile north and south, 3 miles east, and 6 miles west of the plant). Monitoring data were submitted to the State Air Quality Division on a monthly basis. When the plant closed in 1984, the State Agency granted the cessation of ambient monitoring activity.

The White Pine Refinery is unusual in that there is no bleed stream to remove impurities from the electrolyte during the electrowinning process. However, impurities are removed via the anode slimes which collect at the bottom of the cells and are further processed for sale as a byproduct. Similarly, nickel is removed from the process as nickel sulphate (in the Nickel Sulfate Plant) and is sold as a byproduct. Periodically, specially enclosed (Liberator) cells are used to adjust the copper content within the electrolyte. In the event of abnormal conditions, during such operations, an arsine gas detection device coupled to the liberator cells immediately shuts down the operation including the generation of arsine gas from the liberator cells. Abnormal conditions rarely occur during the operation of the liberator cells.

In 1986, EPA Region 5 required that the facility begin analyzing/reporting the inorganic arsenic content of the smelter matte under 40 CFR Part 61 (National Emission Standards for Inorganic Arsenic from Primary Copper Smelters). Arsenic is a volatile gas that may be liberated during the smelting process and released to the environment via smelter stack emissions.

The arsenic data collected by Copper Range Company are sent to both Region 5 and the State. Due to low levels of arsenic detected in matte samples during 1986-1987, Copper Range Company requested that the Region allow the facility to cease monitoring. According to Copper Range Company, no response was received and monitoring continues. Samples are collected and analyzed during each shift and compiled into monthly composite reports. Table 4-9 below summarizes arsenic monitoring conducted by Copper Range Company for 1991 (Copper Range Co. 1992c). Smelter stack emissions of arsenic are not monitored by Copper Range Company, and it is not clear how the matte data relate to arsenic air emissions.

Table 4-9. 1991 Annual Arsenic Monitoring Results

Month	Matte Inorganic Arsenic Analysis (%)	Converter Input Rate (Kg As/Hr)
January	0.047	6.3
February	0.049	7.4
March	0.048	6.4
April	0.051	6.4
May	0.040	5.1
June	0.028	3.9
July	0.030	4.1
August	0.024	36
September	0.022	3.2
October	0.020	3.3
November	0.021	3.3
December	0.028	4.0`

(Source: Copper Range Co. 1992c)

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APPENDIX 4-A

COMMENTS SUBMITTED BY COPPER RANGE COMPANY ON DRAFT SITE VISIT REPORT

[Comments on the draft site visit report were submitted by Copper Range Company in a letter dated December 21, 1992. This letter is not reproduced for this electronic version. Copies may be obtained from U.S. EPA, Office of Solid Wastes, Special Waste Branch.]

APPENDIX 4-B

**EPA RESPONSE TO COMMENTS SUBMITTED BY
COPPER RANGE COMPANY
ON DRAFT SITE VISIT REPORT**

EPA Response to Comments Submitted by
Copper Range Company
on Draft Site Visit Report

EPA has revised the report to incorporate all but one of the comments and suggestions made by Copper Range Company. Copper Range suggested that EPA delete the site visit team's observation that inert wastes are temporarily managed in a landfill between the mill and the tailings impoundment. EPA has retained this observation in the final report. In some cases, EPA made minor changes to wording suggested by Copper Range Company in order to attribute the changes to Copper Range Company or to enhance clarity.