PANTHER CREEK, IDAHO

HABITAT REHABILITATION - FINAL REPORT

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EXECUTIVE SUMMARY

Panther Creek, a tributary of the Salmon River, historically supported large runs of chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (Salmo gairdneri). A gradual decline in these runs occurred during the 1940s when extensive mining activities began in the Blackbird Creek Drainage, a tributary of Panther Creek. The runs were eventually eliminated from the system by the early 1960s, and today the drainage remains largely uninhabitable due to toxic conditions in Panther Creek imposed by mine drainage.

In 1982, as part of a comprehensive Fish and Wildlife Program for the Columbia River Basin, the Northwest Power Planning Council (NWPPC) adapted a program (Section 700) aimed at increasing wild and hatchery production of anadromous fish. Panther Creek was one of the projects to be implemented by the Bonneville Power Administration (BPA) as offsite mitigation. The overall purpose of the project is to achieve full salmon and steelhead production in the Panther Creek basin.

In 1984, Bechtel National, Inc. was contracted by BPA to conduct a multiphase project (Contract No. DE-AC79-84BP17449) focusing on the development of plans for eliminating the source(s) of toxic effluent entering Panther Creek that caused an anadromous fish passage problem. Specific phases included:

- Phase I - Data Acquisition and Review
- Phase II - Mine Reclamation/Effluent Abatement Alternatives
- Phase III – Fisheries Habitat Surveys

The project was conducted over a l2-month period beginning in September 1984.

DESCRIPTION OF STUDY AREA

The Panther Creek study area is located in the Salmon River drainage in east central Idaho in the Salmon National Forest (Figure 1). The Blackbird Mine site lies about 13 ml south of the Salmon River, 21 ml west of Salmon, Idaho, and 9 mi west of the townsite of Cobalt, Idaho. The headwaters of Panther Creek arise near Morgan Creek Summit at an elevation of about 8,000 feet msl. From its headwaters, the stream flows in a north-northwesterly direction for about 44 mi, where it enters the Salmon River. Tributary streams that contain potential anadromous salmonid habitat if the toxic problem is resolved include Musgrove Creek, Moyer Creek, Deep Creek, Napias Creek, Beaver Creek, and Clear Creek (Figure 2). Big Deer Creek and Blackbird Creek are essentially devoid of any aquatic biota due to toxic mine effluent.

Active mining in the Blackbird area began in the 1890s and has continued off and on until the present. The mine is presently owned by Noranda Mining Inc. and is in an inactive state. Some of the earliest reports (ca. 1930) on mining suggest that all mine tailings were channeled directly into Blackbird Creek. Settling ponds and tailing pipelines were subsequently constructed in the 1940s and 1950s. Although some measures for the containment of tailings were in place, the methods often proved ineffective. As a consequence, periodic "spills" of tailings often went unchecked into Blackbird Creek and ultimately into Panther Creek. In the late 1950s, open-pit mining began in the Big Deer Creek drainage. This development resulted in contaminated mine drainage entering Big Deer Creek (via Bucktail Creek), which flows into Panther Creek about 12 miles downstream from Blackbird Creek. Panther Creek therefore has two major pathways for recurring toxic effluent: Blackbird Creek and Bucktail Creek.

Fisheries observations made over the years have confirmed the impact of the mining activity. Redd counts ranged from 4 to 135 during the period 1954 to 1961 and subsequently decreased to zero from 1963 to 1965. Redd counts were ultimately discontinued after 1948; no redds have been observed during periodic field surveys from 1968 to 1977. For comparison, the Idaho

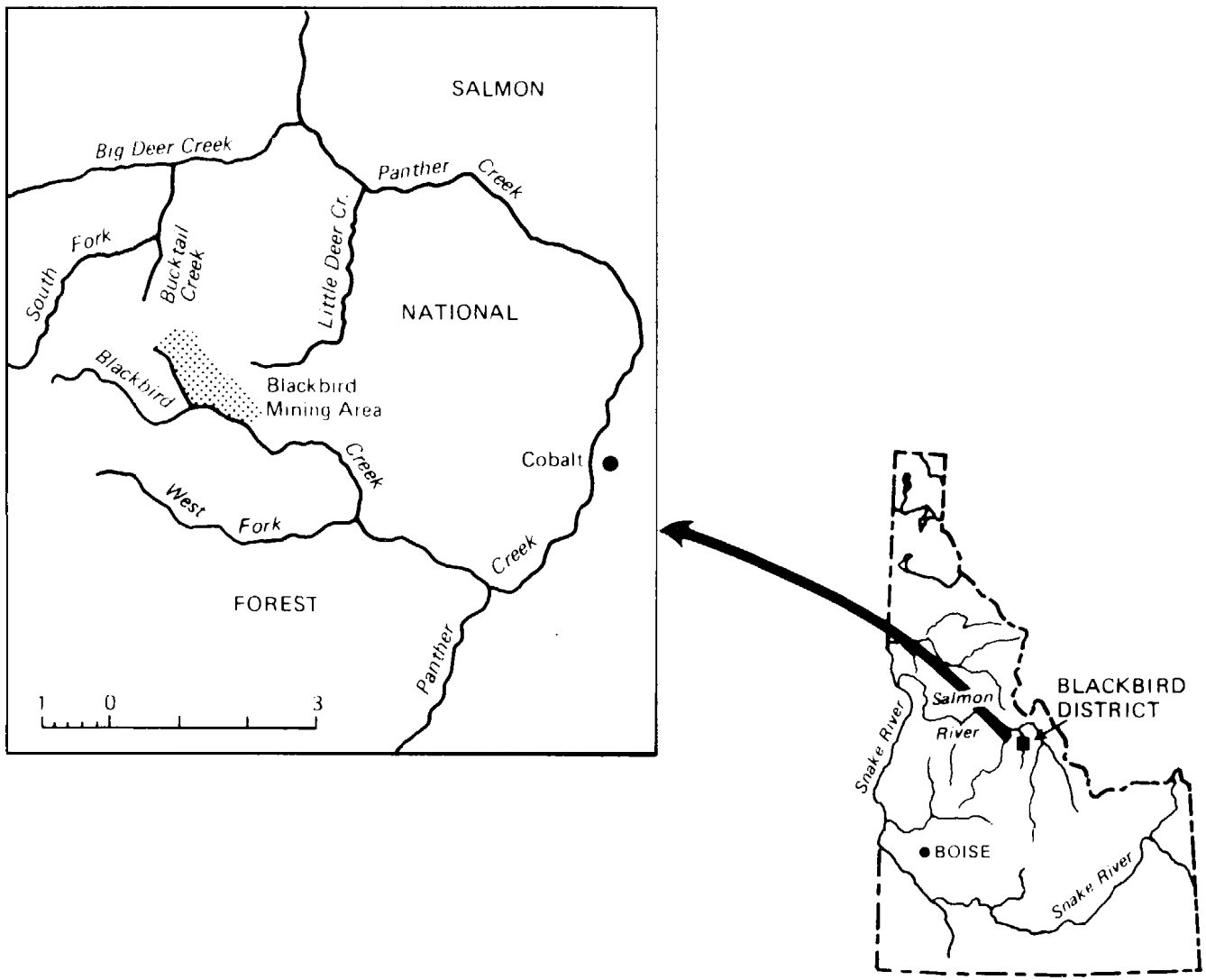


Figure 1 PROJECT STUDY LOCATION

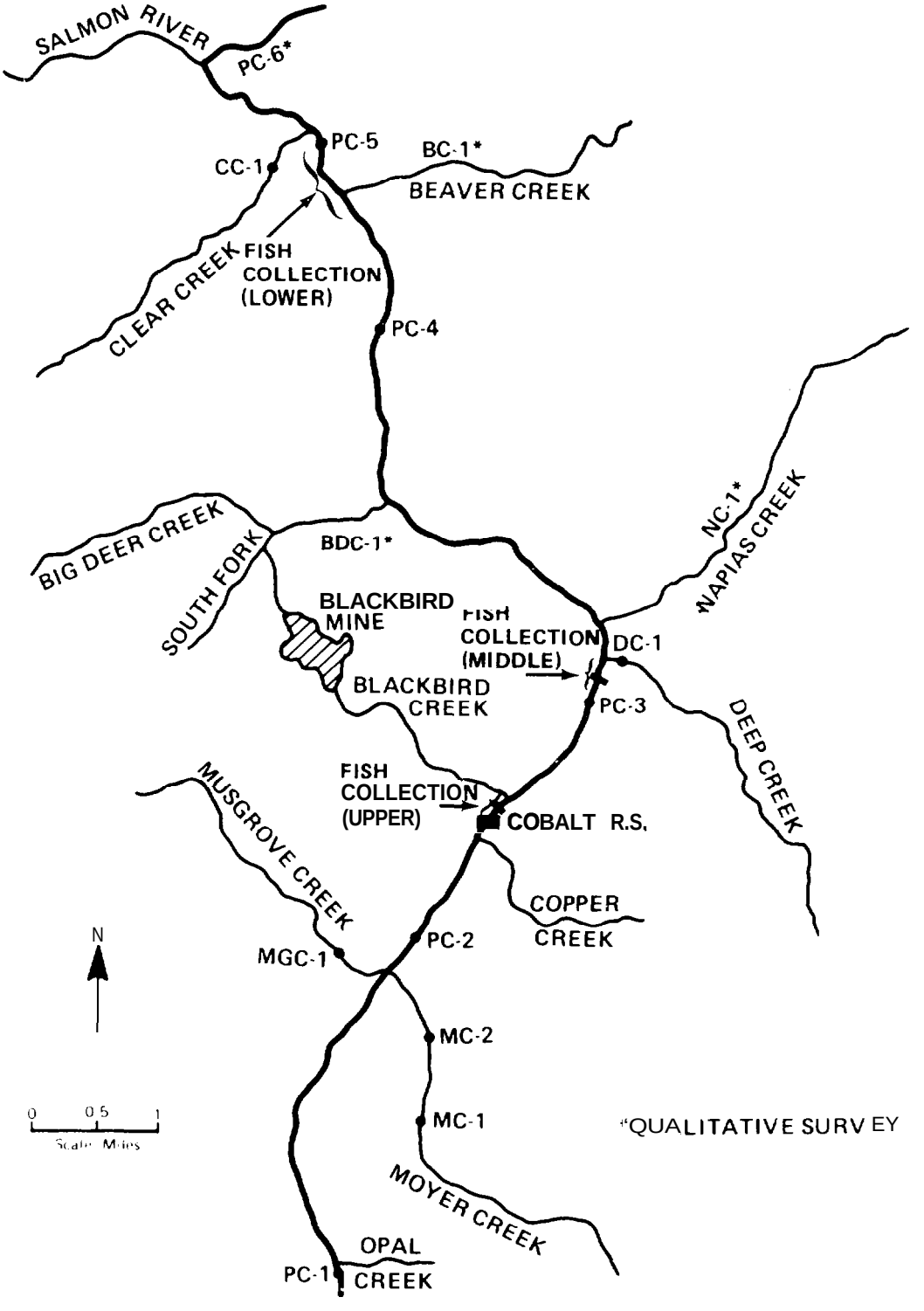


Figure 2 FISHERIES HABITAT STUDY STATIONS AND FISH COLLECTION SITES (FOR TISSUE ANALYSIS) LOCATED IN THE PANTHER CREEK DRAINAGE, FALL 1984 AND 1985

Department of Fish and Game (IDF&G) has estimated that the Panther Creek drainage once supported over 2,000 adult spawners.

PHASE I : DATA ACQUISITION AND REVIEW

Phase I was accomplished via an-extensive review of published and unpublished information and data relevant to the water quality and aquatic ecosystems of the Panther Creek drainage. In addition, personal contacts were made with various state and federal agencies and private organizations, including IDF&G, Noranda Mining Inc., the Idaho Department of Health and Welfare, the U.S. Forest Service, the U.S. Environmental Protection Agency, and the U.S. Geological Survey.

PHASE II: FORMULATION OF ALTERNATIVES

Phase II activities were focused on defining the source(s) and extent of contaminants emanating from the Blackbird Mine area and formulating conceptual engineering alternatives (and associated costs) for abating the toxic effluent problem in Panther Creek. The program included separate fall and spring field surveys. During the field surveys, contaminant sources were identified and quantified, and potential remedial measures for each were formulated. Selected measures were ultimately combined into two alternative abatement programs (Alternatives 1 and 2). Alternative 1 involves treating poor quality water; Alternative 2 relies on passive measures to improve water quality. Table 1 presents a summary of the components included in each.

Alternative 1

The concept of this alternative is to divert all clean water around waste piles and to collect and treat both the direct runoff from waste rock piles as well as mine adit flow. Slightly different approaches were necessary for the Blackbird and Bucktail drainages.

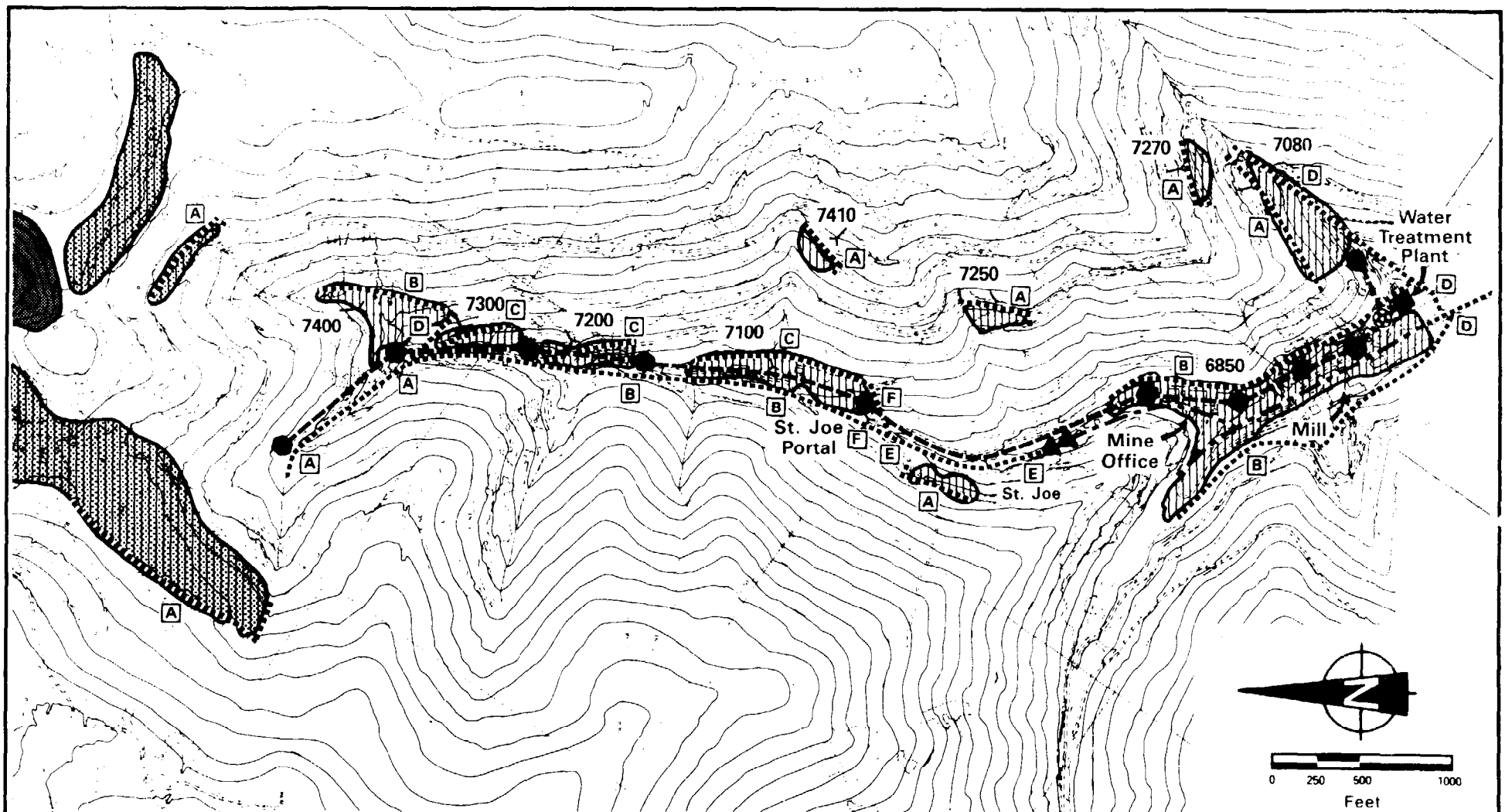
Table 1

COMPARISON OF PROPOSED ALTERNATIVE ABATEMENT PROGRAMS

Abatement Measure	Alternative			
	IA	1B	2A	2B
Reclaim and revegetate	X	X	X	X
Divert surface flows	X	X	X	X
Improve Meadow Creek	X	X	X	X
Replace Blackbird Creek culvert	X	X		
Cap waste rock piles			X	X
Collect mine adit flows	X	X		
Collect water from waste piles	X	X		
Divert Bucktail Creek to 6850 via borehole	X			
Divert Bucktail Creek to 7117 adit		X		
Pump Bucktail Creek		X		
Install Blacktail Pit drain	X	X	X	
Backfill Blacktail Pit				X
Treat water	X	X		
Seal and flood mine				X

For the Blackbird drainage scheme (Alternative 1), all clean water runoff is directed around the waste piles to an improved Meadow Creek channel. This effectively isolates runoff from the waste piles so that it can be collected and treated (Figure 3).

For the Bucktail Drainage, two options were identified: Alternative 1A and 1B. Both options involve diverting flow and collecting poor quality water. The poor quality water is transferred through the subsurface workings to the existing treatment facilities on Blackbird Creek.



WASTE ROCK PILE TO BE REVEGETATED

DIVERSION DITCH

CONTAMINATED WATER PIPE

CLEAN WATER CULVERT

CONTAMINATED WATER CATCH BASIN

SEDIMENTATION POND

GRIT REMOVAL CHAMBER

DIVERSION DITCH TYPE
(See Section A4.2)

Figure 3 BLACKBIRD DRAINAGE ALTERNATIVE 1

Alternative IA is shown in Figure 4. This scheme involves constructing a diversion structure in the Bucktail Creek channel (at about elevation 6,950 ft) and a 1,200 ft long, 12 in. borehole for connecting the diversion structure to the 6850 level. Inside the mine, a 12 in. PVC pipe carries the poor quality water to the treatment plant via the 6850 adit.

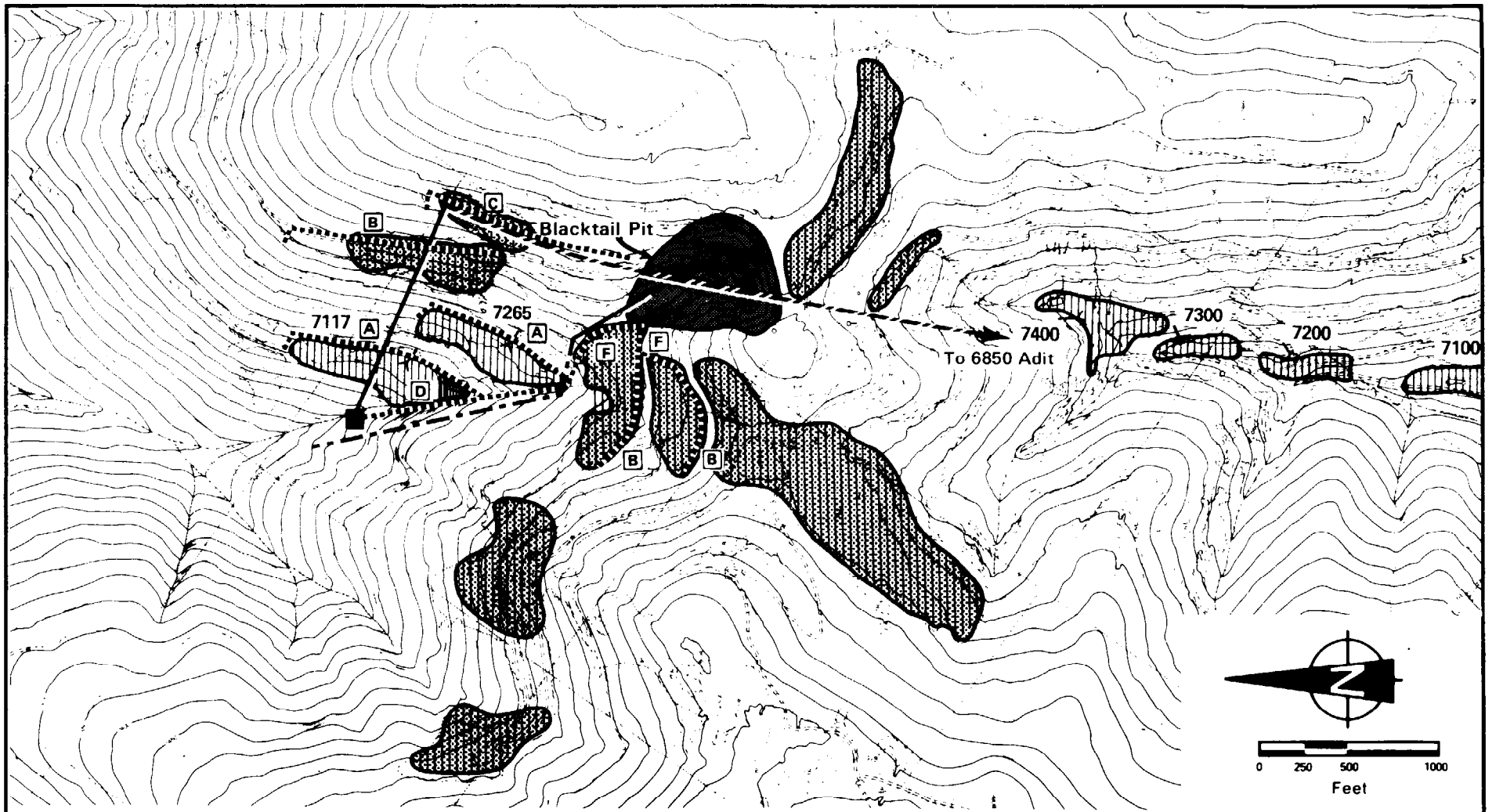
Alternative 1B is shown in Figure 5. For this alternative, the majority of the flow is diverted to the 7117 adit by gravity. A small pump structure located on Bucktail Creek collects the remaining poor quality water and diverts it into the 7117 adit. The combined flow is then conveyed through the mine in a 12 in. PVC pipe to the treatment facility.

Alternative 2

This alternative more effectively isolates the waste piles by capping the flat surfaces of the piles with an impermeable material in addition to diverting runoff around them. The scheme for the Blackbird Drainage is shown in Figure 6. A 12 in. clay layer is used as an impermeable liner to cap the flat surfaces of the waste piles. This will reduce recharge to the piles associated with direct infiltration of snowmelt or rainfall into the waste rock.

In the Bucktail Drainage, two options were developed: Alternative 2A and 2B. Alternative 2A, shown in Figure 7, is conceptually similar to that described for the Blackbird Drainage. Flow is diverted around waste piles, the flat surfaces of the piles are capped, and all waste is revegetated. This alternative also includes a drain for the Blacktail Pit.

Alternative 2B is illustrated in Figure 8. This concept includes excavating the waste rock in the headwaters of Bucktail Creek and placing this material into the open pit. Other waste piles in the Bucktail Drainage are capped and revegetated. After placement in the pit, a clay cap is used to isolate the waste from potential recharge by surface flow.



WASTE ROCK PILE TO BE REVEGETATED

DIVERSION DITCHES

BORE HOLE

CLEAN WATER CULVERT

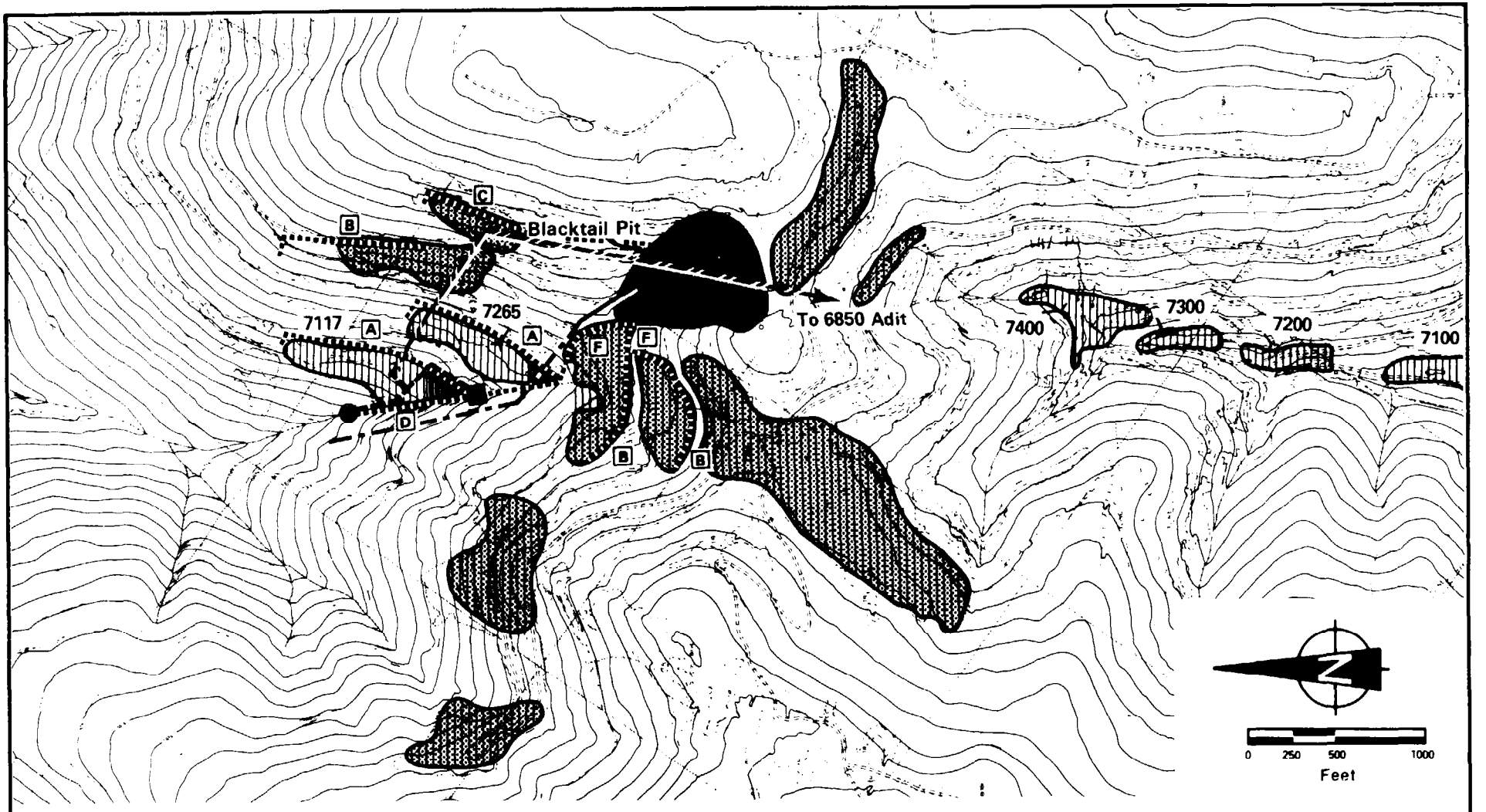
CONTAMINATED WATER PIPE WITHIN MINE

DIVERSION STRUCTURE

SEDIMENTATION POND

DIVERSION DITCH TYPE
(See Section A4.2)

Figure 4 BUCKTAIL DRAINAGE ALTERNATIVE 1A



WASTE ROCK TO BE REVEGETATED

PUMP STRUCTURE

DIVERSION STRUCTURE

SEDIMENTATION POND

DIVERSION DITCH

CONTAMINATED WATER PIPE

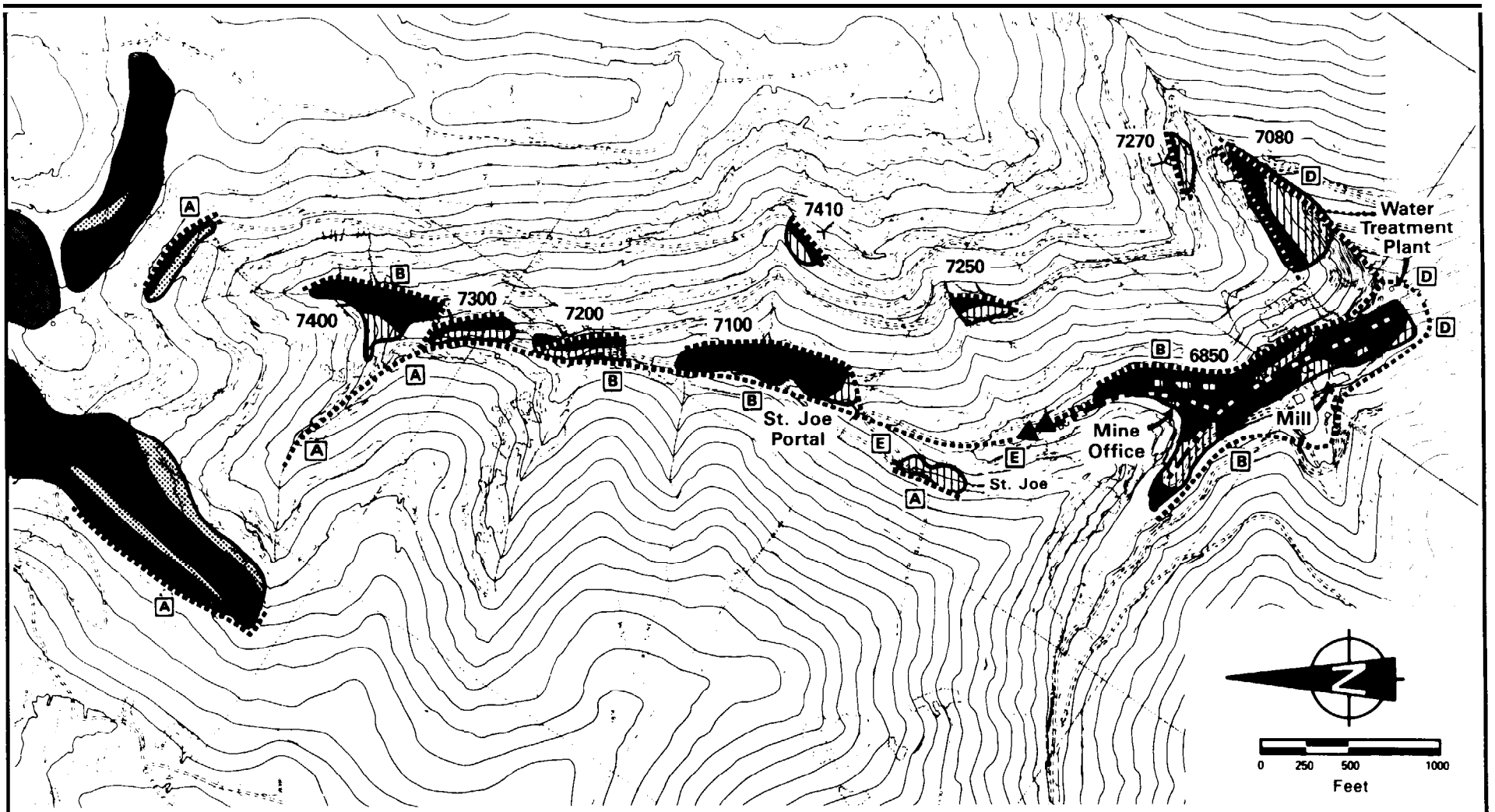
BORE HOLE

CLEANWATERCULVERT

CONTAMINATED WATER PIPE WITHIN MINE

DIVERSION DITCH TYPE (See Section A4.2)

Figure 5 BUCKTAIL DRAINAGE ALTERNATIVE 1 B



WASTE ROCK TO BE REVEGETATED

WASTE ROCKCAPPEDANDREVEGETATED

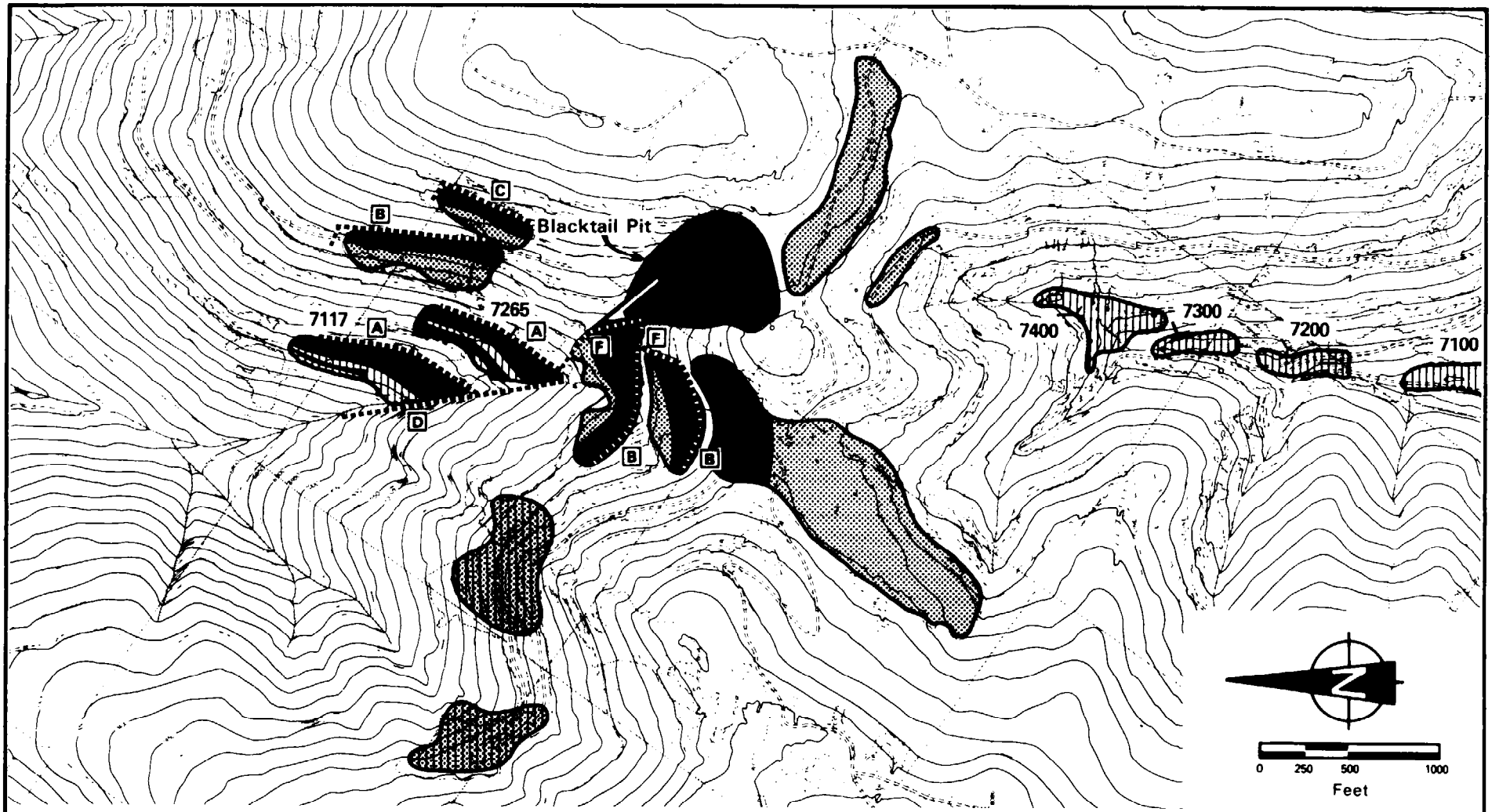
. =======. DIVERSION DITCH

CLEAN WATER CULVERT

SEDIMENTATION POND

DIVERSION DITCH TYPE
(See Section A4.2)

Figure 6 BLACKBIRD DRAINAGE ALTERNATIVE 2



WASTE ROCK PILE TO BE REVEGETATED

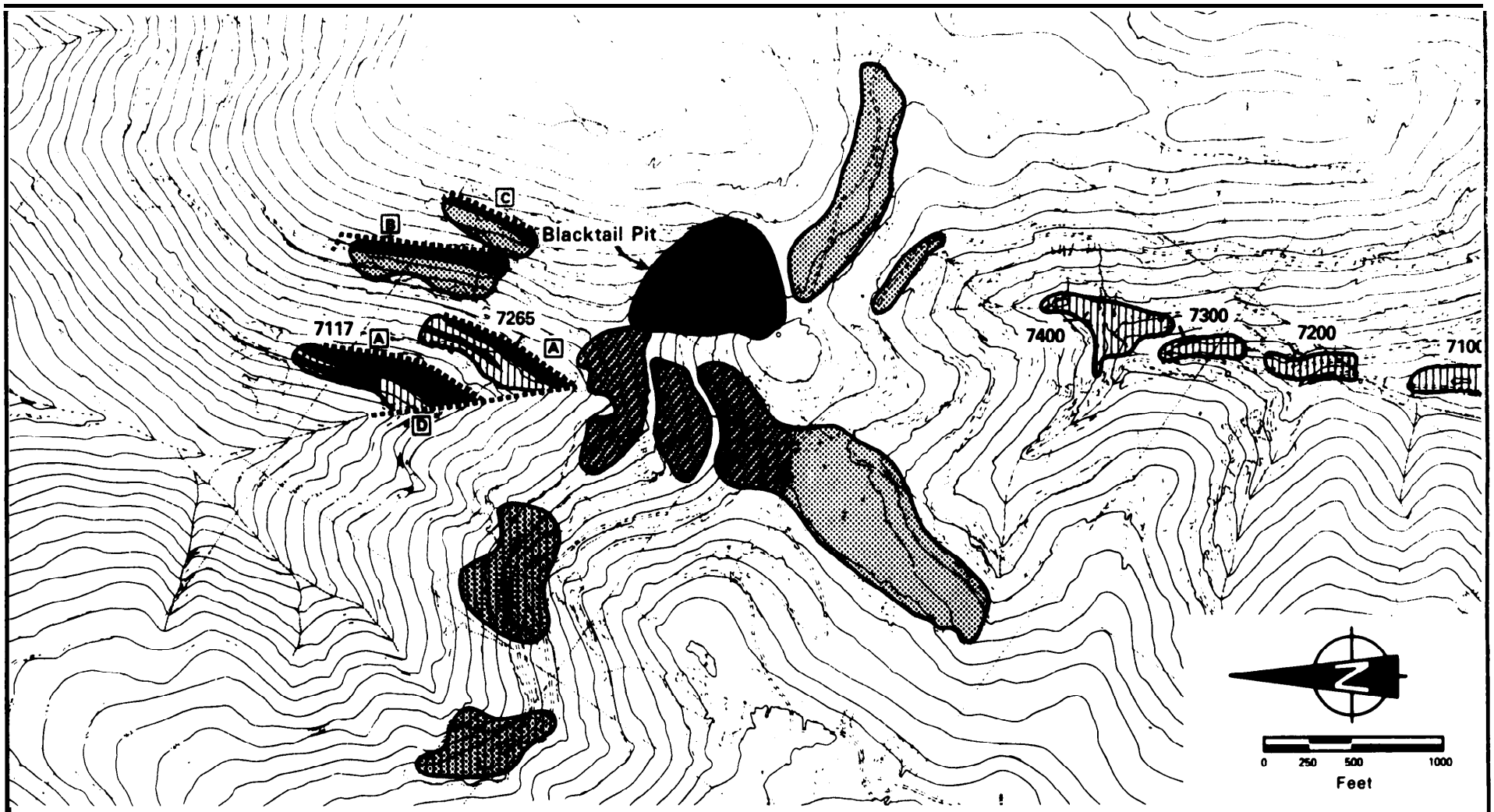
DIVERSION DITCH

WASTE ROCK CAPPED AND REVEGETATED

BORE HOLE

DIVERSION DITCH TYPES
(See Section A4.2)

Figure 7 BUCKTAIL DRAINAGE ALTERNATIVE 2A



WASTE ROCK PILE TO BE REVEGETATED

DIVERSION DITCH

WASTE ROCK EXCAVATED AND PLACED IN PIT; AREA REVEGETATED

WASTE ROCK PILE CAPPED AND REVEGETATED

DIVERSION DITCH TYPE
(See Section A4.2)

Figure 8 BUCKTAIL DRAINAGE ALTERNATIVE 2B

Cost Estimates for Selected Abatement Programs

Conceptual level cost estimates formulated for each of the alternatives are presented in Table 2. The estimates include a 10 percent contingency and are for construction costs only. The total construction cost of Alternative 1 was estimated to be about $3.4 to $3.8 million, depending upon whether the pumping scheme or the gravity scheme is selected. O&M costs of $600,000 include $400,000 per year for treatment plant operation and an allowance of $200,000 per year for maintenance of the ditches, waste pile vegetation cover, and the contaminated water collector system. The total construction costs for Alternative 2 vary from $5.7 to $8.2 million, depending upon whether the open pit is backfilled with the waste rock deposited in the headwaters of Bucktail Creek. An allowance of $200,000 per year is included for maintenance activities.

