HYDROGEOLOGY AND POTENTIAL RECLAMATION PROCEDURES FOR AN UNCONTROLLED MINE WASTE DEPOSITION SITE, KELLOGG, IDAHO

A Thesis

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by

Marc A. Norton

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Authorization To Proceed With Final Draft

A preliminary draft of the thesis entitled "Hydrogeology And Potential Reclamation Procedures For An Uncontrolled Mine Waste Deposition Site, Kellogg, Idaho" by Marc A. Norton for the Master of Science degree with a major in Hydrology has been reviewed and found adequate. The committee hereby grants permission for the preparation of the final copy incorporating suggestions made by the committee. Permission is also given for the scheduling of the final examination to be held when authorized by the graduate dean after submission of two final copies of the thesis to the Graduate School.

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Final Approval

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ABSTRACT

The reclamation of the South Fork of the Coeur d'Alene River basin in northern Idaho from the effects of past mining practices is imperative if the water quality of the river is to meet the requirement of "fishable and swimmable" set by Public Law 92-500, the Federal Water Pollution Control Act Amendments of 1972. Current mining practices are monitored and regulated by the Federal Environmental Protection Agency to ensure that present mining activities are within the regulations.

Mine wastes or tailings were deposited on the flood plain or in the channel of the South Fork of the Coeur d'Alene River. These mine wastes were carried downstream, mixing with the native alluvial material and forming large deposits. In the early 1900's, a series of dams were constructed across the South Fork of the Coeur d'Alene River in an attempt to control the downstream movement of the mine waste. As the South Fork entered the Smelterville Flats study area, located one mile west of Kellogg, Idaho, the coarser sediments were deposited first. The finer materials were deposited in the backwaters of a dam located at the western end of the Flats.

These tailings have high concentrations of zinc, lead, iron, and many other metals. Water movement through these tailings leaches the heavy metals into solution where they are able to enter the water resource system. Piezometers were installed to monitor the water quality and for water level measurements. Soil pits were constructed to determine the depth of mine waste and its physical and chemical properties. The effect on the water quality of the South Fork of the Coeur d'Alene River by ground water in the Smelterville Flats study area is minimal. Based on the data collected, potential reclamation procedures were developed to minimize the long-term effect of the abondoned mine waste on the water resource system. Potential reclamation procedures include removal of the mine waste, fluctuation of the ground water level, or, do nothing at all.

ACKNOWLEDGEMENTS

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INTRODUCTION

Statement of the Problem

Mine wastes were dumped onto the flood plain or directly into the South Fork of the Coeur d'Alene River during the early history of the Coeur d'Alene Mining District. The river reworked and deposited these wastes in the river channel and on the flood plain as a mix with native alluvial material. These deposits extend from Mullan, Idaho, to the confluence of the South Fork of the Coeur d'Alene with the Coeur d'Alene River and further extend down the river to Coeur d'Alene Lake (Figure 1). The mine waste formed a large delta extending into Coeur d'Alene Lake as well as covering most of the lake bottom (Norbeck, 1974, p. 16 and Maxfield and others, 1974 A, p. 1-6). The waste deposits in the river channel, on the flood plains, and in the lake pose potential physical and chemical problems. Wind and river erosion continue to rework and expose the wastes to the river channel and flood plain environments. The chemical problems are complex involving acid formation with the leaching of the heavy metals into the water resource system. When the wastes are disturbed there is a marked increase in metal concentrations in the ground water at the site.

The reclamation of the South Fork of the Coeur d'Alene River is imperative if the objective of the Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500 is to be met. The objective is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. Planning for reclamation of the Coeur d'Alene River requires knowledge of the pollution problem. The Idaho Department of Health and Welfare, through a grant and research program funded by the United States Environmental Protection Agency, issued a contract to

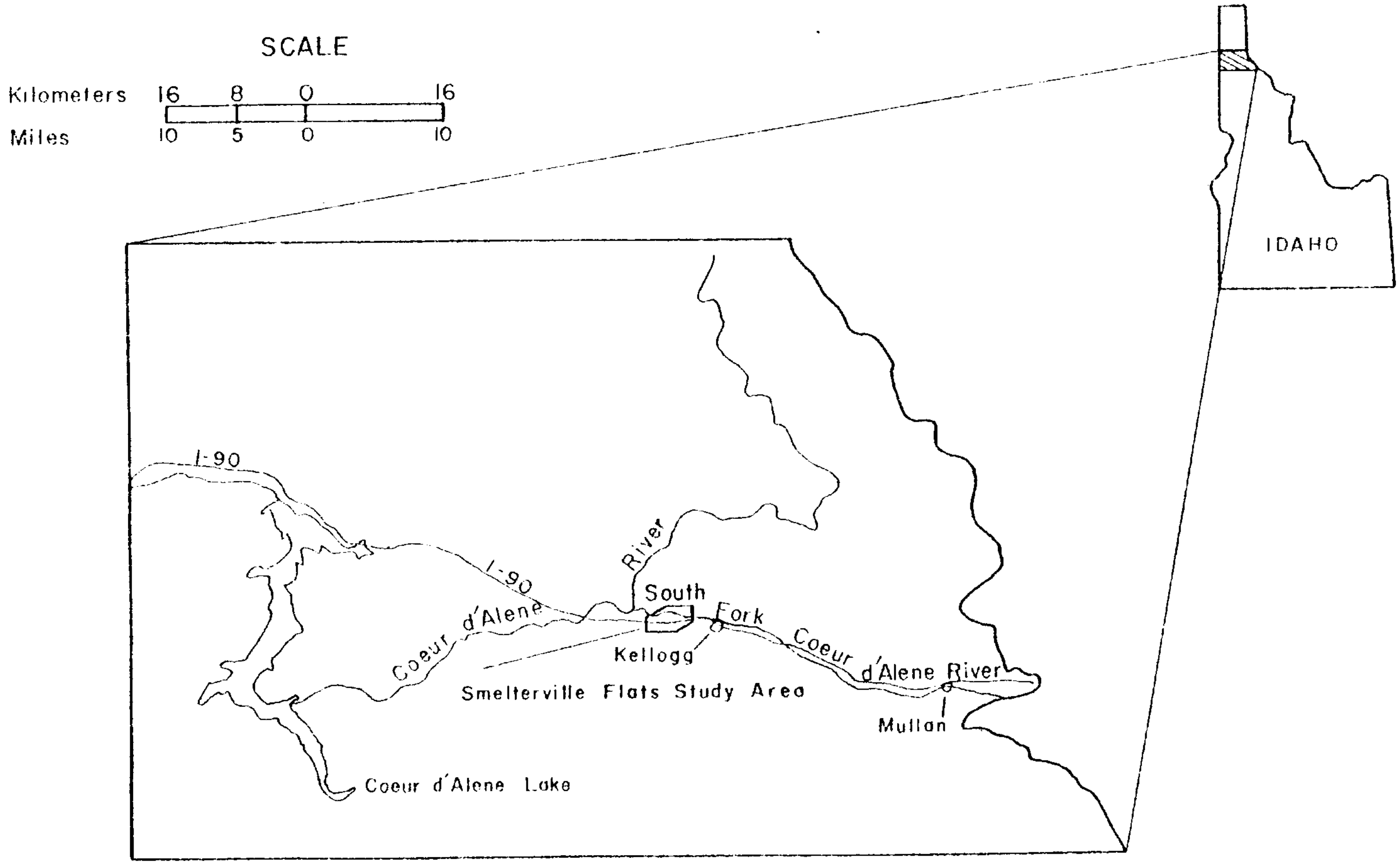


FIGURE 1. Location of the Smelterville Flats study area within the Coeur d'Alene River basin.

the University of Idaho at Moscow, Idaho to study the water quality problem in the South Fork of the Coeur d'Alene River basin, and to develop possible reclamation procedures. The contract was divided into separate projects to study different segments of the total problem. The sediment transport problem was studied by Christos Ioannou (hydrogeology, 1979) while the study of the tailings deposition sites was divided into two projects based on the environment of deposition. Tailings ponds or controlled deposition sites were studied by Mike Gross (hydrogeology, 1979) and the uncontrolled depositional sites, or the flood plains, were investigated by Dale Marcy (chemistry, 1979) and Marc Norton (hydrogeology). This report considers the hydrogeology of the uncontrolled mine waste deposition sites with a section written by Dale Marcy on the chemistry of the surface and ground water included to give the reader the complete setting. Because of the complex nature of the interrelationship between the chemistry and the hydrogeology, the discussion on the relationship of water quality to mine waste and water movement was co-authored by Dale Marcy and Marc Norton.

Purpose and Objectives

Purpose

The purpose of the study was to delineate alternative reclamation procedures to minimize any long-term effects of the mine wastes (uncontrolled deposition) in the Smelterville Flats study area, Idaho.

General Objectives

The general objectives of the study were to determine the interaction of mine wastes with the surface and ground water flow systems and the subsequent impacts in the Smelterville Flats study area. The information gained from the study was used to develop possible reclamation procedures.

Specific Objectives

To meet the purpose and general objectives, several specific objectives were determined:

1. Describe the vertical and horizontal distribution of mine wastes in the shallow alluvium (less than 20 feet (6.1 meters)) of the undeveloped section of the Smelterville Flats study area.

2. Describe the characteristics of the surface and ground water flow systems in the Smelterville Flats study area with respect to space and time.

3. Describe the characteristics of the surface and ground water quality with respect to space and time in the Smelterville Flats study area.

4. Determine the interrelationships between mine wastes, hydrologic characteristics, and the characteristics of the water quality.

5. Delineate potential alternative reclamation procedures to minimize any long-term effects of mine wastes in the Smelterville Flats study area.

Method of Study

A literature search was conducted to determine the mine development history of the Coeur d'Alene River basin as well as the geology, geomorphology, and the depostional history. A field study was organized to collect data on the distribution and chemistry of the mine waste, surface water flow characteristics, distribution of ground water potential, and surface and subsurface water quality. Based on the literature search and the field data, reclamation procedures were developed and examined for cost and physical feasibility.

Decsription of the Coeur d'Alene River Basin

Location of the Basin

Located in northern Idaho, the Coeur d'Alene River basin lies in the Coeur d'Alene Mountains, which are part of the Bitterroot Range of the Northern Rocky Mountains (Figure 1). The terrain of the basin is rugged with few valley floors exceeding half-a-mile in width, and hill-sides generally inclined at angles of 30 degrees or greater. The rich Coeur d'Alene Mining District is located principally within this basin.

Climate and Vegetation

The climate of the Coeur d'Alene River basin is seasonal with snow occurring during the winter, rain in the spring and fall, with summers usually dry except for occasional thundershowers. The basin receives between 30 and 40 inches of precipitation a year with snow persisting until early summer at the higher elevations. Temperatures range from below 0° fahrenheit (F) to over 100° F (-18° to 38° celcius (C)). Prevailing wind directions are either from the east or from the west, which greatly affects the climate and air temperature of the valley.

Vegetation is abundant throughout most of the Coeur d'Alene River basin. Conifers found in the area include pines, firs, hemlock, cedar, spruce, and larch with deciduous trees such as willows, cottonwoods, alder, and aspen occupying the lower slopes, draws, and valley floors. There are many varieties of brush and grasses including buckbrush, huckleberry, twinberry, redtop, and quack grasses (Hobbs and others, 1965, p. 6). Large stands of timber were logged for use in the mines, for construction, and for fuel. A large forest fire in 1910 destroyed much of the remaining timber. Since then new stands of timber and brush have returned, except where smelter fumes have inhibited return growth.

These bare slopes present a water quality problem because precipitation is not retained in the soil, which yields high rates of surface runoff with high suspended and bedload sediment. Vegetation of these slopes is being attempted by the mining companies. Where the tailings have been deposited in the valley floor, vegetation is also limited in abundance.

Regional Geology

The bedrock in the Coeur d'Alene River basin consists mainly of the Precambrian Belt series which is the host rock for the ore deposits being mined in the basin. The Belt series consists of a thick conformable group of fine-grained argillites and quartzites associated with smaller amounts of carbonate bearing dolomite rocks, laid down in a large geosyncline later to be folded and faulted. Igneous rock in the form of diabase and lamprophyre dikes make up the remaining bedrock. These dikes, possible satellites from the Idaho Batholith, intruded the Belt series during the Mesozoic. The Columbia River Basalts flowed up the lower Coeur d'Alene River in middle Miocene time. Pleistocene continental ice sheets twice dammed the Spokane River near the Idaho-Washington border flooding the Coeur d'Alene River basin (Hobbs and others, 1965, p. 11).

Previous Investigations

In the early 1920's, residents of the lower Coeur d'Alene River valley brought suit against the mines operating in the South Fork of the Coeur d'Alene River for alleged damages to their land resulting in crop loss and death to their livestock. The suit alleged that mine wastes deposited on the land by high water produced changes in the soil, and substances left upon the grass killed the animals that fed on the vegetation (Ellis, 1940, p. 3). As a result the legislature of the

State of Idaho set up a commission to investigate the situation. Dr. M. M. Ellis of the United States Bureau of Fisheries studied the effect of the mine waste upon the fisheries of the region.

> "During the month of July, 1932, no live fish were found in the Coeur d'Alene River from its mouth near Harrison to the confluence of the North and South Forks above Cataldo, nor in the South Fork from its junction with the North Fork to a point above Wallace, that is a 50 mile portion of the Coeur d'Alene River carrying the mine waste and mine slimes was without a fish fauna as far as could be determined" (Ellis, 1940, p. 7).

Ellis reported that steamboat captains assured him that there was 40 to 50 feet (12.2 to 15.2 meters) of water in the channel of the Coeur d'Alene River near the Cataldo Mission in 1912-1917. When measured by Ellis twenty years later, the river contained large bars of mine waste and tailings with only 12 to 15 feet (3.7 to 4.6 meters) of water. The river channel was being dredged so that boat traffic could be maintained. These deposits, because of the mass of material involved, constituted a hazard to certain froms of aquatic life regardless of the chemical composition of the waste (Ellis, 1940, p. 2-3).

In December of 1968, a program was initiated by the University of Idaho to study water quality in the Coeur d'Alene River. The study by Mink (1971) showed that concentration of zinc and cadmium exceeded the toxic limits for fish while most of the other elements' concentrations were slightly greater to comparable to the concentrations in the Coeur d'Alene above the confluence with the South Fork. The water quality data indicated two sources of contamination with a possible third source during high flow in the South Fork of the Coeur d'Alene River. Two of the sources were: 1) Canyon Creek near Wallace; and 2) the South Fork east of Smelterville. The third source was believed to be the old tailings that had been deposited on the valley floor of the South Fork and its tributaries (Mink, 1971, p. 23-26).

The construction of tailing ponds by the mining companies in 1968 improved the quality of the South Fork of the Coeur d'Alene River by preventing the mine waste from being dumped onto the flood plain or into the South Fork. The studies have shown that well-managed tailing ponds are effective in improving the general quality of the water in the South Fork; and are especially effective in reducing suspended solids. But in the Coeur d'Alene Mining District, when the ponds receive effluent other than from the concentrating process, several elements were not effectively removed and could constitute a health hazard to the District (Mink, 1972, p. 138-141).

Galbraith (1971) determined that leaching of heavy metals by ground water passing through the mine waste can be initiated by the oxidation of sulfides through the action of microorganisms. The accumulation of heavy metals occurs in plants that draw ground water from the intermixed tailings and natural alluvium. When these plants are ingested by herbivores, death can result due to metal poisoning. Redtop (*Argrostis alba*), a grass which grows abundantly in the mine waste-natural alluvium mix, was found to accumulate zinc, lead, manganese, iron, copper, silver, and magnesium. Some animals grazing on redtop demonstrate symptoms of metal poisoning. This was verified when the bone marrow from a horse diagonosed as having lead poisoning showed abnormally high concentrations of lead (Galbraith, 1971, p. 90-123).

A field study was undertaken by Norbeck in 1974 to map the alluvial mine waste distribution in the South Fork of the Coeur d'Alene River valley. Air photos and field observations were used for the mapping, depth soundings were made using seismic refraction, electrical resistivity, and well logs were used to determine the alluvial thickness. A water level contour map was drawn based on 88 water level measurements in the valley. The computation of zinc mass transport through the valley alluvium was made based on water quality samples from a Bunker Hill Company well with the cross section based on the well log. With the use of Darcy's Law, a value of 3,330 pounds of zinc per day at a total flow rate of 3,250,000 gallons per day was obtained during the month of August, 1971 (150 kilograms of zinc at a total flow of 1,300,000 liters per day) (Norbeck, 1974, p. 1-40).

Morilla (1975) investigated the hydrogeologic factors that control the movement of ground water through an abandoned tailings pond located west of Smelterville. Based on the data collected, Morilla determined that the flow system of the tailings pond was dynamic, responding rapidly to precipitation and to periods of no recharge (Morilla, 1975, p. 72).

In 1973, construction of a sewage treatment facility of the abandoned Page Tailings Pond instigated further studies (Hitt, 1974). The sewage from most of the South Fork valley is gravity fed or pumped to the pond for treatment. The loading impact and increased ground water recharge resulting from the filling of the sewage lagoon in July, 1974, was exhibited by rises in the ground water levels under and near the lagoons. Several springs and seeps occurred along the edges of the dikes (Hitt, 1974, p. 9-17) which were still flowing in 1977 and 1978, with tailings material coming out of one of the seeps.

A study was conducted by the University of Idaho in the Bunker Hill Company tailings pond considering leakage and seepage control from the pond (Williams, and others, 1977). A detailed size analysis was conducted in conjunction with the determination of the engineering properties of the tailings material. The hydrochemistry and hydrogeology were analyzed for the tailings pond.

DESCRIPTION OF THE SMELTERVILLE FLATS STUDY AREA

Introduction

The Smelterville Flats study area was selected to demonstrate an uncontrolled depositional site for mine waste in the South Fork of the Coeur d'Alene River valley. The site is the largest undeveloped deposit of mine waste in the valley. It contains both periods of mine waste generation with deposits of the early jig tailings and the later chemical flotation tailings. The Bunker Hill Company, who owns most of the land, allowed the University of Idaho to do the study on the Smelterville Flats site.

The study area encompasses part of the flood plain of the South Fork of the Coeur d'Alene River west of Kellogg, known as the Smelterville Flats. The boundaries and the land use of the study area are shown in Figure 2. The municipal land use is limited to the townsite of Smelterville, while industrial use is varied. Industrial uses include the Shoshone County Airport, Interstate-90, a lumber yard, and two sewage lagoons. One of these lagoons was built on an abandoned tailings pond, with the second being built solely for sewage disposal. A drive-in-movie theater is located just east of the study area. Recreational use includes a car-snowmobile race track, a race track and hill climbs for motorcycles (Figure 2). The motocross track was constructed by the Bureau of Land Management on their land, but is maintained by the people who use the track. Because of dust problems, the motorcycle race track is not used very often during the summer months.

The climatic pattern described in the preceeding chapter was general because the weather changes with elevation. The elevation of the Coeur d'Alene River basin varies from 2,125 feet above sea level

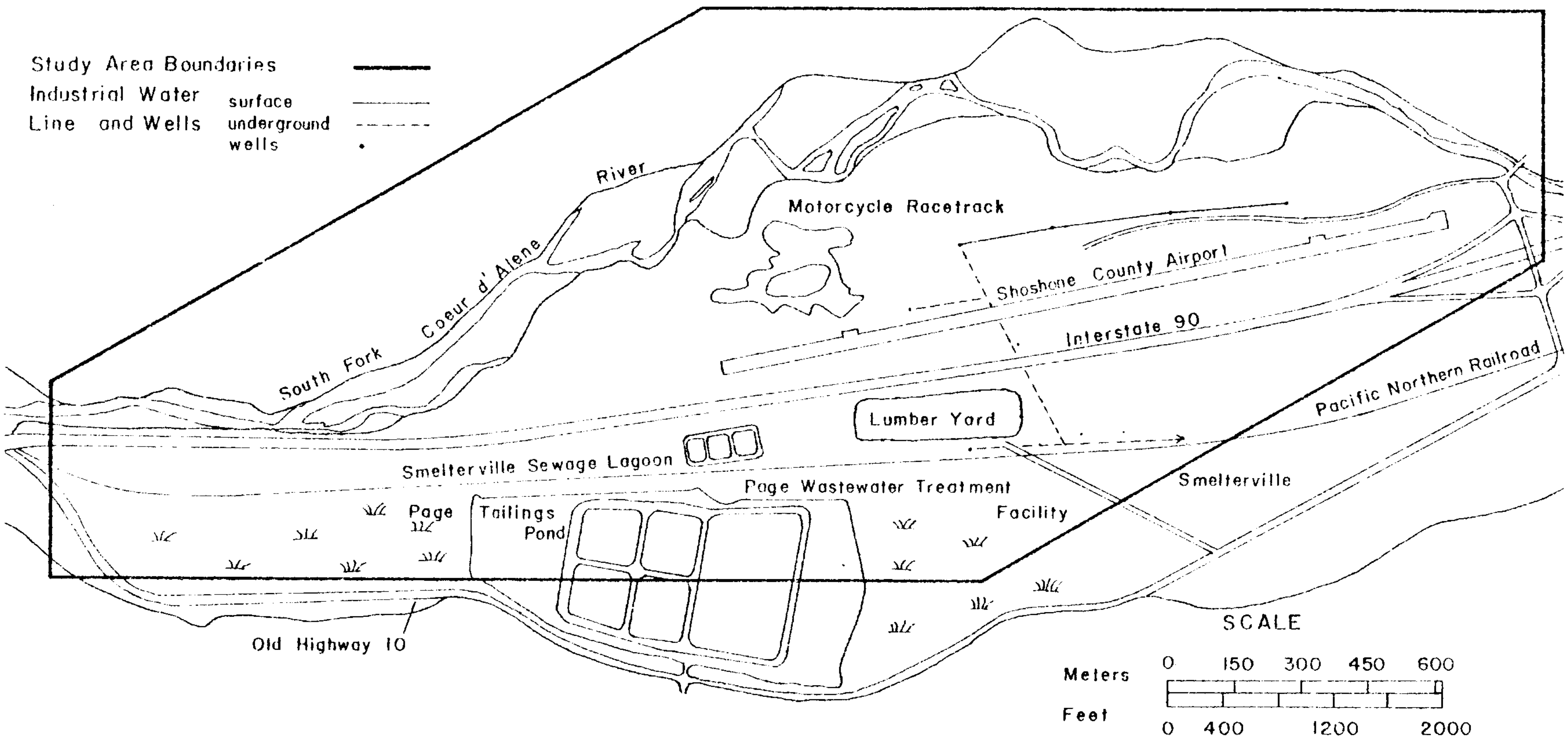


FIGURE 2. Location of study area boundaries and land use, Smelterville Flats study area.

at Coeur d'Alene Lake to 2,200 feet at Smelterville, to over 6,800 feet at Stevens Peak, a nearby mountain (666 to 670 to 2,084 meters above sea level). The study area is located on the valley floor and displays a more moderate climate than the surrounding mountains, as the summer temperatures are generally higher and winter temperatures not as cold. For this reason snow does not generally accumulate on the valley floor; however, during the data collection period (June, 1977 to September, 1978) snow reached a maximum depth of three feet (.97 meters) and stayed for several weeks. Precipitation data are collected by the Bunker Hill Company at a site near the Environmental Affairs Office in Smelterville. The Company has a minimum of thirty years of record of mean monthly precipitation. Average annual precipitation for the study area is 30.80 inches (78.23 centimeters). Most of the precipitation occurs in the winter in the form of snow with July receiving the lowest amount of precipitation (Figure 3).

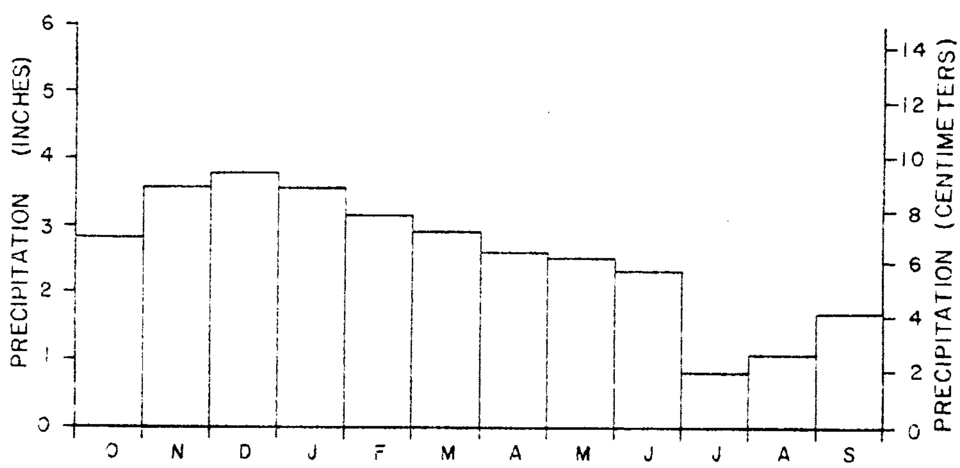


FIGURE 3. Mean monthly precipitation for the Smelterville Flats study area based on a minimum of 30 years of records.

Deciduous trees and grasses make up most of the vegetation found in the study area. A list of plant types found in the study area and an estimate on their population is given in Appendix V. Plant identification was done by Robert Murray, North Idaho College at Coeur d'Alene, and Ed Pomerainian, Forester for the Bunker Hill Company.

Geology

Bedrock

Fine-grained argillites and quartzites of the Precambrian Belt series make up most of the bedrock, which is overlain by alluvial material. Several small dikes outcrop along the valley walls near the western end of the study area. Except where fractured or faulted, the bedrock has a very low saturated hydraulic conductivity value and is assumed to be a no-flow boundary (Trexler and others, 1975, p. 44). There are two major mines near the study area: the Page Mine, which is inactive at this time; and the Bunker Hill Company, which is the largest mining and milling operation in the South Fork valley. Pyrite, an important ingredient in acid formation in the waste deposits, is abundant in the Prichard Formation, which is host to part of the ore bodies tapped by the Bunker Hill and Page mines. Pyrite is also abundant in the waste rock. The bedrock geology plays no major role in the hydrology except as a no-flow boundary. More detail on the geology can be obtained through Hobbs and others, 1965.

Alluvium

There were two periods of aggradation in the Coeur d'Alene River basin. Prior to the basalt flows of the middle Tertiary, the channel of the Coeur d'Alene River was incised to a depth comparable to the present. The damming of the ancient Coeur d'Alene River (Spokane

River) by the Columbia River Basalts near the Idaho-Washington border occurred during middle Tertiary causing accumulations of alluvial material behind the basalt dam to range in depths from 800 to 1,100 feet deep (244 to 335 meters). With continual uplift of the mountains to the east, the streams draining west cut through the basalt dam and eroded most of the gravels deposited behind it. Remnants of the basalt dam and the gravels are still visible today. Approximately 35 million years after the basalts dammed the river, lobes of the Cordilleran ice sheet advanced sufficiently southward to dam the Coeur d'Alene River near the present town of Coeur d'Alene, Idaho. A large lake formed behind the ice dam with the backwaters extending to Wallace, Idaho. Streams originating in the surrounding mountains deposited their sediment load into the backwaters of the ice dammed lake. The material which formed the lake bed deposit graded finer with increased distance from the sources. The material deposited over the gravels in the vicinity of the study area was a twenty-five foot (7.6 meters) thick bed of clay. When the ice dam failed, the old South Fork of the Coeur d'Alene River cut a channel through the clay layer. During the last period of glaciation (Wisconsin) large amounts of sediments were eroded when the valley glaciers melted. These sediments were carried downstream, filling the channel previously cut in the clay layer by the old South Fork, and covered the valley floor downstream. The South Fork of the Coeur d'Alene River is still an agraded river from Wallace to the confluence with the Coeur d'Alene River (Hobbs and others, 1965, p. 63-71).

When mining began, mill wastes dumped into the South Fork of the Coeur d'Alene River mixed with the native alluvial material on the flood plains or were deposited in the river channel. Norbeck (1974) mapped the surface distribution of mine waste and alluvial deposits in the South Fork of the Coeur d'Alene River valley (Figure 4) and determined the depth to bedrock at several locations using seismic refraction, electrical resistivity, and well logs. Cross sections were drawn based on the estimates of the thickness of the valley alluvial material (Figure 5). Moving east to west, the valley becomes narrower and deeper with the cross sectional area reduced from about 600,000 square feet (56,000 square meters) at cross section C-C' to 60,000 square feet (5,600 square meters) at A-A'. Cross section C-C' is based on the log of one of several industrial wells located in the study area. Well logs and locations are presented in Figure 6.

Two of the three well logs (B.H. 6 and B.H. 8) available on the Bunker Hill Company wells in the study area show the four major lithologic layers: 1) the mine waste-native alluvium mix, 2) the sandy gravel deposited by the melting valley glaciers, 3) the clay layer deposited in the ancient lake, and 4) the gravels deposited behind the basalt dam. The third well log (B.H. 7) has only layers 1 and 2 with broken wall rock fragments (talus) and sand below layer 2. This well is believed to be located in the buried river channel. The log of a well (6Y) drilled during the study period supports the depositional history outlined above (Figure 6). The Bunker Hill Company reported similar well logs from around their tailings pond east of the study area. The clay layer separates the upper and lower gravel layers in parts of the study area based on Bunker Hill Company well logs, water level records, and drilling done during the study period.

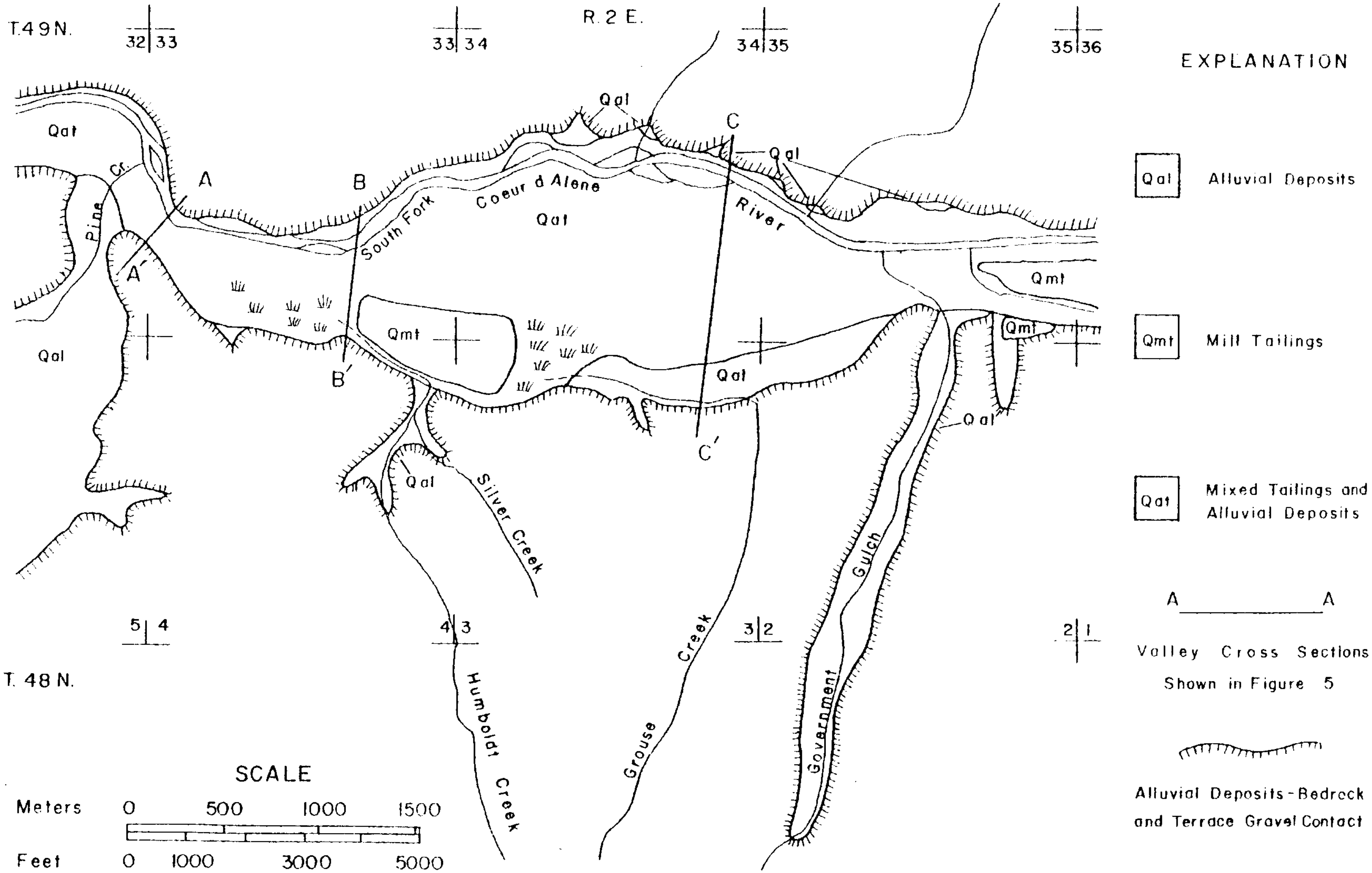


FIGURE 4. Surface distribution of mine wastes and alluvial deposits, Smelterville Flats study area (from Norbeck, 1974).

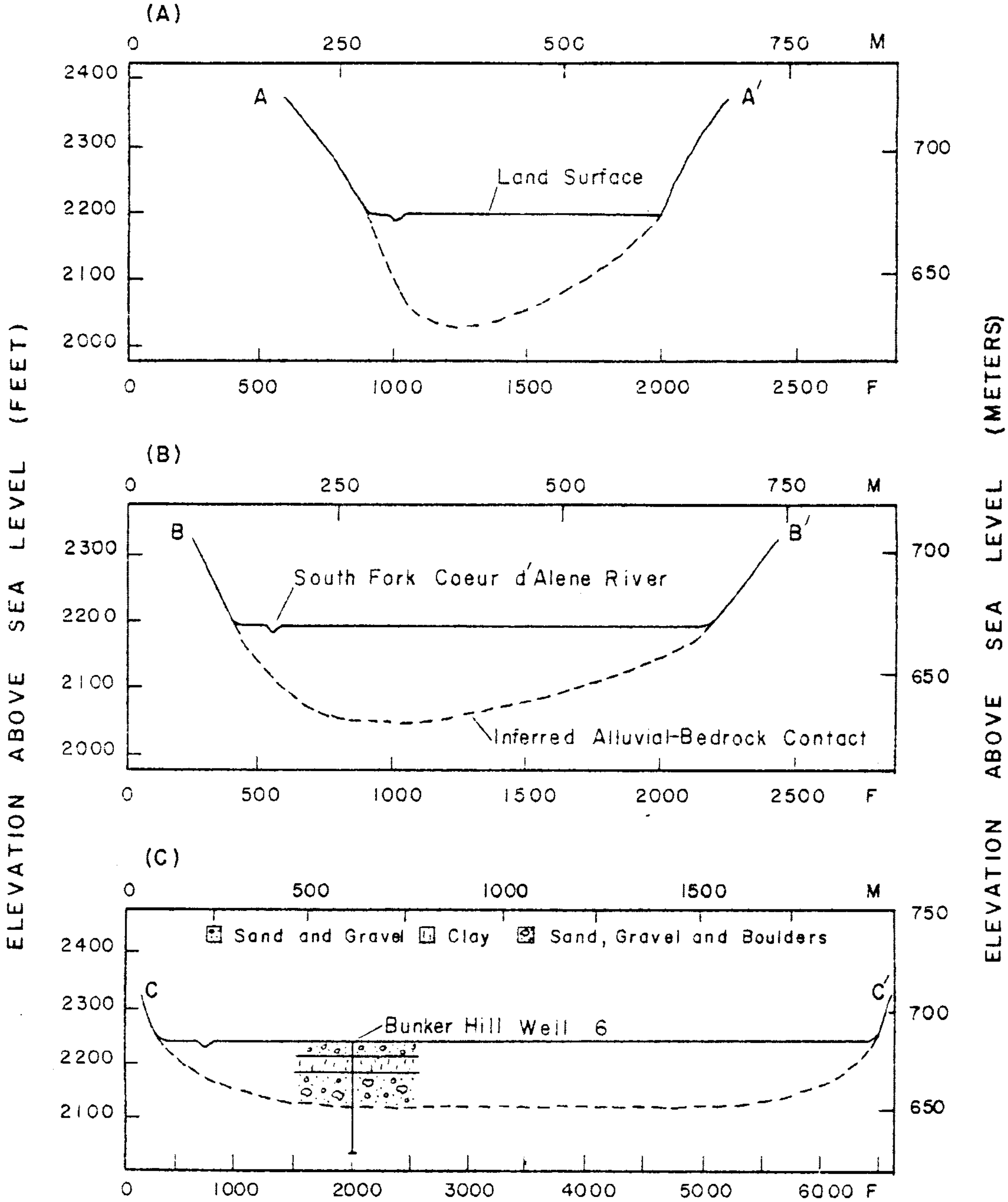


FIGURE 5. Cross sections of the South Fork of the Coeur d'Alene River valley at: (A) Pine Creek, (B) west end of Page Pond, and (C) Smelterville, Idaho, Smelterville Flats study area (from Norbeck, 1974).

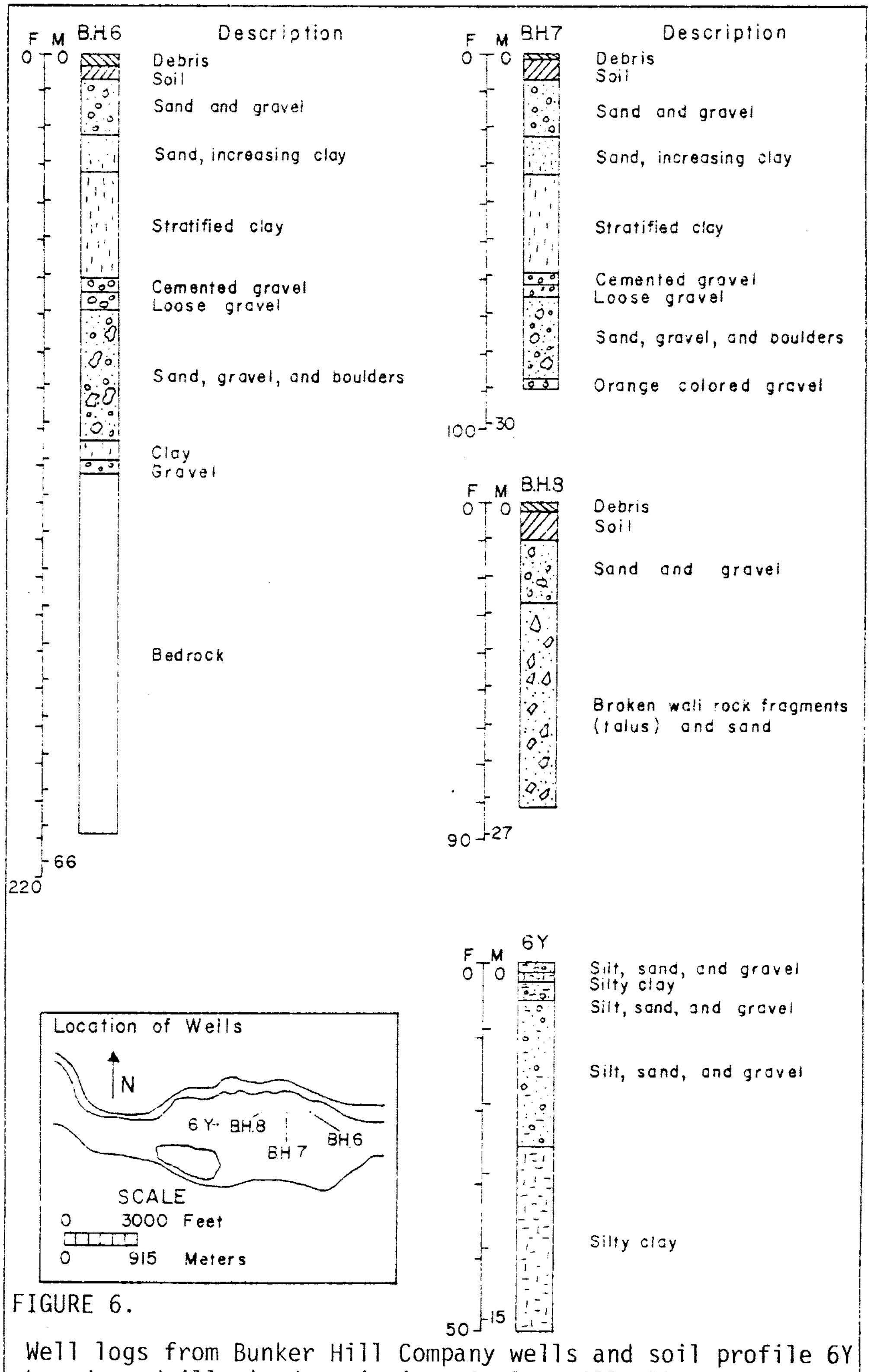


FIGURE 6.

Well logs from Bunker Hill Company wells and soil profile 6Y based on driller's description, Smelterville Flats study area.

Hydrology

Surface Water

The mean monthly discharge rate for the South Fork of the Coeur d'Alene River is presented in Figure 7 and is based on twelve years of record from a combination of two United States Geological Survey stream gaging stations located near the study area. The hydrograph shows the snow melt period of May and June while the low flow comes after the normally dry summer months.

Most of the tributaries of the South Fork of the Coeur d'Alene River in the study area are perennial. The creeks that drain the ridge north of the study area are intermittent with flow only during the snow melt period or due to heavy rains. Humbolt, Silver, and Grouse Creeks drain the ridge to the south, discharging into the swamp around the Page Wastewater Treatment Facility which is located on an abandoned tailings pond (Figure 4). The swamp discharges nearly year-round and empties into the South Fork at the western end of the study area.

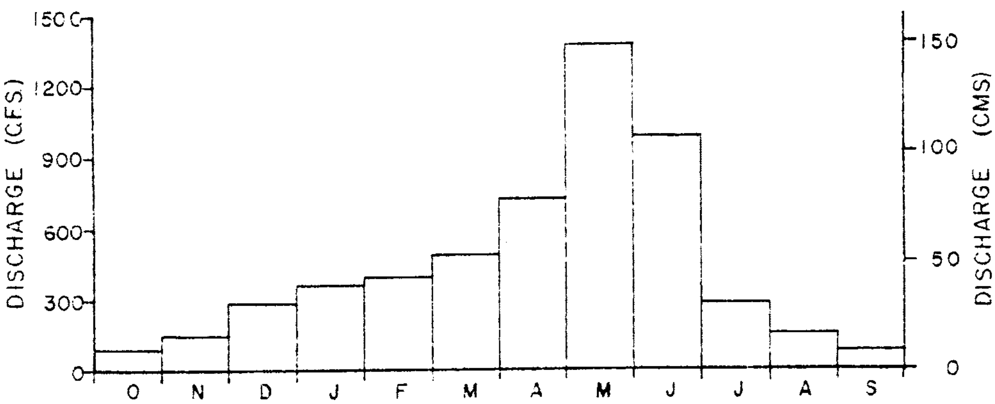


FIGURE 7. Mean monthly discharge of the South Fork of the Coeur d'Alene River at Kellogg, Idaho based on twelve years of record.

Several ponds are present in the study area. The ponds vary in size, water quality, bottom material, and source of water.

Ground Water

Based on available well logs, the ground water system in the study area includes an upper and lower aquifer separated by a discontinuous 25 foot (7.6 meters) thick clay layer. The upper aquifer consists of silt, sand, and gravel with the upper five to ten feet (1.5 to 3.0 meters) consisting of a mixture of mine waste and native alluvium. The lower aquifer is composed of sand, gravel and fractured wall rock (talus). The lower aquifer is tapped by the Bunker Hill Company for industrial use, while the upper aquifer is not used.

Data Collection System

Soil profiles were constructed and samples were collected and analyzed to determine the depth of mine waste, the presence and concentration of certain elements within the soil, and the relationship between size fractions and concentrations. Water level data from piezometers were utilized to describe the interrelationship of precipitation and river discharge with the ground water flow system. Water quality data were utilized to describe the leaching of metals from the abandoned mine wastes. Water quality, water levels, and soil samples were used to determine if the abandoned mine wastes are a source of heavy metal pollution to the water resource system.

Soil Sampling

A hollow stem auger was used for sampling the shallow alluvial material. Nineteen sites were laid out in two parallel lines extending north-south and approximately perpendicular to the direction of ground water flow. All of the sites were drilled to a depth of twenty feet

(6.1 meters) except 6Y, which is fifty feet (15.2 meters) deep. Location of well 6Y is shown in Figure 6. An attempt was made at 6Y to reach the lower aquifer; the drilling ceased above the lower aquifer because of insufficient auger flight. Samples were taken every five feet (1.5 meters) with a split spoon sampler (18 inches by 2 inches (45.7 cm by 5.0 centimeters)). Grab samples were taken midway between the split spoon samples and at changes in soil color, texture, or grain size. The samples were logged, tagged, and stored in plastic bags. Changes in drilling speeds were also recorded.

Soil pits were constructed with shovel or a backhoe to allow more detailed examination of the soil profile and a more accurate sampling program. Soil pits constructed with the shovel range in depth from four to seven feet (1.2 to 2.1 meters) depending on when the river gravels were encountered. A truck mounted backhoe from the Department of Soils, University of Idaho, was used to reach depths of eleven feet (3.4 meters) deep and allowed the examination and sampling of the soil profile at depths not reachable by shovel. Sampling was done in one of two ways: 1) at 0.5 foot (15.2 cm) intervals from the bottom of the pit to the surface (control pit) and 2) at selected beds for comparison with the control pits. A chrome plated hand trowel was used to prevent soil contamination during collection. The samples were logged, tagged, and stored in plastic bags. Soil pit locations are shown in Figure 8 by the type of construction used. Soil profiles based on soil samples and changes in drilling speeds were drawn for each soil pit and are presented in Appendix I.

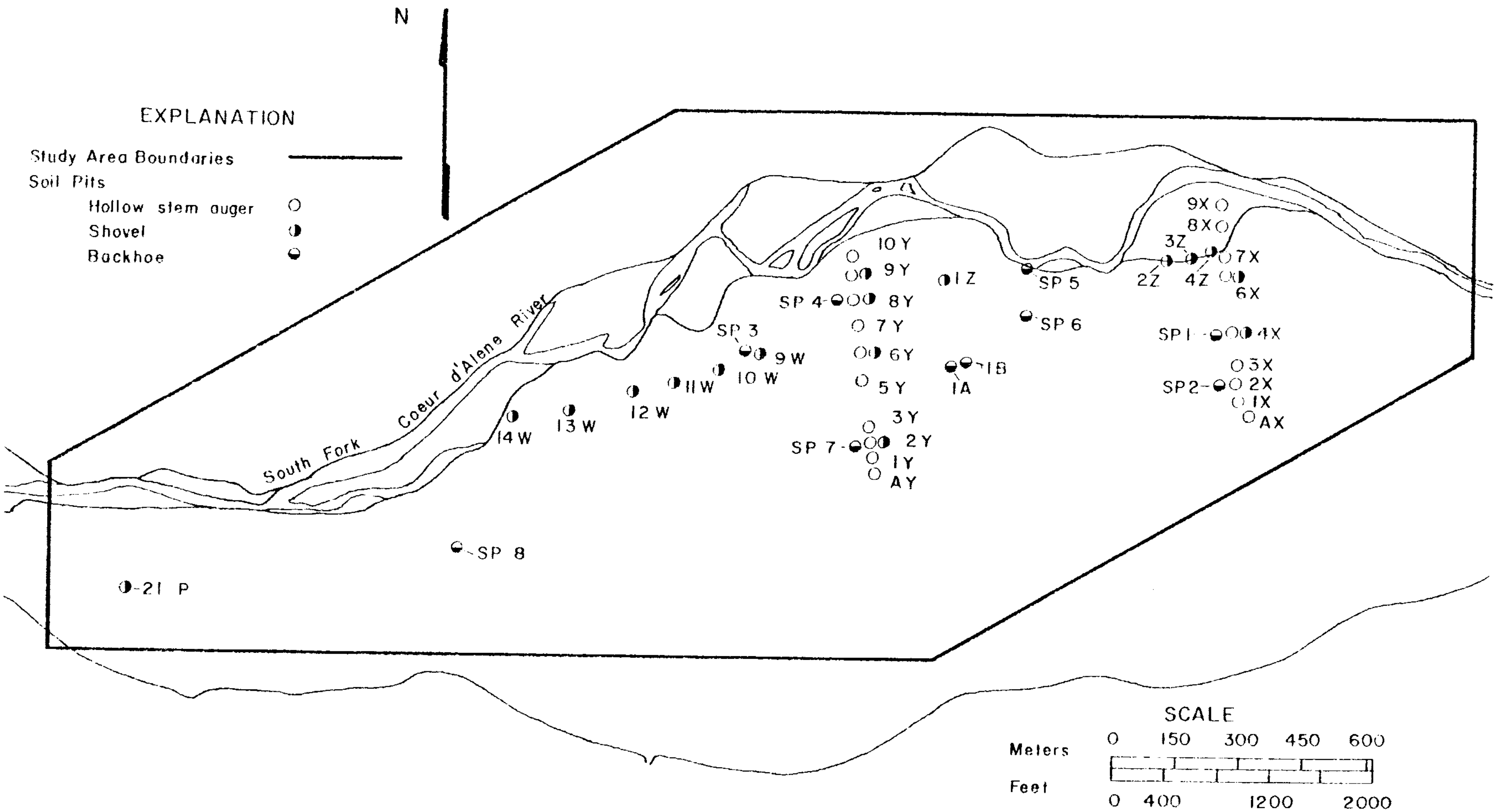


FIGURE 8. Location of soil profiles, Smelterville Flats study area.

The soil samples were taken to the laboratory at the University of Idaho for processing. The samples were dried, sieved, and each size fraction was digested by wet chemistry methods and then analyzed using an atomic absorption spectrometer. Sieve sizes for the soil classification are given in Table 1. For more detail on the sample digestion procedures, see Marcy (1979). The soil samples were analyzed by Dale and Lynn Marcy for cadmium, zinc, lead, iron, maganese, calcium, and magnesium. These values are presented in Appendix II.

Table 1. Sieve sizes for soil samples, Smelterville Flats study area.

Soil Pit Type	Size Fraction (mm)	Grain Size Classification
Control Pits	> 2.362	gravels
	2.362 to .417	very coarse to medium sand
	.417 to .208	fine to very fine sand
	.208 to .075	silt
	.075 >	clay
Selective samples	> .180	gravels to fine sand
	.180 >	very fine sand, silt, clay

Piezometer Construction

Piezometers were installed in the hollow stem auger holes and in the soil pits. A posthole pounder driving two inch (5.0 cm) flush-coupled casing fitted with a polyethylene drive point was also used in the piezometer construction. Three-quarter inch (1.9 cm) polyvinyl chloride (PVC) pipe was used for most of the piezometers (Figure 9A and 9B). Five of the piezometers installed in soil pits dug with the backhoe had four inch (10.2 cm) PVC pipe (Figure 9C). The bottom twelve inches (30.48 cm) of the casing was perforated with a saw or a drill, then wrapped with fiberglass screen which was taped in place. The pipe was lowered into the holes or into the hollow stem auger flight with clean quartz sand being used to backfill around the slotted section when

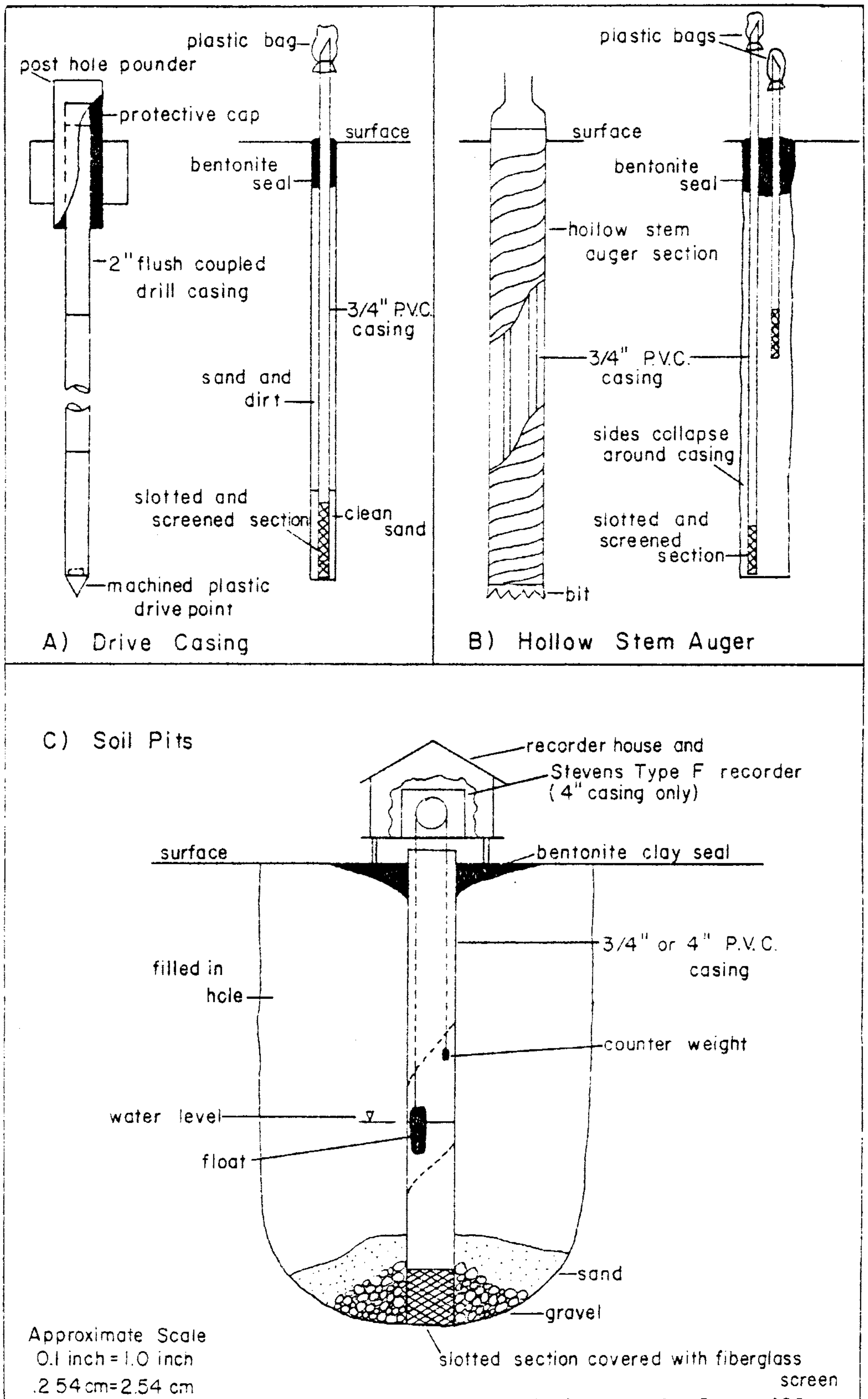


FIGURE 9. Piezometer construction techniques, Smelterville Flats study area.

possible. The auger flight and flush-coupled casing were backed out and the sides were allowed to collapse around the piezometers. Soil pits were backfilled with the material removed to construct the hole. Bentonite clay was used at all of the sites in the upper foot (30.48 cm) to prevent downward movement of water from the surface through the disturbed material. The PVC pipe was extended two to five feet (0.6 to 1.5 meters) above the surface with the top being cut at an angle to provide a measuring point. Plastic bags were placed over the top of piezometers to prevent foreign material from entering the piezometers (Figure 9A, B, C).

Water Level Measurement

The data on depth to water in piezometers were obtained using a chalked steel tape approximately every two weeks from July, 1977, through September, 1978. These data are presented in Appendix III. Water level data were also obtained from staff gages installed in Pond #204 (S.G. 2, Figure 10) and in the South Fork of the Coeur d'Alene River near piezometer 10Y (S.G. 1, Figure 10). Battery powered Stevens Type F recorders were installed on the four inch (10.2 cm) cased piezometers to provide continuous records of water level fluctuations. With the use of the University of Idaho's IBM computer and plotter, hydrographs, contour maps, and three-dimensional diagrams of the potentiometric surface were drawn depicting the direction of ground water movement. Water level measurement sites are presented in Figure 10.