Implementation Schedule

Many uncertainties exist in determining the water quality requirements necessary to re-establish the fishery resource in Panther Creek and its tributaries. There are additional uncertainties in predicting the effects of specific abatement measures on the overall water quality of Panther Creek. Consequently, a phased approach to implementing the abatement program is warranted.

From all available information, the Bucktail drainage is by far the larger contributor to present water quality problems in Panther Creek. In addition, a greater improvement in water quality can be achieved by an incremental expenditure for abatement measures in the Bucktail drainage than with those in the Blackbird drainage. Therefore, initial efforts should be directed toward program measures in the Bucktail drainage. A simplified schedule for implementing the Bucktail abatement program has been developed and is presented in Figure 9. The schedule assumes that the decision to proceed is made before March 1, 1986.

Table 2

CONSTRUCTION COST ESTIMATES FOR ALTERNATIVES 1 AND 2

ltem Item	cost ($l000s) Alternative 1 (Treatment)		Alternative 2 (Non-treatment)	
Blackbird Drainage				
Construct flow diversion ditches	796		796	
Improve Meadow Creek	337		337	
Cap flat surfaces of waste piles			1,342	
Revegetate waste piles	204		204	
Construct contaminated water collection system	229			
Replace Blackbird Creek culvert	284			
Total	1,850		2,679	
Seal Mine Adits	-		1,400	
	Alternative 1A	1B	Alternative 2A	2B
Bucktail Drainage				
Construct flow diversion adits	714	714	714	714
Cap flat surfaces of waste piles			537	537
Revegetate waste piles	124	124	148	148
Install Blacktail Pit drain	217	217	217	-
Backfill Blacktail Pit				2,706
Divert 7117 and 7265 adit flows	20	20	-	-
install borehole to 6850 level	845		-	-
Divert (via gravity) and pump		440		
Total	1,920	1,515	1,616	4,105
Total Construction Costs	3,770[a]	3,365[a]	5,695[b]	8,184[b]
Total O&M Costs	-	600/yr		
Total Maintenance Costs			-	200/yr

a Costs assume existing treatment plant is available for water treatment. Costs do not include engineering, geologic investigations, or water quality monitoring.

b Costs do not include engineering, geologic investigations, or water quality monitoring.

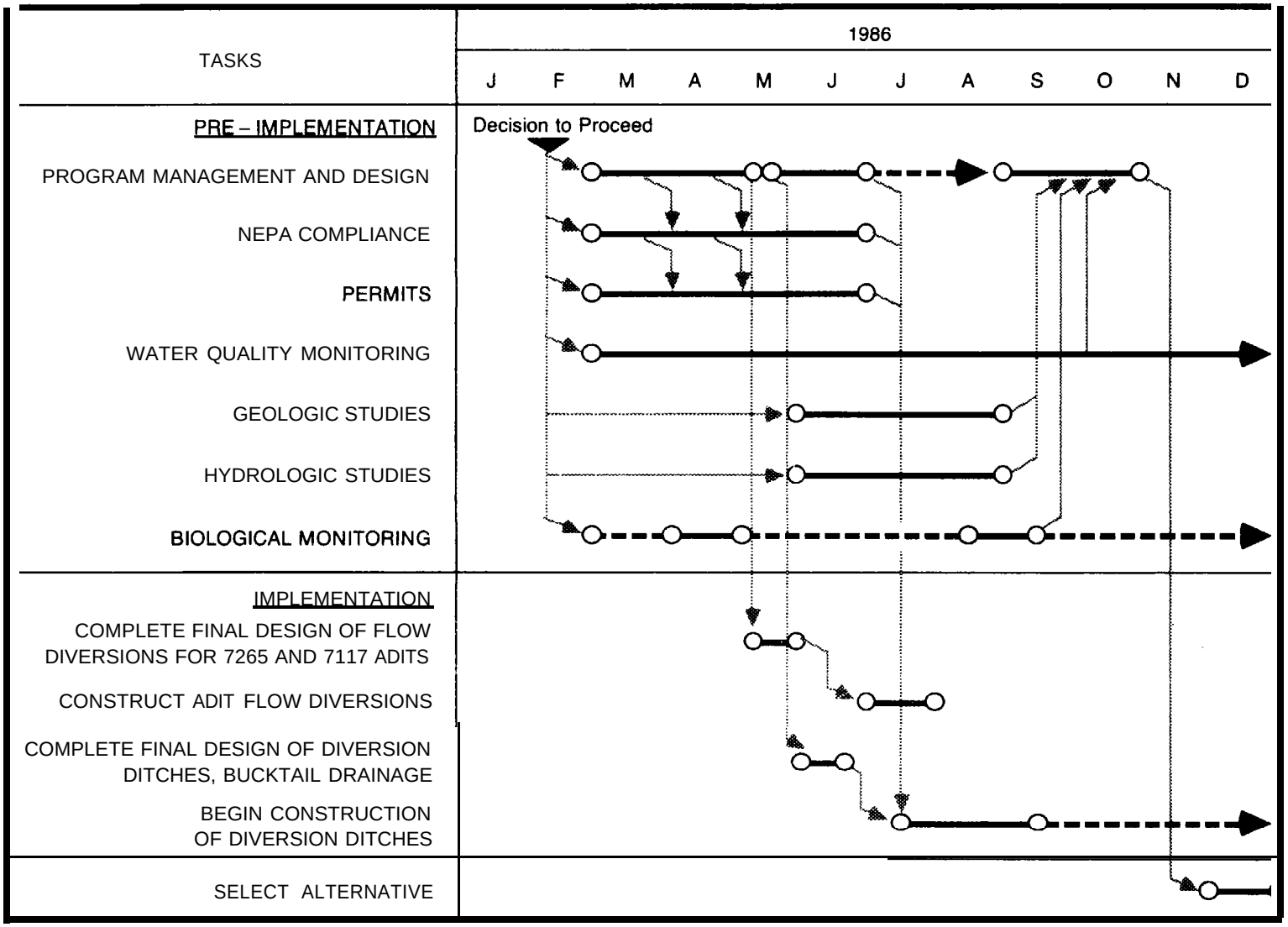


Figure 9 PROPOSED IMPLEMENTATION SCHEDULE FOR ABATEMENT PROGRAM – 1986, BUCKTAIL DRAINAGE

PHASE III: FISHERIES HABITAT SURVEYS

Phase III activities involved conducting detailed habitat surveys in portions of seven streams within the Panther Creek drainage (Figure 2).

Smolt Production Estimates

Based on the results of the surveys, two independent estimates of smolt production were made: one based on spawning habitat, the other on rearing. For spawning, the estimates were made corresponding to redd-area requirements of 36 ft^2 for chinook and 58 ft^2 for steelhead. The chinook rearing estimates were made based on spatial needs of 0.096 fish/ft^2. The steelhead estimates were based on average density information for yearling I+ and II+ age fish (0.0057 fish/ft^2).

Based on spawning area and number of redds for the field measured flow, an estimated 847,080 chinook and 173,746 steelhead smolts could be produced in the Panther Creek Drainage (Table 3). The 847,080 chinook smolt estimates included 562,380 smolts from Panther Creek and 284,700 smolts from the four tributary streams. Of the 173,746 steelhead smolts, Panther Creek provided 122,952, and the tributaries provided 50,794. The majority of smolt production potential based on spawning occurs upstream from both Big Deer Creek (about 95 percent) and Blackbird Creek (about 80 percent).

Smolt production estimates based on rearing habitat were in all cases substantially lower than those for spawning. The chinook estimates included 170,677 from Panther Creek and 44,862 from the four tributaries (Table 3). Estimates of steelhead production followed a similar trend, with Panther Creek contributing 29,697 and the tributaries 6,912. The differences in smolt estimates for spawning and rearing imply that chinook and steelhead production is limited by available rearing habitat. In contrast to the estimates derived from spawning, the majority of smolt production potential based on rearing occurs downstream from Big Deer and Blackbird creeks. For both chinook and steelhead, about 42 percent of the smolt production would occur below Big Deer Creek, and 69 percent below Blackbird Creek. These estimates illustrate the significance of the lower reaches of Panther Creek for production and

Table 3

ESTIMATED CHINOOK AND STEELHEAD SMOLT PRODUCTION IN THE PANTHER CREEK DRAINAGE BASED ON SPAWNING AND REARING HABITAT AT THE FIELD MEASURED FLOW

Stream	Measured Flow (cfs)	Estimated Number of Smolts			
		Spawning Measured Flow		Rearing Measured Flow	
		Chinook[a]	Steelhead[b]	Chinook[a]	Steelhead[b]
Clear Creek	22	29,796	1,853	15,709	2,403
Lower Moyer Creek	16	47,112	8,502	4,178	656
Upper Moyer Creek	16	119,184	33,572	14,827	1,992
Musgrove Creek	9	76,128	5,668	6,825	1,371
Deep Creek	10	12,480	1,199	3,323	490
Panther Creek	variable	562,380	122,952	170,677	29,697
Total		847,080	173,746	215,539	36,609

[a] Numbers derived from chinook redd area estimates of 35.5 ft^2/redd

[b] Numbers derived from steelhead redd area1 estimates of 58 ft^2/redd

emphasize the need for reclamation/abatement measures on the Blackbird Mine to attain the necessary water quality levels to allow complete fish habitation throughout Panther Creek.

Economic Analysis

Economic evaluations were subsequently made to estimate the value of restoring the Panther Creek drainage to production. The economic evaluation was conducted for the range of smolt estimates determined for spawning and rearing habitat, as well as the median value between the two. The number of chinook and steelhead adults returning to Panther Creek were estimated using survival rates based on returns to the IDF&G Pahsimeroi Hatchery. For chinook, the smolt-adult survival rate was 0.50 percent, for steelhead the rate was 1.0 percent (M. Reingold, IDF&G 1985). These rates were applied to the smolt production estimates for rearing to obtain minimum adult return estimates, and to the estimates for spawning to obtain maximum estimates. Such estimates resulted in a range of returning adults of from 1,077 to 4,235 for chinook and from 366 to 1,737 for steelhead; median values for chinook and steelhead were 2,657 and 1,051, respectively (Table 4). These values also reflect the numbers of fish available for harvest in the Columbia, Snake, and Salmon rivers as well as in the Panther Creek system given a 1:l catch/ escapement ratio. From a biological perspective, the median values probably give the best overall estimate of the salmonid production potential in Panther Creek.

The net annual monetary value of restoring chinook and steelhead to Panther Creek was determined using two net value per adult estimates: $137/chinook and 106/steelhead, and $290/chinook and $240/steelhead. Using these estimates, the total annual benefit (based on median smolt values) ranged from $476,505 to $1,026,974 per year (Table 4).

The present worth of the annual benefits were subsequently determined using an interest rate of 7-7/8 percent and assuming that the benefits would be valid for perpetuity. This was done for two separate cases that assumed immediate adult returns at the end of the first year, and a five-year delay in adult returns (Table 4).

Table 4

NET ANNUAL MONETARY AND PRESENT WORTH VALUE OF CHINOOK AND STEELHEAD RESTORED TO THE PANTHER CREEK DRAINAGE[a]

Species/Cost Estimator	No. Smolts	Restored Adults	Annual Benefit ($) Basis[b]	Annual Benefit ($) Basis[c]
Chinook	531,309	2,657	364,647	770,530
Steelhead	105,178	1,051	111,858	256,444
Total Annual Benefit			476,505	1,026,974
Present Worth				
Immediate return			6,047,013	13,032,665
Five-year return			4,138,576	8,919,556

[a] Based on median smolt estimates

[b] Adult values of $137/chinook and $106/steehead

[c] Adult values of $290/chinook and $244/steelhead

For comparison, the present worth of the engineering alternatives were calculated using the 7-7/8 percent interest rate and assuming a project life of 50 years (Table 5). The calculation assumed that construction costs were spread over the first 3 years and that operation and maintenance costs start at the end of the third year. In general, the costs of the proposed alternative abatement programs are of the same relative magnitude as the benefits realized through the restoration of the anadromous fish runs.

Table 5

COST AND PRESENT WORTH OF THE FOUR ENGINEERING ALTERNATIVE ABATEMENT PROGRAMS

Alternative	Total Construction Cost	Operation and Maintenance Cost	Present Worth[a]
1A	3,811,000	600,000/yr	10,680,000
1B	3,406,000	600,000/yr	10,331,000
2A	5,739,000	200,000/yr	7,407,000
2B	8,228,000	200,000/yr	9,550,000

[a] Based on 7-7/8 percent interest rate and project life of 50 years

Section 1: Introduction

Section 1

INTRODUCTION

Panther Creek, a tributary of the Salmon River, historically supported large runs of chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (Salmo gairdneri). A gradual decline in these runs occurred during the 1940s when extensive mining activities began in the Blackbird Creek Drainage, a tributary of Panther Creek (USFS 1982). The runs were eventually eliminated from the system by the early 1960s, and today the drainage remains largely uninhabitable due to toxic conditions in Panther Creek imposed by mine drainage.

In 1982, as part of a comprehensive Fish and Wildlife Program for the Columbia River Basin, the Northwest Power Planning Council (NWPPC) adapted a program (Section 700) aimed at increasing wild and hatchery production of anadromous fish. Section 704 (d)(l) of the program specifically lists several streams within the Salmon River Drainage for habitat enhancement projects (NWPPC 1984). Panther Creek was one of the projects to be implemented by the Bonneville Power Administration (BPA) as offsite mitigation. The overall purpose of the project is to achieve full salmon and steelhead production in the Panther Creek basin.

In 1984, Bechtel National, Inc. was contracted by BPA to conduct a multiphase project (Contract No. DE-AC79-84BP17449) focusing on the development of plans for eliminating the source(s) of toxic effluent entering Panther Creek that caused an anadromous fish passage problem. Specific phases included:

- Phase I - Data Acquisition and Review
- Phase II - Mine Reclamation/Effluent Abatement Alternatives
- Phase III - Fisheries Habitat Surveys

The project is a prerequisite for achieving the long-term goal of the NWPPC, which is the reestablishment of viable runs of chinook salmon and/or steelhead trout in the Panther Creek drainage. The project is also responsive to the future goals and objectives outlined in Idaho's Anadromous Fish Management Plan 1984-1990 (Idaho Department of Fish and Game, IDF&G 1984).

This report (prepared in two volumes) presents the results of the project. Volume 1 is organized into seven major sections in addition to Section 1, INTRODUCTION. These include:

- Section 2 - METHODS, which discusses the methods employed in the conduct of each phase
- Section 3 - CHARACTERISTICS OF MINE AREAS, which presents a descriptive overview of the Blackbird Mine area including its geologic and hydrologic characteristics
- Section 4 - PANTHER CREEK DRAINAGE WATER QUALITY, which identifies and discusses the causes and extent of major water quality problems in Panther Creek
- Section 5 - PROPOSED ALTERNATIVE ABATEMENT PROGRAMS, which presents and discusses several alternative programs (and estimated costs) for effluent abatement
- Section 6 - IMPLEMENTATION SCHEDULE, which presents a proposed schedule for implementing the abatement programs
- Section 7 - FISHERY RESOURCE POTENTIAL AND ECONOMIC VALUE, which presents estimates of smolt production in the Panther Creek drainage and provides an estimate of the economic value of the fishery
- Section 8 - DISCUSSION AND RECOMMENDATIONS, which presents an overview of resource management implications if the reclamation plan is implemented, and discusses needed monitoring and follow-on studies

Volume 1 also includes two major appendices. Appendix A provides detailed information for the Phase II activities, and Appendix B presents details for the Phase III activities. Volume 2 includes copies of all the field data collection sheets and computer printouts from the hydraulic and habitat modeling efforts.

1.1 DESCRIPTION OF STUDY AREA

The Panther Creek study area is located in the Salmon River drainage in east central Idaho within the Salmon National Forest (Figure l-l). The Blackbird Mine site lies about 13 ml south of the Salmon River, 21 ml west of Salmon, Idaho, and 9 mi west of the townsite of Cobalt, Idaho.

The area is characterized by steep and rocky slopes; elevations range from 3,000 f above mean sea level (msl) at the mouth of Panther Creek to over 9,000 ft msl on adjacent peaks. Climatic conditions are typical of the Northern Rocky Mountain region, with a wet season (snowpack) extending from November to March, and a dry season from July to September (USFS 1982). Runoff patterns closely follow these seasons, with peak flows occurring mid-May to mid-June and base flows August through December. The area is dominated by a mixture of lodgepole pine (Pinus contorta) and Douglas fir (Pseudotsuga menziesii) intermixed with some spruce (Picea Sp.) and fir (Abies Sp.).

The headwaters of Panther Creek arise near Morgan Creek Summit at an elevation of about 8,000 feet msl. From its headwaters, the stream flows in a north-northwesterly direction for about 44 ml, where it enters the Salmon River. Stream gradients in Panther Creek vary widely, ranging from 1.2 percent in its lower reaches to over 5 percent near its headwaters.

Tributary streams that contribute to the flow of Panther Creek include (in a downstream direction), Opal Creek, Cabin Creek, Fourth of July Creek, Porphyry Creek, Musgrove Creek, Moyer Creek, Copper Creek, Blackbird Creek, Deep Creek, Napias Creek, Big Deer Creek, Beaver Creek, and Clear Creek. Overall stream gradients of the system are steep, ranging from 2.5 percent in Moyer Creek to over 7 percent in Napias Creek. With the exception of Big Deer and Blackbird creeks, many of these streams presently support viable populations of rainbow trout, cutthroat trout (Salmo clarki), brook trout (Salvelinus fontinalis), Bull trout (Salvelinus malma) and mountain whitefish (Prosopium williamsoni). The latter two streams are essentially devoid of any aquatic biota due to toxic mine effluent.

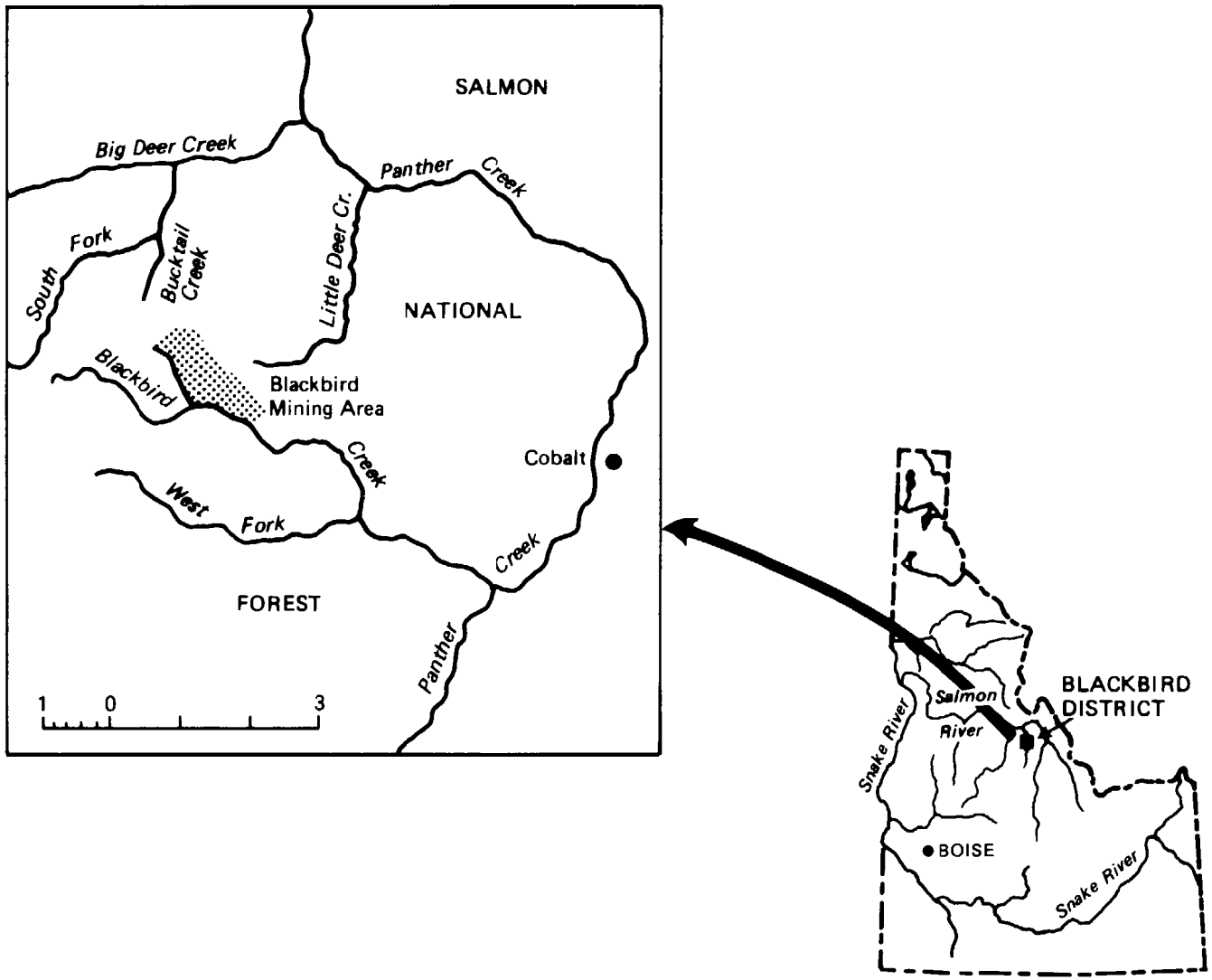


Figure 1-1 PROJECT STUDY LOCATION

Streams that have been identified (M. Reingold, IDF&G 1984; B. May, USFS 1984 pers. comm.) as having potential anadromous salmonid habitat (spawning or rearing) if the toxic effluent problem is resolved include Moyer Creek, Musgrove Creek, Deep Creek, Napias Creek, Beaver Creek, and Clear Creek.

1.2 PROJECT BACKGROUND

1.2.1 Historic Conditions

The Blackbird Creek drainage was identified in the late 1800s as possessing substantial quantities of economically important mineral resources, including cobalt and copper. Active mining in the area began in the 1890s and has continued off and on until the present. The mine has been operated by several different owners, including the Haynes-Stellite Company (operating period 1914-1918), Stevenson operation (operating period 1930s), Calera Mining Company (operating period 1943-1960), Machinery Center (operating period 1963-1966), and the Idaho Mining (Hanna) Company (operating period 1967 to mid-1970s) (Finn 1968). In 1979-1980, Noranda Mining Inc. acquired the property with the intention of reopening the mine for production of cobalt and copper. Baseline studies were conducted in the area and an Environmental Impact Statement (EIS) was prepared (USFS 1982). Noranda has subsequently postponed further developments and the mine is presently inactive.

The loss of anadromous fish runs in the Panther drainage can be linked closely with the level of mining activity and mine practices that occurred at the site. Some of the earliest reports (ca. 1930) on mining in the area suggest that all mine tailings were channeled directly into Blackbird Creek (Finn 1968). Settling ponds and tailing pipelines were subsequently constructed in the 1940s and 1950s. McAuliffe (1985, pers. comm.) suggested that the greatest mine activity occurred in the early to mid-1950s as a result of Department of Defense (DOD) subsidies for obtaining strategic metals. Although some measures for the containment of tailings were in place during this period, the methods often proved inefficient and ineffective, especially during spring runoff. As a consequence, periodic "spills" of tailings often went unchecked into Blackbird Creek (Finch 1954; Pence 1966; Corley 1967), and ultimately into Panther Creek.

In the late 1950s, open-pit mining commenced in the Big Deer Creek drainage. This operation resulted in the excavation and deposition of about 3.8 million tons of waste rock in the headwaters of Blackbird and Bucktail creeks (USFS 1982). In addition, several adits and ventilation shafts were developed in the Bucktail Creek side; some adits are connected with the Blackbird drainage. This development has resulted in contaminated mine drainage entering Big Deer Creek (via Bucktail Creek), which flows into Panther Creek about 12 miles downstream from Blackbird Creek. Panther Creek therefore has two major pathways for recurring toxic effluent: Blackbird Creek and Bucktail Creek.

Fisheries observations made during the above periods attested to the impact of the mining activity. Corley (1967) reported that over 200 dead adult chinook, steelhead, and resident salmonids were found in Panther Creek in 1954. During that year, only 12 redds were observed in the drainage. Subsequent redd counts varied annually for the next 4 years (range 25 to 135), thereafter decreasing to four in 1961 and to zero from 1963 to 1965 (Table l-1). Redd counts were ultimately discontinued after 1968; no redds have been observed during periodic field surveys from 1968 to 1977 (Platts et al. 1979). For comparison, the IDF&G (1984) has estimated that the Panther Creek drainage once supported over 2,000 adult spawners.

1.2.2 Present Conditions

Some of the problems resulting from the early mining operations were corrected in the 1970s. Specifically, the USFS funded a stabilization project for the lower 5,800 ft of Blackbird Creek that included the removal of tailings from the channel (USFS 1976).

In addition, as part of its proposed mining operation, Noranda constructed a mine wastewater treatment facility that currently processes water emanating from the main adit (6,850 ft level). The facility was designed with a treatment capacity of 450 gallons per minute (gpm). The mine normally produces about 90 gpm on a yearly average (R. Hathhorn 1984, pers. comm.). In 1983, the 6,850 adit was plugged (bulkheaded) and the mine allowed to flood; present water elevation in the mine is around 7,000 feet. The water treatment

Table l-l

SUMMARY OF CHINOOK SALMON REDD COUNTS IN PANTHER CREEK, 1954 - 1968

Year	Number of Redds	Comment
1954	12	200 adult chinook killed by acid dump
1955	25	
1956	55	Majority of redds above Blackbird Creek
1957	135	Majority of redds below Blackbird Creek; stream closed to salmon fishing
1958	115	Majority of redds below Blackbird Creek
1959		Water too turbid for observations
1960		Water too turbid for observations
1961	4	Redds located above Blackbird Creek
1962	10	Redds located below Blackbird Creek
1963	0	
1964	0	
1965	0	
1966		No survey
1967		No survey
1968	0	Aerial counts

Data from Corley (1967)
Table modified from ERT (1981a)

plant is presently treating only about 11 to 22 gpm, the amount of water seeping around the plug.

Noranda also instituted several other remedial measures, including debris cleanup in Meadow Creek, and the installation of several culverts for directing water around waste rock (B. Bailey 1984, pers. comm.; USFS 1982).

Recent studies conducted by the IDF&G and the USFS suggest that water quality conditions in Panther Creek just below Blackbird Creek may be improving. Both in 1984 and 1985, the IDF&G conducted 7-day live-car tests using chinook salmon. Low mortalities were observed below Blackbird Creek in the 1984 tests (range 5 to 40 percent), while mortalities ranged from 0 to 5 percent during the 1985 tests (Table l-2). In previous years comparable tests resulted in mortalities ranging from 0 to 100 percent (Platts et al. 1979). Resident salmonids, including rainbow and cutthroat trout have also been periodically captured in Panther Creek below Blackbird Creek (B. May, USFS 1984, pers. comm.). In contrast, conditions below Big Deer Creek show little improvement in water quality; August 1985 live car tests resulted in 95 percent mortality. This was recently confirmed by the IDF&G (1984), which reported observing (snorkel counts) fish in 9 of 10 stations located on Panther Creek (Figure l-2). Only in the station immediately below Big Deer Creek were no fish observed. Additional evidence of some recovery of Panther Creek was provided in September 1984 when several adult steelhead were observed in the lower reaches of the stream.

Since 1983, in an effort to document the water quality conditions in the drainage, the IDF&G; has planted adult steelhead in the Panther Creek drainage above Blackbird Creek (Table l-3). These fish have spawned naturally, and the IDF&G; will be monitoring returns to the system (H. Pollard, IDF&G 1984, pers. comm.). Additionally, the IDF&G has and will continue to plant steelhead smolts in Clear Creek, a lower tributary of Panther Creek (M. Reingold, IDF&G 1984, pers. comm.).

From a biological perspective, a fundamental question remains as to whether present conditions in Panther Creek would actually prevent the successful upstream passage of adults (or downstream migration of smolts) through the

Table 1-2

SUMMARY OF FISH MORTALITY STUDIES IN PANTHER CREEK
(n=20 for all studies, except n=50 for July 1972 and Summer 1967)

Station	Date	Reference[a]	Cumulative Mortality (%) At Time (Hours) 24	48	72	96	120	144	168	192	216	240
Control = just above Blackbird Creek	Summer 1967	1	6		4				-	-	-	
	July 1972	2	2	2		2	2	2	2	2	2	2
	Aug. 1975 [c]	3	0	0	0	0	0		-	-	-	
	Sept. 1975 [c]	3	0	0	0	0	0		-	-	-	
	July 1976	3	0	0	0	0	0		-	-	-	
	April 1977	4	0	0	0		0		-	-	-	
	May 1984 [d]	5	0	0	0	0	0	0	-	-	-	
	May 1985 [d]	6	0	0	0	0	0	0	0	0	0	
	Aug. 1985 [d]	7	0	0	0	0	0	0	0	0	0	
Just below Blackbird Creek	Summer 1967	1			100				-	-	-	
	July 1972	2	0	44		78			-	-	-	86
	Aug. 1975	3	0	0	0	0	5		-	-	-	
	Sept. 1975	3	5	20	50	80	95		-	-	-	
	July 1976	3	10	25	30	30	30		-	-	-	
	April 1977	4	0	50	90		100		-	-	-	
	May 1984	5	0	0	0	0	30	40	-	-	-	
	May 1985	6	0	0	0	0	0	5	5	5	5	
	Aug. 1985	7	0	0	0	0	0	0	0	0	0	

Table l-2

SUMMARY OF FISH MORTALITY STUDIES IN PANTHER CREEK (Continued)
(n=20 for all studies, except n=50 for July 1972 and Summer 1967)

Station	Date	Reference[a]	Cumulative Mortality (%) At Time (Hours) 24	48	72	96	120	144	168	192	216	240
Between Deep and Napias Creek (@ 5 miles downstream of Blackbird Creek)	July 1972	2	0	4		36						48
	Aug. 1975	3	0	0	0	0	0					
	Sept. 1975	3	0	5	10	10	15					
	July 1976	3	10	10	10	10	10					
Above Big Deer Creek	July 1972 [e]	2	0	2		26	40					
	Oct. 1976	3	0	0	0							
	April 1977	4	0	0	0		0					
	May 1984	5	0	0	0	0	0	5				
	May 1985	6	0	0	0	0	0	0	0	0	0	
	Aug. 1985	7	0	5	5	5	5	5	5	5	5	
Below Big Deer Creek	July 1976	3	100	100	100	100	100					
	Oct. 1976	3	0	90	100							
	April 1977	4	0	5	15		20					
	May 1984	5	0	f								
	May 1985	6	0	0	5	5	5	5	10	10	15	
	Aug. 1985 [g]	7	0	48	71	95	95	95	95	95	95	

Table l-2

SUMMARY OF FISH MORTALITY STUDIES IN PANTHER CREEK (Continued)
(n=20 for all studies, except n=50 for July 1972 and Summer 1967)

Station	Date	Reference[a]	Cumulative Mortality (%) At Time (Hours) 24	48	72	96	120	144	168	192	216	240
Mouth of Panther Creek	Oct. 1976	3	0	0	5	-	-	-	-	-	-	-
	April 1977	4	0	0	0	-	5	-	-	-	-	-
	May 1984	5	0	0	0	0	0	0	-	-	-	-
	May 1985	6	0	0	0	0	5	10	15	20	25	
	Aug. 1985	7	0	0	0	0	0	0	0	5	10	-
In Blackbird Creek (@ mouth)	May 1985	6	0	100	-	-	-	-	-	-	-	-
	Aug. 1975	7	0	100	-	-	-	-	-	-	-	-
In Big Deer Creek (@ mouth)	May 1985	6	0	100	-	-	-	-	-	-	-	-
	Aug 1985	7	0	100	-	-	-	-	-	-	-	-

a Sources : 1 - Corley (1967)
2 - IDF&G (1972)
3 - IDF&G (1977)
4 - Jeppson and Ball (1978)
5 - Gard and Reingold (1984)
6 - Torf (1985)
7 - Reingold and Latham (1985)

b - = No result recorded/reported

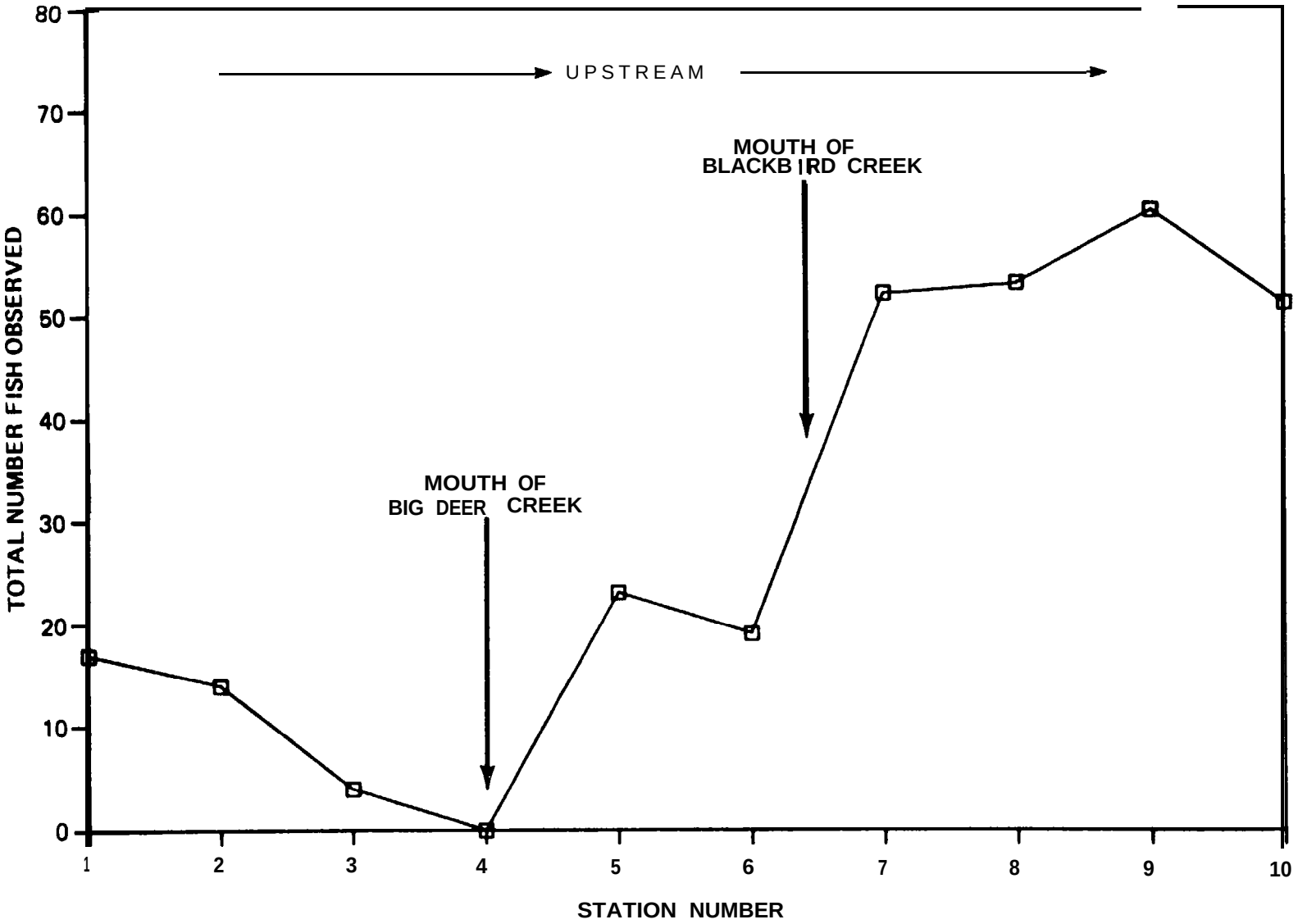
c Aug. measurements taken before, September after, channel dredging in Panther Creek

d Used chinook salmon juveniles on these dates. All other study dates used steelhead/rainbow trout

e Measurement taken just above Little Deer Creek

f Sampling apparatus disappeared on second day

g N = 21 for this sample



DATA FROM IDF&G 1984b

Figure 1-2 SNORKEL COUNTS AT TEN 300 FT SECTIONS PANTHER CREEK, AUGUST 1984

Table 1-3

STOCKING RECORDS FOR PANTHER CREEK, 1968 – 1984
(Idaho Department of Fish and Game)

Year	Species	No. (Pounds)	No. Fish	comment
1968	Hatchery rainbow	1,700	4,510	Released above Blackbird Creek
1969	Hatchery rainbow	950	3,530	Released above Blackbird Creek
1970	Hatchery rainbow	1,350	4,580	Released above Blackbird Creek
1971	Hatchery rainbow	1,700	5,880	Released above Blackbird Creek
1972	Hatchery rainbow	1,905	6,115	Released above Blackbird Creek
1973	Hatchery rainbow	2,000	5,560	Released above Blackbird Creek
1974	Hatchery rainbow	900	3,360	Released above Blackbird Creek
1975	Hatchery rainbow	350	1,575	Released above Blackbird Creek
1976	Hatchery rainbow	335	1,005	Released above Blackbird Creek
1977	Hatchery rainbow	350	700	Released above Blackbird Creek
1978	Hatchery rainbow	500	1,704	Released above Blackbird Creek
1979	Hatchery rainbow	150	555	Released above Blackbird Creek
1980	Hatchery rainbow	775	2,290	Released above Blackbird Creek
1977	Steelhead	25	50,000	
1982	Steelhead	Fry	118,000	
1983	Steelhead	Adults	379	Released above Blackbird Creek
1984	Steelhead	Fry	265,000	
	Steelhead	Fry	40,000	Released in Musgrove Creek
	Steelhead	Adult	677	Released above Blackbird Creek
1977	Chinook salmon	245	46,305	

Data from IFG&G files.

affected reach. Present IDF&G studies suggest that the system is in a borderline condition which may or may not allow passage depending on streamflow and runoff characteristics (M. Reingold, IDF&G 1985, pers. comm.). The answer to the question may be forthcoming in 1987-88 when adult steelhead produced from the 1983 year class will be attempting to return to the upper Panther Creek drainage.

1.3 OBJECTIVES

This study was undertaken to formulate a reclamation and effluent abatement program that would allow the reestablishment of both anadromous and resident fish throughout Panther Creek. Major objectives of the study were to:

- Review literature and data pertaining to mining activities and fisheries habitat in the Panther Creek drainage
- Locate and define the sources, characteristics, and quantities of toxic effluents entering Panther Creek
- Formulate engineering alternatives for eliminating toxic effluents entering Panther Creek
- Conduct fisheries habitat surveys in Panther Creek and selected tributaries, and estimate steelhead trout and chinook salmon production
- Evaluate the alternatives and the estimated economic value of the potentially reclaimed habitat, and present a recommended program for effluent abatement and habitat enhancement

Section 2: Methods

Section 2

METHODS

The project was conducted over a 12-month period beginning in September 1984. Methods used to accomplish each of the phases noted in Section 1 are presented below. A more detailed explanation of the methods used and results obtained are provided in Appendices A (Phase II) and B (Phase III) of this report.

2.1 PHASE I: DATA ACQUISITION AND REVIEW

A substantial amount of information exists concerning the Blackbird Mine site and regionalized biology. As background for preparing alternative reclamation plans, Bechtel conducted an extensive review of published and unpublished information and data relevant to the water quality and aquatic ecosystems of the Panther Creek drainage. Of particular value were the reports of Baldwin et al. (1978), Farmer et al. (1976), Farmer and Richardson (1981), Richardson and Farmer (1981), USFS (1982), Davis (1972), ESA (1981), and the various baseline reports prepared by Environmental Research and Technology (ERT) in 1980-81 (ERT 1980, 1981a, 1981b, 1981c, 1981d, 1981e).

Most information related to the mine site was obtained directly from Noranda Inc. via Mr. Brent Bailey (Noranda's Environmental Coordinator) and Mr. Ray Hathhorn (Mine Superintendent). The information included monthly detailed water quality data collected at various sites in the drainage (Noranda 1980), as well as detailed maps of the mine property. These data were used extensively in formulating engineering alternatives.

Additional data pertaining to the site were obtained from state and federal agencies including:

- Idaho Department of Health and Welfare (IDH&W) - historic and present water quality data; water treatment plant specifications

- U.S. Environmental Protection Agency (EPA) - present and proposed National Pollution Discharge Elimination System (NPDES) permits for the mine site
- U.S. Geological Survey (USGS) - discharge and flood frequency data
- U.S. Forest Service (USFS) - fisheries habitat data, aerial photographs, land ownership, hydrologic data
- Idaho Department of Fish and Game (IDF&G) - historical and present fisheries data (redd counts, live car tests, stocking records)

2.2 PHASE II: FORMULATION OF ALTERNATIVES

This phase focused on defining the source(s) and extent of contaminants emanating from the Blackbird Mine area and formulating conceptual engineering alternatives (and associated costs) for abating the toxic effluent problem in Panther Creek.

2.2.1 Identification of Contaminant Sources

To properly formulate and evaluate potential abatement measures, it was necessary to identify and quantify sources of contaminants entering Panther Creek. In this regard, Bechtel conducted a combined hydrology/geology field program in portions of the Panther Creek drainage affected by the Blackbird Mine. The program included separate fall and spring field surveys, the first completed during a l0-day period from September 11-21, 1984, the second during a 5-day period from May 13-17, 1985.

For the fall surveys, 31 stations were established along the Bucktail Creek drainage (Figure 2-l) and 45 stations along the Blackbird Creek/Meadow Creek drainage (Figure 2-2) from which selected water quality measurements were made (See Appendix A, Section A2 for a discussion of sources of pollution to Panther Creek.). During the survey, tailings and dredge material and various portals and waste piles were located and mapped. In addition, a regional study of water quality was performed to identify other potential sources of contaminated water to Panther Creek. A similar, although abbreviated, program was conducted in the spring of 1985.

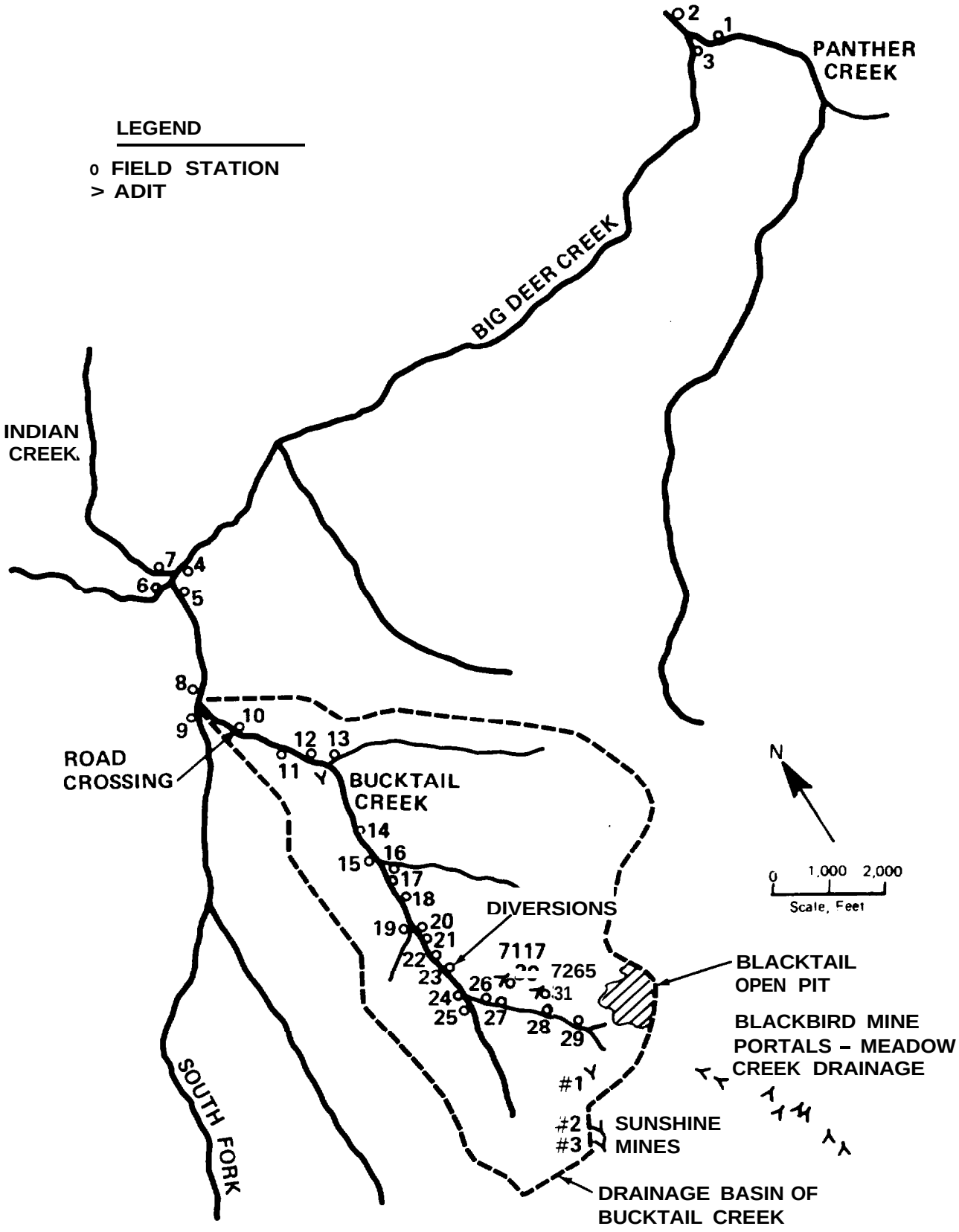


Figure 2-1 BUCKTAIL CREEK DRAINAGE, FIELD SAMPLING LOCATIONS, FALL 1984

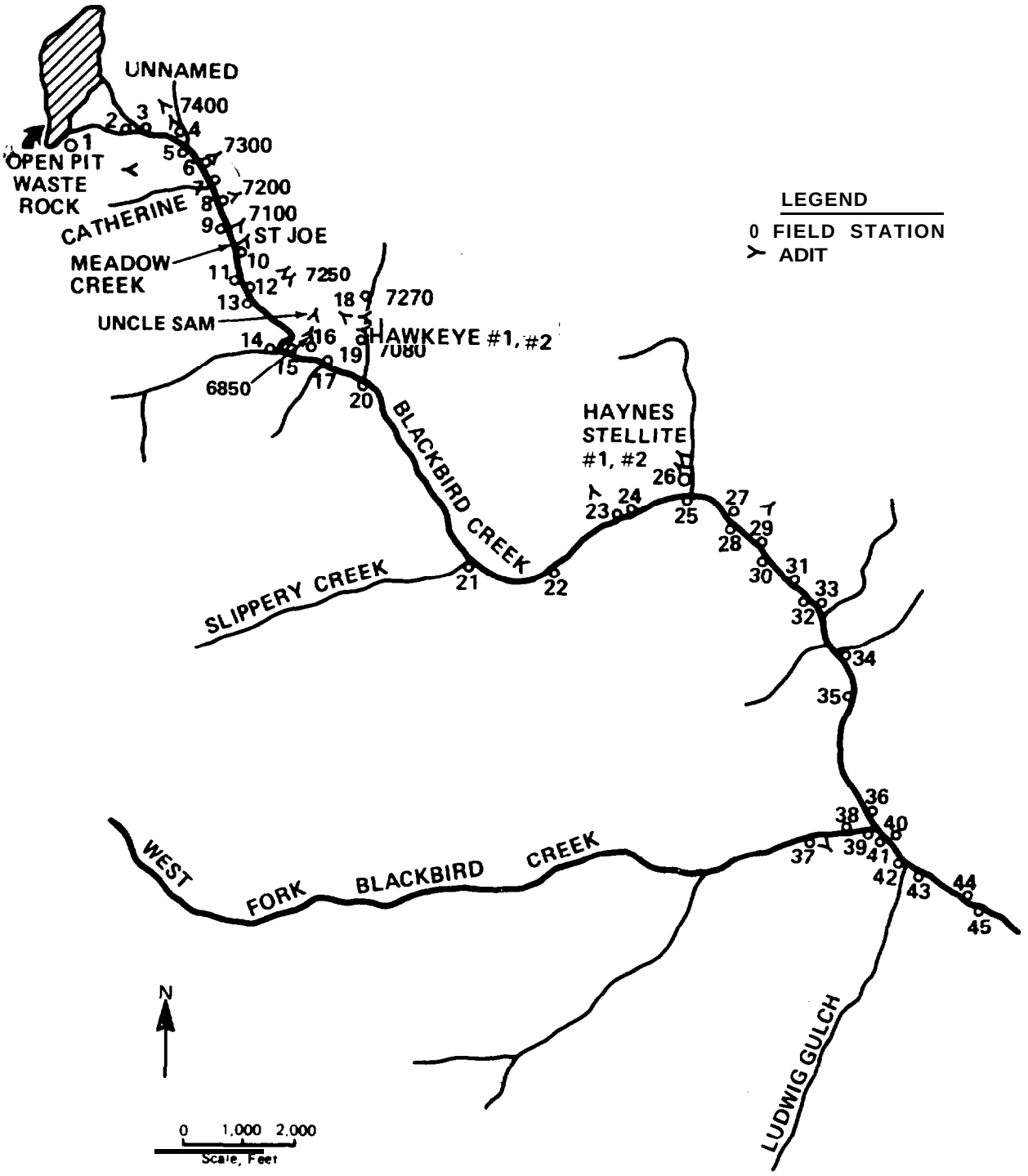


Figure 2-2 BLACKBIRD CREEK DRAINAGE, FIELD SAMPLING LOCATIONS, FALL 1984

2.2.2 Formulation of Alternatives

The formulation of alternatives was predicated on eliminating the sources of toxic effluents entering Panther Creek, thereby allowing the re-establishment of anadromous fish throughout the drainage. This objective required defining a target copper concentration in Panther Creek deemed acceptable for fish production and to which remedial measures could be designed.

From a review of literature and discussions with state and federal agencies, a total copper concentration of 0.05 mg/l was selected as the "not-to-exceed" criterion for the sections of Panther Creek just below Blackbird and Big Deer Creeks. This concentration level includes copper in both the dissolved and suspended states, with the apportionment of each dependent on the buffering capacity and pH of Panther Creek. Overall, it is anticipated that attainment of the criterion will result in dissolved copper concentrations in the affected reach of Panther Creek in the range of 0.01 to 0.02 mg/l, depending on the background levels above Blackbird Creek. The reader should refer to Appendix A for a more detailed discussion of the rationale for the criterion selection.

Once the target water quality levels were selected, specific engineering concepts were formulated. Special attention was given to developing concepts that would be compatible with future mining operations at the site. Initially in this effort a comprehensive list of remedial measures was compiled relative to each contaminant source. Measures considered included:

- Divert clean water around waste piles
- Divert and collect contaminated water to treatment facilities
- Treat all contaminated water
- Chrry out in situ treatment (e.g., instream limestone treatment)
- Fili-in Blacktail Pit with waste rock and seal
- Remove waste rock - place in new disposal area
- Regrade - seal (clay line) - revegetate wastepiles and tailings dam

- Seal mine adits (mine inactive)
- Seal drill holes
- Seal and shape surface depressions
- Remove tailings from within Blacktail channel
- Construct storage reservoir for controlled flow releases
- Temporarily store runoff in mine (mine inactive)
- Construct sediment retention ponds
- Channelize/dredge Blackbird Creek

This list was the basis for formulating conceptual engineering alternatives for eliminating the toxic effluent problems in Panther Creek. In general, the alternatives were organized into two main headings, those with treatment and those without.

Separate alternative abatement programs were identified for the Bucktail and Blackbird drainages although some inter-drainage dependency existed for specific measures selected. This was primarily associated with measures in the Bucktail drainage. For example, a diversion and treatment option (i.e., direct contaminated water to the Blackbird side for treatment) on the Bucktail side would also require use of treatment on the Blackbird side. However, the plans were, in general, sufficiently flexible to allow intermixing or substituting specific remedial measures between the different alternatives.

Order-of-magnitude cost estimates were subsequently made for each of the alternative schemes. Appendix A, Section A5 presents the detailed work sheets used for making the engineering cost estimates.

2.3 PHASE III: FISHERIES HABITAT SURVEYS

As part of the stream enhancement study, detailed habitat surveys were conducted in portions of eight streams within the Panther Creek drainage (Figure 2-3). Specific reaches included five sites on Panther Creek, two

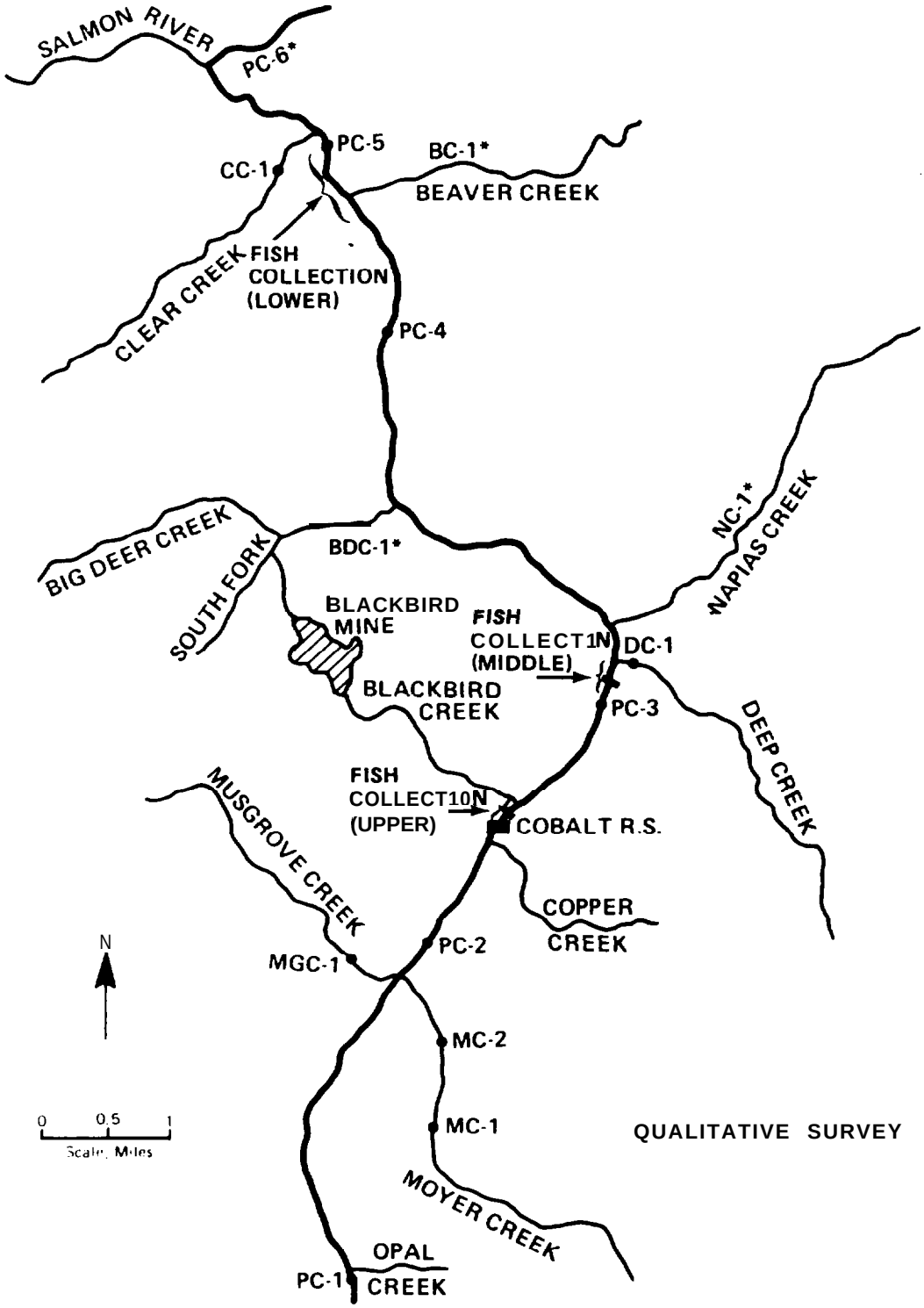


Figure 2-3 FISHERIES HABITAT STUDY STATIONS AND FISH COLLECTION SITES, (FOR TISSUE ANALYSIS) LOCATED IN THE PANTHER CREEK DRAINAGE, FALL 1984AND 1985

sites on Moyer Creek, and single sites on Musgrove, Deep, Napias, Big Deer, Beaver, and Clear creeks. The majority of the field studies were completed during a 20-day period extending from September 11-30, 1984; Big Deer Creek was evaluated during a field trip that occurred from September 9-12, 1985. A fish tissue analysis study was also conducted as part of the fall 1985 sampling. This study was conducted to determine the potential human health hazards from the consumption of fish taken from Panther Creek below Big Deer and Blackbird creeks (see Appendix B, Section B1.8).

The streams all have potential for anadromous fish production should the toxic mine effluent problem be resolved. Results of the habitat surveys were used to estimate potential smolt production and the economic value of restoring chinook and steelhead runs to the drainage. The detailed methods and results of the surveys are presented in Appendix B, Sections Bl and B2.

The habitat surveys were coordinated with fisheries biologists from the USFS (Bruce May) and the IDF&G (Mel Reingold, Herb Pollard, and Terry Holubetz). In particular, the IDF&G had recently completed several qualitative fish surveys at stations throughout the Panther Creek drainage (T. Holubetz, IDF&G 1984, pers. comm.). To the extent possible, habitat stations were selected in close proximity to the IDF&G stations.

The surveys included both qualitative and quantitative habitat assessments. The qualitative evaluations were made using procedures modified after the General Aquatic and Wildlife System (GAWS) method (USFS 1976) and the Stream Reach Inventory and Channel Stability Index (SRI CSI; Pfankuch 1975). The quantitative assessments were conducted using the U.S. Fish and Wildlife Service (USFWS) Instream Flow Incremental Methodology (IFIM; Bovee 1982; Milhous et al. 1984). Use of the IFIM and its computer support software, Physical Habitat Simulation System (PHABSIM), provided a means of estimating habitat as a function of streamflows. For the Panther Creek project, independent estimates were made for chinook salmon and steelhead trout spawning and juvenile rearing habitat.

Smolt production estimates were subsequently made based on the available spawning and juvenile rearing habitat in the drainage, and on fish spatial requirements (e.g., smolt densities, redd area). For juvenile habitat, smolt production for both species was estimated for each stream as:

Total no. smolts (at limiting flows) =

Total juvenile habitat (ft^2) x spatial needs of smolt ($smolt/ft^2$)

Steelhead spatial needs were estimated at 0.0057 $fish/ft^2$, which is the average density of age I+ and II+ SH as reported for several Idaho streams in Reiser and Bjornn (1979). Chinook salmon spatial requirements were estimated at 0.096 $fish/ft^2$.

For spawning, smolt production estimates were based on the following:

- Redd area1 estimates corresponding to the average field measured area of a redd (Burner 1951; Orcutt et al. 1968; Reiser and Bjornn 1979):

Species	Average area of redd (ft^2)
SH	35.5
CK	58.1

- Fecundity of females (no. of eggs) estimated at

  SH - 3,500 (Bell 1973)

  CK - 5,000 (Bell 1973)

- Percent survival - egg to alevin

  25 percent survival (0.25)

- Percent survival - alevin to fry

  50 percent survival (0.50)

- Percent survival - fry to juvenile (smolt)

  - 25 percent survival (0.25)

Thus, the estimated number of smolts/redd for SH and CK was 109 and 156, respectively.

As a final step in the analysis, an evaluation was made of the economic value of the fishery should the habitat be returned to full production. This evaluation was made in part using data from the Galloway Dam Model (Army Corps of Engineers, ACOE 1985), which is based on survival and mortality rates (smolt to ocean, ocean to adult), harvest rates, and economic worth of harvested fish (sport and commercial catch).

Section 3: Characteristics of Mine Areas

Section 3

CHARACTERISTICS OF MINE AREAS

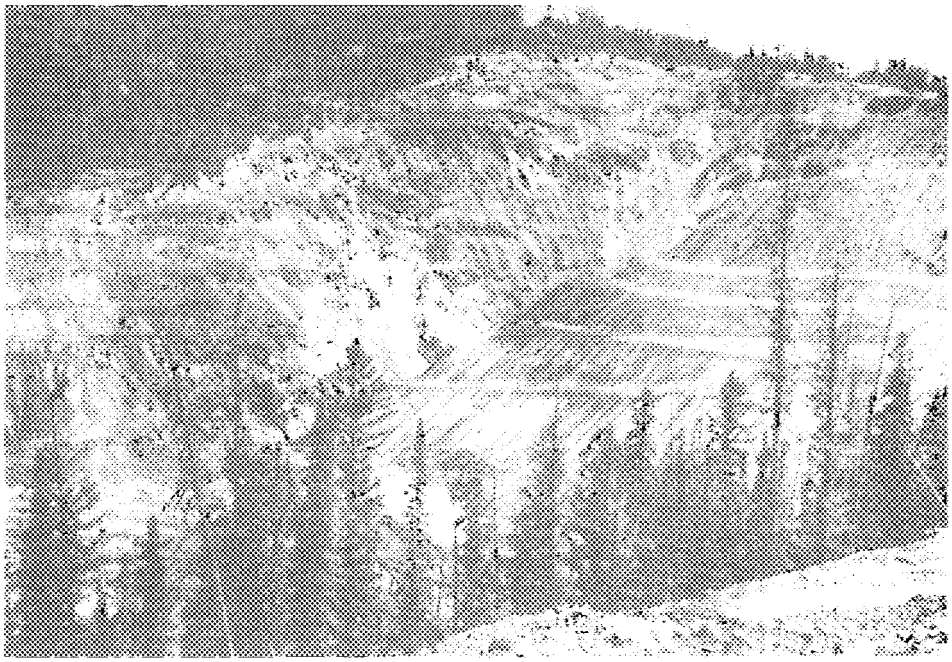
This section presents an overview of the mine area, including a discussion of the geologic and hydrologic characteristics and major contamination sources. The information presented was compiled from existing reports and documents (USFS 1982; Baldwin et al. 1978; ESA 1981; and others) as well as data collected during this study.

3.1 MINE FFATURES AND PROPERTY BOUNDARIES

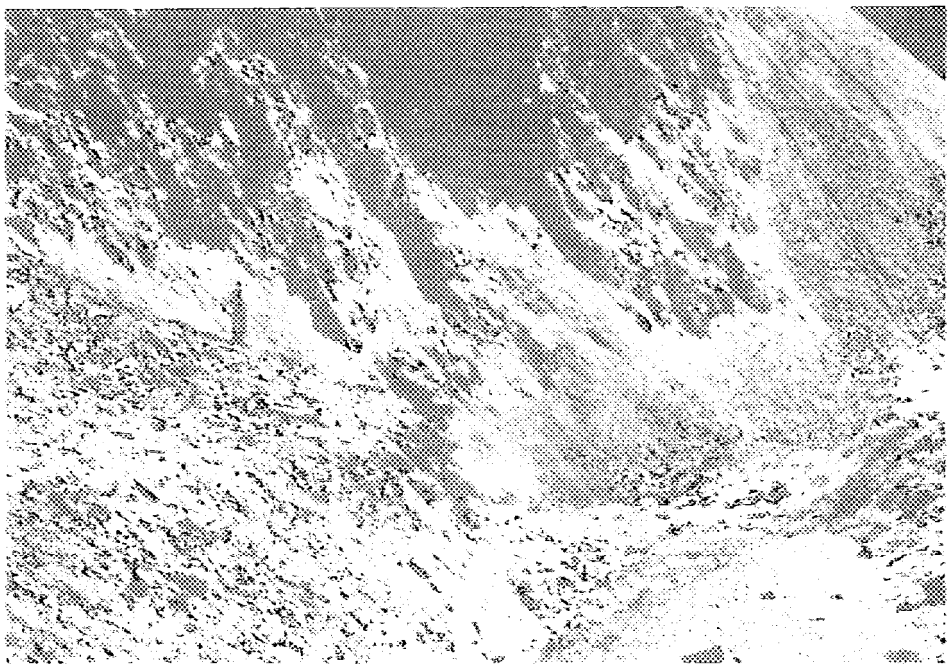
The Blackbird Mine area is located within the Cobalt Ranger District of the Salmon National Forest and includes portions of two drainage areas, the Meadow Creek/Blackbird Creek drainage, and the Bucktail Creek drainage. Both drainages contain patented mine lands.

Major features of the mine area include the mine and mill complex; a 12-acre open pit (Blacktail Pit); several waste rock piles, the largest of which is from the open pit and contains about 3.8 million tons of material; a tailings impoundment located on the West Fork of Blackbird Creek (containing about 2 million tons oftailings); more than 15 adits and portals; and numerous graded roads. Figures 3-l through 3-5 depict many of these features as they presently exist. A small pond for potable water is located in upper Blackbird Creek. In addition, three small (about 40 by 40 ft0 abandoned settling ponds are located at the mouth of the South Fork of Big Deer Creek. These structures were constructed and used in the mid-1970s by a private individual (Darrold Slavin) who recovered elemental copper from Bucktail Creek.

Major structures within the mine complex include a crusher building, mill, several off ice and warehouse structures, sedimentation/sludge ponds, and a water treatment plant. This latter structure became operational in 1980 and presently treats seepage water coming from the 6850 adit.



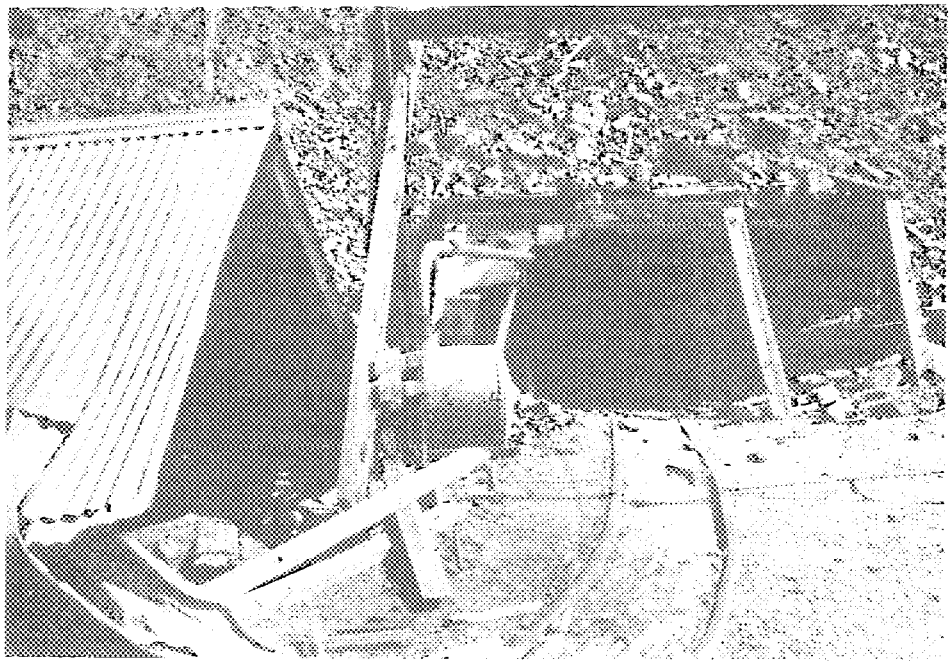
BLACKTAIL OPEN PIT



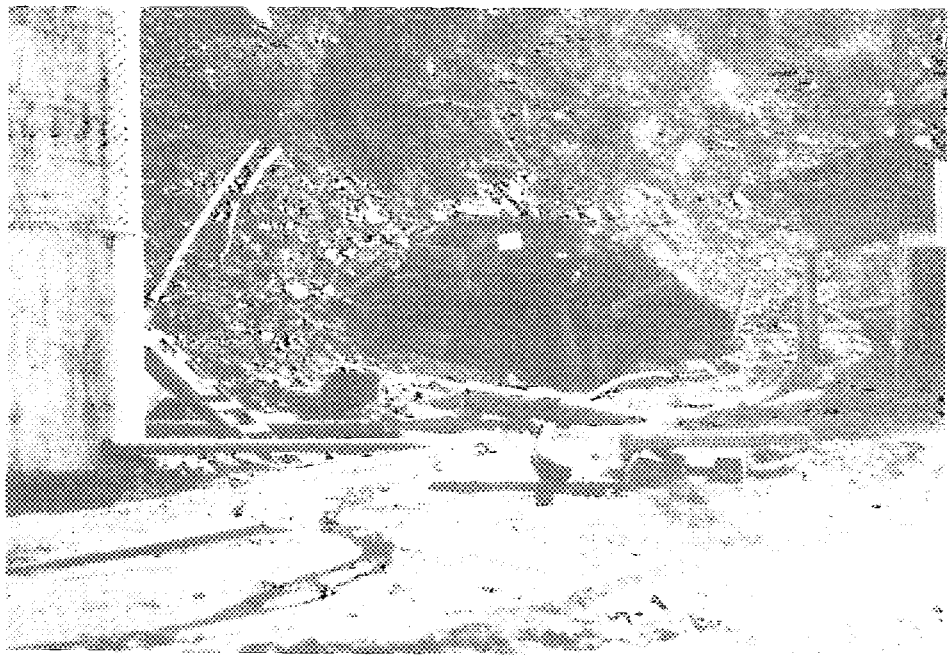
VIEW LOOKING INTO BLACKTAtL PIT

Figure 3-1 PANORAMIC (UPPER) AND CLOSE-UP (LOWER) VIEWS OF THE BLACKTAIL OPEN PIT, BUCKTAIL CREEK DRAINAGE

Figure 3-2 HEADWATERS OF BUCKTAIL CREEK LOCATED JUST BELOW OPEN PIT WASTE PILE (LEFT) AND MOUTH OF SOUTH FORK BIG DEER CREEK AND CONFLUENCE WITH BIG DEER CREEK (RIGHT)

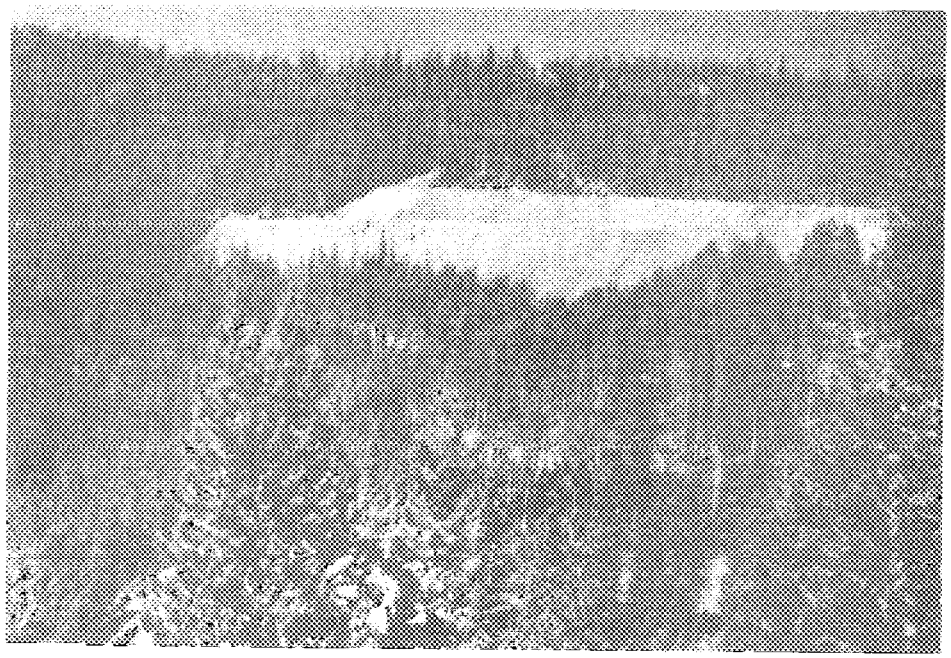


7117 ADIT

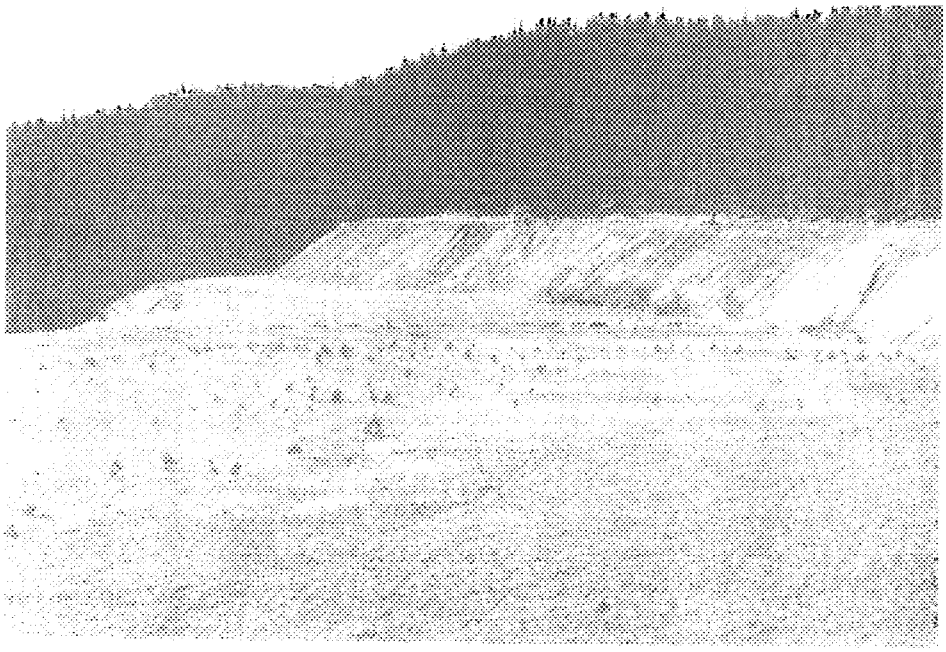


7265 ADIT

Figure 3-3 THE 7117 (UPPER) AND 7265 (LOWER) ADITS LOCATED IN THE BUCKTAIL CREEK DRAINAGE (BOTH CONTRIBUTE ACID MINE DRAINAGE TO BUCKTAIL CREEK.)

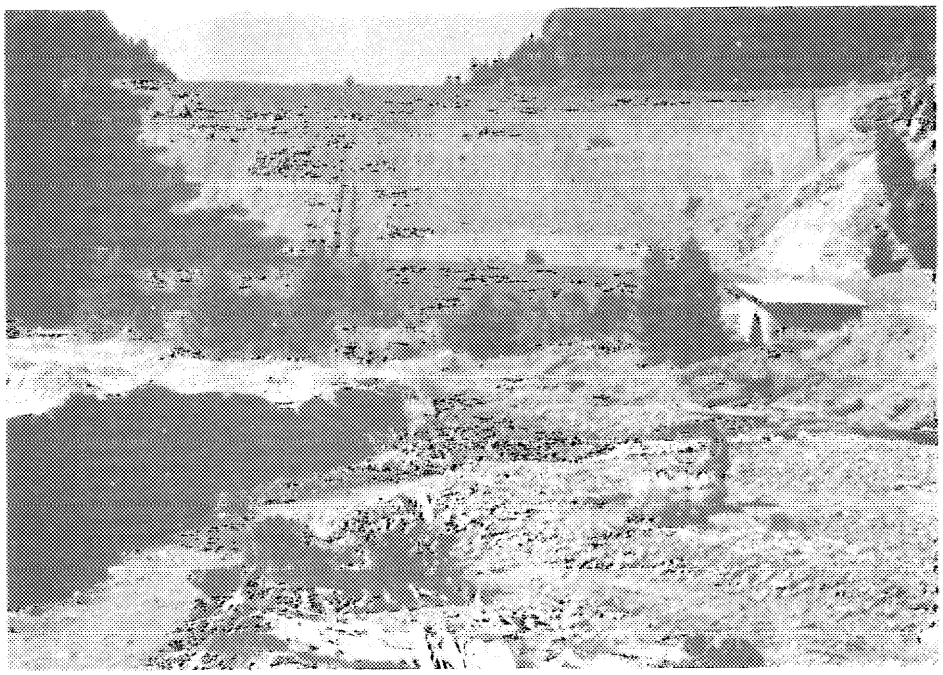


OPEN PIT WASTEPILE

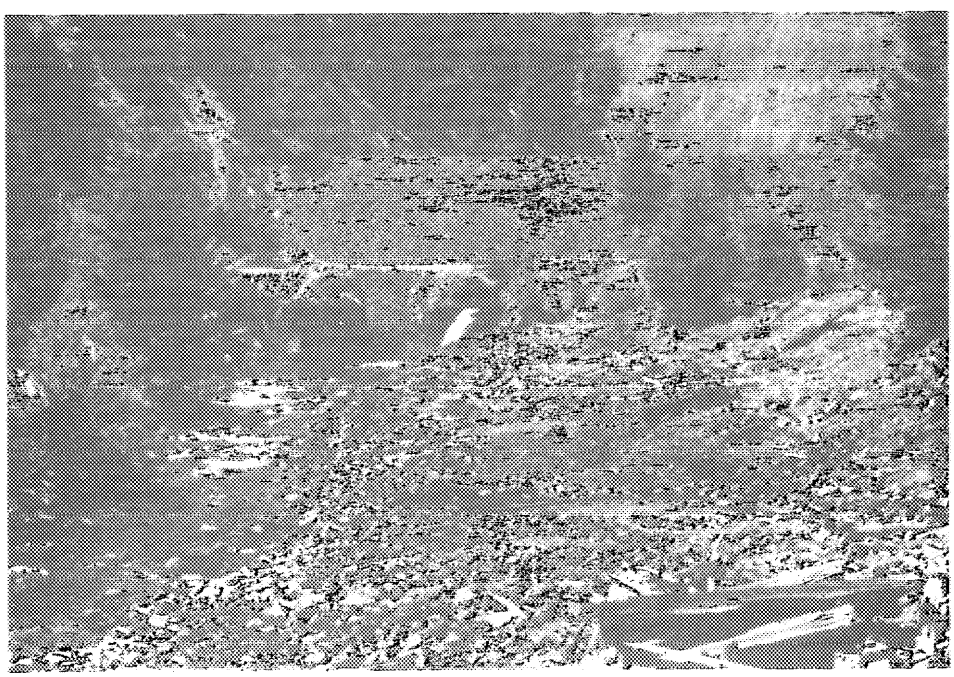


TOP OF OPEN PIT WASTEPILE SHOWING
U.S. FOREST SERVICE REVEGETATION PLOTS

Figure 3-4 PANORAMIC (UPPER) AND CLOSE-UP (LOWER) OF OPEN PIT WASTEPILE. (THE WASTEPILE EXTENDS INTO BOTH THE BLACKBIRD AND BUCKTAIL DRAINAGES.)