Water Quality Sampling

Initially, ground water samples were retrieved by lowering a plastic test tube into the piezometer. The piezometers were not bailed before sampling. Early field techniques used metal nuts glued to the

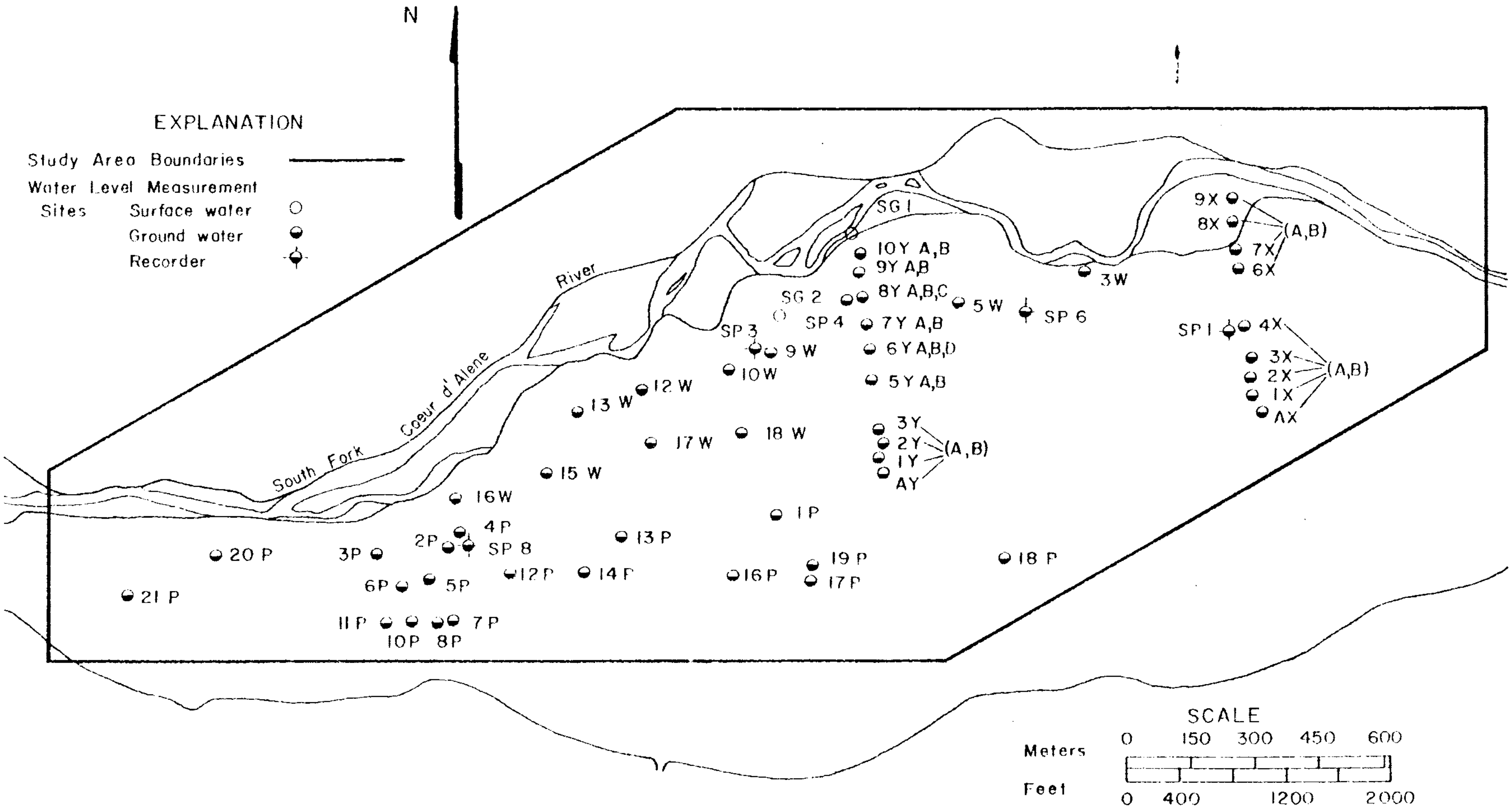


FIGURE 10. Location of water level measurement sites, Smelterville Flats study area.

top of the test tube for weight, but this method was abandoned because of probable heavy metal contamination from the plated nuts. An aluminum tube with a lead plug sealed in the bottom for weight was designed to prevent contamination of the water sample. The sample tube was rinsed twice with demineralized water before being lowered into the piezometer. Approximately 200 milliliters (ml) of water was withdrawn and placed in an acid washed 250 ml linear polyethylene (LPE) bottle. Temperature and pH data were taken in the field with a mercury thermometer (C) and a Sargent Welch meter, respectively. When Eh was measured, it was done at the sample site with an Orion Redox Electrode. In the field lab, the electrical conductivity (EC) of each sample was measured with a Yellow Springs Instrument (YSI) before being filtered through a 0.45 μ filter paper in a Millipore apparatus. The filtrate was transferred to an acid washed 135 ml LPE bottle which contained 6.5 ml of 1:1 HNO_3. At the University of Idaho laboratory, the samples were diluted with 2.4 percent HNO_3 to get a sample concentration more suitable for analysis on an atomic absorption spectrometer for zinc, cadmium, lead, iron, and manganese. A lanthanum solution was added to the samples to give a final concentration of 1 percent lanthanum (vol/vol). Solutions were then analyzed for calcium and magnesium on the atomic absorption spectrometer. The concentrations were corrected for blanks and reported as metal concentrations in milligrams per liter (mg/l) (Marcy, personal communication, 1978). Water quality data are presented in Appendix IV with sample locations shown on Figure 11. The sampling and analyzing methods were in direct accordance with the Environmental Protection Agency (Manual of Methods for Chemical Analysis of Water and Wastes, 1976).

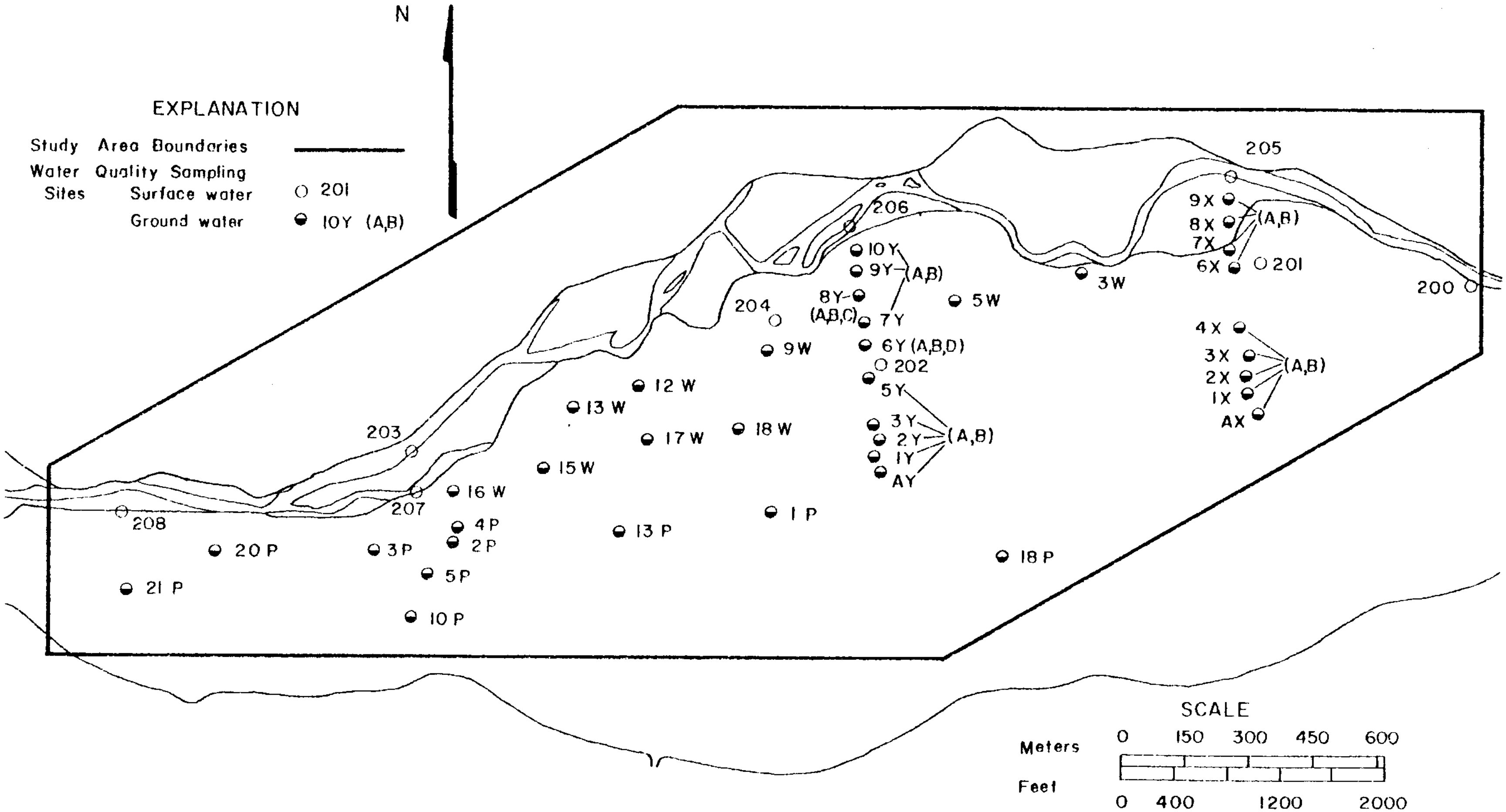


FIGURE 11. Location of water quality sampling sites, Smelterville Flats study area.

DISTRIBUTION AND CHARACTERISTICS OF MINE WASTES IN THE VALLEY ALLUVIUM

Developments in the Mining Industry

The first concentrator or stamp mill started operation within a year after Noah Kellogg discovered galena along the South Fork of the Coeur d'Alene River. Mechanical hammers were used to crush the ore to a suitable size for shipping. A method known as jigging was used to separate the heavy and light grained materials resulting from the crushing process. Mink (1972, p. 7) describes the jigging method as:

> "In its simplest form a jig consisted of a box without a top and with a perforated bottom. A shallow bed of grains was formed by fluctuating water currents. The heavy grains passed to the bottom, intermediate mixtures remained in the middle; and the lightest rose to the top of the bed. Some devices were hand-operated or power-driven units in which the jig was moved up and down in the water; others were stationary jigs in which the water was pulsated by plungers or paddles."

After being washed from the jig tables the waste rock was dumped onto the flood plain or directly into the South Fork of the Coeur d'Alene River. The jig tailings, one-quarter inch to microscopic (rock powder) in size, were often high in lead and zinc. A method was not available to process lead and there was no attempt to remove the zinc. Lead assays for typical tailings were 0.90 - 1.5 percent, as the jigging method only removed the heaviest ores (Mink, 1972, p. 8).

The chemical flotation method was started in 1916 and gradually replaced the jigging method by 1928. After grinding the ore to a fine-grained pulp, chemicals which bind with the metal ion are then added and the mixture is sent through agitators which forms a froth. Particles of the ore cover the froth which is skimmed off and sent to thickners where the ore settles before being filtered into the final concentrate. This process is repeated for each metal to be extracted with the remaining pulp being discharged as tailings (Mink, 1972, p. 8). The selective chemical flotation method resulted in nearly complete extraction of metals of economic importance, so lower grade ore could be mined economically.

The average grain size of the waste was reduced to silt size (0.200 mesh) and smaller. Because of the reduction in the size of the tailings, or slimes as they are termed, the South Fork and the main stem of the Coeur d'Alene River were able to transport the flotation tailings for longer distances than the jig tailings. Large deposits of tailings material formed in the slow sections of the channel and on the flood plains of the South Fork as well as the Coeur d'Alene River below the confluence with the South Fork. A large delta formed where the Coeur d'Alene River empties into Coeur d'Alene Lake. In 1974 two studies were conducted on material deposited in the delta and on the lake bottom. High concentrations of antimony, cadmium, copper, lead, silver, and zinc were found in the sediments collected from the delta and the lake bottom (Maxfield and others, 1974 A, p. 1-6, and Maxfield and others, 1974 B, p. 263-266).

Increased efficiency of the selective chemical flotation method made it profitable to rework jig tailings deposited along the South Fork of the Coeur d'Alene River and its tributaries. Waste deposits along Canyon Creek, Ninemile Creek, Big Creek, and the South Fork were processed from 1943 to 1948. The equipment used removed most of the jig tailings, but mixed the remaining mine waste with the upper native alluvium (Norbeck, 1974, p. 12).

The use of tailings ponds to treat mill wastes began in the 1920's but did not gain widespread use until 1968 when they were constructed to meet federal mining regulations. One of the two mining companies with direct depositional impact on the Smelterville Flats study area began construction of their tailing pond in the 1920's, approximately one mile upstream. It is not known what percentage of the tailings were deposited in the pond. The second mining company, located south of the study area, deposited their tailings between the old highway and the railroad tracks until sometime after 1937, when they constructed embankments around most of their deposits (Figure 12). The waste from the mining companies upstream from the Smelterville Flats accumulated on the flood plain within the study area from stream deposition.

A series of dams were built across the South Fork in the early 1900's to stop the downstream migration of mine wastes as a result of a law suit filed by the residents of the lower Coeur d'Alene River valley against the Mine Owners Association. The residents claimed that during high flow, mine wastes were deposited on their fields located on the flood plain. These deposits were believed to be the cause of death of livestock that were pastured in the fields contaminated by mine waste. One of these dams was constructed (1901) at the west end of the Smelterville Flats study area, but was abandoned in 1930 and mostly destroyed by a flood in 1932-1933 (Clements, 1978, personal communication). Remnants of the dam are still visible on the north side of the valley (Figure 12). Mine wastes deposited behind the dam covered a large portion of the Smelterville Flats.

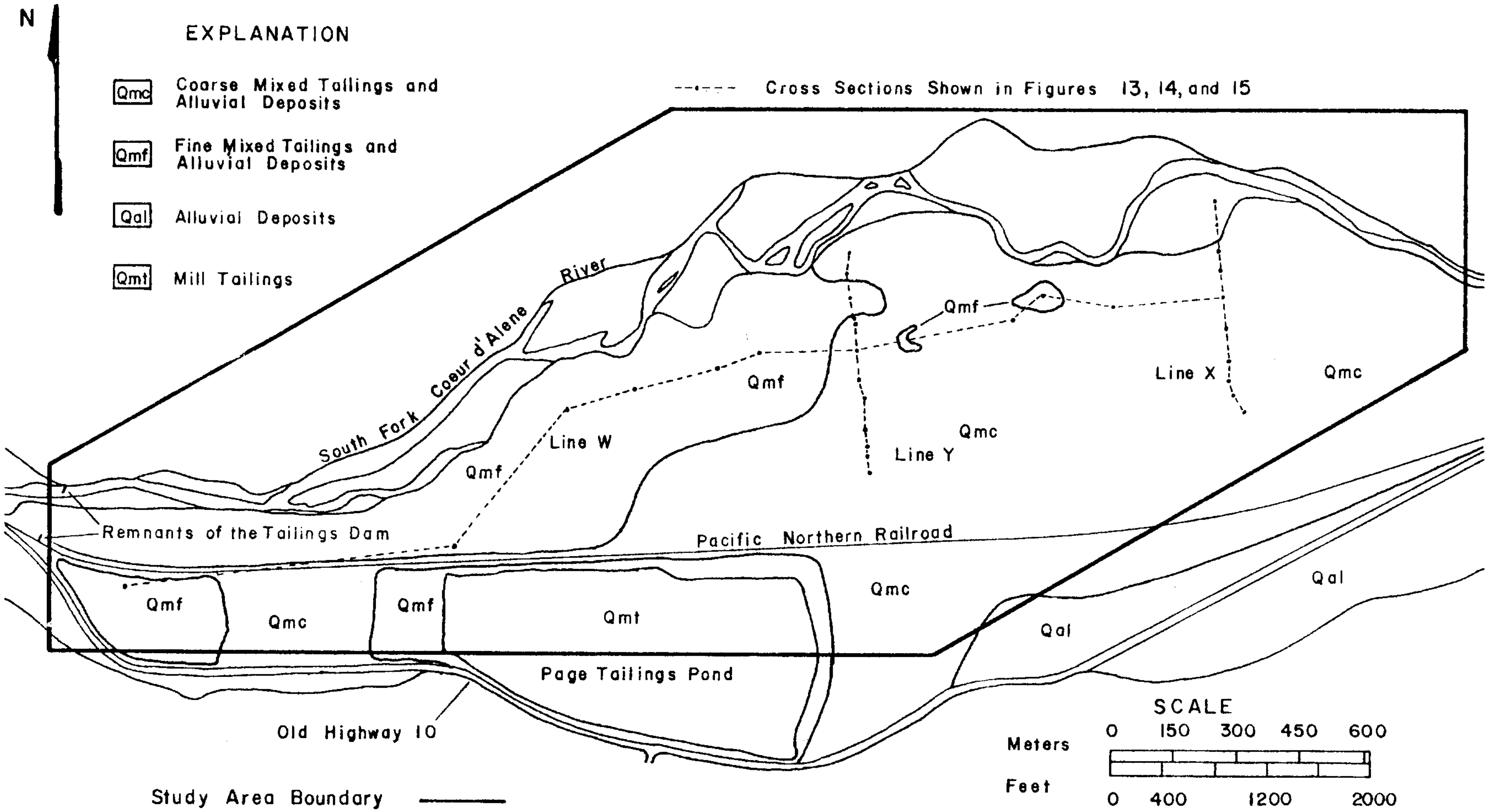


FIGURE 12. Surface distribution of mine waste and location of cross sections, Smelterville Flats study area.

Distribution of the Mine Waste

Spacial Distribution

The distribution of mine wastes within the study area was mapped with more detail than Norbeck (1974) (Figure 12). With the use of air photos dating back to 1937 and field observations, the tailings deposits were delineated into coarse tailings (jigging method) and fine tailings (rock powder and flotation tailings). As the South Fork of the Coeur d'Alene River entered the Smelterville Flats, the coarser, larger grained sediments were deposited. The finer sediments were deposited at the west end of the study area in the backwaters of the dam constructed to prevent downstream movement of tailings by the South Fork. The waste material from the Page mine was deposited between the Pacific Northern Railroad tracks and Old Highway 10 (Figure 12). The waste on the north side of the tracks is from upstream mining operations.

Vertical Distribution

The geologic logs from the auger holes were of limited value in delineating the wastes as caving and mixing of the grab samples made it difficult to determine changes in the sediments. The large gap between the split spoon samples (5 feet or 1.5 meters) coupled with the loss of some soil samples, or an incorrect sample, added to the difficulty. Under saturated conditions, some of the samples were washed out of the sampler, or sand would come up the inside of the auger flight, preventing the sampler from sampling the real material. Changes in drilling rates indicated differences in the alluvial material, especially the gravel zones. Cross sections (Figure 12) were drawn based on the soil profiles from the auger holes, the soil pits, and the geologic logs from Bunker Hill Company wells #6, #7, and #8. Based on this information, the lower limit of the mine waste was determined to be the top of the river gravel which was generally encountered between five to ten feet (1.5 to 3.1 meters) below the surface. Cross section X (Figure 13) shows the mine waste-native alluvium mix which is the surficial layer of the upper aquifer. This layer has been eroded by the South Fork of the Coeur d'Alene River along the northern part of cross section X. Several of the auger holes in cross section X reached the clay layer which separates the two aquifers. Cross section Y (Figure 14) shows similar features as cross section X, except that the clay layer was only encountered at station 6Y where the auger hole penetrated most of the clay layer. Fingers of the fine grained material deposited in the dam's backwaters are evident beneath station 6Y and 8Y, while the rest of the cross section shows a mixture of silt, sand, and gravel. Cross section W (Figure 15) shows the zone of fine grained material that was deposited behind the dam, which grades coarser towards the east as a result of natural flood plain deposition. The probable location of the buried river channel is noted at the break in the clay layer at B. H. well #8.

Mine Waste Characteristics

The type of soil at the Smelterville Flats study area is based on the size fractions of mine waste that are mixed with the soil. Type one is indicative of the coarse grained jig tailings because the size fractions are silt, sand, and gravel; while the second type of soil is indicative of the finer fraction of the tailings (rock powder and flotation) and consists of clay, silt, and sand. The type of soil found is location oriented, based on whether the alluvial material was deposited in the backwaters of the dam (type 2) or by the South Fork

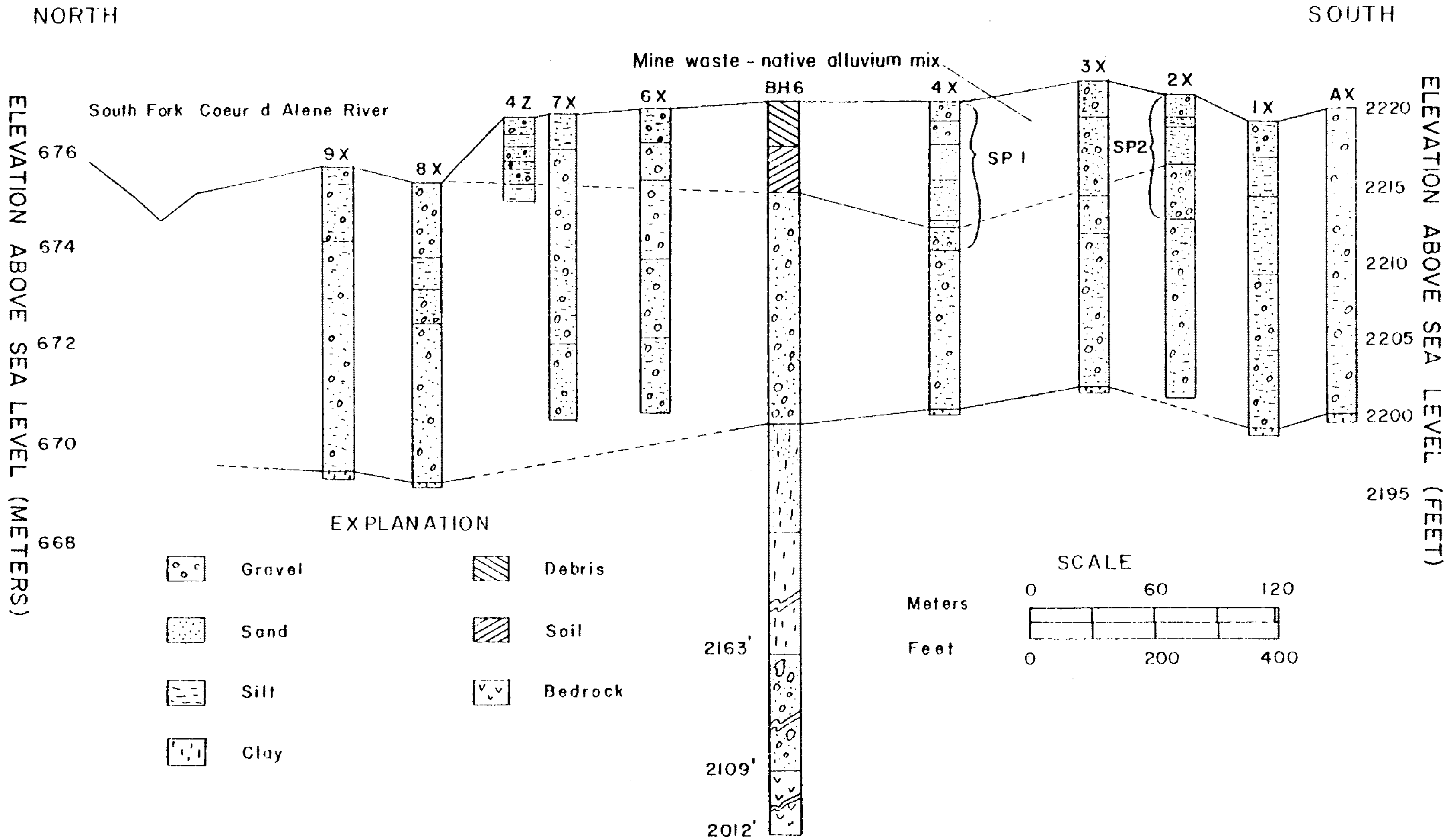


FIGURE 13. Cross section Line X, Smelterville Flats study area.

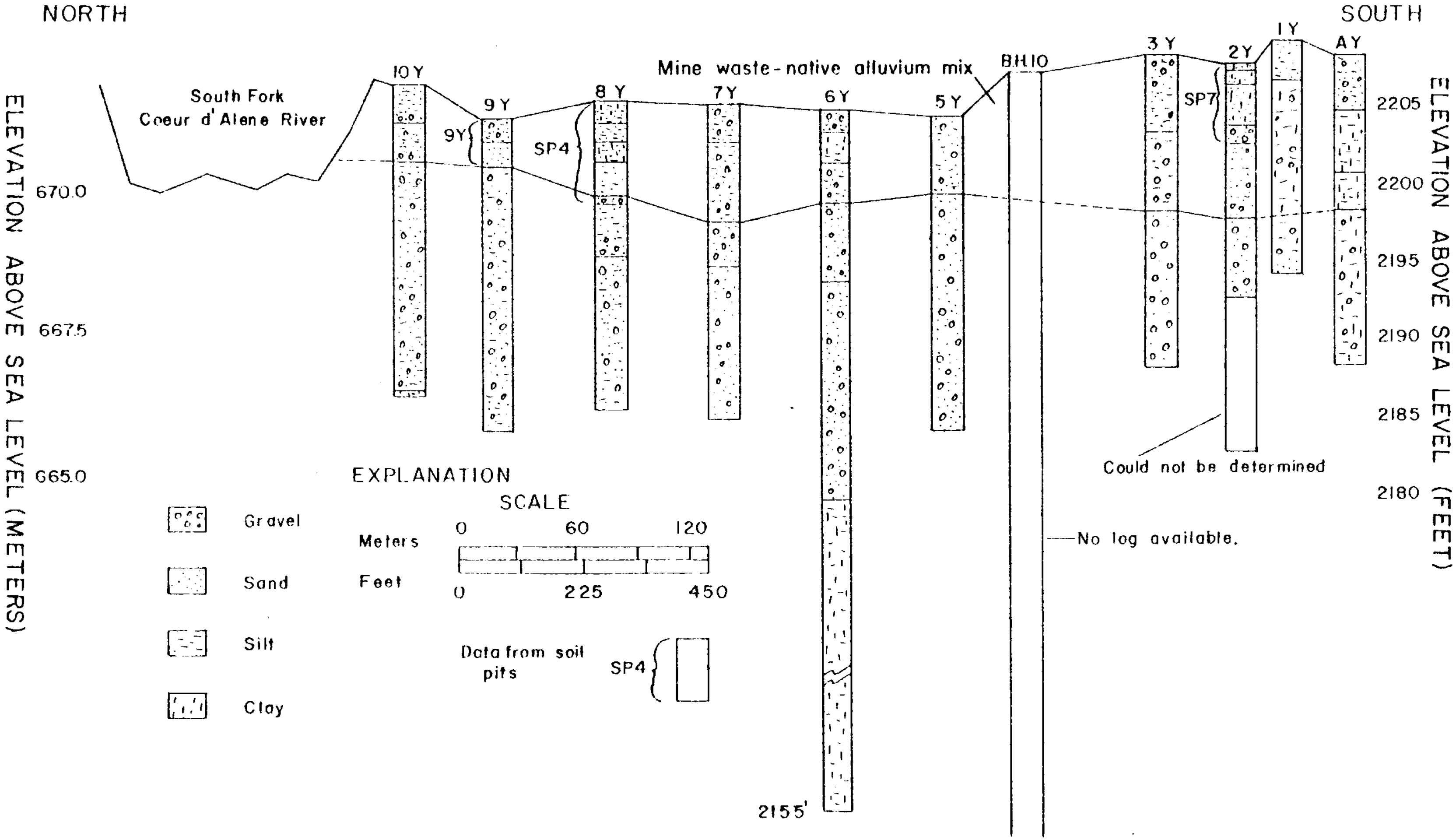


FIGURE 14. Cross section Line Y, Smelterville Flats study area.

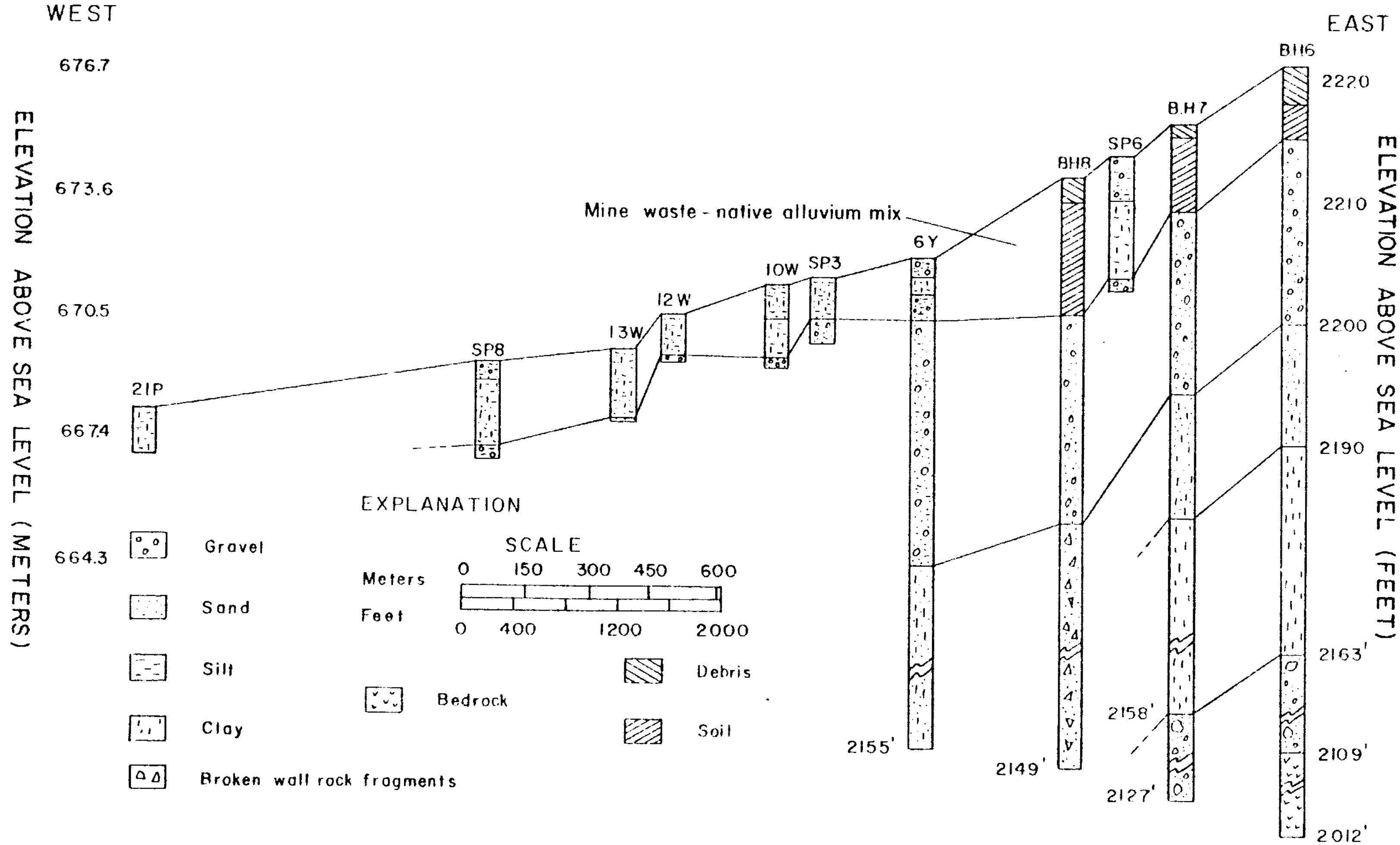


FIGURE 15. Cross section Line W, Smelterville Flats study area.

(type 1) on the flood plain in the eastern portion of the study area.

Metal concentrations are not directly dependent on the type of soil and thus, the soil size distribution. The finer size fraction has greater surface area available for chemical reactions than the coarser size fraction. Thus, leaching of soluable metals can be expected to occur more readily than in the coarse size fractions. The amount of oxidation that has taken place, as indicated by the amount and gradation of orange-red color, is less in the finer material than in the coarser material. This indicates that there is a lack of oxygen available in the finer materials for chemical reactions. A "zone of concentration" is evident when the metal concentrations are plotted versus depth (Figure 16 A). A similar trend is demonstrated by plotting the percent of metal concentration of each metal for each size fraction of the sample versus depth (Figure 16 B). The percent of metal concentration (% PPM) is calculated by multiplying the metal concentration (PPM) for a given size fraction by the percent by weight (%) for the size fraction of the total sample. The soil size fractions are listed in Table 1 on page 24. The "zone of concentration" is present in each of the size fractions, and based on the soil pit data, is restricted to the upper six feet (1.8 meters) of soil. Four generalizations can be stated to show the complex relationship between metal concentrations and size fractions: 1) the largest size fractions tends to have the lowest metal concentrations: 2) metal concentrations are generally independent of the size fraction in that each size fraction can have high metal concentrations; 3) the percentage of concentration tends to be higher for the smaller size fractions; and 4) the largest concentrations for four elements (Pb, Fe, Mn, Mg) are in the size fraction .417 to .208 milli-

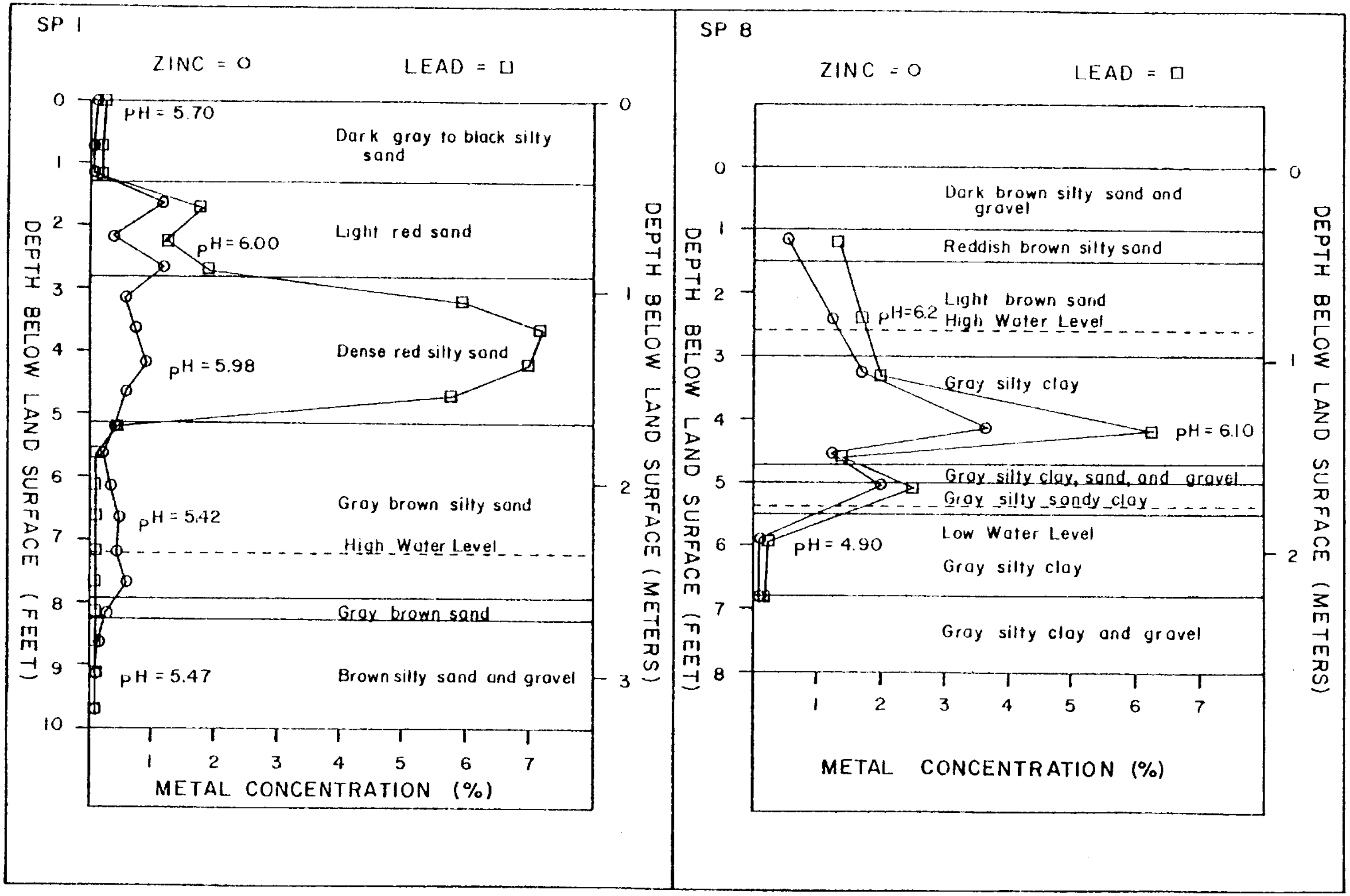


FIGURE 16A. Plots of zinc and lead concentrations in the soils, Smelterville Flats study area.

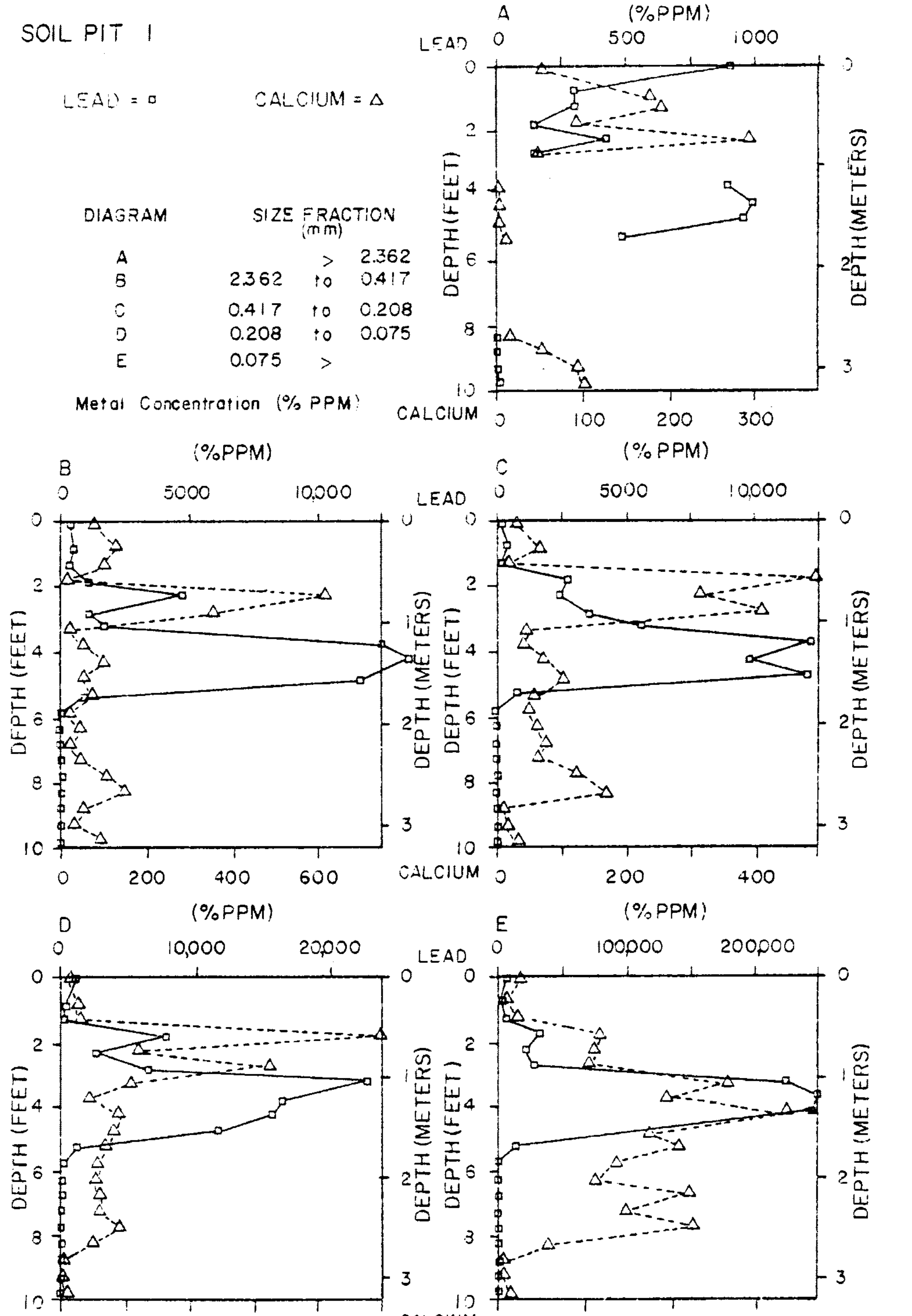


FIGURE 16B. Lead and calcium plotted as % PPM which is calculated by multiplying the metal concentration (PPM) for a size fraction by the percent by weight (%) for that size fraction of the total sample, Smelterville Flats study area.

meters. The metal concentrations in the soils of the Smelterville Flats study area are still high even after being in the environment since the early 1900's. This indicates that the metal concentrations will not decrease appreciably over the next 100 years if left alone. The movement of metals from the soil into the water resource system will be discussed in a later section.

CHARACTERISTICS OF THE SURFACE AND GROUND WATER FLOW SYSTEMS

Hydrogeology

Surface Water

Channel Description and Movement

The channel of the South Fork of the Coeur d'Alene River is braided through most of the study area, except where the river is contained against the hillside by Interstate-90, or where the Smelterville Bridge artificially channelizes the river. Generally, when two rivers of a given discharge are compared, braided channels occur on steep slopes, while a meandering river occurs on flat slopes. The South Fork of the Coeur d'Alene River has the capability to erode and transport sediment the size of the jig tailings and the slimes that were dumped onto the flood plain and into the channel. This over-supply of sediment often leads to a braided river channel. The well braided stream channel which had developed prior to 1937 has gradually evolved into a laterally meandering incising stream since the sediment load being dumped into the river or on the flood plain has been reduced due to current mining practices. A significant portion of the river's sediment load probably originates from the lateral meandering of the channel and from downcutting. Continued erosion of the mine waste will eventually result in their removal from the area where possible. The steep slopes of the braided channel contribute to both sediment transport and bank erosion and are often associated with coarse heterogeneous materials (Leopold, Wolman, and Miller, 1964, p. 292). This is the case of the South Fork through most of the study area. In the study area, the channel width of the South Fork in the channelized sections varies from 60 to 160 feet

(183 to 488 meters). The average width of the South Fork channel in the study area is approximately 450 feet (1,372 meters) with the widest section over 800 feet (2,438 meters) (Figure 17). The average gradient of the channel through the study area is 0.40 feet per 100 feet (0.14 meters per 100 meters).

Ioannau (1979) described the sediment transport capabilities of the South Fork of the Coeur d'Alene River. As part of his study, cross sections were surveyed in February, 1978, and again in August, 1978 (Figures 18 and 19). The cross sections showed both deposition and erosion over the seven month period. Cross section 18B shows that the river cut a deep channel south of the former channel, eroding a large volume of bank material. It is estimated that 4,200 cubic feet (120 cubic meters) of material was eroded from the bank on the southern end of cross section 18B between February 1978, and August 1978. Cross section 19C showed some erosion, but mostly deposition with the channel extremely braided through this section. Considerable deposition was evident at cross section 19D, with an average depositional depth of twelve inches (0.3 meters). A possible source for the material deposited could be sediment eroded from the bank upstream near cross section 18B.

The ability of the South Fork of the Coeur d'Alene River to move laterally within the study area is depicted by a series of air photos. The position of the river, dikes and dams used to control the river, and land use developments within the study area were transcribed from the photos onto maps (Figure 20). Figure 20A shows the study area in 1937 when the Page Mine was depositing tailings between the railroad and Highway 10 without the use of embankments. Remnants of the tailings dam built by the Mine Owners Association in 1901 were still evident

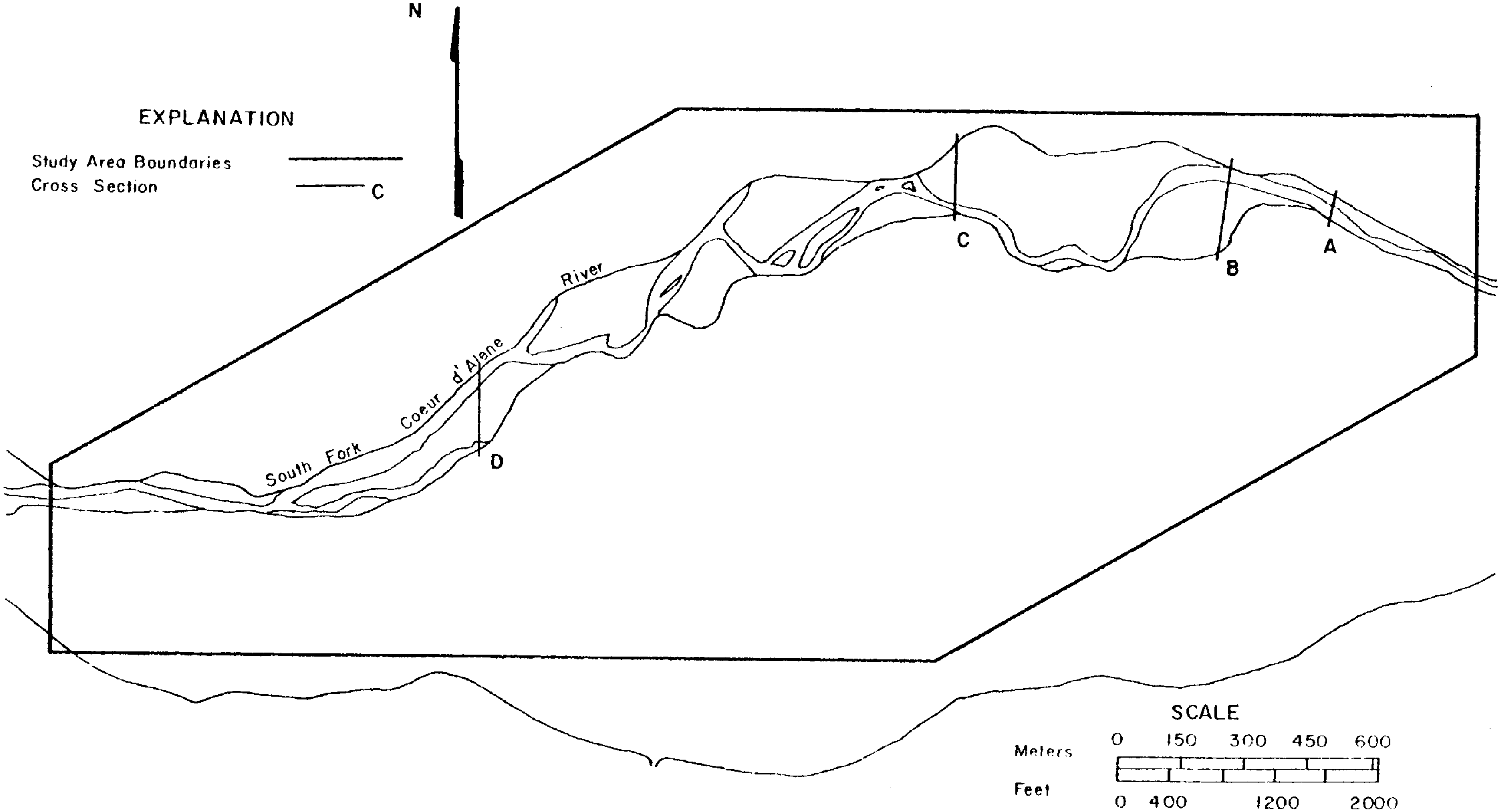


FIGURE 17. Location of the river channel cross sections, Smelterville Flats study area.

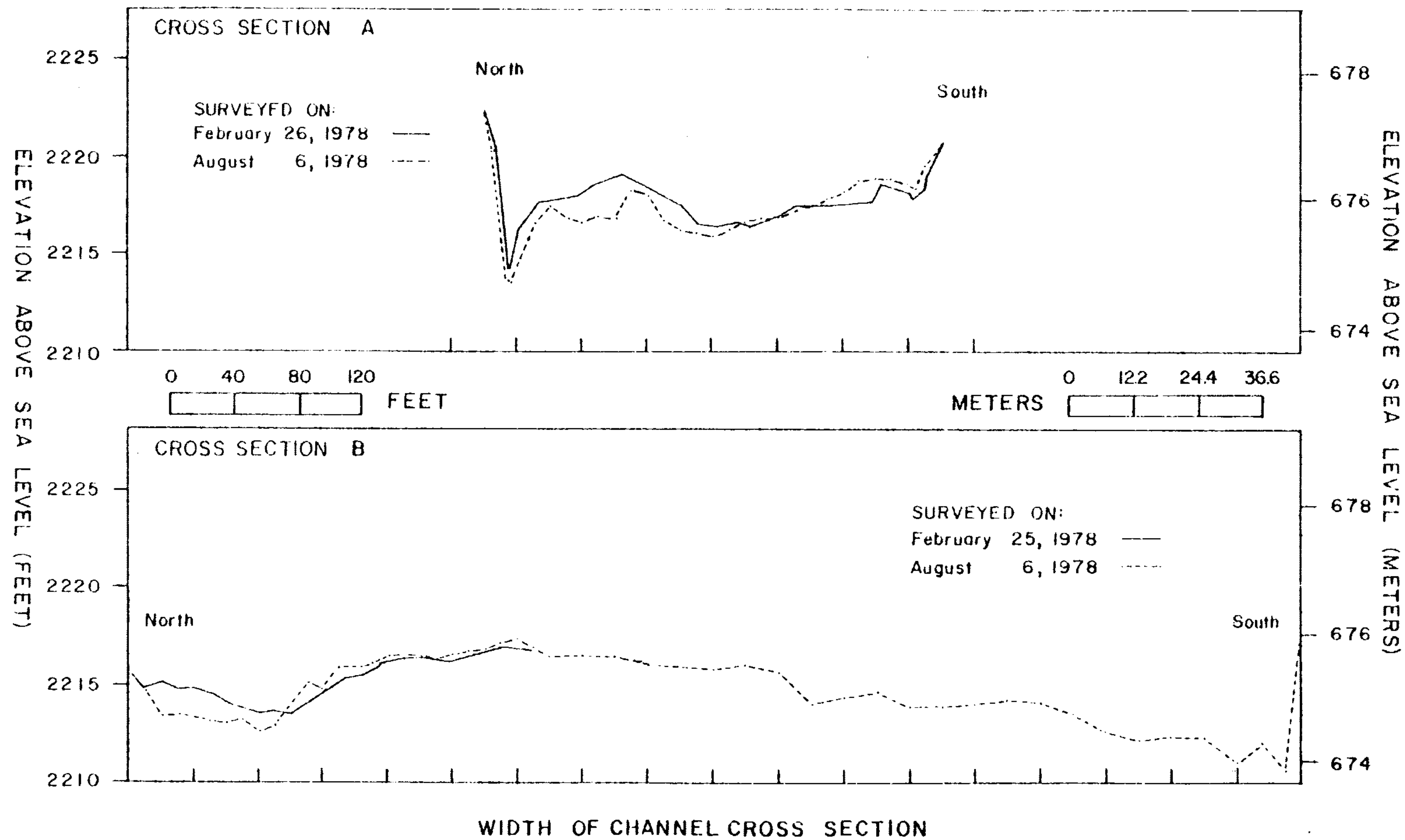


FIGURE 18. River channel cross sections (A) and (B), Smelterville Flats study area, (Data from Ioannou, 1979).

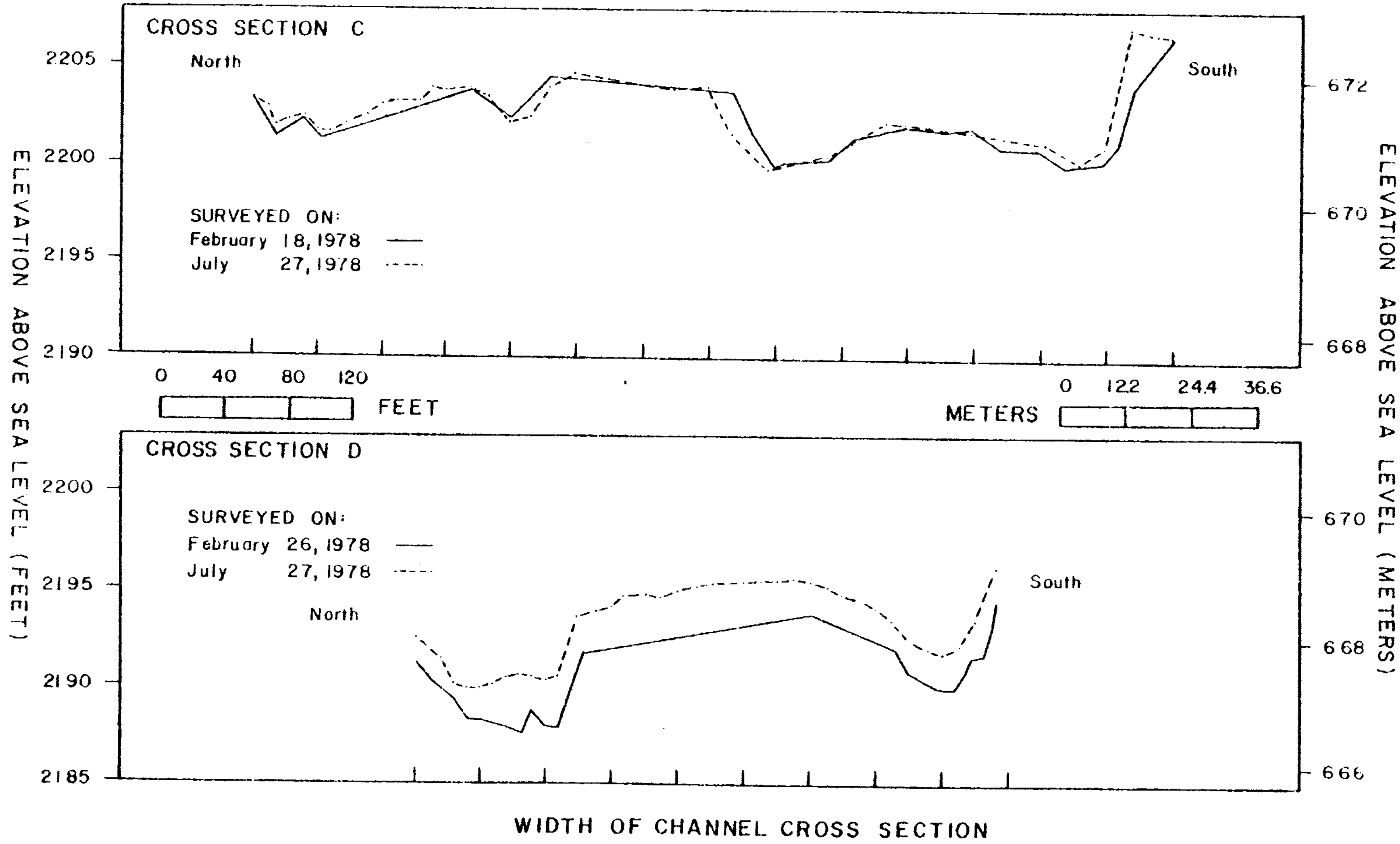


FIGURE 19. River channel cross sections (C) and (D), Smelterville Flats study area, (Data from Ioannou, 1979).

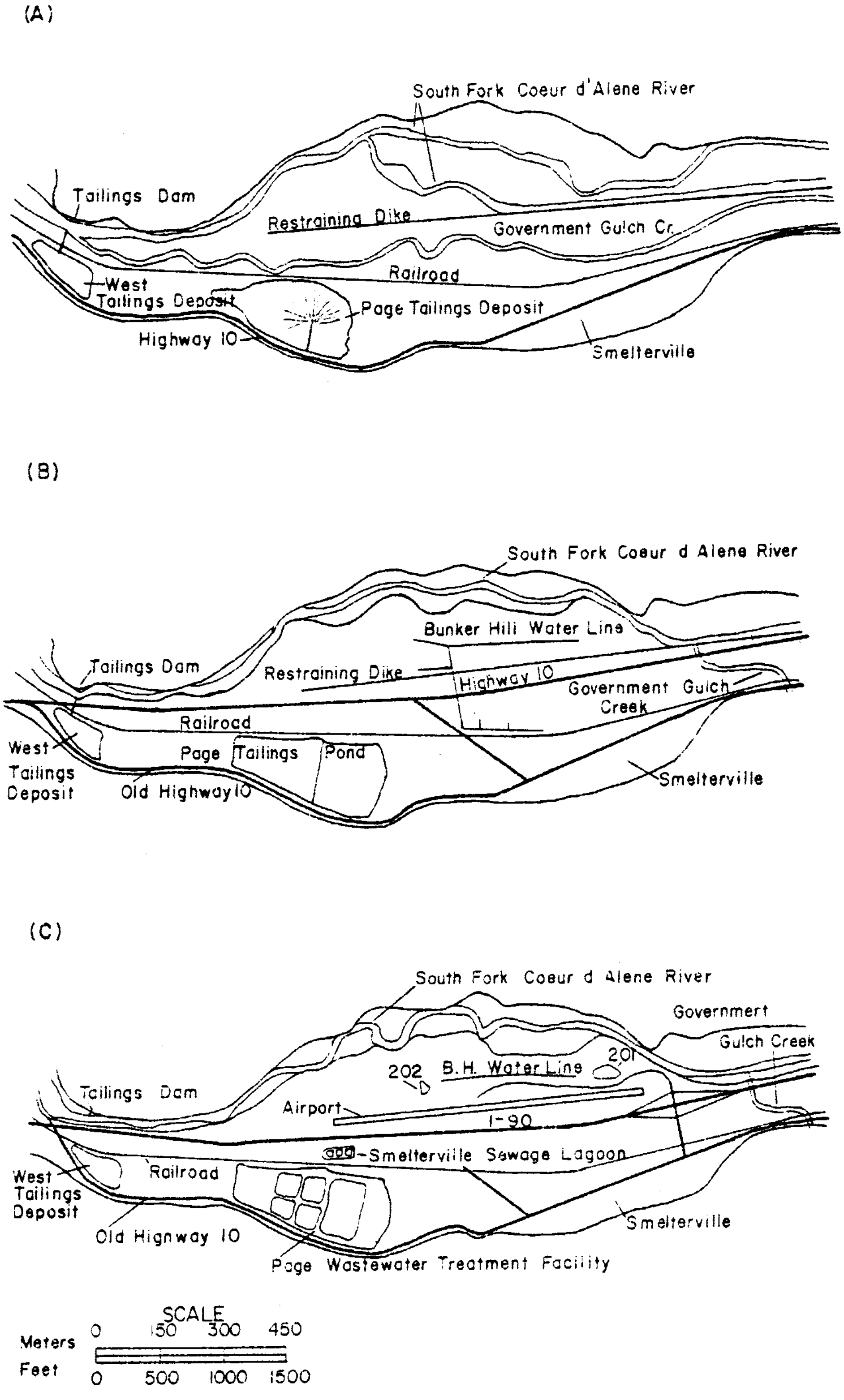


FIGURE 20. Aerial view of the Smelterville Flats study area in (A) 1937, (B) 1954, and (C) 1975.

abutted against the railroad and the hillside at the west end of the study area. Tailings from the mining operations around Kellogg and Smelterville were deposited between the railroad and restraining dike. The restraining dike may have been built to protect the railroad tracks from the South Fork. A tailings deposit located between the railroad and Highway 10 at the west end of the study area near the tailings dam could have originated from two possible sources: 1) tailings could have been piped from a mining operation for disposal, although the pipeline is not visible in the photo, or 2) the tailings may have been siphoned or piped from the backwaters of the tailings dam.

By 1954 embankments had been constructed around most of the tailings deposited by the Page Mine south of the railroad (Figure 20B). The embankments were possibly built on top of tailings, which could be an explanation for the seeps and springs at the toe of the embankments. Highway 10 had been relocated to its present location in the center of the valley. The restraining dike was still intact, but the South Fork had started to cut a channel against the northern hillside through the mine waste-native alluvium material. By 1954, the Bunker Hill Company waterline had been constructed with most of it on the surface. Government Gulch Creek was diverted to the South Fork at the east end of the study area. The surface ponds present in 1978 had not yet appeared.

A 1968 photograph of the area (not included on Figure 20) showed the construction of Interstate-90 and the Shoshone County Airport within the study area. The photo demonstrates that only a short section of the Bunker Hill Company waterline remained above ground. Surface ponds #201 and #202 have appeared. During the construction of the airport, borrow material may have been removed from the site of pond #201, which would allow the water table to have surface expression. The Page tailings pond was still receiving tailings material and the South Fork had widened the channel considerably.

By 1975 the sewage lagoon had been constructed on the Page tailings pond, and the Smelterville sewage lagoon was also in operation (Figure 20C). The South Fork of the Coeur d'Alene River has continued to enlarge its channel by eroding the mine waste-native alluvium material along its south bank. Few changes in the study area have occurred during the period from 1975 to 1978 except for the position of the South Fork within its banks.

The series of photos show that if the South Fork of the Coeur d'Alene River is left alone, the river will continue to widen its channel. This will render useless larger portions of the valley floor in an area that is short of flat building sites. The drainage pattern has been improved with the diversion of Government Gulch Creek.