WEST FORK TAILINGS DAM



TAILINGS DAM CULVERT (CONFLUENCE OF BLACKBIRD CREEK IS JUST DOWNSTREAM)

Figure 3-5 WEST FORK TAILINGS DAM (UPPER) AND ASSOCIATED CULVERT (LOWER). (THE CULVERT TRANSPORTS THE FLOW OF THE WEST FORK THROUGH THE LENGTH OF THE TAILING DAM.)

3.2 HYDROLOGY

As noted above, the Blackbird Mine area is drained by the Meadow Creek/Blackbird Creek Drainage in the south, and the Bucktail Creek drainage in the north (Figure 2-1 and 2-2). Blackbird Creek flows generally to the southeast and joins Panther Creek about 2 mi upstream from the Cobalt townsite. Meadow Creek and the West Fork of Blackbird Creek are tributaries to Blackbird Creek. The northern side of the mining area is drained by Bucktail Creek. Bucktail Creek flows generally north and joins with the South Fork of Big Deer Creek and eventually with Big Deer Creek. Big Peer Creek flows into Panther Creek about 8 mi downstream from the town of Cobalt. Thus, the two major transporters of contaminants to Panther Creek are separated by about 11 to 12 miles. The drainage area of Blackbird Creek is about 23 square miles while that for Bucktail Creek is approximately 1.7 sq mi.

The climate of the Blackbird Mine area is typical of the mountainous areas of Idaho, with precipitation occurring as thunderstorm rainfall during the summer months and as snowfall during the winter months. Precipitation data collected at the Cobalt townsite between 1961 and 1976 indicates an average annual precipitation of about 18.4 in. (Table 3-l). Monthly averages indicate that precipitation varies only slightly throughout the year. Precipitation measurements made at Cobalt, the Blackbird Mine mill complex, and at the Blacktail Open Pit between October 1979 and November 1979 indicate that precipitation increases with elevation (Baldwin et al. 1978). No snow depth measurements have been recorded in the mine area, but snow does cover much of the mine complex during the winter months. Farmer and Richardson (1980) collected snow samples from the mine area for water quality analysis of heavy metals. The measurements made between 1968 and 1975 by the U.S. Soil Conservation Service on the Williams Creek Summit snow course indicated an average snow depth and water content of 50 and 14.9 in., respectively (USFS 1982).

Streamflow in the region is highest during the snowmelt periods of April, May, and early June. The lowest flows typically occur during the winter months of December and (January when virtually all precipitation falls as snow. Stream discharge has been measured only on an irregular basis for the Blackbird Mine

Table 3-l

MONTHLY AVERAGE PRECIPITATION AND TEMPERATURE FOR COBALT, IDAHO
(Idaho State Climatologist 1981)

Month	Mean Precipitation (in.)	Temperature (OF)		
		Maximum	Minimum	Mean
Jan	1.90	29.5	6.3	17.9
Feb	1.01	38.6	11.2	24..9
Mar	1.29	44.9	16.1	30.5
Apr	1.80	53.9	23.9	38.9
May	1.65	65.7	31.7	48.7
Jun	2.32	74.2	39.3	56.8
Jul	1.50	83.4	42.3	62.9
Aug	1.16	81.7	41.0	61.4
Sep	1.44	71.7	33.7	52.7
Oct	1.30	57.6	26.3	42.0
Nov	1.41	41.7	18.9	30.3
Dec	1.63	29.6	9.3	19.5

Mean Annual Precipitation = 18.41 inches.

Period of Record is 12 to 16 years.

Data from ERT (1981d)

area. The U.S. Geological Survey (USGS) maintained a gage at the mouth of Blackbird Creek during 1971 only. Figure 3-6 depicts the monthly discharge at this gage. The University of Idaho recorded discharges during 1974, 1975, and 1976 on several streams in the mine area. These included numerous spot measurements at several locations in the Blackbird Creek and Big Deer Creek drainages. Other miscellaneous measurements of discharge were also collected by the Idaho Mining Company in 1969 and 1971. However, even combined, the measurements are too sparse to allow the prediction of average or peak flows for any of the streams in the area.

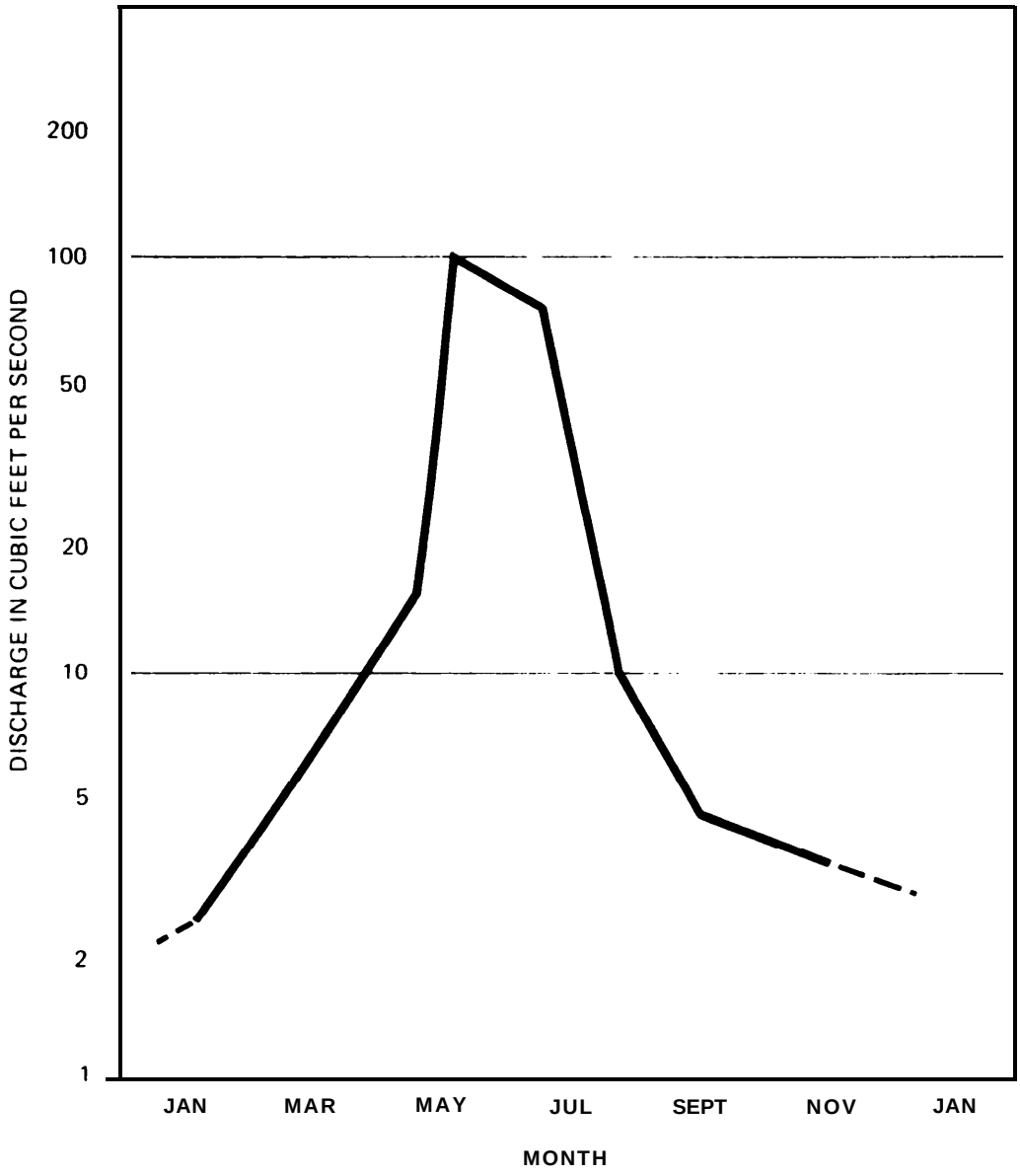
Flood flows in streams within the Blackbird Mine region can occur as a result of thunderstorms, snowmelt, or rain on snow combined with snowmelt. Thunderstorms are generally of short duration and can be expected to produce high peak flows with relatively small volumes of runoff. Snowmelt floods (including rain on snow events) can be expected to produce large volumes of runoff with relatively smaller peaks.

The USGS has studied flood flows for streams in Idaho (Kjelstrom and Moffatt 1981). In their report, regionalized regression equations were developed for the mean and standard deviations of logarithms of annual maximum discharges. The means and standard deviations were used with an assumed Log Pearson Type III distribution to obtain peak-flood frequency values. Using these methods, the peak flood frequency values were plotted and are assumed to be applicable to the streams in the region of the Blackbird Mine (Figure 3-7). The data were generally developed from snowmelt events that tend to control peak flows in larger drainages in Idaho. Values predicted by the USGS publication were increased by 50 percent for design purposes to account for the following:

- Thunderstorms that would probably control peak discharges for the small drainages at the Blackbird Mine
- The large degree of disturbance of the land areas involved

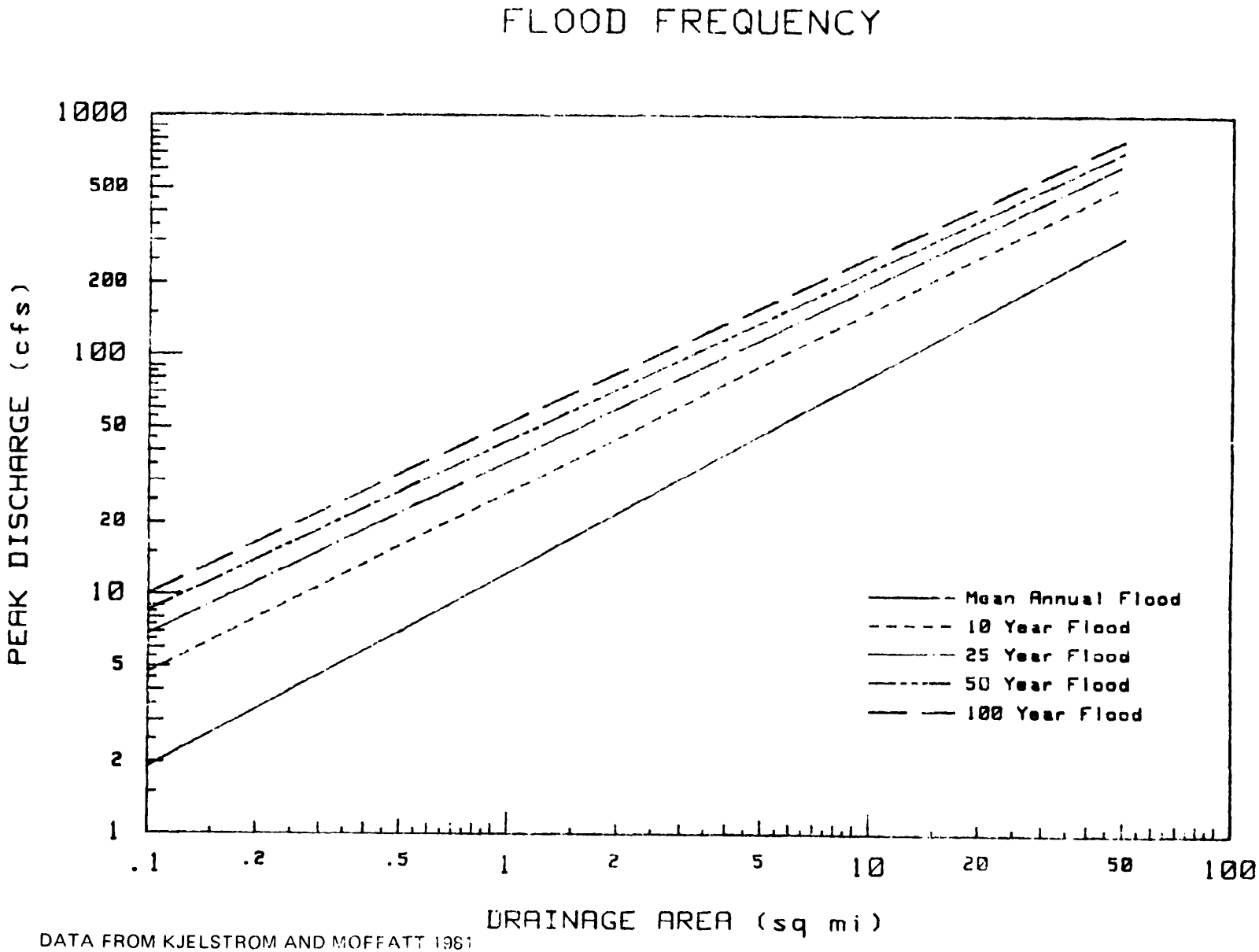
3.3 GEOLOGY

The rocks in the Blackbird Mine area are primarily Precambrian crystalline metasediments and intrusives that have undergone several episodes of folding and faulting. Large-scale thrust faulting, block faulting, and Tertiary



DATA FROM USGS. MODIFIED FROM BALDWIN et al. 1978

Figure 3-6 STREAMFLOW HYDROGRAPH OF BLACKBIRD CREEK AT MOUTH FOR 1971



DATA FROM KJELSTROM AND MOFFATT 1981

Figure 3-7 FLOOD FREQUENCY VALUES FOR STREAMS WITHIN THE PANTHER CREEK DRAINAGE

igneous activity have contributed to the geologic complexity of the region. Reconnaissance geologic mapping in the mine area was conducted to determine potential pathways of groundwater movement in these deformed crystalline basement rocks. Bedrock lithology and major shear zones were mapped previously by Bennett (1977) and are shown on Figure 3-8. The ore body is primarily in what Bennett calls the "mixed rock" unit consisting of quartzites, schists, phyllites and argillites. Most of the Meadow Creek drainage is underlain by this unit. The Bucktail drainage headwaters are predominantly underlain by a garnet schist. Bennett (1977) described the contact of the garnet schist with the mixed rock unit as conformable.

Bennett (1977) has mapped two major north-trending shear zones that border the Blackbird Mine on the east and west (Figure 3-8). The White Ledge Shear zone extends down the upper West Fork of Bucktail Creek and crosses Bucktail Creek near the first road crossing (Figure 2-1, Station 23). This shear zone may localize spring discharge along Bucktail Creek at Station 22 (Figure 2-l). The Slippery Creek fault truncates the ore body to the east and extends along Hawkeye Gulch.

Bedrock in the mine area is heavily fractured. Fracture orientations were measured in the field and obtained from unpublished Noranda geologic maps. The major fracture pattern strikes N10^{o}W to N50^{o}W and dips from 25° to 60° east (Figure 3-8). The fractures are generally open in weathered rock but appear to be tight in fresh, unweathered exposures. They are generally spaced at 1 to 4 in. In the 6850 level adit, groundwater was observed to be flowing to the adit along these fractures, which suggests that the fractures are potential pathways for groundwater movement.

Two sets of secondary fractures are also present. These are generally spaced at 1 to 4 ft, are tight and commonly indistinct. One set strikes about N60^{o} to 80°W and dips 50° to 80° southwest. The other set strikes N60^{o} to 80°E and dips 50° to 60° northwest.

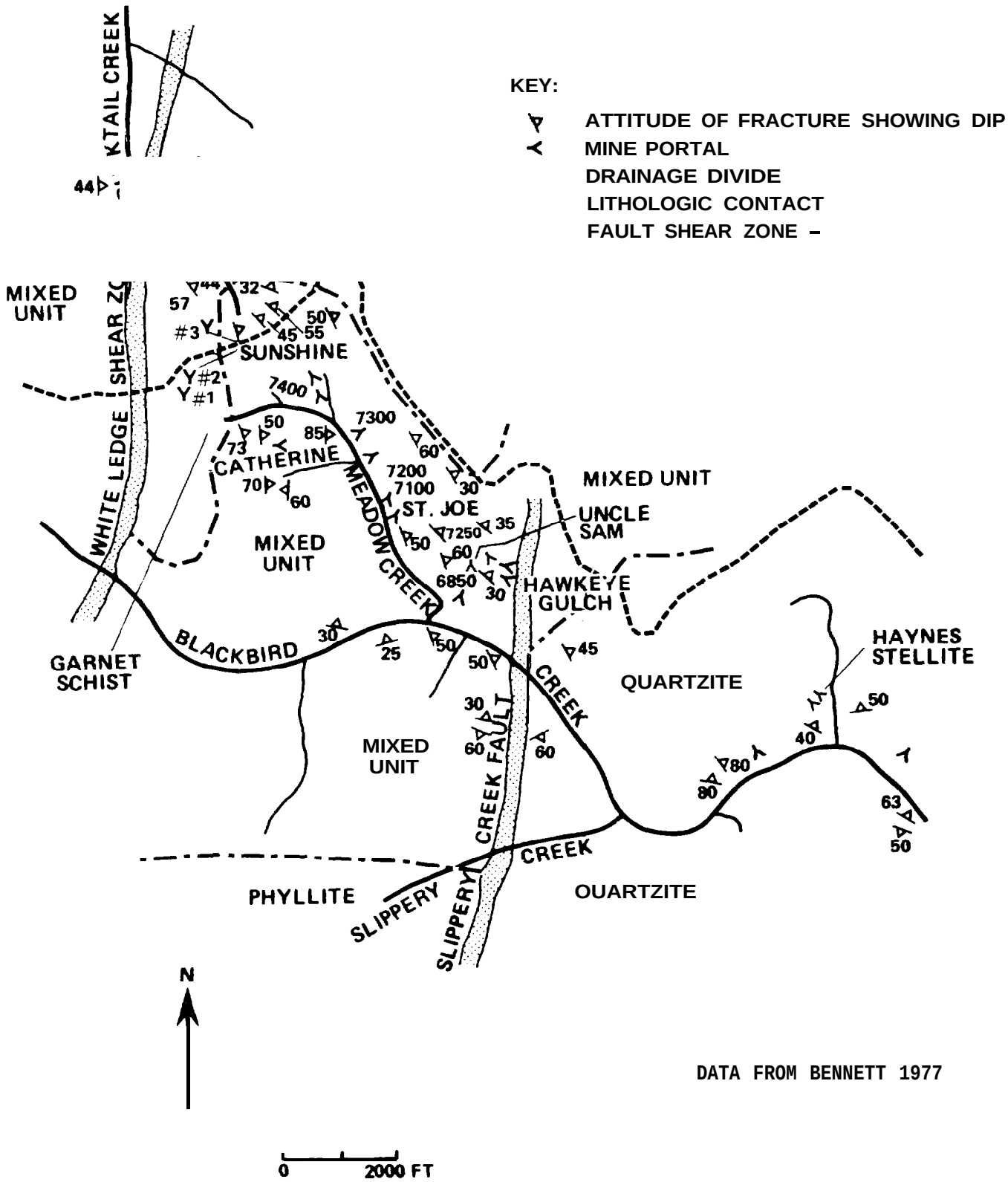


Figure 3-8 GEOLOGIC MAPPING OF THE BLACKBIRD MINE AREA

3.3.1 Soils

As noted by the USFS (1982) and ERT (1981c), the soils in the area are gravelly silty loams, loams, and sandy loams. Below the mine, a soil mantle of about 2 to 3 ft exists, which is comprised of about 40 to 60 percent rock fragments. Slopes in the area are as steep as 90 percent and average 50 percent.

Above the mine, the soil is more developed and consists of sandy loams, loams, and silt loams. The soil mantles in the area often exceed 5 ft thick, with the surface layers covered by a litter layer. Studies by Farmer et al. (1976) and Richardson and Farmer (1981) have noted that the soils in these upper areas are very acidic due to the extensive deposits of waste rock.

ERT (198lc) noted that the majority of soils in the drainage have moderate permeability and storage capacities; effective rooting depths range from 20 to 60 in. However, there is very little topsoil within the Blackbird Mine area that could be used for reclamation activities (see Appendix A, Section A4).

3.3.2 Riprap Sources

Extensive quantities of riprap suitable for lining diversion channels (see Appendix A, Section A4) are available in the immediate vicinity of the Blackbird Mine. These consist of fractured schists of the mixed rock unit that underly the Meadow Creek and the upper Blackbird Creek drainage basins, and fractured quartzites of the Yellowjacket Formation (Bennett 1977) that underly the West Fork and lower Blackbird Creek drainage basins. The fractured bedrock commonly breaks into equidimensional, angular fragments typically ranging from 6 in. to 2 ft across. The rock fragments form extensive talus slopes in the Blackbird drainage basin, some of which are more than 20 ft thick.

3.3.3 Clay and Limestone Sources

Reconnaissance field studies were conducted as part of this study, to evaluate potential sources of clay and limestone. Clay would be required for remedial alternatives requiring an impermeable clay liner, blanket, seal, slurry wall,

or dam core. Limestone will be required for alternatives requiring lime to improve groundwater or surface-water quality.

Two sources of clay exist in the region: the Forney site along Panther Creek and the Moccasin Creek site above Napias Creek. The Fomey site is located at the confluence of Panther Creek and Porphyry Creek, approximately 13 mi from the mine site. The clay is contained in a large earth flow composed of weathered volcanic tuff and appears to be bentonite. Detailed field studies by Wahler and Associates (1980) indicated that the earth flow is predominantly a moderate to highly plastic gravelly clay and that approximately 1.7 million cubic yards of suitable material are available.

The Moccasin Creek site is located north of Moccasin Creek, approximately 3 mi upstream from its confluence with Napias Creek and 21 mi from the Blackbird Mine. Wahler and Associates (1980) estimated that 5 million cubic yards of silts and 900,000 cubic yards of clay are available at the site.

The Forney site is recommended by Wahler and Associates for several reasons:

- The site is closest to the mine
- Access roads are better
- The terrain is more suitable (less steep and less rugged) for excavation
- Special design features will not be required to excavate and transport the clay

Sources of limestone are not present in the immediate mine vicinity. The closest sources of carbonate rock are at Poison Peak about 20 mi south of the town of Salmon, Idaho along State Highway 93, and in the Paleozoic rocks located over 20 mi southeast of the town of Salmon along State Highway 28. It is not known if either source contains reactive carbonate. Lime required for remedial alternatives may need to be imported from considerable distances at significant cost (see Appendix A, Section A4). Experiments using lime to reduce water toxicity at the Blackbird Mine were implemented by the Idaho Mining Company in the mid 1960s (Platts 1967; 1968). However, the source of

lime used for these studies was not reported. Noranda presently obtains lime for its treatment facility from sources in California.

3.4 HYDROGEOLOGY

Groundwater flow in the mine area has been described by Baldwin et al. (1978) and ESA (1961). The flow system is a secondary fracture-dominated-type flow through the metamorphic bedrock that is intercepted by mine workings. Primary, or pore permeability of the "mixed rock" unit and garnet schist is very low. ESA (1981) described the Blackbird Mine as a relatively "dry" mine. Even with nearly 10 mi of adits, raises, and winzes, flow from the workings was only 221 gpm at peak annual discharge prior to groundwater flow design modifications implemented by Noranda (ESA 1981).

Because of the lack of porosity in the metamorphic bedrock, ESA (1981) concluded that the groundwater storage volumes were low. Hydrographs for surface flow,and adit flow indicated that seepage into the mine is directly related to surface recharge.

Baldwin et al. (1978) and ESA (1981) reported field observations and tracer test data suggesting that the groundwater flow direction in the Blackbird Mountain area is to the northeast. The northeast flow is opposite from the topographic gradient (i.e., away from Meadow Creek), and is probably controlled by the northeast dipping principal fracture orientation. Such results were not confirmed during the present study. Indirectly, however, groundwater flow along fractures is supported by fracture-flow observed in the 6850 level adit. In addition, springs along strike and down-dip from the mine area have high conductivities and metal concentrations that indirectly supports the hypothesis that groundwater flow is from the mine workings to the springs through fractures.

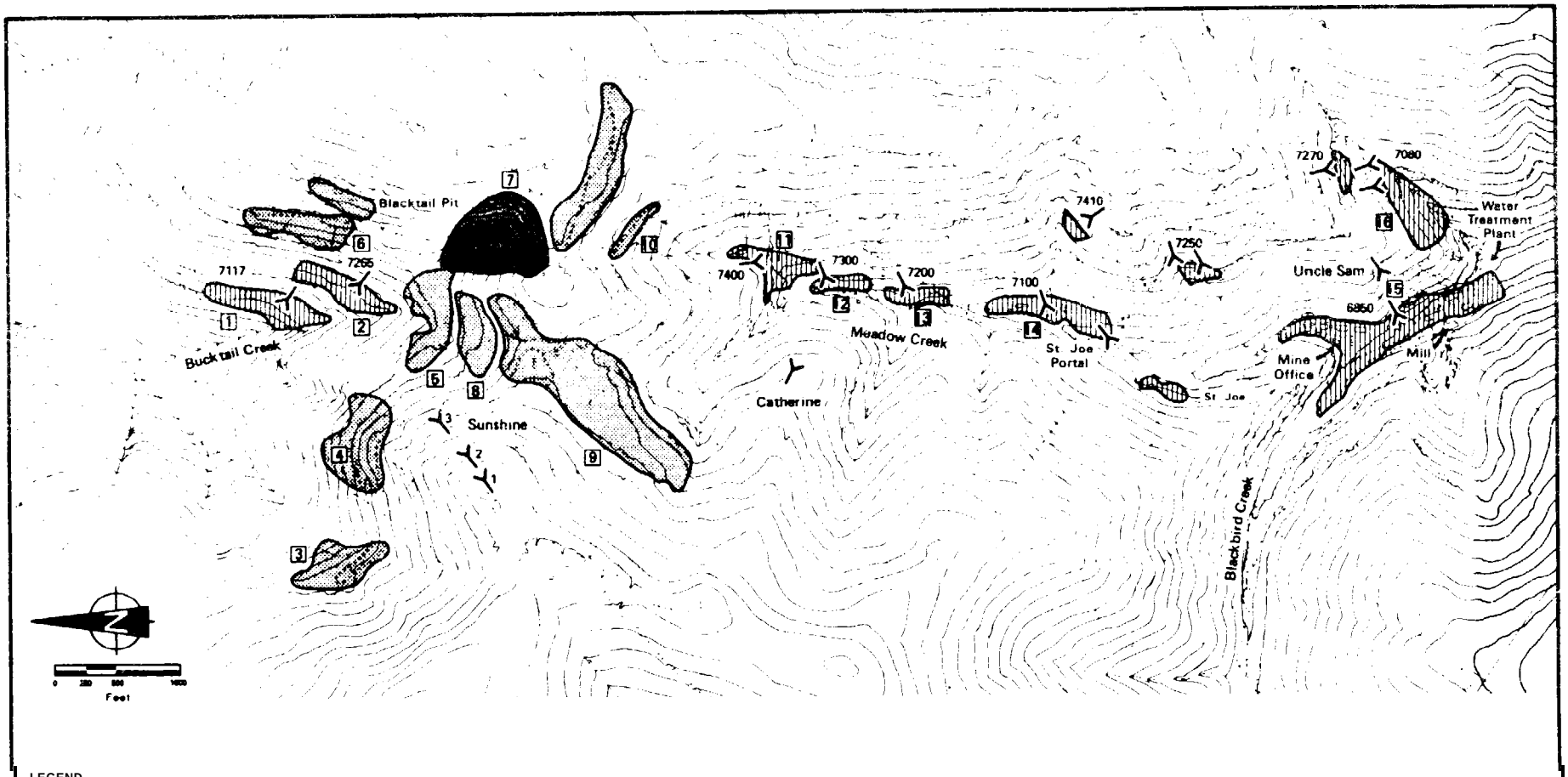
As described earlier, groundwater that is intercepted and transmitted by underground mine workings is acidic and relatively high in dissolved metals. Prior to 1980, untreated seepage from some of the mine adits flowed directly into Meadow, Blackbird, and Bucktail creeks. The distribution of portals and

their associated waste piles is shown on Figure 3-9 and described in Table 3-2. In the early 1980s, Noranda diverted much of this flow to the 6850 level adit and constructed a water treatment facility to treat flow from the adit prior to discharge into Blackbird Creek.

The water treatment facility constructed by Noranda is capable of treating about 450 to 500 gpm. As described earlier, peak annual discharge from the mine is about 221 gpm, well within the facility's capacity. Noranda has currently sealed the 6850 portal to reduce operational costs of the treatment facility and is treating only seepage water of about 10 to 25 gpm. Thus the water level in the mine 1s rising, and in September 1984, the water level was estimated to be above elevation 7000 ft. Portals above this level are not sealed and, as the mine continues to flood, acidic mine water may begin flowing from these portals. The Uncle Sam adit (elevation 7038) may be the first affected.

The exact underground design modifications to the drifts implemented by Noranda to divert water to the treatment facility are not presently known to Bechtel. Adit flows from the 7400, 7300, 7200, and 7100 portals have been diverted to the 6850 level by underground modifications (ESA 1981). Unnamed adits shown on Figure 3-9 are also dry but may not be connected by the underground modifications to the treatment facility. The St. Joe adit was flowing contaminated water under low-flow conditions. The adit is not interconnected with the main mine workings. The Hawkeye Gulch adits were dry.

Noranda did not divert mine waters from the 7117 and 7265 level adits in the Bucktail drainage. Water was flowing from these during this study. The 7400 and 6850 level adits extend into the Bucktail drainage subsurface but do not portal into the Bucktail drainage. The 7400 ft adit approaches within 100 to 200 ft of the surface and was a source of groundwater to Bucktail Creek in the past (ESA 1981). The slopes of the 7400 and 6850 adits are not known, but Noranda reportedly diverted all waters in these adits to the water treatment facility.



LEGEND

- BLACKTAIL OPEN PIT AREA
- OPEN PIT WASTE ROCK DISPOSAL AREA
- ELEVATION AND PORTAL OF WASTE ROCK DISPOSAL AREA
- MINE PORTAL

SOURCE: NORANDA

Figure 3-9 LOCATION OF MINE PORTALS AND ASSOCIATED WASTE PILES (See Table 3-2 for details)

Table 3-2

WASTE ROCK AREAS LOCATED IN THE
BUCKTAIL AND BLACKBIRD DRAINAGES
(See Figure 3-9 for Locations)

Station	Waste Rock Description	Comments
1	Waste from 7117 adit. Approx. 51,500 cubic yards.	Waste partially blocks Bucktail Creek. Adit water and Bucktail Creek flow over waste.
2	Waste from 7265 adit. Approx. 25,000 cubic yards.	Waste partially blocks Bucktail Creek. Adit flow and Bucktail Creek flow over waste. Much erosion.
3	Road fill. Fill includes cut rock and waste rock,	Partially blocks headwaters of Bucktail west fork.
4	Road fill, Fill includes cut rock and waste rock.	Ridge cut on mine road.
5	Waste rock from open pit.	Waste covers headwaters of Bucktail Creek.
6	Road fill. Fill includes cut rock and much waste rock.	Mine road.
7	Blacktail Open Pit.	Internally drained pit. Much waste rock exposed. Water probably infiltrates to mine workings.
8	Road fill and open-pit waste rock.	Fill for access roads to open pit, includes much waste rock at headwaters of Bucktail drainage.
9	Open pit waste rock. Approx. 1.1 million cubic yards.	7100 ft volume of waste rock at headwaters of Meadow Creek and Bucktail Creek.
10	Road fill. Small body of fill and/or waste rock from open pit.	

Table 3-2 (Continued)

WASTE ROCK AREAS LOCATED IN THE
BUCKTAIL AND BLACKBIRD DRAINAGES
(See Figure 3-9 for Locations)

Station	Waste Rock Description	Comments
11	7400 waste pile. Approx, 65,000 cubic yards.	Large waste pile completely blocking north fork of Meadow Creek. Severe erosion.
12	7300 waste pile. Approx. 15,400 cubic yards.	Moderate waste pile partially in Meadow Creek.
13	7200 waste pile. Approx. 45,400 cubic yards.	Large waste pile from two adits. Does not block Meadow Creek. Minor erosion.
14	7100 adit and St. Joe adit waste pile. Approx. 102,000 cubic yards.	7100 ft waste pile completely blocking Meadow Creek. Severe erosion. Seepage still occurring.
15	Mine buildings fill. Large volume of waste rock, cut rock, and tailings. Approx. 157,000 cubic yards.	Completely fills confluence of Meadow and Blackbird Creeks. Water volume increases through culvert suggesting breaks.
16	Uncle Sam and Hawkeye waste piles. Approx. 70,400 cubic yards.	Large waste piles partially or completely blocking Hawkeye gulch. Severe erosion.

3.5 MAJOR CONTAMINANT SOURCES

In general, the principal sources of contaminants within the Blackbird Mine area include:

- Waste rock piles
- Adit flows (acid mine drainage)
- Contaminated seeps and springs

Sources representative of each of these are found in both the Bucktail and Meadow Creek/Blackbird drainages. The major sources on a seasonal basis are summarized in Tables 3-3 and 3-4. It should be noted that the high flow sources are related to surface runoff and erosion. A detailed discussion of all pollution sources identified in the study is presented in Appendix A, Section A2.

The major contaminant sources are the extensive numbers of waste rock piles located in the mine area. Over 16 areas were located on the mine site, which contained varying amounts of waste rock and/or low grade ore material. These are described in Table 3-2 and are depicted in Figure 3-9. The largest of the waste rock areas is the open pit waste pile, which contains over 1 million cubic yards of material. Other major waste piles, in order of decreasing size, include those associated with the mine complex, 7100 adit, 7400 adit, 7117 adit and the 7200 adit (Table 3-2).

Discharge of acidic mine water from adits has likewise represented a significant source of poor quality water. Prior to diversion of water within the mine to the 6850 level, significant discharge occurred from several portals in the Meadow Creek/Blackbird Creek drainage basin. These included the 7400, 7300, St. Joe, and 6850 portals. Of these, the 7400 and 6850 levels contributed about 95 percent of the total discharge (Baldwin et al. 1978). Suhsequent diversions within the mine implemented by Noranda in the late 1970s have redirected water to the 6850 level. The St. Joe adit is not connected to the inner mine workings. A bulkhead installed in the 6850 adit has reduced discharge from the 6850 portal. Water seeping around the bulkhead is currently collected and treated at the existing water treatment facility.

Table 3-3

MAJOR CONTAMINANT SOURCES IN THE BUCKTAIL CREEK DRAINAGE

Summer/Fall Sources	Winter/Spring Sources
Mine Water - 7117 and 7265 adit flow - Culvert at base of open pit waste pile	Increased flow through summer/fall sources
Waste Rock - Infiltration through open pit waste pile, 7117 and 7265 waste piles - Roads surfaced by open pit waste rock - Waste rock veneers on slope below road cuts	Erosion of Waste Rock - Sheet runoff removes thin layer containing Cu and Co evaporation salts - Gulley and debris flow
Springs - Spring at base of open pit waste pile - Springs at base of 7117 and 7265 waste piles - Contaminated natural springs and subchannel seepage between 7117 waste pile and el. 7550	Channel Scour - Dissolving and/or eroding Cu and Co - Summer precipitates - Increased sediment load containing contaminants
Streams - Seep at mouth of upper West Fork to Bucktail Creek	Snowmelt - Containing contaminated dust layers

Table 3-4

MAJOR CONTAMINANT SOURCES IN THE MEADOW CREEK/BLACKBIRD CREEK DRAINAGE

Summer/Fall Sources	Winter/Spring Sources
Mine Water - St. Joe adit - Hawkeye no. 2 adit - 7200 no. 1 adit - Haynes Stellite no. 1 adit	Increased flow through summer/fall sources
Waste Rock - Open pit waste pile - 71.00 adit waste pile, - Fill for mine buildings (mixed with tailings)	Erosion of Waste Rock - Sheet runoff removes thin layer containing Cu and Co evaporation salts from waste piles, tailings piles, and road surfaces - Gulley erosion of open pit waste pile and adit waste piles, particularly: 0 7400 pile blocking large gulch 0 7100 pile blocking Meadow Creek 0 Hawkeye piles blocking Hawkeye Gulch
Springs - Nonpoint seep at base of debris flow from open pit waste pile. - Spring from west bank below 7400 adit waste pile - Seep at base of 7100 adit waste pile - Springs from east bank of Blackbird Creek between Haynes Stellite Mine and West Fork - Seeps and subchannel flow from West Fork Tailings dam	Channel Scour and Snow Melt (same as Bucktail) - Channel erosion of dredge and tailings material along Blackbird Creek - Erosion of fill for mine buildings

Along Bucktail Creek, acid mine drainage presently flows from two adits, the 7265 and 7117 (Figure 3-4); flow seepage from both contain high levels of copper.

Contaminated springs and seeps occur at several localities in the Bucktail and Blackbird drainage. During this study, over 12 point-source springs were located along Bucktail Creek, the majority associated with the 7117 wastepile. These sources correspond to "seep zone 1," described by Baldwin et al. (1978) as a significant source of metal loading to Bucktail Creek. In the Blackbird Creek drainage, at least 15 springs were identified along its course between Meadow Creek and Indian Gulch. Nine of these springs were considered as contaminant sources. Collectively, the contaminated springs and seeps represent significant low-flow contributors to Bucktail and Blackbird creeks.

Section 4: Water Quality Problems of Panther Creek

Section 4

WATER QUALITY PROBLEMS OF PANTHER CREEK

The water-quality problems in Panther Creek stem from the extensive mining that has occurred in the Blackbird Mine area since the 1890s. The elimination of virtually all aquatic life in Panther Creek, including significant runs of chinook salmon and steelhead trout, has been attributed to this mining activity. Acid drainage from both mine portals and mine waste deposits, which contain high concentrations of dissolved metals, has caused severe degradation in water quality (see Section 3.5). Copper has been identified as the primary and most critical toxicant presently limiting the ability of Panther Creek to support aquatic life. Poor quality water enters Panther Creek from Blackbird Creek and Big Deer Creek, both of which drain the Blackbird Mine.

In support of the Environmental Impact Statement for the reopening of the Blackbird Mine by Noranda Mining Inc., Davies (1981) prepared a summary and review of all previously collected water quality data in the Blackbird area. In general, although a great deal of data has been accumulated, its interpretation has been clouded by numerous factors. These factors include water chemistry complications, variations in sampling techniques, variations in sampling locations, and the lack of simultaneous measurements of water quality and discharge.

Water chemistry plays an important role in the water quality of Panther Creek. As discussed earlier, high levels of dissolved copper are considered to be the most limiting factor for aquatic life. A review of the available water quality data indicates that a large portion of the copper, which is measured near its source, precipitates out prior to reaching Panther Creek as dilution flows raise the pH of the water. This occurs in Blackbird and Big Deer creeks. As indicated from the data collected in May 1985, a total copper loading of approximately 90 lb/day was measured just below the mine gate. At the mouth of Blackbird Creek, however, the copper loading was measured as only 58 lb/day. Similarly, in Bucktail Creek, the copper loadings were measured as

325 lb/day; however, at the mouth of Big Deer Creek, 268 lb/day were measured. In both instances, copper precipitates were being stored in stream channels between the contaminant source and Panther Creek. These precipitates are then flushed during high flow events. Consequently, the pH of the water along its course plays an important role in determining how much of the loading from a source will result in dissolved copper levels in Panther Creek. Since a considerable amount of excess copper enters panther Creek in precipitate form,the reduction of the copper loading at its source may not result in a corresponding reduction in dissolved copper concentrations. It may only result in a reduction in the precipitates, which are not the major contributor to the toxicity problem (provided they do not redissolve further downstream).

Another problem is the difficulty involved in determining the loading associated with a particular source and then predicting what change can be expected as a result of a specific abatement measure.

4.1 THE ACID MINE DRAINAGE PROBLEM

The problem of acid mine drainage has been studied extensively, especially as it relates to the coal mines of the eastern U.S. Acid mine drainage from western hard-rock mines occur in a similar manner through the oxidation of iron pyrite (FeS_2) to produce sulfuric acid. The sulfuric acid produced from pyrite leaches copper and other heavy metals from mines and from mining wastes. Metal sulfide minerals, such as copper sulfide, do not produce acidity in mine waters; the acidity comes only from the weathering of pyrite. In fact, for each mole of pyrite oxidized, two moles of sulfuric acid must ultimately be neutralized.

There are several chemical reactions that occur in the formation of acid from pyrite. The first reaction that occurs is the direct reaction of pyrite with molecular oxygen which occurs at higher (although acidic) pH's:

$$2FeS_2 + 7O_2 + 2H_2O = 2H_2SO_4 + 2FeSO_4 \quad (1)$$

There is also direct reaction of the ferrous ions with molecular oxygen to produce ferric ions:

$$4FeSO_4 + 0_2 + 2H_2SO_4 = 2Fe_2(SO_4)_3 + 2H_2O \quad (2)$$

As the pH and the available oxygen concentration both decrease, reaction 1 becomes less important. Reaction 2 is then catalyzed by the iron bacterium Metallogenium until a pH of about 3 to 3.5 is attained. At this point the bacteria Ferrobacillus ferrooxidans, F. sulfooxidans, and Thiobacillus ferrooxidans become the catalyzing agents for reaction 2, which greatly accelerates the reaction.

The ferric ions react with additional pyrite to produce additional acidity:

$$FeS_2 + 7Fe_2(SO_4)_3 + 8H_2O = 15FeSO_4 + 8H_2SO_4 \quad (3)$$

The ferric ions also hydrolyze in the normal pH range to produce yellow ferric hydroxide precipitate (known to miners as "yellow boy") and additional acid:

$$Fe_2(SO_4)_3 + 6H_2O = 2Fe(OH)_3 + 3H_2SO_4 \quad (4)$$

Thus, the oxidation of pyrite occurs either directly by reaction with molecular oxygen or by reduction of ferric ion to ferrous ion.

Copper is leached from chalcopyrite ore (which resists normal acid leaching) by the following reaction:

$$CuFeS2 + 2Fe_2(SO_4)_3 + 2H_2O + 30_2 = CuSO_4 + 5FeSO_4 + 2H_2SO_4$$

Formation of acid mine drainage occurs because mining operations have exposed pyritic formations to the air. Oxidation follows rapidly from that point. Investigations of pyrite dissolution have shown that oxidation takes place only in the top few inches of a waste pile. The products of oxidation are leached out of the pile during rainfall or runoff and enter nearby streams. Erosion of the pile continually exposes new surfaces where the oxidation continues. Such conditions presently occur in the Blackbird Mine area.

4.2 REVIEW OF EXISTING CONDITIONS IN PANTHER CREEK

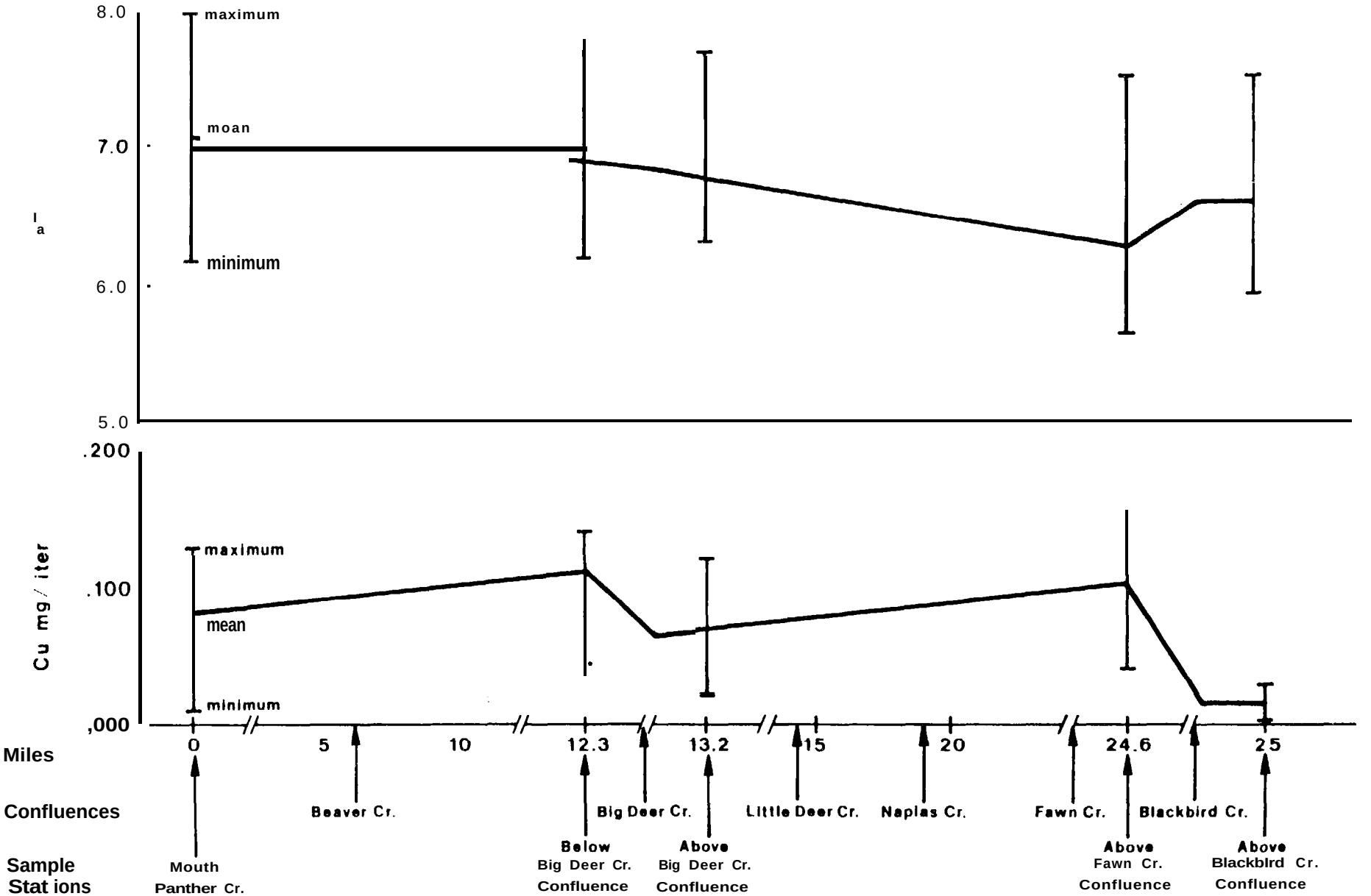
Relatively high concentrations of metals continue to flow into Panther Creek even though more than 20 years have passed since all major mining activity has ceased at the Blackbird Mine. Noranda implemented and presently maintains certain abatement measures (see Section 1). There are some indications that conditions have improved since Noranda implemented those measures. However, insufficient data have been collected since that time to determine how much improvement,if any, has occurred since these measures were taken. Problems with comparing different sets of water quality measurements along Panther Creek are particularly difficult. In many instances , the measurements made in Panther Creek probably do not represent average conditions across the stream. In particular, the stations below Blackbird Creek and below Big Deer Creek were often chosen at locations where complete mixing had not yet occurred. In addition, local effects like a nearby spring can have a major effect on a single sample taken within 2 ft of the bank of a stream more than 50 ft wide. Unfortunately, discharge data were seldom available to evaluate whether the water quality readings were consistent. As a result of these complications, the measured metal concentrations are probably, in general, skewed too high below Blackbird Creek and too low below Big Deer Creek due to the accessibility of the stream relative to their confluence with Panther Creek.

From all available data, Davies (1981) developed curves depicting the spatial variations of pH and copper concentrations in Panther Creek. As can be seen from Figure (4-l), there is high variability in both the pH and the copper concentrations. The mean copper concentrations along Panther Creek exceeds 0.05 mg/l from Blackbird Creek to its confluence with the Salmon River. Maximum values greater than 0.2 mg/l have been recorded in Panther Creek in recent years.

4.3 WATER QUALITY IN THE BLACKBIRD CREEK DRAINAGE

4.3.1 Water Quality Monitoring, 1974-1976

A major water quality data collection program was conducted by Baldwin et al. (1978) during 1974, 1975, and 1976. In this program, the investigators identified major sources of contaminated water in the Blackbird drainage. Sampling locations for their program are shown in Figures 4-2 and 4-3. The



ADAPTED FROM DAVIES (1981)

Figure 4-1 SPATIAL CHANGE IN pH AND COPPER CONCENTRATION IN PANTHER CREEK

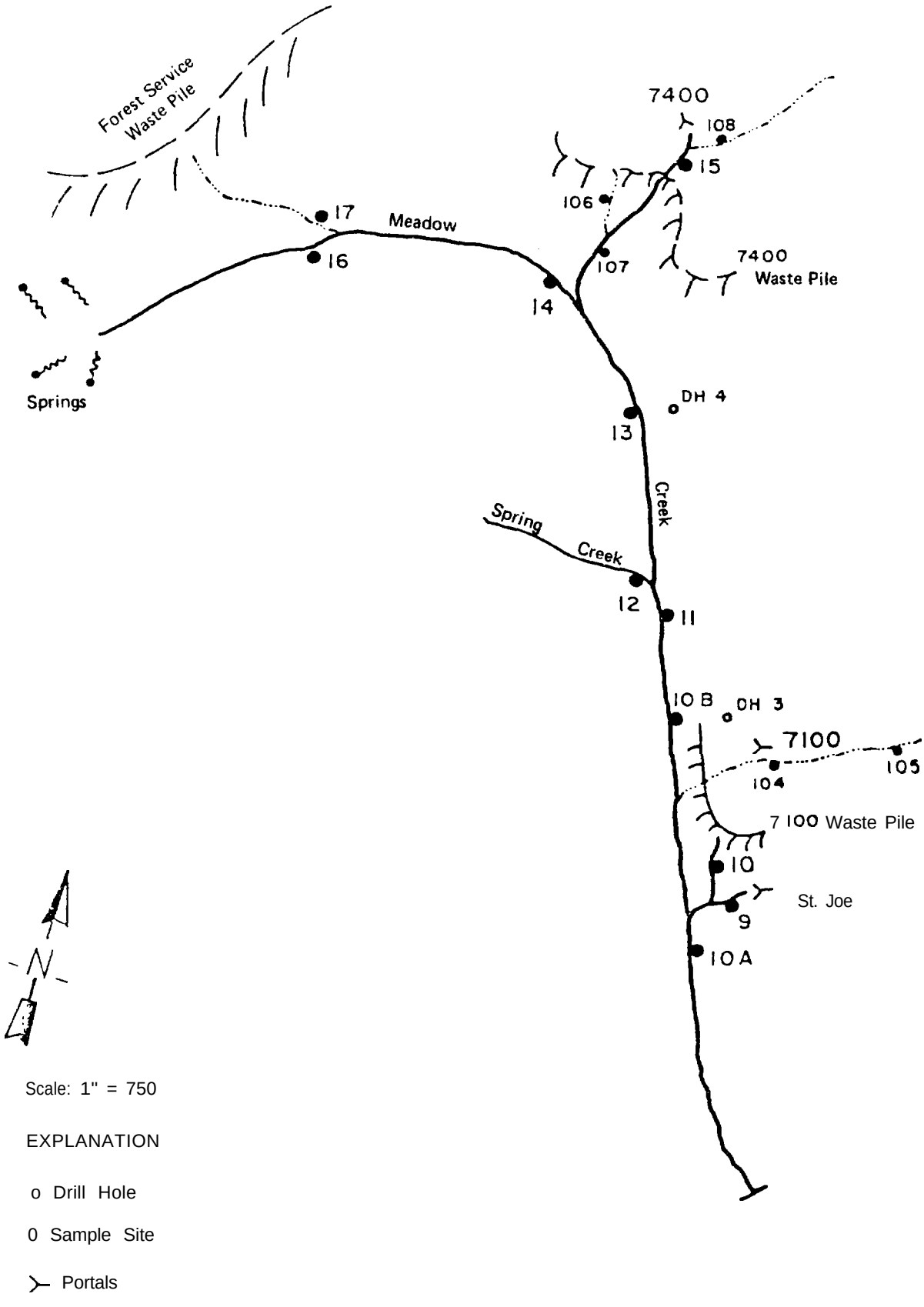


Figure 4-2 LOCATION OF BALDWIN et al. (1978) SAMPLING STATIONS ON MEADOW CREEK

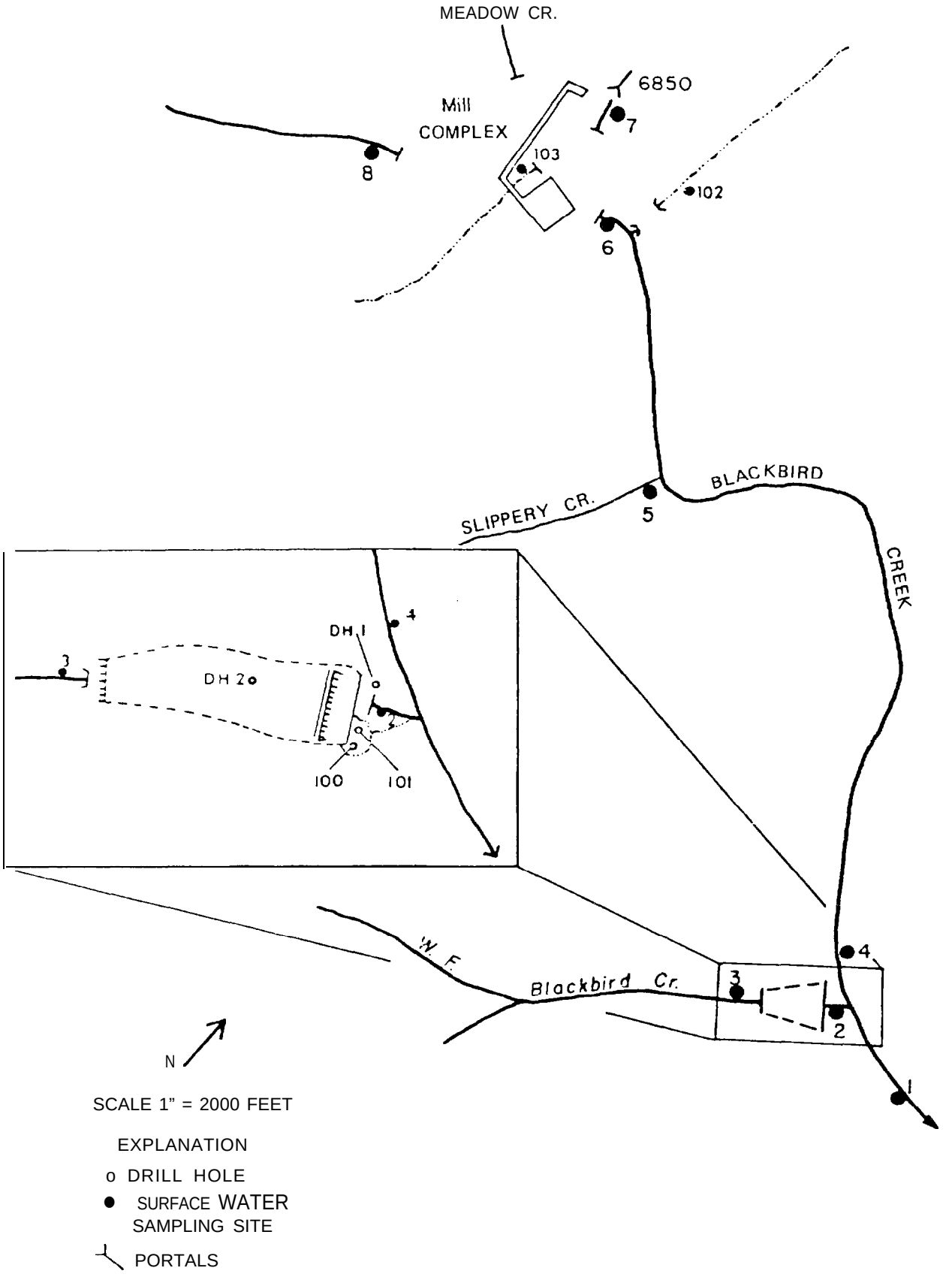


Figure 4-3 LOCATION OF BALDWIN et al. (1978) SAMPLING STATIONS ON BLACKBIRD CREEK

investigators also used a mass balance to check whether all sources had been located. The results of this mass balance are shown in Tables 4-l and 4-2 for Meadow and Blackbird creeks, respectively. As indicated in Table 4-1, measured sources accounted for about 50 percent of the copper loading in Meadow Creek. The major sources were identified as the open pit waste pile, the 7400 ft adit, the 7100 ft waste pile, and the St. Joe adit. The major unmeasured sources were considered to be the groundwater flow from the open pit waste pile, metal leached from the Meadow Creek channel which flowed through the 7100 ft waste pile, and the groundwater flow from the 7400 ft waste pile.

For all of Blackbird Creek, Baldwin identified the sources in Meadow Creek and the 6850 ft adit flows as contributing to more than 90 percent of all metal loadings in Blackbird Creek (see Table 4-2).

Subsequent to the studies performed by Baldwin et al. (1978), Noranda diverted the 7400 ft adit flow to the 6850 ft level where all flow has been treated since 1980. In addition, Noranda installed a culvert through the 7100 ft waste pile to prevent recharge from Meadow Creek. These improvements were predicted to reduce the total metal loading in Blackbird Creek by about 50 percent (Davies 1981). Insufficient data have been collected since that time to assess whether these improvements have achieved that level of reduction in metals loading.

4.3.2 Water Quality Monitoring, 1979-1981

A water quality monitoring program was instituted by Noranda from 1979 to 1981 during the period that pilot studies were underway in anticipation of reopening the mine. A significant amount of water quality data was collected, but flows were not consistently measured to provide a good basis for mass loading estimates. Flows were available for some of the data. Figure 4-4 shows the mean monthly copper loading at two places in the Blackbird Creek basin; Blackbird Creek above West Fork, and Meadow Creek above Blackbird. The treatment facility was reported to have started operating in mid-December 1980. These data seem to imply that additional sources of metal loading exist below Meadow Creek, contrary to the findings of Baldwin et al. (1978). Davies

Table 4-l

MASS BALANCE COMPARISONS FOR MEADOW CREEK
FOR THE PERIOD MAY 1 to JULY 31, 1976

Item	Metal Load (tons)			Discharge (Acre-feet)
	Co	Cu	Fe	
Input				
Open Pit Waste Pile (Station 17 [a])	0.1	0.3	b	4
7400 Portal (Station 15)	0.6	2.6	0.7	10
7100 Waste Pile (Station 10)	0.4	0.4	1.0	c
St. Joe Portal (Station 9)	0.03	0.06	0.08	c
Total	1.1	3.3	1.7	
output				
Meadow Creek (Station 10A)	2.3	6.7	2.3	270

a 5-19 to 6-21-76. No surface discharge at station 17 after 6-21-76.

b Iron concentrations were below detection limits, therefore no iron metal load was reported.

c Discharge at these stations is from recharge from Meadow Creek.

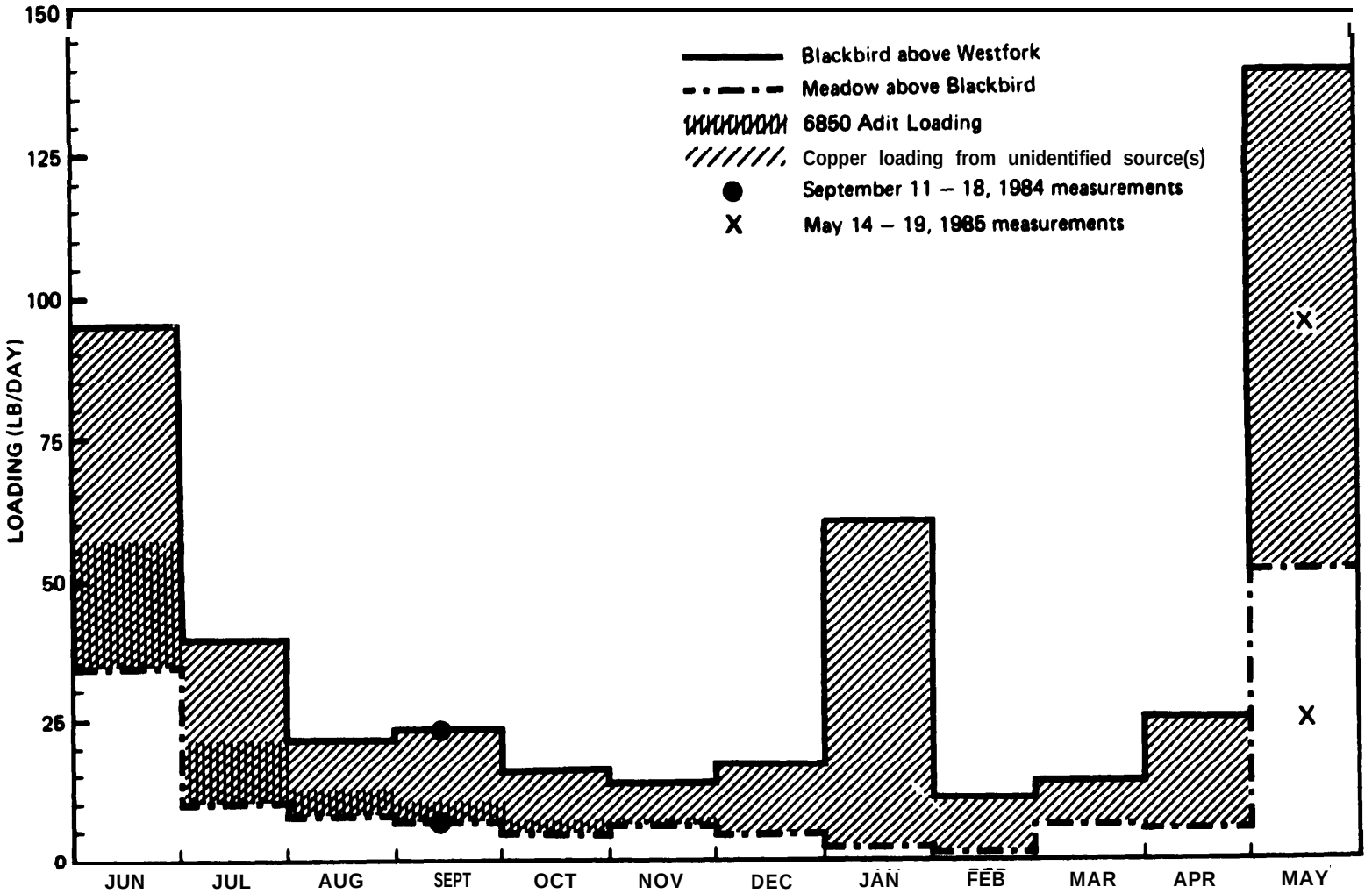
Source: Baldwin et al. (1978)

Table 4-2

MASS BALANCE COMPARISONS FOR BLACKBIRD CREEK
FOR THE PERIOD MAY 1 TO JULY 31, 1976

Item	Metal Load (tons)			Discharge (Acre-feet)
	Co	Cu	Fe	
Input				
Station 10A (Meadow Creek)	2.3	6.7	2.3	270
Station 7 (6850 portal)	0.8	1.0	9.5	33
Total	3.1	7.7	11.8	303
Output				
Station 4 (Blackbird Creek)	3.5	8.4	11.2	3,270
For the 1976 Water Year:				
Output				
Station 4 (Blackbird Creek)	7.5	13.4	15.2	5,800

Source: Baldwin et al. (1978)



Source: NORANDA

Figure 4-4 MEAN MONTHLY COPPER LOADING IN BLACKBIRD AND MEADOW CREEKS, JUNE 1980-MAY 1981

(1981) noted similar trends when reviewing the data of Baldwin and others. He indicated that a possible source of additional copper loading was from ore stored above the mine gate. This material was reportedly removed by Noranda.

4.3.3 Water Quality Monitoring, 1984-1985

Since all mining activity has ceased at the Blackbird Mine, the 6850 ft level has been bulkheaded, and the mine is presently flooding with water. The water level is reportedly at about 7000 ft elevation and rising as of May 1985. Water that seeps through fractures around the bulkhead is diverted to the treatment plant. Available drawings of the mine workings indicate that water would first discharge from the Uncle Sam adit that enters the mine at the 7038 ft level (if the water level were not monitored and managed).

As part of this study, Bechtel made measurements of water quality and discharge at several places along Meadow and Blackbird Creeks. These measurements were made during September 1984, and May 1985. Figure 4-5 depicts the copper loadings in Meadow and Blackbird Creeks. From the data taken in the fall of 1984, it was noted that approximately half of the copper loading appeared to be unaccounted for between Meadow Creek above the mine complex and the mine gate. At that time, the culvert that carried Meadow Creek through the mine complex had been damaged. Meadow Creek flowed along the road and joined Blackbird Creek in the open ditch above the mill. Although this was considered a possible source of some of the unaccountable copper, it did not explain the large discrepancy in metals loading.

During the field program in May 1985, special care was taken to identify any additional sources of poor quality water between Meadow Creek and the mine gate. The Meadow Creek culvert had been replaced so that Meadow Creek no longer flowed through the mine yard. After measuring all known flows entering the culvert system that underlies the mine yard, a total of 45 lb/day of copper was unaccountable as compared with the 90 lb/day measured at the mine gate. In addition, approximately 200 gal/min of flow was unaccounted for. Available drawings of the culvert system beneath the mine yard indicated that the primary culvert is a 42 in. concrete tile pipe. In addition, in the general vicinity of the mill about 120 ft of 5 by 5 ft wood cribbing was used

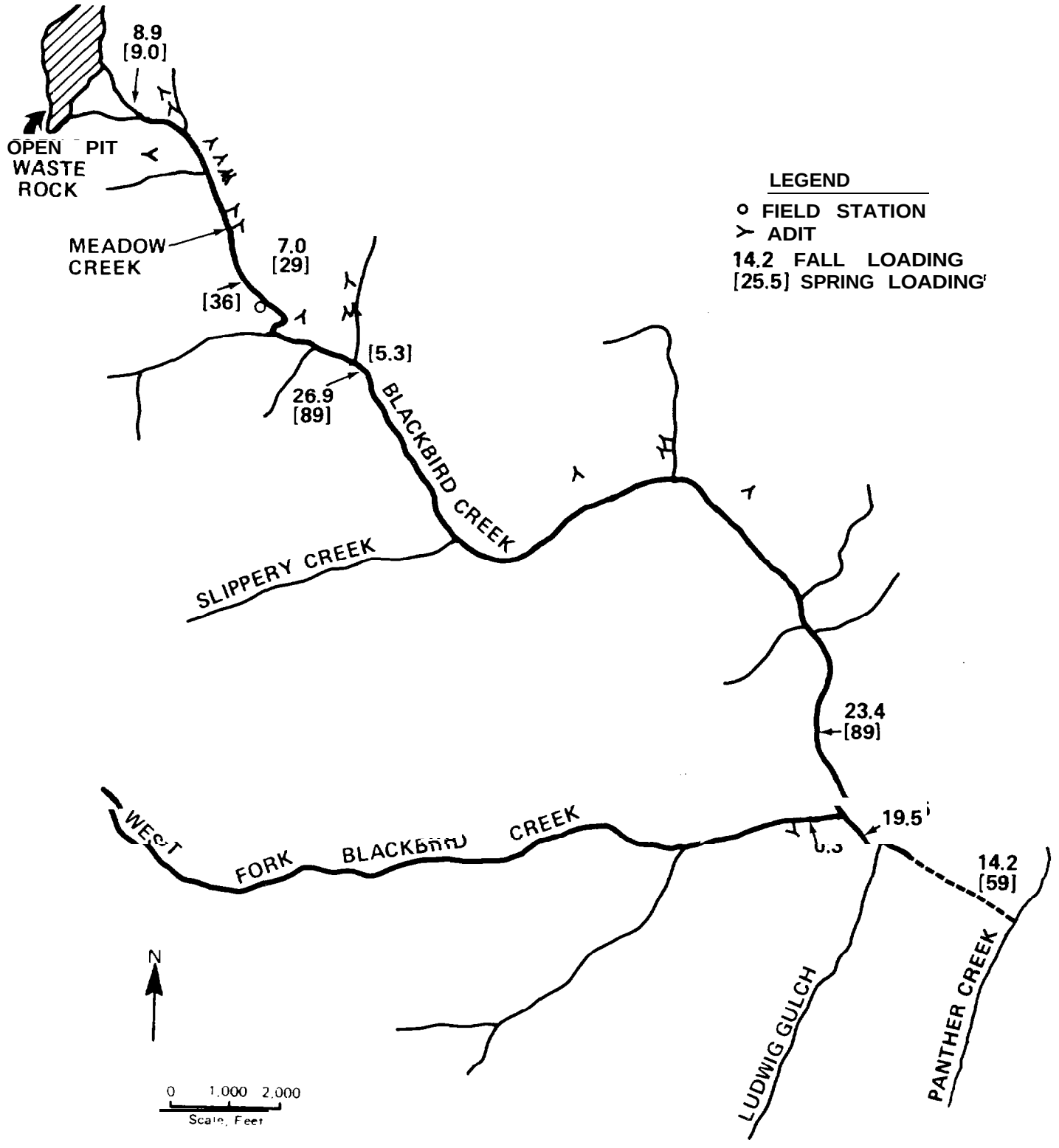


Figure 4-5 MEADOW CREEK-BLACKBIRD CREEK, COPPER LOADING IN POUNDS PER DAY

in place of the culvert to intercept groundwater. Noranda personnel indicated that this system was installed in the 1950s to keep the area dry. Apparently a significant number of springs has been buried by the mine yard. This culvert system is the most probable source of the unaccounted flow and copper loading.

The source of this poor quality water is unknown. It could be from subsurface flows originating in Meadow Creek; it may be good quality water from groundwater springs that degrade as they pass through waste material below the mine yard; or it may be associated with the flooding of the mine. However, the data obtained during 1980 and 1981 tend to rule out the latter source since the mine was not flooded during that period.

4.4 WATER OUALITY IN BUCKTAIL DRAINAGE

The collection of water quality data has been much more limited in the Bucktail Drainage than in the Blackbird Drainage. This is mainly because the Bucktail Drainage is inaccessible for about 7 months of the year due to snow accumulation. The most comprehensive data collection program for this area was conducted by Baldwin et al. (1978).

The major sources of acid drainage and metals production were identified by Baldwin as the Blacktail Open Pit waste pile at the headwater of Bucktail Creek, the 7265 and 7117 waste piles, and the 7265 and 7117 adit flows (see Section 3.5). Figure 4-6 and 4-7 show the sampling locations that Baldwin selected for his program. During August 1975, Baldwin measured copper loadings as high as 275 lb/day along Bucktail Creek between the 7117 waste pile and the first road crossing (Station 23). The variation in the copper loading along Bucktail Creek is seen in Figure 4-8. Two major seep zones below the 7117 adit apparently contribute a major portion of the copper loading. Baldwin suggests that these seep zones-may be surface expressions of fault or fracture zones that carry poor quality water from the vicinity of the Blacktail Pit.

Copper loading data collected during this study in September 1984 and May 1985 are shown in Figure 4-9. These data confirm the large increase in copper

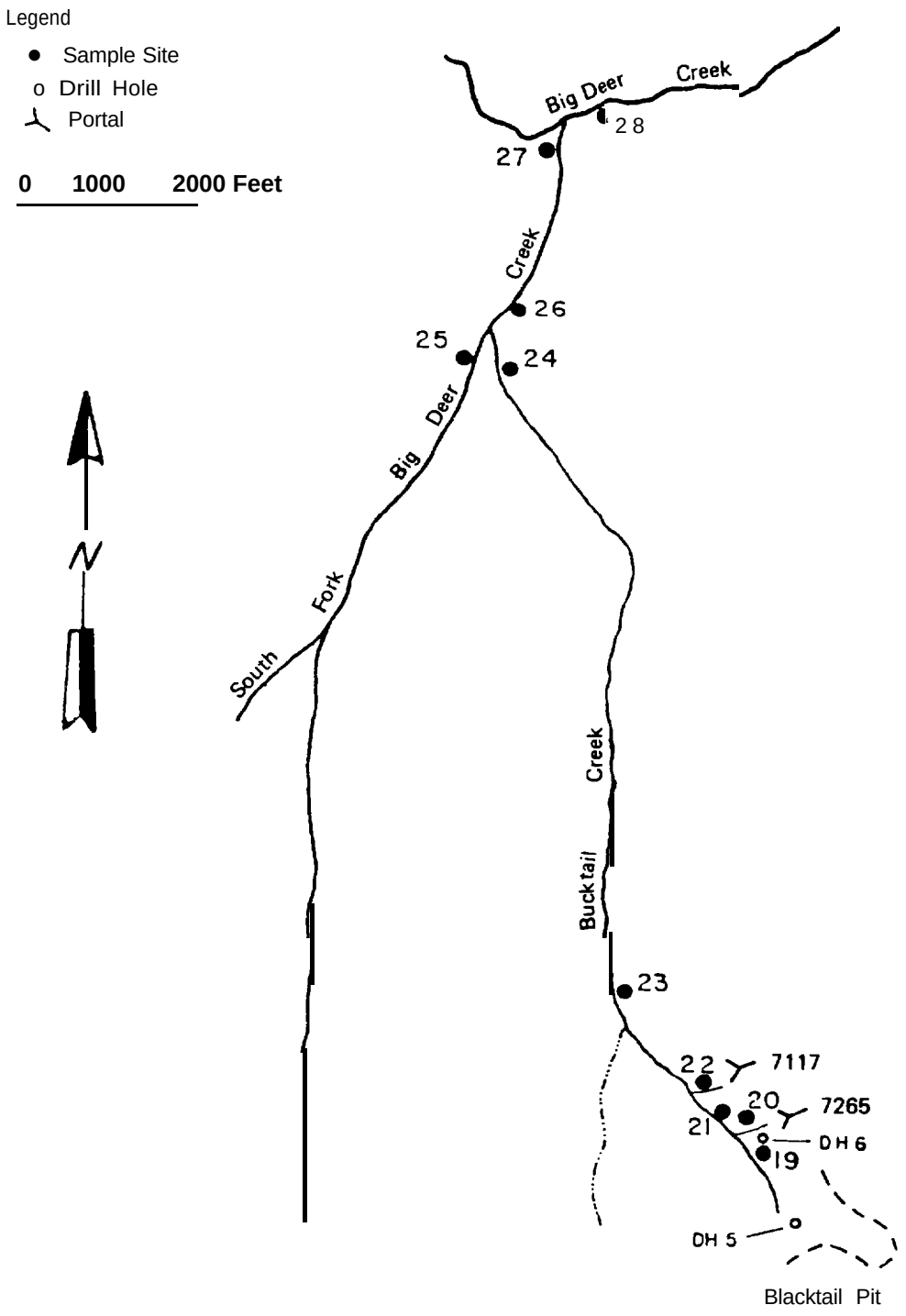


Figure 4-6 LOCATIONS OF BALDWIN et al. (1978) SAMPLING STATIONS ON BUCKTAIL CREEK

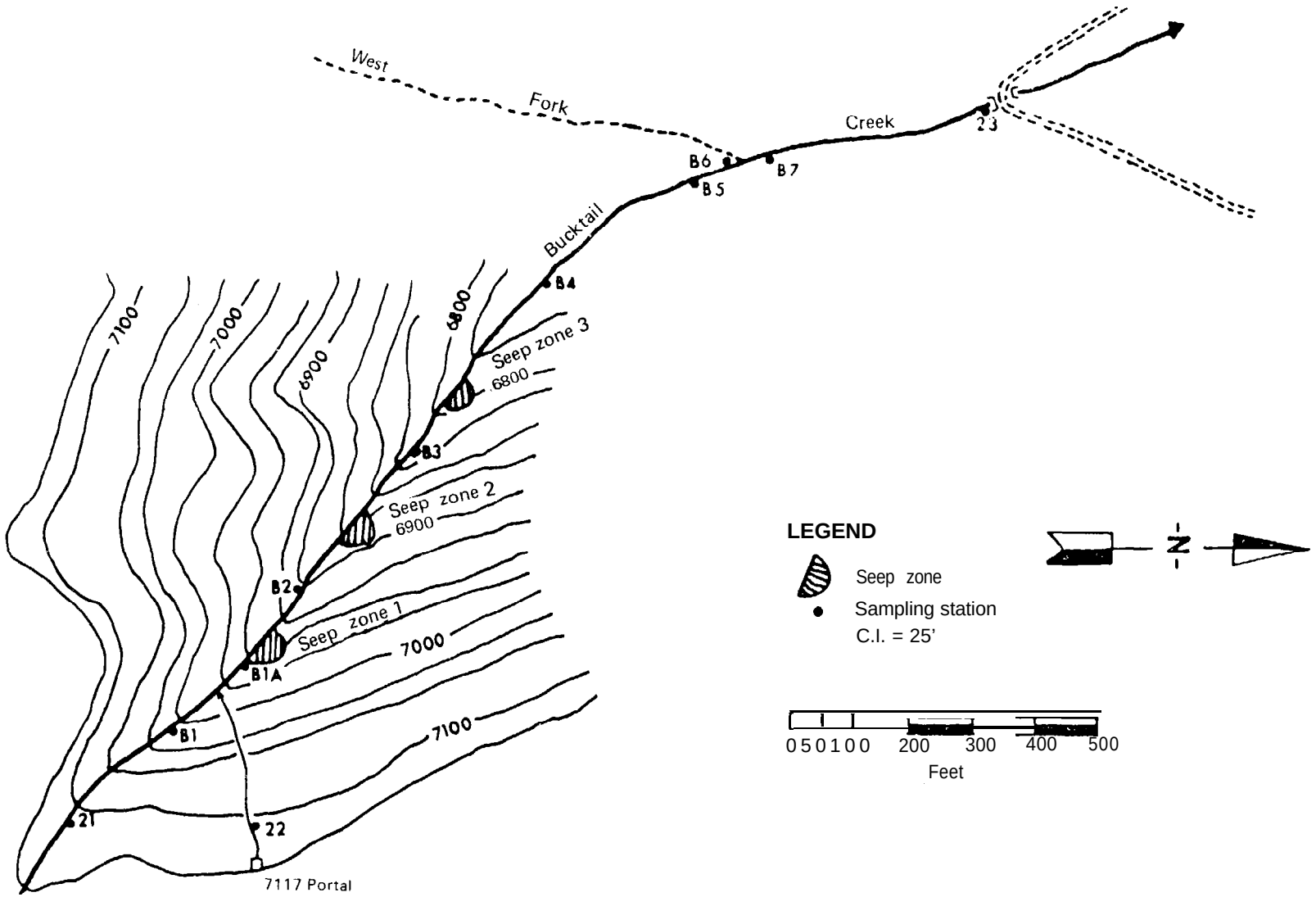
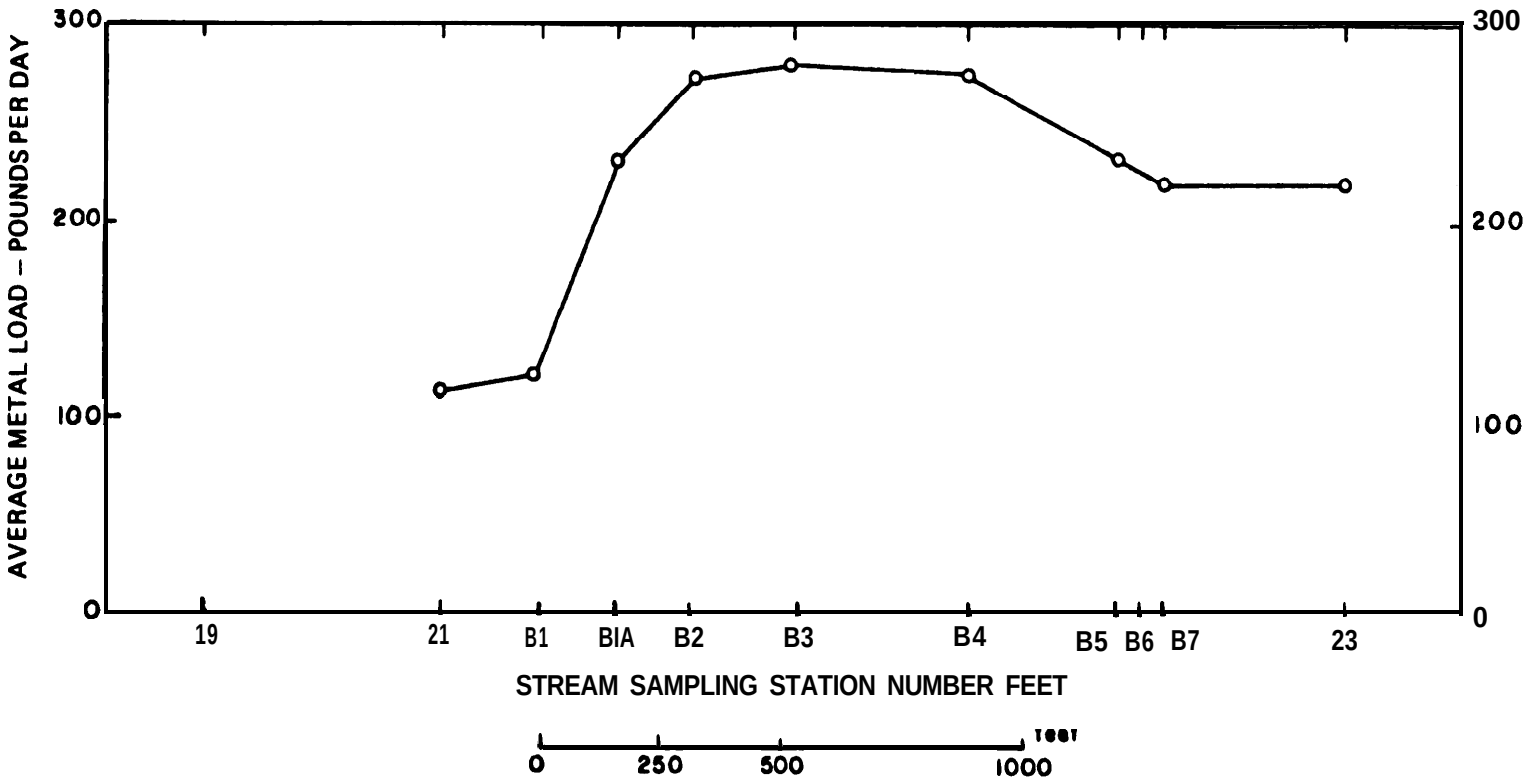