Discharge Characteristics

The discharge measurements for the South Fork of the Coeur d'Alene River presented in this report are the combination of data from two United States Geological Survey stream gaging stations. The first gaging station was located at Smelterville, Idaho, and had records from November 1966, through March 1974. The new station, located at Kellogg, Idaho, replaced the Smelterville site in April 1974, after a flood damaged the old station. The Kellogg station does not measure the discharge of two small tributaries which enter the South Fork between the two gaging stations. The amount of discharge from the two creeks is small and considered insignificant when compared to the discharge of the South Fork. The size of the watershed for the Kellogg station is

202 square miles (523 square kilometers) and the size of the previous Smelterville station is 210 square miles (544 square kilometers).

During the fifteen months that data were collected on this study, the monthly discharge of the South Fork of the Coeur d'Alene River was below average during eleven months, above average three months, and average for one month (Figure 21). Based on twelve years of record, the mean monthly discharges range from a low flow of 111 cubic feet per second (cfs) in September, to a high flow of 1,382 cfs in May (3.1 to 39.1 cubic meters per second (cms)). Mean daily discharge rates range from 59 cfs (1.7 cms) in January, 1977 to a high of 2,260 cfs (64.0 cms) in May, 1976. The low flow in January, 1977 occurred midway through ten months of drought that affected the western United States; while the high flow of May, 1976 was the result of snow melt of above normal snow fall that occurred during the previous winter. Peak discharges in the South Fork of the Coeur d'Alene River generally occur as a result of rapid snow melt. Flooding generally occurs when the ground is frozen beneath the snow pack and the snow melts rapidly.

The streams that drain the hillsides north of the study area are intermittent, discharging to the South Fork of the Coeur d'Alene River only after periods of snow melt or after a heavy rain. Due to sparse vegetation on these slopes, the discharge was high in suspended and bedload sediments. The sediments could contain high concentrations of zinc and lead from the fumes emitted by the smelters in the valley (Chaney, 1959). Streams that drain the slopes to the south of the study area are perennial, emptying into the swamp around the Page Wastewater Treatment Facility. Most of the sediments carried by these streams would settle out before the water reaches the South Fork of the

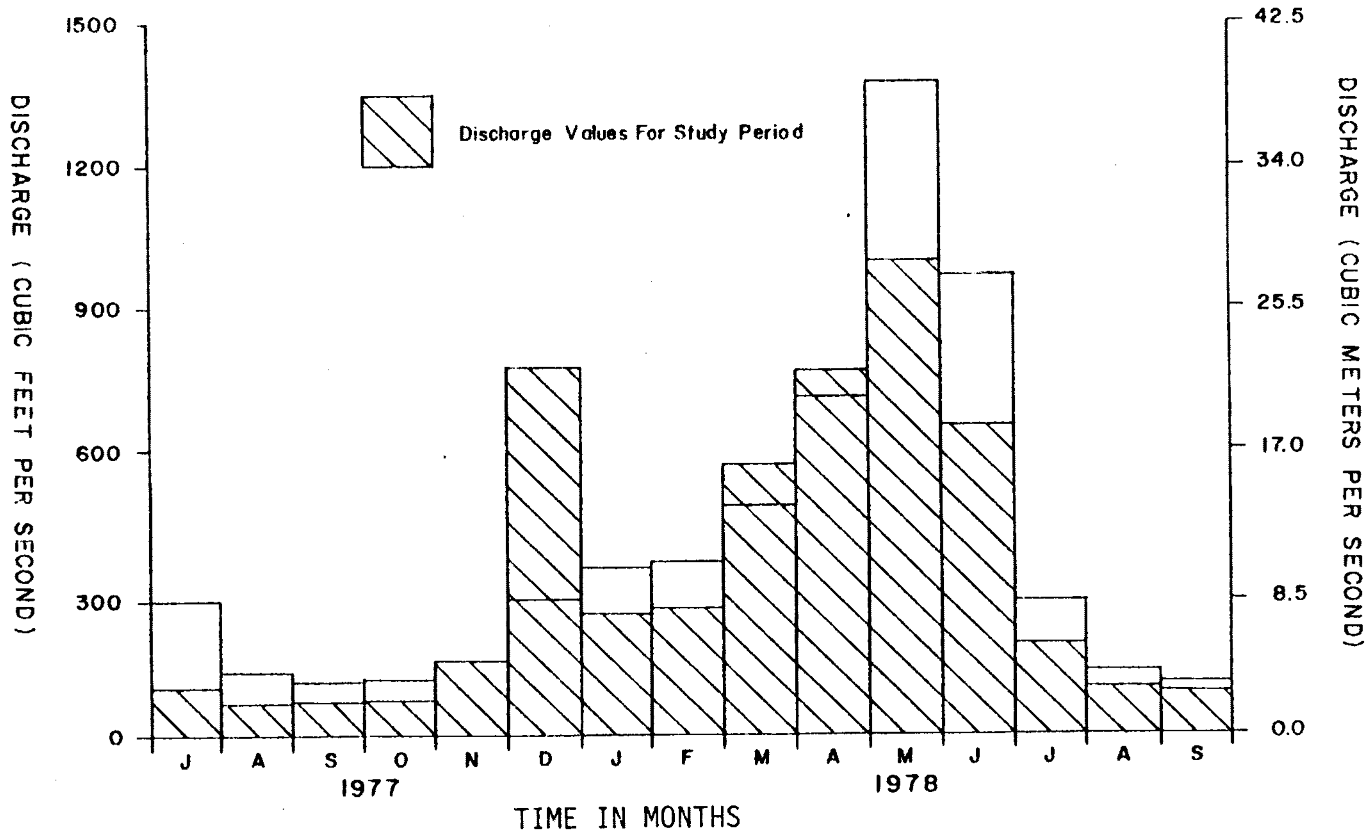


FIGURE 21. Monthly and mean monthly discharge for the South Fork of the Coeur d'Alene River at Kellogg, Idaho, Smelterville Flats study area.

Coeur d'Alene River.

Pond Characteristics

Several ponds are present in the Smelterville Flats study area (Figure 22). Pond #201 has no surface inflow or outflow, and had water in it the entire study period. Plant growth is dense in and around the pond compared to the rest of the study area. The high water mark from past years, noted by debris surrounding the pond, is approximately 2.5 feet (0.72 meters) higher than the maximum level reached during the study period. The water level in the pond responds similarly to the fluctuation of the ground water levels measured by nearby piezometers.

Pond #202 has no surface inflow or outflow. As the potentiometric surface rose, several small ponds appeared around pond #202, with surface flow occurring between them. During the summers of 1977 and 1978, the potentiometric surface dropped below the bottom of pond #202. A coating of an iron precipitate covers the bottom of the main pond and several of the small ponds. No vegetation grows in the pond and only a few grasses grow around it.

Pond #204 is one of several small ponds which were formed when the motorcycle racetrack was constructed. A bulldozer was used to build up certain parts of the track for jumps and banking for corners, and it formed depressions that fill with water when the potentiometric surface rose above the bottom depressions of the pond. The pond did not dry up during the study period and has no surface inflow or outflow. Vegetation does grow in and around pond #204. A staff gage was installed in pond #204 and water levels were recorded when the piezometers were measured. Water level information was not continuous during the study period, as the staff gage flooded out in early December 1977, and was not replaced

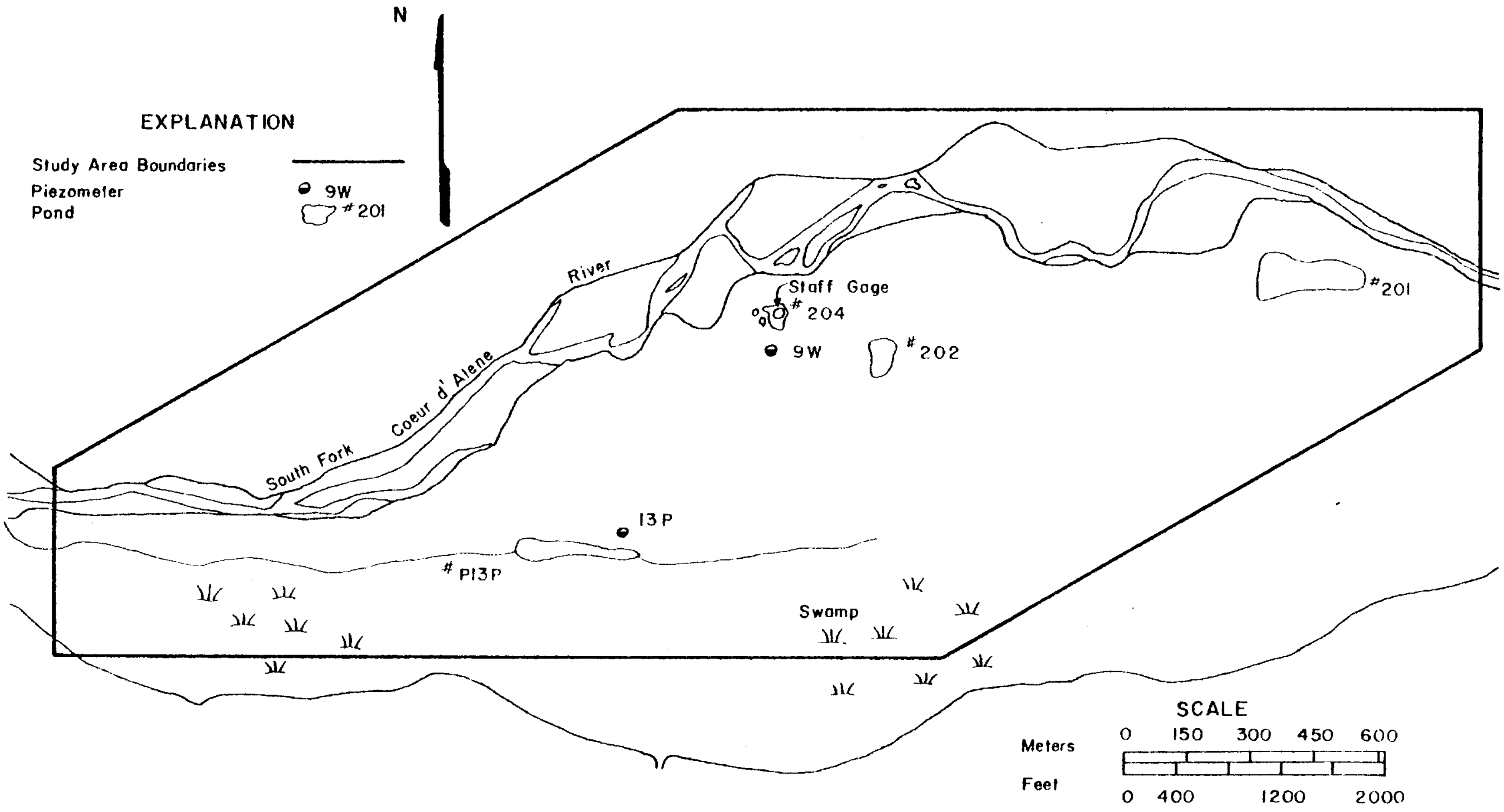


FIGURE 22. Location of several piezometers and the surface ponds, Smelterville Flats study area.

until April 1978. The hydrograph for the staff gage is presented in Figure 23 along with the hydrograph from 9W, a piezometer located 250 feet (75.1 meters) to the west and down gradient. The hydrographs are similar, indicating the pond is hydrologically connected to the upper aquifer. Piezometer 9W may be under confined conditions while pond #204 is under water table conditions, which might explain the difference in fluctuations.

Pond P13P, located by the Smelterville sewage lagoon has surface inflow and outflow. The main source of water for the pond is from a ditch that collects water from leaks in the fresh water line of the

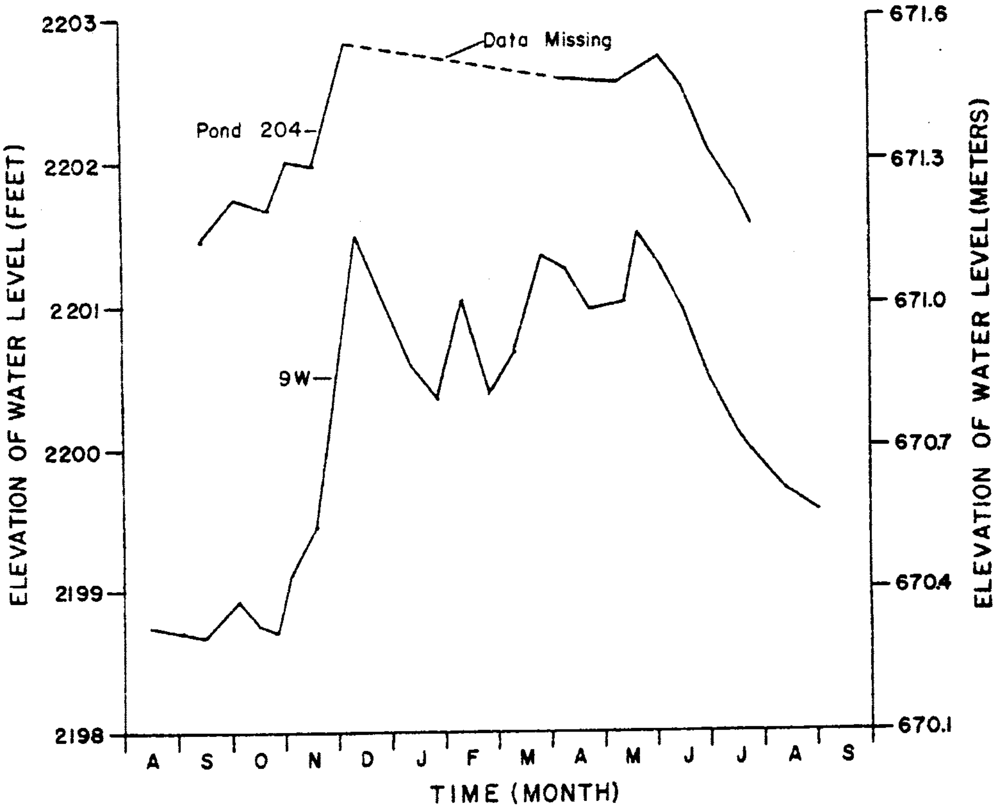


FIGURE 23. Hydrographs of surface pond #204 and piezometer 9W, Smelterville Flats study area.

Bunker Hill Company that parallels the railroad tracks. Water is pumped from wells located near the Coeur d'Alene River upstream from its confluence with the South Fork. Surface water discharge from the pond flows along the railroad tracks towards the west end of the study area, either infiltrating into the surface material, or discharging into the South Fork of the Coeur d'Alene River. It is believed that the water level in this pond is above the local potentiometric surface. The pond probably does recharge the upper aquifer to some extent. The water quality data, which are presented later, tends to support this idea.

The swamp, (PWS) that surrounds the Page Wastewater Treatment Facility, receives surface inflow from the streams that drain the southern hillside. During the high water period (April to June) there was flow around the facility on the north side. Vegetation in the swamp is very thick and abundant.

Surface Water Quality

Water quality for the South Fork of the Coeur d'Alene River will be discussed in detail in the section on the interaction between the river and ground water . Water quality differs tremendously between the ponds (Table 2). Ponds #201 and #204 both support plant life and have similar water quality, with pond #204 having higher concentrations of Fe, Zn, Ca, and Ma. These differences in concentrations may have resulted because pond #201 is closer to the main source of recharge, while pond #204 is much farther away. This increased distance would allow time for the build-up of metal concentrations. Pond #202 does not support plant life and has iron concentrations higher that the rest of the ponds, as well as small amounts of lead and cadmium which were not detected in the water of the other ponds. Pond P13P has low concentrations of the metals analyzed, but this is probably due to dilution with water from the fresh water line. The swamp (PWS), measured hydrologically down gradient from the sewage lagoons, is the only pond to have a pH greater than seven. This pH may have resulted due to dense vegetation in the area. The water quality of the ponds is affected by distance from the source of recharge, metal concentrations in the soils near each pond, and the chemical environment.

Table 3 presents water quality values for piezometers located near the ponds. The water quality in ponds #201 and #204 is very similar to the quality of the ground water measured near the ponds. Pond #202 has higher Fe, Pb, Cd, and Zn concentrations than the ground water in the nearby piezometers. Piezometer 13P has greater concentrations of Fe, Cd, Zn, and Ca than pond P13P. The swamp (PWS) has much lower concentrations of Fe, Zn, Ca, and Mn than piezometer 21P. The high concentrations of iron in the ground water indicates an anaerobic environment, since iron precipitates in the presence of free oxygen, such as in a pond.

Table 2. Water quality on August 12, 1978 for ponds in the Smelterville Flats study area.

Pond	Temp °C	pH	Fe	Pb	Cd	Zn	Ca	Mn
			Concentrations in PPM					
#201	20.7	6.5	0.00	0.00	0.00	5.60	46.5	0.78
#202	18.0	6.0	9.80	0.01	0.24	24.80	58.0	9.80
#204	18.0	6.2	0.05	0.00	0.00	33.20	63.3	8.90
P13P	19.5	6.3	0.05	0.00	0.00	4.70	7.8	1.80
PWS	16.0	7.3	0.05	0.00	0.00	0.82	11.0	0.37

Table 3. Water quality values on August 12, 1978 for the ground water near the ponds in the Smelterville Flats study area.

Station	Near Pond	Temp °C	pH	Fe	Pb	Cd	Zn	Ca	Mn
				Concentrations in PPM					
4XB	#201	15.5	6.3	0.00	0.0	0.00	7.6	28.0	0.54
5YB	#202	18.0	6.0	0.00	0.0	0.00	10.5	82.6	43.00
8YB	#204	14.0	6.1	0.00	0.0	0.00	3.3	50.9	30.00
13P	P13P	16.5	6.0	0.24	0.0	0.54	47.2	54.5	1.40
21P	PWS	13.7	6.6	70.90	0.0	0.00	14.5	149.0	20.40

GROUND WATER

Aquifer Description

Based on available geologic logs and water level data, the ground water system is believed to consist of an upper and a lower aquifer separated by a discontinuous 25-foot (7.6 meters) thick clay layer. The mine wastes are mixed with the upper alluvial material; therefore the leaching and flushing of the metals into the ground water can occur only in the upper aquifer. The water from the lower aquifer contains heavy metals, but the concentrations are derived from the downward movement of water from the upper aquifer.

Based on the geology and the water level records, the lower aquifer is considered to be leaky artesian. The gradation and discontinuous nature of the separating clay layer probably allows some movement of water between the aquifers. The amount of inter-aquifer water movement within the study area is believed to be small for the following reasons: 1) the differences between the hydrographs from piezometers 6YA, 6YB, and 6YD, 2) the lack of responses in the shallow piezometers to pumping from the lower aquifer, and 3) the differences in water quality from piezometers penetrating the upper aquifer, the clay layer, and the lower aquifer. These reasons are discussed in detail on the following pages.

Piezometers 6YA, 6YB, and 6YD (Figure 11) obtain water from depths of 20 feet, 10 feet, and 50 feet, respectively (6.1, 3.0, 15.2 meters). The hydrograph for each piezometer is presented in Figure 24. Piezometer 6YD is open near the lower limit of the clay layer that separates the two aquifers and responds to the pumping from a nearby well (B. H. #10) which derives water from the lower aquifer. Piezometers 6YA and 6YB

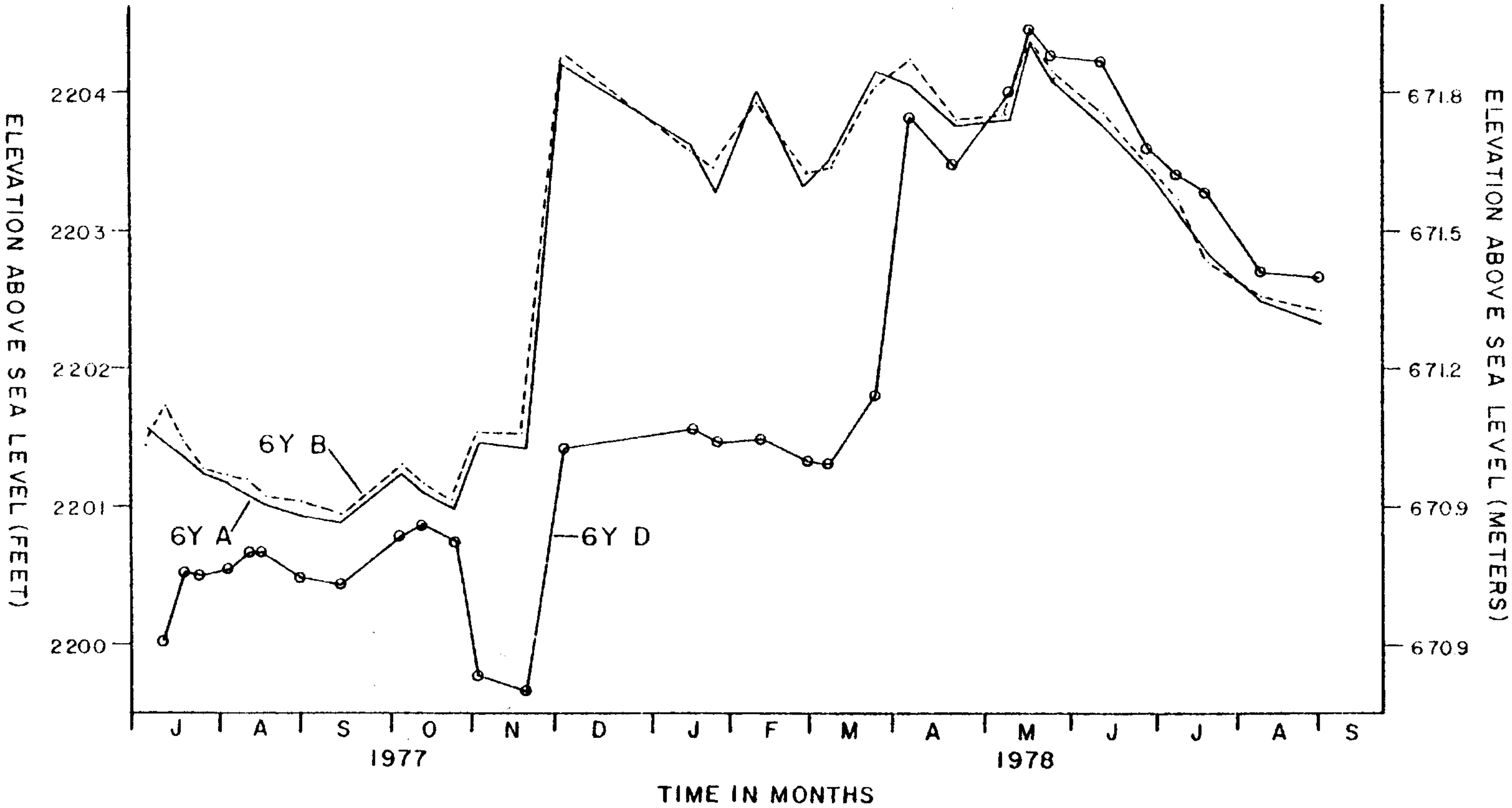


FIGURE 24. Hydrographs for piezometers 6YA, 6YB, and 6YD, Smelterville Flats study area.

are open to the upper aquifer and do not show the affects of pumping from the lower aquifer. Bunker Hill well # 10 was pumped for approximately 40 days in October and November, 1977. Piezometer 6YD responded to the pumping with a drop in water level, then recovered to a water level higher than prepumping conditions. This indicates some recharge to the lower aquifer during the pumping period. During this time the upper aquifer was responding to a recharge event on December 2, 1977. Piezometer 6YD may have responded to the recharge event in the middle of March, which would indicate a delay in response time of three months. Detailed information on Bunker Hill Company pumping schedules were not available. Thus, it is possible that changes in the pumping schedule of the wellfield may be responsible for the apparent lag of the potentiometric surface in 6YD. On May 9, 1978 the head in 6YD was higher than the head in either 6YA or 6YB, and remained higher for the rest of the study period. This trend is a reversal of the water level relationships at the beginning of the study period. An upward direction of ground water movement would limit contamination of the lower aquifer within the Smelterville Flats area. The lower aquifer may have been discharging more before the study period than was being recharged, either through natural discharge or through pumping, which maintained the potentiometric surface in the lower aquifer below that of the upper aquifer. Possibly, the reversal of this trend may have been caused by increased recharge into the lower aquifer, which would cause an increase in head. Horizontal hydraulic conductivity is higher than vertical hydraulic conductivity because of the non-homogeneity and anisotropic conditions described for the ground water flow system. The chemical characteristics of the water from the lower aquifer are different from those in the upper aquifer (Table 4).

Manganese is almost non-existent in the lower aquifer, while the upper aquifer has values that range from 0.54 to 43.0 parts per million (ppm). Calcium concentrations are also higher in the upper aquifer, while zinc concentrations can be higher in the lower aquifer than in the upper aquifer. Zinc concentrations in the upper aquifer vary a great deal and exceed the values of the lower aquifer in other parts of the study area. Concentrations of zinc range from 0.010 mg/l at 7XA to 132.0 mg/l at 4P for the upper aquifer, while the lower aquifer has concentrations that range from 25.8 mg/l to 26.2 mg/l. It should be noted that there were only two sampling points in the lower aquifer and they could only be sampled when the well was pumping. Based on the water quality differences, water levels, the probable permeability of the separating clay, and the lack of response in the upper aquifer to pumping from the lower aquifer, it is believed that the intermixing between the upper and lower aquifers is small in the study area.

The upper aquifer is extremely non-homogeneous and anisotropic with a higher horizontal than vertical permeability. Based on this and differences in water level fluctuations within the upper aquifer in different areas, the upper aquifer is considered to be an unconfined environment with locally confined areas due to the deposition of the low permeability, finer size fractions (slimes and rock powder) of the mine wastes below the potentiometric surface. The ability of the slimes to form a confining layer was demonstrated during the excavation of soil pits 6 and 8. Artesian flow was encountered upon entering the gravel layer beneath the mine waste, with water levels rising approximately 12 inches (0.3 meters) above the contact between the mine waste and

Table 4. Water quality values on August 12, 1978, comparing the surface water, and the ground water from both the upper and lower aquifers in the Smelterville Flats study area.

Station	Source of water*	Temp °C	pH	Concentrations in PPM Fe	Pb	Cd	Zn	Ca	Mn
4XA	UGW	15.0	6.1	0.48	0.23	0.25	16.5	59.8	6.6
4XB	UGW	15.5	6.3	0.0	0.0	0.0	7.0	28.0	0.54
B.H. #6	LGW	14.8	5.6	0.0	0.0	0.0	26.2	22.7	0.06
Pond #201	SW	20.7	6.5	0.0	0.0	0.0	5.6	46.5	0.78
B.H. #10	LGW	13.8	5.8	0.02	0.0	0.0	25.8	23.6	0.06
6YA	UGW	19.2	5.4	0.0	0.0	0.0	18.5	43.0	4.0
6YB	UGW	19.0	5.8	0.0	0.0	0.0	7.4	104.0	17.8
6YD	UGW	18.5	6.4	0.0	0.0	0.0	0.04	35.1	2.2
Pond #202	SW	18.0	6.0	9.8	0.01	0.24	24.8	58.0	9.8

* SW - Surface water; LGW - Lower aquifer; UGW - Upper aquifer

gravel layer.

Ground Water Movement

The collection of data was concentrated in the upper aquifer because it is in contact with or is formed by the mine wastes deposited in the Smelterville Flats study area. Ground water flow though the upper aquifer would be the primary transporting agent for metals in solution. Unless otherwise stated, the following discussion will pertain to ground water flow in the upper aquifer. All of the piezometers were not installed at one time, but were put in over the study period after the initial drilling (July 1977). As gaps in the collection network were found or an interesting change in chemistry discovered, new piezometers were installed to better monitor the system. The last piezometers (P20 and P21) were installed on July 22, 1978. Consequently, there is more complete data presentation farther into the study period.

Contour maps and three-dimensional diagrams were drawn of the potentiometric surface in the Smelterville Flats study area with the use of the IBM 370/145 computer and the Calcomp 936 drum plotter at the Computer Center, University of Idaho. The program used for contour plotting is called STAMPEDE, and the program for three-dimensional diagrams is called BLOCK 2. STAMPEDE stands for Surface Techniques, Annotation, and Mapping Program for Exploration, Development, and Engineering. The package takes irregularly spaced data points that define a surface and produces values at the mesh points of a square grid system superimposed on the original surface. From that square grid, a contour map is produced for graphical display on the plotter. The degree of accuracy of the final map depends upon how closely the original data approximates the grid in their distribution over the surface.

BLOCK 2 is a three-dimensional plotting program accepting data in square grid form, in this case, the grid superimposed over the original irregularly spaced data by STAMPEDE. The surface may be viewed at any angle or distance and the surface itself may be tilted or viewed in stereo pairs. Any misrepresentation of the original surface by STAMPEDE will be carried over into BLOCK 2.

The deposition of sediments by the South Fork of the Coeur d'Alene River greatly affected the grain size distribution in the Smelterville Flats study area. The change in width of the valley floor is believed to have resulted in a distinct pattern of grain size distrubution. The coarsest sediments would be deposited in the narrow portion of the valley with the finer material being deposited in the wide area. This would result due to decreasing velocity of the water in the South Fork after passing through the constriction of the valley sides east of the study area. The average grain size of the material being deposited is believed to grade finer downstream in the wide section of the study area. This pattern of deposition is demonstrated by the mine waste deposited by the South Fork in the Smelterville Flats. Soil pit 1 (SP 1) has a greater percentage of large size fractions than SP 8 (Figure 16 A, 16 B).

The river is believed to lose water into the upper aquifer in the eastern portion of the Smelterville Flats. Profiles of the water level in the South Fork and of the potentiometric surface of the ground water system are plotted in Figure 25. Piezometers used in Figure 25 include: 7XB, 3W, 5W, 7YB, 9W, 10W, 12W, 13W, and 15W. Surface water elevations were taken during channel surveys in February, 1978. The potentiometric surface is below the surface of the South Fork in the eastern portion of the study area. The reverse occurs in the western

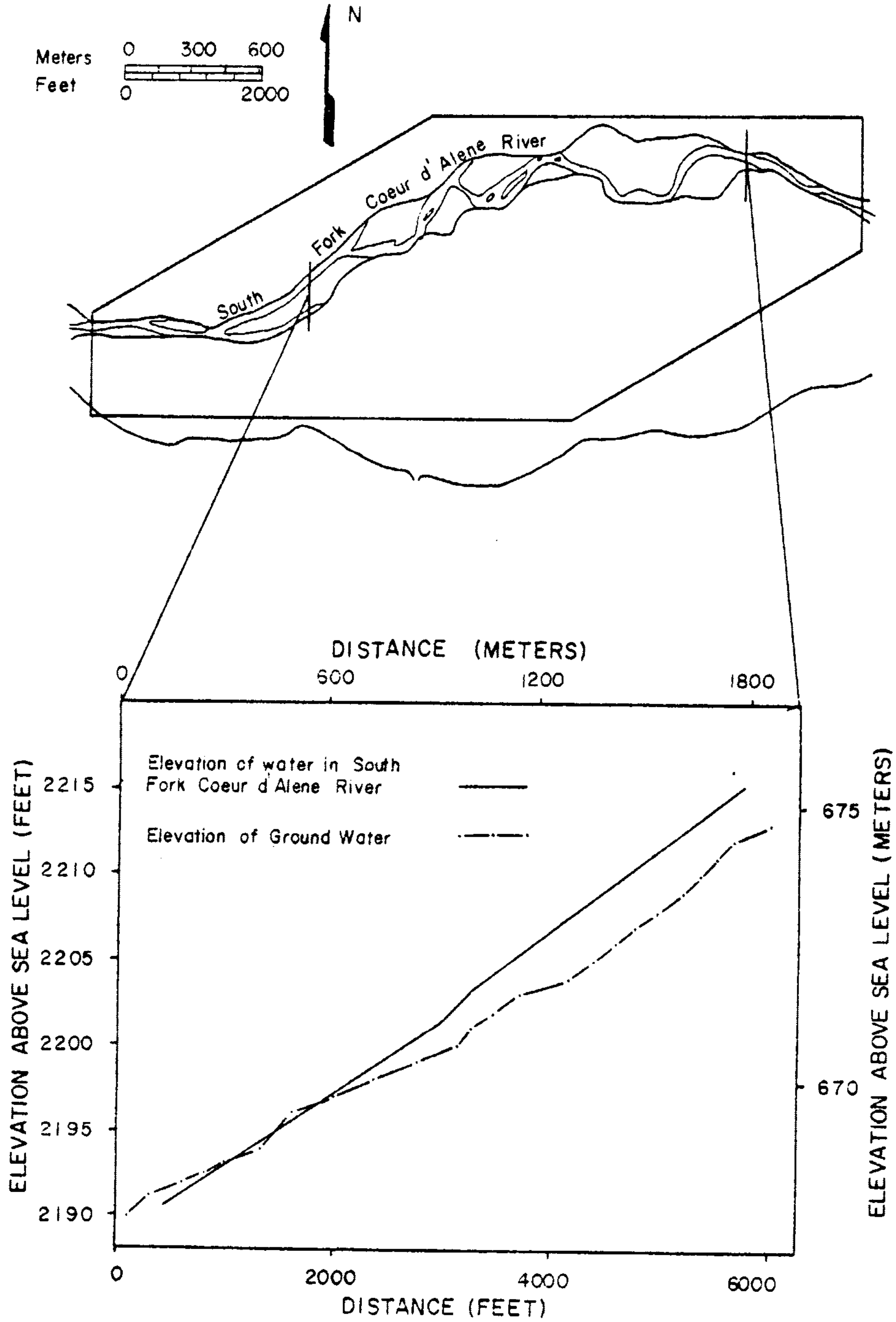


FIGURE 25. Plot of ground water elevation versus elevation of water level of the South Fork of the Coeur d'Alene River, Smelterville Flats study area.

portion of the study area with the river gaining water in this reach.

A large recharge event took place in early December 1977, which resulted in increases in ground water levels from 1.7 to 7.0 feet (0.52 to 2.33 meters). The recharge event consisted of a snow melt caused by a rise in temperatures coupled with a 2.52 inch (6.40 cm) rainfall event on December 2, 1977. Discharge in the South Fork of the Coeur d'Alene River at Kellogg increased from 294 cfs (8.3 cm^3/sec) on December 1, 1977 to 1890 cfs (53.5 cm^3/sec) on December 3, 1977 as a result of the snow melt and rainfall. The South Fork did not leave its channel, but water did cover most of it. Figures 26 and 27 are contour maps of the potentiometric surface on November 19, 1977 and December 4, 1977, respectively. Figure 28 is a contour map of the change in ground water levels between the two dates. The greatest water level change occurred in the eastern part of the study area. The changes along the X-Line, located on Figure 12, have been interpreted as indicating recharge occurring from the South Fork. The amount of change is even across the Y-Line, indicating that the river had little direct effect on the water table rise in this area. The contour lines then swing west, showing the effects of recharge from the creeks that drain the south hillside as well as leakage from the Page Wastewater Treatment Facility (Hitt, 1974, p. 46). The distribution of the change in water levels can be shown by the plot of water levels in relationship to cross sections Line X, Line Y, and Line W (Figures 29 and 30). The increase in the potentiometric surface is greatest at cross section X, with an increase in water level of 7.0 feet (2.1 meters) at 9X near the river, to 4.2 feet (1.3 meters) at AX near the center of the valley. This is interpreted as indicating that 9X is closer to the source of recharge

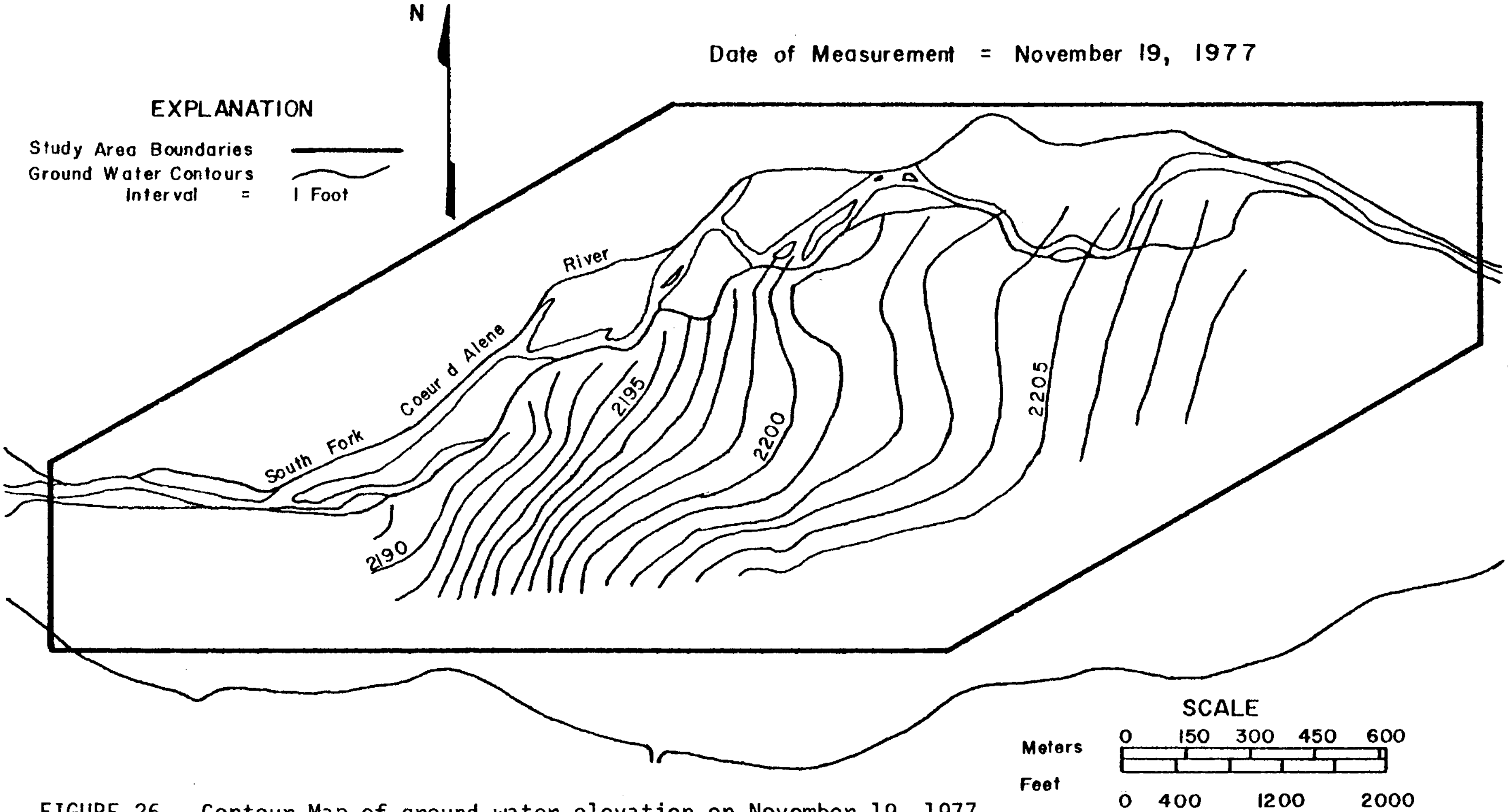


FIGURE 26. Contour Map of ground water elevation on November 19, 1977, Smelterville Flats study area.

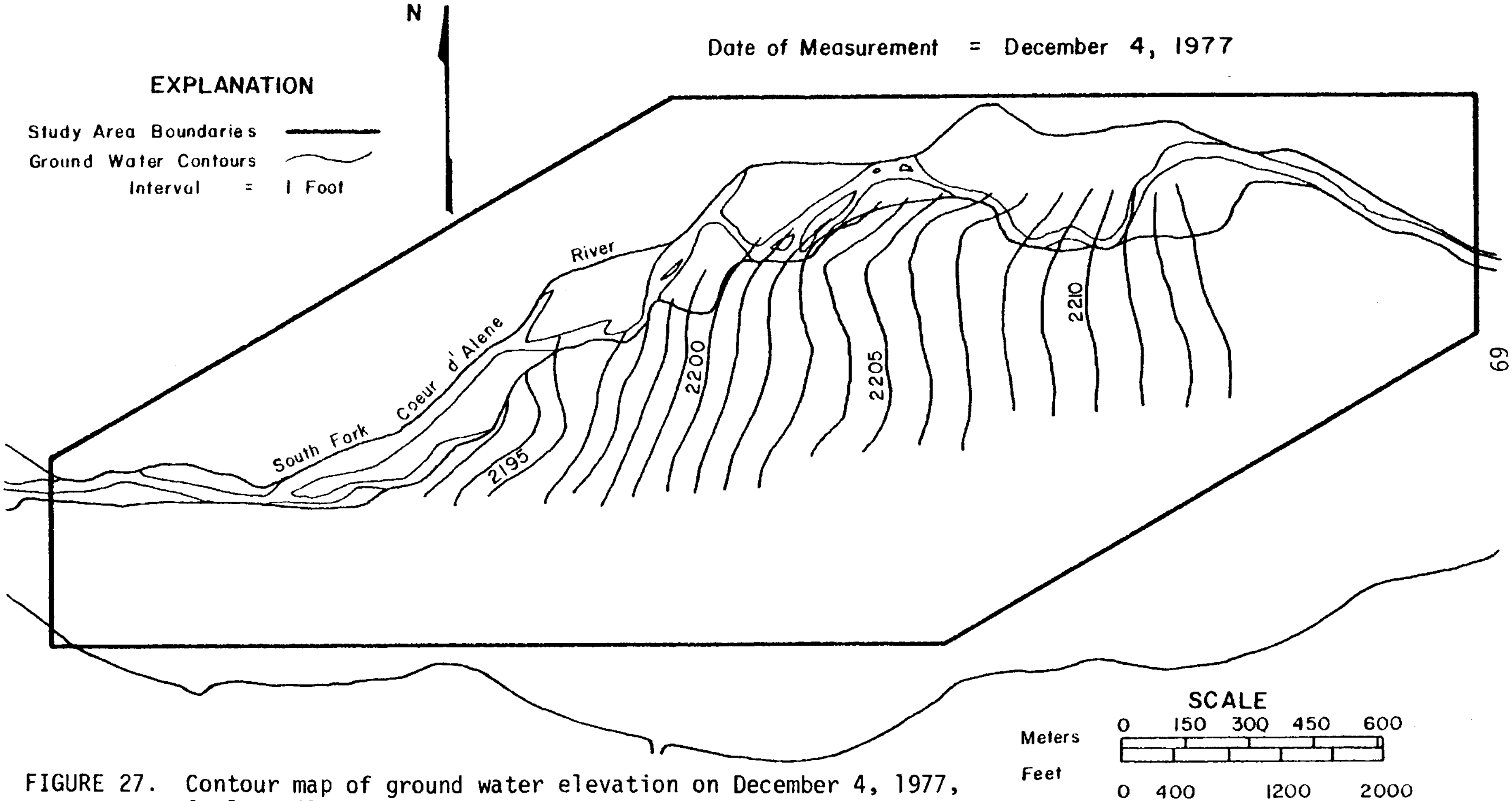


FIGURE 27. Contour map of ground water elevation on December 4, 1977, Smelterville Flats study area.

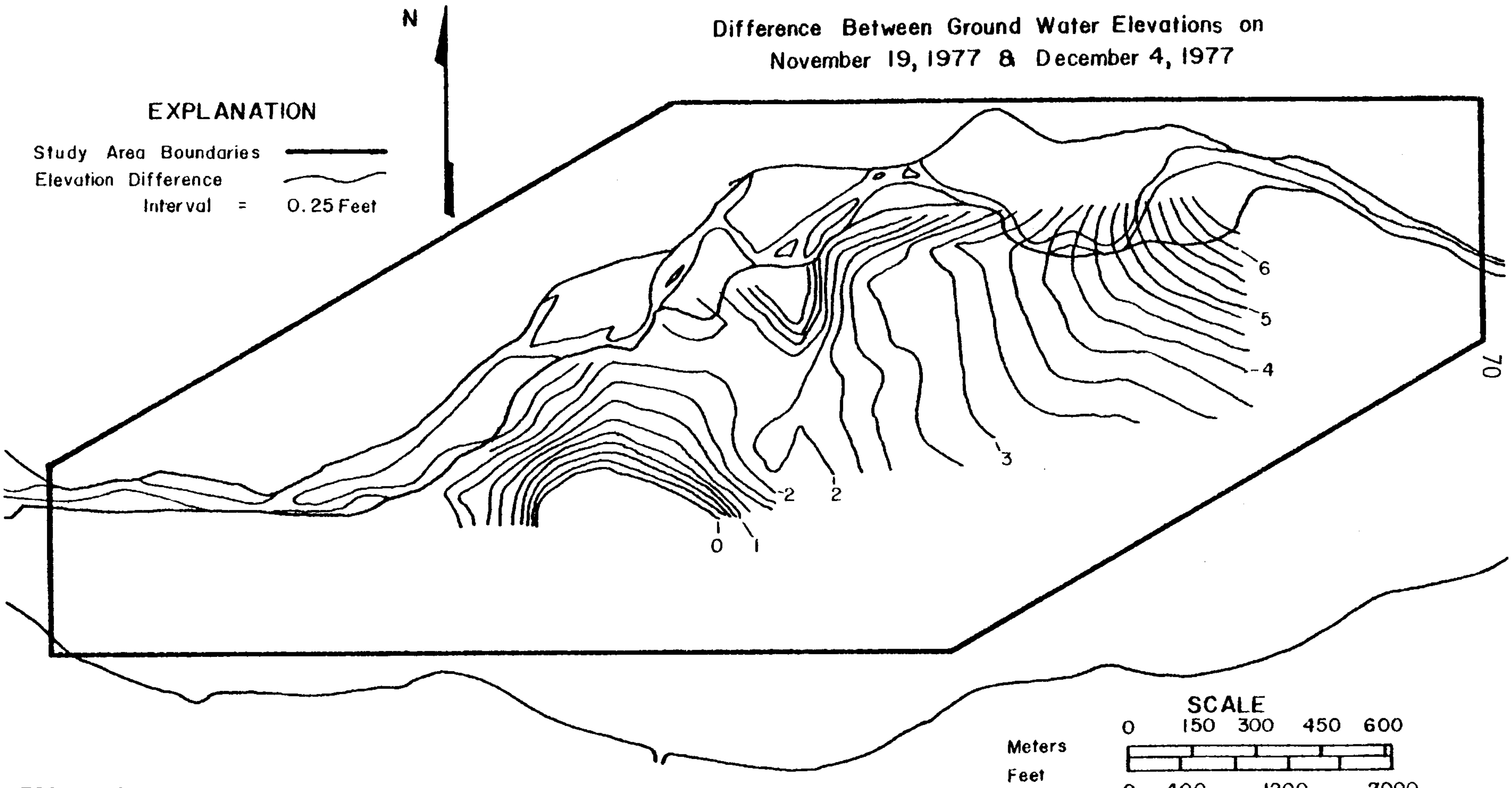


FIGURE 28. Contour map of difference between ground water elevation on November 19, and December 4, 1977, Smelterville Flats study area.

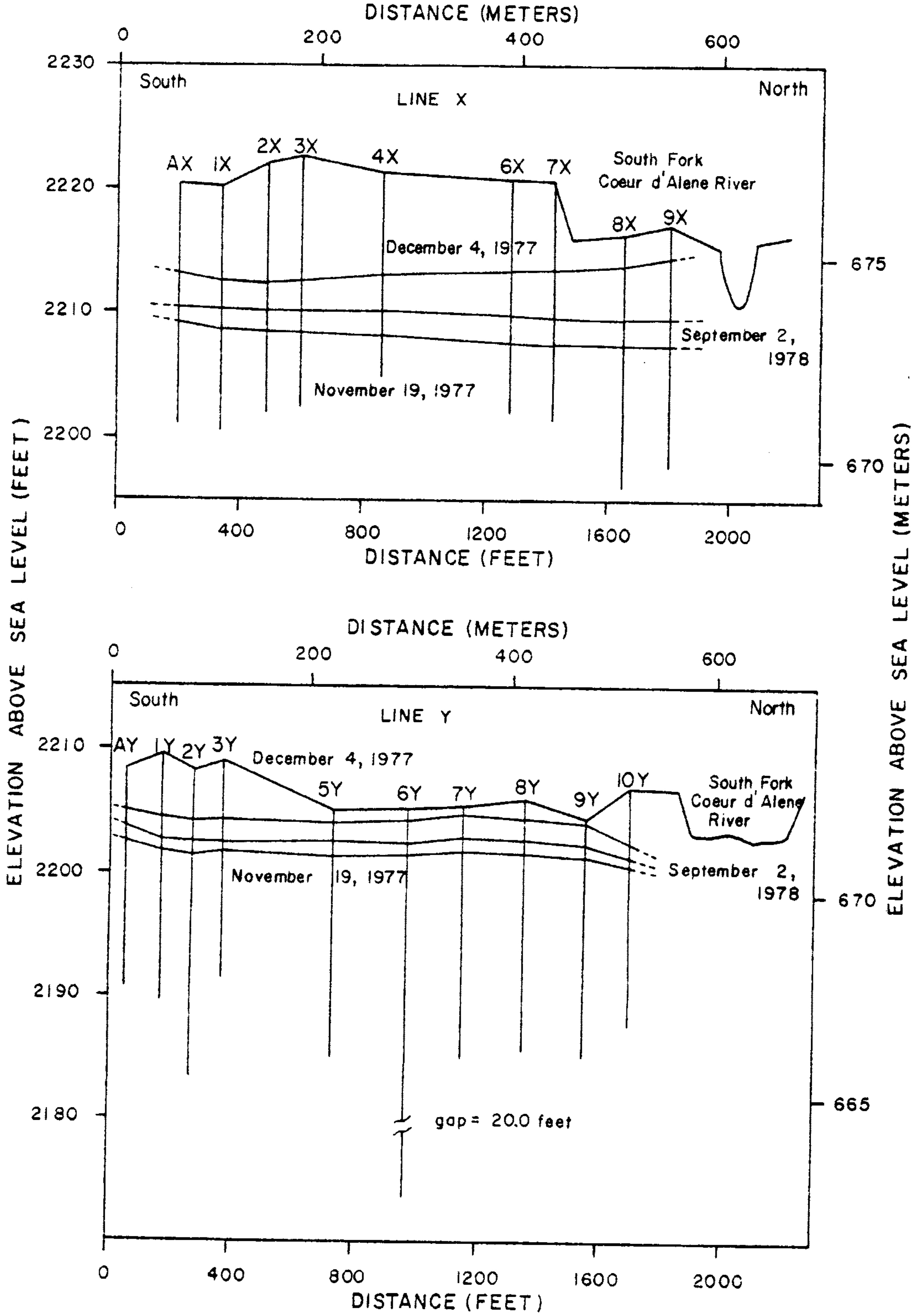


FIGURE 29. Cross sections of Line X and Line Y, showing ground water elevations, Smelterville Flats study area.

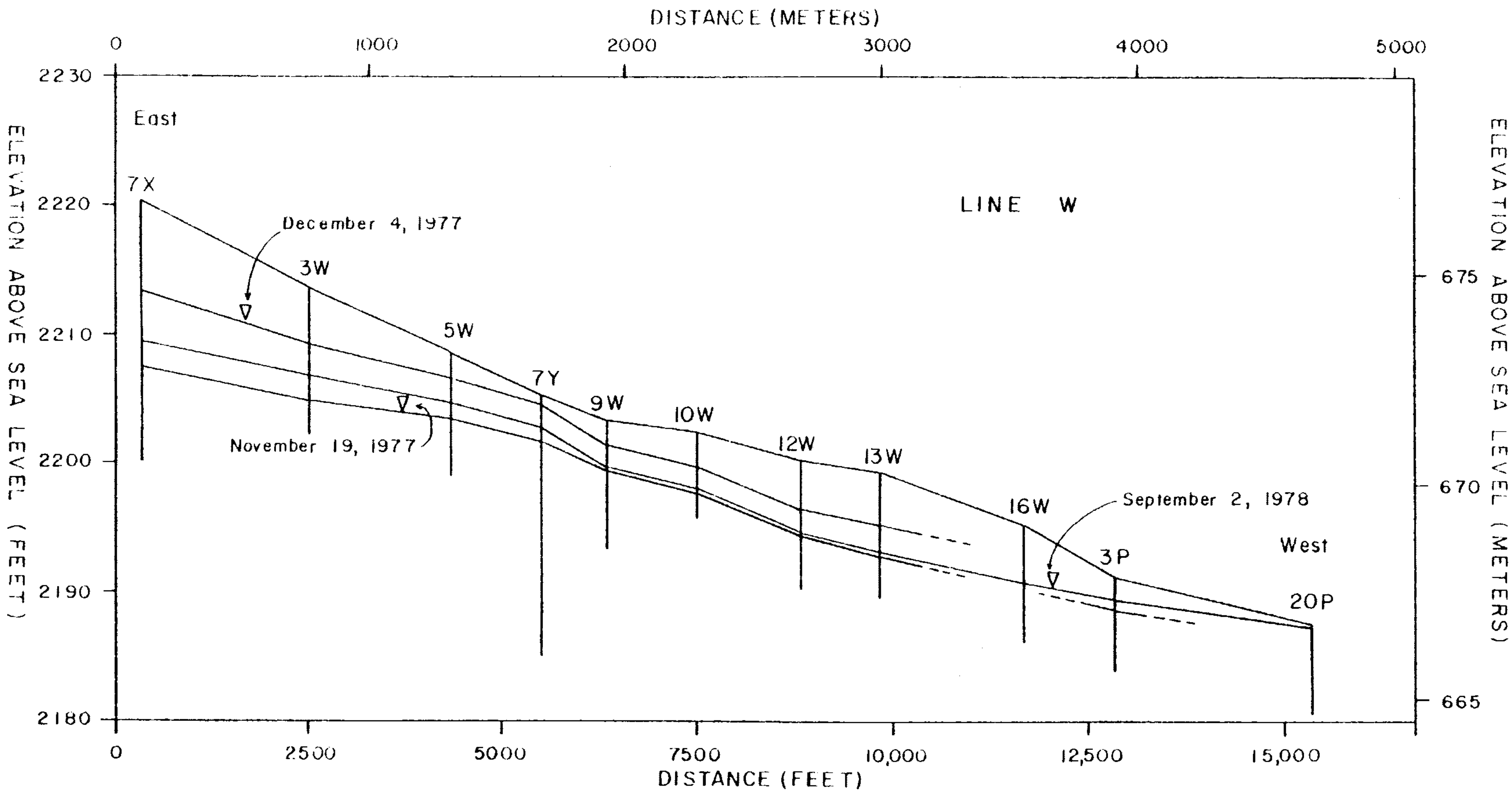


FIGURE 30. Cross section of Line W, showing ground water elevations, Smelterville Flats study area.

than AX. The change in water level on the Y-Line is uniform except from 8Y to 10Y, where the gradient slopes towards the river, indicating ground water flow towards the South Fork. Water level changes along the W cross section indicate a greater rise in the potentiometric surface in the eastern end of the study area than in the western end. A change in the hydraulic gradient is also noted west of piezometer 7Y, which is due to a change in the permeability of the aquifer.

Recharge to the upper aquifer also occurs from direct precipitation on the surface material. Precipitation in the study area did not create major surface water runoff; much of the precipitation is believed to have infiltrated into the upper portion of the alluvial-mine waste material. The grain size of the soils would control the downward movement of water to the water table. The greatest recharge from precipitation would tend to occur where the surficial sediments are coarser. Recharge from precipitation would be restricted where the finer fraction of the mine wastes have been deposited at the surface.

Water quality data also indicates that ground water is recharged by surface water originating from the South Fork of the Coeur d'Alene River and from the swamp around the Page Wastewater Treatment Facility. Table 5 lists water quality data for several piezometers in the recharge zones. Stations 200 and 205 are surface water samples taken in the South Fork of the Coeur d'Alene River at the Smelterville Bridge and downstream near piezometer 9X, respectively. The values presented in Table 5 for piezometers 7X, 8X, and 9X exhibit similar trends between the two depths; "A" depth is open for a one foot (30.48 cm) interval, approximately 20 feet (6.1 meters) below the surface, and "B" depth is open for a one foot (30.48 cm) interval between 12 to 17 feet (3.7 to

Table 5. Water quality values for stations in ground water recharge zones, March 25, 1978, Smelterville Flats study area.

Station	Temp °C	pH	Concentrations in PPM Fe	Pb	Cd	Zn	Ca	Mn
7XA	5.2	6.7	-0.5*	0.0	0.0	11.03	64.6	16.8
7XB	4.9	6.6	0.0	0.09	0.037	5.1	27.0	0.05
8XA	7.4	6.8	0.15	0.0	0.0	0.079	71.2	8.3
8XB	9.0	6.5	0.0	0.0	0.71	6.9	27.1	0.16
9XA	7.0	6.8	0.57	0.0	0.0	0.079	50.8	7.2
9XB	7.0	6.4	-0.05	0.12	0.102	10.5	31.0	0.8
200	6.0	6.5	0.37	0.0	0.022	1.9	16.1	0.40
205	7.0	6.6	0.28	0.0	0.02	1.8	14.4	0.36
3W	5.5	6.4	-0.05	0.0	0.047	3.7	23.2	-0.04
18P	9.0	6.3	-0.05	0.0	0.025	3.2	23.2	0.43
4P	7.2	6.2	46.2	0.0	0.027	108.0	93.9	46.0

* (-) Metal was present but below accuracy of instrumentation.

5.2 meters) below the surface. The values measured at the "A" and "B" depths are measurements of the reaction products from acid water production and the metals taken into solution by the acid. Concentrations of metals for samples 7XB, 8XB, and 9XB are generally above the concentrations of the samples taken from the South Fork except for iron. The differences in metal concentrations between 7X, and 8X-9X can be explained in that 8X and 9X are located in the river channel where most of the mine waste has been carred away, while 7X penetrates the mine waste material.

The concentrations of zinc are related to their position within the ground water flow system (Figure 31). As water enters the waste, either through infiltration of precipitation or ground water level fluctuations, metals that have been weathered into a soluable state are leached. The water measured at 7X originated from up gradient in the ground water flow system and has been affected by more mine waste than the water measured at either 8X or 9X. The differences in zinc concentrations with depth are probably due to variations in the mineral content of the aquifer material that the water passed through prior to reaching the piezometer. This is discussed in more detail in the section on chemistry of water. Piezometer 18P is located hydraulically up gradient from the Page area, with concentration of zinc increasing down gradient, indicating that zinc is going into solution between piezometers 18P and 4P.

The average gradient of the potentiometric surface is about 0.0037 feet/feet (0.0011 meters/meters) from piezometer AX to piezometer 15W for both the "A" and "B" depths. The gradient steepens towards the west with a drop of 0.0052 feet/feet (0.0016 meters/meters) from piezometer AY to piezometer 15W. The change in gradient is a function of a change in the amount of water in the system, the cross sectional area, or the properties of the soil that the water moves through as demonstrated by the Darcy equation (Todd, 1959, p. 46):

$$Q = KIA$$

Where: Q = rate of flow through a cross sectional area in gallons per day (gpd),

K = hydraulic conductivity of the aquifer in gallons per day per square feet (gpd/ft^2),

A = cross sectional flow area in square feet (ft^2), and

I = hydraulic gradient in feet per feet (ft/ft).