Figure 4-7 LOCATIONS OF BALDWIN et al. (1978) SAMPLING STATIONS, BUCKTAIL CREEK



ADAPTED FROM BALDWIN et al. (1978)

Figure 4-8 AVERAGE COPPER METAL LOAD IN POUNDS PER DAY ALONG BUCKTAIL CREEK FOR THE PERIOD AUGUST 1 TO AUGUST 14,1975

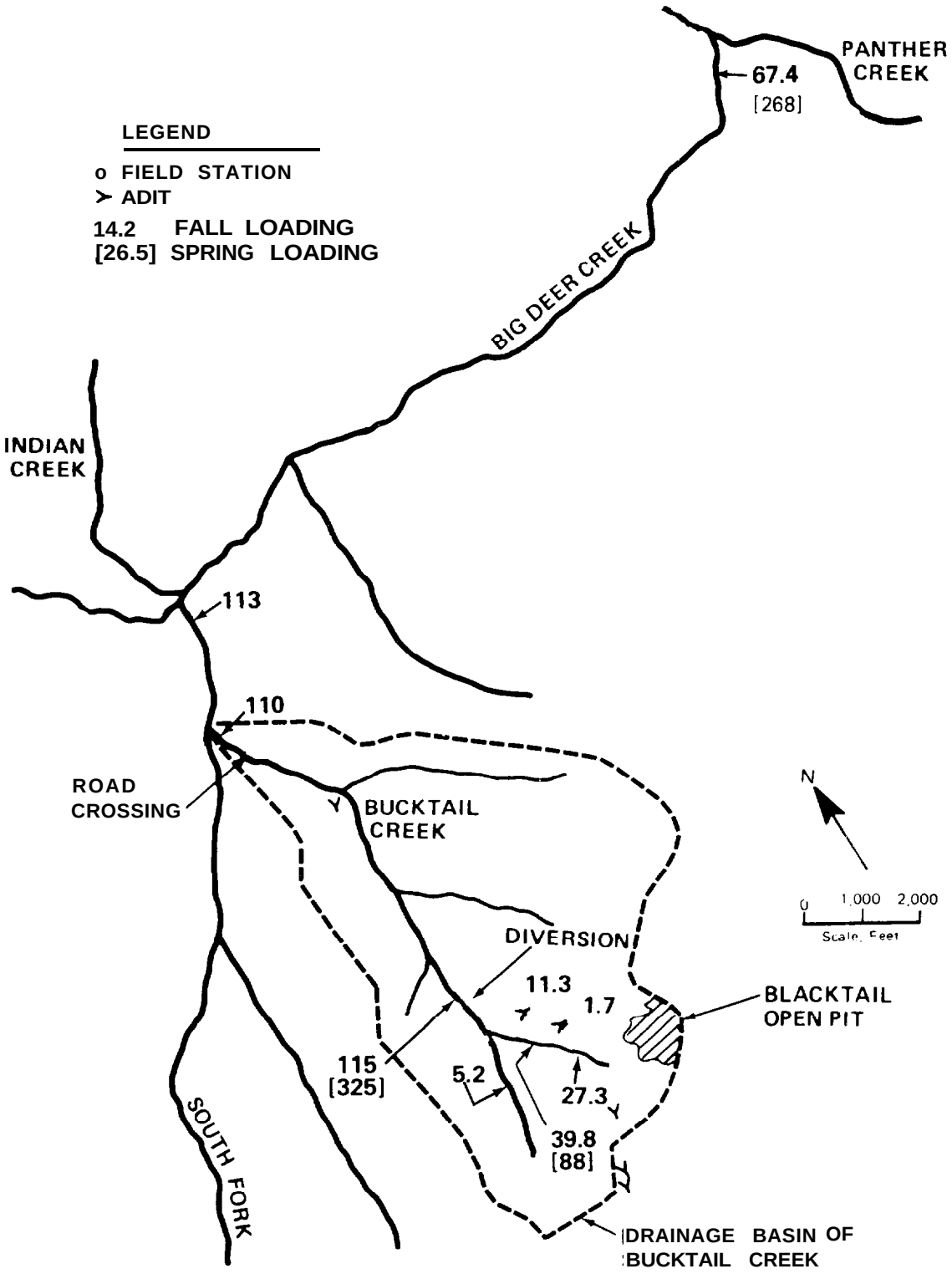


Figure 4-9 BUCKTAIL CREEK COPPER LOADING IN POUNDS PER DAY

loadings in the stretch of stream below the 7117 adit and the first road crossing.

It should be noted that significantly higher copper loadings are associated with Bucktail Creek than with Blackbird Creek. In September 1984, the copper loading in Bucktail Creek at the first road crossing was estimated to be 115 lb/day compared with about 27 lb/day at the mine gate on Blackbird Creek. Similar trends were found in May 1985 when the copper loading above the first road crossing on Bucktail Creek was measured to be about 325 lb/day compared to about 88 lb/day at the mine gate on Blackbird Creek. In both cases, approximately four times as much copper was produced in the Bucktail drainage than was produced in the Blackbird drainage. One compensating factor is that Panther Creek has about twice the flow at its confluence with Big Deer Creek than at its confluence with Blackbird Creek.

4.5 DESIGN LEVELS FOR ABATEMENT MEASURES

For the purposes of developing design criteria for abatement measures, a target copper concentration of 0.05 mg/l was selected as the maximum year-round level anywhere in Panther Creek (excluding the mixing zones below Blackbird and Big Deer Creeks). Using this criterion, considerably lower concentrations would be expected at most times of the year. A target value is selected only for the purpose of determining the level of effort required in the abatement measures to achieve acceptable water quality in Panther Creek. There is a greater deal of uncertainty involved in determining an acceptable level as well as determining the effect of an abatement measure on the water quality in Panther Creek.

Although the critical component of the water quality in Panther Creek is the dissolved copper level, it is extremely difficult to assess the impact of an abatement measure on this constituent. Consequently, the 0.05 mg/l copper level will be assessed with respect to the total copper loading at the source. For instance, in May 1985, 89 lb/day of copper were measured below the main gate in Blackbird Creek. The flow in Panther Creek just below Blackbird Creek was 148 cfs at that time. This is an equivalent copper contribution of 0.11 mg/l. Measurements by the State of Idaho, Department of

Health and Welfare indicated that the total copper in Panther Creek at that time was 0.07 mg/l and the dissolved component was 0.05 mg/l. Evidently, copper precipitates were being stored in the stream channels. These precipitates eventually wash into Panther Creek and may redissolve depending upon the pH of the receiving waters. In addition,a reduction in the total copper loading at its source may not result in a corresponding reduction in dissolved copper levels in Panther Creek. It may simply reduce the precipitate loading to the stream. Consequently,the total copper loading at its source was selected to evaluate the level of abatement required to achieve improvements in the water quality of Panther Creek.

The impact of this loading criterion is shown in Figure 4-10, which indicates the May 1985 copper loading originating in Blackbird and Bucktail Creeks as well as the allowable loadings based on 0.05 mg/l in Panther Creek. A baseline copper level of 0.01 mg/l was assumed in Panther Creek above Blackbird. To meet the above criterion in Panther Creek below Blackbird Creek, the copper loading would need to be reduced from 89 lb/day (May 1985 level) to 33 lb/day, a 63 percent reduction. For Bucktail Creek, the measured loading of 325 lb/day would need to be reduced to 48 lb/day, which is an 85 percent reduction in copper loading. This implies that abatement measures must provide major reductions in copper loading to achieve the equivalent of 0.05 mg/l in Panther Creek. This may be difficult to achieve in practice due to the difficulty of identifying and isolating all major sources. In the Blackbird Creek Drainage, for example, a full 50 percent of the loading measured in May 1985 was unaccountable and presumed to be associated with the mine yard (see Section 4.2).

As such, there is a great deal of uncertainty involved in attempting to determine what levels of dissolved copper can be anticipated for various abatement measures. However, the simplistic approach suggested by the previous discussion indicates that a major effort will be required to accomplish significant improvements in the water quality of Panther Creek. Abatement programs must, therefore, provide major reductions in copper loading to meet the water quality requirements.

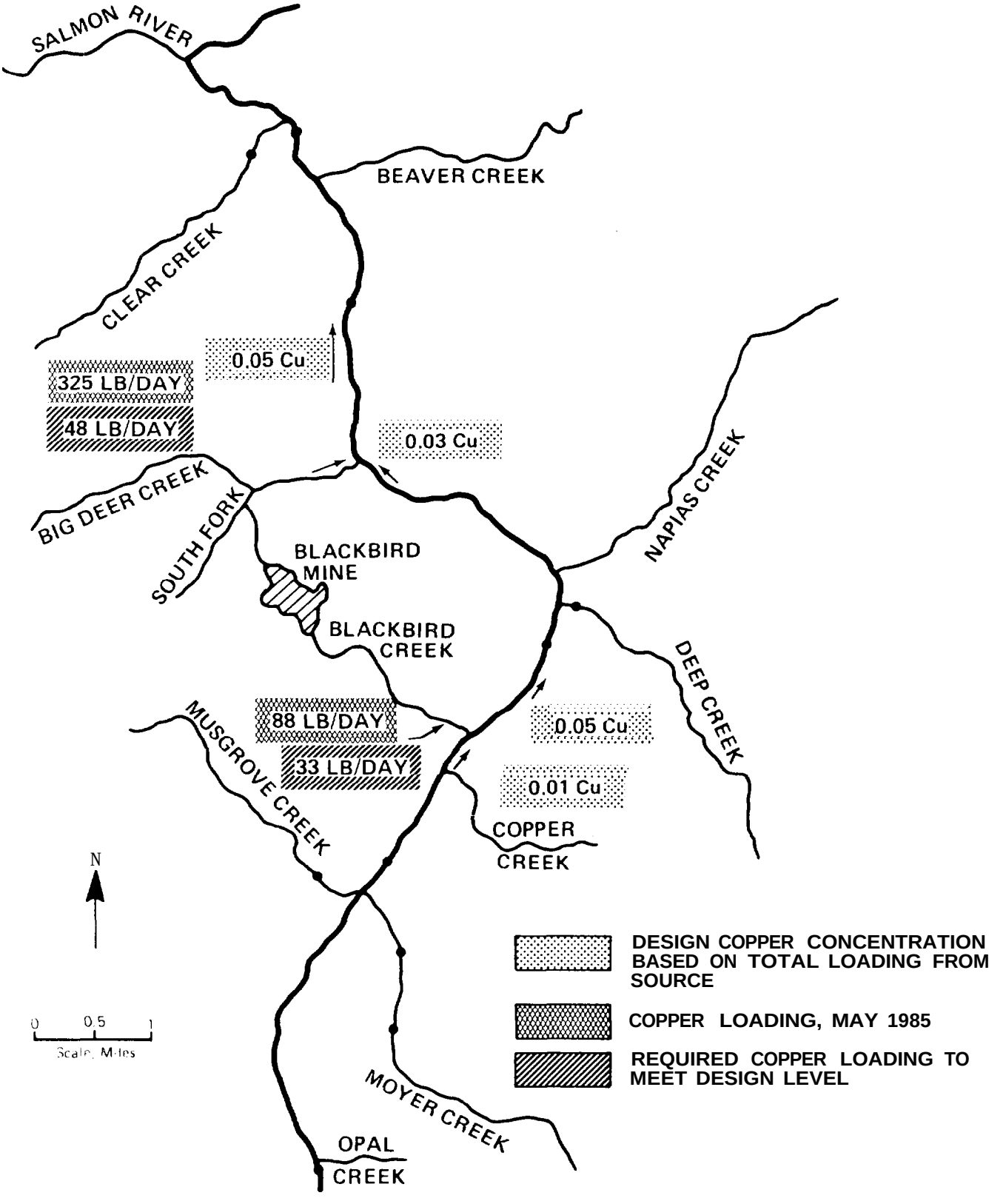


Figure 4-10 ALLOWABLE LIMITS AND PRESENT LOADING IN PANTHER CREEK BASED ON MAY 1985 FIELD SURVEY

Section 5: Proposed Alternative Abatement Programs

Section 5

PROPOSED ALTERNATIVE ABATEMENT PROGRAMS

The conceptual development of a complete abatement program was accomplished by first identifying individual abatement measures for specific sources of contamination. Individual measures were then combined into a program to achieve acceptable water quality levels in Panther Creek. Programs were developed that would not preclude future mining, but specific mine plans were not considered. It is assumed that any future mine operation will need to develop and operate a suitable water quality control plan.

This section includes a brief description of each of the abatement measures and two alternative abatement programs. The major difference between the two alternatives is that Alternative 1 includes water treatment and Alternative 2 utilizes passive measures wtthout treatment. Summary cost information is included for the two alternatives. More details about individual abatement measures and costs are provided in Appendix A, Section Aft.

5.1 ABATEMENT MEASURES

The following individual abatement measures were identified and incorporated into the two proposed abatement programs:

- Reclaim and revegetate
- Divert surface flows
- Improve Meadow Creek Channel
- Replace Blackbird Creek diversion culvert
- Cap waste rock piles
- Collect mine adit flows for treatment
- Collect contaminated water from waste rock piles
- Divert Bucktail Creek to the 6850 level via borehole
- Divert Upper Bucktail Creek to the 7117 adit

- Pump Bucktail Creek from Elevation 6950 ft to 7117 adit
- Install Blacktail Pit drain
- Backfill Blacktail Pit with waste rock and cap
- Treat poor quality water
- Seal and flood mine

These measures are components of the abatement programs. Each measure is briefly described below.

5.1.1 Reclaim and Revegetate

This is a long-term measure designed to help reduce the quantity of acidic leachate and improve the quality of water emanating from waste piles. Although a weil established vegetation cover may not dramatically decrease the concentration of metals in acidic leackates, it will reduce the volume of drainage percolating through the sulfide wastes. In addition, vegetation will reduce surface erosion and promote the development of an organic soil profile that provides a barrier to oxidation of subsurface sulfide materials.

The revegetation program was based on research performed at the Blackbird Mine by the USFS. It entails neutralizing the surface of the waste piles with ground agricultural limestone, adding fertilizers, and applying mulch and netting (for steep slopes) to enhance and ensure seed germination and intial plant establishment. Eighty-five acres of the Blackbird Mine area were identified as requiring reclamation, of which about half are steep terrained. Recommended seed mixtures, trees and shrubs, and application rates for lime and fertilizers are outlined in Appendix A.

5.1.2 Divert Surface Flows

The waste rock piles contribute the majority of the metal-laden acid drainage to Panther Creek. Recharge of these waste piles takes place in the form of direct infiltration of snow melt, as well as infiltration of surface flows that originate higher in the drainage basin. Diversion ditches around the waste piles can significantly reduce the recharge to the waste piles and

facilitate the stabilization of the waste piles for revegetation. Conceptually, the diversion ditches are located where the natural hillside meets the waste rock pile as shown in Figure 5-1. Regular maintenance of these diversion ditches will be required at least until new vegetation has been established.

To increase the effectiveness of the diversion ditches, they must be lined with an impermeable material. Six channel types were selected for the design of the diversion channel system. Five of the six are clay-lined channels and the sixth is a half-round corrugated metal section. The dimensions and riprap requirements of the clay-lined channels differ depending on bottom slope and discharge requirements. Layouts for the ditches are described and depicted in Section 5-2; additional details are provided in Appendix A.

5.1.3 Improve Meadow Creek Channel

Meadow Creek has been identified as a source of recharge to the mine workings and valley fill material (Baldwin et. al. 1978). The clay-lined channel design described in the previous section will reduce this source of recharge. Meadow Creek flows are intercepted just below the open pit waste pile; the improved channel collects the flow from diversion ditches and delivers it to the culvert system that passes beneath the mine yard and discharges below the mine gate.

5.1.4 Replace Blackbird Creek Diversion Culvert

Blackbird Creek flows in a culvert from the freah water reservoir to the mine gate. A section of the culvert in the vicinity of the mill consists of a wooden crib conduit that was installed to help dewater the mine yard. This culvert is believed to collect poor quality groundwater. Abatement programs that include the isolation and collection of poor quality water for treatment require that this culvert be replaced.

5.1.5 Cap Waste Rock Piles

Placing a clay Lining on the flat surfaces of the waste piles would greatly reduce the direct infiltration of rainfall and snowmelt into the piles.

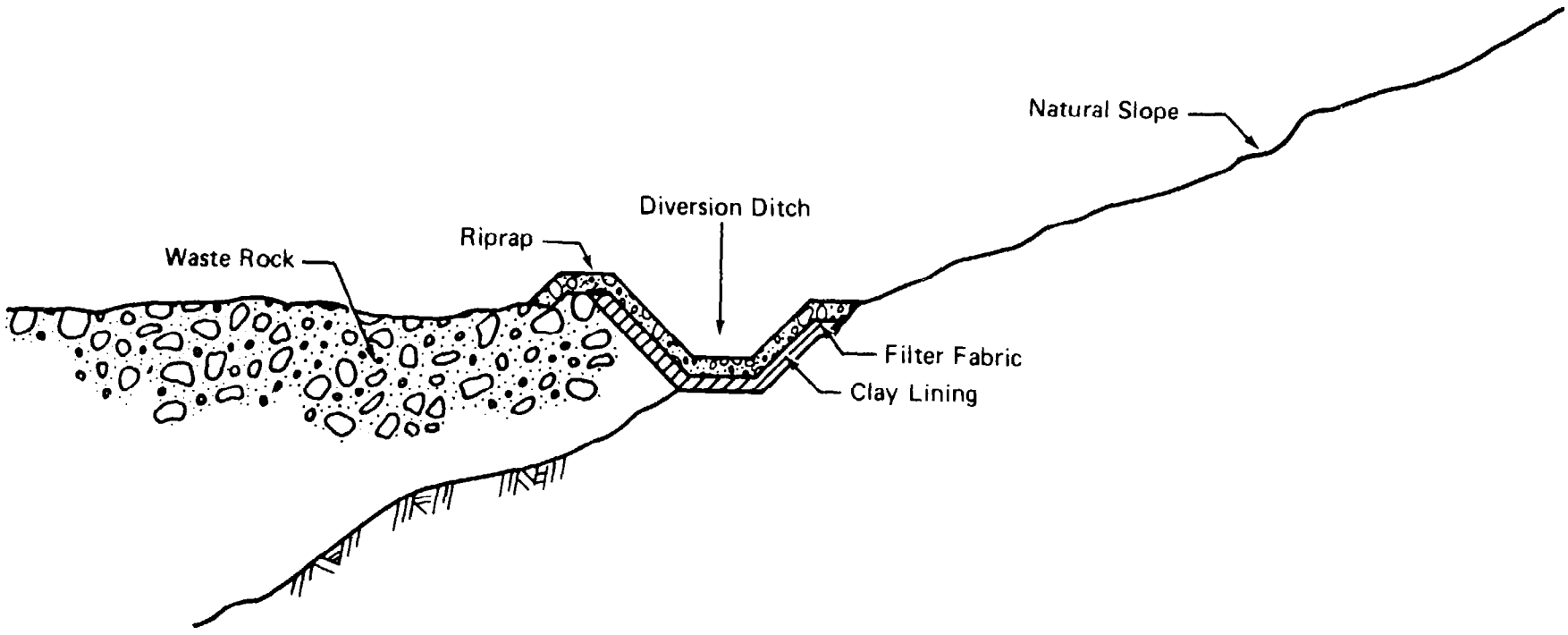


Figure 5-1 DIVERSION DITCH AT UPHILL SIDE OF WASTE-ROCK PILES

Installing the lining would be accomplished by excavating the top 24 in. of the waste rock, placing a 12 in. clay layer over the surface, backfilling the waste rock, and revegetating the surface.

5.1.6 Collect Mine Adit Flows for Treatment

Noranda has diverted flows from all adits in the Blackbird Drainage (which connect to the main mine workings) to the 6850 level. Similar diversions are necessary for the 7265 and 7117 adits in the Bucktail Drainage to eliminate these sources of acid mine drainage.

5.1.7 Collect Contaminated Water from Waste Piles

The flow diversion scheme outlined in Section 5.1.2 will effectively isolate the waste piles from surface runoff that does not originate from the piles. Therefore, the poor quality water associated with the waste piles can be collected and treated. Figure 5-2 shows a catch basin at the base of a waste rock pile. A perforated riser at each interceptor collects poor quality groundwater. The catch basins are interconnected by a 15 in. PVC pipe that directs the flow to the treatment plant as shown in Figure 5-3.

5.1.8 Divert Bucktail Creek to the 6850 Level via Borehole

Since a large majority of the flow in Bucktail Creek above Elevation 6,950 ft is associated with seepage from waste piles, diverting the entire stream for treatment has been suggested. This concept entails boring a 12 in. diameter hole from Bucktail Creek at approximately Elevation 6,950 ft to the 6,850 level within the mine utilizing specialized directional drilling equipment. A PVC pipe conveys Bucktail flows through the mine to the treatment plant in the Blackbird Drainage. In addition to the borehole, a sedimentation pond is constructed in the 7117 waste pile and a diversion structure is constructed in Bucktail Creek. Refer to Figure 5-4 for the layout of the borehole. Appendix A4 presents a detailed description of the measure.

5.1.9 Divert Bucktail Creek to the 7117 Adit

Upper Bucktail Creek could be diverted above the 7117 waste pile into the mine, There is an existing raise between the 6850 level and the 7117 level

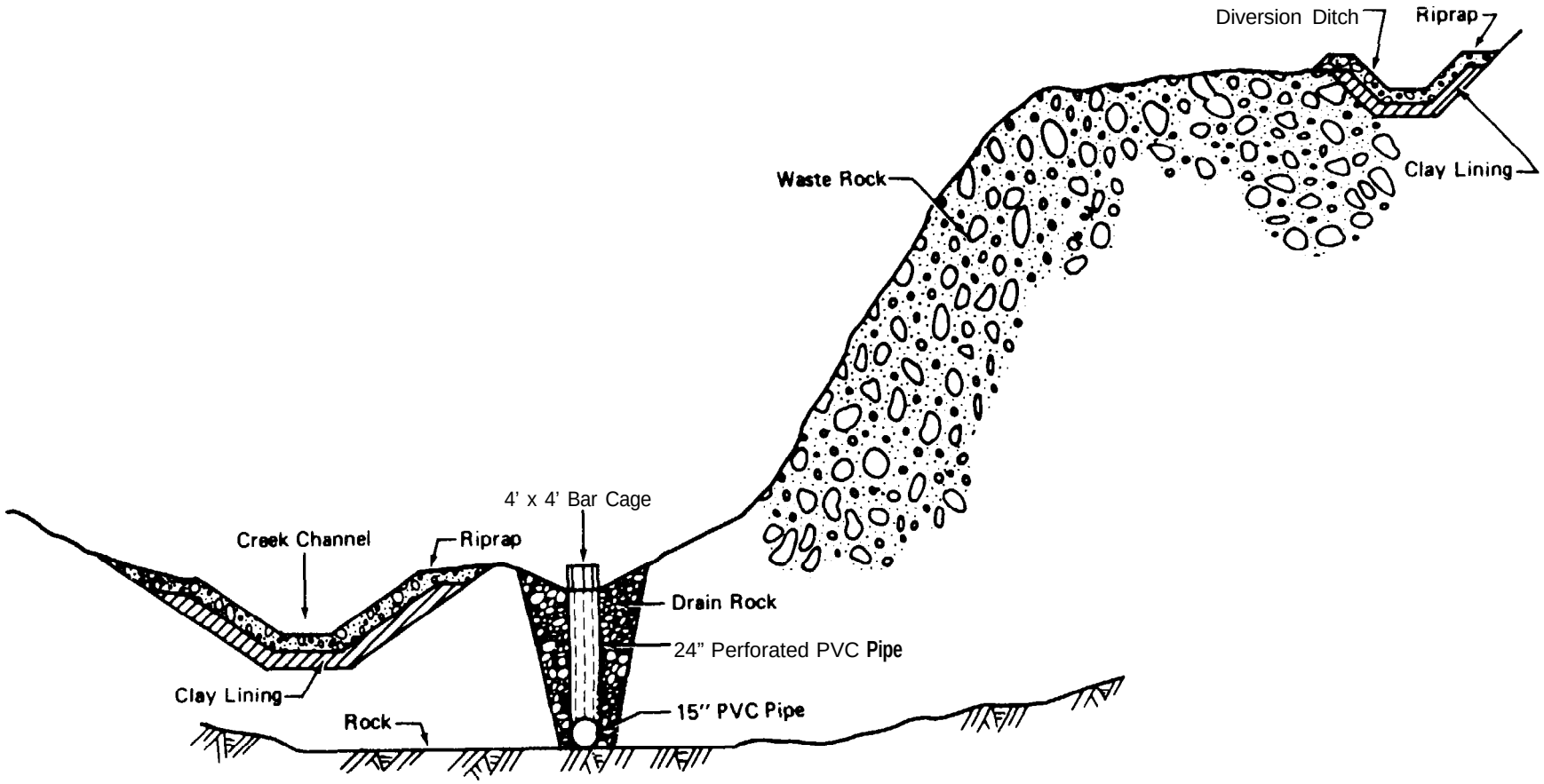


Figure 5-2 DETAIL OF CONTAMINATED WATER COLLECTION SYSTEM

that would permit the transfer of water from Bucktail Creek through the mine to the treatment facilities. A sedimentation pond can be constructed in the 7265 waste pile and a diversion structure can be built at about elevation 7,175 ft. A 12 in. diameter pipe would transfer Bucktail flows from the diversion structure to the treatment building.

5.1.10 Pump Bucktail Creek from Elevation 6950 to the 7117 Adit

A significant amount of poor quality water enters Bucktail Creek below the 7117 adit. This additional flow can be collected and pumped back to the 7117 level and piped through the mine to the treatment facilities. Pumping facilities with a capacity of 500 gpm and 40 hp are adequate. A diversion and pump structure can be built in Bucktail Creek. The flow would be piped to the 7117 adit where it would join the gravity flow from upper Bucktail Creek (Section 5.1.9) and continue to the treatment building.

5.1.11 Install Blacktail Pit Drain

The open pit is a major source of recharge to the mine workings. This source of recharge can be eliminated by draining the pit with a 6 in. diameter slant borehole from the bottom of the pit to the Bucktail Drainage. A 12 in. thick clay liner would be used to prevent infiltration through the bottom of the pit.

5.1.12 Backfill Blacktail Pit with Waste Rock and Can

This concept involves excavating the waste rock piles in the headwaters of Bucktail Creek and placing them into the open pit to effectively isolate this major source of poor quality water. After backfilling the pit, a 12 in. thick clay liner can be used to cap the waste rock. Twenty-four in. of neutralized waste rock can be placed over the cap and then the surface can be vegetated.

5.1.13 Treat Poor Quality Water

For alternatives that include treatment, the use of the existing treatment facilities is proposed as an initial approach. During the peak of spring runoff and during intense thunderstorm activity, the flows will exceed the capacity of the treatment facilities. However, other abatement measures,

particularly flow diversion and reclamation, should be very effective during these periods. Consequently, the water quality in Panther Creek may be acceptable even if all of the poor quality water is not treated. The proposed design philosophy is, therefore, to install collection facilities capable of carrying the annual flood but not increase the treatment capacity (or storage) unless future monitoring dictates it. Further discussion is provided in Appendix A4.

5.1.14 Seal and Flood the Mine

This measure would reduce the quantity of acid mine drainage emanating from mine adits. The water quality should also improve because it will limit the production of acid that occurs as a consequence of oxidation of sulfide minerals. This measure would be applicable for the mine in an inactive state. A preliminary bulkhead design was developed for costing purposes, and it was assumed that 17 adits and 5 raises may require bulkheads. There are technical and safety concerns that must be evaluated through geotechnical investigations prior to implementing this measure.

5.2 DEVELOPMENT OF ALTERNATIVE ABATEMENT PROGRAMS

Two alternative abatement programs were developed from the individual components outlined in the previous section. Alternative 1 is an alternative that involves treating poor quality water. Alternative 2 relies on passive measures to improve water quality. Table 5-l presents a summary of the components included in each alternative.

The abatement programs were developed as the combination of a number of individual components so that the affect of variations on these programs would be easy to evaluate. For instance, if a passive program is preferable with the mine in an active state, mine sealing would not be included but some treatment would be included. With the information provided in Appendix A, the cost implications of variations to the proposed programs can be easily determined.

Table 5-l

COMPARISON OF PROPOSED ALTERNATIVE ABATEMENT PROGRAMS

Abatement Measure	Alternative			
	1A	1B	2A	2B
Reclaim and revegetate	X	X	X	X
Divert surface flows	X	X	X	X
Improve Meadow Creek	X	X	X	X
Replace Blackbird Creek culvert	X	X		
Cap waste rock piles			X	X
Collect mine adit flows	X	X		
Collect water from waste piles	X	X		
Divert Bucktail Creek to 6850 via a borehole	X			
Divert Bucktail Creek to 7117 adit		X		
Pump Bucktail Creek		X		
Install Blacktail Pit drain	X	X	X	
Backfill Blacktail Pit				X
Treat water	X	X		
Seal and flood mine				X

5.3 ALTERNATIVE 1

The basic concept of this alternative is to divert all clean water around waste piles and to collect and treat both the direct runoff from the waste pile as well as the mine adit flow. Slightly different approaches were necessary for the Blackbird and Bucktail drainages.

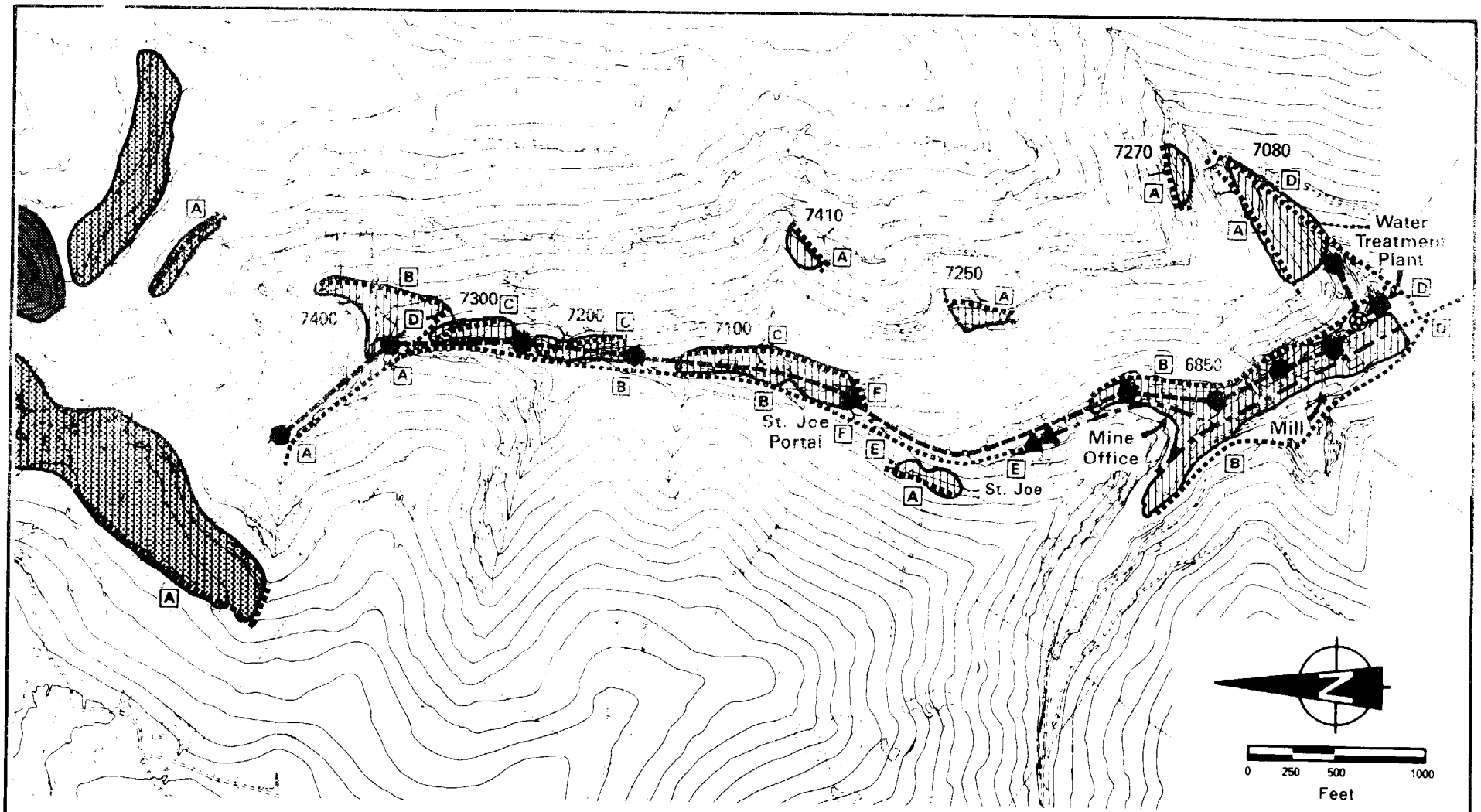
The scheme for the Blackbird Drainage is shown in Figure 5-3. For this scheme, all clean water runoff is directed around the waste piles to the improved Meadow Creek channel. This effectively isolates runoff from the waste piles so that it can be collected and treated. The primary components of Alternative 1 are to:

- Divert flow
- Revegetate waste piles
- Treat contaminated water from waste piles
- Drain the mine and treat the adit flows

A contaminated-water collection system, consisting of a series of 10 catch basins, intercepts both surface and subsurface flows from the waste piles and directs them to the treatment facility. The design incorporates a grit removal chamber located just upstream of the existing storage tank (beneath the treatment building).

For the Bucktail Drainage, two options were identified for Alternative 1. Both options involve diverting flow and collecting poor quality water. The poor quality water is transferred through the subsurface workings to the existing treatment facilities on Blackbird Creek. Both options also include a drain for the Blacktail Pit.

Alternative IA is shown in Figure 5-4. This scheme involves constructing a diversion structure in the Bucktail Creek Channel at about elevation 6,950 ft. A 1,500 ft long, 12 in. borehole connects the diversion structure on Bucktail Creek to the 6850 level. Inside the mine, a 12 in. PVC pipe carries the poor quality water to the treatment plant via the 6850 adit. A



WASTE ROCK PILE TO BE REVEGETATED

======-s DIVERSION DITCH

CONTAMINATED WATER PIPE

CLEAN WATER CULVERT

CONTAMINATED WATER CATCH BASIN

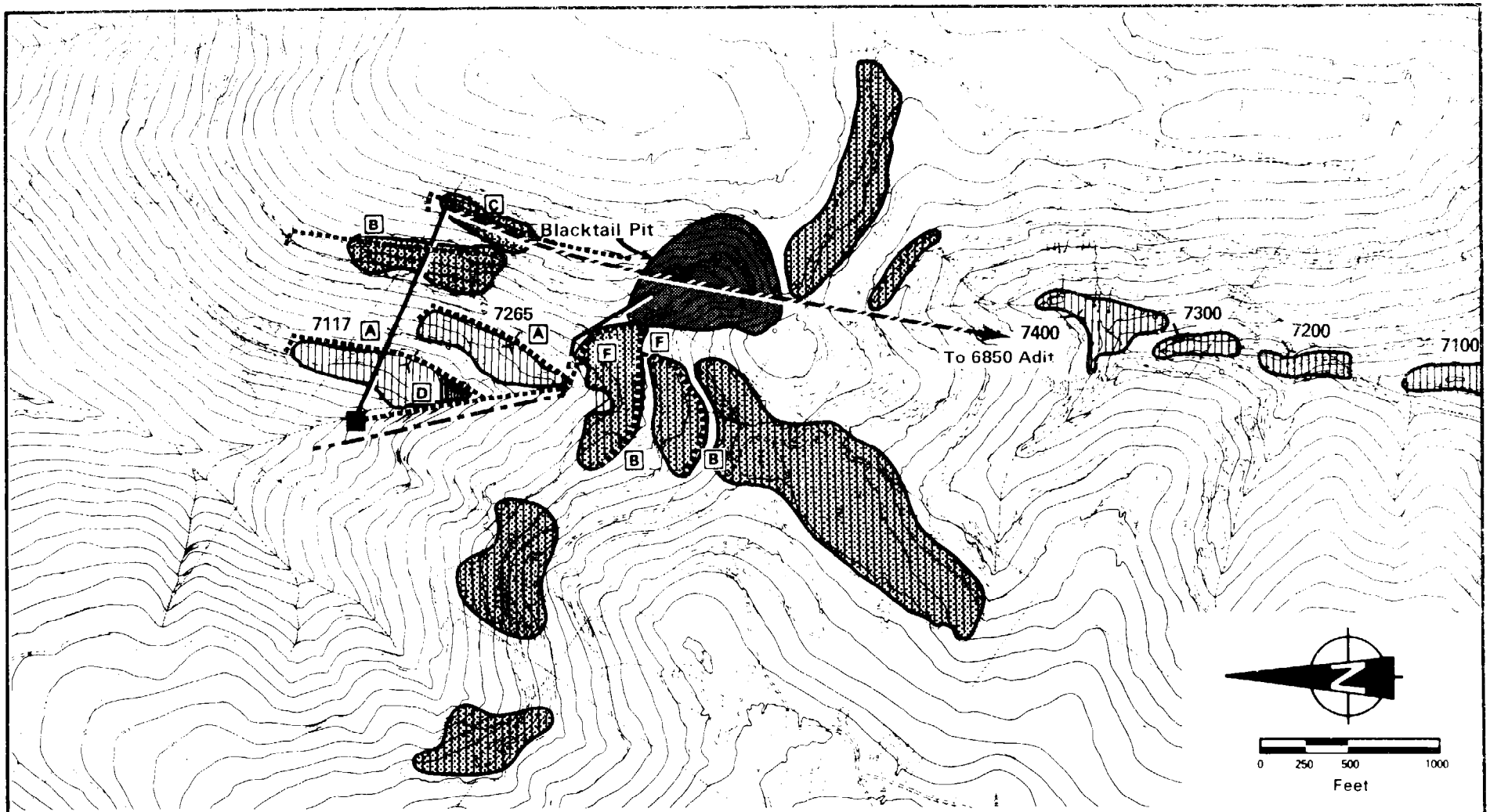
SEDIMENTATION POND

GRIT REMOVAL CHAMBER

DIVERSION DITCH TYPE (See Section A4.2)

Figure 5-3

BLACKBIRD DRAINAGE ALTERNATIVE 1



WASTE ROCK PILE TO BE REVEGETATED

=*==*==' DIVERSION DITCHES

BORE HOLE

CLEAN WATER CULVERT

CONTAMINATED WATER PIPE WITHIN MINE

DIVERSION STRUCTURE

SEDIMENTATION POND

DIVERSION DITCH TYPE
(See Section A4.2)

Figure 5-4

BUCKTAIL DRAINAGE ALTERNATIVE 1A

clay-lined sedimentation pond is constructed in the 7117 waste pile to reduce debris and sediment Loading at the diversion structure. The sedimentation basin has a capacity of about 500 cu yd and has both a pipe outlet and an overflow channel.