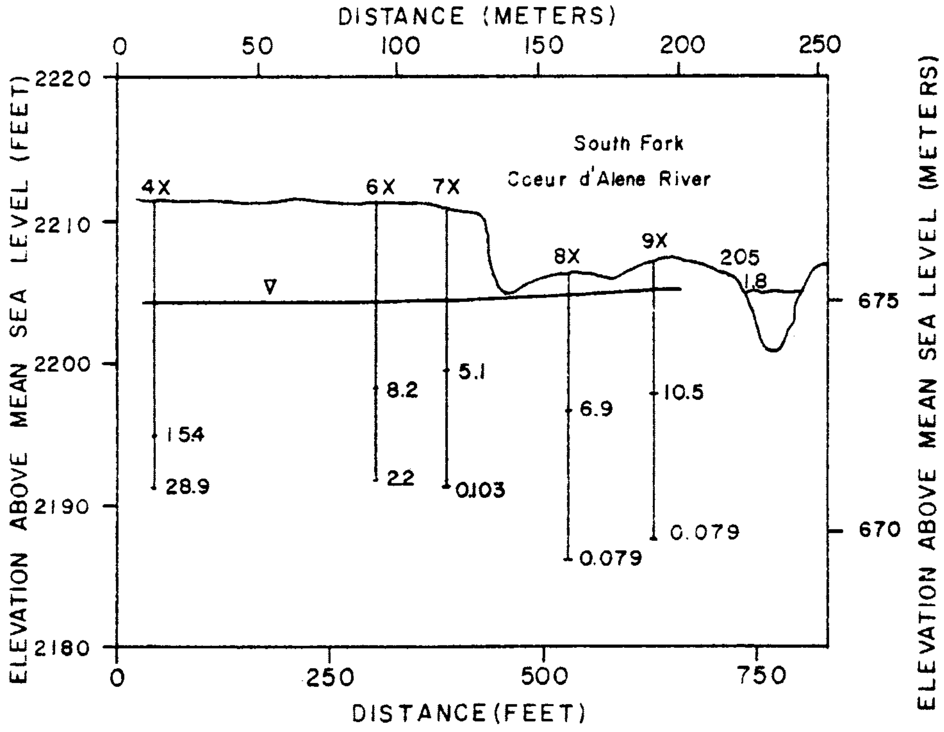


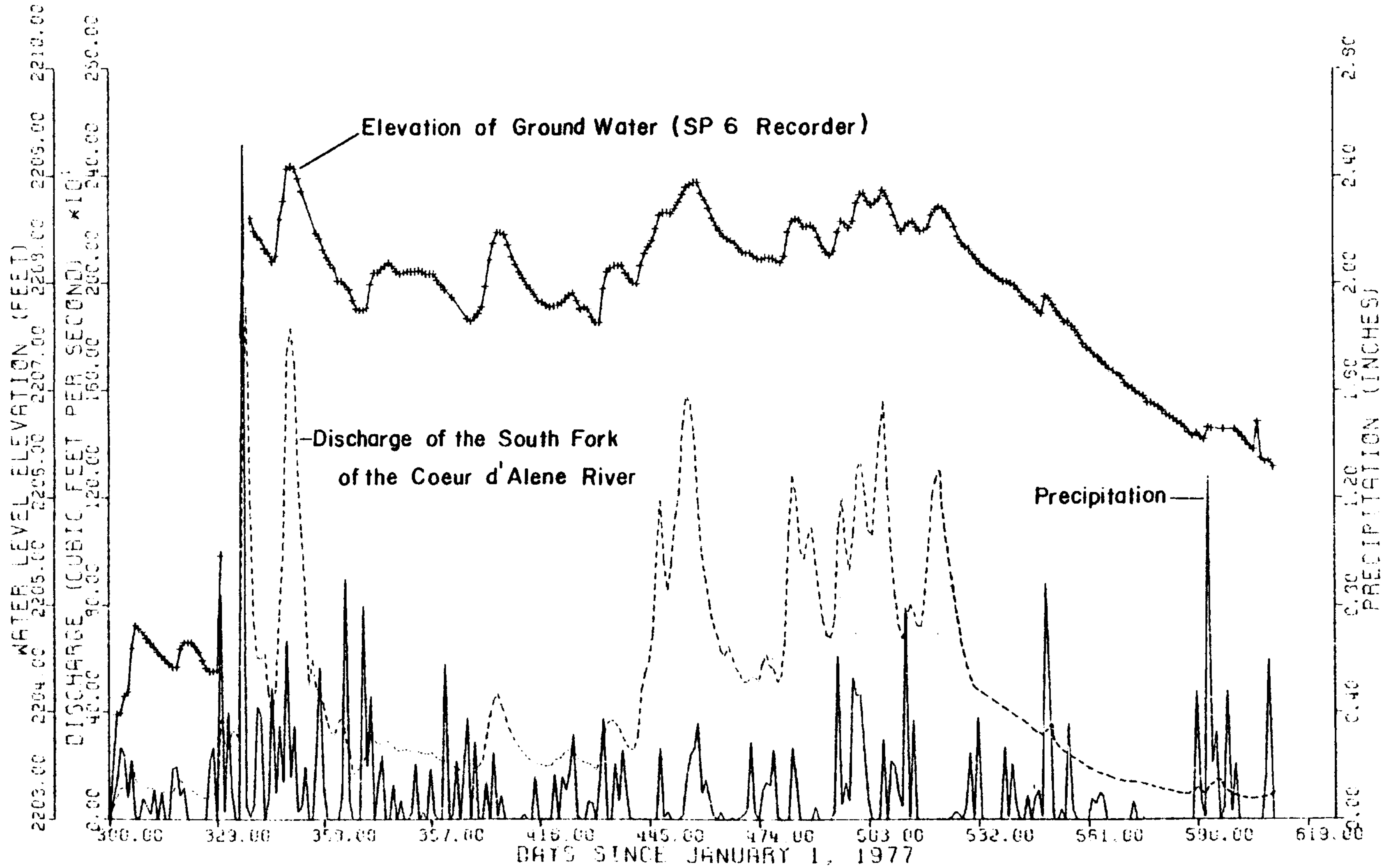
FIGURE 31. Plot of zinc concentrations versus depth at piezometers 4X, 6X, 7X, 8X, and 9X on March 25, 1978, Smelterville Flats study area.

Assuming that the rate of flow (Q) and the cross sectional area (A) remain constant, then when the hydraulic conductivity (K) decreases, the gradient (I) increases. The cross sectional area (A) was approximated perpendicular to flow and where the contour lines were evenly spaces and constant.

The flow through cross section C-C' (Figure 5) was determined by Darcy's Law. The hydraulic conductivity for both the upper and the lower aquifers was estimated to be 1,000 gpd/ft (12.4 m^2/day) each based on the grain sizes of which the aquifer is composed (Todd, 1959, p. 53). The cross sectional area is 130,000 square feet (12,000 square meters) for the upper aquifer and 270,000 square feet (25,000 square meters) for the lower aquifer at cross section C-C'. Only 15 feet (4.6 meters) of the upper aquifer is saturated, so the cross sectional area is only 90,000 square feet (8,400 square meters). The hydraulic gradient from piezometer AX to piezometer 15W is 0.0037 feet/feet (0.0011 meters/meters). The total flow through both aquifers is estimated to be 35,000 gallons per day (1.3×10^5 liters per day). The flow of the South Fork of the Coeur d'Alene River at Kellogg averages between 3.8×10^7 gallons per day (1.4×10^8 liters per day) to 1.5×10^9 gallons per day (5.7×10^9 liters per day).

The response time of the ground water flow system to snow melt and precipitation events and changes in discharge of the South Fork of the Coeur d'Alene River and its tributaries is very short, generally less than twenty-four hours. Figure 32 shows daily values for precipitation, discharge of the South Fork, and ground water levels at soil pit 6 (SP 6). On December, 2, 1977, 2.52 inches (6.54 cm) of rainfall were recorded at Kellogg, Idaho. This precipitation, coupled with a

FIGURE 32. Daily values for precipitation, water level at Soil Pit 6, and discharge for the South Fork of the Coeur d'Alene River at Kellogg, Smelterville Flats study area.



snow melt at the higher elevations, caused the South Fork to rise and then fall very rapidly. The rapid response of the river to the rainfall event was probably due to the frozen condition of the soil and the melting of the snow pack. The ground water level rose almost as rapidly as the river. Additional rain fell during the middle of December, causing an increase in the discharge of the Coeur d'Alene River, thus, resulting in additional recharge to the aquifer. After the second recharge event, the ground water level declined again. The total accumulative rise in water level at SP 6 following the two recharge events was 4.8 feet (1.5 meters). The hydrograph from SP 6 only declined 1.5 feet (0.5 meters) over the next 30 days, then fluctuated within a two-foot interval (0.6 meters). The hydrograph began dropping in late May 1978, and continued to decline until the end of the data collection period on September 2, 1978, with only a couple of small recharge events (Figure 32). Ground water levels in August 1978, did not decline as low as they did in August 1977. For the water year 1978, ground water levels had increases ranging from 0.59 to 2.66 feet (0.18 to 0.81 meters). These increases in water levels for the year are the result of the recovery of the ground water system from a drought that affected most of the western United States from August, 1976 to July, 1977. The accumulative departure from mean monthly precipitation shows the drought period with the recovery beginning during the study period (Figure 33).

Continuous water level recorders were installed at three different locations in the study area to determine if there were differences in short term water level fluctuations between sites. A base recorder was installed at SP 6 so that the data from the other recorders could be compared to similar records. Two of the sites showed artesian

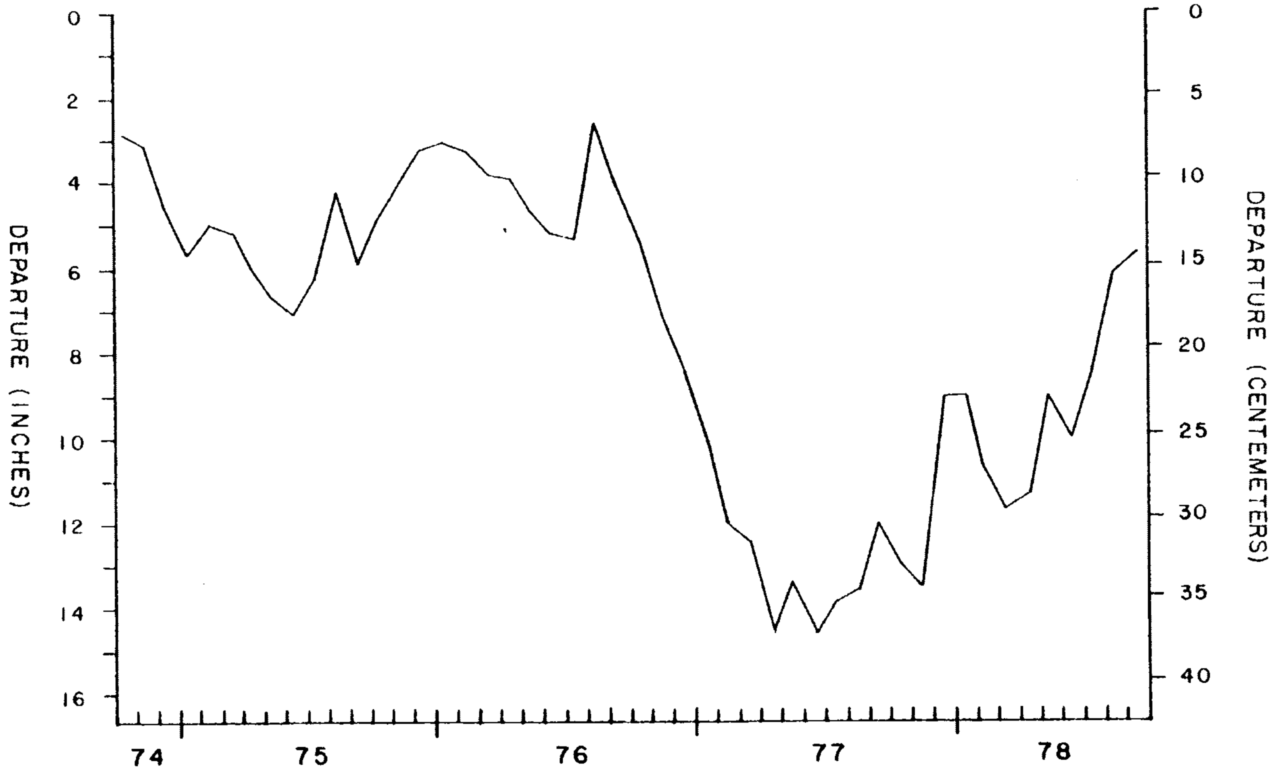


FIGURE 33. Accumulative departure from mean monthly precipitation, Smelterville Flats study area.

pressure while being constructed (SP 6 and SP 8), while SP 3 showed water table conditions. As water levels rose, SP 3 may have become semi-confined. Because the hydrographs of SP 3 and SP 6 responded similarly to changes in water level, only SP 6 was plotted on Figure 34. A general trend is shown by SP 8 that follows that of SP 6 (Figure 34). The hydrograph of SP 8 may be affected by wind, fluctuations in barometric pressure, and pressure applied by the loading of the aquifer by passing trains, and from seepage from the bottom of the two sewage lagoons located near the recorder. The water level fluctuations of SP 8 on April 12-23 and April 19-20 are not as evident at SP 6. Small precipitation events took place during these dates, and the discharge of the South Fork of the Coeur d'Alene River increased slightly. The surface water flow around the Page Wastewater Treatment Facility may be responsible for the larger increase in ground water level at SP 8. This difference in response of the water levels between the two locations (SP 6 and SP 8) demonstrates the complex nature of the ground water flow system in the Smelterville Flats.

Piezometer data also indicate that fluctuations of the ground water level are similar over the study area with the magnitude of the changes varying. Several hydrographs are presented in Figures 35 through 38. The largest fluctuations occur at piezometers in the eastern end of the study area, represented by piezometers 2XA, 2XB, and 9XA. The farther west, the less magnitude of the change that occurs in the water levels as shown by piezometers 2YA, and 2YB, 10YA and 10YB, 3W, 5W, 9W, and 1P-4P. The hydrographs for "A" and "B" depths are similar to each other for the X-Line and the Y-Line piezometers. The fluctuations follow seasonal trends and are in response to aquifer recharge

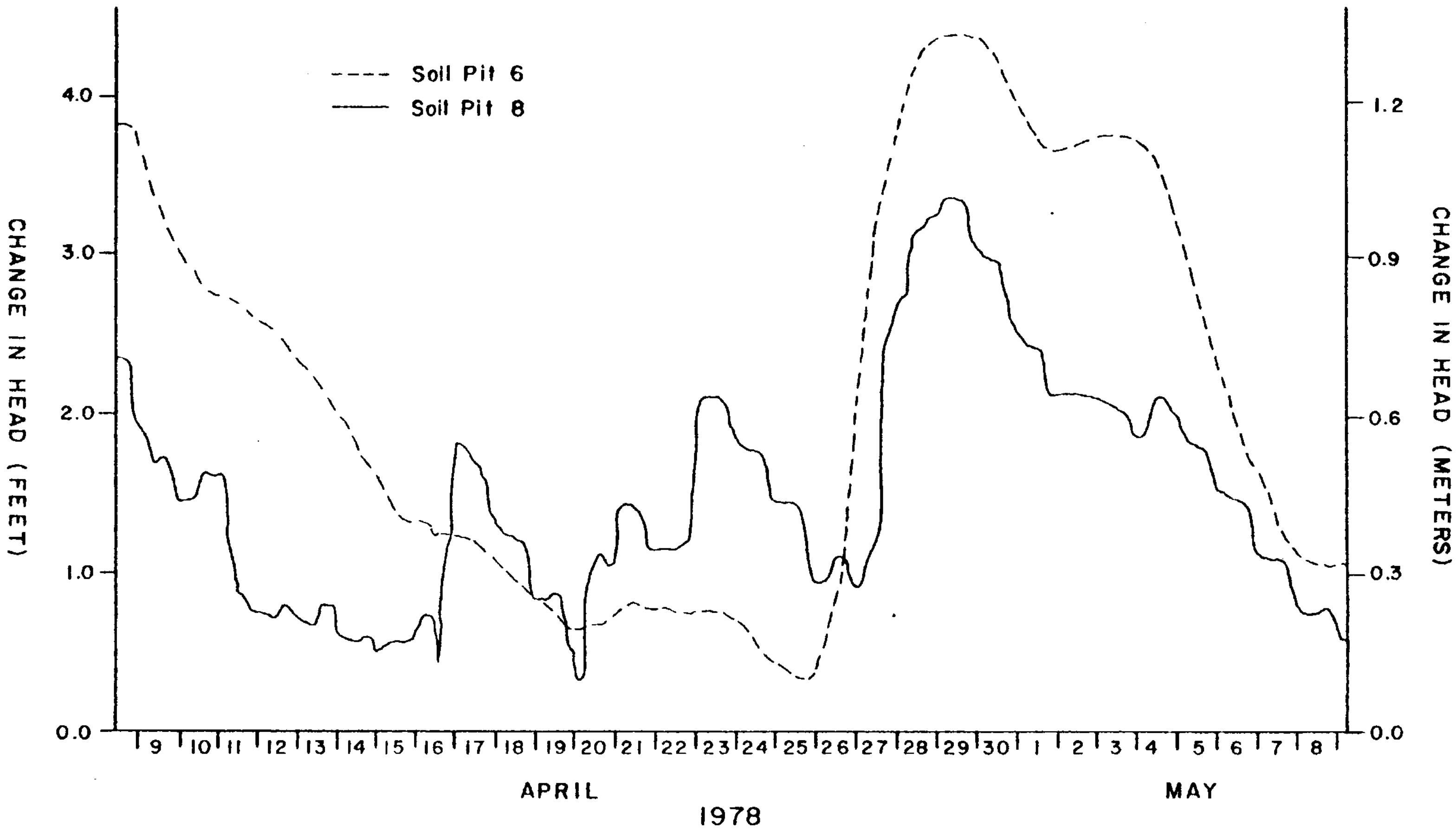


FIGURE 34. Hydrographs for SP 6 and SP 8 taken from water level recorders, Smeltervile Flats study area.

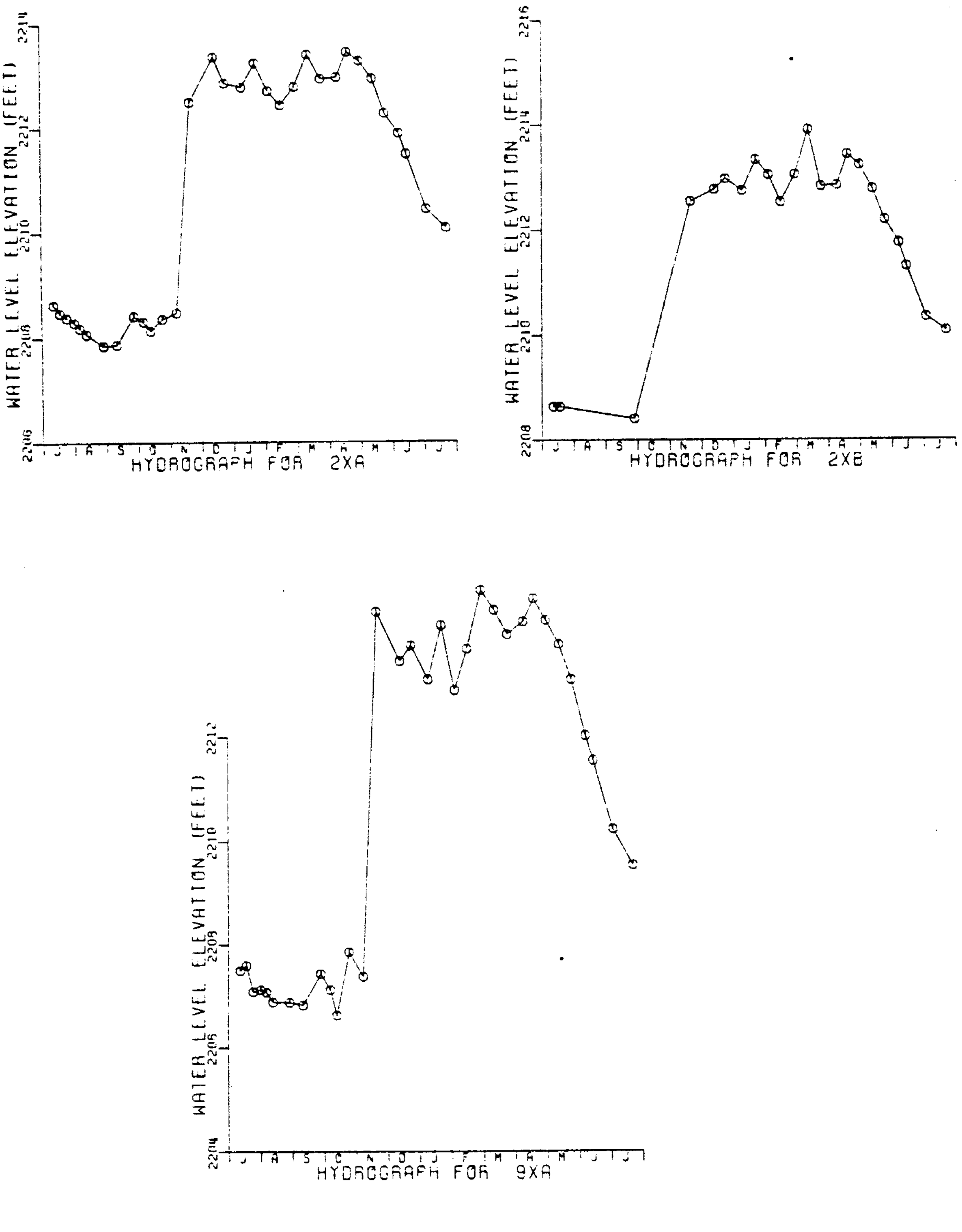


FIGURE 35. Hydrographs for piezometers 2XA, 2XB, and 9XA from July, 1977 to July, 1978, Smelterville Flats study area.

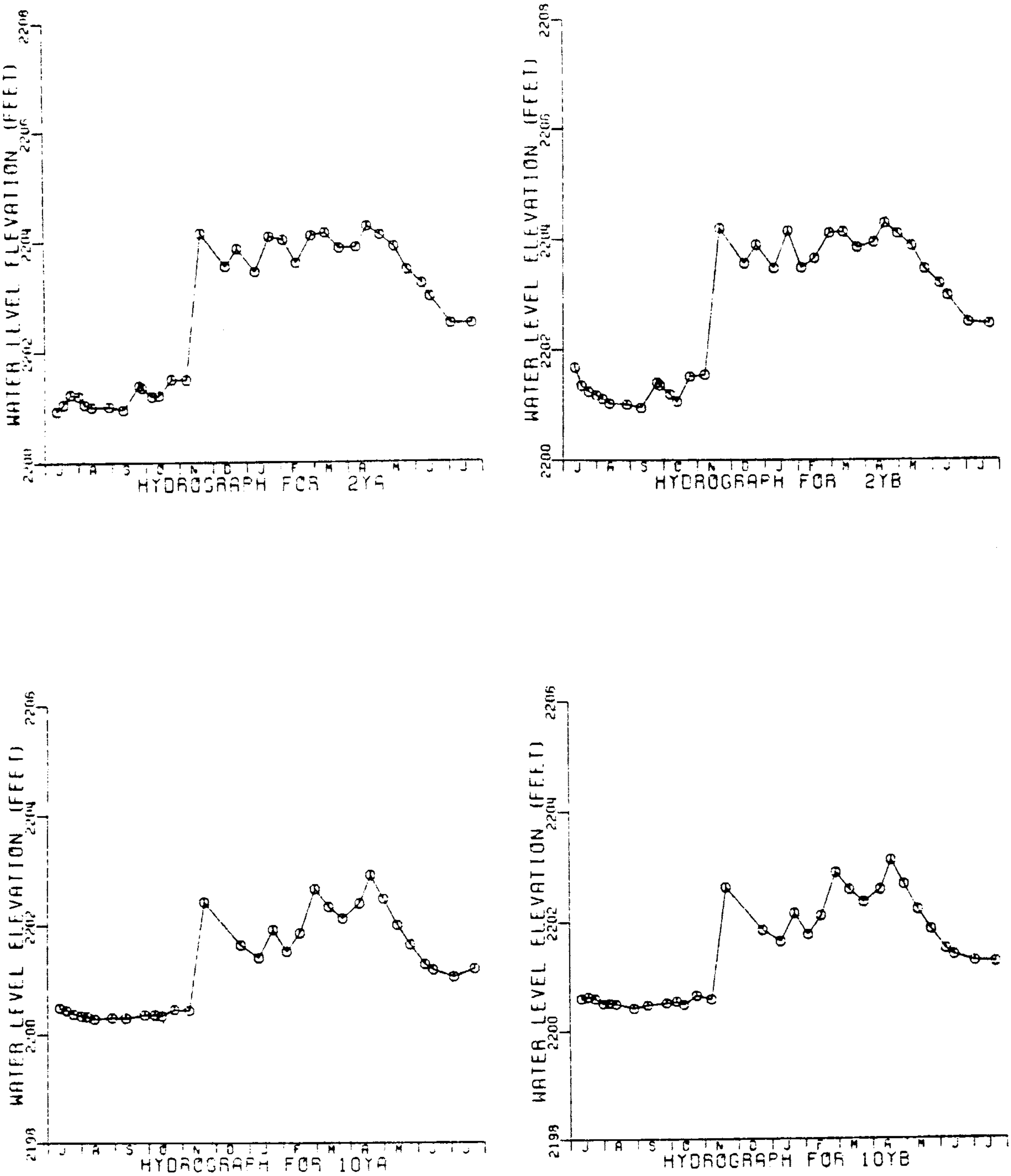


FIGURE 36. Hydrographs for piezometers 2YA, 2YB, 10YA, and 10YB from July, 1977 to July, 1978, Smelterville Flats study area.

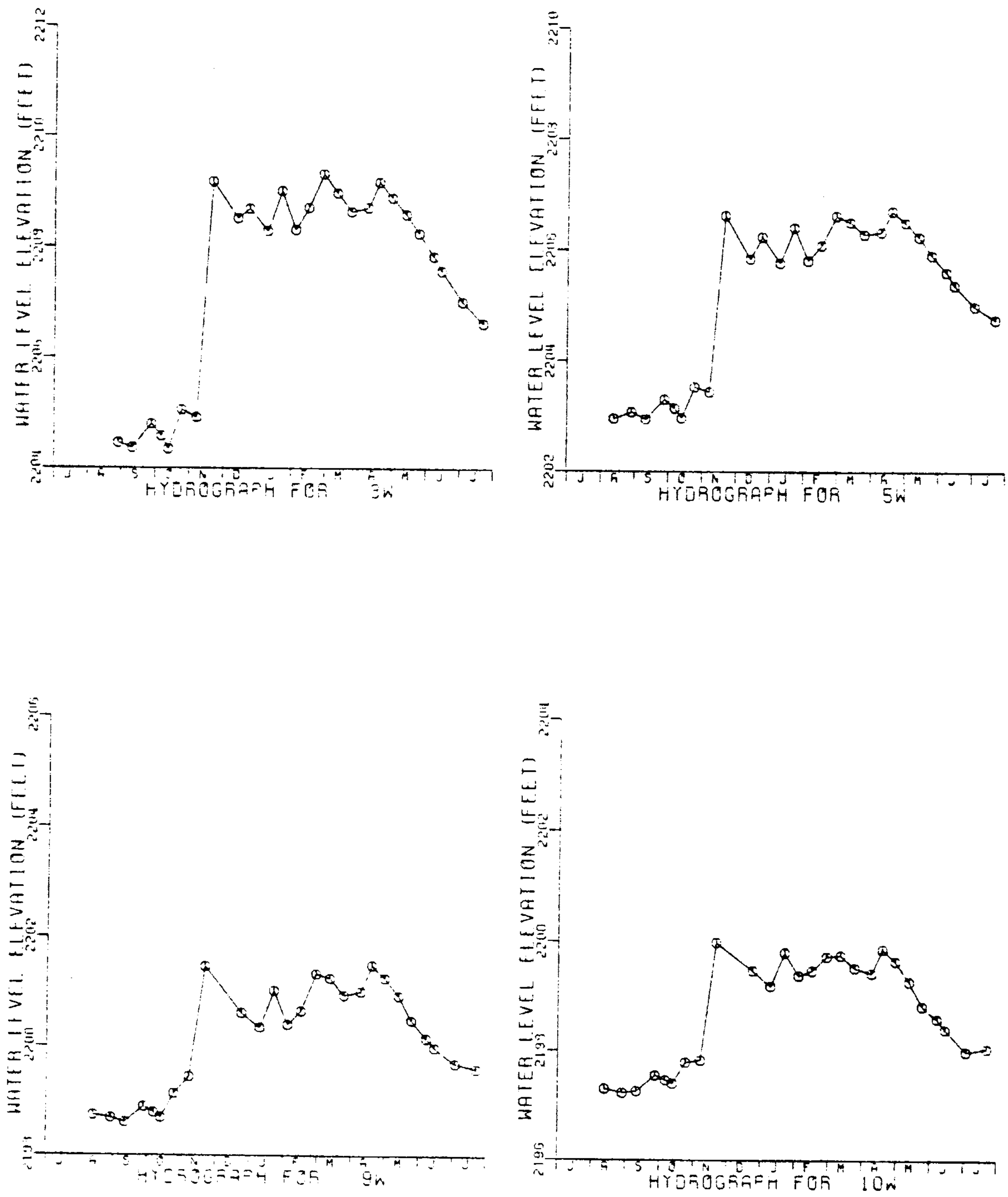


FIGURE 37. Hydrographs for piezometers 3W, 5W, 9W, and 10W from July, 1977 to July, 1978, Smelterville Flats study area.

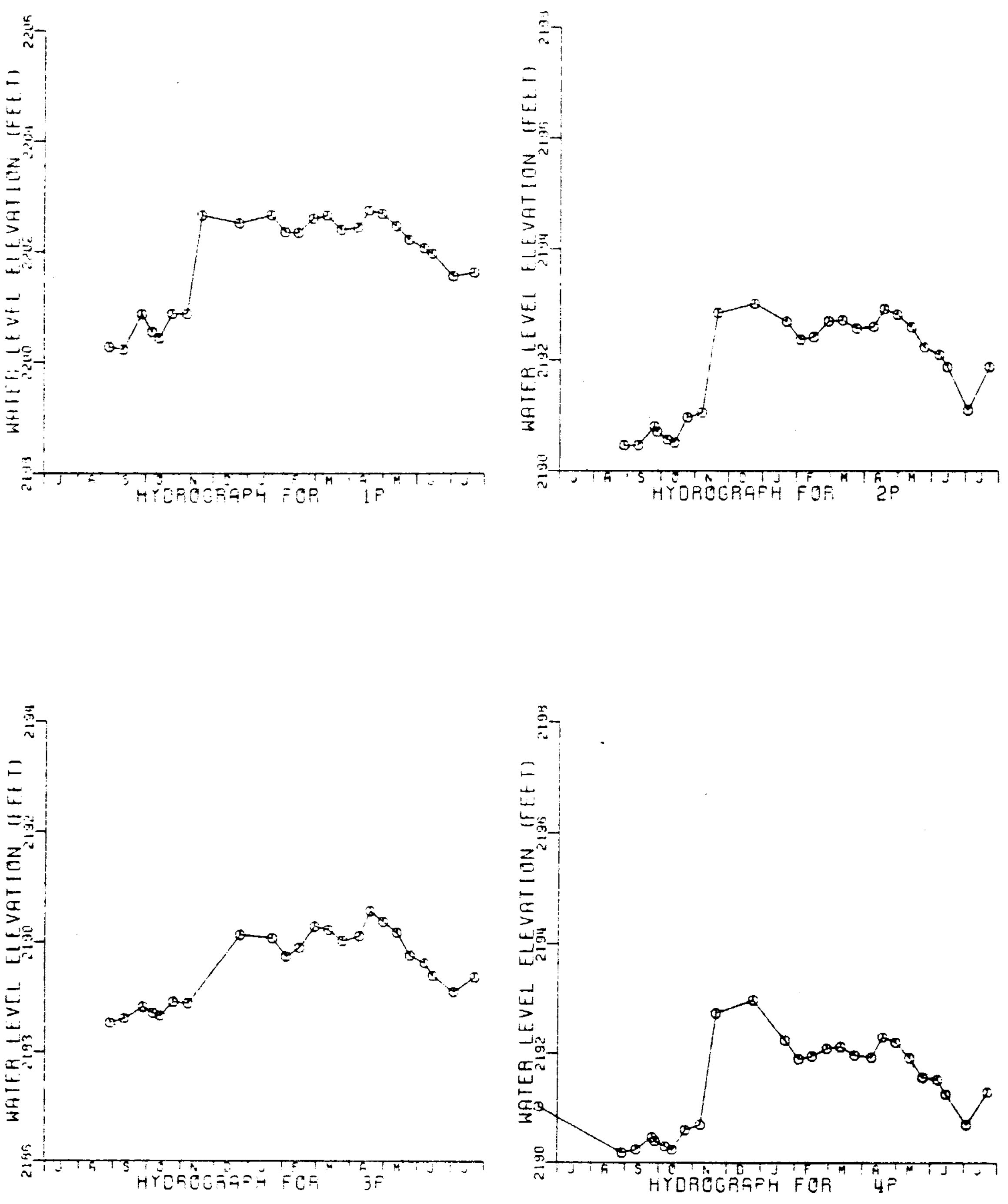


FIGURE 38. Hydrographs for piezometers 1P, 2P, 3P, and 4P from July, 1977 to July, 1978, Smelterville Flats study area.

and discharge and to precipitation. All of the hydrographs show an increase in the ground water level over the year from August of 1977 to August of 1978.

Chemistry of the Ground Water

by

Dale Marcy

The following material has been abstracted from a more complete discussion of the chemistry of the ground water prepared in this study (Marcy, 1979). The material presented here describes some of the reactions occurring in the mine waste and the removal of the reaction products to the river via the ground water system.

The water samples collected from the piezometers are assumed to be representative of the ground water in the sediments. The sample cannot be considered to be representative of all the water in the vertical section, but rather an average of the water contained in sediments sampled by the perforated interval of the piezometer. Locations of higher and lower concentrations must be assumed to be present.

The water chemistry discussed in this section is based on the observed concentrations at selected piezometer sites. Each piezometer is considered as a closed system, comprised of a piezometer and a cylindrical column of sediments surrounding the piezometer. No water movement across the system will be discussed. The relation of water quality to ground water flow will be discussed in the next chapter.

Piezometers 2P and 4P

Water quality data from piezometers 2P and 4P near the Page Tailings pond are used to describe the chemical processes which are believed to occur in the abandoned mine waste. The primary reason for using these sites as the initial discussion is due to the high concentrations of metals found which allows easier discussion of the chemical reactions.

The general outline of this discussion will be the description of the environmental aspects of the metal concentrations and other parameters measured in the study. Then the proposed mechanisms of achieving the conditions measured will be discussed. Zinc will be the first metal addressed since the dissolution of sphalerite involves many of the important chemical reactions believed to be occurring in the Flats.

Zinc

Zinc is an essential element in human metabolism; for preschool-aged children the daily requirement is 0.3 mg/kg body weight (Vallee, 1957). Community water supplies have been found to contain 11 to 27 mg/l without harmful effects (Bartow and Weigle, 1932). The quality of the water is poor since above 4 mg/l zinc, the water has an astringent taste. For this reason the maximum concentration recommended for domestic water supplies has been set at 5 mg/l (EPA, 1976).

Fish are not so tolerant as human beings when exposed to high concentrations of zinc. The toxicity is modified by several environmental factors, particularly hardness, dissolved oxygen, pH, and temperature (EPA, 1976). The most sensitive fish in the Smelterville Flats area is the rainbow trout, *Salmo gairdneri*. The acute toxicity TL_{50} 96 hour (toxic limit for 50% within 96 hours), ranges from 0.10 mg/l to 0.91 mg/l depending on the size of the fish and the other water quality parameters referred to above. The graphs of water quality (Figure 39) as a function of time indicate that much higher concentrations are possible in the ground water of the Smelterville Flats.

The table describing the mineralogical composition of the ore types found in the Bunker Hill Mine, Table 6, can be used as being indicative of the minerals deposited on the Flats. The zinc would have

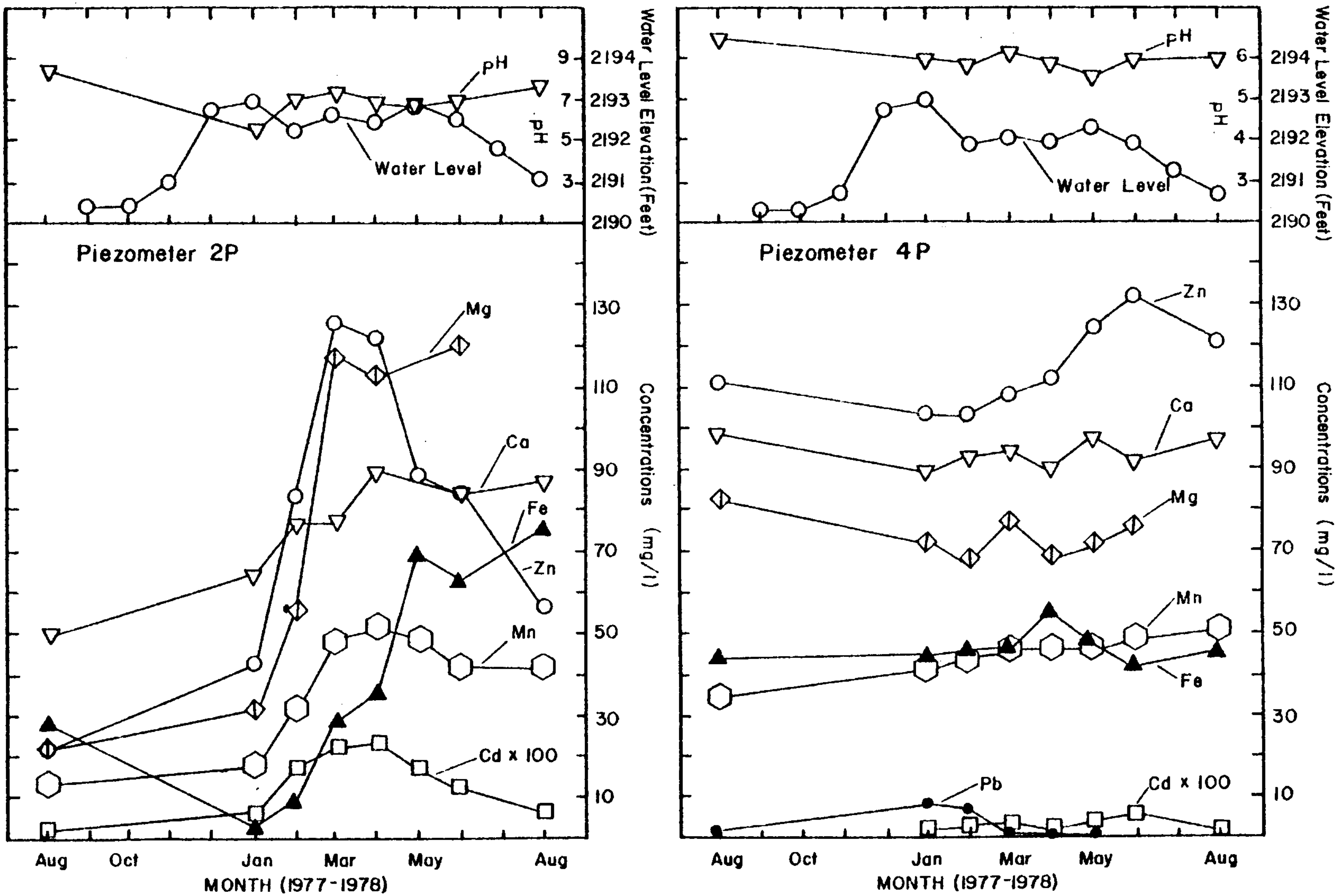


FIGURE 39. Time plots of metal concentrations for piezometers 2P and 4P, Smelterville Flats study area.

Table 6. Mineralogical composition of the ore types found in the Bunker Hill Company Mine (Ralston, 1973).

Minerals	Bluebird (Flood Stanley Ore Body)	Bunker Hill (March Ore Body)	Jersy
Galena, PbS	A	A	A
Sphalerite, ZnS	A	R-P	A
Pyrite, FeS_2	A	R-P	R
Arsenopyrite, FeAsS	P	N	N
Chalcopyrite, $CuFeS_2$	P	P	N
Tetrahedrite, $(Cu, Fe, Zn, Ag)_{12}Sb_4S_3$	P	P	P-A
Siderite, $FeCO_3$	A	A	P-A
Ferrodolomite, $Ca(Mg, Fe)(CO_3)_2$	A	A	P-A
Quartz, SiO_2	A	P	A
Bournonite, $PbCuSbS_3$	R	N	N
Boalangerite, $Pb_5Sb_4S_{11}$	R	N	N
Stibnite, Sb_2S_3	R	N	N
Sericite, $K\,Al_2(AlSi_3O_{10})(OH)_2$	P	P	P
Chlorite, $Mg_3(Si_4O_{10})OH_2\text{-}Mg(OH_{10})_6$	P	P	P
Limonite, $FeO(OH)n\ H_2O$	A	N	N
Cerussite, $PbCO_3$	R	N	N

A = Very Abundundant
P = Present
R = Rare
N = None Noted

been deposited as tetrahedrite ($Cu_{12}Sb_4S_{13}$) and sphalerite (ZnS (Fe, Mn, Cd)); the sphalerite will be used in the following discussion of chemistry. The sphalerite reached the Flats due to the incomplete separation of the mineral from the gangue in the concentration of the ore prior to smelting. As shown in the discussion of the Soil Pits, the zone of concentration for zinc in the waste varies with the bedding of the wastes. To start, look at the Figure 16 for soil pit 8, located near piezometers 2P and 4P and the graphs of metal concentration as a function of time for 2P and 4P (Figure 39). As can be seen from the graphs, high zinc concentrations are found in the sediments and the ground water. How did the zinc deposited as a solid in the sediments become dissolved in the ground water?

The dissolution of zinc is an important chemical reaction since it is necessary to weather the zinc into a soluble state for leaching. The simplest reaction would be the oxidation of sphalerite by molecular oxygen as shown in the reaction

$$ZnS_{(5)} + 2O_2 = Zn^{2+} + SO_4^{\ 2-} \qquad \text{(EQ = 1)}$$

Using Hesse's Law, the standard free energy formation can be calculated using data from the <u>Handbook of Chemistry and Physics</u>.

$$-177.34 - 35.184 - (-47.4) - 0 = -165.12 \text{ K cal/mole} \qquad \text{(EQ = 2)}$$

This large negative value indicates that the reaction is spontaneous as written; it does not show the reaction rate.

Sphalerite in the presence of dry air undergoes neglible oxidation. The chances that two molecules of oxygen will collide with the sphalerite crystal with the energy necessary for reactions is too small. If the sphalerite is in the presence of water and oxygen, a mechanism could be written as:

$$2H_2O + 2CO_2 = 2H_2CO_3 \qquad (EQ = 3)$$

$$ZnS + 2H_2CO_3 = Zn^{2+} + 2HCO_3 + H_2S \qquad (EQ = 4)$$

$$H_2S + 2O_2 = SO_4^{2-} + 2H^+ \qquad (EQ = 5)$$

$$2H^+ + 2HCO_3^- = 2H_2O + 2CO_2 \qquad (EQ = 6)$$

When reactions 3 through 6 are added, the sum is the reaction written in equation 1. The conclusion is that water and carbon dioxide act as catalysts in the oxidation of sphalerite. The reactions could occur at the sphalerite crystal's surface so that very small amounts of the intermediate compounds, HCO_3^- and H_2S, could be present in the system and the reaction would still occur.

Another mechanism has been postulated for the oxidation of sulfide ore (Sato, 1960). In this mechanism, water and oxygen come from trace amounts of hydrogen peroxide which then acts as the oxidizing agent. The reactions may be written as:

$$2H_2O_{(g)} + O_{2(g)} = 2H_2O_{2(g)} \qquad (EQ = 7)$$

$$4H_2O_{2(g)} + Zn_{(s)} = Zn^{2+} + SO_4 + 4H_2O \qquad (EQ = 8)$$

Equation 7 was postulated as being rate controlling. Evidence supporting this mechanism has been provided by the observation that the redox potential for mine water lies in the vicinity of the O_2 - H_2O_2 couple

$$H_2O_2 = O_2 + 2H^+ + 2e^- \qquad Eh = 1.22 - 0.059\ pH \qquad (EQ = 9)$$

instead of the theoretical O_2 - H_2O couple

$$2H_2O = O_2 + 4H^+ \qquad Eh = 0.68 - 0.059\ pH \qquad (EQ = 10)$$

Another possible mechanism could be formulated based on the generation of acid water from pyrite oxidation. The first two reactions could be those producing ferric ions from pyrite (FeS_2).

$$FeS_{2(s)} + 7/2O_2 + H_2O = Fe^{2+} + 2SO_4^{2-} + 2H^+ \quad (EQ = 11)$$

$$Fe^{2+} + 1/4O_2 + H^+ = Fe^{3+} + 1/2H_2O \quad (EQ = 12)$$

If before the ferric ion produced by equation 12 is hydrolyzed, the ferric ion contacts sphalerite, the following oxidation could occur:

$$ZnS + 8Fe^{3+} + 4H_2O = 8Fe^{2+} + SO_4^{2-} + 8H^+ \quad (EQ = 13)$$

The standard free energy for the reaction is:

$$8(-20.3) - 35.184 - 177.34 + 0 - -47.4 + 8(-2.52) + 4(-56.69) = -80.60 \frac{\text{Kcal}}{\text{mole}} \quad (EQ = 14)$$

Once again, the negative value indicates the spontaniety of the reaction, not the rate. In this case the reaction will be kinetically controlled by the oxidation of ferrous to ferric ion, the oxidation of sphalerite by the ferric ion, and the diffusion of the ferric ion to the sphalerite surface where reaction 13 occurs.

If the environment were only controlled by physical chemistry, these mechanisms might suffice to describe dissolution of sulfide ores. The environment is an ecological system, though, so the organisms living in the sediments must also be considered.

The sphalerite could also be oxidized by chemautotrophic bacteria (Alexander, 1961). This group of bacteria obtain the energy necessary for growth and biosynthetic reactions from the oxidation of inorganic materials and the carbon required from the assimilation of carbon dioxide.

The genus Thiobacillus contains five species which have been the subject of considerable investigation. The T. thiooxidans and the T. ferrooxidans have been shown to be involved in the acid water production in coal mines (Silverman, 1967). These bacteria have an optimum growth in a medium with a pH range from 2.0-3.5. This is in many cases the pH observed in gob pile drainage and coal mine drainage. However, in the soil water of the Smelterville Flats study area, the pH is sufficiently high to prevent these bacteria from playing a major role. This is not to say that these bacteria could not exist in the higher pH's found in the Smelterville Flats' sediments, it only indicates that the growth would not be rapid.

Other bacteria in the genera can exist in the near neutral range. The T. novellus and T. thioparus can oxidize inorganic sulfide compounds into sulfate. The presence of a particular species of Thiobacillus can be inferred from the pH developed in the media (Alexander, 1961). The genus Thiobacillus has been shown to be present in the Cataldo Flats (Galbraith, 1971). Since these bacteria are considered to be ubiquitous to sulfide containing soils, a safe assumption to make is that the Thiobacillus are also present in the sediments of the Smelterville Flats and that the organisms optimum in near neutral range are dominant in number.

The sphalerite is oxidized by one of the mechanisms just described in the aerobic zone of the sediments. The reactions will be limited by the diffusion of oxygen into the sediments where the sulfide ores exist. The rate of reaction will be the highest during low moisture content of the sediments since the diffusion of oxygen is much larger through soil air than through soil moisture. The major amount of oxidation will occur during the summer months.

The water movement in the zone of aeration can be represented by Figure 40. As late fall rains arrive and wash through the oxidized zone, the reaction products will be washed into the ground water. This can be observed in the time plots of 2P and 4P (Figure 39). As the water levels rise on the plots from fall rains, the zinc concentration also rises. The change in zinc concentration in 4P is lower due to dilution, but considering the large rises in water quantity in the ground water system, the actual amount of zinc dissolved in the system actually increases. In piezometer 2P, even with the increase in water level, the concentration of zinc in the ground water increases.

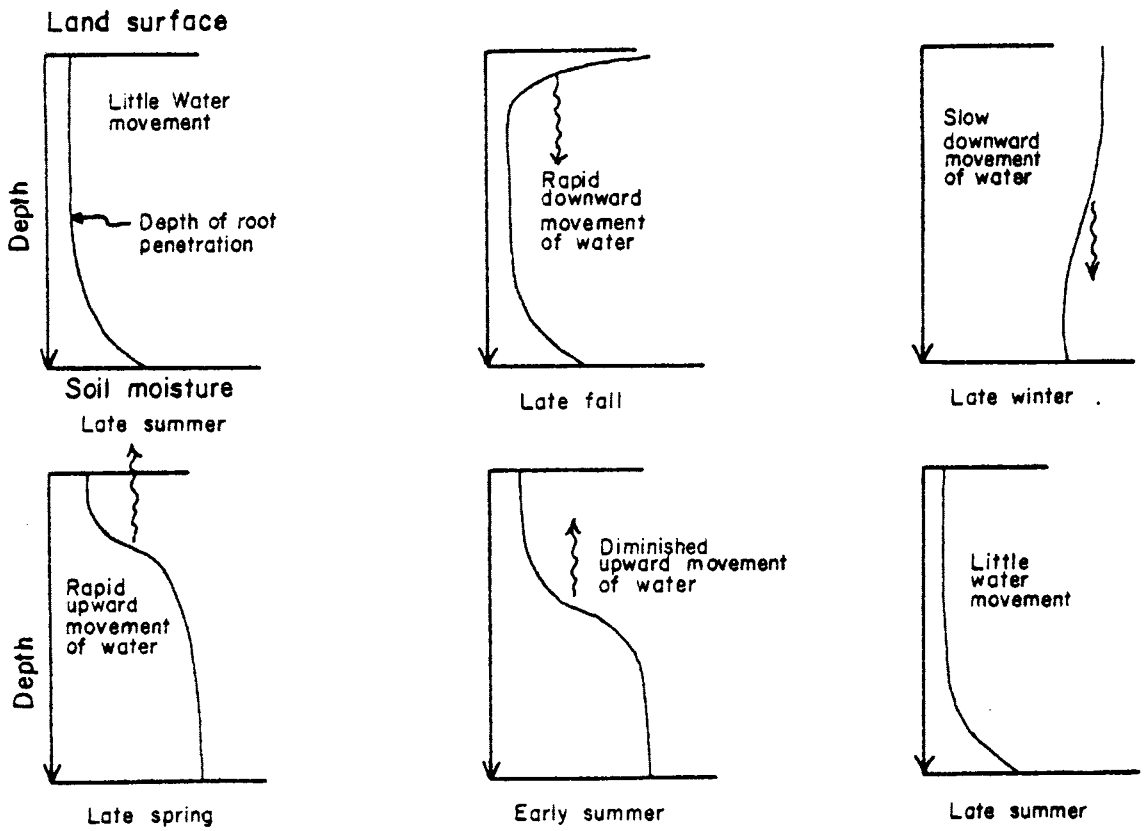


FIGURE 40. Soil-moisture profiles of a hypothetical soil in a region having wet winters and dry summers (Davis and Deweist, 1966).

In addition to the washing of the reaction sites by rain moving through the sediments, the water levels rise into the zone of aeration. This also washes the oxidized layer from the sediment particles. The combination of rinsing and flooding of the oxidized zone causes the increase in dissolved zinc.

As the water level falls in the summer the reaction products are carried away and the concentration of zinc in the ground water decreases. Oxygen enters the sediments under a concentration gradient and the oxidation reactions begin again.

Calcium

Calcium is the principle cation in most natural water. It is not normally considered a pollutant as far as toxicology is concerned. The primary concern for calcium is related to hardness of the water which relates to the toxicity of other metals (EPA, 1976); see the discussion of zinc.

The calcium in the Smelterville Flats was probably deposited as silicates, such as feldspars ($CaAl_2Si_1 08$) and as ferrodolomite, $Ca(Mg,Fe)(CO_3)_2$. Weathering of these minerals would increase the concentration of Ca^{2+} in the ground water. The reaction of feldspars, represented here by anorthite

$$CaAl_2Si_2O_8 + H_2O + 2H^+ = Al_2Si_2O_5(OH)_4 + Ca^{2+} \quad (EQ = 15)$$

is slow, and would not maintain a high Ca^{2+} concentration.

The Ca^{2+} ions in the ground water of the Flats were probably derived from dissolution of the ferrodolomite. For representation in this work, the formula used will be for calcite, since the consideration of equations and solubility are much the same.

The calcium carbonates react with acids according to

$$CaCO_3 + H_2CO_3 = Ca^{2+} + 2HCO_3^- \qquad (EQ = 16)$$

This reaction shows that the solubility of calcite will be pH dependent. At low pH the reaction will proceed as written, increasing Ca^{2+} concentration. At high pH the reverse reaction will predominate causing the precipitation of calcite.

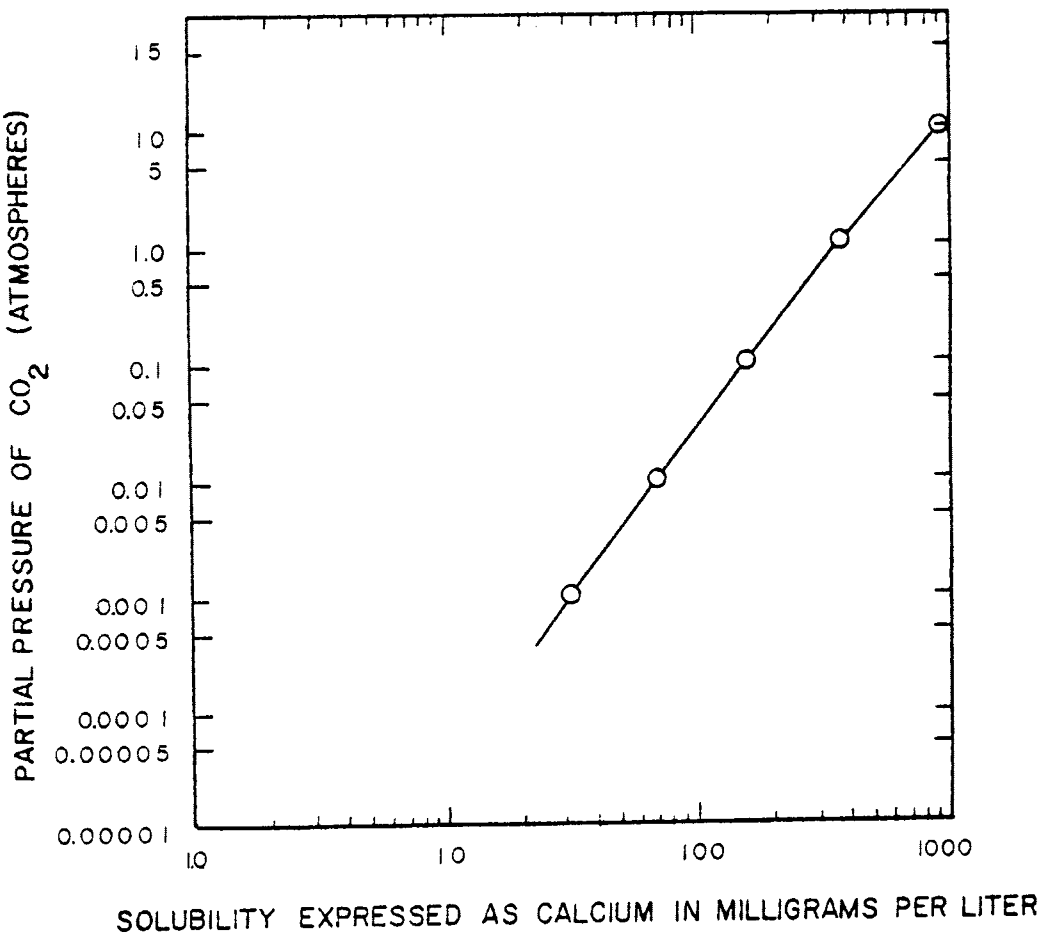


FIGURE 41. Solubility of calcium carbonate (calcite) in water at 25°C in the presence of carbon dioxide (Hem, 1970).

The carbonic acid shown in the equation can be formed from carbon dioxide and water

$$H_2O + CO_2 = H_2CO_3.$$

The dissolution of calcite is related to the partial pressure of carbon dioxide. Figure 41 (page 98) shows the solubility of calcite as related to the partial pressure of CO_2.

The Ca^{2+} concentrations shown in piezometers 2P and 4P are probably not generated by reaction with the weak carbonic acid, but are due to the reaction with the acid waste generated by pyrite oxidation.

$$FeS_{2(s)} + 7/2O_2 + H_2O = Fe^{2+} + 2SO_4^{2-} + 2H^+ \quad (EQ = 17)$$

The acid produced reacts with the calcite

$$CaCO_3 + H^+ = Ca^{2+} + HCO_3^- \quad (EQ = 18)$$

The amount of carbonate minerals present in relation to the abundance of pyrite oxidized, will determine the acidity of the ground water. Such considerations have been explored in detail on the ores of the Bunker Hill Mine (Reece, 1974).

Equilibria involving carbonates are considered to be the major factor limiting the solubility of Ca^{2+} in natural water systems (Hem, 1970). A graphical relationship for equation 18 is shown in Figure 42. This graph allows a quick estimate of whether the ground water is supersaturated with respect to calcite. The calcium concentrations in 2P and 4P fluctuate between 90 and 100 mg/l at the maximum. From Figure 42, the values for 2P and 4P are well below the saturation level at the pH and alkalinity measured.

The Ca^{2+} concentration is probably controlled by the reactions 17 and 18 given above. The hydrogen ions produced by pyrite, then indirectly control the amount of Ca^{2+} observed in the ground water.

As the time plots for metal concentrations show, the Ca^{2+} moved into the ground water increases. In 2P the concentration increases even with the increase in water quantity. In 4P the concentration fluctuates between 90 and 100 mg/l, even with the increase in water quantity. This indicates a washing of Ca^{2+} into the water. The hydrogen ions that are washed away from the pyrite reaction sites, encounter calcite or dolomite and react according to reaction 18 and produce an increase in Ca^{2+} in the ground water.

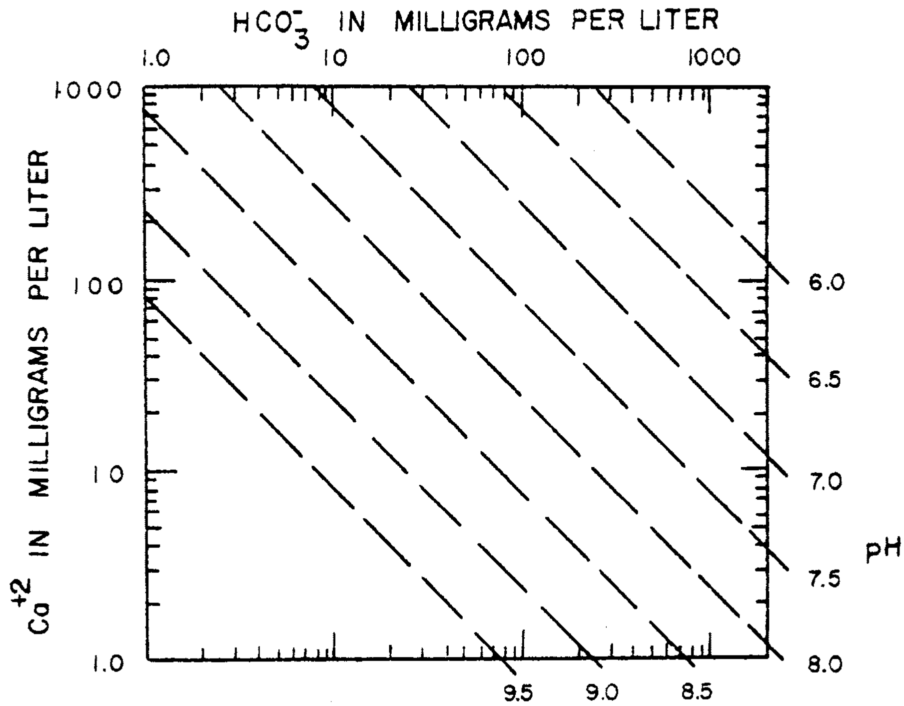


FIGURE 42. Equilibrium pH in relation to calcium and bicarbonate activities in solution in contact with calcite. Total pressure 1 atmosphere; temperature 25°C (Hem, 1970).

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RELATIONSHIP OF WATER QUALITY TO THE MINE WASTE AND WATER LEVEL FLUCTUATIONS

by

Dale Marcy and Marc Norton

In the previous chapter, the discussion on water quality changes as a function of time; the piezometer sites were considered as closed systems. In this section an attempt will be made to correlate water movement with changes in water quality of the entire Smelterville Flats study area. The discussion of water level fluctuation will only consider the upper aquifer as it is in contact with the mine wastes deposited in the study area and is believed to be the primary transporting system for metal movement through the ground water system and into the South Fork of the Coeur d'Alene River. Several statements about the hydrology and chemistry will be stated before the discussion on water quality movement in the study area.

The ground water flow system of the upper aquifer in the Smelterville Flats study area is a dynamic system in that there is recharge, lateral flow, and discharge. Recharge occurs from the South Fork of the Coeur d'Alene River, from Grouse and Humboldt Creeks which discharge into the swamp around the Page facility, and from direct precipitation on the surface. The water levels form a hydraulic gradient which slopes downward to the west, indicating ground water flow in the direction of decreasing head. The ground water level is below the level of water in the South Fork in the eastern part of the study area. This trend is reversed midway through the study area with the ground water level being higher in the western part of the study area than the level of the water in the South Fork. This indicates discharge of ground water into the

South Fork of the Coeur d'Alene River in the western portion of the study area.

Direct recharge from the South Fork of the Coeur d'Alene River to the ground water flow system is believed to occur only in the eastern portion of the Smelterville Flats with most of the recharge occurring up gradient of the study area. The alluvial deposits are believed to grade finer toward the west with the large size fractions being deposited first, creating a very permeable zone for recharge. Hydrographs from piezometers show the greatest amount of fluctuation from the recharge event in early December 1977, are in the east (X-Line) with the decreasing amounts of fluctuation farther west except around the Page Wastewater Treatment Facility. The contour plot of the change in head after the recharge event supports the hypothesis that most of the recharge is occurring east of the study area. Water quality tends to support the recharge from the South Fork in the eastern part of the study area.

Recharge to the ground water flow system occurs from direct precipitation mainly in the eastern portion of the study area. Very little surface runoff occurs after rainstorms or after snowmelt. The surface material generally consists of silt, sand, and gravel, which allows the infiltration of the precipitation. Vertical permeability markedly decreases when the finer fractions of the mine waste (rock powder and slimes) are encountered. This would tend to create a temporary perched water table if the surface material becomes saturated. When the coarse fractions (jig tailings) are encountered, the precipitation is able to reach the ground water table. This is demonstrated by the concentrations of zinc in piezometers 4X, 3X, 2X, and 1X. The water level is below the "zone of concentration" yet there are still considerable amounts of zinc in the ground water. The water level did not rise into the mine waste, but the metal concentrations were transported to the water table by precipitation moving through the waste.

From hydrologic and water chemistry points of view, the upper aquifer in the Smelterville Flats study area is isolated from the lower flow system. The geomorphology of the study area based on geologic history and well logs, indicates a fairly continuous 25-foot thick clay layer (7.6 meters) which separates the two aquifers. The water levels in piezometers 6YA, 6YB, and 6YD indicate separate systems. The piezometer in the lower portion of the clay layer (6YD) responds to pumping of a nearby well while the upper aquifer (6YA, 6YB) does not. The chemistry of the ground water from the upper aquifer, the lower aquifer, and the clay layer tend to support the hypothesis that there is very little interconnection between the two aquifers. One of the well logs indicates a buried river channel that penetrates the clay layer; and there are three abandoned wells that have collapsed, all of which would allow a vertical movement of water between aquifers.

The oxidation of zinc minerals (sphalerite and tetrahedrite) occurs very slowly in the presence of oxygen, but occurs more rapidly in the presence of water and carbon dioxide. Hydrogen peroxide can also act as the oxidizing agent. The formation of acid water from pyrite oxidation is another means of weathering the zinc material. Bacteria can play an important role in the rate of the above reactions (Marcy, 1979).

Calcium ions probably enter the ground water flow system through the dissolution of ferrodolomite. The reaction of the calcium mineral is pH dependent; at low pH, Ca^{2+} concentration increases, and for high pH, the reaction is reversed with calcium precipitating out (Marcy, 1979).

The ground water quality as measured in individual piezometers is affected predominantly by the character of the material by the piezometer screen. The ground water chemistry is site specific; an example is the extreme differences between piezometers 6YA and 8YA. The anaerobic, or reducing environment of piezometer 8YA has lower concentrations than that of 6YA, which is aerobic, or an oxidizing environment. If there is ground water flow, then there will be transportation of metals in solution. After the metals have been transported to a new location, the metal concentrations are under the control of the geochemistry of the new site.

The total quantity of metals leached and transported by the upper aquifer of the ground water flow system in the Smelterville Flats study area is small when compared to the volume of metal transported by the South Fork of the Coeur d'Alene River. The upper aquifer discharges approximately 35,000 gallons per day (1.0×10^6 liters/day) into the South Fork. With an average zinc concentration of 40 milligrams per liter, 5300 grams of zinc per day are transported into the South Fork. The river itself, with a flow of 60 cubic feet per second (1700 liters/sec) on August 22, 1977, and a zinc concentration of 5.90 milligrams per liter, was transporting 8.7×10^5 grams per day. On May 20, 1978, with a high flow of 1270 cubic feet per second (36,000 liters/sec) and a zinc concentration of 1.2 milligrams per liter, the South Fork transports 3.7×10^6 grams per day. On August 22, 1977, the zinc concentration of the upper aquifer to the river would only be 0.61 percent of the zinc transported to the eastern boundary of the study area by the

South Fork for the same day. On May 20, 1978, the percentage is even less - only 0.14 percent. Therefore, the affect of ground water discharge from the Smelterville Flats upon the South Fork of the Coeur d'Alene River is minimal. As noted by Mink (1971, p. 25), the concentration of zinc in the South Fork drops with an increase in discharge, but the total volume of zinc transported is greater. This characteristic would tend to camouflage any affect of the study area on the South Fork.

The impact of the Smelterville Flats study area on the South Fork of the Coeur d'Alene River is demonstrated by the contour maps of calcium (Ca^{2+}) and zinc (Zn^{2+}) concentrations in the ground water for March, 1978 (Figure 43). Calcium and zinc were chosen for mapping because of their high mobility, single oxidation state, and in the case of Zn^{2+}, its toxicity to fresh water organisms. The map of Ca^{2+} concentrations shows the transport of the metal through the study area. A series of close contour intervals can be seen in the lower right hand corner of the map where the AX, 1X, and 2X piezometers are located. This area is one of the area with high acid water production and resulting netralization which generates high concentrations of Ca^{2+}. As the water flows to the west in the upper aquifer, the Ca^{2+} concentration decreases. This decrease could be due to dilution or to the removal of Ca^{2+} on the soil exchanger; or probably both. The decrease in Ca^{2+} concentrations at 6X, 7X, 8X, and 9X is caused by dilution from the recharge of water from the South Fork upstream.

As the water flows across the Y-Line from the east, the concentrations hold fairly constant. As the ground water enters the area adjacent to the South Fork of the Coeur d'Alene River, the concentrations

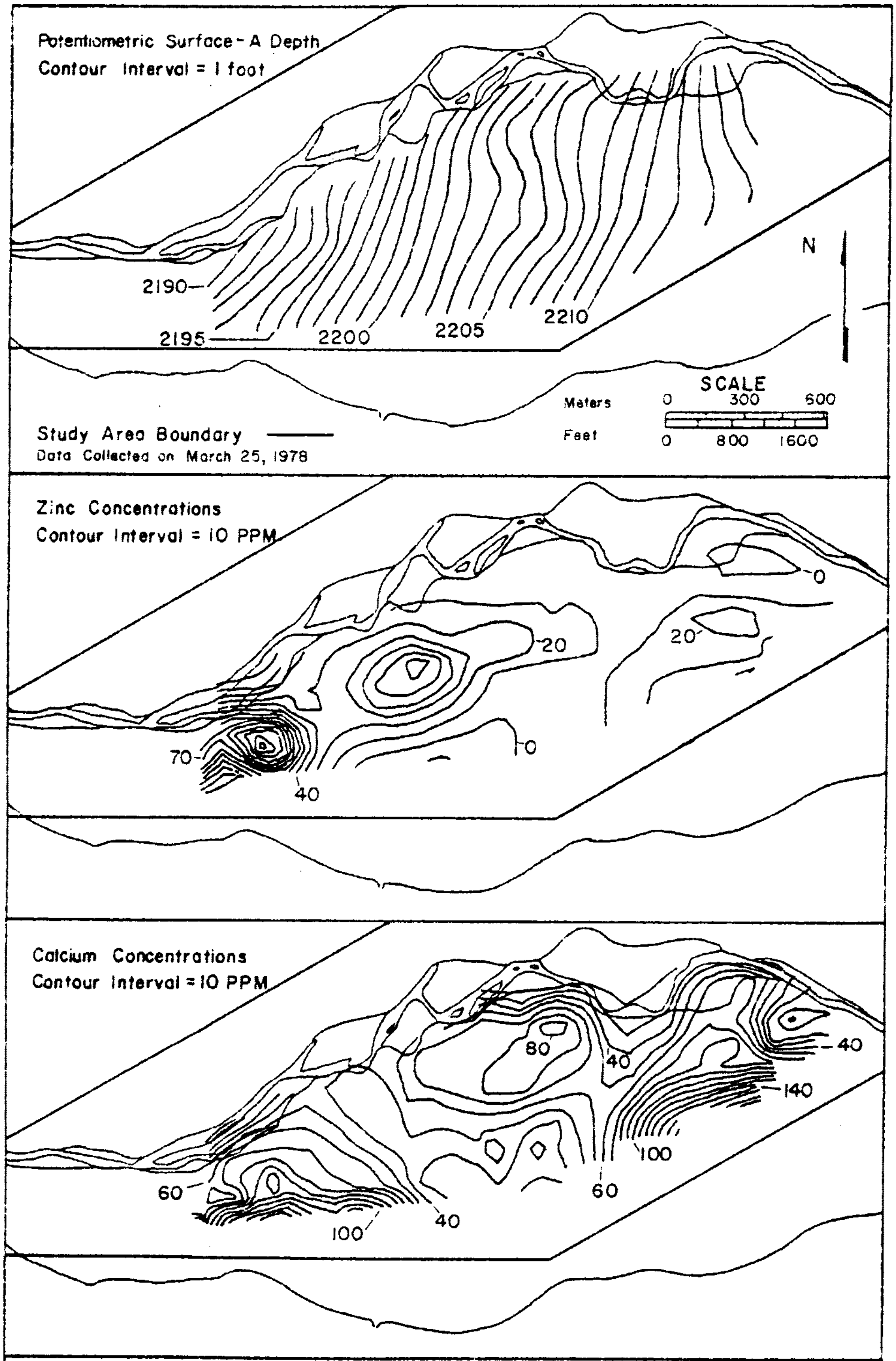

FIGURE 43. Contour maps for ground water elevations and for zinc and calcium concentrations on March 25, 1978, Smelterville Flats study area.

decrease again by removal.

A region of low concentrations of Ca^{2+} occurs from the dilution effect of the recharge from the swamp east of the Page Wastewater Treatment Facility. As the Ca^{2+} in the ground water moves northwest through the aquifer, the concentration increases due to mixing of this water with the water already high in Ca^{2+} concentration from the remainder of the study area. As the ground water encounters the mine waste described in the discussion of SP 8 near piezometers 2P and 4P, the concentration of Ca^{2+} changes rapidly and abruptly as shown by the closely spaced contour lines. This change in concentration indicates that the swamp at the west end of the Page Facility must cover material generating acid and hence cause neutralization and generation of high levels of Ca^{2+}. The concentration of Ca^{2+} decreases as the water moves towards the South Fork. For location of sample sites, see Figure 11.

Farther east near piezometers 2P and 4P, the concentration is once again high. Again, acid water neutralization is the probable explanation for the generation of high Ca^{2+} levels. Decrease in concentration once again occurs in the direction of the river by dilution and removal.

The contour plot for Zn^{2+} shows much the same general trends in concentration with water movement except for the area around the central Y-Line piezometers. Starting in the southeast section of the study area, the same decrease in concentration can be seen away from the AX piezometer. A rapid increase in concentration of Zn^{2+} occurs as the water enters the ground water flow system from the South Fork of the Coeur d'Alene River, and a decrease in concentration as the water moves across the study area. The same poor quality water can be seen emerging from the recharge zone east of the Page Facility, which increases in concentration as it moves into the area where the mine waste is deposited, and helps remove Zn^{2+} as a reaction product in sequence of acid water production and resulting mine waste oxidation.

The Zn^{2+} concentration is shown to be rapidly increasing out of the swamp from the west end of the Page Facility as the mine waste in the area, described by SP 8, is encountered. These high concentrations then decrease as the water moves in the direction of the South Fork.

The only difference in trends from that described for Ca^{2+} occurs in the area surrounding the Y-Line. The concentrations fall to the 0.05 milligrams per liter (mg/l) level from a level of 20 mg/l. The movement of the water from the region of the X-Line (aerobic environment) into the higher S^{2-} containing area of the Y-Line (anaerobic environment) causes the decrease in Zn^{2+} levels. As the water moves from the area of the Y-Line into the area sampled by the W piezometers, the concentration rapidly increases again as the water moves out of the zone of S^{2-} concentration. By the time the water reaches the 18W piezometer, a concentration of approximately 80 mg/l is encountered. The concentration declines again as the water moves toward the river.

The three-dimensional diagrams of water level and of the Zn^{2+} and Ca^{2+} concentrations in the Smelterville Flats study area show, through vertical displacement, the same changes which were described for the contour maps (Figures 44, 45, and 46). Annotation of the three-dimensional diagrams is not possible, but by comparing the contour map and the three-dimensional diagram, a close approximation for the location can be determined.

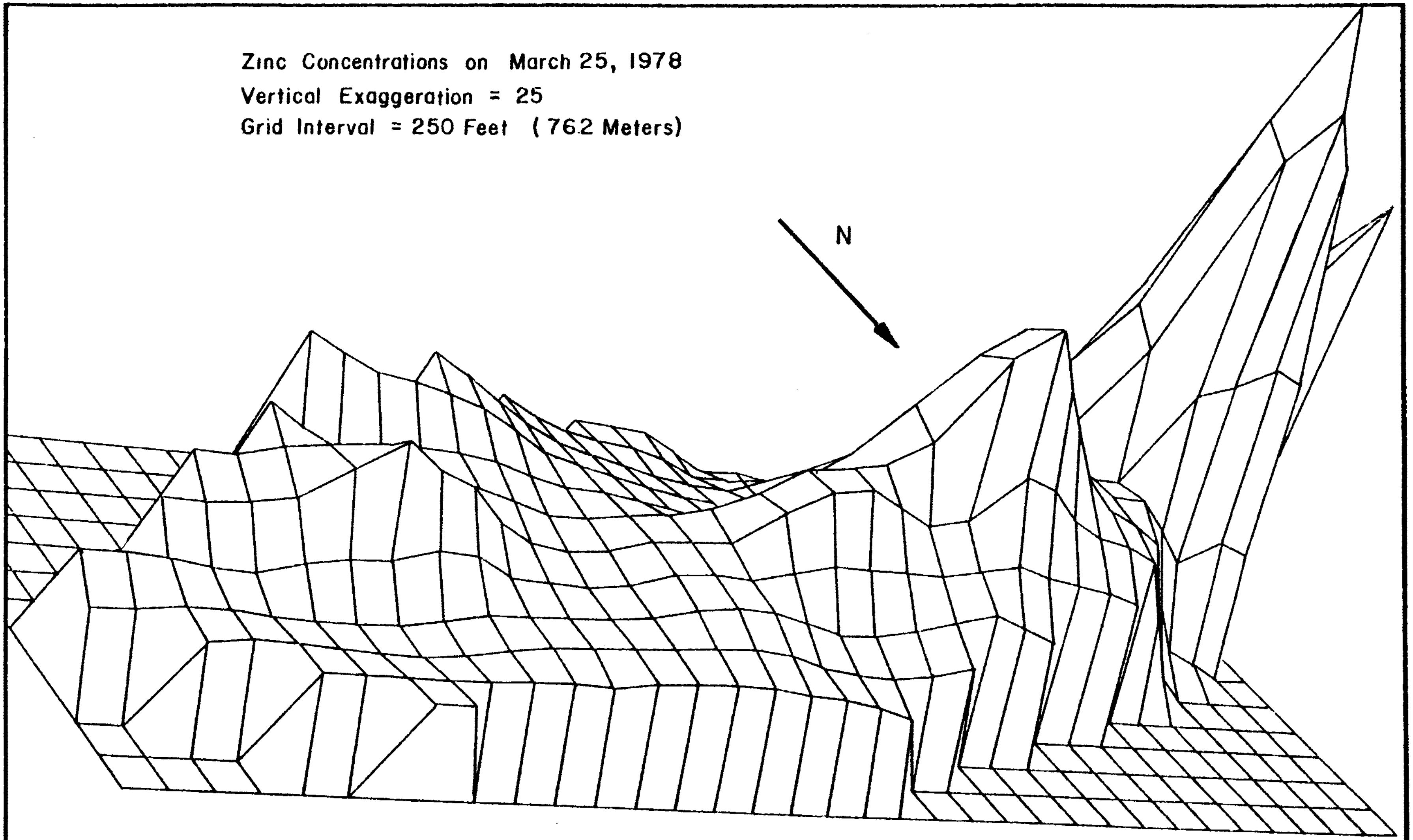

FIGURE 44. Three dimensional diagram of zinc concentrations on March 25, 1978, Smelterville Flats study area.

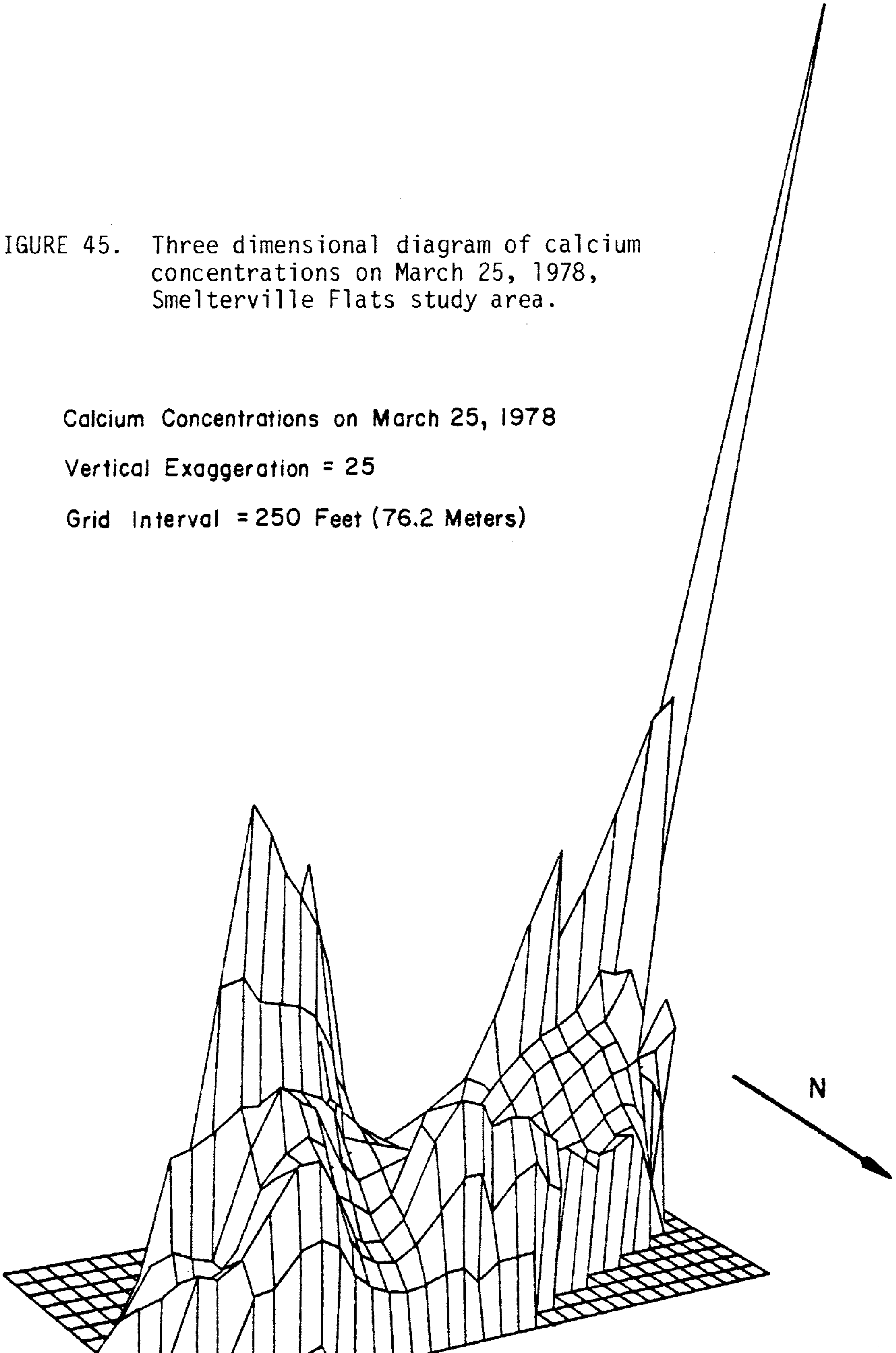

FIGURE 45. Three dimensional diagram of calcium concentrations on March 25, 1978, Smelterville Flats study area.

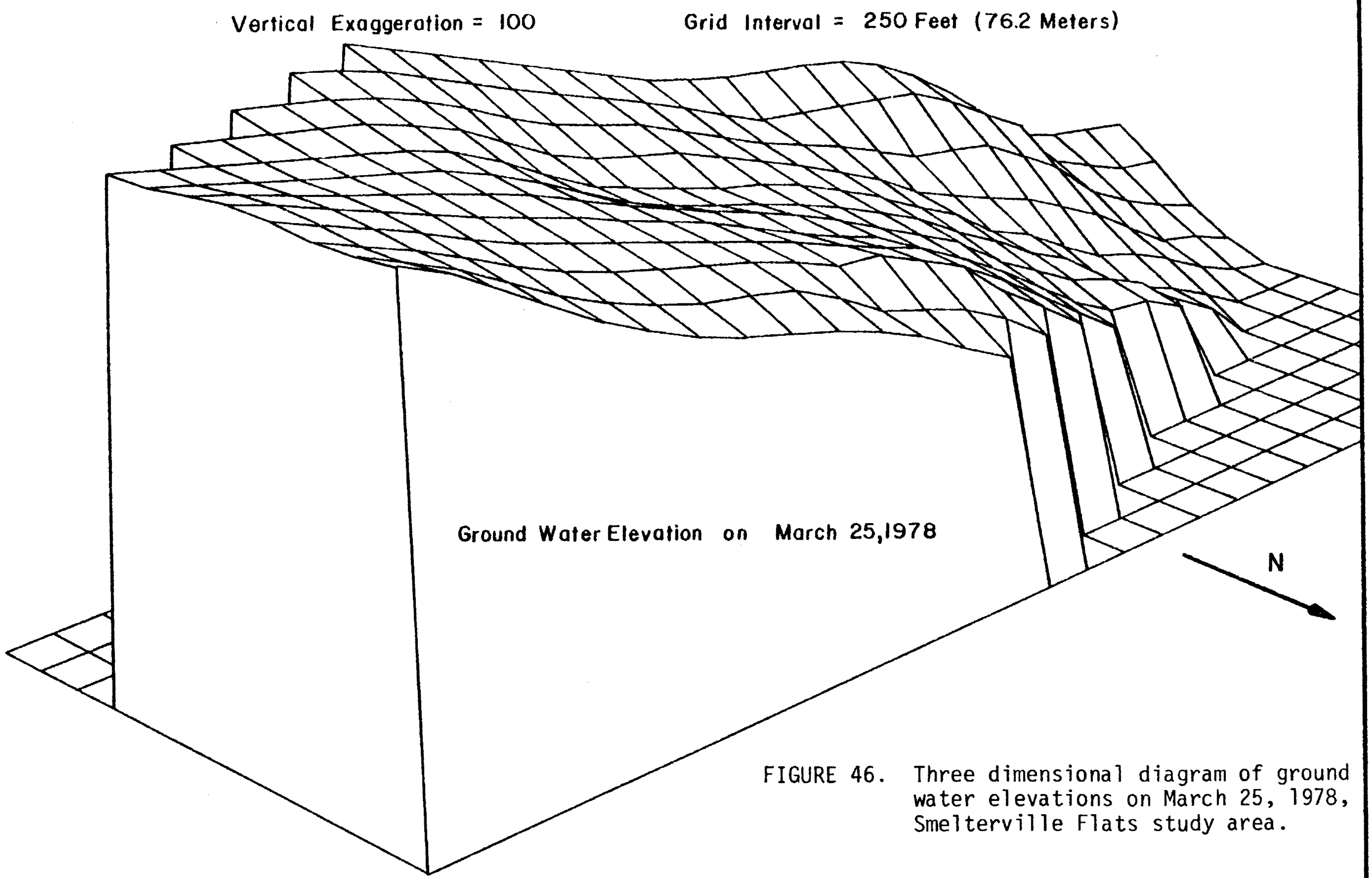

FIGURE 46. Three dimensional diagram of ground water elevations on March 25, 1978, Smelterville Flats study area.

The same general trends just described for the March water samples and measurements can be observed for the samples and water levels taken and graphically displayed for January, May, and August (Figures 47, 48, and 49). These concentrations and water movements show that during the spring runoff the Smelterville Flats does have a small impact on the South Fork of the Coeur d'Alene River.

The water level and water quality data collected on August 12, 1978 will be used to describe the flow system for the discussion of the low water level period (July, August, September). This date, instead of August, 1977 values, will be used due to the greater number of sampling sites that were installed during the course of the study period. As the study proceeded, it became more apparent that a larger sampling base was required to adequately map the system. The main additions occurred on the west end of the study area which was expanded to include points on the south side of Interstate-90 and points farther west.

The water level countour maps indicate that the water movement in the system during low levels (Figures 47, 48, and 49) is much the same as the movement contoured for the high levels. The concentrations of Zn^{2+} and Ca^{2+} show the same general high spots at the south end of the X-Line, the 2P and 4P piezometers near the Page Facility, and an area surrounding the 9W and 18W piezometer sites. The zinc concentration throughout the study area appears to have decreased in value by as much as 10 mg/l in some of the locations. The general trend is still decreasing concentrations with movement toward the South Fork. The concentration distribution indicates a leveling effect across the study area with the decrease in water levels. Some of the steep contours are

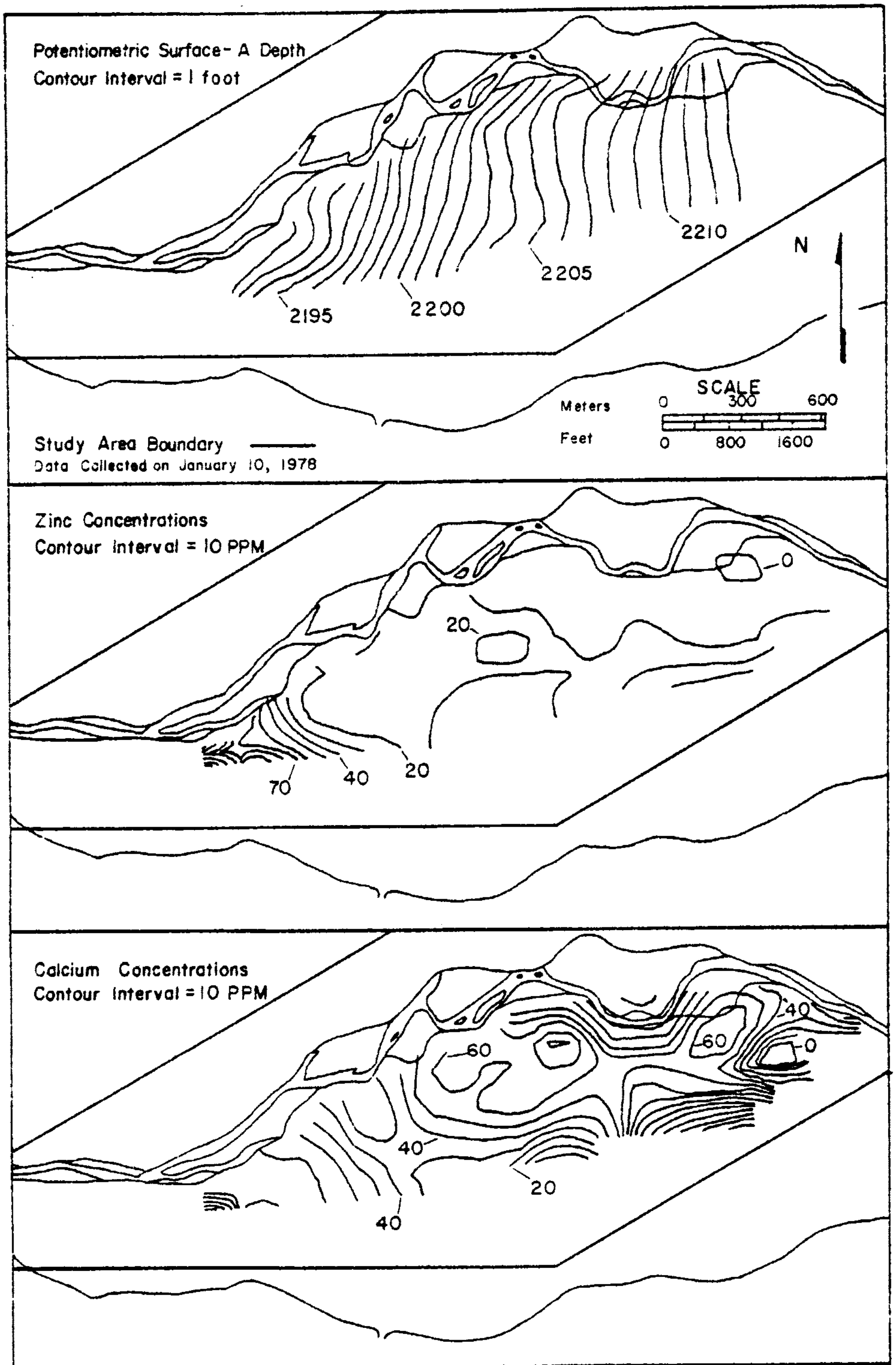

FIGURE 47. Contour maps for ground water elevations and for zinc and calcium concentrations on January 10, 1978, Smelterville Flats study area.

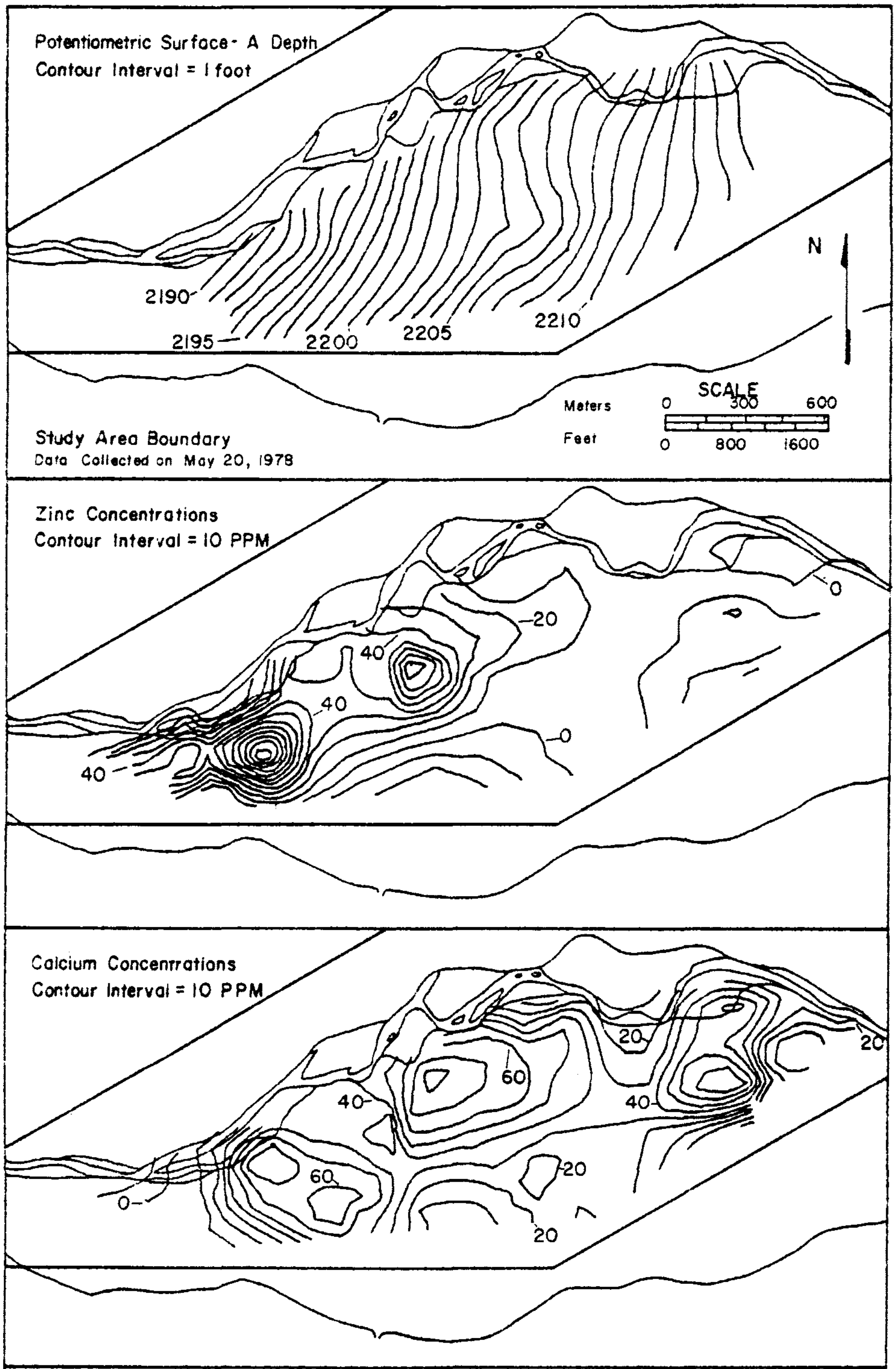

FIGURE 48. Contour maps for ground water elevations and for zinc and calcium concentrations on May 20, 1978, Smelterville Flats study area.

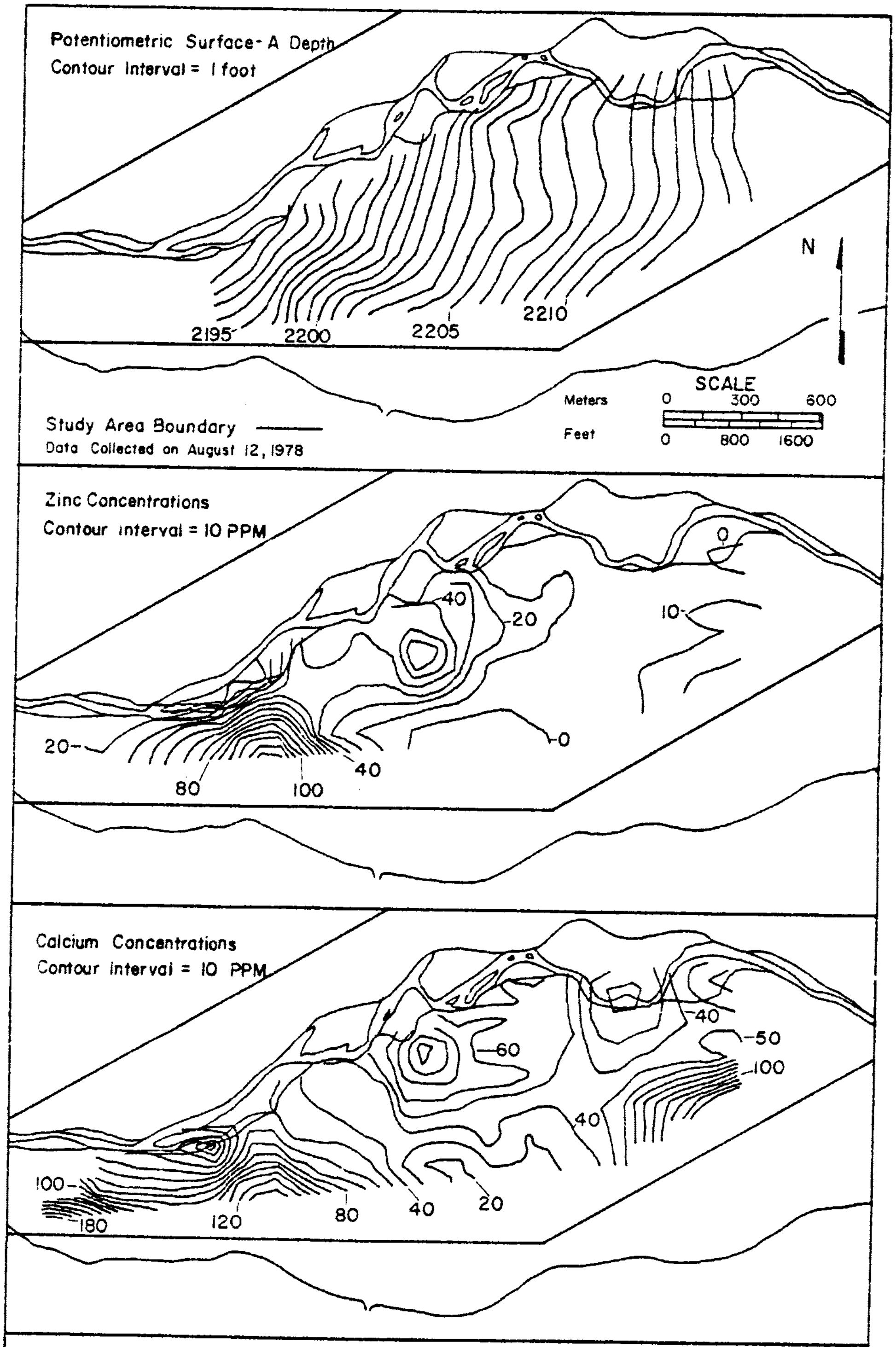

FIGURE 49. Contour maps for ground water elevations and for zinc and calcium concentrations on August 12, 1978, Smelterville Flats study area.

smoothed showing a more even distribution of the Ca^{2+}. The general trend is a decrease in concentrations toward the South Fork of the Coeur d'Alene River.

POTENTIAL RECLAMATION PROCEDURES

The physical and chemical factors that can be influenced by reclamation procedures to limit the movement of heavy metals in the water resource system of the Smelterville Flats study area are:

1) the availability of mine waste,
2) the concentration of pyrite in the mine waste,
3) the availability of oxygen for chemical reactions,
4) the availability of water as a transporting mechanism, and
5) the presence of microorganisms that regulate chemical kinetics.

The presence of mine waste, pyrite, oxygen, water, and microorganisms can be controllable variables to some degree depending on location. In some cases these variables can also be uncontrollable. Several potential reclamation procedures are described in the following pages based on the data collected during this and other studies. The physical and chemical factors described above will be used by themselves or in combination with each other to limit the movement of heavy metals. These procedures or methods for reclamation of the uncontrolled mine waste deposits in the South Fork of the Coeur d'Alene River valley have been grouped into three "Procedures" solely for the purpose of description. The methods described can be used by themselves or in combinations. The method or methods used may very depending on each deposit of mine waste.

The availability of mine waste and the concentration of pyrite can be addressed at the same time. If the mine waste was removed, leaching of heavy metals into the ground water system would not take place. Any practical method used to remove the mine waste would not be complete as mixing would occur with the soil below the mine waste. Mine waste would also be left in the environment under towns and other structures of the South Fork of the Coeur d'Alene River valley. If the mine waste were removed, most of the pyrite would also be removed. Because only a small amount of pyrite is needed in acid production, any pyrite left would continue to produce acid in the presence of oxygen and water. Manipulation of the supply of oxygen and water can also be used to limit heavy metals from going into solution or from leaving the reaction site. The presence of microorganisms can be indirectly controlled by limiting the energy source of the bacteria.

Procedure One

The heavy metals could be precipitated out of the ground water by passing the water through an anaerobic zone the width of the valley near the west end of the Shoshone County Airport runway. This zone, similar to that of the Y-Line, could be formed by adding microorganisms that use most of the available oxygen. Sealing the surface would prevent the diffussion of oxygen through the soil voids and stop the infiltration of precipitation from recharging the oxygen supply. A second method to minimize the usable oxygen would be to create a subsurface dam to inhibit ground water flow at the constriction in the valley sides at the west end of the Smelterville Flats study area. This would cause the ground water levels to rise, therefore minimizing the volume of sediments above the water table. Seasonal fluctuations would also be minimized.

Neither method to eliminate the supply of oxygen by itself would be sufficient and problems would arise. The addition of a microorganism to the system might create a larger problem if the microorganism were transported to the South Fork of the Coeur d'Alene River and were carried to Lake Coeur d'Alene. If a strip of surface material the width of the valley were sealed in combination with microorganisms, an effective barrier to heavy metal movement might be created. The width of the strip of sealant would have to be determined based on the ability of the microorganisms to use the available oxygen.

Procedure Two

The availability of mine waste and pyrite can be reduced by surface mining methods where the mine waste can be removed. One major problem with this method is that not all of the mine waste can be mined. The Shoshone County Airport, Interstate-90, and a large percent of the buildings in the Smelterville Flats study area are built on the mine waste-native alluvium mix. The mine waste deposits that could not be mined in this manner would have to be treated with a different method or methods. Mining should start at the upper most section of each creek above where past mining practices took place. This is to prevent the movement of mine waste back over an area that had been reclaimed. The South Fork of the Coeur d'Alene River and its tributaries would have to be relocated and/or channelized to prevent the transport of the disturbed material downstream. In some places, the potentiometric surface would be above the post-reclamation ground surface. This could be a problem in some cases. Surface mining reclamation methods have been used in the past at the Smelterville Flats and at Canyon Creek. In both cases, it was the economic value of the mine waste that caused the mining activity.

This economic value can be used to help defray the costs of reclamation. The mine waste varies in mineral composition so the economic value will also vary. Based an an average price of $0.59 a pound ($1.30 per 1,000 grams) for lead and $0.405 a pound ($.89 per 1,000 grams) for zinc, the soil sampled at SP 1 is worth $82.08 a cubic yard

($108.57 per cubic meter) for lead and $22.41 a cubic yard ($29.62 per cubic meter) for zinc. The soil sampled at SP 8 has the same value for lead as SP 1. The value of zinc is higher at $32.94 a cubic yard ($43.57 per cubic meter). With an estimated volume of mine waste in the Smelterville Flats study area of 3.7 million cubic yards (2.8 million cubic meters) the value of the lead is 303 million dollars, and the value of the zinc is 102.5 million dollars. These values assume an overall average metal concentration and do not take into account the cost of mining, smelting, or the reclamation of the land. The value of the mine waste would help to defray the cost of reclamation. Other valuable minerals may be present in the mine waste, but were not determined.

The mine waste deposits that could not be reclaimed by surface mining methods should be treated with a different method. The next alternative to be discussed could be used. This includes preventing precipitation from infiltrating into the mine waste and leaching the heavy metals down to the ground water system and maintaining the ground water level below the mine waste so as not to wash the heavy metals into solution.

Procedure Three

Limiting the transfer of heavy metals in the water resource system may be accomplished by isolating the mine waste from the transporting agent - water. This includes preventing infiltration of precipitation and surface water to the ground water system and/or controlling the lateral and vertical flow of the ground water system. By eliminating the recharge of water into the ground water system where acid production occurs, the leaching of heavy metals into solution could be reduced. The South Fork of the Coeur d'Alene River should be lined to prevent leakage from the bottom and sides of the channel. Tributaries of the South Fork should also be controlled. The surface of the mine waste-native alluvium mix should be sealed to prevent infiltration of surface water and precipitation.

There are several methods that could be used to maintain ground water levels below the mine waste. Gravity drainage of the ground water by a field of ditches or buried perforated pipes to a collection point where the water collected would have to be pumped into the river or into a treatment plant. The South Fork should be lined to prevent increased leakage from the river into the aquifer. The perforated pipe used should be poly-vinyl chloride pipe to prevent the corrosive action of the acidic environment from destroying the drain field.

A network of large diameter, shallow wells could be installed to maintain the ground water level below the mine waste. The wells should penetrate the entire saturated thickness of the upper aquifer and be constructed with a gravel pack to prevent sand and silt from entering the well. Another method of lowering the potentiometric surface might be to lower the channel of the South Fork of the Coeur d'Alene River so that the upper aquifer would only discharge into the river.

Problems are inherent with any reclamation plan. The drainage ditches would have a bank stability problem and the presence of open ditches would be a health hazard and would prevent the development of the study area. Perforated PVC drainage pipe would have problems with sediment coming into the lines and maintenance could be high. Pumping of the water would be a continual cost which includes electricity for power, maintenance of the pump and discharge line, and the treatment of the water if needed. Lowering of the South Fork of the Coeur d'Alene River channel would not be practical except at limited locations because the depth of the mine waste is too great. If the ground water level in the Smelterville Flats was lowered below the channel of the South Fork, it might increase the amount of seepage from the channel, therefore the South Fork should be lined to prevent leakage to the ground water system.

Lining the channel of the South Fork of the Coeur d'Alene River would solve the physical problem of bank erosion. Sealing the surface to prevent infiltration of precipitation would help to solve the blowing dust problem. Removal of the mine waste by surface mining methods would temporarily eliminate the need for revegetation. As part of the reclamation plan, vegetation of the new surface after mining should be considered. Because of water and soil quality, revegetation would be limited to selected plant types. Several vegetation test plots were planted in the Smelterville Flats study area with varying degrees of success (Gordon, 1977). One of the test plots involved the mixing of wood wastes from a nearby lumber yard with the surface material. Pine tree seedlings were planted in the test plot and later replanted on the hillsides around the Bunker Hill Company complex. In with the wood waste were clover seeds that began to grow with the spring rain. Several years later, the test plot has an extensive growth of clover through spring and early summer. The plant tops die as ground water levels drop below the root zone. The tops had turned brown by August, 1977 when the test plot was irrigated with water from the Bunker Hill Company wells. Within a week, the second crop of clover had begun to grow. The Bunker Hill Company has been given approval to build and operate a sawmill near Smelterville, Idaho, with the wood waste to be used in reclamation activities. With planting, fertilizing, and watering, the Smelterville Flats could be turned green. It is doubtful if the clover could be harvested as cattle feed because the clover picks up metals in the soil through the plants' roots.

The Bunker Hill Company has projected a long-range plan for the possible construction of a tailings pond in the Smelterville Flats. This will have to be considered when reclamation plans are made for the Smelterville Flats. If the South Fork of the Coeur d'Alene River was channelized now, the river would probably be placed against the hillside to the north to minimize the space required. In addition, only one dike would be required. If the tailings pond is constructed, it probably would be placed against the north hillside with the South Fork channelized against it rather than have the river flowing on both sides of the pond.

The information gained from this study is transferable within the confines of the Coeur d'Alene Mining District. When augmented with site specific data, the reclamation procedures described in this section for the Smelterville Flats study area could be used throughout the valley of the South Fork of the Coeur d'Alene River. Some of the site specific data might include a detailed soil sampling pit with chemical analysis on the samples to correlate with the soil material of the Smelterville Flats. Other data might include the volume of mine waste, depth of mine waste, and potentiometric surface. This data along with the new sites' location in the valley would be used to determine which method or methods for reclamation would work the best for the site.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. A pattern of deposition was observed in the mine wastes of the Smelterville Flats study area. Due to natural deposition and the constuction of a dam across the South Fork of the Coeur d'Alene River at the west end of the Smeltermille Flats, the coarser sediments were deposited out in the eastern position of the flats, grading finer towards the west.

2. Based on the logs from auger holes, wells, and soil pits, the lower limit of the mine wastes in the Smelterville Flats study area was determined to be the top of the river gravel which was generally encountered between five to ten feet (1.5 to 3.1 meters) below the surface.

3. Metal concentrations of the alluvium in the Smelterville Flats study area are not directly dependent on the soil type. One type of soil is a mixture of native alluvium and jig tailings, the coarser size fractions (silt, sand, and gravel). The second type is a mixture of native alluvium and the finer size fraction. The clay, silt, and sand which make up the finer size fraction have two sources; the flotation tailings and the rock powder from the jigging process.

4. A "zone of concentration" of metals was present in the soil of the Smelterville Flats study area. This zone was exhibited by most metals in most of the size fractions and extends six feet (1.8 meters) below the land surface. The lowest concentration for all metals was in the largest size fraction (>2.362). Metal concentrations are generally independent of the size fraction in that each size fraction has high metal concentrations. The smaller size fraction generally has a high percent of concentration for four of the seven metals sampled (Pb, Fe,

Mn, and Mg) were in the size fraction .417 to .208 millimeters.

5. Erosion and deposition by the South Fork of the Coeur d'Alene River continues to rework and mix the mine waste along its channel. With time, the water quality of the river will continue to improve with more mine waste being carried farther downstream. This is not a solution, but a transfer of the problem.

6. Several surface ponds exist in the Smelterville Flats study area with each pond having different characteristics: source of water, water quality, plant growth, and degree of hydraulic connection to the upper aquifer.

7. The ground water flow system in the Smelterville Flats study area consists of an upper aquifer, a seperating discontinuous clay layer, and a lower aquifer. Ground water pollution as a result of the mine waste in the study area occurs only in the upper aquifer as the clay layer apparently provides adequate hydraulic seperation of the two aquifers to prevent significant degradation in water quality in the lower aquifer in the vicinity of the Bunker Hill well field. Upstream from the study area, the clay layer probably becomes thinner and sandier, which would facilitate water movement between the two aquifers.

8. The upper aquifer ground water flow system in the Smelterville Flats study area is a dynamic system in that there is recharge, lateral flow, and discharge.

9. Direct recharge from the South Fork of the Coeur d'Alene River to the upper aquifer occurs to the east of the study area and in the eastern portion of the study area.

10. Recharge to the upper aquifer of the ground water flow system occurs from direct precipitation. Surface materials have suf-

ficient permeability to preclude surface runoff during precipitation events provided the water table is below the land surface.

11. Water level contour maps of the potentiometric surface in the upper aquifer of the Smelterville Flats study area indicate the general direction of lateral flow is from east to west. A curving of the contour lines in the western portion of the study area is caused by recharge from the area around the Page Wastewater Treatment Facility and from the facility itself.

12. Based on water level contour maps, the upper aquifer of the ground water flow system in the Smelterville Flats discharges into the South Fork of the Coeur d'Alene River in the western portion of the study area.

13. The ground water quality as measured in individual piezometers is affected predominantly by the mineralogical character of the material in the vicinity of the piezometer screen.

14. The metals enter the ground water flow system by: 1) surface water and precipitation moving down through the "zone of concentration" leaching the metals down to the ground water; or 2) the water table rises and falls through the "zone of concentration" thereby leaching the metals from the reaction site.

15. The total quantity of metals leached and transported through the upper aquifer of the ground water flow system in the Smelterville Flats study area is small compared to the volume of metal transported by the South Fork of the Coeur d'Alene River. The upper aquifer transports 5300 grams per day into the South Fork at a flow of 35,000 gallons per day (1.0×10^5 liters/day) with a zinc concentration of 40 milligrams per liter. This is 0.61 percent of the zinc transported by the South

Fork at the eastern section of the study area during low flow. During high flow the precentage is even less (0.14%).

16. The only physical and chemical factors that may be influenced by reclamation procedures to limit the formation of acid water and the subsequent leaching and transfer of heavy metals from the Smelterville Flats study area are:

a) the availability of mine waste,
b) the availability of pyrite in the mine waste,
c) the availability of oxygen for chemical reactions,
d) the availability of water as a transporting mechanism, and
e) the presence of microorganisms that regulate chemical kinetics.

Reclamation procedures were developed based upon these factors.

Recommendations

1. Future work in the Coeur d'Alene Mining District similar to this should spend a great deal of time and thought concerning the data collection network. Possible personnel to consult would be a hydrogeologist, a chemist, and a computer technician. The use of the computer to handle the data collected makes it manditory that a computer technician be consulted in the design of the collection system and the methods of data analysis. The student(s) involved should also be consulted.

2. It is the opinion of this writer that the best method of reclamation for the Smelterville Flats study area and the valley of the South Fork of the Coeur d'Alene River would be to mine as much of the mine waste-alluvial mix as physically and economically possible. Removal of the mine waste is permanent and the metals recovered from the mine wastes would help to defray the cost of reclaiming the land.

3. Data should be collected at each site within the valley to determine the mineral content of the mine waste, the depth of the mine waste and the possible depth to ground water. This information could be used to determine which reclamation method or combination of methods best suits each site. This will also keep the damage to the environment during reclamation at a minimum.

4. A more detailed study of the geochemical and geohydrologic data collected from June, 1977 through September, 1978 should be undertaken. Part of the new study should include a model of the study area to demonstrate ion movement through the system. The model could also be used to test the reclamation procedures.

5. The use of sewage sludge as a fertilizer and treated sewage effluent for irrigation purposes could be used with the reclamation

procedures previously mentioned. The discharge from the Page Wastewater Treatment Facility could be used for irrigation. The crops grown should be native to the valley or as suitable to the environment as possible.

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APPENDIX I

Soil Profiles

Hollow Stem Auger

Symbol Explanation

Ω = Probable type of mine waste in this zone is jig tailings.

† = Probable type of mine waste in this zone is rock powder and flotation tailings (slimes).

Alluvial Profiles of the Smelterville Flats

Station No.: AX Date: July 8, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0–2.5	1	2.5	Brown sandy gravel.
2.5–5	2	2.5	Light brown silty sand and gravel.
5	5		Split spoon sample. 5.0 - 5.8' Dark brown to black sand and gravel.
5–7.5	3	2.5	Light brown silty sand and gravel.
7.5–10	4	2.5	Light brown silty sand and gravel.
10	8		Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: AX Date: July 8, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample 10.0 - 11.2' Brown silty sand and gravel.
11			
12			
	6	5.0	Brown sandy gravel.
13			
14			
15	9		Split spoon sample. 15.0 - 16.5' Brown silty sand and gravel.
16			
17			
	7	5.0	Brown silty sand and gravel.
18			
19			
20	10		Split spoon sample. 20.0 - 21.5' Brown silty sand.

Alluvial Profiles of the Smelterville Flats

Station No.: 1X Date: July 8, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0				
1	1	Ω	2.5	Dark brown silty sand and small gravel, loose, wood.
2				
3				
4	2	Ω	2.5	Reddish brown silty sand, cohesive.
5	5			Split spoon sample. 5.0 - 5.3' Brown silt. 5.3 - 5.6' Gray sand. 5.6 - 5.7' Brown silt. 5.7 - 6.1' Red silt sand and gravel. 6.1 - 6.5' Gray sand.
6				
7	3	Ω	2.5	Dark gray brown silty sand, cohesive.
8				
9	4	Ω	2.5	Dark gray brown silty sand, cohesive.
10	8			Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 1X Date: July 8, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample. 10.0 - 10.9' Water. 10.9 - 11.5' Reddish brown rock fragments.
11			
12			
	6	5.0	Reddish brown silty sand and gravel.
13			
14			
15	9		Split spoon sample. 15.0 - 16.5' Light brown sand and gravel.
16			
17			
	7	5.0	Brown silty sand and gravel, red staining, cohesive.
18			
19			
20	10		Split spoon sample. 20.0 - 21.5' Brown silty sand.

Alluvial Profiles of the Smelterville Flats

Station No.: 2X Date: July 6, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0				
1	1	Ω	2.5	Brown silty sand with reddish brown lenses, loose.
2				
3	2	Ω	2.5	Brown silty sand, cohesive.
4				
5	5			Split spoon sample. 5.0 - 6.0' Brown gravel with a silty clay interbed.
6	3	Ω	2.5	Brown silty sand, cohesive.
7				
8	4		2.5	Light brown sandy gravel.
9				
10	8			Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 2X Date: July 6, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample 10.0 - 11.0' Brown gravel with some silt and sand.
11			
12			
	6	5.0	Light brown silty sand and gravel.
13			
14			
15	9		Split spoon sample. 15.0 - 16.5' Reddish brown silty sand and gravel.
16			
17			
18			Sample not recovered.
19			
			Split spoon sample. 20.0 - 21.5' Brown silty sand and small gravel.
20			

Alluvial Profiles of the Smelterville Flats

Station No.: 3X   Date: July 6, 1977   Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0				
1	1	Ω	2.5	Brown silty sand and gravel, loose.
2				
3				
4	2	Ω	2.5	Reddish brown silty sand and gravel, cohesive.
5	5			Split spoon sample. 5.0 - 6.1' Gray silt and reddish brown silty sand.
6	3	Ω	2.5	Reddish brown silty sand and gravel, cohesive.
7				
8	4		2.5	Light brown sand gravel.
9				
10	8			Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 3X Date: July 6, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample. 10.0 - 10.7' Brown silty sand and gravel, rock fragments.
11			
12			
	6	2.5	Brown silty sand and gravel.
13			
14			
15	9		Split spoon sample. 15.0 - 16.5' Brown silty sand and gravel.
16			
17			
	7	2.5	Brown silty sand and gravel, rock fragments.
18			
19			
20	10		Split spoon sample. 20.0 - 21.5' Brown silty sand.