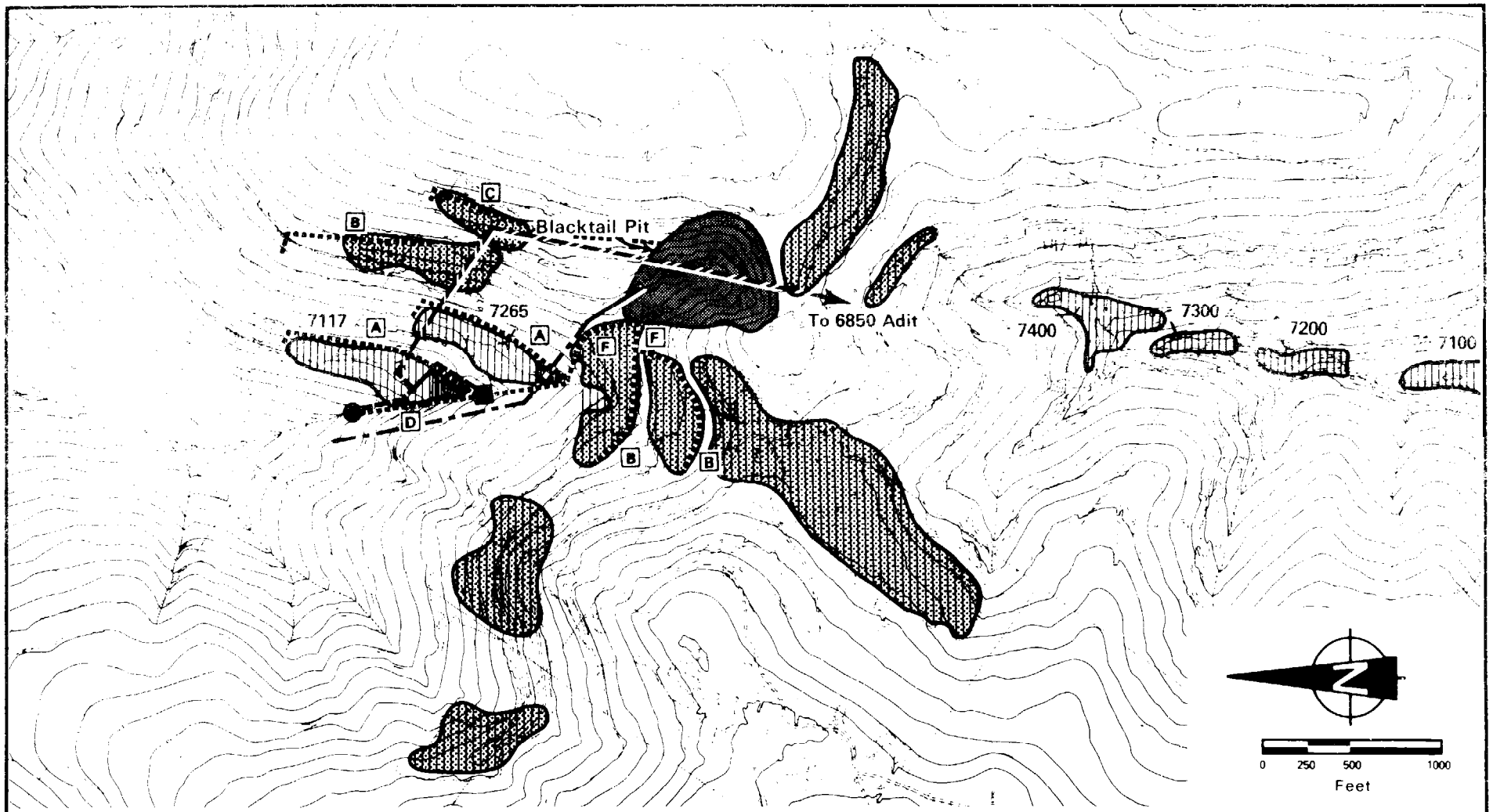
Alternative 1B is shown in Figure 5-5. This alternative avoids the need for the borehole to the 6850 level. Instead, the majority of the flow is diverted to the 7117 adit by gravity. A small pump structure located on Bucktail Creek at elevation 6,950 collects the remaining poor quality water and diverts it into the 7117 adit. The combined flow from both sources is then conveyed through the mine in a 12 in. PVC pipe to the treatment facility. This scheme incorporates a sedimentation pond at the 7265 and the 7117 waste piles.

Alternative 1 has the following advantages:

- Lower initial capital cost
- The ability to incrementally improve water quality by improving collection facilities or adding additional treatment/storage facilities as needed
- More consistent water quality under varying hydrologic conditions

Alternative 1 has the following disadvantages:

- Long-term operation of the water treatment facility. It will take many years before reclamation/revegetation efforts accomplish the required improvement in water quality.
- Susceptibility to uncontrolled releases of contaminants caused by a failure in the collection or treatment facilities. Such failures could be caused by debris flows over an intake, power failures, or failures in any link of the process. No additional storage is provided in the system other than the storage tank presently beneath the treatment building. However, in an inactive state, the mine itself could be used for temporary emergency storage.
- High operating costs associated with continuous operation of the treatment plant,



WASTE ROCK TO BE REVEGETATED

PUMP STRUCTURE

DIVERSION STRUCTURE

SEDIMENTATION POND

DIVERSION DITCH

CONTAMINATED WATER PIPE

BORE HOLE

CLEAN WATER CULVERT

CONTAMINATED WATER PIPE WITHIN MINE

DIVERSION DITCH TYPE (See Section A4.2)

Figure 5-5

BUCKTAIL DRAINAGE ALTERNATIVE 1B

5.4 ALTERNATIVE 2

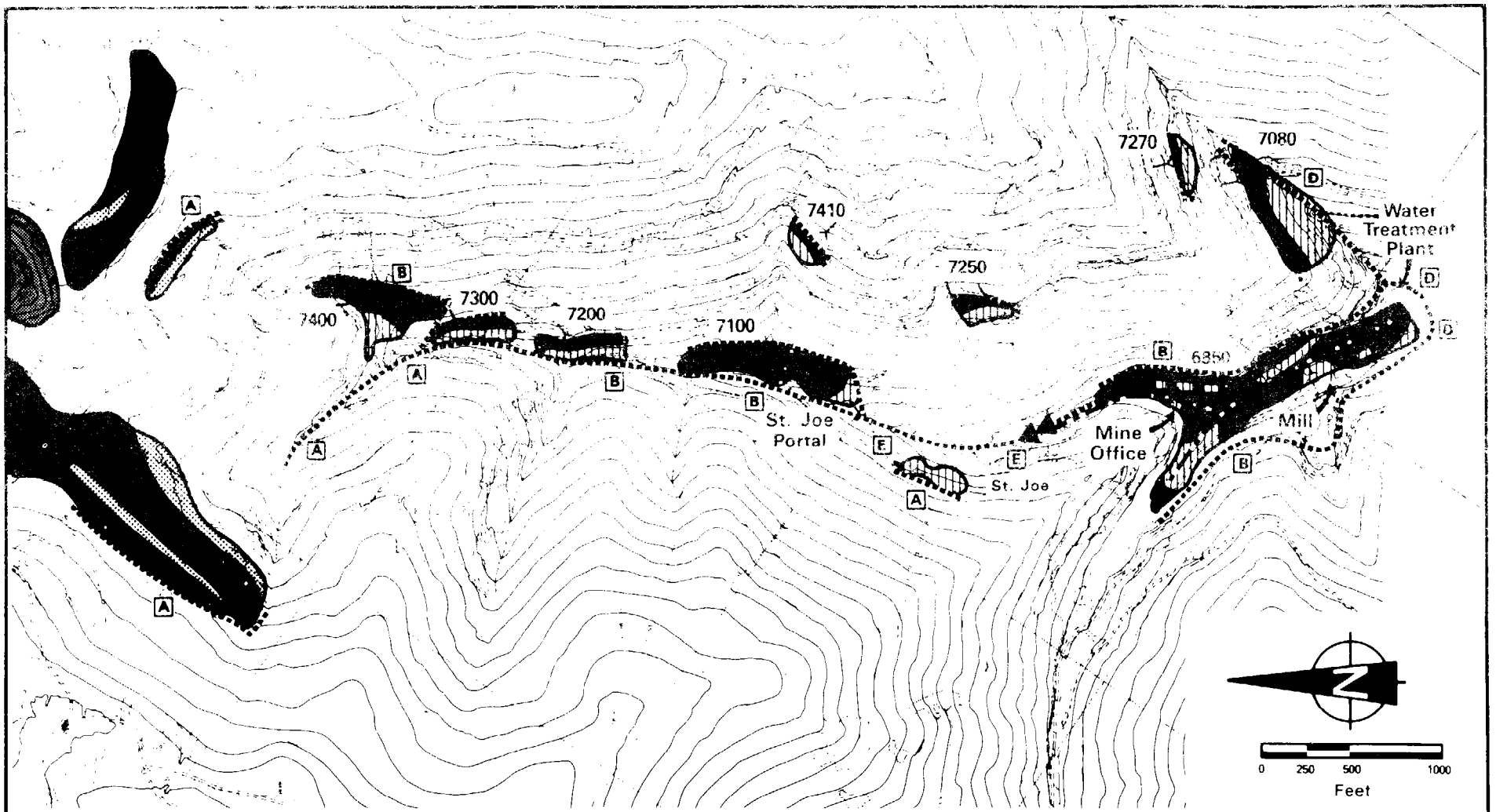
This alternative more effectively isolates the waste piles by capping the flat surfaces of the piles with an impermeable material in addition to diverting runoff around them.

The scheme for the Blackbird Drainage is shown in Figure 5-6. A 12 in. clay layer is used as an impermeable liner to cap the flat surfaces of the waste piles. This will reduce recharge to the piles associated with direct infiltration of snowmelt or rainfall into the waste rock. The primary components of Alternative 2 are to:

- Divert flow
- Cap and revegetate waste piles
- Seal and flood the mine

In the Bucktail Drainage, two options were developed. The first option, Alternative 2A, is shown in Figure 5-7. Conceptually, it is similar to that described for the Blackbird Drainage. Flow is diverted around waste piles and the flat surfaces of the piles are capped; all waste is then revegetated. This alternative also includes a drain for the Blacktail Pit.

Alternative 2B is illustrated in Figure 5-8. This concept includes the excavation of the waste rock in the headwaters of Bucktail Creek and the placement of this material into the Open Pit. Other waste piles in the Bucktail Drainage are capped and revegetated. After placement in the pit, a clay cap is used to isolate the waste from potential recharge by surface flow. This alternative was developed since the water quality data indicate that the waste material at the headwaters of Bucktail Creek is a major source of contamination. Since this waste pile is reportedly recharged by springs buried beneath the pile, capping of the pile in place may not provide a sufficient reduction in metal loading. In addition, the magnitude of reduction in copper loading required for Bucktail Creek (see Section 4) Indicates that more stringent measures are necessary. Consequently, if a passive, no treatment alternative is preferred to meet the water quality requirements in Panther Creek, it may be necessary to implement Alternative 2B, which includes backfilling of the Open Pit.



WASTE ROCK TO BE REVEGETATED

WASTE ROCK CAPPED AND REVEGETATED

DIVERSION DITCH

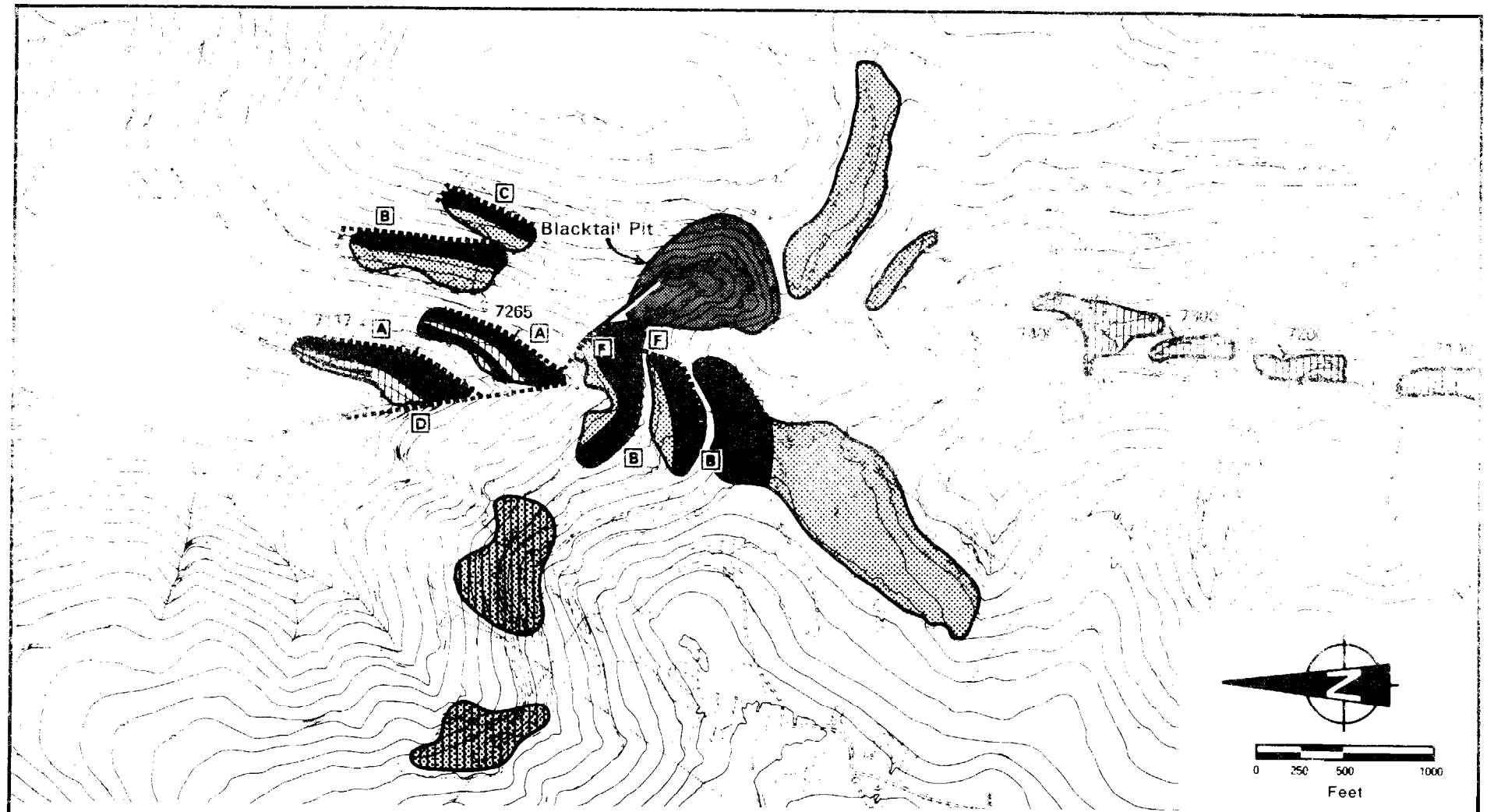
CLEAN WATER CULVERT

SEDIMENTATION POND

DIVERSION DITCH TYPE
(See Section A4.2)

Figure 5-6

BLACKBIRD DRAINAGE ALTERNATIVE 2



WASTE ROCK PILE TO BE REVEGETATED

DIVERSION DITCH

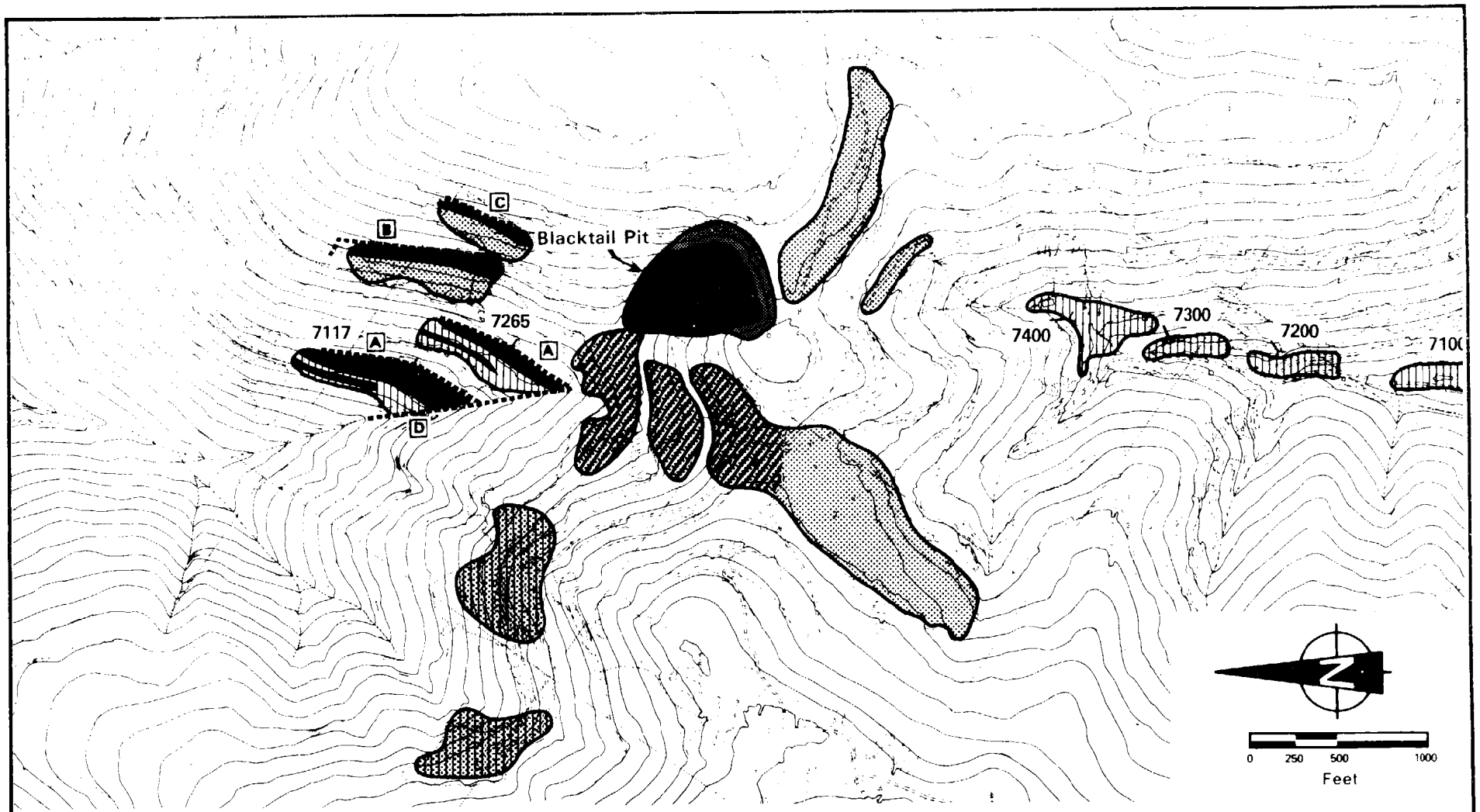
WASTE ROCK CAPPED AND REVEGETATED

BORE HOLE

DIVERSION DITCH TYPES
(See Section A4.2)

Figure 5-7

BUCKTAIL DRAINAGE ALTERNATIVE 2A



WASTE ROCK PILE TO BE REVEGETATED

DIVERSION DITCH

WASTE ROCK EXCAVATED AND PLACED IN PIT; AREA REVEGETATED

WASTE ROCK PILE CAPPED AND REVEGETATED

DIVERSION DITCH TYPE (See Section A4.2)

Figure 5-8

BUCKTAIL DRAINAGE ALTERNATIVE 2B

In accordance with the development of a "no treatment" option, the sealing and flooding of the mine is incorporated into Alternative 2. This assumes that the mine would remain in an inactive state. Should active mining resume, the mine seals would be removed after the stored water has been drained and treated. More detailed geotechnical and hydraulic investigations are required before implementing the sealing of the mine. The mine seals could be installed in a phased approach. As the mine fills with water, additional adit bulkheads could be installed as necessary. At this time, insufficient information is available to determine how high the water would rise in the mine. It is anticipated, however, that the mine will not fill completely. The leakage through fractures in the rock will eventually reach an equilibrium condition with the water entering the mine. For costing purposes, it was assumed that 17 portals and 5 raises require bulkheads.

Alternative 2 has the following advantages:

- The passive measures employed are less susceptible to failures that might allow high uncontrolled releases of pollutants.
- Low operation and maintenance (O&M) costs during initial years diminish to minimal costs after successful reclamation.

Alternative 2 has the following disadvantages:

- There are uncertainties in determining the effectiveness of the proposed abatement measures. Although it is anticipated that the proposed measures will produce acceptable levels of water quality in Panther Creek, it is difficult to determine the exact level of improvement these measures will produce. If, after implementation of the abatement measures, acceptable water quality has not been achieved in Panther Creek, it may be difficult to provide additional improvement in water quality without major expenditures.
- The technical and economic feasibility of sealing and flooding the mine has not been established.
- Alternative 2B includes backfilling of the Open Pit with waste rock from the headwaters of Bucktail Creek. This operation is extremely costly. The need for this measure is predicated on the assumption that this waste is the major contributor to poor quality water in Bucktail Creek. Since

this aspect has not been confirmed by detailed geotechnical investigations, questions remain regarding the effectiveness of this proposed abatement measure.

- Alternative 2B has high initial costs.

5.5 COST ESTIMATES FOR SELECTED ABATEMENT PROGRAMS

The cost estimates provided in this report are conceptual level estimates. The estimates include a 10 percent contingency and are for construction costs only. In general, where the site conditions were unknown, they were assumed to be favorable. Therefore, the cost estimates may be lower than actual construction costs if unexpected site conditions are encountered. The cost estimates for Alternatives 1 and 2 are summarized in Tables 5-2 and 5-3, respectively. More details about the costs are given for each abatement measure in Appendix A4; detailed cost estimate worksheets are contained in Appendix A5.

The total construction cost of Alternative 1 was estimated to be about $3.4 to $3.8 million, depending upon whether the pumping scheme or the gravity scheme is selected. O&M costs of $600,000 include $400,000 per year for treatment plant operation (see Section A4) and an allowance of $200,000 per year for maintenance of the ditches, waste-pile vegetation cover, and the contaminated water collector system. O&M costs are highly dependent upon what, if any, activities continue at the mine.

The total construction costs for Alternative 2 vary from $5.7 to $8.2 million, depending upon whether the Open Pit is backfilled with the waste rock deposited in the headwaters of Bucktail Creek. An allowance of $200,000 per year is included for maintenance activities.

Estimated costs were based on the assumption that reclamation activities would not be coordinated with mine operation. If the mine were operating, some costs such as that for boring the hole to the 6850 level on the Bucktail side could be much lower because the necessary equipment would be available at the site. In addition, operation and maintenance costs could be greatly reduced if they were incorporated with mining activities.

Table 5-2

CONSTRUCTION COST ESTIMATES FOR ALTERNATIVE 1

Item	Cost($)
Blackbird Drainage	
Construct flow diversion ditches	796,000
Improve Meadow Creek	337,000
Revegetate waste piles	204,000
Construct contaminated water collection system	229,000
Replace Blackbird Creek culvert	284,000
Total	1,850,OOO
Bucktail Drainage	
Construct flow diversion ditches	714,000
Revegetate waste piles	124,000
Install Blacktail Pit drain	217,000
Divert 7117 and 7265 adit flows	20,000
Install borehole to 6850 level (1A)	845,000
Divert (gravity) and pump (1B)	440,000
Total (lA)	1,920,000
Total (1B)	1,515,000
Alternative 1A - Total construction costs	3,770,000 [a]
Alternative 1B	
Total construction costs	3,365,000 [a]
O&M costs	600,000/yr

a Costs assume existing treatment plant is available for water treatment. Costs do not include engineering, geologic investigations, and water quality monitoring.

Table 5-3

CONSTRUCTION COST ESTIMATES FOR ALTERNATIVE 2

Item	Cost($)
Blackbird Creek Drainage	
Construct flow diversion ditches	796,000
Improve Meadow Creek	337,000
Cap flat surfaces of waste piles	1,342,000
Revegetate waste piles	204,000
Total	2,679,000
Bucktail Drainage	
Construct flow diversion ditches	714,000
Cap flat surfaces of waste piles	537,000
Revegetate waste piles	148,000
Install Blacktail Pit drain (2A)	217,000
Backfill Blacktail Pit (2B)	2,706,000
Total (2A)	1,616,000
Total (2B)	4,105,000
Seal Mine Adits	1,400,000
Alternative 2A - Total construction costs	5,695,000 [a]
Alternative 2B	
Total construction costs	8,184,000 [a]
Maintenance costs	200,000/yr

a Costs do not include engineering, geologic investigations, or water quality monitoring.

Section 6: Implementation Schedule

Section 6

IMPLEMENTATION SCHEDULE

There are many uncertainties in determining the water quality requirements necessary to re-establish the fishery resource in Panther Creek and its tributaries. There are additional uncertainties in predicting the effects of specific abatement measures on the overall water quality of Panther Creek. Consequently, a phased approach to implementing the abatement program is warranted. At the same time, geologic investigations and monitoring studies (both water quality and biological) should be initiated to resolve as many of the unknowns as possible and thereby provide an effective abatement scheme. It is expected that the final design of the abatement program will evolve as the results of the geologic investigations become available and as the performance of the initial abatement measures are evaluated through monitoring studies.

From all available information, the Bucktail drainage is by far the larger contributor to present water quality problems in Panther Creek. In addition, a greater improvement in water quality can be achieved by an incremental expenditure for abatement measures in the Bucktail drainage than with those in the Blackbird drainage. Therefore, initial efforts should be directed toward program measures in the Bucktail drainage. A simplified schedule for implementing the Bucktail abatement program has been developed. The schedule assumes that the decision to proceed is made before March 1, 1986 (Figure 6-l).

The proposed implementation schedule requires that a decision be made by the end of 1986 as to which abatement program is preferred for the Blackbird mine. To provide input to this decision, geologic investigations and monitoring studies must begin early in 1986. In addition, the engineering design for the program must also begin early in 1986 in preparation for the following activities:

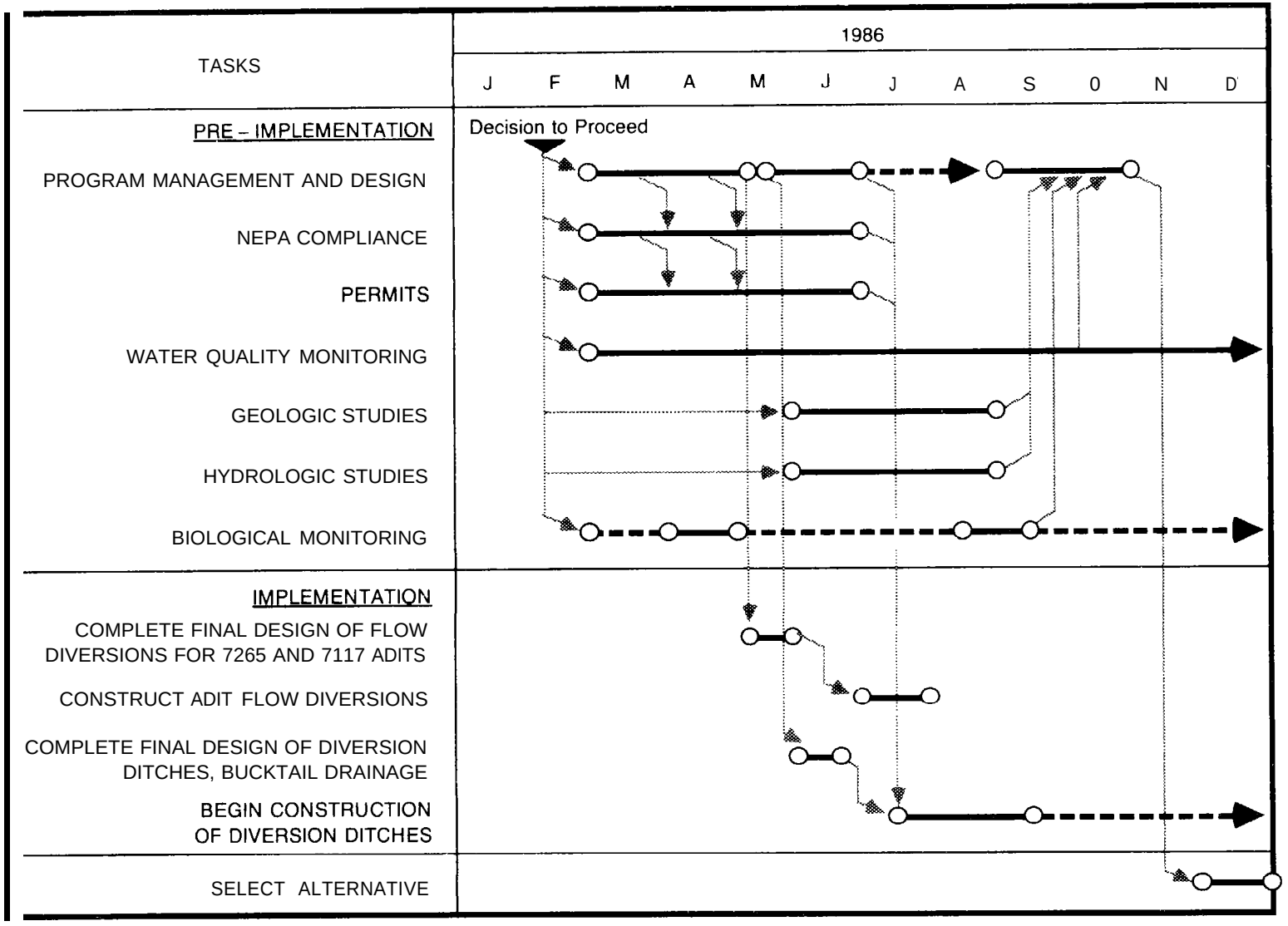


Figure 6- 1 PROPOSED IMPLEMENTATION SCHEDULE FOR ABATEMENT PROGRAM – 1986, BUCKTAIL DRAINAGE

- Coordinating abatement programs with mining plans
- Initiating permitting activities and environmental compliance
- Developing bid packages for construction of initial phases of abatement program

Diversion of the 7265 and 7117 adit flows to treatment has also been identified as a high priority item because these flows:

- Are major contributors to water quality problems in the drainage.
- Do not require major expenditures.

Any additional funds available in 1986 can be used to start construction of the diversion ditches that are common to all alternatives.

The implementation schedule for the remainder of the program is contingent upon which alternative is selected. A simplified implementation schedule for each alternative is outlined briefly in the following sections. The year-by-year program was developed to maximize the initial benefit of the abatement program while keeping abatement measures on schedule.

6.1 ALTERNATIVE 1A

This alternative is a treatment alternative that entails drilling a borehole from the Bucktail drainage to the 6850 level (Figure 6-2). Major work items include:

1987
- Drill borehole from Bucktail to 6850 level
- Continue diversion ditch construction
- Continue monitoring studies

1988
- Complete diversion ditches
- Revegetate waste piles
- Install Blacktail pit drain
- Continue monitoring studies

1989
- Continue revegetation
- Continue monitoring studies

1990
- Continue monitoring studies

ALTERNATIVE 1A (TREATMENT - WITH BOREHOLE DIVERSION)

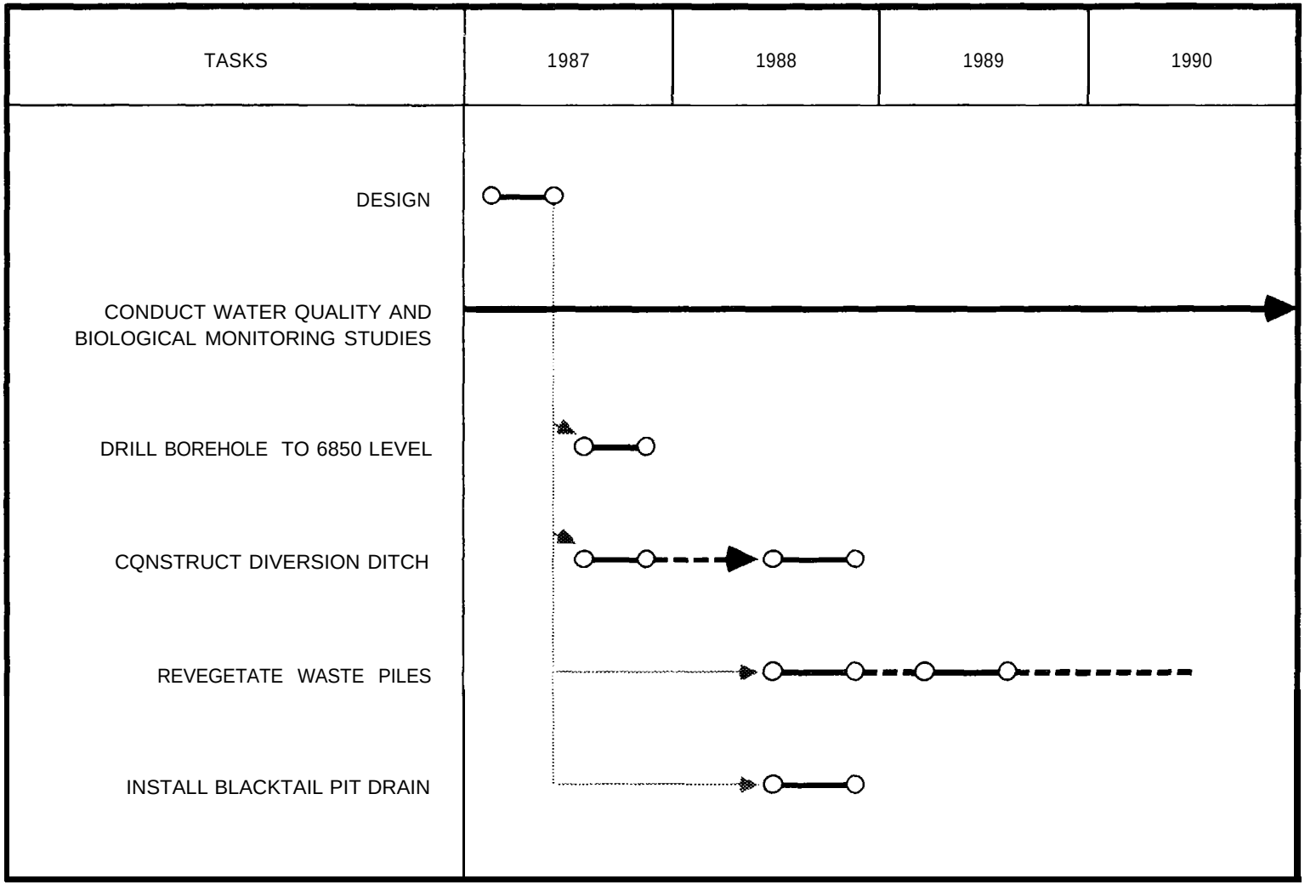


Figure 6-2 PROPOSED IMPLEMENTATION SCHEDULE FOR ABATEMENT PROGRAM - ALTERNATIVE 1A. BUCKTAIL DRAINAGE

6.2 ALTERNATIVE 1B

This alternative is also a treatment alternative (Figure 6-3). It differs from Alternative lA only in that gravity diversion and pumping are used instead of a bore hole to transfer Bucktail Creek flows to the treatment facilities in the Blackbird drainage. Since the diversion facilities can be constructed in stages, the gravity diversion should be constructed first; monitoring may indicate that the pump station is not required. Major work items include:

1987
- Construct gravity diversion to 7117 adit
- Complete diversion ditch construction
- Continue monitoring studies

1988
- Install Blacktail pit drain
- Revegetate waste piles
- Construct pump station

1989
- Continue revegetation
- Continue monitoring studies

1990
- Continue monitoring studies

6.3 ALTERNATIVE 2A

This alternative relies on impervious caps for the, waste piles and diversion. ditches to produce the required reduction in metal loading in Bucktail Creek (Figure 6-4). Since the metal loading in Bucktail Creek is high, and since a major reduction in loading is needed to meet water quality requirements, this alternative may not produce the desired level of improvement. Geologic and hydrologic investigations may provide higher confidence in this alternative, but it may be necessary to implement and monitor it to ascertain its effectiveness. If the level of improvement does not meet required levels, it may be necessary to implement Alternative 2B. Work items include:

1987
- Install mine seals as needed on Bucktail side
- Complete diversion ditches
- Begin capping and revegetation
- Continue monitoring studies

1988
- Complete capping
- Continue revegetation
- Install Blacktail pit drain
- Continue monitoring studies

ALTERNATIVE 1B (TREATMENT - WITH GRAVITY DIVERSION)

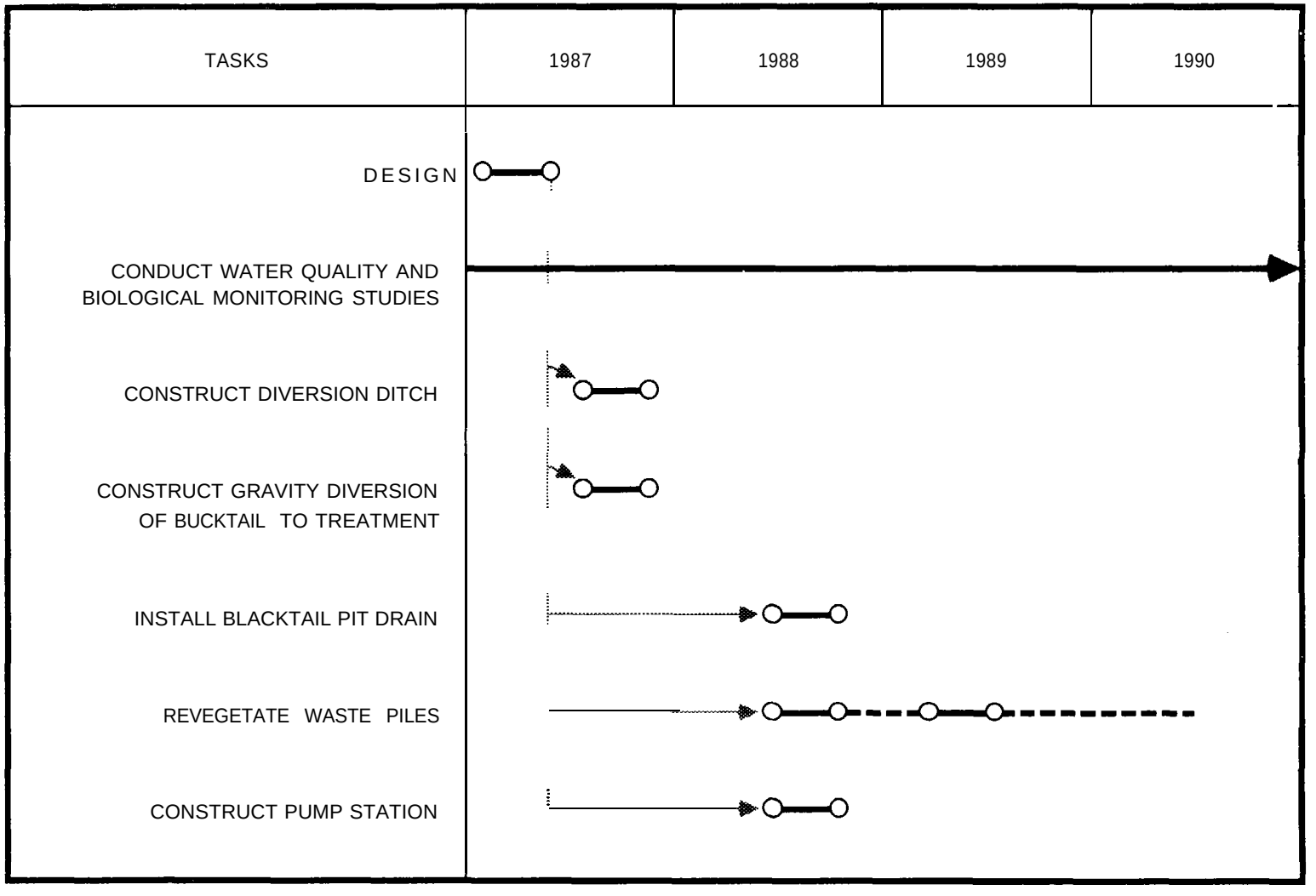


Figure 6- 3 PROPOSED IMPLEMENTATION SCHEDULE FOR ABATEMENT PROGRAM - ALTERNATIVE 1B, BUCKTAIL DRAINAGE

ALTERNATIVE 2A (NONTREATMENT)