Alluvial Profiles of the Smelterville Flats

Station No.: 4X Date: July 6, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0				
1	1	Ω	2.5	Reddish brown silty sand with a few gravels, loose.
2				
3	2	Ω	2.5	Brownish red silty sand, dense, cohesive.
4				
5	5			Split spoon sample 5.0 - 5.5' Dark gray sand. 5.5 - 5.9' Dark gray silt. 5.9 - 6.2' Dark gray sand. 6.2 - 6.5' Red stained gravel.
6	3	Ω	2.5	Gray brown silty sand, cohesive, dense.
7				
8	4		2.5	Brown silty sand with red staining, loose.
9				
10	8			Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 4X Date: July 6, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample. 10.0 - 10.9' Light brown silty sand and gravel.
11–14	6	3.8	Brown silty sand and gravel.
14	11	1.2	Reddish brown silty sand and gravel.
15	9		Split spoon sample. 15.0 - 16.5' Brown silty sand and gravel.
16–19	7	2.5	Brown sandy gravel.
20	10		Split spoon sample, mostly water. 20.0 - 20.8' Gray-brown silt. 20.8 - 21.5' Brown silt sand and gravel.

Alluvial Profiles of the Smelterville Flats

Station No.: 6X Date: July 5, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0			
1	1	2.5	Dark brown silty sand and gravel.
2			
3			
4	2	2.5	Brown sand and gravel.
5	5		Split spoon sample. 5.0 - 5.6' Brown silty sand and gravel.
6	3	2.5	Brown silty sand and gravel.
7			
8			
9	4	2.5	Brown silty sand and gravel.
10	8		

Alluvial Profiles of the Smelterville Flats

Station No.: 6X Date: July 5, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample. 10.0 - 11.0' Gray brown silty sand with one .17' rock and wood pieces.
11			
12	6	2.5	Brown sandy gravel.
13			
14			
15	9		Split spoon sample. Brown muddy silt, sand and gravel.
16			
17	7	2.5	Brown silty sand and gravel.
18			
19			
20	10		Split spoon sample. 20.0 - 21.5' Brown silt.

Alluvial Profiles of the Smelterville Flats

Station No.: 7X Date: July 5, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0–2.5	1	Ω	2.5	Dark brown silty sand, loose, soil like in texture.
2.5–5	2	Ω	2.5	Dark brown silty sand and gravel.
5	5			Split spoon sample. 5.0 - 6.1' Light brown silty sand and gravel.
5–7.5	3		2.5	Brown silty sand and gravel.
7.5–10	4		2.5	Yellow brown silty sand and gravel.
10	8			Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 7X Date: July 5, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample.
11			
12			
	6	2.5	Brown silty sand and gravel.
13			
14			
15	9		Split spoon sample. 15.0 - 15.8' Brown silty sand and gravel.
16			
17			
	7	2.5	Brown sand and gravel.
18			
19			
20	10		Split spoon sample. Sample not recovered.

Alluvial Profiles of the Smelterville Flats

Station No.: 8X Date: July 5, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0	1	2.5	Brown small gravel with some sand, (less than .25').
2.5	2	2.5	Brown small gravel with some sand, (less than .25'). Split spoon sample.
5	5		5.0 - 6.0' Brown silty sand and gravel.
	3	2.5	Brown silty sand, loose, soil like in texture.
7.5	4	2.5	Brown silty sand and gravel. Split spoon sample.
10	8		

Alluvial Profiles of the Smelterville Flats

Station No.: 8X Date: July 5, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample. 10.0 - 10.9' Brown sand and gravel.
11			
12			
	6		Brown sand and gravel.
13			
14			
15	9		Split spoon sample. 15.0 - 15.5' Brown gravel. 15.5 - 16.5' Brown silt and sand.
16			
17			
	7		Brown sand and gravel.
18			
19			
20	10		Split spoon sample. 20.0 - 21.5 Brown silt.

Alluvial Profiles of the Smelterville Flats

Station No.: 9X   Date: July 5, 1977   Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0–2.5	1	2.5	Light brown silty sand and gravel.
2.5–5	2	2.5	Light brown silty sand with some gravel.
5	5		Split spoon sample. 5.0 - 6.1' Brown silty sand and gravel.
5–7.5	3	2.5	Brown silty sand and gravel.
7.5–10	4	2.5	Brown silty sand and gravel.
10	8		Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 9X Date: July 5, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample. 10.0 - 11.4' Brown silty sand and gravel.
12–13	6	5.0	Brown silty sand and gravel.
15	9		Split spoon sample. 15.0 - 16.5' Brown silty sand and gravel.
17–18	7	5.0	Brown silty sand and gravel.
20	10		Split spoon sample. 20.0 - 21.5' Brown silty sand with some gravel.

Alluvial Profiles of the Smelterville Flats

Station No.: AY Date: July 8, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0				
1	1		2.0	Dark brown silty sand and gravels, loose.
2				
3	2		1.5	Medium brown silty sand, loose, cohesive.
4	11	÷	1.5	Dark gray silty clay, cohesive.
5	5			Split spoon sample 5.0 - 5.5' Gray brown silt. 5.5 - 6.0' Brown sandy gravel.
6	3	÷	2.5	Gray silty clay.
7				
8				
9	4	Ω	2.5	Brown gray silt with a few gravels.
10	8			Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: AY Date: July 8, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample 10.0 - 10.7' Gray sand. 10.7 - 11.5' Gray sandy gravel.
11			
12			
	6	5.0	Dark gray silty clay.
13			
14			
15	9		Split spoon sample. 15.0 - 15.6' Gray sand. 15.6 - 16.5' Gray sandy gravel.
16			
17			
	7	5.0	Dark gray silty clay.
18			
19			
20	10		Split spoon sample. 20.0 - 20.8' Brown sand. 20.8 - 21.5' Brown sandy gravel.

Alluvial Profiles of the Smelterville Flats

Station No.: 1Y   Date: July 8, 1977   Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0–2.5	1		2.5	Brown silty sand, loose, a few gravels.
2.5–5	2	Ω	2.5	Brown silty clay, a few gravels, cohesive.
5	5			Split spoon sample. 5.0 - 5.8' Brown sandy gravel.
5–7.5	3	Ω	2.5	Brown silty clay, a few gravels, cohesive.
7.5–10	4	Ω	2.5	Reddish brown silty clay, a few gravels, cohesive.
10	8			Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 1Y   Date: July 8, 1977   Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample. 10.0 - 11.5' Brown sandy gravel.
11			
12			
	6	5.0	Brown silty clay, a few gravels, cohesive.
13			
14			
15	9		Split spoon sample. 15.0 - 16.5' Reddish brown silty sand and gravel.
16			
17			Samples were not recovered below 15' because sand came up the auger flight.
18			
19			
20			

Alluvial Profiles of the Smelterville Flats

Station No.: 2Y Date: July 7, 1977 Depth: 25 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0			
1	1	2.5	Brown silty sand, loose, roots.
3–4	2	2.5	Gray brown silty sand, cohesive, roots.
5	5		Split spoon sample. 5.0 - 5.8' Brown sandy gravel, wood.
6	3	2.5	Light brown silty sand, some gravels, roots.
8–9	4	2.5	Light brown silty sand, some gravels, roots.
10	8		Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 2Y Date: July 7, 1977 Depth: 25 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample. 10.0 - 11.4' Brown sandy gravel.
11			
12			
	6	5.0	Brown sandy gravel.
13			
14			
15	9		Split spoon sample 15.0 - 16.5' Brown sand.
16			
			Was to be a 50 foot hole, sand was coming up the hole faster than could be bailed out.
17			
18			
19			
20	10		Split spoon sample 20.0 - 21.5' Brown sand.

Alluvial Profiles of the Smelterville Flats

Station No.: 3Y   Date: July 7, 1977   Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0			
1	1	2.5	Brown silty sand with a few gravels, loose, roots.
2.5	2	2.5	Brown silty sand, some iron staining, pieces of wood.
5	5		Split spoon sample. 5.0 - 5.8' Brown silty sand and gravel.
5	3	2.5	Brown silty gravel, pïeces of wood.
7.5	4	2.5	Brown silty gravel.
10	8		Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 3Y   Date: July 7, 1977   Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample 10.0 - 11.5' Brown silty sand and gravel.
11			
12			
			Gravel - sample not recovered.
13			
14			
15	9		Split spoon sample 15.0 - 16.5' Brown sand.
16			
17			
			Gravel - sample not recovered.
18			
19			
20	10		Split spoon sample. 20.0 - 21.5' Brown sand.

Alluvial Profiles of the Smelterville Flats

Station No.: 5Y Date: July 7, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0–2.5	1	2.5	Dark brown silty sand and gravel.
2.5–5	2	2.5	Dark brown silty sand and gravel.
5	5		Split spoon sample. 5.0 - 5.5' Brown sand. 5.5 - 6.5' Brown silty sand and gravel.
5–7.5	3	2.5	Brown sandy gravel.
7.5–10	4	2.5	Brown sandy gravel.
10	8		Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 5Y Date: July 7, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample. 10.0 - 10.6' Brown sand. 10.6 - 11.5' Brown sandy gravel.
12–13	6	5.0	Brown sandy gravel.
15	9		Split spoon sample. 15.0 - 15.8' Brown sand. 15.8 - 16.5' Brown sandy gravel.
17–18	7	5.0	Brown sandy gravel.
20	10		Split spoon sample. 20.0 - 20.9' Brown sandy gravel.

Alluvial Profiles of the Smelterville Flats

Station No.: 6Y Date: July 7, 1977 Depth: 50 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0				
1	1	Ω	1.7	Reddish brown silty sand and gravel, loose.
2	2	†	1.8	Gray brown silty clay, cohesive.
3–5	2A		2.5	Light brown silty sand and gravel.
5	5			Split spoon sample. 5.0 - 6.5' Red silty sand and gravel with wood.
6–7	3		2.5	Brown sandy gravel.
8–9	4		2.5	Brown sandy gravel.
10	8			Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 6Y Date: July 7, 1977 Depth: 50 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample. 10.0 - 10.5' Brown sand. 10.5 - 11.5' Brown silty sand and gravel.
11			
12			
	6		Sample not recovered.
13			
14			
15	9		Split spoon sample 15.0 - 15.5' Brown sand. 15.5 - 16.5' Brown silty sand and gravel.
16			
17			
	7		Sample not recovered.
18			
19			
20	10		Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 6Y   Date: July 7, 1977   Depth: 50 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
20	10		Split spoon sample. 20.0 - 21.5' Brown sand grading to sandy gravel.
21			
22			Sample not recovered.
23			
24			
25	11		Split spoon sample.* 25.0 - 25.9' Brown sand. 25.9 - 26.5' Gray silty clay.
26			
27			Sample not recovered.
28			
29			
30	12		Split spoon sample.*

*Believe sand not to be true sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 6Y Date: July 7, 1977 Depth: 50 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
30	12		Split spoon sample.* 30.0 - 30.8' Brown sand. 30.8 - 31.5' Gray silty clay.
31–34			Sample not recovered.
35	13		Split spoon sample.* 35.0 - 35.7' Brown sand. 35.7 - 36.5' Gray silty clay.
37–38	17	5.0	Brownish gray silty clay, cohesive.
40	14		Split spoon sample.*

*Believe sand not to be true sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 6Y   Date: July 7, 1977   Depth: 50 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
40	14		Split spoon sample. 40.0 - 40.5' Brown sand. 40.5 - 41.5' Gray silty clay.
41			
42			
	18	5.0	Brownish gray silty clay, cohesive
43			
44			
45	15		Split spoon sample. 45.0 - 46.5' Gray silty clay.
46			
47			
	19	5.0	Brownish gray silty clay, cohesive.
48			
49			
50	16		Split spoon sample. 50.0 - 51.5' Gray silty clay.

Alluvial Profiles of the Smelterville Flats

Station No.: 7Y Date: July 6, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0			
1	1	2.5	Black brown silty sand and gravel.
2			
3			
4	2	2.5	Brown silty sand and gravel.
5	5		Split spoon sample. 5.0 - 5.4' Brown silt. 5.4 - 5.6' White silty sand, gravel. 5.6 - 5.9' Brown silty sand, gravel.
6	3	2.5	Brown silty sand and gravel.
7			
8			
9	4	2.5	Brown sandy gravel.
10	8		Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 7Y   Date: July 6, 1977   Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample. 10.0 - 10.6' Red sand. 10.6 - 11.5' Red silty sand and gravel.
11			
12			
	6	5.0	Brown sandy gravel.
13			
14			
15	9		Split spoon sample. 15.0 - 16.5' Brown sandy gravel.
16			
17			
	7	5.0	Brown sandy gravel.
18			
19			
20	10		Split spoon sample. 20.0 - 21.5' Brown silty sand.

Alluvial Profiles of the Smelterville Flats

Station No.: 8Y Date: July 6, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0				
	1	Ω	0.9	Red silty sand, loose.
1				
	11	†	0.9	Light brown silty clay.
2				
	12	†	1.4	Dark gray silty clay.
3				
4	2	†	1.8	Dark gray silty clay, some brown silt.
5	5			Split spoon sample. 5.0 - 5.8' Brown silty sand with lenses of silt and sand.
6	3		2.5	Dark brown silty sand.
7				
8				
	4		2.5	Brown silty sand, gravels near the bottom.
9				
10	8			Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 8Y   Date: July 6, 1977   Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample. 10.0 - 11.5' Brown silty sand and gravel.
11			
12	6	5.0	Sample not recovered. Drilling rate indicated a gravel layer at 12.0'.
13			
14			
15	9		Split spoon sample. 15.0 - 15.7' Brown silty sand and gravel. 15.7 - 16.5' Brown silt.
16			
17	7	5.0	Brown silty sand.
18			
19			
20	10		Split spoon sample. 20.0 - 21.5' Brown silty sand and gravel.

Alluvial Profiles of the Smelterville Flats

Station No.: 9Y   Date: July 6, 1977   Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0			
1	1 Ω	2.5	Brown sandy gravel.
2			
3			
4	2	2.5	Brown sandy gravel.
5	5		Split spoon sample. 5.0 - 5.0' Brown silty sand and gravel.
6	3	2.5	Brown sandy gravel.
7			
8			
9	4	2.5	Sample not recovered.
10	8		Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 9Y Date: July 6, 1977 Depth: 20 feet
Construction Method: Hollow stem auger.

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample. 10.0 - 10.4' Brown sand. 10.4 - 10.9' Brown sand and gravel. 10.9 - 11.2' Brown silt. 11.2 - 11.5' Brown sand and gravel.
11			
12			
	6	2.5	Brown sandy gravel.
13			
14			
15	9		Split spoon sample. 15.0 - 15.9' Brown silt, sand, gravel. 15.9 - 16.5' Brown coarse sand and gravel.
16			
17			
	7	2.5	Sample not recovered.
18			
19			
20	10		Split spoon sample. 20.0 - 21.5' Brown silty sand and gravel.

Alluvial Profiles of the Smelterville Flats

Station No.: 10Y Date: July 6, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0 – 2.5	1	2.5	Light brown silty sand, loose. Gravel near the bottom.
2.5 – 5	2	2.5	Dark brown silty sand and gravel. Mostly gravel near the bottom.
5	5		Split spoon sample. 5.0 - 5.7' Brown gravel, some silt and sand.
5 – 7.5	3	2.5	Brown silty sand and gravel, mostly gravel.
7.5 – 10	4	2.5	Sample not recovered, very hard drilling, probably large gravels.
10	8		Split spoon sample.

Alluvial Profiles of the Smelterville Flats

Station No.: 10Y Date: July 6, 1977 Depth: 20 feet
Construction Method: Hollow stem auger

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10	8		Split spoon sample. 10.0 - 10.8' Brown silty sand. (?) 10.8 - 11.5' Brown gravel.
11			
12			
	6		Brown sandy gravel.
13			
14			
15	9		Split spoon sample. 15.0 - 16.5' Brown silty sand and gravel.
16			
17			
	7	2.5	Brown sandy gravel.
18			
19			
20	10		Split spoon sample. 20.0 - (?)' Mostly water with a silty clay lense at the bottom.

Backhoe

Symbol Exp;anation

Ω = Probable type of mine waste in this zone is jig tailings.

† = Probable type of mine waste in this zone is rock powder and flotation tailings (slimes).

Alluvial Profiles of the Smelterville Flats

Station No.: 1A Date: June 21, 1977 Depth: 3.7 feet
Construction Method: Backhoe, dug to repair water line.

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0				
	7		1.0	Brown silty sand grades into light brown sand.
1	6			
	5		1.0	Dark to light brown silty sand and gravel.
	4			
2				
	3	†	0.5	Dark gray silty clay.
3	2	Ω	0.7	Dark brown silty sand.
	1	†		Light gray silty clay.
4				
5				
6				
7				
8				
9				
10				

Alluvial Profiles of the Smelterville Flats

Station No.: 1B Date: June 21, 1977 Depth: 4.5 feet
Construction Method: Backhoe, dug to repair water line.

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0–0.9	7		0.9	Reddish brown to dark brown sand.
0.9–1.3	6	†	0.4	Gray silty sand.
1.3–2.1	5	†	0.8	Light red to tan silty sand.
2.1–2.4	4	†	0.3	Light gray silty clay.
2.4–3.0	3	†	0.6	Light red to tan silty sand.
3.0–4.2	2	†	1.2	Dark gray silty clay, organics.
4.2–	1	†		Light gray silty clay.

Depth in Feet: 0 1 2 3 4 5 6 7 8 9 10

Alluvial Profiles of the Smelterville Flats

Station No.: SP-1 Date: October 1, 1977 Depth: 9.7 feet
Construction Method: Soil pit - Backhoe.

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0, 1	20, 19, 18	Ω (19)	1.3	Dark gray to black silty sand and gravel, lenses of dark red sand, tree limbs.
2	17, 16, 15	Ω (16)	1.5	Light red sand with a few pebbles, cross bedding, pebble lenses.
3, 4	14, 13, 12, 11	Ω (12)	2.3	Red silty sand, dense, with purple crystal layers (small) which lay parallel and perpendicular to bedding, lenses of organic material.
5, 6, 7	10, 9, 8, 7, 6, 5		2.8	Gray brown silty sand with lenses of organic material, limb at 7.4 feet.
8	4		0.3	Gray brown sand, some iron staining.
9, 10	3, 2, 1			Brown silty sand and large gravel, iron staining.

Alluvial Profiles of the Smelterville Flats

Station No.: SP-2 Date: October 1, 1977 Depth: 7.9 feet
Construction Method: Soil pit - Backhoe.

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0–1.4			1.4	Dark gray to black silty sand and gravel, lenses of red sand, roots and limbs.
1.5–2.2	3	Ω	0.7	Orange-red medium dense silt to sand, coarser towards the top, alot of roots, poor lateral continuity.
2.2–4.5	2		2.3	Brown medium dense silty sand, pockets of red-yellow to charcoal color around pieces of wood.
4.5–	1			Light gray to light brown sand and gravel with pockets of iron staining and roots.

Depth in Feet: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Alluvial Profiles of the Smelterville Flats

Station No.: SP-3 Date: October 1, 1977 Depth: 5.3 feet
Construction Method: Soil pit - Backhoe.

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0	10		0.3	Reddish brown silty sand.
1	9, 8	†	1.2	Tan sand and gray silty clay, organics.
2	7, 6	†	0.9	Red dense sand, sparse organics.
3	5	†	0.8	Dark gray silty clay, tree limbs, thickness varies drastically.
4, 5	4, 3, 2, 1			Brown silty sand and gravel, irregular thickness, significant lenses of iron staining.
6, 7, 8, 9, 10				

Sample 7A Deep red to purple - appears to be concentration gradient from medium red to purple at center.

Sample 8 Sample for oxidation test by drying.

Sample 11 Extra red concentration on opposite side from sample profile, color appears to be mainly on rock surface, at about 3 feet deep.

Alluvial Profiles of the Smelterville Flats

Station No.: SP-4 Date: October 1, 1977 Depth: 5.7 feet
Construction Method: Soil pit - Backhoe.

Sample Location & Number		Thickness (feet)	Description of Material
12		0.3	Medium red to dark brown silty sand.
11	†	0.8	Brown sand and medium to light gray silty clay, pockets or iron staining, organic material.
10, 9	†	1.1	Tan to light gray silty sand, pockets of iron staining, organics.
8, 7	†	1.1	Dark gray silty clay, fine black organic material, few large roots.
6, 5, 4, 3, 2	†	2.3	Medium gray silty sand, small amounts of iron staining, small roots and other organic matter.
1			Brown sandy gravel.

Depth in Feet: 0 1 2 3 4 5 6 7 8 9 10

The bottom gravel layer appears to be an artesian aquifer due to considerable inflow of water into the soil pit after penetrating the gravel layer. Water level was at a depth of 4.6 feet.

Alluvial Profiles of the Smelterville Flats

Station No.: SP-5 Date: October 2, 1977 Depth: 6.0 feet
Construction Method: Soil pit - Backhoe, river bank.

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0			
1	Ω		Jumble of silt, sand, and gravels, pockets of medium gray to reddish brown silty clay.
2			
3			
4			
5			
6			
7			
8			
9			
10			

Alluvial Profiles of the Smelterville Flats

Station No.: SP-6 Date: October 2, 1977 Depth: 11.0 feet
Construction Method: Soil pit - Backhoe.

Depth in Feet: 0–10

Sample Location & Number		Thickness (feet)	Description of Material
		0.9	Reddish brown to medium dark brown silty sand and gravel, organic material.
		1.1	Brown transitional sand and gravel.
4	Ω	1.4	Light to medium brown sand which grades coarser upward.
3	†	0.4	Band of prominant iron staining on silty clays, organic material.
2 1	†	3.7	Gray silty clay with pockets of iron staining, large gravel lense at a depth of 5.5 feet, roots.
	†	2.4	Gray silty clay with gravels increasing in amount towards the bottom.

Alluvial Profiles of the Smelterville Flats

Station No.: SP-6 Date: October 2, 1977 Depth: 11.0 feet
Construction Method: Soil pit - Backhoe.

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
10–12			Brown sandy gravel.
12–20			The hole was dug to a depth of 9.5 feet, then sampled, then extended to a depth of 11.0 feet. At 10.0 feet, a brown sandy gravel was encountered and upon entering this bed, artesian flow occurred. Water level was at a depth of 9.0 feet.

Alluvial Profiles of the Smelterville Flats

Station No.: SP-7 Date: October 2, 1977 Depth: 5.2 feet
Construction Method: Soil pit - Backhoe.

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0		0.7	Dark brown sandy silt, organic material.
1	Ω	0.8	Light brown to reddish brown sand silt, very dense, iron staining.
2	2	0.4	Dark to medium brown silty sand, loam.
3–4	1	2.5	Light brown silty sand, organic matter.
5			Brown sandy gravel, small pockets of iron staining.
6–7			SP-7 3 Special sample, black and red material platted onto the surface of rocks, sample is from near the bottom.
8			
9			
10			

Alluvial Profiles of the Smelterville Flats

Station No.: SP-8 Date: October 2, 1977 Depth: 7.8 feet
Construction Method: Soil pit - Backhoe.

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0–1.0			1.0	Dark brown silty sand and gravel, roots.
1.0–1.5	8	†	0.5	Reddish to medium brown silty sand, lenses of iron stain, organic matter.
1.5–3.0	7	†	1.5	Light to medium brown sand, lenses of gray silty clay, iron staining.
3.0–4.8	6, 5, 4	†	1.7	Gray silty clay with lenses of yellow staining.
4.8–5.1		†	0.3	Gray silty clay, sand, gravel.
5.1–5.6	3	†	0.5	Gray sandy silty clay, flecks of iron staining, organic material.
5.6–6.9	2, 1	†	1.3	Gray silty clay.
6.9–		Ω		Gray silty clay and gravel.

Depth in Feet: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Shovel

Symbol Explanation

Ω = Probable type of mine waste in this zone is jig tailings.

† = Probable type of mine waste in this zone is rock powder and flotation tailings (slimes).

Alluvial Profiles of the Smelterville Flats

Station No.: 4X Date: June, 1977 Depth: 4.0 feet
Construction Method: Soil pit - shovel

Sample Location & Number	Thickness (feet)	Description of Material
7 6	.3	Gray silty sand and gravel.
5 4 3	1.95	Light brown to dark brown silty sand with cross bedding, pebble lense at 1.2, sample 4, roots and wood pieces.
2 1 Ω	1.75	Red silty sand, dense, twigs and roots, gray silty clay lense at the top, (.2'), sample 2.
		Brown silty sand and gravel.

Depth in Feet: 0 1 2 3 4 5 6 7 8 9 10

Alluvial Profiles of the Smelterville Flats

Station No.: 6X Date: June, 1977 Depth: 4.0 feet
Construction Method: Soil pit - shovel

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0–1.6	4, 3	1.6	Gray to black sand and gravel, dark gray sand lense (.3 - .5'), gravel less than .25', wood pieces.
1.6–2.7	2 Ω	1.1	Light to dark red silty sand, dense, wood pieces.
2.7–4.0	1	1.3	Brown silty sand.
4.0–			Brown silty sand and gravels.

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Alluvial Profiles of the Smelterville Flats

Station No.: 2Y   Date: June, 1977   Depth: 4.0 feet
Construction Method: Soil pit - shovel

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0	3	.2	Gray brown fine grained sand, wood chips.
1	2 †	1.8	Reddish brown to yellow red sand with some gray sand lenses, very dense, wood pieces.
2		.2	Black organic lense, roots, leaves.
3	1	1.8	Brown silty sand, very dense, root.
4			Brown silty sand and gravel.
5			
6			
7			
8			
9			
10			

Alluvial Profiles of the Smelterville Flats

Station No.: 6Y Date: June, 1977 Depth: 2.6 feet
Construction Method: Soil pit - shovel

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0	2		White surface precipitate.
1	1	2.6	Reddish brown sandy gravel with lenses of heavy iron stain.
2			
3			
4			
5			
6			
7			
8			
9			
10			

Alluvial Profiles of the Smelterville Flats

Station No.: 8Y   Date: June, 1977   Depth: 5.0 feet
Construction Method: Soil pit - shovel

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0 – 1.2	9, 8, 7	Ω	1.2	Reddish brown to brown silty sand, black gravel lense (.2 - .7'), some roots and limbs.
1.2 – 2.7	6, 5, 4, 3, 2	†	1.5	Gray to tan silty sand with layers of gray silty clay, iron staining, roots.
2.7 – 5.0	1	Ω	2.3	Light brown silty sands with gravels towards the bottom
5.0 –				Brown silty sand and gravels.

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Alluvial Profiles of the Smelterville Flats

Station No.: 9Y Date: June, 1977 Depth: 3.1 feet
Construction Method: Soil pit - shovel

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0				
1	3 2	Ω	1.4	Reddish brown silty sand and gravel, gravel less than .25', sample 2, iron staining. Black stain from .5 - .7', sample 3.
2	1		1.7	Brown fine sand, iron staining at the top, some wood at the bottom.
3				
				Brown silty sand and gravel.
4				
5				
6				
7				
8				
9				
10				

Alluvial Profiles of the Smelterville Flats

Station No.: 9W Date: August, 1977 Depth: 3.0 feet
Construction Method: Soil pit - shovel.

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0	7		0.4	Reddish brown silty sand, loose.
1	6	†	0.5	Light brown to tan silty sand.
	5 4	†	1.1	Red silt, dense, lense of gray silt.
2	2		0.2	Black organic layer.
	3		0.8	Brown silty sand.
3	1			Brown sandy gravel.
4				
5				
6				
7				
8				
9				
10				

Alluvial Profiles of the Smelterville Flats

Station No.: 10W Date: August, 1977 Depth: 6.5 feet
Construction Method: Soil pit - shovel.

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0–3	Ω	3.0	Brown silty sand, cross bedding, gray silty clay lense at 1.2-1.4.
3–4.4	†	1.4	Dark gray silty clay, roots.
4.4–6	†	1.6	Light gray silt with roots.
6–			Brown sandy gravel.

Alluvial Profiles of the Smelterville Flats

Station No.: 11W Date: August, 1977 Depth: 4.0 feet
Construction Method: Soil pit - shovel.

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0	6		0.7	Brown silty sand.
1	5	Ω	0.4	Gray silty sand and gravel.
2	4	Ω	1.1	Red silty sand and gravel.
	3	†	0.2	Brown to gray to red silt.
3	2	†	0.8	Gray silty clay, leaves, with black organic layer at the bottom.
4	1			Brown silty sand and gravel.
5				
6				
7				
8				
9				
10				

Alluvial Profiles of the Smelterville Flats

Station No.: 12W Date: August, 1977 Depth: 3.5 feet
Construction Method: Soil pit - shovel.

Sample Location & Number		Thickness (feet)	Description of Material
1	Ω	0.8	Brown silty sand with dark red lenses.
2 3	†	0.6	Red silty sand & gray silty clay.
6	†	0.6	Red and gray silt layers, dense, wood.
4	†	1.4	Gray brown silty sand.
5			Brown silty sand and gravel.

Depth in Feet: 0 1 2 3 4 5 6 7 8 9 10

Alluvial Profiles of the Smelterville Flats

Station No.: 13W   Date: August, 1977   Depth: 6.0 feet
Construction Method: Soil pit - shovel.

Sample Location & Number		Thickness (feet)	Description of Material
6	Ω	1.1	Dark red brown silty sand, degree of red varies, dense.
5	†	1.4	Brownish red silty sands with lenses of gray silty clays and organics.
4	†	0.5	Dark gray silt.
3	†	0.2	Brown silt.
2	†	0.3	Dark gray silt.
1	†		Light gray silty sand with reddish brownspots, very dense.

Depth in Feet

0 1 2 3 4 5 6 7 8 9 10

Alluvial Profiles of the Smelterville Flats

Station No.: 14W   Date: August, 1977   Depth: 5.0 feet
Construction Method: Soil pit - shovel.

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0				
	1	Ω	0.9	Gray silty sand and gravel.
1				
2				
3	2	Ω	4.0	Brown silty sand and gravel, layering, cross bedding.
4				
5	3			Red stained gravel.
6				
7				
8				
9				
10				

Alluvial Profiles of the Smelterville Flats

Station No.: P-21 Date: July 22, 1978 Depth: 3.6 feet
Construction Method: Soil Pit - shovel

Depth in Feet	Sample Location & Number	Thickness (feet)	Description of Material
0–1.4	1	1.4	Red to brown to tan silty clay with a lense of iron concretions at 1.0 feet.
1.4–3.6	2, 3	2.2	Light to dark gray silty clay, organic material, red oxidized zones.

(Depth scale: 0 to 10 feet)

Alluvial Profiles of the Smelterville Flats

Station No.: 1Z Date: August, 1977 Depth: 5.0 feet
Construction Method: Soil pit - shovel.

Sample Location & Number		Thickness (feet)	Description of Material
1	Ω	1.5	Light gray silty sand with small gravel, cross bedding, wood.
2		0.5	White silty sand.
3	Ω	0.3	Red stained silty sand.
4		2.7	Brown silty sand.
			Brown sandy gravel.

Depth in Feet: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Alluvial Profiles of the Smelterville Flats

Station No.: 2Z Date: August, 1977 Depth: 6.0 feet
Construction Method: Soil pit - shovel, river bank.

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0	4		0.3	Gray silty sand and gravel.
	5 3	Ω	0.7	Red to reddish brown silty sand.
1				
2				
	2		3.0	Brown silty sand, some gravel.
3				
4				
5	1			Light brown silty sand and gravel.
6				
7				
8				
9				
10				

Alluvial Profiles of the Smelterville Flats

Station No.: 3Z Date: August, 1977 Depth: 6.0 feet
Construction Method: Soil pit - shovel, river bank.

Depth in Feet	Sample Location & Number		Thickness (feet)	Description of Material
0–1	5	Ω	1.0	Dark brown to gray silty sand, some gravel, roots.
1–2	4	Ω	1.0	Red to white silty sand, wood.
2–3	3 2	Ω	1.0	Gray to red silty sands with small gravels, cross bedding.
3–	1			Light brown silty sand with some gravel.

Alluvial Profiles of the Smelterville Flats

Station No.: 4Z Date: August, 1977 Depth: 5.5 feet
Construction Method: Soil pit - shovel, river bank.

Sample Location & Number		Thickness (feet)	Description of Material
1		1.2	Gray silty sand and gravel.
2	Ω	0.8	Red silty sand, wood, and leaves.
3	Ω	1.0	Brown silty sand and gravel.
	Ω	0.5	Brown gravel, some silt and sand.
4	Ω	1.0	Brown silty sand with red stained gravel.
5			Brown silty sand and gravel.

Depth in Feet: 0 1 2 3 4 5 6 7 8 9 10

APPENDIX II

Soil Chemistry

Appendix II. Soil chemistry data, Smelterville Flats study area.

Sample Site	Sample No.	Depth Below L.S.D. (feet)	Size Fraction (mm)	Percent of Sample by Weight	Concentrations in Parts Per Million: Cd	Zn	Pb	Fe	Mn	Ca	Mg
SP-1	1	9.7	> 2.362	57	--	550	34	21,000	94	180	1,500
			2.362 > to > .417	29	2.4	520	48	12,000	95	330	1,800
			.417 > to > .208	9	5.6	800	220	12,000	170	390	1,900
			.208 > to > .075	3	14	1,400	820	14,000	480	490	1,900
			.075 >	2	20	3,300	1,900	22,000	660	860	2,400
SP-1	2	9.2	> 2.362	76	7.8	390	19	16,000	95	130	3,400
			2.362 > to > .417	13	10	470	52	11,000	91	270	1,400
			.417 > to > .208	7	9.9	690	25	14,000	86	320	2,000
			.208 > to > .075	3	--	1,100	46	17,000	110	320	2,000
			.075 >	1	2.6	2,600	190	36,000	230	670	2,500
SP-1	3	8.7	> 2.362	70	6.2	12	10	2,900	21	90	41
			2.362 > to > .417	25	--	621	41	29,900	84	248	2,400
			.417 > to > .208	2	--	586	40	22,100	99	590	2,100
			.208 > to > .075	2	--	1,200	110	23,000	110	360	1,800
			.075 >	1	--	3,200	180	58,200	400	520	2,200
SP-1	4	8.2	> 2.362	1	122	37,500	170	8,300	810	2,400	1,400
			2.362 > to > .417	21	2.8	6,100	58	13,000	180	720	1,900
			.417 > to > .208	42	--	2,200	25	7,900	120	410	2,100
			.208 > to > .075	27	--	3,000	57	8,700	120	430	2,100
			.075 >	10	2.5	5,800	150	13,000	190	690	2,300
SP-1	5	7.7	> 2.362	1	No Sample						
			2.362 > to > .417	10	150	20,000	140	5,200	650	1,100	2,100
			.417 > to > .208	22	34	6,300	130	5,100	240	580	2,300
			.208 > to > .075	39	31	5,600	65	5,300	180	580	2,100
			.075 >	29	72	9,800	100	6,200	210	770	2,500

Appendix II. Cont'd

Sample		Depth Below L.S.D. (feet)	Size Fraction (mm)	Percent of Sample by Weight	Concentrations in Parts Per Million						
Site	No.				Cd	Zn	Pb	Fe	Mn	Ca	Mg
SP-1	6	7.2	> 2.362	.3	No Sample	--	--	--	--	--	--
			2.362 > to > .417	4	95	24,000	117	4,900	630	1,200	2,200
			.417 > to > .208	15	9	4,700	50	6,600	150	470	2,400
			.208 > to > .075	50	2.8	3,400	39	5,600	100	310	2,100
			.075 >	30	8.2	6,000	75	7,000	160	500	2,300
SP-1	7	6.7	> 2.362	--	No Sample						
			2.362 > to > .417	3	65	11,000	120	7,500	490	700	2,500
			.417 > to > .208	9	32	8,600	120	11,000	290	860	3,500
			.208 > to > .075	50	2.8	3,600	54	6,700	130	310	2,100
			.075 >	38	14	5,800	100	8,100	200	590	2,400
SP-1	8	6.2	> 2.362	1	No Sample						
			2.362 > to > .417	6	1,060	9,600	140	8,100	750	760	2,400
			.417 > to > .208	23	170	2,700	42	7,500	190	270	2,200
			.208 > to > .075	47	130	2,400	37	6,900	140	270	2,100
			.075 >	23	247	4,400	95	9,300	240	490	2,500
SP-1	9	5.7	> 2.362	--	No Sample						
			2.362 > to > .417	2	120	3,800	110	8,600	480	520	2,700
			.417 > to > .208	13	95	2,850	90	8,500	330	423	2,470
			.208 > to > .075	56	25	1,300	37	6,500	120	240	1,900
			.075 >	28	67	3,000	100	9,000	250	500	2,500
SP-1	10	5.2	> 2.362	2	7,800	26,900	24,900	1,800	3,100	760	980
			2.362 > to > .417	14	85	3,800	6,800	11,000	1,300	550	2,500
			.417 > to > .208	10	83	3,800	7,360	12,000	1,100	601	2,730
			.208 > to > .075	36	40	2,600	3,900	10,000	610	410	2,500
			.075 >	38	43	3,000	4,450	13,000	710	560	2,700

Appendix II. Cont'd

Sample		Depth Below L.S.D. (feet)	Size Fraction (mm)	Percent of Sample by Weight	Concentrations in Parts Per Million						
Site	No.				Cd	Zn	Pb	Fe	Mn	Ca	Mg
SP-1	11	4.7	> 2.362	1	45	9,300	96,800	148,000	7,480	740	2,400
			2.362 > to > .417	11	40	8,500	106,000	135,000	18,800	600	2,300
			.417 > to > .208	20	24	5,700	60,900	95,600	7,980	530	2,300
			.208 > to > .075	39	34	4,700	38,900	73,600	5,700	490	2,300
			.075 >	29	41	8,100	42,900	122,000	7,670	630	2,200
SP-1	12	4.2	> 2.362	1	31	12,000	99,000	194,000	6,700	780	2,600
			2.362 > to > .417	14	40	11,000	96,900	168,000	5,770	700	2,400
			.417 > to > .208	10	33	9,200	98,800	161,000	7,570	770	2,900
			.208 > to > .075	29	25	7,100	71,800	147,000	7,310	740	3,000
			.075 >	46	35	10,000	53,200	157,000	5,800	740	2,600
SP-1	13	3.7	> 2.362	1	47	13,000	91,600	185,000	2,700	390	740
			2.362 > to > .417	13	48	10,000	96,900	152,000	4,800	410	660
			.417 > to > .208	11	39	9,200	111,000	139,000	11,000	430	790
			.208 > to > .075	28	26	7,200	78,000	110,000	7,120	390	920
			.075 >	47	33	8,800	53,300	133,000	5,230	410	950
SP-1	14	3.2	> 2.362	1	No Sample						
			2.362 > to > .417	2	160	10,000	85,200	120,000	9,770	1,100	1,800
			.417 > to > .208	6	69	7,700	94,700	137,000	7,630	820	2,000
			.208 > to > .075	48	20	4,500	60,700	87,800	3,300	550	1,600
			.075 >	44	35	7,300	51,200	132,000	3,000	610	1,700
SP-1	15	2.7	> 2.362	12	--	470	1,200	23,000	2,400	410	820
			2.362 > to > .417	36	15	1,300	3,580	65,000	6,940	1,000	2,200
			.417 > to > .208	18	110	13,000	20,000	179,000	18,900	2,300	6,700
			.208 > to > .075	30	260	32,000	28,100	211,000	23,000	2,700	7,000
			.075 >	5	230	24,000	53,800	202,000	19,200	2,200	5,800

Appendix II. Cont'd

Sample Site	Sample No.	Depth Below L.S.D. (feet)	Size Fraction (mm)	Percent of Sample by Weight	Concentrations in Parts Per Million: Cd	Zn	Pb	Fe	Mn	Ca	Mg
SP-1	16	2.2	> 2.362	47	4.7	520	950	55,500	4,400	620	1,400
			2.362 > to > .417	25	20	2,700	19,000	182,000	20,000	2,500	6,700
			.417 > to > .208	11	91	11,000	23,000	219,000	24,100	2,900	8,100
			.208 > to > .075	12	130	16,000	26,100	211,000	23,000	2,500	7,900
			.075 >	6	38	7,000	33,800	182,000	16,400	1,900	6,000
SP-1	17	1.7	> 2.362	18	2.5	1,700	850	30,000	950	550	5,000
			2.362 > to > .417	8	5.6	2,500	13,000	70,600	7,660	2,000	4,200
			.417 > to > .208	18	70	12,000	16,000	227,000	29,400	2,800	8,400
			.208 > to > .075	49	130	18,000	21,000	220,000	23,000	2,500	7,200
			.075 >	6	220	32,900	55,700	214,000	18,200	2,000	5,800
SP-1	18	1.2	> 2.362	73	2	380	430	6,900	490	260	1,300
			2.362 > to > .417	19	13	1,500	1,200	30,000	2,900	590	3,000
			.417 > to > .208	2	30	4,900	9,900	133,000	12,600	1,100	2,200
			.208 > to > .075	5	52	7,500	11,000	170,000	17,700	1,500	2,500
			.075 >	2	56	8,700	13,000	142,000	12,800	1,400	2,100
SP-1	19	.7	> 2.362	63	--	270	470	4,300	270	290	2,000
			2.362 > to > .417	23	2.5	760	1,900	53,300	3,300	560	2,100
			.417 > to > .208	8	25	4,400	6,500	96,900	7,280	890	2,200
			.208 > to > .075	6	61	8,600	11,000	213,000	20,900	1,200	2,400
			.075 >	1	75	11,000	15,000	174,000	17,900	1,400	2,600
SP-1	20	0.0	> 2.362	65	1.9	210	1,400	19,000	110	96	840
			2.362 > to > .417	16	60	11,000	2,000	31,000	1,600	500	1,500
			.417 > to > .208	5	34	4,200	7,500	91,100	8,960	780	2,300
			.208 > to > .075	9	64	7,100	15,000	174,000	16,500	730	2,600
			.075 >	5	87	8,000	15,012	123,000	11,900	770	2,300

Appendix II. Cont'd

Sample Site	Sample No.	Depth Below L.S.D. (feet)	Size Fraction (mm)	Percent of Sample by Weight	Cd	Zn	Pb	Fe	Mn	Ca	Mg
					Concentrations in Parts Per Million						
SP-2	1	5.5	> .180	97	--	500	650	19,000	550	300	1,600
			.180 >	3	41	1,500	2,100	24,000	1,500	240	3,000
SP-2	2	2.9	> .180	18	39	1,000	250	21,000	950	620	3,300
			.180 >	82	35	1,100	240	21,000	630	540	3,300
SP-2	3	1.8	> .180	13	53	6,000	47,100	90,700	22,200	1,100	3,000
			.180 >	87	47	9,000	41,900	152,000	10,200	1,200	3,800
SP-2	4	.7	> .180	88	88	12,000	27,000	149,000	16,400	1,400	2,600
			.180 >	12	200	31,100	33,600	251,000	23,400	1,400	2,800
SP-3	1	4.8	> .180	99	5.2	210	150	12,000	620	300	1,200
			.180 >	1	26	1,500	3,530	23,000	6,600	1,200	2,100
SP-3	2	4.3	> .180	98	2.5	210	180	12,000	350	300	1,000
			.180 >	2	16	1,700	2,200	28,000	3,100	1,300	2,300
SP-3	3	3.8	> .180	85	4.7	380	280	18,000	380	390	1,700
			.180 >	15	10	1,300	770	23,000	570	850	2,200
SP-3	4	3.3	> .180	89	4.7	470	660	16,000	640	390	1,900
			.180 >	11	8.9	1,400	1,300	29,000	570	920	2,100
SP-3	5	2.8	> .180	7	305	25,000	58,000	88,000	6,880	2,300	3,400
			.180 >	93	226	29,300	45,800	93,700	9,200	3,200	4,100
SP-3	6	2.3	> .180	24	130	15,000	29,900	115,000	7,200	1,700	4,200
			.180 >	76	190	20,000	32,100	87,600	8,650	2,500	4,200

Appendix II. Cont'd

Sample Site	Sample No.	Depth Below L.S.D. (feet)	Size Fraction (mm)	Percent of Sample by Weight	Concentrations in Parts Per Million: Cd	Zn	Pb	Fe	Mn	Ca	Mg
SP-3	7	1.8	> .180	27	52	6,400	14,000	67,000	2,100	1,100	4,400
			.180 >	73	44	7,000	19,000	124,000	9,460	1,300	4,000
SP-3	8	1.3	> .180	16	484	15,000	32,900	91,000	8,830	2,600	4,600
			.180 >	84	396	15,000	29,500	96,400	9,360	2,600	4,800
SP-3	9	.8	> .180	6	190	13,000	31,300	46,900	5,850	1,600	2,800
			.180 >	94	59	6,900	18,000	118,000	12,000	1,800	4,970
SP-3	10	0.0	> .180	4	63	6,300	12,000	37,000	7,300	890	2,100
			.180 >	96	90	12,000	19,000	132,000	13,400	1,800	5,000
SP-3	11	2.0	> .180	98	--	270	260	14,000	200	220	820
			.180 >	2	26	2,600	4,230	211,000	990	780	1,100
SP-4	1	5.7	> .180	90	2.1	350	290	7,400	78	193	990
			.180 >	10	19	3,300	2,800	32,000	1,800	830	2,600
SP-4	2	5.2	> .180	17	--	1,100	97	8,700	150	820	2,500
			.180 >	83	--	960	85	9,900	170	990	3,200
SP-4	3	4.7	> .180	16	2.5	790	86	8,900	140	690	2,500
			.180 >	84	--	850	89	9,400	160	710	2,400
SP-4	4	4.2	> .180	13	--	2,800	210	26,000	862	880	2,500
			.180 >	87	--	1,800	100	14,000	210	800	2,400
SP-4	5	3.7	> .180	25	21	2,400	68	10,000	180	760	2,300
			.180 >	75	4.9	2,100	68	11,000	180	730	2,300

Appendix II. Cont'd

Sample Site	Sample No.	Depth Below L.S.D. (feet)	Size Fraction (mm)	Percent of Sample by Weight	Cd	Zn	Pb	Fe	Mn	Ca	Mg
					Concentrations in Parts Per Million						
SP-4	6	3.2	> .180	40	--	5,000	78	14,000	420	1,000	2,600
			.180 >	60	--	3,800	96	14,000	294	1,300	2,500
SP-4	7	2.7	> .180	63	9.5	15,000	11,000	25,000	2,100	1,900	2,700
			.180 >	37	9	12,000	15,000	39,000	2,900	2,500	3,000
SP-4	8	2.2	> .180	50	1,600	39,900	63,600	99,800	9,200	2,800	4,100
			.180 >	50	380	42,400	47,100	139,000	13,400	2,800	5,500
SP-4	9	1.7	> .180	26	93	9,300	35,300	124,000	13,200	2,400	5,500
			.180 >	74	219	30,900	33,700	162,000	16,600	2,900	6,100
SP-4	10	1.2	> .180	4	540	13,200	56,800	113,000	10,300	1,650	3,430
			.180 >	96	120	17,900	30,900	149,000	15,000	2,000	4,660
SP-4	11	.7	> .180	22	94	9,000	37,000	105,000	12,700	1,500	4,200
			.180 >	78	94	10,000	24,600	158,000	16,200	2,000	5,100
SP-4	12	.2	> .180	14	66	8,300	15,000	87,600	12,600	1,200	3,600
			.180 >	86	65	10,000	19,000	175,000	18,000	1,900	5,100
SP-6	1	6.9	> .180	30	5.6	5,100	110	7,100	220	860	2,900
			.180 >	70	6.9	5,300	120	6,900	240	850	2,800
SP-6	2	6.3	> .180	21	16	2,800	480	34,000	850	730	3,000
			.180 >	79	15	2,900	470	29,000	460	780	2,900
SP-6	3	3.8	> .180	12	440	13,000	113,000	106,000	5,790	1,600	1,800
			.180 >	88	371	22,000	63,500	106,000	9,890	1,900	4,800

Appendix II. Cont'd

Sample Site	Sample No.	Depth Below L.S.D. (feet)	Size Fraction (mm)	Percent of Sample by Weight	Cd	Zn	Pb	Fe	Mn	Ca	Mg
					Concentrations in Parts Per Million						
SP-6	4	2.7	> .180	42	58	6,800	13,000	119,000	12,400	1,800	5,070
			.180 >	58	120	14,000	31,500	210,000	23,300	2,520	7,600
SP-7	1	3.3	> .180	15	34	480	92	15,000	1,510	690	2,700
			.180 >	85	28	490	110	17,000	1,140	810	2,800
SP-6	2	1.7	> .180	4	48	6,100	74,300	121,000	22,600	2,600	2,700
			.180 >	96	31	5,100	34,800	126,000	8,460	1,900	3,100
SP-8	1	6.8	> 2.362	46	11	28	14	3,300	33	67	1,100
			2.362 > to > .417	19	10	38	25	4,500	58	351	1,800
			.417 > to > .208	14	9.6	48	12	3,800	67	326	1,600
			.208 > to > .075	13	10	50	30	5,000	80	371	1,800
			.075 >	8	23	127	93	9,300	170	650	2,300
SP-8	2	6.1	> 2.362	5	12	800	70	8,900	360	560	2,500
			2.362 > to > .417	18	9.2	740	58	9,700	330	650	2,500
			.417 > to > .208	15	10	560	62	7,800	233	490	2,300
			.208 > to > .075	24	12	463	52	7,300	220	480	2,200
			.075 >	38	10	760	89	12,000	390	730	2,700
SP-8	3	5.3	> 2.362	8	12	2,800	6,500	30,000	2,200	710	1,230
			2.362 > to > .417	11	49	7,400	17,000	68,000	7,060	1,800	3,670
			.417 > to > .208	24	41	8,200	19,000	136,000	13,600	2,500	6,000
			.208 > to > .075	39	180	29,200	18,000	189,000	20,200	2,100	7,700
			.075 >	17	230	35,300	63,300	125,000	12,000	3,200	5,100
SP-8	4	4.8	> 2.362	16	1.5	360	810	18,000	1,200	280	780
			2.362 > to > .417	26	4.9	1,100	12,000	44,000	4,000	980	2,100

Appendix II. Cont'd

Sample Site	Sample No.	Depth Below L.S.D. (feet)	Size Fraction (mm)	Percent of Sample by Weight	Concentrations in Parts Per Million: Cd	Zn	Pb	Fe	Mn	Ca	Mg
SP-8	4		.417 > to > .208	26	56	10,000	14,000	172,000	17,400	2,800	7,290
			.208 > to > .075	22	200	30,200	20,000	199,000	20,300	3,200	8,100
			.075 >	9	253	34,500	61,500	125,000	12,600	3,100	5,300
SP-8	5	4.3	> 2.362	0	No Sample						
			2.362 > to > .417	0	No Sample						
			.417 > to > .208	1	110	12,000	27,900	95,700	9,780	3,000	4,400
			.208 > to > .075	9	180	24,000	37,500	141,000	14,600	3,700	4,700
			.075 >	91	200	37,700	63,200	122,000	12,200	2,900	5,200
SP-8	6	3.4	> 2.362	0	No Sample						
			2.362 > to > .417	2	260	24,000	37,900	83,600	6,120	1,600	2,600
			.417 > to > .208	4	110	15,000	20,000	130,000	11,700	1,900	5,100
			.208 > to > .075	16	160	24,000	26,500	165,000	16,400	2,700	6,500
			.075 >	78	88	16,000	18,000	129,000	12,100	3,500	5,300
SP-8	7	2.5	> 2.362	0	No Sample						
			2.362 > to > .417	1	130	15,000	56,400	131,000	5,590	1,400	2,500
			.417 > to > .208	3	120	13,000	38,000	75,900	6,810	1,600	3,200
			.208 > to > .075	50	96	14,000	16,000	99,300	9,630	1,620	4,100
			.075 >	47	71	10,000	19,000	105,000	9,000	1,800	4,200
SP-8	8	1.4	> 2.362	0	No Sample						
			2.362 > to > .417	1	66	7,300	16,000	62,000	5,800	880	2,600
			.417 > to > .208	4	52	7,700	35,600	95,600	11,700	1,200	3,500
			.208 > to > .075	26	25	4,400	14,000	140,000	7,630	1,128	3,300
			.075 >	68	38	6,600	14,000	74,800	5,460	1,170	3,100

-- below detection

APPENDIX III

Water Levels

Appendix III. Dates used for computer Printouts of water level and water quality - Smelterville Flats study area.

Date	Computer Number	Date	Computer Number
Elevation of Land Surface	100	January, 1978	
		10	375 (W.Q.)
July, 1977		28	393
7	188*	February, 1978	
11	192		
18	199	11	407
25	206	25	421
August, 1977		March, 1978	
2	214	10	434
8	220	25	449 (W.Q)
15	227		
22	234 (W.Q. only)	April, 1978	
September, 1977		8	463
		22	477 (W.Q.)
2	245		
16	259	May, 1978	
October, 1977		9	494
		20	505 (W.Q.)
2	275*		
5	278	June, 1978	
15	288		
22	295	2	518
28	301 (W.Q.)*	16	532 (W.Q.)
		29	545
November, 1977			
		July, 1978	
4	308		
19	323	14	560
		22	568
December, 1977			
		August, 1978	
4	338*		
29	363	12	589 (W.Q.)
		September, 1978	
		2	610

Computer Dates start from January 1, 1977.

* Partial data for the date.

(W.Q.) Water level and water quality samples taken on this date.

Appendix III. Water level data for 1977 - 1978, Smelterville Flats study area.

STATION	DATE	WATER LEVEL
AXA	100	2220.78
AXA	192	2209.02
AXA	199	2208.73
AXA	206	2208.65
AXA	214	2208.62
AXA	220	2208.52
AXA	227	2208.35
AXA	245	2208.31
AXA	259	2208.29
AXA	278	2208.03
AXA	288	2208.64
AXA	295	2208.44
AXA	308	2209.29
AXA	323	2209.11
AXA	338	2213.11
AXA	375	2213.18
AXA	393	2212.99
AXA	407	2213.55
AXA	421	2212.82
AXA	434	2212.68
AXA	449	2213.17
AXA	477	2213.06
AXA	494	2213.16
AXA	505	2213.61
AXA	518	2213.41
AXA	532	2212.96
AXA	545	2212.37
AXA	560	2212.01
AXA	568	2211.53
AXA	589	2210.63
AXA	610	2210.42

STATION	DATE	WATER LEVEL
AXB	100	2220.78
AXB	338	2212.46
AXB	375	2213.37
AXB	393	2212.97
AXB	407	2213.59
AXB	421	2212.77
AXB	434	2212.73
AXB	449	2213.19
AXB	477	2212.99
AXB	494	2212.99
AXB	505	2213.87
AXB	518	2213.43
AXB	532	2212.99
AXB	545	2212.37
AXB	560	2211.97
AXB	568	2211.53

STATION	DATE	WATER LEVEL
1XA	100	2213.73
1XA	192	2208.74
1XA	199	2208.53
1XA	206	2208.39
1XA	214	2208.41
1XA	220	2208.28
1XA	227	2208.14
1XA	245	2208.06
1XA	259	2208.01
1XA	278	2208.91
1XA	288	2208.37
1XA	295	2208.18
1XA	308	2208.56
1XA	323	2208.64
1XA	338	2212.57
1XA	363	2213.03
1XA	375	2213.05
1XA	393	2212.84
1XA	407	2213.40
1XA	421	2212.59
1XA	434	2212.54
1XA	449	2213.05
1XA	463	2213.40
1XA	477	2212.84
1XA	494	2212.92
1XA	505	2213.67
1XA	518	2213.29
1XA	532	2212.86
1XA	545	2212.30
1XA	560	2211.94
1XA	568	2211.44
1XA	589	2210.49
1XA	610	2210.24

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
1XB	100	2219.73
1XB	338	2212.54
1XB	363	2212.80
1XB	375	2213.03
1XB	393	2212.80
1XB	407	2213.45
1XB	421	2212.62
1XB	434	2212.56
1XB	449	2213.03
1XB	463	2213.41
1XB	477	2212.82
1XB	494	2212.66
1XB	505	2213.46
1XB	518	2213.27
1XB	532	2212.80
1XB	545	2212.22
1XB	560	2211.80
1XB	568	2211.38
1XB	589	2210.43
1XB	610	2210.20

STATION	DATE	WATER LEVEL
2XA	100	2221.64
2XA	188	2208.65
2XA	192	2208.63
2XA	199	2208.47
2XA	206	2208.38
2XA	214	2208.29
2XA	220	2208.18
2XA	227	2208.07
2XA	245	2207.85
2XA	259	2207.87
2XA	278	2208.41
2XA	288	2208.30
2XA	295	2208.13
2XA	308	2208.35
2XA	323	2208.47
2XA	338	2212.48
2XA	363	2213.35
2XA	375	2212.84
2XA	393	2212.76
2XA	407	2213.22
2XA	421	2212.69
2XA	434	2212.42
2XA	449	2212.77
2XA	463	2213.39
2XA	477	2212.92
2XA	494	2212.95
2XA	505	2213.44
2XA	518	2213.26
2XA	532	2212.92
2XA	545	2212.26
2XA	560	2211.88
2XA	568	2211.48
2XA	589	2210.43
2XA	610	2210.07

STATION	DATE	WATER LEVEL
2XB	100	2221.64
2XB	192	2208.64
2XB	199	2208.64
2XB	278	2208.41
2XB	338	2212.54
2XB	363	2212.77
2XB	375	2212.97
2XB	393	2212.74
2XB	407	2213.33
2XB	421	2213.04
2XB	434	2212.52
2XB	449	2213.05
2XB	463	2213.90
2XB	477	2212.82
2XB	494	2212.84
2XB	505	2213.43
2XB	518	2213.23
2XB	532	2212.77
2XB	545	2212.19
2XB	560	2211.75
2XB	568	2211.30
2XB	589	2210.34
2XB	610	2210.08

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
3XA	100	2222.48
3XA	188	2208.78
3XA	192	2208.62
3XA	199	2208.35
3XA	206	2208.21
3XA	214	2208.20
3XA	220	2208.09
3XA	227	2207.96
3XA	245	2207.87
3XA	259	2208.14
3XA	278	2208.43
3XA	288	2208.19
3XA	295	2207.97
3XA	308	2208.47
3XA	323	2208.47
3XA	338	2212.69
3XA	363	2212.90
3XA	375	2213.08
3XA	393	2212.85
3XA	407	2213.48
3XA	421	2212.68
3XA	434	2212.63
3XA	449	2213.28
3XA	463	2213.58
3XA	477	2212.98
3XA	494	2213.03
3XA	505	2213.62
3XA	518	2213.47
3XA	532	2212.95
3XA	545	2212.33
3XA	560	2211.84
3XA	568	2211.39
3XA	589	2210.40
3XA	610	2210.08

STATION	DATE	WATER LEVEL
3XB	100	2222.48
3XB	188	2208.77
3XB	192	2208.63
3XB	199	2208.24
3XB	206	2208.24
3XB	214	2208.14
3XB	278	2208.36
3XB	295	2208.14
3XB	308	2208.44
3XB	323	2208.45
3XB	338	2212.78
3XB	363	2212.99
3XB	375	2213.16
3XB	393	2212.92
3XB	407	2213.57
3XB	421	2212.98
3XB	434	2212.72
3XB	449	2213.38
3XB	463	2213.72
3XB	477	2213.11
3XB	494	2213.16
3XB	505	2214.02
3XB	518	2213.52
3XB	532	2213.06
3XB	545	2212.48
3XB	560	2211.94
3XB	568	2211.43
3XB	589	2210.43
3XB	610	2210.12

STATION	DATE	WATER LEVEL
4XA	100	2221.09
4XA	188	2208.54
4XA	192	2208.43
4XA	199	2208.19
4XA	206	2207.97
4XA	214	2207.95
4XA	220	2207.92
4XA	227	2207.76
4XA	245	2207.64
4XA	259	2207.60
4XA	275	2208.07
4XA	278	2208.25
4XA	288	2208.00
4XA	295	2207.74
4XA	308	2208.36
4XA	323	2208.27
4XA	338	2212.98
4XA	363	2213.14
4XA	375	2213.25
4XA	393	2213.16
4XA	407	2213.63
4XA	421	2213.00
4XA	434	2212.70
4XA	449	2213.62
4XA	463	2213.99
4XA	477	2213.40
4XA	494	2213.42
4XA	505	2213.91
4XA	518	2213.73
4XA	532	2213.39
4XA	545	2212.69
4XA	560	2212.16
4XA	568	2211.65
4XA	589	2210.56
4XA	610	2210.08

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
4XB	100	2221.09
4XB	188	2208.52
4XB	192	2208.42
4XB	199	2208.08
4XB	206	2207.97
4XB	214	2207.95
4XB	220	2207.86
4XB	227	2207.72
4XB	245	2207.70
4XB	259	2207.59
4XB	275	2208.17
4XB	278	2208.22
4XB	288	2207.95
4XB	295	2207.74
4XB	308	2208.33
4XB	323	2208.26
4XB	338	2212.97
4XB	363	2213.11
4XB	375	2213.27
4XB	393	2212.99
4XB	407	2213.65
4XB	421	2212.76
4XB	434	2212.82
4XB	449	2213.69
4XB	463	2213.89
4XB	477	2213.28
4XB	494	2213.33
4XB	505	2213.89
4XB	518	2213.61
4XB	532	2213.18
4XB	545	2212.56
4XB	560	2211.43
4XB	568	2211.44
4XB	589	2210.38
4XB	610	2209.96

STATION	DATE	WATER LEVEL
6XA	100	2220.82
6XA	188	2207.92
6XA	192	2207.60
6XA	199	2207.43
6XA	206	2207.30
6XA	214	2207.30
6XA	220	2207.21
6XA	227	2207.07
6XA	245	2207.01
6XA	259	2206.93
6XA	278	2207.54
6XA	288	2207.21
6XA	295	2206.99
6XA	308	2207.90
6XA	323	2207.70
6XA	338	2213.35
6XA	363	2213.15
6XA	375	2213.21
6XA	393	2213.73
6XA	407	2213.58
6XA	421	2212.68
6XA	434	2213.02
6XA	449	2213.98
6XA	463	2213.94
6XA	477	2213.40
6XA	494	2213.47
6XA	505	2213.92
6XA	518	2213.70
6XA	532	2213.25
6XA	545	2212.65
6XA	560	2211.79
6XA	568	2211.31
6XA	589	2210.15
6XA	610	2209.59

STATION	DATE	WATER LEVEL
6XB	100	2220.82
6XB	192	2208.06
6XB	199	2207.96
6XB	338	2213.38
6XB	363	2213.12
6XB	375	2213.26
6XB	393	2212.96
6XB	407	2213.62
6XB	421	2212.71
6XB	434	2213.01
6XB	449	2215.00
6XB	463	2214.08
6XB	477	2213.43
6XB	494	2213.56
6XB	505	2214.11
6XB	518	2213.68
6XB	532	2213.29
6XB	545	2212.65
6XB	560	2211.78
6XB	568	2211.29
6XB	589	2210.13
6XB	610	2209.56

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
7XA	100	2220.26
7XA	188	2207.75
7XA	192	2207.55
7XA	199	2207.44
7XA	206	2207.13
7XA	214	2207.14
7XA	220	2207.07
7XA	227	2206.93
7XA	245	2206.86
7XA	259	2206.77
7XA	278	2207.42
7XA	288	2207.12
7XA	295	2206.84
7XA	308	2207.78
7XA	323	2207.48
7XA	338	2213.44
7XA	363	2212.98
7XA	375	2213.15
7XA	393	2212.75
7XA	407	2213.54
7XA	421	2212.09
7XA	434	2213.00
7XA	449	2213.99
7XA	463	2213.86
7XA	477	2213.37
7XA	494	2213.42
7XA	505	2213.87
7XA	518	2213.60
7XA	532	2213.19
7XA	545	2212.61
7XA	560	2211.69
7XA	568	2211.21
7XA	589	2210.04
7XA	610	2209.46

STATION	DATE	WATER LEVEL
7XB	100	2220.26
7XB	278	2209.02
7XB	338	2213.88
7XB	363	2213.08
7XB	375	2213.18
7XB	393	2212.80
7XB	407	2213.47
7XB	421	2212.61
7XB	434	2213.06
7XB	449	2214.08
7XB	463	2213.92
7XB	477	2213.40
7XB	494	2213.45
7XB	505	2213.93
7XB	518	2213.66
7XB	532	2213.21
7XB	545	2212.64
7XB	560	2211.73
7XB	568	2211.24
7XB	589	2210.08
7XB	610	2209.47

STATION	DATE	WATER LEVEL
8XA	100	2215.95
8XA	188	2207.76
8XA	192	2207.53
8XA	199	2207.26
8XA	206	2207.13
8XA	214	2207.14
8XA	220	2207.07
8XA	227	2206.92
8XA	245	2206.89
8XA	259	2206.78
8XA	278	2207.45
8XA	288	2207.11
8XA	295	2206.83
8XA	308	2207.82
8XA	323	2207.44
8XA	338	2213.86
8XA	363	2213.14
8XA	375	2213.35
8XA	393	2212.87
8XA	407	2213.81
8XA	421	2212.68
8XA	434	2213.40
8XA	449	2214.35
8XA	463	2214.12
8XA	477	2213.65
8XA	494	2213.73
8XA	505	2214.20
8XA	518	2213.88
8XA	532	2213.42
8XA	545	2212.83
8XA	560	2211.85
8XA	568	2211.36
8XA	589	2210.13
8XA	610	2209.50

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
8XB	100	2215.95
8XB	188	2207.69
8XB	192	2207.50
8XB	199	2207.22
8XB	206	2207.09
8XB	214	2207.09
8XB	220	2207.04
8XB	227	2206.85
8XB	245	2206.79
8XB	259	2206.70
8XB	278	2207.39
8XB	288	2207.08
8XB	295	2206.75
8XB	308	2207.83
8XB	323	2207.45
8XB	338	2213.77
8XB	363	2213.36
8XB	375	2213.38
8XB	393	2212.89
8XB	407	2213.85
8XB	421	2212.74
8XB	434	2213.37
8XB	449	2214.38
8XB	463	2214.13
8XB	477	2213.64
8XB	494	2213.53
8XB	505	2214.20
8XB	518	2213.86
8XB	532	2213.41
8XB	545	2212.77
8XB	560	2211.89
8XB	568	2211.33
8XB	589	2210.09
8XB	610	2209.47

STATION	DATE	WATER LEVEL
9XA	100	2216.89
9XA	188	2207.71
9XA	192	2207.50
9XA	199	2207.60
9XA	206	2207.09
9XA	214	2207.13
9XA	220	2207.08
9XA	227	2206.89
9XA	245	2206.88
9XA	259	2206.83
9XA	278	2207.44
9XA	288	2207.13
9XA	295	2206.63
9XA	308	2207.86
9XA	323	2207.39
9XA	338	2214.39
9XA	363	2213.44
9XA	375	2213.74
9XA	393	2213.09
9XA	407	2214.12
9XA	421	2212.88
9XA	434	2213.67
9XA	449	2214.79
9XA	463	2214.41
9XA	477	2213.94
9XA	494	2214.18
9XA	505	2214.62
9XA	518	2214.21
9XA	532	2213.75
9XA	545	2213.08
9XA	560	2212.01
9XA	568	2211.54
9XA	589	2210.23
9XA	610	2209.54

STATION	DATE	WATER LEVEL
9XB	100	2216.89
9XB	308	2207.77
9XB	338	2214.47
9XB	363	2213.52
9XB	375	2213.87
9XB	393	2213.21
9XB	407	2214.20
9XB	421	2213.07
9XB	434	2213.73
9XB	449	2215.02
9XB	463	2214.62
9XB	477	2213.99
9XB	494	2214.76
9XB	505	2214.69
9XB	518	2214.27
9XB	532	2213.78
9XB	545	2213.13
9XB	560	2212.05
9XB	568	2211.55
9XB	589	2210.23
9XB	610	2209.54

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
AYA	100	2208.42
AYA	192	2202.20
AYA	199	2202.16
AYA	206	2202.05
AYA	214	2202.06
AYA	220	2201.97
AYA	227	2201.86
AYA	245	2201.80
AYA	259	2201.94
AYA	278	2202.19
AYA	288	2202.05
AYA	295	2201.92
AYA	308	2202.31
AYA	323	2202.33
AYA	338	2204.92
AYA	375	2204.79
AYA	393	2204.56
AYA	407	2205.00
AYA	421	2204.49
AYA	434	2204.47
AYA	449	2204.86
AYA	463	2204.57
AYA	477	2204.76
AYA	494	2204.82
AYA	505	2205.11
AYA	518	2205.00
AYA	532	2204.87
AYA	545	2204.50
AYA	560	2204.32
AYA	568	2204.58
AYA	589	2203.52
AYA	610	2203.42

STATION	DATE	WATER LEVEL
AYB	100	2208.42
AYB	192	2202.31
AYB	199	2202.16
AYB	206	2202.07
AYB	214	2202.03
AYB	220	2201.97
AYB	227	2201.84
AYB	245	2201.84
AYB	259	2201.77
AYB	278	2202.22
AYB	288	2202.05
AYB	295	2201.88
AYB	308	2202.36
AYB	323	2202.41
AYB	338	2205.02
AYB	375	2204.84
AYB	393	2204.45
AYB	407	2205.16
AYB	421	2204.45
AYB	434	2204.60
AYB	449	2205.02
AYB	463	2205.11
AYB	477	2204.80
AYB	494	2204.84
AYB	505	2205.13
AYB	518	2205.03
AYB	532	2204.82
AYB	545	2204.48
AYB	560	2204.29
AYB	568	2203.49
AYB	589	2203.44
AYB	610	2203.41

STATION	DATE	WATER LEVEL
1YA	100	2209.44
1YA	192	2201.51
1YA	199	2201.47
1YA	206	2201.34
1YA	214	2201.29
1YA	220	2201.16
1YA	227	2201.09
1YA	245	2201.08
1YA	259	2201.00
1YA	278	2201.40
1YA	288	2201.25
1YA	295	2201.12
1YA	308	2201.55
1YA	323	2201.60
1YA	338	2204.27
1YA	363	2203.75
1YA	375	2203.93
1YA	393	2203.68
1YA	407	2204.77
1YA	421	2203.63
1YA	434	2203.70
1YA	449	2204.17
1YA	463	2204.30
1YA	477	2203.95
1YA	494	2203.98
1YA	505	2204.08
1YA	518	2204.20
1YA	532	2203.97
1YA	545	2203.60
1YA	560	2203.43
1YA	568	2203.14
1YA	589	2202.59
1YA	610	2202.52

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
1YB	100	2209.44
1YB	192	2201.52
1YB	199	2201.36
1YB	206	2201.26
1YB	214	2201.21
1YB	220	2201.14
1YB	227	2201.16
1YB	245	2201.03
1YB	259	2200.99
1YB	278	2201.38
1YB	288	2201.22
1YB	295	2201.08
1YB	308	2201.57
1YB	323	2201.59
1YB	338	2204.22
1YB	363	2203.59
1YB	375	2203.93
1YB	393	2203.53
1YB	407	2204.56
1YB	421	2203.52
1YB	434	2203.70
1YB	449	2204.14
1YB	463	2204.17
1YB	477	2203.89
1YB	494	2203.94
1YB	505	2204.27
1YB	518	2204.14
1YB	532	2203.91
1YB	545	2203.52
1YB	560	2203.25
1YB	568	2203.03
1YB	589	2202.54
1YB	610	2202.50

STATION	DATE	WATER LEVEL
2YA	100	2208.10
2YA	188	2185.41
2YA	192	2200.93
2YA	199	2201.05
2YA	206	2201.23
2YA	214	2201.20
2YA	220	2201.05
2YA	227	2201.00
2YA	245	2201.01
2YA	259	2200.95
2YA	275	2201.39
2YA	278	2201.35
2YA	288	2201.19
2YA	295	2201.20
2YA	308	2201.50
2YA	323	2201.49
2YA	338	2204.15
2YA	363	2203.54
2YA	375	2203.86
2YA	393	2203.44
2YA	407	2204.08
2YA	421	2204.02
2YA	434	2203.60
2YA	449	2204.10
2YA	463	2204.15
2YA	477	2203.87
2YA	494	2203.89
2YA	505	2204.27
2YA	518	2204.11
2YA	532	2203.90
2YA	545	2203.48
2YA	560	2203.23
2YA	568	2202.99
2YA	589	2202.50
2YA	610	2202.50

STATION	DATE	WATER LEVEL
2YB	100	2208.10
2YB	188	2199.18
2YB	192	2201.68
2YB	199	2201.35
2YB	206	2201.24
2YB	214	2201.17
2YB	220	2201.11
2YB	227	2201.02
2YB	245	2201.00
2YB	259	2200.94
2YB	275	2201.40
2YB	278	2201.35
2YB	288	2201.19
2YB	295	2201.05
2YB	308	2201.51
2YB	323	2201.54
2YB	338	2204.19
2YB	363	2203.55
2YB	375	2203.89
2YB	393	2203.46
2YB	407	2204.14
2YB	421	2203.47
2YB	434	2203.64
2YB	449	2204.10
2YB	463	2204.12
2YB	477	2203.84
2YB	494	2203.93
2YB	505	2204.28
2YB	518	2204.09
2YB	532	2203.87
2YB	545	2203.45
2YB	560	2203.19
2YB	568	2202.97
2YB	589	2202.48
2YB	610	2202.45

Appendix III. Cont'd

STATION	DATE	WATER LEVEL	STATION	DATE	WATER LEVEL	STATION	DATE	WATER LEVEL
3YA	100	2208.79	3YB	100	2208.79	5YA	100	2204.80
3YA	192	2201.43	3YB	192	2201.53	5YA	188	2200.79
3YA	199	2201.48	3YB	199	2201.50	5YA	192	2201.03
3YA	206	2201.40	3YB	206	2201.41	5YA	199	2201.14
3YA	214	2201.30	3YB	214	2201.26	5YA	206	2201.12
3YA	220	2201.23	3YB	220	2201.16	5YA	214	2201.14
3YA	227	2201.03	3YB	227	2201.06	5YA	220	2201.17
3YA	245	2201.20	3YB	245	2201.07	5YA	227	2201.13
3YA	259	2201.00	3YB	259	2201.00	5YA	245	2200.91
3YA	275	2201.43	3YB	275	2200.46	5YA	259	2200.91
3YA	278	2201.38	3YB	278	2201.39	5YA	278	2201.18
3YA	288	2201.27	3YB	288	2201.28	5YA	288	2201.22
3YA	295	2201.12	3YB	295	2201.10	5YA	295	2201.18
3YA	308	2201.57	3YB	308	2201.58	5YA	308	2201.21
3YA	323	2201.60	3YB	323	2201.58	5YA	323	2201.39
3YA	338	2204.26	3YB	338	2204.22	5YA	338	2204.00
3YA	363	2203.69	3YB	363	2203.58	5YA	363	2203.51
3YA	375	2203.89	3YB	375	2203.89	5YA	375	2203.85
3YA	393	2203.55	3YB	393	2203.50	5YA	393	2203.81
3YA	407	2204.14	3YB	407	2204.16	5YA	407	2203.62
3YA	421	2203.51	3YB	421	2203.48	5YA	421	2203.60
3YA	434	2203.64	3YB	434	2203.65	5YA	434	2203.55
3YA	449	2204.14	3YB	449	2204.14	5YA	449	2203.68
3YA	463	2204.25	3YB	463	2204.16	5YA	463	2204.29
3YA	477	2203.89	3YB	477	2203.84	5YA	477	2204.08
3YA	494	2203.92	3YB	494	2203.89	5YA	494	2204.06
3YA	505	2204.34	3YB	505	2204.30	5YA	505	2204.38
3YA	518	2204.16	3YB	518	2204.14	5YA	518	2204.33
3YA	532	2203.95	3YB	532	2203.88	5YA	532	2204.14
3YA	545	2203.53	3YB	545	2203.48	5YA	545	2203.64
3YA	560	2203.25	3YB	560	2203.22	5YA	560	2203.45
3YA	568	2203.01	3YB	568	2202.99	5YA	568	2203.26
3YA	589	2202.51	3YB	589	2202.52	5YA	589	2202.72
3YA	610	2202.49	3YB	610	2202.49	5YA	610	2202.56

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
5YB	100	2204.80
5YB	188	2201.63
5YB	192	2201.51
5YB	199	2201.39
5YB	206	2201.30
5YB	214	2201.24
5YB	220	2201.15
5YB	227	2201.06
5YB	245	2201.04
5YB	259	2200.96
5YB	278	2201.34
5YB	288	2201.20
5YB	295	2201.06
5YB	308	2201.55
5YB	323	2201.52
5YB	338	2204.35
5YB	363	2203.61
5YB	375	2203.86
5YB	393	2203.54
5YB	407	2204.13
5YB	421	2203.00
5YB	434	2203.68
5YB	449	2204.19
5YB	463	2204.18
5YB	477	2203.85
5YB	494	2203.92
5YB	505	2204.41
5YB	518	2204.13
5YB	532	2203.87
5YB	545	2203.60
5YB	560	2203.27
5YB	568	2203.05
5YB	589	2202.57
5YB	610	2202.50

STATION	DATE	WATER LEVEL
6YA	100	2205.03
6YA	188	2201.58
6YA	192	2201.40
6YA	199	2201.31
6YA	206	2201.24
6YA	214	2201.14
6YA	220	2201.06
6YA	227	2201.01
6YA	245	2200.91
6YA	259	2200.89
6YA	278	2201.25
6YA	288	2201.11
6YA	295	2200.98
6YA	308	2201.46
6YA	323	2201.41
6YA	338	2204.23
6YA	375	2203.66
6YA	393	2203.30
6YA	407	2204.00
6YA	421	2203.35
6YA	434	2203.53
6YA	449	2204.15
6YA	463	2204.10
6YA	477	2203.75
6YA	494	2203.85
6YA	505	2204.33
6YA	518	2204.06
6YA	532	2203.78
6YA	545	2203.41
6YA	560	2203.11
6YA	568	2202.88
6YA	589	2202.46
6YA	610	2202.36

STATION	DATE	WATER LEVEL
6YB	100	2205.03
6YB	188	2201.41
6YB	192	2201.74
6YB	199	2201.48
6YB	206	2201.29
6YB	214	2201.23
6YB	220	2201.18
6YB	227	2201.09
6YB	245	2201.02
6YB	259	2200.94
6YB	278	2201.30
6YB	288	2201.18
6YB	295	2201.03
6YB	308	2201.52
6YB	323	2201.55
6YB	338	2204.26
6YB	375	2203.68
6YB	393	2203.45
6YB	407	2203.90
6YB	421	2203.43
6YB	434	2203.49
6YB	449	2204.09
6YB	463	2204.26
6YB	477	2203.76
6YB	494	2203.88
6YB	505	2204.37
6YB	518	2204.10
6YB	532	2203.87
6YB	545	2203.49
6YB	560	2203.24
6YB	568	2202.97
6YB	589	2202.49
6YB	610	2202.41

Appendix III. Cont'd

STATION	DATE	WATER LEVEL	STATION	DATE	WATER LEVEL	STATION	DATE	WATER LEVEL
6YD	100	2205.03	7YA	100	2205.32	7YB	100	2205.32
6YD	188	2175.39	7YA	188	2201.78	7YB	188	2201.72
6YD	192	2200.60	7YA	192	2201.79	7YB	192	2201.81
6YD	199	2200.56	7YA	199	2201.70	7YB	199	2201.70
6YD	206	2200.51	7YA	206	2201.59	7YB	206	2201.56
6YD	214	2200.57	7YA	214	2201.53	7YB	214	2201.52
6YD	220	2200.68	7YA	220	2201.47	7YB	220	2201.42
6YD	227	2200.68	7YA	227	2201.41	7YB	227	2201.43
6YD	245	2200.46	7YA	245	2201.36	7YB	245	2201.34
6YD	259	2200.40	7YA	259	2201.27	7YB	259	2201.26
6YD	278	2200.78	7YA	278	2201.65	7YB	278	2201.61
6YD	288	2200.87	7YA	288	2201.52	7YB	288	2201.48
6YD	295	2200.76	7YA	295	2201.36	7YB	295	2201.34
6YD	308	2199.78	7YA	308	2201.86	7YB	308	2201.82
6YD	323	2199.65	7YA	323	2201.82	7YB	323	2201.79
6YD	338	2201.42	7YA	338	2204.68	7YB	338	2204.61
6YD	375	2201.59	7YA	375	2204.07	7YB	375	2204.03
6YD	393	2201.48	7YA	393	2203.75	7YB	393	2203.74
6YD	407	2201.50	7YA	407	2204.39	7YB	407	2204.38
6YD	421	2201.37	7YA	421	2203.75	7YB	421	2203.75
6YD	434	2201.33	7YA	434	2203.91	7YB	434	2203.93
6YD	449	2201.86	7YA	449	2204.57	7YB	449	2204.55
6YD	463	2203.62	7YA	463	2204.50	7YB	463	2204.60
6YD	477	2203.41	7YA	477	2204.20	7YB	477	2204.18
6YD	494	2203.94	7YA	494	2204.31	7YB	494	2204.28
6YD	505	2204.41	7YA	505	2204.73	7YB	505	2204.71
6YD	518	2204.25	7YA	518	2204.49	7YB	518	2204.47
6YD	532	2204.24	7YA	532	2204.22	7YB	532	2204.21
6YD	545	2203.62	7YA	545	2203.88	7YB	545	2203.82
6YD	560	2203.38	7YA	560	2203.52	7YB	560	2203.52
6YD	568	2203.27	7YA	568	2203.30	7YB	568	2203.31
6YD	589	2202.69	7YA	589	2202.87	7YB	589	2202.23
6YD	610	2202.63	7YA	610	2202.84	7YB	610	2202.31

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
8YA	100	2205.87
8YA	188	2201.14
8YA	192	2201.31
8YA	199	2201.54
8YA	206	2201.45
8YA	214	2201.40
8YA	220	2201.39
8YA	227	2201.31
8YA	245	2201.22
8YA	259	2201.15
8YA	275	2201.44
8YA	278	2201.47
8YA	288	2201.39
8YA	295	2201.24
8YA	308	2201.57
8YA	323	2201.63
8YA	338	2204.44
8YA	375	2203.74
8YA	393	2203.53
8YA	407	2204.41
8YA	421	2203.47
8YA	434	2203.52
8YA	449	2204.13
8YA	463	2204.44
8YA	464	2204.12
8YA	477	2203.98
8YA	505	2204.48
8YA	518	2204.36
8YA	532	2204.22
8YA	545	2204.65
8YA	560	2203.44
8YA	568	2203.23
8YA	589	2202.78
8YA	610	2202.65

STATION	DATE	WATER LEVEL
8YB	100	2205.87
8YB	188	2201.01
8YB	192	2201.31
8YB	199	2201.56
8YB	206	2201.46
8YB	214	2201.39
8YB	220	2201.32
8YB	227	2201.27
8YB	245	2201.22
8YB	259	2201.16
8YB	275	2201.50
8YB	278	2201.47
8YB	288	2201.36
8YB	295	2201.21
8YB	308	2201.68
8YB	323	2201.62
8YB	338	2204.41
8YB	375	2203.77
8YB	393	2203.47
8YB	407	2204.10
8YB	421	2203.49
8YB	434	2203.66
8YB	449	2204.09
8YB	463	2204.31
8YB	477	2203.93
8YB	494	2204.01
8YB	505	2204.47
8YB	518	2204.21
8YB	532	2203.94
8YB	545	2203.58
8YB	560	2203.30
8YB	568	2203.07
8YB	589	2202.62
8YB	610	2202.59

STATION	DATE	WATER LEVEL
8YC	100	2205.70
8YC	199	2201.57
8YC	206	2201.48
8YC	214	2201.41
8YC	220	2201.33
8YC	227	2201.25
8YC	245	2201.22
8YC	259	2201.16
8YC	275	2201.51
8YC	278	2201.46
8YC	288	2201.35
8YC	295	2201.21
8YC	308	2201.70
8YC	323	2201.62
8YC	338	2204.37
8YC	375	2203.82
8YC	393	2203.49
8YC	407	2204.19
8YC	421	2203.52
8YC	434	2203.68
8YC	449	2204.11
8YC	463	2204.21
8YC	477	2203.94
8YC	494	2204.09
8YC	505	2204.50
8YC	518	2204.13
8YC	532	2203.94
8YC	545	2203.58
8YC	560	2203.27
8YC	568	2203.07
8YC	589	2202.71
8YC	610	2202.57

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
9YA	100	2204.28
9YA	188	2191.58
9YA	192	2201.22
9YA	199	2201.26
9YA	206	2201.16
9YA	214	2201.09
9YA	220	2201.05
9YA	227	2200.98
9YA	245	2200.96
9YA	259	2200.90
9YA	275	2201.19
9YA	278	2201.13
9YA	288	2201.05
9YA	295	2200.95
9YA	308	2201.36
9YA	323	2201.28
9YA	338	2204.01
9YA	375	2203.07
9YA	393	2202.18
9YA	407	2203.39
9YA	421	2202.87
9YA	434	2202.99
9YA	449	2203.75
9YA	463	2203.85
9YA	477	2203.39
9YA	494	2203.53
9YA	505	2203.95
9YA	518	2203.68
9YA	532	2203.47
9YA	545	2203.06
9YA	560	2202.76
9YA	568	2202.56
9YA	589	2202.20
9YA	610	2202.09

STATION	DATE	WATER LEVEL
9YB	100	2204.50
9YB	188	2201.68
9YB	192	2201.54
9YB	199	2201.44
9YB	206	2201.37
9YB	214	2201.25
9YB	275	2201.40
9YB	278	2201.34
9YB	308	2201.59
9YB	323	2201.47
9YB	338	2204.32
9YB	375	2203.56
9YB	393	2204.04
9YB	407	2203.87
9YB	421	2203.25
9YB	434	2203.52
9YB	449	2204.17
9YB	463	2203.98
9YB	477	2203.73
9YB	494	2203.89
9YB	505	2204.33
9YB	518	2204.00
9YB	532	2203.71
9YB	545	2203.36
9YB	560	2203.06
9YB	568	2202.87
9YB	589	2202.57
9YB	610	2202.42

STATION	DATE	WATER LEVEL
10YA	100	2206.80
10YA	188	2193.84
10YA	192	2200.49
10YA	199	2200.45
10YA	206	2200.38
10YA	214	2200.34
10YA	220	2200.33
10YA	227	2200.29
10YA	245	2200.31
10YA	259	2200.30
10YA	278	2200.36
10YA	288	2200.36
10YA	295	2200.34
10YA	308	2200.46
10YA	323	2200.44
10YA	338	2202.43
10YA	375	2201.64
10YA	393	2201.41
10YA	407	2201.92
10YA	421	2201.52
10YA	434	2201.86
10YA	449	2202.67
10YA	463	2202.34
10YA	477	2202.13
10YA	494	2202.40
10YA	505	2202.92
10YA	518	2202.49
10YA	532	2202.01
10YA	545	2201.65
10YA	560	2201.29
10YA	568	2201.19
10YA	589	2201.06
10YA	610	2201.21

Appendix III. Cont'd

STATION	DATE	WATER LEVEL	STATION	DATE	WATER LEVEL	STATION	DATE	WATER LEVEL
10YB	100	2206.80	3W	100	2213.58	5W	100	2203.82
10YB	188	2200.66	3W	245	2204.45	5W	227	2202.95
10YB	192	2200.61	3W	259	2204.36	5W	245	2203.07
10YB	199	2200.64	3W	278	2204.79	5W	259	2202.94
10YB	206	2200.61	3W	288	2204.57	5W	278	2203.30
10YB	214	2200.51	3W	295	2204.34	5W	288	2203.14
10YB	220	2200.52	3W	308	2205.05	5W	295	2202.96
10YB	227	2200.50	3W	323	2204.91	5W	308	2203.53
10YB	245	2200.42	3W	338	2209.17	5W	323	2203.44
10YB	259	2200.48	3W	363	2208.51	5W	338	2206.63
10YB	278	2200.52	3W	375	2208.68	5W	363	2205.84
10YB	288	2200.55	3W	393	2208.28	5W	375	2206.24
10YB	295	2200.49	3W	407	2209.00	5W	393	2205.77
10YB	308	2200.66	3W	421	2208.30	5W	407	2206.41
10YB	323	2200.59	3W	434	2208.70	5W	421	2205.81
10YB	338	2202.62	3W	449	2209.31	5W	434	2206.09
10YB	375	2201.84	3W	463	2208.96	5W	449	2206.63
10YB	393	2201.63	3W	477	2208.63	5W	463	2206.51
10YB	407	2202.14	3W	494	2208.70	5W	477	2206.29
10YB	421	2201.75	3W	494	2145.70	5W	494	2206.33
10YB	434	2202.10	3W	505	2209.16	5W	505	2206.71
10YB	449	2202.88	3W	518	2208.88	5W	518	2206.50
10YB	463	2202.57	3W	532	2208.58	5W	532	2206.24
10YB	477	2202.34	3W	545	2208.24	5W	545	2205.91
10YB	494	2202.57	3W	560	2207.82	5W	560	2205.60
10YB	505	2203.10	3W	568	2207.56	5W	568	2205.37
10YB	518	2202.66	3W	589	2207.01	5W	589	2204.99
10YB	532	2202.20	3W	610	2206.62	5W	610	2204.75
10YB	545	2201.85						
10YB	560	2201.49						
10YB	568	2201.38						
10YB	589	2201.27						
10YB	610	2201.25						

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
9W	100	2203.42
9W	227	2198.73
9W	245	2198.68
9W	259	2198.60
9W	278	2198.89
9W	288	2198.78
9W	295	2198.69
9W	308	2199.13
9W	323	2199.44
9W	338	2201.46
9W	375	2200.62
9W	393	2200.35
9W	407	2201.02
9W	421	2200.41
9W	434	2200.66
9W	449	2201.33
9W	463	2201.25
9W	477	2200.94
9W	494	2201.01
9W	505	2201.49
9W	518	2201.25
9W	532	2200.93
9W	545	2200.49
9W	560	2200.15
9W	568	2199.98
9W	589	2199.69
9W	610	2199.59

STATION	DATE	WATER LEVEL
10W	100	2202.79
10W	227	2197.30
10W	245	2197.23
10W	259	2197.26
10W	278	2197.55
10W	288	2197.46
10W	295	2197.40
10W	308	2197.79
10W	323	2197.83
10W	338	2199.98
10W	375	2199.47
10W	393	2199.19
10W	407	2199.80
10W	421	2199.38
10W	434	2199.47
10W	449	2199.73
10W	463	2199.75
10W	477	2199.52
10W	494	2199.42
10W	505	2199.86
10W	518	2199.64
10W	532	2199.27
10W	545	2198.83
10W	560	2198.60
10W	568	2198.40
10W	589	2197.99
10W	610	2198.05

STATION	DATE	WATER LEVEL
12W	100	2200.40
12W	227	2193.95
12W	245	2194.27
12W	259	2193.97
12W	278	2194.14
12W	288	2194.05
12W	295	2194.01
12W	308	2194.41
12W	323	2194.35
12W	338	2196.30
12W	375	2195.32
12W	393	2195.07
12W	407	2195.67
12W	421	2195.15
12W	434	2195.49
12W	449	2196.35
12W	463	2196.04
12W	477	2195.69
12W	494	2195.84
12W	505	2196.33
12W	518	2196.04
12W	532	2195.60
12W	545	2195.21
12W	560	2194.84
12W	568	2194.65
12W	589	2194.47
12W	610	2194.36

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
13W	100	2197.59
13W	227	2192.38
13W	245	2192.53
13W	259	2192.48
13W	278	2192.69
13W	288	2192.63
13W	295	2192.57
13W	308	2193.00
13W	323	2192.92
13W	338	2195.18
13W	375	2193.87
13W	393	2193.62
13W	407	2194.11
13W	421	2193.64
13W	434	2193.72
13W	449	2194.51
13W	463	2194.62
13W	477	2194.07
13W	494	2194.29
13W	505	2194.70
13W	518	2194.44
13W	532	2194.22
13W	545	2193.77
13W	560	2193.52
13W	568	2193.33
13W	589	2192.94
13W	610	2193.04

STATION	DATE	WATER LEVEL
15W	100	2197.77
15W	227	2191.60
15W	245	2191.73
15W	259	2191.68
15W	278	2191.87
15W	288	2191.79
15W	295	2191.73
15W	308	2192.13
15W	323	2192.12
15W	338	2193.77
15W	375	2192.88
15W	393	2192.69
15W	407	2193.13
15W	421	2192.74
15W	434	2192.92
15W	449	2193.50
15W	463	2193.32
15W	477	2193.12
15W	494	2193.20
15W	505	2193.60
15W	518	2193.41
15W	532	2193.18
15W	545	2192.95
15W	560	2192.68
15W	568	2192.51
15W	589	2192.23
15W	610	2192.32

STATION	DATE	WATER LEVEL
16W	100	2196.23
16W	434	2190.48
16W	449	2191.19
16W	463	2191.06
16W	477	2190.96
16W	494	2191.09
16W	505	2191.25
16W	518	2191.18
16W	532	2191.10
16W	545	2190.92
16W	560	2190.80
16W	568	2190.71
16W	589	2190.57
16W	610	2190.75

STATION	DATE	WATER LEVEL
17W	100	2201.28
17W	434	2196.95
17W	449	2197.59
17W	463	2197.60
17W	477	2197.14
17W	494	2197.25
17W	505	2197.69
17W	518	2197.42
17W	532	2197.08
17W	545	2196.72
17W	560	2196.43
17W	568	2196.25
17W	589	2195.96
17W	610	2195.90

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
18W	100	2207.25
18W	449	2200.80
18W	463	2200.86
18W	477	2200.83
18W	494	2200.52
18W	505	2200.96
18W	518	2200.75
18W	532	2200.46
18W	545	2200.10
18W	560	2199.84
18W	568	2199.66
18W	589	2199.31
18W	610	2199.32

STATION	DATE	WATER LEVEL
1P	100	2204.54
1P	245	2200.27
1P	259	2200.22
1P	278	2200.86
1P	288	2200.54
1P	295	2200.43
1P	308	2200.87
1P	323	2200.87
1P	338	2202.66
1P	375	2202.52
1P	407	2202.67
1P	421	2202.36
1P	434	2202.35
1P	449	2202.61
1P	463	2202.66
1P	477	2202.40
1P	494	2204.44
1P	505	2202.75
1P	518	2202.69
1P	532	2202.47
1P	545	2202.22
1P	560	2202.07
1P	568	2201.97
1P	589	2201.56
1P	610	2201.63

STATION	DATE	WATER LEVEL
2P	100	2196.31
2P	245	2190.46
2P	259	2190.46
2P	275	2190.80
2P	278	2190.70
2P	288	2190.56
2P	295	2190.51
2P	308	2190.96
2P	323	2191.05
2P	338	2192.84
2P	375	2193.01
2P	407	2192.68
2P	421	2192.36
2P	434	2192.41
2P	449	2192.69
2P	463	2192.71
2P	477	2192.56
2P	494	2192.59
2P	505	2192.91
2P	518	2192.81
2P	532	2192.58
2P	545	2192.22
2P	560	2192.09
2P	568	2191.87
2P	589	2191.09
2P	610	2191.87

STATION	DATE	WATER LEVEL
3P	100	2192.44
3P	245	2188.53
3P	259	2188.61
3P	278	2188.82
3P	268	2188.71
3P	295	2188.66
3P	308	2188.91
3P	323	2188.88
3P	375	2190.13
3P	407	2190.07
3P	421	2187.74
3P	434	2189.90
3P	449	2190.28
3P	463	2190.22
3P	477	2190.02
3P	494	2190.11
3P	505	2190.56
3P	518	2190.37
3P	532	2190.17
3P	545	2189.76
3P	560	2189.62
3P	568	2189.39
3P	589	2189.10
3P	610	2189.37

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
4P	100	2195.54
4P	161	2191.02
4P	245	2190.18
4P	259	2190.24
4P	275	2190.47
4P	278	2190.40
4P	288	2190.30
4P	295	2190.24
4P	308	2190.60
4P	323	2190.70
4P	338	2192.74
4P	375	2192.58
4P	407	2192.24
4P	421	2191.90
4P	434	2191.95
4P	449	2192.09
4P	463	2192.12
4P	477	2191.97
4P	494	2191.93
4P	505	2192.30
4P	518	2192.20
4P	532	2191.92
4P	545	2191.57
4P	560	2191.53
4P	568	2191.26
4P	589	2190.70
4P	610	2191.30

STATION	DATE	WATER LEVEL
5P	100	2194.11
5P	161	2190.41
5P	245	2189.66
5P	259	2189.66
5P	278	2189.95
5P	288	2189.81
5P	295	2189.71
5P	308	2190.00
5P	323	2190.00
5P	338	2193.42
5P	407	2193.29
5P	421	2193.11
5P	434	2193.09
5P	449	2193.16
5P	477	2192.90
5P	505	2193.11
5P	518	2193.00
5P	532	2192.50
5P	545	2191.75
5P	560	2191.48
5P	568	2191.01
5P	589	2190.23
5P	610	2191.31

STATION	DATE	WATER LEVEL
6P	100	2193.05
6P	161	2190.51
6P	245	2189.67
6P	259	2189.65
6P	278	2190.10
6P	288	2189.59
6P	295	2189.74
6P	308	2190.04
6P	323	2189.89
6P	407	2192.24
6P	421	2192.07
6P	434	2192.14
6P	518	2192.38
6P	532	2192.01
6P	545	2191.50
6P	560	2191.31
6P	568	2190.86
6P	589	2190.26
6P	610	2190.91

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
7P	100	2196.63
7P	161	2193.30
7P	245	2191.53
7P	259	2191.73
7P	278	2193.15
7P	288	2192.90
7P	295	2192.50
7P	308	2193.49
7P	323	2193.33
7P	407	2196.01
7P	421	2195.68
7P	434	2195.37
7P	518	2195.17
7P	532	2194.26
7P	545	2193.61
7P	560	2194.27
7P	568	2193.62
7P	589	2192.47
7P	610	2194.54

STATION	DATE	WATER LEVEL
8P	100	2195.63
8P	161	2192.82
8P	245	2191.81
8P	259	2191.79
8P	278	2192.44
8P	288	2191.89
8P	295	2191.72
8P	308	2191.73
8P	323	2191.25
8P	407	2193.53
8P	421	2193.36
8P	434	2193.40
8P	518	2194.44
8P	532	2194.12
8P	545	2193.76
8P	560	2193.63
8P	568	2193.38
8P	589	2192.76
8P	610	2193.33

STATION	DATE	WATER LEVEL
10P	100	2194.37
10P	161	2192.35
10P	245	2191.41
10P	259	2191.39
10P	278	2192.02
10P	288	2191.51
10P	295	2191.36
10P	308	2191.41
10P	323	2190.97
10P	407	2193.20
10P	421	2193.05
10P	434	2193.09
10P	449	2193.23
10P	477	2193.75
10P	505	2194.02
10P	518	2193.95
10P	532	2193.67
10P	545	2193.30
10P	560	2193.14
10P	568	2192.88
10P	589	2192.33
10P	610	2192.83

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
11P	100	2193.82
11P	161	2192.15
11P	245	2190.99
11P	259	2190.99
11P	278	2191.65
11P	288	2191.18
11P	295	2191.01
11P	308	2191.13
11P	323	2190.65
11P	407	2193.03
11P	421	2192.92
11P	434	2192.98
11P	449	2193.08
11P	532	2193.28
11P	545	2192.85
11P	560	2192.70
11P	568	2192.43
11P	589	2191.97
11P	610	2192.38

STATION	DATE	WATER LEVEL
12P	100	2197.28
12P	161	2196.15
12P	245	2194.32
12P	259	2194.24
12P	278	2193.87
12P	288	2194.12
12P	295	2193.44
12P	308	2194.74
12P	323	2194.56
12P	407	2196.56
12P	434	2196.31
12P	532	2196.48

STATION	DATE	WATER LEVEL
13P	100	2199.42
13P	434	2197.91
13P	449	2198.04
13P	463	2198.40
13P	477	2198.09
13P	494	2198.06
13P	505	2198.62
13P	518	2198.34
13P	532	2198.13
13P	545	2197.78
13P	560	2197.92
13P	568	2197.70
13P	589	2196.93
13P	610	2196.99

STATION	DATE	WATER LEVEL
14P	100	2199.38
14P	161	2199.04
14P	245	2199.06
14P	259	2199.06
14P	278	2198.95
14P	288	2198.87
14P	295	2198.86
14P	308	2198.99
14P	323	2199.01
14P	407	2199.82
14P	434	2199.69
14P	532	2199.68

STATION	DATE	WATER LEVEL
16P	100	2204.46
16P	245	2203.02
16P	278	2203.97
16P	283	2203.97
16P	295	2203.72
16P	308	2204.30
16P	323	2203.58
16P	407	2204.38
16P	434	2204.50

STATION	DATE	WATER LEVEL
17P	100	2204.66
17P	161	2204.52
17P	278	2204.30
17P	288	2204.36
17P	295	2204.29
17P	308	2204.48
17P	323	2204.51
17P	407	2204.85
17P	434	2204.78
17P	532	2204.73

STATION	DATE	WATER LEVEL
18P	100	2210.39
18P	449	2209.87
18P	463	2209.99
18P	477	2209.31
18P	494	2209.76
18P	505	2209.87
18P	518	2210.04
18P	532	2209.94
18P	545	2209.64
18P	560	2209.62
18P	568	2209.52
18P	589	2209.05
18P	610	2208.45

Appendix III. Cont'd

STATION	DATE	WATER LEVEL
19P	100	2204.22
19P	161	2203.95
19P	245	2201.21
19P	259	2201.00
19P	278	2204.14
19P	288	2204.22
19P	295	2204.13
19P	308	2204.13
19P	323	2204.37
19P	407	2204.67
19P	434	2204.66
19P	505	2205.67
19P	518	2204.84
19P	532	2204.57

STATION	DATE	WATER LEVEL
20P	100	2189.54
20P	568	2187.54
20P	589	2187.07
20P	610	2187.24

STATION	DATE	WATER LEVEL
21P	100	2192.24
21P	568	2186.05
21P	589	2185.61
21P	610	2185.76

STATION	DATE	WATER LEVEL
SG1	259	2200.36
SG1	278	2200.36
SG1	288	2200.36
SG1	295	2200.36
SG1	308	2200.50
SG1	323	2200.39
SG1	518	2202.51
SG1	532	2201.93
SG1	545	2201.54
SG1	560	2201.18
SG1	568	2201.07

STATION	DATE	WATER LEVEL
SG2	259	2201.49
SG2	278	2201.77
SG2	288	2201.68
SG2	295	2201.62
SG2	308	2202.02
SG2	323	2201.98
SG2	463	2202.57
SG2	494	2202.53
SG2	518	2202.70
SG2	532	2202.51
SG2	545	2202.11
SG2	560	2201.81
SG2	568	2201.61
SG2	589	2202.98

STATION	DATE	WATER LEVEL
SP6	295	2204.02
SP6	301	2203.98
SP6	308	2204.77
SP6	323	2204.61
SP6	338	2208.61
SP6	356	2208.49
SP6	363	2207.99
SP6	375	2208.18
SP6	393	2207.87
SP6	407	2208.46
SP6	421	2207.80
SP6	434	2208.13
SP6	449	2208.66
SP6	463	2209.54
SP6	477	2208.24
SP6	494	2208.30
SP6	505	2208.79
SP6	518	2203.48
SP6	532	2208.23
SP6	545	2207.85
SP6	560	2207.44
SP6	568	2207.18
SP6	589	2206.61

APPENDIX IV

Water Quality

Appendix IV. Water quality data for 1977 - 1978, Smelterville Flats study area.

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
AXA	234	16.3	6.4	1070	0.0	0.010	0.0	60.600	128.100	25.400	43.000
AXA	234	15.9	6.5	1070	0.0	0.010	0.0	62.700	130.200	24.200	43.700
AXA	234	15.0	6.6	1070	0.0	0.0	0.0	63.200	133.400	23.400	44.000
AXA	*234	15.7	6.5	1070	0.0	0.007	0.0	62.170	131.000	24.330	43.570
AXA	375	9.0	6.1	867	0.360	0.063	0.0	47.200	138.000	43.100	43.100
AXA	449	9.8	6.0	949	-0.050	0.059	0.0	41.000	178.000	47.000	43.000
AXA	477	3.0	5.7	898	0.240	0.0	0.0	39.600	173.000	46.700	43.000
AXA	505	12.0	6.0	1020	0.150	0.0	0.031	40.950	0.0	45.200	0.0
AXA	532	11.5	5.7	970	0.0	0.180	0.050	42.300	145.700	43.000	44.100
AXA	589	12.7	6.1	0	0.0	0.010	0.0	37.100	152.000	48.200	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
AXB	449	10.0	5.0	1010	-0.050	0.240	0.800	53.100	158.000	23.100	52.000
AXB	477	9.0	5.1	806	0.0	0.280	0.640	41.500	121.000	18.400	39.000
AXB	505	12.6	5.2	780	0.0	0.160	0.520	35.700	0.0	14.500	0.0
AXB	532	12.5	5.5	730	0.0	0.0	0.540	35.700	97.000	13.100	30.900

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
1XA	234	12.2	6.3	1030	0.0	0.530	0.0	44.700	160.000	37.300	46.200
1XA	234	12.8	6.3	1120	0.0	0.540	0.0	44.900	166.000	37.300	46.500
1XA	234	12.5	6.3	1140	0.0	0.550	0.0	45.100	161.000	36.900	46.300
1XA	*234	12.5	6.3	1097	0.0	0.540	0.0	44.900	162.000	37.170	46.330
1XA	375	8.5	6.6	938	-0.050	0.120	0.010	16.100	151.000	76.100	42.200
1XA	449	8.3	6.2	898	0.064	0.0	0.0	13.400	158.000	76.700	42.000
1XA	477	3.4	6.2	898	0.260	0.0	0.0	14.000	188.000	67.400	40.000
1XA	505	11.1	5.9	1000	0.260	0.0	0.030	11.550	0.0	62.600	0.0
1XA	532	12.8	5.9	950	0.0	0.0	0.050	10.300	125.600	54.100	35.100
1XA	589	14.0	6.1	0	0.0	0.0	0.0	11.200	120.000	54.100	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
1XB	375	8.5	5.9	622	0.053	0.430	0.480	39.100	107.000	8.000	30.300
1XB	449	8.3	5.2	683	-0.050	0.330	0.550	40.700	109.000	12.300	38.000
1XB	477	3.2	5.3	485	0.0	0.450	0.360	30.100	78.000	7.400	27.000
1XB	505	10.8	5.7	410	0.0	0.290	0.240	19.950	49.200	4.000	17.200
1XB	532	12.9	5.7	405	0.0	0.360	0.240	20.400	42.600	34.600	18.300

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
2XA	234	15.0	6.6	989	0.061	0.390	0.0	48.600	151.000	23.400	44.400
2XA	234	14.7	6.6	1020	0.065	0.530	0.0	45.100	150.000	20.100	43.600
2XA	234	16.3	6.5	1020	0.044	0.540	0.0	45.100	152.000	20.100	44.100
2XA	*234	15.3	6.6	1010	0.057	0.487	0.0	46.270	151.000	21.200	44.030
2XA	375	8.7	6.5	806	-0.050	0.0	0.011	7.500	118.000	86.100	37.500
2XA	449	7.4	6.5	796	0.049	0.0	0.015	6.700	119.000	88.200	39.000
2XA	477	7.3	6.3	755	0.290	0.0	0.0	6.500	113.000	77.200	35.000
2XA	505	9.0	6.2	790	0.0	0.0	0.018	5.800	110.200	58.700	28.100
2XA	532	10.7	6.1	750	0.0	0.0	0.020	5.700	91.400	55.600	30.400
2XA	589	12.1	6.5	0	0.0	0.0	0.0	4.500	89.800	57.400	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
2XB	449	7.2	6.0	592	-0.050	0.150	0.400	32.600	89.300	22.600	37.000
2XB	477	7.1	6.0	383	0.0	0.0	0.210	22.600	57.200	10.500	23.000
2XB	505	9.8	6.0	340	0.0	0.060	0.190	16.800	41.600	5.500	16.600
2XB	532	11.1	6.0	315	0.0	0.050	0.160	16.300	32.800	43.000	15.300

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
3XA	234	13.0	6.4	832.0	0.0	0.400	0.0	46.000	111.000	9.000	37.200
3XA	234	12.5	6.5	806.0	0.0	0.390	0.0	45.400	114.000	9.800	37.200
3XA	234	12.8	6.5	836.0	0.0	0.380	0.0	44.900	113.000	9.800	37.300
3XA	*234	12.8	6.5	824.7	0.0	0.390	0.0	45.433	112.667	9.533	37.233
3XA	375	8.5	5.7	326.0	-0.050	0.0	0.190	18.300	49.400	2.000	16.900
3XA	449	6.2	5.8	309.0	0.0	0.0	0.130	16.300	48.000	1.100	17.000
3XA	477	6.5	6.3	214.0	0.0	0.0	0.074	11.200	29.100	0.980	12.000
3XA	505	10.0	6.0	210.0	0.050	0.0	0.074	9.100	22.000	0.380	8.600
3XA	532	13.9	6.1	210.0	0.0	0.0	0.070	9.200	19.700	0.350	8.000
3XA	589	13.8	5.9	0.0	0.0	0.0	0.0	8.800	24.500	0.370	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
3XB	477	6.7	6.1	1040	1.600	0.100	0.0	17.300	136.000	145.000	67.000
3XB	505	10.9	6.0	1100	0.940	0.0	0.034	17.800	0.0	114.000	0.0
3XB	532	12.8	6.0	830	0.840	0.0	0.032	16.300	78.500	81.900	44.300

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
4XA	234	12.8	6.7	867	0.0	0.940	0.0	46.700	121.000	13.400	42.000
4XA	234	13.0	6.5	908	0.0	0.960	0.0	47.300	123.000	13.400	42.000
4XA	234	13.0	6.6	847	0.0	0.730	0.0	49.900	118.000	14.000	42.000
4XA	*234	12.9	6.6	874	0.0	0.877	0.0	47.970	121.000	13.600	42.000
4XA	407	3.0	6.3	493	-0.050	0.190	0.110	33.200	98.000	15.000	28.000
4XA	449	5.0	6.2	490	0.0	0.280	0.140	28.900	88.200	13.300	26.000
4XA	477	8.7	6.0	435	0.050	0.320	0.180	26.600	79.700	11.000	23.000
4XA	505	11.5	5.9	520	0.0	0.210	0.230	22.100	68.000	9.600	18.500
4XA	532	14.2	6.1	435	0.0	0.320	0.230	18.900	56.400	0.0	16.800
4XA	589	15.0	6.1	0	0.480	0.230	0.250	16.500	59.800	6.600	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
4XB	375	5.8	6.2	398.0	-0.050	0.083	0.160	39.000	111.000	17.900	33.400
4XB	407	2.2	6.5	273.0	-0.050	0.120	0.240	17.300	47.300	2.700	17.000
4XB	449	5.0	6.2	272.0	0.0	0.0	0.110	15.400	41.400	1.500	16.000
4XB	477	8.6	5.9	192.0	0.0	0.0	0.061	8.900	24.000	0.910	9.900
4XB	505	11.7	5.8	208.0	0.0	0.0	0.074	8.000	22.000	0.260	7.900
4XB	532	14.3	6.3	185.0	0.0	0.0	0.060	6.700	18.300	0.260	6.900
4XB	589	15.5	6.3	0.0	0.0	0.0	0.0	7.000	28.000	0.540	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
6XA	234	13.0	6.9	571	0.270	0.0	0.0	15.600	78.600	5.700	21.000
6XA	234	12.5	7.0	551	0.380	0.0	0.0	15.900	79.300	6.300	21.100
6XA	234	12.4	7.1	530	0.290	0.0	0.0	16.400	74.200	6.800	21.100
6XA	*234	12.6	7.0	551	0.313	0.0	0.0	15.970	77.000	6.270	21.070
6XA	375	4.0	6.6	365	-0.050	0.0	0.0	0.870	65.100	17.900	22.100
6XA	449	5.0	7.0	347	0.0	0.0	0.0	2.200	62.400	14.200	21.000
6XA	477	6.8	6.5	321	0.0	0.0	0.0	2.200	54.900	13.100	21.000
6XA	505	11.6	6.3	403	0.0	0.0	0.011	2.000	50.400	12.300	16.200
6XA	532	11.0	5.9	323	C.0	0.0	0.0	2.300	48.500	9.400	15.800
6XA	589	14.3	6.3	0	0.0	0.0	0.0	2.100	44.700	8.100	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
6XB	375	4.0	6.3	350	-0.050	0.120	0.150	13.300	66.200	3.800	19.700
6XB	449	5.0	6.6	217	0.0	0.0	0.069	8.200	33.200	1.300	12.000
6XB	477	7.0	6.2	122	0.0	0.0	0.040	4.700	18.400	0.100	7.400
6XB	505	11.9	6.3	168	0.0	0.0	0.046	4.300	16.800	0.140	5.900
6XB	532	11.0	6.1	135	0.0	0.0	0.050	4.600	17.000	0.120	5.700

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
7XA	234	13.8	6.9	411	0.0	0.0	0.0	8.100	61.600	1.600	12.600
7XA	234	14.0	7.1	413	0.0	0.0	0.0	8.100	63.000	1.400	12.300
7XA	234	13.3	7.1	412	0.0	0.0	0.0	9.300	62.800	2.000	12.600
7XA	*234	13.9	7.0	414	0.0	0.0	0.0	8.500	62.000	1.670	12.500
7XA	375	5.0	6.3	314	0.970	0.0	0.0	0.047	59.300	16.900	13.800
7XA	407	2.0	6.5	275	0.230	0.0	0.0	0.270	58.600	16.600	14.000
7XA	449	5.2	6.7	328	-0.050	0.0	0.0	0.103	64.600	16.800	11.000
7XA	477	6.0	6.4	311	0.0	0.0	0.0	0.120	60.000	15.800	14.000
7XA	505	11.3	6.2	418	0.0	0.0	0.018	0.120	56.900	16.200	13.300
7XA	532	9.3	6.0	330	0.0	0.0	0.0	0.070	58.400	13.100	13.600
7XA	589	14.2	6.2	0	0.0	0.0	0.0	0.020	61.500	15.800	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
7XB	449	4.9	6.6	173.0	0.0	0.090	0.037	5.100	27.100	0.050	8.900
7XB	477	6.0	6.5	112.0	0.0	0.088	0.020	3.300	16.700	0.050	6.100
7XB	505	10.3	6.4	140.0	0.0	0.090	0.032	2.800	14.700	0.080	4.900
7XB	532	9.0	6.1	103.0	0.0	0.060	0.020	2.900	12.600	0.160	4.600

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
8XA	234	14.9	7.2	452.0	0.0	0.0	0.0	1.000	70.200	0.420	15.100
8XA	234	14.5	7.3	441.0	0.0	0.0	0.0	0.360	69.300	0.410	15.200
8XA	234	14.8	7.3	442.0	0.0	0.0	0.0	0.560	71.500	0.400	15.300
8XA	*234	14.7	7.3	444.0	0.0	0.0	0.0	0.570	70.075	0.410	15.200
8XA	375	2.8	6.5	284.0	0.720	0.0	0.0	0.088	60.400	8.600	16.300
8XA	449	7.4	6.8	337.0	0.150	0.0	0.0	0.079	71.200	8.300	16.000
8XA	477	7.5	6.6	304.0	0.690	0.0	-0.010	0.065	61.600	8.400	16.000
8XA	505	12.0	6.3	413.0	0.720	0.0	0.010	0.032	60.200	7.080	15.300
8XA	532	12.4	5.8	330.0	0.520	0.0	0.0	0.050	61.300	6.500	15.800
8XA	589	15.8	6.5	0.0	0.470	0.0	0.0	0.010	66.800	7.900	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
8XB	375	3.0	6.3	469	-0.050	0.0	0.032	1.050	98.500	31.500	28.900
8XB	449	8.0	6.5	194	0.0	0.0	0.071	6.900	27.100	0.160	7.900
8XB	477	7.5	6.3	128	0.0	0.0	0.040	4.600	19.000	0.060	6.100
8XB	505	14.0	6.1	175	0.0	0.0	0.044	4.200	17.800	0.090	4.800
8XB	532	12.4	6.0	120	0.0	0.0	0.030	4.600	15.500	0.030	4.600
8XB	589	16.8	6.3	0	0.0	0.0	0.0	3.500	28.000	2.400	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
9XA	234	16.0	7.4	365	0.0	0.0	0.0	0.750	54.000	0.580	11.100
9XA	234	16.0	7.5	356	0.0	0.0	0.0	0.720	54.800	0.590	11.000
9XA	234	16.0	7.1	375	0.0	0.0	0.0	1.200	56.600	0.590	11.100
9XA	*234	16.0	7.3	365	0.0	0.0	0.0	0.890	55.000	0.590	11.070
9XA	375	2.5	6.7	238	0.092	0.0	0.0	0.084	54.400	6.900	17.600
9XA	449	7.0	6.8	268	0.570	0.0	0.0	0.079	50.800	7.200	12.000
9XA	477	7.4	6.3	245	0.830	0.0	0.0	0.027	47.000	7.700	12.000
9XA	505	12.4	6.3	345	0.060	0.0	0.0	0.016	45.200	6.660	10.800
9XA	532	12.8	5.8	255	0.520	0.0	0.0	0.040	45.600	6.500	10.900
9XA	589	18.0	6.2	0	0.070	0.0	0.0	0.030	36.900	7.500	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
9XB	375	2.0	6.3	248	0.063	0.220	0.200	20.000	42.200	1.800	13.200
9XB	449	7.0	6.4	206	-0.050	0.120	0.102	10.500	31.000	0.800	8.400
9XB	477	7.0	6.3	150	0.0	0.070	0.078	10.200	20.200	1.300	6.500
9XB	505	12.6	6.2	157	0.050	0.0	0.044	4.500	15.000	0.740	4.000
9XB	532	12.4	6.2	110	0.0	0.0	0.020	3.900	15.500	0.410	3.600

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
AYA	234	16.0	7.0	306	0.0	0.0	0.0	8.600	29.400	11.800	13.300
AYA	234	16.2	6.9	309	0.0	0.0	0.0	8.800	29.200	11.600	13.400
AYA	234	12.0	6.8	320	0.0	0.0	0.0	6.500	29.400	11.600	13.300
AYA	*234	14.7	6.9	312	0.0	0.0	0.0	8.630	29.000	11.670	13.330
AYA	375	4.5	6.4	204	3.800	0.0	0.0	1.500	25.700	15.800	12.600
AYA	449	8.3	6.4	286	2.000	0.0	0.0	0.049	41.200	16.000	12.000
AYA	477	7.8	6.2	230	3.600	0.0	0.0	0.023	30.600	16.300	12.000
AYA	505	11.6	6.5	297	2.600	0.0	0.033	0.021	30.700	16.300	12.700
AYA	532	12.5	5.9	295	3.200	0.0	0.0	0.070	32.800	15.800	13.600
AYA	589	15.0	6.7	0	1.200	0.0	0.0	0.160	42.100	16.400	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
AYB	234	17.3	6.9	350.0	1.760	0.0	0.0	7.600	29.200	18.300	17.000
AYB	234	17.5	6.8	340.0	0.880	0.0	0.0	7.200	28.000	16.600	16.500
AYB	234	17.3	6.9	356.0	1.390	0.0	0.0	8.100	28.800	18.300	16.600
AYB	*234	17.4	6.9	348.7	1.343	0.0	0.0	7.633	28.667	17.733	16.700
AYB	375	5.2	6.4	243.0	0.280	0.0	0.0	7.200	35.900	11.000	14.700
AYB	449	7.1	6.1	355.0	1.420	0.0	0.0	10.500	54.300	12.600	16.000
AYB	477	8.0	6.0	408.0	13.000	0.0	0.0	16.100	56.000	16.300	23.000
AYB	505	11.8	6.1	480.0	2.500	0.0	0.060	14.700	59.700	15.800	22.900
AYB	532	11.9	5.8	530.0	12.600	0.0	0.0	20.000	56.900	14.700	29.400
AYB	589	15.0	6.2	0.0	13.300	0.0	0.0	19.200	65.100	15.800	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
1YA	234	15.5	6.5	298	0.0	0.0	0.0	8.500	26.500	5.200	12.800
1YA	234	14.5	6.6	291	0.0	0.0	0.0	8.300	26.200	5.200	13.000
1YA	234	13.8	6.7	274	0.0	0.0	0.0	6.500	25.600	5.600	13.000
1YA	*234	14.6	6.6	283	0.0	0.0	0.0	7.770	26.000	5.330	12.930
1YA	375	7.0	6.4	224	-0.050	0.0	0.0	6.800	29.200	6.700	12.700
1YA	449	7.8	6.5	242	0.570	0.0	0.0	6.600	33.100	6.600	13.000
1YA	477	8.5	6.6	255	0.410	0.0	0.0	6.800	34.800	7.000	13.000
1YA	505	9.8	6.3	278	0.370	0.0	0.028	6.800	33.600	6.300	12.700
1YA	532	11.7	6.4	312	0.320	0.0	0.0	5.500	34.000	6.400	13.000
1YA	589	13.8	5.9	0	0.450	0.0	0.0	6.200	40.300	6.900	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
1YB	234	14.0	6.7	406	0.0	0.0	0.0	7.100	28.200	25.000	20.800
1YB	234	13.8	6.6	375	0.0	0.0	0.0	6.200	26.700	22.300	20.400
1YB	234	14.0	6.7	417	0.0	0.0	0.0	7.400	32.200	25.600	20.600
1YB	*234	13.9	6.7	399	0.0	0.0	0.0	6.900	29.000	24.300	20.600
1YB	375	7.0	6.4	243	-0.050	0.0	0.120	10.500	28.900	5.800	16.200
1YB	449	7.0	6.4	286	0.200	0.0	0.046	10.000	33.100	11.000	19.000
1YB	477	8.6	6.5	328	0.100	0.0	0.051	10.200	38.100	15.800	20.000
1YB	505	10.5	6.1	385	0.050	0.0	0.084	11.200	39.700	14.700	21.800
1YB	532	12.0	6.1	405	0.0	0.0	0.060	15.000	34.000	10.500	24.200
1YB	589	14.0	6.0	0	0.330	0.0	0.0	14.500	36.900	9.400	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
2YA	234	13.0	7.1	411	0.052	0.0	0.0	0.095	65.400	4.200	20.000
2YA	234	13.2	7.1	430	0.094	0.0	0.0	0.036	67.000	4.000	20.500
2YA	*234	13.1	7.1	421	0.073	0.0	0.0	0.070	66.000	4.100	20.250
2YA	375	8.0	6.4	355	0.500	0.0	0.0	0.084	66.200	5.600	20.000
2YA	449	7.5	6.6	365	0.470	0.0	0.0	0.029	66.800	6.900	20.000
2YA	477	8.2	6.7	377	0.320	0.0	0.0	0.030	66.600	8.100	20.000
2YA	505	10.0	6.2	367	0.320	0.0	0.030	0.030	55.900	6.800	18.200
2YA	532	11.6	6.3	400	0.470	0.0	0.0	-0.040	49.800	7.000	20.000
2YA	589	12.8	5.9	0	0.740	0.0	0.0	0.050	57.100	7.700	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
2YB	234	13.0	7.1	270	0.0	0.0	0.0	1.400	20.000	18.600	14.100
2YB	234	13.0	7.2	254	0.0	0.0	0.0	0.410	16.800	17.800	13.000
2YB	234	13.0	6.9	278	0.0	0.0	0.0	0.560	18.500	18.600	13.800
2YB	*234	13.0	7.1	267	0.0	0.0	0.0	0.790	18.000	18.330	13.630
2YB	375	8.0	6.6	221	0.053	0.0	0.0	0.890	24.700	20.000	14.400
2YB	449	8.0	6.8	263	0.0	0.0	0.012	1.500	28.800	21.700	15.000
2YB	477	8.4	6.6	302	0.096	0.0	-0.010	1.600	34.600	24.200	17.000
2YB	505	10.2	6.4	348	0.0	0.0	0.029	1.000	29.900	34.600	19.100
2YB	532	10.8	6.4	395	0.500	0.0	0.0	0.980	34.000	29.900	21.400
2YB	589	13.0	5.9	0	0.750	0.0	0.0	0.730	35.900	33.000	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
3YA	234	15.0	6.8	306	0.0	0.0	0.0	5.500	23.900	18.600	13.300
3YA	234	15.0	6.8	311	0.0	0.0	0.0	5.300	22.200	18.200	13.000
3YA	234	14.0	6.9	291	0.0	0.0	0.0	5.900	23.000	18.600	12.900
3YA	*234	14.7	6.8	303	0.0	0.0	0.0	5.570	23.000	18.470	13.070
3YA	375	8.0	6.5	221	-0.050	0.0	0.0	4.300	25.200	18.900	11.800
3YA	449	8.3	6.4	235	0.0	0.0	0.0	4.300	25.500	19.400	10.000
3YA	477	8.9	6.7	248	0.0	0.0	0.0	4.300	30.200	19.400	12.000
3YA	505	11.0	6.3	280	0.0	0.0	0.043	4.400	26.200	20.000	10.900
3YA	532	11.3	6.4	298	0.0	0.0	0.0	4.700	28.400	17.800	13.600
3YA	589	13.0	5.8	0	0.0	0.0	0.0	4.100	31.500	20.700	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
3YB	234	17.0	6.8	315	0.0	0.0	0.0	6.300	23.200	25.700	17.500
3YB	234	17.1	6.9	328	0.0	0.0	0.0	2.600	23.400	25.400	17.200
3YB	234	17.8	6.8	291	0.0	0.0	0.0	1.300	20.000	23.600	16.700
3YB	*234	17.3	6.8	311	0.0	0.0	0.0	3.400	22.000	24.900	17.130
3YB	375	8.0	6.4	179	-0.050	0.0	0.027	3.600	21.000	15.800	10.300
3YB	449	8.0	6.4	224	0.0	0.0	0.032	2.800	25.500	22.100	12.000
3YB	477	9.0	6.7	277	0.0	0.0	0.042	4.600	29.700	22.600	15.000
3YB	505	11.0	6.2	315	0.0	0.0	0.063	4.400	28.700	25.700	15.600
3YB	532	11.9	6.3	360	0.0	0.0	0.020	5.300	29.800	25.700	18.900
3YB	589	13.0	5.8	0	0.0	0.0	0.0	6.100	38.600	29.700	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
5YA	234	20.1	0.0	0	0.0	0.0	0.0	17.400	79.700	31.900	26.800
5YA	234	21.2	6.5	847	0.0	0.0	0.0	17.100	79.300	31.200	26.600
5YA	234	20.7	6.5	836	0.0	0.0	0.0	17.300	80.200	31.300	26.700
5YA	*234	20.7	4.3	561	0.0	0.0	0.0	17.270	80.300	31.470	26.700
5YA	375	3.0	6.2	444	0.440	0.060	0.0	12.600	67.200	43.100	23.100
5YA	449	7.4	6.4	490	0.084	0.0	0.0	11.900	72.800	44.900	23.000
5YA	477	9.0	6.6	551	0.072	0.0	0.0	12.100	73.300	44.100	22.000
5YA	505	13.0	6.4	580	0.0	0.0	0.041	10.900	75.400	43.100	22.900
5YA	532	15.4	6.3	650	0.0	0.0	0.0	10.800	72.700	42.000	23.100
5YA	589	18.0	6.0	0	0.0	0.0	0.0	10.500	82.600	43.000	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
5YB	375	3.0	6.2	316	0.050	0.150	0.130	12.100	42.000	13.600	28.400
5YB	449	7.4	6.4	421	0.110	0.140	0.150	19.400	40.700	15.400	37.000
5YB	477	7.8	6.3	520	0.200	0.220	0.170	23.100	62.200	15.400	44.000
5YB	505	13.3	6.2	620	0.180	0.130	0.200	21.000	65.600	11.600	52.100
5YB	532	16.3	6.1	730	0.0	0.0	0.170	19.200	69.900	9.400	53.600
5YB	589	19.4	5.9	0	0.0	0.0	0.240	26.500	83.600	15.800	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
6YA	234	22.0	6.4	1000	0.0	0.0	0.076	26.800	120.000	12.200	32.700
6YA	234	22.9	6.3	1020	0.0	0.0	0.075	26.300	121.000	12.100	32.900
6YA	234	22.0	6.4	1020	0.0	0.0	0.080	26.300	118.000	11.800	32.900
6YA	*234	22.3	6.4	1013	0.0	0.0	0.077	26.470	120.000	12.030	32.830
6YA	375	3.0	5.8	337	-0.050	0.096	0.220	20.500	56.500	5.100	16.200
6YA	407	2.0	5.8	323	-0.050	0.0	0.240	22.500	60.900	5.300	17.000
6YA	449	8.8	5.8	428	0.0	0.102	0.250	23.100	67.800	5.500	16.000
6YA	477	8.9	6.0	428	0.0	0.093	0.230	23.100	66.900	5.800	18.000
6YA	505	14.0	5.9	480	0.0	0.0	0.280	25.200	66.500	5.700	19.600
6YA	532	15.3	6.0	420	0.0	0.0	0.230	23.200	48.300	4.500	18.900
6YA	589	19.2	5.4	0	0.0	0.0	0.190	18.500	43.000	4.000	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
6YB	234	23.0	6.7	1071	6.700	0.0	0.0	5.700	119.000	25.500	36.500
6YB	234	22.2	6.6	946	8.300	0.0	0.0	10.700	103.000	24.400	37.800
6YB	234	22.2	6.7	1030	6.800	0.0	0.0	8.000	116.000	25.700	37.100
6YB	*234	22.5	6.7	1016	7.267	0.0	0.0	8.130	114.000	25.200	37.130
6YB	375	3.5	6.6	592	0.400	0.0	0.0	3.200	109.000	23.100	36.900
6YB	407	2.1	6.5	492	3.130	0.0	0.0	4.600	116.000	23.600	37.000
6YB	449	9.2	6.3	724	0.0	0.0	0.0	5.000	123.000	23.100	39.000
6YB	477	8.5	6.7	704	2.200	0.0	-0.010	7.500	118.000	21.000	37.000
6YB	505	14.0	6.4	730	0.050	0.0	0.040	9.000	110.200	19.700	35.000
6YB	532	15.0	6.4	730	0.0	0.0	0.0	6.900	108.600	16.800	34.400
6YB	589	19.0	5.8	0	0.0	0.0	0.0	7.400	104.000	17.800	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
6YD	234	20.8	7.4	296	0.0	0.0	0.0	0.460	34.600	2.700	7.700
6YD	234	19.3	7.5	284	0.0	0.0	0.0	0.370	34.900	2.600	7.600
6YD	234	21.8	7.4	303	0.0	0.0	0.0	0.460	35.700	2.700	7.700
6YD	*234	20.6	7.4	294	0.0	0.0	0.0	0.430	35.000	2.670	7.670
6YD	301	11.0	6.8	214	0.140	0.0	0.0	0.140	0.0	2.300	0.0
6YD	375	4.0	6.5	176	0.041	0.0	0.0	0.120	34.500	2.400	7.600
6YD	407	4.0	6.6	159	0.086	0.0	0.0	0.035	33.600	2.300	7.400
6YD	449	7.9	6.8	190	0.052	0.0	0.0	0.049	34.100	2.300	7.000
6YD	477	8.8	6.6	201	0.080	0.0	0.0	0.037	35.300	2.300	7.400
6YD	505	13.5	6.4	202	0.050	0.0	0.020	0.030	33.100	2.300	7.400
6YD	532	15.5	6.6	217	0.0	0.0	0.0	-0.040	31.300	2.100	5.200
6YD	589	18.5	6.4	0	0.0	0.0	0.0	0.040	35.100	2.200	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
7YA	234	19.5	6.7	714	0.980	0.0	0.0	20.000	79.100	14.000	23.400
7YA	234	20.0	6.7	714	0.930	0.0	0.0	20.200	77.400	13.900	23.100
7YA	234	20.8	6.7	724	0.810	0.0	0.0	19.800	76.000	13.900	23.300
7YA	*234	20.1	6.7	717	0.907	0.0	0.0	20.000	77.000	13.930	23.270
7YA	375	5.3	6.4	457	-0.050	0.0	0.011	14.600	79.200	23.800	26.800
7YA	449	8.9	6.4	551	-0.050	0.0	0.0	14.700	88.500	24.400	26.000
7YA	477	8.7	6.4	581	0.0	0.0	0.0	14.700	92.300	24.400	26.000
7YA	505	13.8	6.2	620	0.0	0.0	0.044	21.000	80.800	27.700	27.900
7YA	532	15.0	6.2	600	0.0	0.0	0.0	20.000	75.600	24.200	26.500
7YA	589	18.0	5.8	0	0.0	0.0	0.0	18.500	70.400	25.700	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
7YB	234	20.8	6.8	745	0.230	0.0	0.043	13.100	66.800	34.000	25.300
7YB	234	20.8	6.7	775	0.120	0.0	0.042	14.500	65.300	33.600	25.300
7YB	234	21.9	6.7	765	0.090	0.0	0.040	11.200	63.700	35.100	25.000
7YB	*234	21.2	6.7	762	0.147	0.0	0.042	12.930	65.000	34.230	25.200
7YB	375	5.0	6.4	478	0.230	0.170	0.021	15.800	73.200	41.000	28.600
7YB	477	8.7	6.3	612	0.0	0.120	0.083	24.200	87.900	28.900	30.000
7YB	505	13.3	6.0	600	0.050	0.190	0.150	25.200	81.900	23.900	27.500
7YB	532	15.0	6.1	600	0.0	0.240	0.130	23.600	74.300	17.800	27.800
7YB	589	17.6	5.9	0	0.0	0.230	0.120	21.100	70.400	19.000	0.0

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STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
8YA	234	15.7	7.1	449	0.0	0.0	0.0	9.700	51.400	10.900	16.200
8YA	234	16.0	7.1	461	0.0	0.0	0.0	9.700	51.100	10.700	15.900
8YA	234	15.0	7.1	435	0.0	0.0	0.0	9.600	51.000	10.900	16.200
8YA	*234	15.6	7.1	448	0.0	0.0	0.0	9.670	51.000	10.830	16.100
8YA	375	5.8	6.5	306	0.650	0.0	0.0	2.600	48.300	17.300	15.200
8YA	407	3.5	6.8	279	0.710	0.0	0.0	0.049	49.600	18.900	15.000
8YA	449	7.8	6.6	326	0.990	0.0	0.0	1.300	50.200	20.000	15.000
8YA	477	7.4	6.6	321	1.400	0.0	0.0	0.030	48.700	20.000	15.000
8YA	505	11.2	6.5	361	0.500	0.0	0.010	0.026	48.300	24.200	16.300
8YA	532	10.4	6.5	392	0.740	0.0	0.0	-0.040	47.000	24.200	16.400
8YA	589	14.0	6.0	0	0.780	0.0	0.0	0.040	50.900	27.000	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
8YB	234	16.5	6.9	734	0.0	0.0	0.0	15.200	70.400	27.500	24.700
8YB	234	15.8	6.9	714	0.0	0.0	0.0	14.400	69.900	31.500	25.000
8YB	234	17.2	7.9	745	0.0	0.0	0.042	16.600	72.600	25.700	24.500
8YB	*234	16.5	7.2	731	0.0	0.0	0.014	15.400	71.000	28.230	24.730
8YB	375	6.0	6.5	409	0.250	0.0	0.0	6.800	61.400	36.100	22.400
8YB	449	7.2	6.5	444	0.290	0.0	0.0	6.200	68.500	37.300	22.000
8YB	477	7.7	6.5	439	0.400	0.0	-0.010	5.400	63.800	36.800	21.000
8YB	505	10.7	6.5	440	0.0	0.0	0.021	4.400	55.900	34.500	20.200
8YB	532	12.7	6.4	430	0.0	0.0	0.0	4.600	52.700	26.200	17.800
8YB	589	14.0	6.1	0	0.0	0.0	0.0	3.300	50.900	30.000	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
8YC	505	11.3	6.4	1000	0.280	1.700	0.150	142.800	0.0	54.400	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
9YA	234	16.0	7.9	427	0.0	0.0	0.110	10.600	57.000	4.900	13.900
9YA	234	16.0	7.8	427	0.0	0.0	0.100	10.800	58.000	4.900	14.200
9YA	234	17.0	7.7	427	0.0	0.0	0.092	10.100	57.400	5.000	14.200
9YA	*234	16.3	7.8	427	0.0	0.0	0.101	10.500	57.000	4.930	14.100
9YA	375	4.5	6.4	329	0.102	0.0	0.027	4.700	63.500	11.200	14.200
9YA	449	9.0	6.7	350	0.370	0.0	0.0	0.580	66.800	12.300	13.000
9YA	477	8.0	6.7	349	0.430	0.0	0.0	0.250	66.600	12.600	14.000
9YA	505	12.0	6.4	368	0.320	0.0	0.013	0.100	61.500	12.100	13.900
9YA	532	14.0	6.5	370	0.100	0.0	0.0	0.070	56.900	8.400	13.200
9YA	589·	14.0	6.0	0	0.810	0.0	0.0	0.030	60.700	11.800	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
9YB	505	12.5	6.2	570	0.180	0.0	0.078	5.000	55.600	8.900	59.500
9YB	532	15.0	6.3	570	0.0	0.0	0.120	5.400	47.000	12.200	58.800

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
10YA	234	12.1	6.9	359	0.0	0.0	0.043	7.600	45.200	5.000	13.000
10YA	234	13.1	6.9	376	0.0	0.0	0.026	7.200	47.200	5.200	13.300
10YA	234	12.9	6.9	367	0.0	0.0	0.047	7.600	44.400	4.900	13.000
10YA	*234	12.7	6.9	367	0.0	0.0	0.039	7.470	46.000	5.030	13.100
10YA	449	7.9	6.6	260	-0.050	0.0	0.0	0.750	37.200	12.100	11.000
10YA	477	7.5	6.5	262	0.0	0.0	0.0	0.830	37.300	12.100	11.000
10YA	505	8.4	6.3	275	0.0	0.0	0.021	0.620	34.300	13.000	12.100
10YA	532	10.5	6.7	280	0.0	0.0	0.0	0.500	34.000	12.600	11.600
10YA	569	12.0	6.4	0	0.0	0.0	0.0	0.770	35.100	13.800	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
10YB	234	13.1	7.1	430	0.0	0.0	0.034	3.400	51.100	25.200	18.800
10YB	234	13.0	7.0	441	0.0	0.0	0.045	5.500	55.600	20.700	17.800
10YB	234	13.1	7.1	393	0.0	0.0	0.040	2.900	46.600	24.800	18.500
10YB	*234	13.1	7.1	421	0.0	0.0	0.040	3.930	51.000	23.570	18.370
10YB	375	8.0	6.3	277	-0.050	0.0	0.0	4.100	40.000	15.200	14.700
10YB	449	7.7	6.5	294	-0.050	0.0	0.039	4.900	40.100	16.600	14.000
10YB	477	8.0	6.7	291	0.0	0.0	0.020	2.800	41.000	21.000	14.000
10YB	505	8.5	6.3	312	0.0	0.0	0.048	2.400	40.000	20.000	13.900
10YB	532	11.0	6.7	265	0.0	0.0	0.030	5.500	28.400	10.500	10.100
10YB	589	12.5	6.4	0	0.0	0.0	0.0	1.900	33.300	17.800	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
3W	234	16.5	6.3	452	0.0	0.0	0.100	11.000	62.500	0.270	18.100
3W	234	15.9	6.5	439	0.0	0.0	0.088	10.600	63.300	0.610	18.000
3W	234	15.7	6.5	435	0.0	0.0	0.089	10.500	65.100	0.740	17.600
3W	*234	16.0	6.4	442	0.0	0.0	0.092	10.700	64.000	0.540	17.900
3W	375	3.5	6.2	156	-0.050	0.0	0.039	4.600	25.000	-0.040	7.400
3W	449	5.5	6.4	154	-0.050	0.0	0.047	3.700	23.200	-0.040	7.100
3W	477	6.8	6.6	102	0.0	0.0	0.010	2.300	15.900	-0.040	4.500
3W	505	10.0	6.4	120	0.0	0.0	0.039	2.400	15.800	0.0	4.800
3W	532	11.0	6.2	115	0.0	0.0	0.020	2.600	13.400	0.050	4.200
3W	589	17.0	6.1	0	0.0	0.0	0.0	2.700	19.200	0.010	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
5W	234	17.5	6.9	352	0.0	0.0	0.052	7.800	51.400	0.810	11.200
5W	234	19.0	6.7	337	0.0	0.0	0.074	9.700	46.900	0.840	10.800
5W	234	17.0	6.9	369	0.0	0.0	0.038	5.200	57.600	0.660	11.900
5W	*234	17.8	6.8	353	0.0	0.0	0.055	7.570	52.000	0.770	11.300
5W	375	7.0	6.2	353	-0.050	0.0	0.053	7.700	76.400	1.400	13.000
5W	449	5.7	6.5	367	-0.050	0.0	0.077	9.700	79.600	1.100	14.000
5W	477	6.8	6.4	360	0.0	0.0	0.071	11.600	75.700	0.760	15.000
5W	505	11.3	6.3	390	0.0	0.0	0.089	11.600	52.000	0.510	14.700
5W	532	10.7	6.0	330	0.100	0.0	0.070	10.300	55.400	0.460	13.000
5W	589	14.5	6.2	0	0.0	0.0	0.0	10.500	57.100	0.670	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
9W	234	15.0	6.2	612	0.0	0.290	0.250	37.000	87.700	9.300	25.200
9W	234	15.8	6.2	612	0.0	0.260	0.200	37.800	88.400	9.200	25.400
9W	234	15.0	6.2	612	0.0	0.290	0.250	33.900	87.700	9.700	25.000
9W	*234	15.3	6.2	612	0.0	0.280	0.233	36.230	88.000	9.400	25.200
9W	301	12.2	6.6	516	0.063	0.0	0.210	26.700	0.0	10.700	0.0
9W	375	7.5	6.4	337	-0.050	0.0	0.160	16.800	61.400	7.800	13.600
9W	449	9.4	6.2	393	0.0	0.0	0.170	17.600	68.100	7.600	15.000
9W	477	8.7	6.2	405	0.0	0.0	0.180	18.900	67.300	7.400	15.000
9W	505	11.3	5.8	600	0.050	0.0	0.350	34.600	79.800	7.200	27.500
9W	532	12.0	5.9	670	0.100	0.0	0.400	43.000	89.900	7.200	31.500
9W	589	13.0	5.1	0	0.020	0.0	0.370	38.100	86.200	7.900	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
12W	234	16.2	6.6	291	0.0	0.0	0.084	15.000	38.100	0.760	11.400
12W	234	18.0	6.5	284	0.0	0.0	0.064	16.200	41.000	0.820	11.600
12W	234	13.0	6.6	314	0.0	0.0	0.076	18.800	35.700	0.850	11.700
12W	*234	17.4	6.6	296	0.0	0.0	0.068	16.670	38.000	0.810	11.570
12W	375	7.2	6.2	199	-0.050	0.063	0.120	19.100	23.700	0.420	11.600
12W	407	5.0	6.1	204	-0.050	0.0	0.130	20.300	26.200	0.540	13.000
12W	449	8.0	6.0	236	-0.050	0.0	0.160	26.300	34.100	0.670	17.000
12W	477	8.5	6.3	337	0.0	0.083	0.200	38.300	36.400	0.930	22.000
12W	505	11.0	5.9	393	0.050	0.0	0.230	41.000	36.400	1.000	25.200
12W	532	10.9	6.0	375	0.0	0.0	0.230	45.200	32.800	0.840	24.400
12W	539	12.5	5.3	0	0.030	0.0	0.200	39.800	36.900	0.840	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
13W	234	16.7	6.6	481	0.0	0.0	0.210	31.600	48.100	7.000	25.000
13W	234	16.2	6.6	489	0.0	0.0	0.250	29.200	49.800	6.800	25.600
13W	234	15.2	6.6	377	0.0	0.0	0.160	22.900	37.900	6.300	20.100
13W	*234	16.0	6.6	449	0.0	0.0	0.207	27.970	45.000	6.700	23.570
13W	375	6.0	6.5	268	2.600	0.063	0.077	17.600	41.000	6.300	14.400
13W	449	7.5	6.4	316	1.000	0.0	0.017	21.000	46.200	6.100	16.000
13W	477	8.8	6.1	347	1.800	0.0	0.100	32.000	45.200	6.300	21.000
13W	505	11.5	5.9	405	0.0	0.0	0.220	44.100	34.100	4.700	23.100
13W	532	11.5	5.9	390	0.100	0.0	0.270	48.300	34.000	0.400	23.100
13W	589	14.2	5.7	0	1.600	0.0	0.220	44.300	36.900	3.800	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
15W	234	17.0	6.7	338	0.0	0.0	0.047	15.500	35.300	3.500	14.700
15W	234	18.4	6.7	345	0.0	0.0	0.052	15.400	32.600	2.500	15.100
15W	234	19.0	6.7	345	0.0	0.0	0.067	15.900	35.300	2.600	15.400
15W	*234	18.1	6.7	343	0.0	0.0	0.055	15.600	34.000	2.870	15.070
15W	375	5.8	6.5	342	0.072	0.0	0.015	15.800	63.500	5.600	19.700
15W	449	6.5	6.4	408	3.520	0.0	0.0	19.400	67.000	7.900	25.000
15W	477	8.3	6.3	449	7.900	0.0	-0.010	27.000	63.400	8.000	34.000
15W	532	12.8	5.9	549	4.700	0.0	0.050	39.200	51.200	5.900	37.800
15W	589	16.0	5.8	0	7.900	0.0	0.0	35.200	44.700	5.900	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
16W	449	8.5	6.0	520	2.570	0.0	0.150	45.500	75.800	10.500	44.000
16W	477	9.0	6.1	592	12.000	0.0	0.055	42.000	75.700	10.000	40.000
16W	505	12.8	5.9	690	10.500	0.0	0.076	39.900	70.400	8.000	37.100
16W	532	12.9	5.8	610	8.700	0.0	0.070	40.200	67.000	8.100	35.700
16W	589	14.5	6.0	0	5.400	0.0	0.0	36.400	67.700	8.100	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
17W	449	6.7	5.9	367	-0.050	0.150	0.240	51.500	35.300	2.300	26.000
17W	477	6.7	5.8	357	0.140	0.094	0.220	45.500	30.800	1.800	24.000
17W	505	11.0	5.7	377	0.180	0.070	0.220	43.000	26.800	1.500	23.100
17W	532	12.1	5.8	353	0.100	0.180	0.220	44.600	26.900	1.000	22.000
17W	589	15.0	5.2	0	0.010	0.030	0.170	35.600	31.500	1.200	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
18W	449	6.8	6.1	408	0.110	0.090	0.350	54.400	44.200	2.900	27.000
18W	477	8.0	6.0	530	0.0	0.083	0.400	71.400	57.800	4.800	32.000
18W	505	10.9	5.9	620	0.100	0.0	0.390	72.400	62.600	4.600	32.800
18W	532	11.2	6.0	530	0.0	0.0	0.350	64.000	56.900	4.000	29.000
18W	589	14.0	6.0	0	0.280	0.0	0.280	58.400	58.900	4.200	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
1P	234	20.0	6.6	180	0.770	0.0	0.0	4.800	14.800	5.600	7.600
1P	234	20.4	6.7	207	1.060	0.0	0.0	11.800	16.600	5.600	8.000
1P	234	21.8	7.1	207	0.550	0.0	0.0	9.100	16.200	5.400	8.000
1P	*234	20.7	6.8	198	0.793	0.0	0.0	8.570	17.000	5.530	7.870
1P	375	0.0	0.0	157	0.350	0.063	0.027	6.100	24.200	6.300	11.300
1P	449	8.3	5.4	204	0.050	0.130	0.033	4.900	26.000	5.500	14.000
1P	477	9.0	6.5	196	0.0	0.088	0.020	4.100	25.700	5.000	13.000
1P	505	13.0	6.3	196	0.100	0.0	0.032	3.500	22.000	4.200	12.600
1P	532	15.2	6.4	220	0.160	0.0	0.0	3.400	21.200	3.900	11.600
1P	589	20.0	6.2	0	0.230	0.0	0.020	2.600	24.500	4.000	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
2P	234	15.9	6.7	530	26.800	0.0	0.0	21.300	49.000	12.900	19.400
2P	234	16.0	6.7	505	29.400	0.0	0.0	21.600	50.400	12.800	20.000
2P	234	15.7	6.6	530	27.800	0.0	0.0	22.100	50.600	14.300	23.600
2P	*234	15.9	6.7	522	28.000	0.0	0.0	21.670	50.000	13.330	21.000
2P	375	4.5	5.3	428	2.900	0.0	0.055	42.500	64.600	17.900	31.400
2P	407	1.5	6.0	592	9.500	0.0	0.170	83.000	76.700	31.800	55.000
2P	449	6.5	6.2	1040	28.700	0.0	0.220	126.000	77.400	48.300	117.000
2P	477	7.5	5.9	1163	36.000	0.0	0.230	122.000	89.800	52.000	113.000
2P	505	10.1	5.9	1460	69.300	0.0	0.170	88.200	0.0	48.300	0.0
2P	532	12.0	6.0	1470	63.000	0.0	0.120	84.600	84.200	42.000	120.000
2P	589	14.0	6.2	0	76.200	0.0	0.060	56.300	87.000	41.700	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
3P	234	17.8	6.4	765	27.400	0.080	0.0	47.700	63.000	10.600	44.100
3P	234	16.5	6.5	796	28.400	0.060	0.0	45.800	65.100	11.000	42.500
3P	234	16.4	6.6	755	27.100	0.080	0.0	46.200	66.100	10.900	43.500
3P	*234	16.9	6.5	772	27.633	0.073	0.0	46.570	65.000	10.830	43.370
3P	375	4.0	5.3	479	0.0	0.0	0.103	61.200	54.900	6.900	54.100
3P	449	6.8	6.2	887	0.0	0.0	0.370	78.200	73.600	3.600	128.000
3P	477	9.0	6.1	949	0.100	0.0	0.550	66.200	78.500	1.600	113.000
3P	505	12.3	5.8	1100	0.0	0.0	0.660	59.800	0.0	0.190	0.0
3P	532	14.0	6.0	1180	0.0	0.0	0.670	56.700	68.500	0.230	126.000
3P	589	16.5	6.0	0	0.240	0.0	0.540	47.200	54.500	1.400	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
4P	234	21.3	6.5	1430	44.000	0.0	0.0	112.000	96.600	33.800	81.900
4P	234	18.5	6.6	1350	46.400	0.0	0.0	112.000	100.800	34.100	81.900
4P	234	17.7	6.6	1370	44.100	0.0	0.0	110.000	98.200	34.100	82.400
4P	*234	19.2	6.6	1363	44.833	0.0	0.0	111.330	99.000	34.000	82.070
4P	301	19.1	6.2	1061	88.000	0.083	0.045	118.000	0.0	42.000	0.0
4P	375	4.0	6.0	785	44.000	0.074	0.015	103.400	89.000	41.000	71.400
4P	407	3.0	5.9	765	45.800	0.069	0.027	103.100	92.300	43.100	67.000
4P	449	7.2	6.2	959	46.200	0.0	0.027	108.000	93.900	46.000	77.000
4P	477	8.2	5.9	1000	0.550	0.0	0.020	112.000	89.800	46.200	68.000
4P	505	10.2	5.6	1130	48.300	0.0	0.042	124.000	97.300	46.200	71.400
4P	532	12.5	6.0	1340	42.000	0.0	0.050	132.000	91.400	48.300	75.600
4P	589	14.3	6.0	0	45.200	0.0	0.020	121.000	96.800	50.600	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
5P	234	17.0	6.0	1040	0.810	0.0	0.250	26.800	156.000	1.700	52.500
5P	234	17.5	6.0	1050	0.600	0.0	0.270	26.600	152.000	1.600	51.600
5P	234	16.8	6.1	1040	0.680	0.0	0.240	26.300	158.000	1.700	52.500
5P	*234	17.1	6.0	1043	0.697	0.0	0.253	26.570	155.000	1.670	52.200
5P	301	9.6	6.7	959	0.250	0.063	0.350	33.300	0.0	1.600	0.0
5P	449	7.3	6.8	184	0.064	0.0	0.037	5.700	27.000	0.160	7.400
5P	477	10.0	6.7	164	0.0	0.0	0.040	5.000	26.900	0.270	7.700
5P	505	14.0	6.3	225	0.0	0.0	0.063	5.000	13.600	0.590	7.900
5P	532	17.3	6.4	243	0.0	0.0	0.050	4.800	26.900	1.700	7.400

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
10P	234	15.0	6.8	1610	76.400	0.0	0.0	4.300	233.000	18.200	52.700
10P	234	14.6	6.9	1570	77.500	0.0	0.0	3.500	229.000	18.300	52.700
10P	234	15.0	6.8	1530	77.200	0.0	0.0	3.100	233.000	18.100	52.500
10P	*234	14.9	6.8	1570	77.700	0.0	0.0	3.600	232.000	18.200	52.630
10P	449	7.3	6.5	1438	78.800	0.0	0.0	4.400	331.000	28.000	64.000
10P	477	9.0	6.4	1663	131.000	0.130	-0.010	3.600	0.0	31.700	78.000
10P	505	12.6	6.3	1930	5.800	0.0	0.0	1.400	0.0	32.600	72.400
10P	532	14.0	6.3	1980	39.900	0.0	0.0	1.600	357.000	25.700	73.500

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
11P	234	16.9	7.0	836	41.500	0.0	0.0	0.900	109.000	7.700	31.900
11P	234	15.5	7.0	836	46.100	0.0	0.0	0.540	118.000	7.700	31.900
11P	234	15.0	7.0	816	48.300	0.0	0.0	0.170	116.000	7.400	30.600
11P	*234	15.3	7.0	829	45.300	0.0	0.0	0.540	114.300	7.600	31.470
11P	449	7.5	6.7	592	0.082	0.0	0.0	1.300	127.000	7.200	27.000

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
13P	449	7.5	6.4	520	16.100	0.0	0.0	12.900	69.200	8.500	37.000
13P	477	8.5	6.3	551	21.000	0.0	-0.010	13.600	70.700	18.400	39.000
13P	505	13.0	6.2	600	23.100	0.0	0.0	13.600	59.300	9.300	35.700
13P	532	13.0	6.1	640	23.100	0.0	0.0	14.000	56.900	9.100	38.000
13P	589	19.5	6.3	0	23.100	0.0	0.0	12.500	56.300	9.400	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
18P	449	9.0	6.3	163	-0.050	0.0	0.025	3.200	23.200	0.430	6.300
18P	477	10.2	6.8	208	0.0	0.0	0.010	2.500	35.300	0.640	7.400
18P	505	15.2	6.3	210	0.050	0.0	0.021	2.300	29.900	0.840	6.500
18P	532	15.5	6.5	220	0.0	0.0	0.0	1.600	31.300	0.840	6.100
18P	589	14.0	6.5	0	0.070	0.0	0.0	1.400	30.700	1.300	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
20P	589	18.0	6.5	0	8.900	0.0	0.0	7.600	68.600	4.300	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
21P	589	13.7	6.6	0	70.900	0.0	0.0	14.500	149.000	20.400	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
200	234	16.0	7.1	354.0	2.700	0.0	0.0	5.800	40.700	4.800	13.300
200	234	16.0	7.2	354.0	2.700	0.0	0.0	5.800	41.300	4.800	12.700
200	234	16.0	7.0	354.0	2.800	0.0	0.0	5.900	40.800	4.700	13.300
200	*234	16.0	7.1	354.0	2.733	0.0	0.0	5.833	40.933	4.767	13.100
200	375	4.0	6.5	170.0	0.820	0.0	0.110	4.300	32.600	1.700	7.900
200	449	6.0	6.5	105.0	0.370	0.0	0.022	1.900	16.100	0.400	4.400
200	477	6.2	6.6	133.0	0.600	0.0	-0.010	1.800	23.500	0.550	5.500
200	505	10.0	6.5	107.0	0.0	0.0	0.028	1.200	15.100	0.320	2.700
200	532	11.3	5.9	145.0	0.440	0.0	0.020	1.600	24.200	0.400	4.200
200	589	15.5	6.6	0.0	1.700	0.0	0.0	4.500	59.800	2.000	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
201	234	18.2	6.9	592.0	0.0	0.0	0.051	14.900	76.600	0.570	22.900
201	234	18.2	7.0	602.0	0.0	0.0	0.051	14.600	77.100	0.560	23.100
201	234	18.2	7.0	592.0	0.0	0.0	0.042	14.600	75.700	0.570	22.900
201	*234	18.2	7.0	595.3	0.0	0.0	0.048	14.700	76.467	0.567	22.967
201	375	0.0	6.5	56.0	-0.050	1.400	0.160	4.300	7.700	-0.040	2.500
201	449	9.5	6.6	201.0	0.0	0.0	0.049	7.800	27.300	0.070	10.200
201	477	9.8	6.7	151.0	0.0	0.0	0.0	5.400	20.400	0.050	7.900
201	505	11.5	6.3	170.0	0.0	0.0	0.032	4.400	18.800	0.040	6.500
201	532	14.1	6.2	143.0	0.0	0.0	0.020	4.300	17.000	0.050	6.100
201	589	20.7	6.5	0.0	0.0	0.0	0.0	5.600	46.500	0.780	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
202	375	3.7	5.9	469.0	6.100	0.960	0.320	36.500	69.000	11.600	29.400
202	449	9.0	6.0	612.0	2.200	0.610	0.380	41.500	81.800	10.200	40.000
202	477	10.1	6.0	683.0	4.400	0.550	0.430	43.600	90.300	12.600	28.000
202	505	18.3	5.9	550.0	2.500	0.510	0.300	29.400	56.100	6.300	22.000
202	532	16.8	5.7	530.0	4.200	0.230	0.280	31.000	61.300	7.700	25.200
202	589	18.0	6.0	0.0	9.800	0.010	0.240	24.800	58.000	9.800	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
203	234	21.0	6.8	390	0.480	0.0	0.0	6.200	43.200	2.700	13.600
203	234	21.0	6.8	387	0.480	0.0	0.0	6.200	43.600	2.700	13.600
203	234	21.0	6.8	390	0.470	0.0	0.0	6.200	44.000	2.600	13.800
203	*234	21.0	6.8	389	0.477	0.0	0.0	6.200	44.000	2.670	13.670
203	449	9.8	6.7	107	0.260	0.0	0.022	2.100	14.900	0.420	4.400
203	505	11.9	6.5	108	0.0	0.0	0.020	1.500	12.700	0.320	0.0
203	532	11.7	6.1	158	0.200	0.0	0.0	2.000	22.700	0.430	4.600
203	589	14.8	6.5	0	0.760	0.0	0.0	5.800	58.000	2.000	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
204	589	18.0	6.2	0	0.050	0.0	0.0	33.200	63.300	8.900	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
205	234	17.0	7.1	376	1.600	0.0	-0.020	5.300	40.700	2.700	13.200
205	234	17.0	7.0	376	1.700	0.0	0.022	5.200	40.700	2.700	13.200
205	234	17.0	7.1	376	1.600	0.0	-0.020	5.400	41.400	2.600	13.200
205	*234	17.0	7.1	376	1.633	0.0	-0.006	5.300	41.000	2.670	13.200
205	375	4.0	6.5	166	0.680	0.0	0.120	3.500	31.500	1.600	7.900
205	449	7.0	6.6	102	0.280	0.0	0.020	1.800	14.400	0.360	4.200
205	477	4.5	6.4	112	0.190	0.0	0.0	1.800	20.400	0.490	4.900
205	505	10.5	6.5	110	0.0	0.0	0.022	0.900	13.600	0.280	3.200
205	532	13.0	6.0	136	0.100	0.0	0.0	1.200	21.200	0.380	4.200
205	589	15.5	6.7	0	1.200	0.0	0.0	4.300	58.000	2.000	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
206	234	21.5	7.0	375	0.089	0.0	0.0	3.100	40.400	2.200	12.700
206	234	21.5	6.9	367	0.081	0.0	0.0	3.100	42.100	2.200	12.400
206	234	21.5	7.0	378	0.053	0.0	0.0	2.700	39.700	2.100	12.900
206	*234	21.5	7.0	373	0.074	0.0	0.0	2.970	41.000	2.170	12.670
206	375	5.0	6.4	194	0.560	0.0	0.084	4.300	32.600	1.700	8.400
206	449	7.2	6.6	105	0.270	0.0	0.0	1.900	14.400	0.410	4.400
206	477	6.0	6.4	130	0.390	0.0	-0.010	1.800	21.200	0.520	5.200
206	505	6.5	6.5	85	0.0	0.0	0.032	1.300	12.000	0.290	3.200
206	532	11.3	6.2	135	0.260	0.0	0.0	1.700	21.200	0.420	4.200
206	589	15.8	6.7	0	0.890	0.0	0.0	4.300	58.000	1.900	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
207	505	13.3	6.3	225	0.0	0.0	0.040	6.600	21.000	1.600	3.700
207	532	14.8	6.0	227	0.740	0.0	0.0	4.400	22.700	0.880	3.000
207	589	19.0	6.9	0	0.090	0.0	0.0	0.930	19.200	0.470	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
207A	589	20.0	9.0	0	0.070	0.0	0.0	0.040	16.600	0.060	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
207B	589	15.0	6.2	0	0.240	0.0	0.0	2.200	13.900	0.300	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
208	505	10.0	6.5	98	0.0	0.0	0.038	1.400	12.100	0.290	3.600
208	532	11.8	6.2	149	0.200	0.0	0.0	1.800	21.200	0.430	4.600
208	589	14.8	6.6	0	0.540	0.0	0.0	5.400	58.000	2.000	0.0

Appendix IV. Cont'd

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
PWS	589	16.0	7.3	0	0.030	0.0	0.0	0.320	111.000	0.370	0.0

STATION	DATE	TEMP	PH	EC	FE	PB	CD	ZN	CA	MN	MG
P132	589	19.5	6.3	0	0.050	0.0	0.0	4.700	7.800	1.800	0.0

APPENDIX V

Plant List and Survey Notes

Appendix V. Plant List

Smelterville Flats Study Area

	Scientific Name Genu	Species	Common Name	Abundance
Conifers				
1.	Pinus	monlicola	White Pine	S
2.			Brislecone Pine-Monteray Jack	S
Deciduous				
3.	Betala	occidentalis	Birch	A
4.	Populus	angustifolia	Cottonwood	VA
5.	Crataequs	douglasii	Black Hawthorn	A
6.	Salix	amydalaicles(?)	Willow	A
Shrubs and Grasses				
7.	Pranis	americana	Bitter Cherry	A
8.	Artemesia		Sage	S
9.	Apocynum	androsaemifolium	Doglane	A
10.	Equisetum	arriense		VA
11.	Phragmittes	communis		A
12.	Pachistima	myrsinites		A
13.	Agrostis	alba	Red Top	VA
14.	Agropyron	repens	Quack Grass	VA
15.	Linaria	vulgaris	Toadflax	A
16.			Clover	A

S = Scarce
A = Abundant
VA = Very Abundant

Appendix V. Plant list and survey notes, Smelterville Flats study area.

Station	+ Sight	Instrumental Height	- Sight	Elevation	Remarks
BM-1				2223.98	E. Run
	3.50	2227.48			
AX G.L.			6.70	2220.78	
AX-A M.P.			5.27	2222.21	
AX-B M.P.			6.03	2221.45	
Stake @ AX			5.64	2221.84	
1X G.L.			7.75	2219.73	
1X-A M.P.			4.74	2222.74	
1X-B M.P.			5.38	2222.10	
Stake @ 1X			7.23	2220.25	
2X G.L.			5.84	2221.64	
2X-A M.P.			2.93	2224.55	
2X-B M.P.			2.04	2225.44	
Stake @ 2X			5.29	2222.19	
SP #2 G.L.			5.81	2221.67	
SP #2 M.P.			2.62	2224.86	
3X G.L.			5.00	2222.48	
3X-A M.P.			2.65	2224.83	
3X-B M.P.			2.36	2225.12	
Stake @ 3X			4.45	2223.03	
BM-1			3.505	2223.975	
BM-1				2223.98	
	3.39	2227.37			
4X G.L.			6.28	2221.09	
4X-A M.P.			3.84	2223.53	
4X-B M.P.			4.41	2222.96	
Stake @ 4X			5.98	2221.39	
SP #1 G.L.			6.11	2221.26	
SP #1 M.P.			4.14	2223.23	
Stake @ 6X			5.33	2222.04	
	3.35	2225.40			
6X G.L.			4.58	2220.82	
6X-A M.P.			1.30	2224.10	
6X-B M.P.			1.24	2224.16	
7X G.L.			5.14	2220.26	
7X-A M.P.			2.86	2222.54	
7X-B M.P.			2.95	22222.45	
Stake @ 7X			4.64	2220.76	
Stake @ 8X			8.89	2216.51	
	7.10	2223.62			
8X G.L.			7.67	2215.95	
8X-A M.P.			4.92	2218.70	
8X-B M.P.			3.36	2220.26	
9X G.L.			6.73	2216.89	
Stake @ 9X			6.28	2217.34	
9X-A M.P.			1.34	2222.28	
9X-B M.P.			1.40	2222.22	
T.P.			5.75	2217.87	
	9.18	2227.06			
Stake @ Staff			11.59	2215.47	By Pond
	12.21	2227.69			
BM-1			3.71	2223.98	
BM-2				2208.72	
	8.34	2217.06			
3Y G.L.			8.27	2208.79	
3Y-A M.P.			5.18	2211.88	
3Y-B M.P.			6.12	2210.94	
2Y G.L.			8.96	2208.10	
2Y-A M.P.			6.43	2210.63	
2Y-B M.P.			6.84	2210.22	
Stake @ 2Y			9.23	2207.83	
1Y G.L.			7.62	2209.44	
1Y-A M.P.			4.51	2212.55	
1Y-B M.P.			4.72	2212.34	
AY G.L.			8.64	2208.42	
AY-A M.P.			4.84	2212.22	
AY-B M.P.			5.42	2211.64	
TBM-2			4.74	2212.32	South Side I-90
BM-2			8.34	2208.72	
BM-2				2208.72	
	2.58	2211.30			
T.P.			3.36	2207.94	
	2.65	2210.59			
5Y G.L.			5.79	2204.80	
5Y-A M.P.			2.71	2207.88	
5Y-B M.P.			2.63	2207.96	
Stake @ 5Y			4.92	2205.67	

Appendix V. Cont'd

Station	+ Sight	Instrumental Height	- Sight	Elevation	Remarks
6Y G.L.			5.56	2205.03	
6Y-D M.P.			2.58	2208.01	
6Y-A M.P.			2.39	2208.20	
6Y-B M.P.			2.70	2207.89	
Stake @ 6Y			5.10	2205.49	
7Y G.L.			5.27	2205.32	
7Y-A M.P.			1.52	2209.07	
7Y-B M.P.			1.88	2208.71	
TBM-1			4.62	2205.97	
	3.30	2209.27			
8Y G.L.			3.40	2205.87	
8Y-A M.P.			0.51	2208.76	
8Y-B M.P.			1.16	2208.11	
8Y-C G.L.			3.57	2205.70	
Stake @ 8Y			3.02	2206.25	
SP #4 G.L.			3.42	2205.85	
SP #4 M.P.			0.58	2208.69	
9Y-A G.L.			4.99	2204.28	
9Y-A M.P.			3.12	2206.15	
9Y-B G.L.			4.77	2204.50	
9Y-B M.P.			2.03	2207.24	
Stake @ 9Y			3.71	2205.56	
10Y G.L.			2.47	2206.80	
10Y-A M.P.			1.53	2207.74	
10Y-B M.P.			1.60	2207.67	
Stake @ 10Y			2.65	2205.62	
TBM-1			3.30	2205.97	
TBM-1				2205.97	
	6.85	2212.82			
5W G.L.			4.00	2208.82	
5W M.P.			1.49	2211.33	
Stake @ 5W			3.33	2209.49	
	6.75	22.6.24			
3W G.L.			2.66	2213.58	
3W M.P.			0.54	2215.70	
Stake @ 3W			2.47	2213.77	
SP #6 M.P.			2.80	2213.44	
Stake @ SP #6			2.53	2213.71	
T.P.			6.75	2209.49	
	3.28	2212.77			

Station	+ Sight	Instrumental Height	- Sight	Elevation	Remarks
TBM-1			6.81	2205.96	
TBM-1				2205.97	
	3.99	2209.96			
T.P.			5.47	2204.49	
	4.76	2209.25			
9W G.L.			5.83	2203.42	
9W M.P.			3.62	2205.63	
SP #3 G.L.			5.58	2203.67	
SP #3 M.P.			2.52	2206.73	
Stake @ 9W			5.52	2203.73	
10W G.L.			6.46	2202.79	
10W M.P.			3.13	2206.12	
Stake @ 10W			5.96	2203.29	
	3.39	2206.68			
12W G.L.			6.28	2200.40	
12W M.P.			3.74	2202.94	
Stake @ 12W			6.14	2200.54	
	3.43	2203.97			
13W G.L.			6.38	2197.59	
13W M.P.			3.95	2200.02	
Stake @ 13W			5.79	2198.18	
15W G.L.			6.20	2197.77	
15W M.P.			3.19	2200.78	
Stake @ 15W			6.00	2197.97	
T.P.			2.37	2201.60	
	5.09	2206.69			
T.P.			0.71	2205.98	
	6.35	2212.33			
BM-2			3.57	2208.76	
TBM-A				2197.97	Stake @ 15W
	5.01	2202.98			
TP-1			5.81	2197.17	
	4.84	2202.01			
TP-2			6.36	2195.65	
	4.50	2200.15			
16W G.L.			3.92	2196.23	
16W M.P.			0.55	2199.60	
Stake @ 16W			3.44	2196.71	

Appendix V. Cont'd

Station	+ Sight	Instrumental Height	- Sight	Elevation	Remarks
TP-3			2.64	2196.51	
	5.67	2202.18			
TP-4			5.01	2197.17	
	6.33	2203.50			
TBM-A			5.54	2197.96	Stake @ 15W
TBM-B				2203.29	Stake @ 10W
	5.12	2208.41			
TP-1			4.49	2203.92	
	5.39	2209.31			
18W G.L.			2.06	2207.25	
18W M.P.			3.19	2210.44	Measured from ground level
TP-2			6.35	2202.96	
	4.59	2207.55			
TP-3			6.01	2201.54	
	4.85	2206.39			
17W G.L.			5.11	2201.28	
17W M.P.			2.64	2203.75	
TP-4			4.55	2201.84	
	4.87	2206.71			
TBM-C			3.75	2202.96	12W top of Piezometer
9W	4.32	2209.95		2205.63	
TP-1			5.31	2204.64	
	5.41	2210.05			
			8.18	2201.87	at Pond #204
			6.79	2203.26	
			7.01	2203.04	
			6.52	2203.53	
TP-2			5.71	2204.34	
9W			4.43	2205.62	
10Y-A	1.61	2209.35		2207.74	
			4.49	2204.86	at 10Y River

Station	+ Sight	Instrumental Height	- Sight	Elevation	Remarks
			5.92	2203.43	
			6.66	2202.69	
			7.35	2202.00	
10Y-A			1.61	2207.74	
TBM-2				2212.32	
	.88	2213.20			
TP-1			6.55	2206.65	
	5.42	2212.07			
1P G.L.			7.53	2204.54	
1P M.P.			4.51	2207.56	
TP-2			6.72	2205.35	
	6.64	2211.99			
17P G.L.			7.33	2204.66	
17P M.P.			5.35	2206.64	
19P G.L.			7.77	2204.22	
19P M.P.			4.08	2207.91	
16P G.L.			7.53	2204.46	
16P M.P.			4.24	2207.75	
TBM-A			4.21	2207.78	
TBM-B				2196.66	
	5.96	2202.62			
TP-8			2.46	2200.16	
	3.76	2203.92			
12P G.L.			6.64	2197.28	
12P M.P.			4.16	2199.76	
TP-9			2.37	2201.55	
	3.87	2205.42			
14P G.L.			6.04	2199.38	
14P M.P.			3.54	2201.88	
TP-10			4.15	2201.27	
	3.78	2205.05			
Reference Stake			5.03	2200.02	At 13P
TBM-B				2196.66	
	6.94	2203.60			

Appendix V. Cont'd

Station	+ Sight	Instrumental Height	- Sight	Elevation	Remarks
5P G.L.			9.49	2194.11	
5P M.P.			5.89	2197.71	
TP-B-1			9.20	2194.40	
	5.82	2200.22			
7P G.L.			3.59	2196.63	
7P M.P.			3.12	2197.10	
8P G.L.			4.59	2195.63	
8P M.P.			3.14	2197.08	
10P G.L.			5.85	2194.37	
10P M.P.			4.31	2195.91	
11P G.L.			6.40	2193.82	
11P M.P.			3.12	2197.10	
TP-B-2			5.95	2194.27	
	3.93	2198.20			
6P G.L.			5.15	2193.05	
6P M.P.			0.39	2197.81	
TP-B-3			2.01	2196.19	
	3.85	2200.04			
3P G.L.			7.60	2192.44	
3P M.P.			4.57	2195.47	
Reference Stake			6.66	2193.38	
TBM-B			3.39	2196.65	
TBM-2				2212.32	
	.81	2213.13			
AY-A			.90	2212.23	Top of Piezometer
TP-1			4.71	2208.42	
	6.32	2214.74			
TP-2			4.55	2210.19	
	6.85	2217.04			
18P G.L.			6.65	2210.39	
18P M.P.			3.93	2213.11	
TP-3			7.16	2209.88	
	4.62	2214.50			
TP-4			5.50	2208.90	
	3.86	2212.76			
TBM-2			0.44	2212.32	

Station	+ Sight	Instrumental Height	- Sight	Elevation	Remarks
TBM-2				2212.32	
	.44	2212.76			
TP-1			4.88	2207.88	
	3.95	2211.83			
TP-2-TBMA			4.04	2207.79	
	1.48	2209.27			
TP-3			5.11	2204.16	
	3.76	2207.92			
TP-4			5.87	2202.05	
	3.35	2205.40			
13P G.L.			5.98	2199.42	
13P M.P.			2.91	2202.49	
Reference Stake			5.36	2200.04	
TP-5			6.23	2199.17	
	3.48	2202.65			
TP-6			5.53	2197.12	
	3.84	2200.96			
4P G.L.			5.42	2195.54	
4P M.P.			.83	2200.12	
SP #8			3.47	2197.49	
2P G.L.			4.65	2196.31	
2P M.P.			.78	2200.18	
TBM-B			4.30	2196.66	
	4.30	2200.96			
TP-7			3.84	2197.12	
	6.45	2203.57			
TP-8			5.50	2198.07	
	6.86	2204.93			
TP-9			4.13	2200.80	
	6.93	2207.73			
TP-10			3.86	2203.87	
	5.98	2209.85			
TP-11			5.35	2204.50	
	7.20	2211.70			
TP-12			5.52	2206.18	
	6.79	2212.97			
TBM-2			0.64	2212.33	
TBM-W	2.50	2197.97		2195.47	P3 top of Piezometer

Appendix V. Cont'd

Station	+ Sight	Instrumental Height	- Sight	Elevation	Remarks	Station	+ Sight	Instrumental Height	- Sight	Elevation	Remarks
A			3.67	2194.30							
	3.35	2197.65									
1			4.27	2193.38							
	3.84	2197.22									
2			6.00	2191.22							
	4.89	2196.11									
TP-1			4.17	2191.94							
	2.15	2194.09									
Stake 3			1.52	2192.57							
TP-2			5.58	2188.51							
	3.99	2192.50									
4			3.99	2188.51							
5			3.22	2189.28							
	9.42	2198.70									
6			7.27	2191.43							
	7.27	2198.70		2191.43							
5			9.42	2189.28							
	2.96	2192.24									
4			3.73	2188.51							
	5.24	2193.75									
3			1.18	2192.57							
	3.19	2195.76									
2			4.54	2191.22							
	5.27	2196.49									
1			3.12	2193.37							
	4.38	2197.75									
A			3.46	2194.29							
	4.52	2198.81									
TBM-W			3.34	2195.47	P3 Top of Piezometer						
Stake 3	3.19	2195.76		2192.57							
20P G.L.			6.22	2189.54							
20P M.P.			2.98	2192.78							
Stake 3			3.19	2192.57							
Stake 6	3.73	2195.16		2191.43							
21P G.L.			3.92	2191.24							
21P M.P.			1.13	2194.03							
Stake 6			3.73	2191.43							