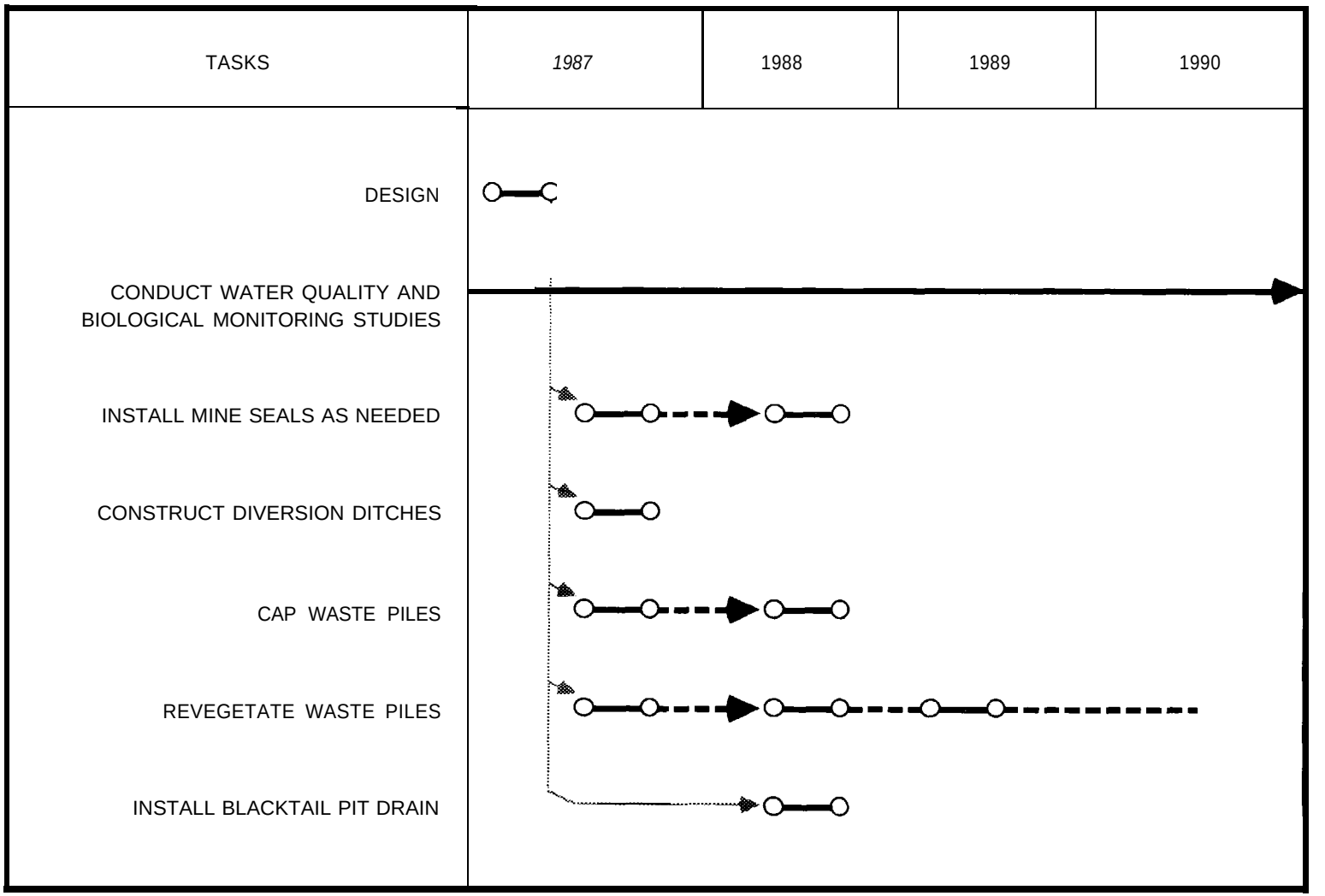


Figure 6- 4 PROPOSED IMPLEMENTATION SCHEDULE FOR ABATEMENT PROGRAM - ALTERNATIVE 2A, BUCKTAIL DRAINAGE

1989
- Continue revegetation
- Continue monitoring studies

1990
- Continue monitoring studies

6.4 ALTERNATIVE 2B

This alternative is costly because it entails excavating waste piles in the headwaters of Bucktail Creek and placing the material into the Blacktail open pit under an impervious cover (Figure 6-5). Because of its high cost, the need for implementing Alternative 2B should be verified by further investigation and monitoring studies. The schedule outlined below assumes that the need for this program is confirmed in 1986

1987
- Install mine seals as needed
- Construct diversion ditches
- Begin backfill of pit
- Begin capping and revegetation
  Selected waste piles
- Continue monitoring studies

1988
- Complete backfill of pit
- Continue monitoring studies

1989
- Cap and revegetate waste piles
  Backfilled Blacktail pit
  Disturbed waste rock areas
- Continue monitoring studies

1990
- Continue revegetation
- Continue monitoring studies

ALTERNATIVE 2B (NONTREATMENT AND BACKFILL BLACKTAIL PIT)

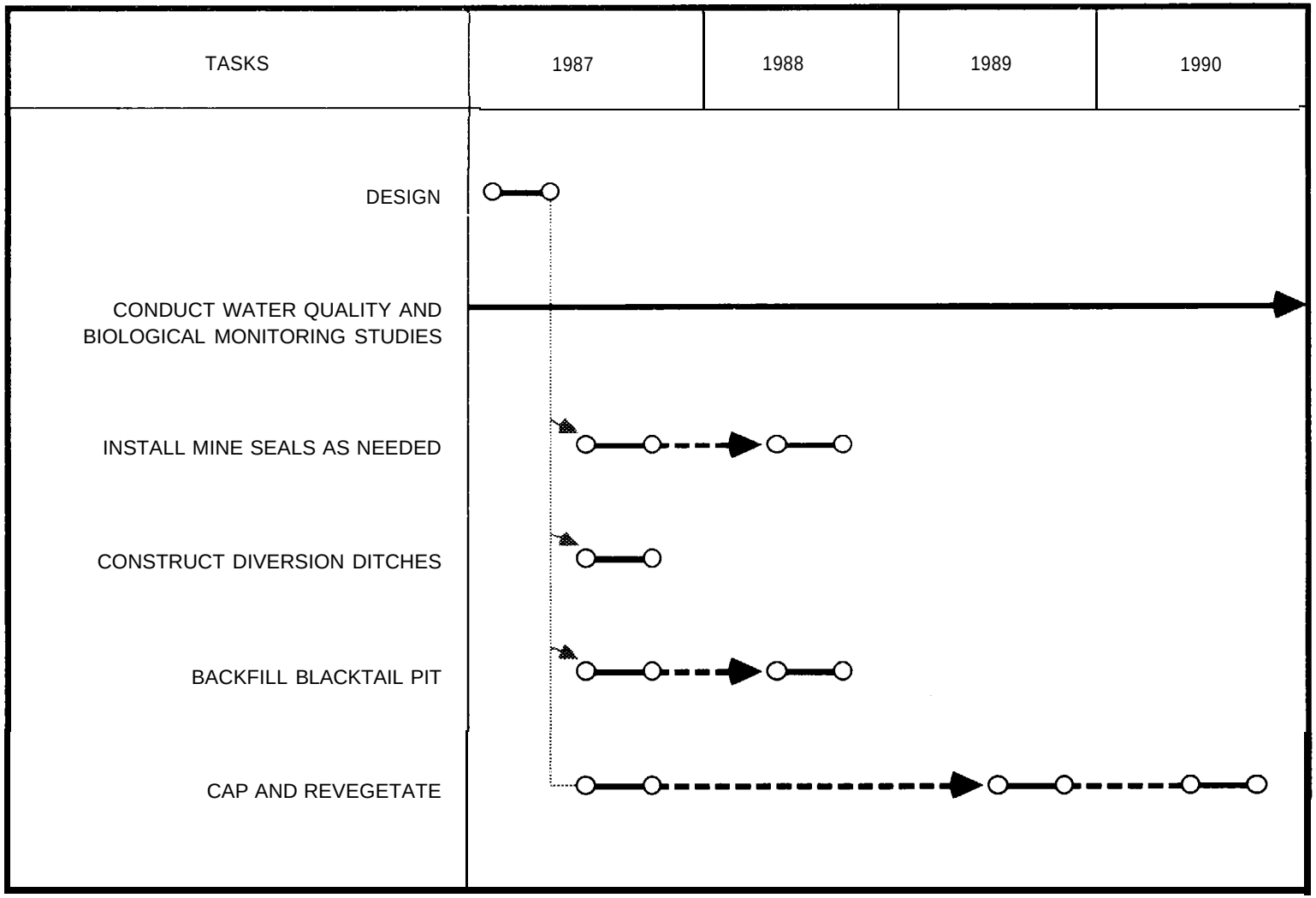


Figure 6- 5 PROPOSED IMPLEMENTATION SCHEDULE FOR ABATEMENT PROGRAM - ALTERNATIVE 2B, BUCKTAIL DRAINAGE

Section 7: Smolt Production Potential and Economic Value

Section 7

SMOLT PRODUCTION POTENTIAL AND ECONOMIC VALUE

7.1 SMOLT PRODUCTION ESTIMATES

Based on the quantitative analyses of habitat in the Panther Creek drainage (see Appendix B, Sections Bl and B2), two independent estimates of smolt production were made: one based on spawning habitat, the other on rearing. These estimates were used to determine the limiting habitat component in the system. To demonstrate the variability in production levels at different base flow conditions, the estimates were made for up to four different flows. For spawning, the estimates were made corresponding to the redd-area requirements previously described (36 ft^2 for chinook and 58 ft^2 for steelhead). The chinook rearing estimates were made based on spatial needs of 0.096 fish/ft^2. The steelhead estimates were based on average density information for yearling I+ and II+ age fish (0.0057 fish/ft^2).

7.1.1 Spawning Habitat Estimates

Based on spawning area and number of redds for the field measured flow, an estimated 847,080 chinook and 173,746 steelhead smolts could be produced in the Panther Creek Drainage (Table 7-l). The 847,080 chinook smolt estimates included 562,380 smolts from Panther Creek and 284,700 smolts from the four tributary streams (Table 7-l). Of the latter amount, Moyer Creek contributed 166,296 smolts, indicating it is the most important tributary system of Panther Creek for spawning. Next in order of abundance was Musgrove Creek, followed by Clear and Deep creeks.

Steelhead smolt production estimates followed a similar trend. Of the 173,746 smolts, Panther Creek provided 122,952, and the tributaries provided 50,794, of which Moyer Creek's contribution was 42,074.

As depicted in Figure 7-1, the majority of smolt production potential based on spawning occurs upstream from Big Deer and Blackbird creeks (see Appendix B,

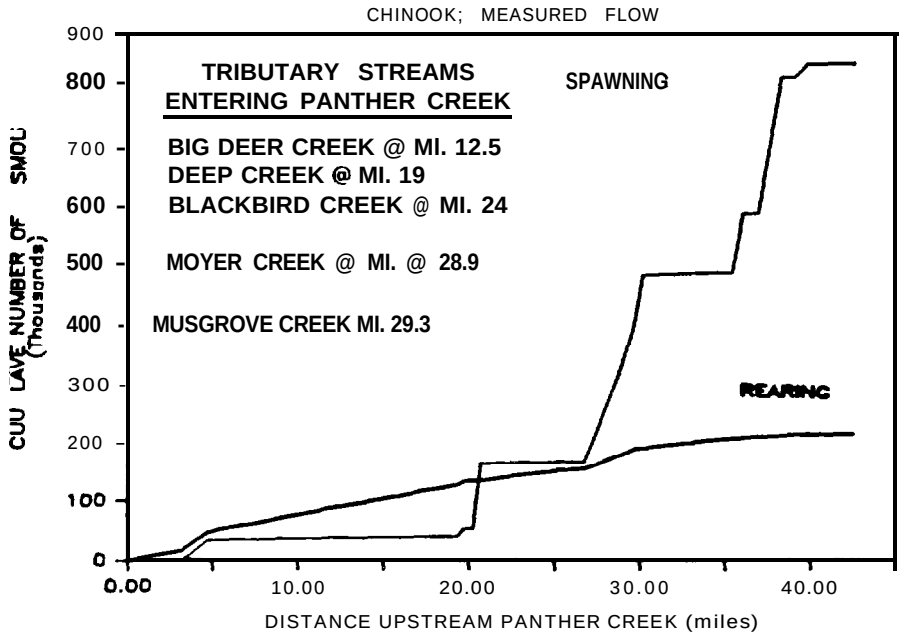
Table 7-l

ESTIMATED TOTAL CHINOOK AND STEELHEAD SMOLT PRODUCTION IN THE PANTHER CREEK DRAINAGE
BASED ON SPAWNING HABITAT AT THREE FLOWS

Stream	Length (Miles)	Measured Flow (cfs)	Estimated Number of Smolts from Redds					
			0.4 X Measured Flow		Measured Flow		2.5 X Meaured Flow	
			Chinook[a]	Steelhead[b]	Chinook[a]	Steelhead[b]	Chinook[a]	Steelheadb
Clear Creek	4.0	22	5,304	3,270	29,796	1,853	289,848	41,747
Lower Moyer Creek	2.1	16	9,672	1,962	47,112	8,502	44,304	5,668
Upper Moyer Creek	3.6	16	46,800	11,118	119,184	33,572	205,452	27,032
Musgrove Creek	4.0	9	12,636	872	76,128	5,668	125,424	20,710
Deep Creek	4.0	10	1,092	0	12,480	1,199	51,792	7,194
Panther Creek	42.0		253,968	72,376	562,380	122,952	822,900	102,896
Total			329,472	89,598	847,080	173,746	1,539,720	205,247

[a] Numbers derived from chinook redd area estimates of 35.5 ft^2/redd

[b] Numbers derived from steelhead redd area1 estimates of 58 ft^2/redd



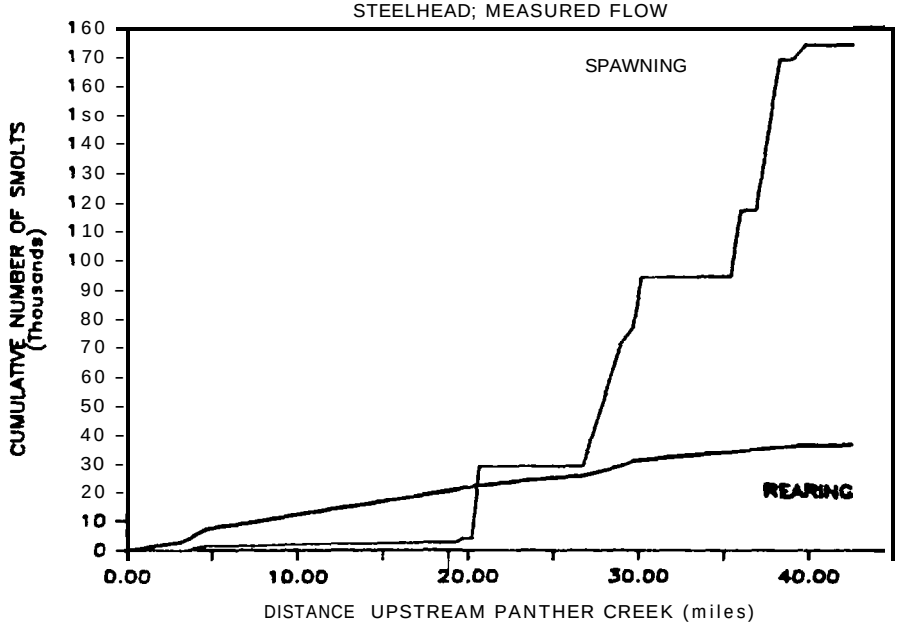


Figure 7-1 CHINOOK AND STEELHEAD SMOLT PRODUCTION POTENTIAL BASED ON SPAWNING AND REARING HABITAT, AS A FUNCTION OF DISTANCE UPSTREAM FROM THE MOUTH OF PANTHER CREEK

Section B10 for tabular results). The contribution of chinook smolts below Big Deer Creek is only about 38,376 (4.5 percent of total), which includes Clear Creek. Below Blackbird Creek, which includes Deep Creek, an estimated 166,140 smoits (20 percent of total) could be produced. Thus, about 80 percent of the chinook production from spawning would occur above Blackbird Creek, and over 95 percent above Big Deer Creek. For steelhead, only 1.5 percent (2,507) and 17 percent (29,103) of smolt production potential exists below Big Deer and Blackbird creeks, respectively.

7.1.2 Rearing Habitat Estimates

Smolt production estimates based on rearing habitat were in all cases substantially lower than those for spawning when made for the field measured calibration flow; chinook rearing estimates were about 0.25 and steelhead estimates about 0.21 of the spawning estimates. The chinook estimates included 170,677 from Panther Creek and 44,862 from the four tributaries (Table 7-2). The contribution of chinook smolts from the tributaries was dominated by Moyer Creek (19,005) and Clear Creek (15,709). Estimates of steelhead production followed a similar trend, with Panther Creek contributing 29,697 and the tributaries 6,912. Moyer and Clear creeks again constituted the major part of the tributary estimate.

The differences in smolt estimates noted above for spawning and rearing imply that chinook and steelhead production is limited by available rearing habitat. In particular for this system, it is likely that summer rearing habitat is the limiting factor for both chinook and steelhead. This has also been documented for many other Idaho streams (T. Holubetz and C. Petrosky, IDF&G, pers. comm.). In Panther Creek, there is a general lack of instream cover (e.g., boulders, debris jams, logs, etc.) throughout much of the system (see Appendix B, Section B6). This material creates good rearing habitat by providing needed cover and resting areas. The Salmon National Forest has recognized this and has implemented several habitat enhancement projects in Panther Creek designed to increase the amount of available rearing habitat. Such projects could, in the future, significantly increase the smolt production potential in the Panther Creek drainage to levels approaching the estimates based on spawning.

Table 7-2

ESTIMATED TOTAL CHINOOK AND STEELHFAD SMOLT PRODUCTION IN THE PANTHER CREEK DRAINAGE
BASED ON AVAILABLE REARING HABITAT AT THREE FLOWS

			Estimated Rearing Area (ft^2)					
Stream	Length	Measured Flow	0.4 x Measured Flow		Measured Flow		2.5 x Measured Flow	
	(Miles)	(cfs)	Chinook	Steelhead	Chinook	Steelhead	Chinook	Steelhead
Clear Creek (CC-l)	7.0	22	8,248	1,378	15,709	2,403	30,149	4,936
Lower Moyer Creek (MC-2)	2.1	16	2,460	439	4,178	656	5,565	847
Upper Moyer Creek (MC-l)	7.5	16	9,467	1,228	14,827	1,992	19,165	7,829
Musgrove Creek (MCG-1)	7.0	9	3,082	560	6,825	1,371	13,111	2,597
Deep Creek (DC-1)	4.0	10	2,223	289	3,323	490	6,567	894
Panther Creek	42	variable	153,209	23,751	170,677	29,697	175,003	34,160
Total			178,689	27,645	215,539	36,609	249,560	42,263

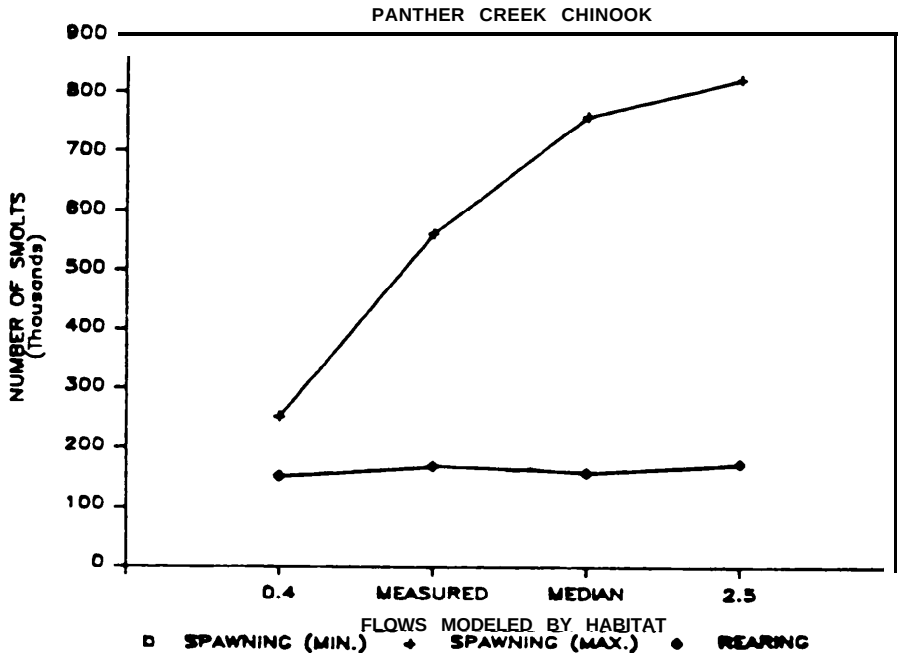
In contrast to the estimates derived from spawning, the majority of smolt production potential based on rearing occurs downstream from Big Deer and Blackbird creeks (Figure 7-l). For chinook, 42 percent (92,260) of the smolt production would occur below Big Deer Creek, and 69 percent (149,929) below Blackbird Creek. The steelhead estimates were similar: 41 percent (14,863) of the production below Big Deer Creek and 68 percent (24,651) below Blackbird Creek. These estimates illustrate the significance of the lower reaches of Panther Creek for production. In addition, they emphasize the need for reclamation/abatement measures on the Blackbird Mine to attain the necessary water quality levels to allow complete fish habitation throughout Panther Creek. Simply providing passage through the affected reach will only open the system to spawning but will not provide for sufficient rearing habitat.

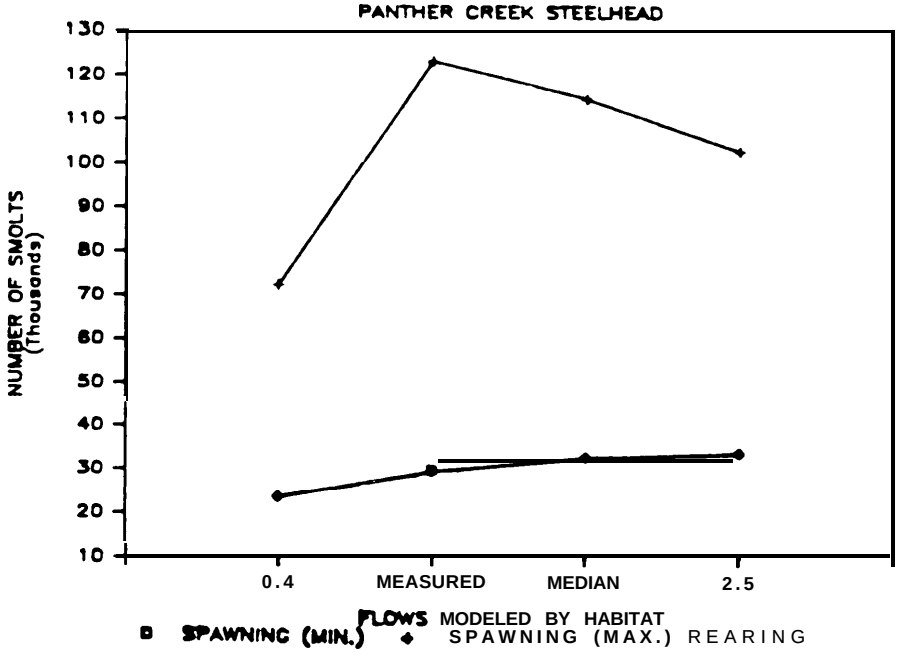
7.1.3 Effects of Flow on Smolt Estimates

Figure 7-2 depicts the variability in smolt production estimates as influenced by changes in baseflow and shifts in the limiting habitat component. In general, for the flow modeled, a positive relationship exists between number of smolts and streamflow, which reflects the positive habitat flow relationship previously described. The degree of change in smolt numbers does vary depending on whether it is based on spawning or rearing habitat. Compare the following for Panther Creek. Based on rearing area, at 0.4 and 2.5 of the calibration flow, the estimated chinook smolt production is 153,000 smolts and 175,000 smolts, respectively, which is only a l.l-fold increase. Based on spawning areas, these flows would result in estimates ranging from about 253,900 to 823,000 smolts, which is a 3-fold increase. A similar trend occurs for steelhead. Thus, smolt production estimates could range widely depending on limiting flow conditions. Appendix B, Section B2.2.3 describes the relationship of flow variability to smolt production for the tributary streams.

7.2 ECONOMIC ANALYSIS

Economic evaluations were subsequently made to estimate the value of restoring the Panther Creek drainage to production. The analyses involved a three-step process consisting of:





NOTE: TRIBUTARY STREAMS NOT INCLUDED;
SEE SECTION B2 FOR DETAILS.

Figure 7-2 PANTHER CREEK CHINOOK AND STEELHEAD SMOLT PRODUCTION ESTIMATES BASED ON SPAWNING AND REARING HABITAT AT FOUR FLOWS

1) Estimating adult returns from the smolt estimates

2) Assigning a dollar value to adult returns

3) Estimating the net annual benefit and present worth of the restored fish

The economic evaluation was conducted for the range of smolt estimates as determined for spawning and rearing habitat, as well as the median value between the two. This provided estlmates of the present-day minimum and maximum monetary worth of the restoration of anadromous fish runs in Panther Creek. Results of the fish tissue analysis indicate that no human health hazards would result from the consumption of fish taken from the Panther Creek drainage. Therefore, no effects on the economic value of the resource would occur (see Appendix B, Section R2.4).

7.2.1 Estimating the Adult Returns

The number of chinook and steelhead adults returning to Panther Creek were estimated using survival rates based on returns to the IDF&G Pahsimeroi Hatchery. For chinook, the smolt-adult survival rate was 0.50 percent, for steelhead the rate was 1.0 percent (M. Reingold, IDF&G 1985). These rates were applied to the smolt production estimates for rearing to obtain minimum adult return estimates, and to the estimates for spawning (maximum numbers) to obtain maximum estimates. Such estimates resulted in a range of returning adults of from 1,077 to 4,235 for chinook and from 366 to 1,737 for steelhead; median values for chinook and steelhead were 2,657 and 1,051, respectively (Table 7-3). These values also reflect the numbers of fish available for harvest in the Columbia, Snake, and Salmon rivers as well as in the Panther Creek system given a 1:1 catch/escapement ratio. From a biological perspective, the median values probably give the best overall estimate of the salmonid production potential in Panther Creek, assuming long-term increases in rearing habitat can be achieved through enhancement measures.

7.2.2 Assigning Dollar Values

Assigning dollar values to the restored adults was based on previous economic studies of Meyer (1982), Meyer et al. (1983), Theurer et al. (1985), and the

Table 7-3

MAXIMUM AND MINIMUM NET ANNUAL MONETARY VALUE OF CHINOOK AND STEELHEAD RESTORED TO THE PANTHER CREEK DRAINAGE BASED ON ADULT RETURN VALUES OF $137 PER CHINOOK AND $106 PER STEELHEAD

	Chinook			Steelhead			
Estimate	Number Smolts	Restored[a] Adults	Annual[b] Benefit	Number Smolts	Restored[a] Adults	Annual[b] Benefit	Total Annual Benefit
Minimum	215,539	1,078	$147,948	36,609	366	$ 38,953	$186,901
Maximum	847,080	4,235	$581,211	173,746	1,737	$184,869	$766,080
Median[c]	531,309	2,657	$364,647	105,178	1,051	$111,858	$476,505

[a] CK - Based on 0.50 percent smolt - adult return survival (M. Reingold, IDF&G 1985)
SH - Based on 1.0 percent smolt - adult return survival (M. Reingold, IDF&G 1985)

[b] CK - Based on $137.24 per adult (ACOE 1985)
SH - Based on $106.43 per adult (ACOE 1985)

[c] Median between maximum and minimum smolt estimates

ACOE (1985). The latter study made a distinction between fishing values for enhancement versus restoration. Enhancement implied increases above present fish production levels; restoration meant replacing a loss of normal fish production (ACOE 1985). For Panther Creek where the normal fish runs have been eliminated, fishery values for restoration would clearly apply. The ACOE (1985) study combined commercial and sport fish restoration values adjusted for catch rates to provide an estimate of the net value per adult for chinook and steelhead. The values estimated were $137.24 for chinook and $106.43 for steelhead. These values were formulated for use in conjunction with the Galloway Project on the Weiser River in Idaho, and hence should be applicable to Panther Creek. In contrast, Theurer et al. (1985) used estimates of $290 and $240 for chinook and steelhead, respectively, for assessing the value of a restoration project on the Tucannon River in southeastern Washington. For comparative purposes, both estimates were used in the economic evaluation for Panther Creek.

7.2.3 Estimating Annual Net Benefit

From these rates, the net annual monetary value of restoring chinook and steelhead to Panther Creek was determined. Using the ACOE (1985) estimates, the annual benefit ranged from $186,760 to $766,080 per year with a median value of $476,442 per year (Table 7-3). Using the estimate of Theurer et al. (1985), the annual dollar value ranged from $401,924 to $1,651,978, with a median value of $1,026,974 (Table 7-4).

The present worth of the annual benefits were subsequently determined using an interest rate of 7-7/18 percent and assuming that the benefits would be valid for perpetuity. This was done for two separate cases which assumed:

- Immediate adult returns at the end of the first year (annuity beginning in year zero)
- Five-year delay in adult returns (annuity beginning in year five)

Table 7-4

MAXIMUM AND MINIMUM NET ANNUAL MONETARY VALUE OF CHINOOK AND STEELHEAD RESTORED TO THE PANTHER CREEK DRAINAGE BASED ON ADULT RETURN VALUES OF $290 PER CHINOOK AND $244 PER STEELHEAD

	Chinook			Steelhead			
Estimate	Number Smolts	Restored[a] Adults	Annual[b] Benefit	Number Smolts	Restored[a] Adults	Annual[b] Benefit	Total Annual Benefit
Minimum	215,539	1,078	$ 312,620	36,609	366	$ 89,304	$ 401,924
Maximum	847,080	4,235	$1,228,150	173,746	1,737	$423,828	$1,651,978
Median[c]	531,309	2,657	$ 770,530	105,178	1,051	$256,444	$1,026,974

a CK - Based on 0.50 percent smolt - adult return survival (M. Reingold, IDF&G 1985)
SH - Based on 1.0 percent smolt - adult return survival (M. Reingold, IDF&G 1985)

b CK - Based on $290.00 per adult (Meyer et al. 1983; Theurer et al. 1983)
SH - Based on $244 per adult (Meyer et al. 1983; Theurer et al. 1983)

c Median between maximum and minimum smolt estimates

Immediate adult returns would require that the estimated number of adults be available and could utilize the drainage at the end of the first year following initial implementation. This would be unlikely given that all engineering measures would not be fully developed in one year.

A 5-year delay in adult returns is more realistic for the Panther Creek Project. In this case, it is assumed that full escapement to the drainage would not occur for 5 years, a period sufficient for the construction and operation of the abatement measures.

Table 7-5 displays the estimates of the present worth of the restored anadromous fish runs to the Panther Creek drainage. For the immediate returns, the present worth ranges from $2.3 million to over $20.9 million; for the 5-year delay, the range extends from $1.6 million to $14.3 million. This wide variation points out how changes in smolt production estimates and adult fish values can dramatically influence present worth estimates.

For comparison, the present worth of the engineering alternatives were calculated using the 7-7/8 percent interest rate and assuming a project life of 50 years (Table 7-6). The calculation assumed that construction costs were spread over the first 3 years and operation and maintenance costs start at the end of the third year. From these estimates, Alternative 2A has the lowest overall cost and would therefore have the potential for providing the greatest benefit. The relatively high costs of Alternatives 1A and 1B result from the high operation and maintenance costs associated with the treatment facility.

It should be emphasized that the above evaluation represents only a rough approximation of the economic potential of the restoration of Panther Creek. As previously stated, many uncertainties exist with respect to the smolt production capacity of the drainage and the dollar value per adult, as well as with the level of cleanup that will actually be required to allow full utilization of the drainage. The analysis would also likely change if the cleanup efforts for each drainage, including funding allocations, were handled independently. It should be noted that in general, the costs of the proposed alternative abatement programs are of the same relative magnitude as the benefits realized through the restoration of the anadromous fish runs.

Table 7-5

PRESENT WORTH OF ANADROMOUS FISH RUNS
RESTORED TO THE PANTHER CREEK DRAINAGE[a]

	Present Worth Adult Returns at $137/Chinook and $106/Steelhead[b]					
	Chinook		Steelhead		Total	
Estimate	Immediate	Five-Year	Immediate	Five-Year	Immediate	Five-Year
Minimum	1,877,471	1,284,941	494,332	338,321	2,371,813	1,632,262
Maximum	7,375,779	5,047,983	2,346,052	1,605,638	9,721,831	6,653,621
Median	4,627,496	3,167,058	1,419,517	971,517	6,047,013	4,138,576

	Present Worth Adult Returns at $290/Chinook and $244/Steelhead[c]					
	Chinook		Steelhead		Total	
Estimate	Immediate	Five-Year	Immediate	Five-Year	Immediate	Five-Year
Minimum	3,967,259	2,715,192	1,133,299	775,630	5,100,558	3,490,822
Maximum	15,585,660	10,666,826	5,378,528	3,681,065	20,964,188	14,347,890
Median	9,778,299	6,692,268	3,254,365	2,227,288	13,032,665	8,919,556

[a] Based on an immediate return and a 5-year delay (in adult escapement to the drainage) for the two adult return values
[b] Army Corps of Engineers (1985)
[c] Meyer et al. (1983), Theurer et al. (1985)

Table 7-6

COST AND PRESENT WORTH OF THE FOUR ENGINEERING ALTERNATIVE ABATEMENT PROGRAMS

Alternative	Total Construction Cost	Operation and Maintenance Cost	Present Worth[a]
1A	3,811,000	600,000/yr	10,680,000
1B	3,406,000	600,000/yr	10,331,000
2A	5,739,000	200,000/yr	7,407,000
2B	8,228,000	200,000/yr	9,550,000

[a] Based on 7-7/8 percent interest rate and project life of 50 years

Section 8: Discussion and Recommendations

Section 8

DISCUSSION AND RECOMMENDATIONS

From the preceding analysis, it is apparent the Panther Creek drainage contains a significant amount of habitat suitable for production of anadromous salmonids. It is equally obvious that a substantial number of remedial measures will need to be implemented before its full production potential can be realized. Because the measures are costly, it is important that the implementation of the engineering abatement programs be coordinated closely with fisheries restoration efforts so that maximum benefits (i.e., adult returns) can be achieved in the shortest amount of time. This is important since the economic viability of the restoration program is sensitive to when adult escapements will initially occur to the drainage. Therefore, the phased seeding of the drainage with chinook and steelhead juveniles should begin immediately so that adult returns will synchronize with the completion of the abatement program. In this regard, the IDF&G has recently begun planting steelhead in several areas of Panther Creek with adult returns expected in 1987-88. Such plants should continue in the future but the coverage will most certainly need to be expanded (include other tributary streams) and should include chinook salmon.

Although engineering alternatives were selected that would not specifically preclude mining, no specific mining plans were considered during their development. Cobalt is a strategic metal, and the Blackbird Mine represents the largest known reserve of cobalt in North America. Therefore, this reserve must be protected for possible future demand. Consequently, prior to selecting and implementing an engineering alternative, the details of each alternative should be reviewed to assess compatability with potential future mining plans. This could most easily be accomplished through coordination with the owners of the mine (presently Noranda Inc.).

With respect to the engineering alternatives, a phased approach toward implementation is recommended. This is warranted since many uncertainties exist in determining the actual level of cleanup that will occur from a given abatement measure. It is anticipated that the final design of the abatement program will evolve following the monitoring of initial abatement measures and the completion of more detailed geologic investigations. From the information generated from this study, it is apparent the Bucktail Creek drainage is the larger contributer to the water quality problem in Panther Creek. As such, remedial measures should initially be implemented in the Bucktail drainage (see Section 6).

8.1 PRE-IMPLEMENTATION STUDIES

Critical to the success of selected abatement programs will be the conduct of several pre-implementation studies that will be used for defining and refining proposed remedial measures. Such studies include both geologic and hydrologic investigations as described below. In addition, an environmental assessment will be required to evaluate the potential impacts of the construction and operation of the abatement program.

8.1.1 Detailed Mapping of Mine Workings

Detailed mapping of the underground mine workings are recommended to determine present underground conditions (collapsed areas, flow direction, etc.), the sequence in which mine adits would be flooded, and which adits and raises are open to or near the surface. This information would be used to determine the order of bulkhead installation, the number of bulkheads required, areas of potential instability and safety hazard, and the feasibility of diverting water from the Bucktail drainage to the water treatment facility.

8.1.2 Groundwater Hydrology Studies

Groundwater hydrology studies are recommended to determine groundwater flow conditions and to predict the level that groundwater would rise within the mine under flooded conditions. These studies would require drilling and installing observation wells to characterize groundwater conditions, including

fracture permeability, storage, and flow direction. Subsequent monitoring of the observation wells can be used to assess the impact of sealing and flooding the mine on the local groundwater flow regime (e.g., when the mine is acting as a sink or as a source for groundwater flow).

8.1.3 Field Studies of Contaminated Springs

Field studies are recommended to determine the source of water in contaminated springs along Bucktail Creek. Many of the springs occur at, or near the intersection of the stream with known bedrock shear zones. The shear zones may be acting as a flow path for contaminated groundwater from the mine. Conversely, the springs may represent seeps draining from the 7117 and 7265 waste piles. This information is important for selecting the appropriate abatement alternatives and for assessing the benefits and design of various abatement measures.

8.1.4 Field Studies of Background Water Quality

Field studies are recommended to determine natural background water quality characteristics in the Panther Creek drainage. Preliminary studies suggest that groundwater in the region (unaffected by the Blackbird Mine) may naturally carry some copper and cobalt. Assessing the natural background levels of metals in groundwater and surface water will provide additional rationale for selecting a suitable concentration level for design.

8.1.5 Geologic and Soils Surveys

Several geologic and soils surveys are recommended. Soils surveys are needed to indentify and evaluate available sources of material that could be used as a growing medium for revegetation. Additional soils surveys will be needed to confirm the suitable and availability of hard clay materials (e.g., Forney site) for use in the capping of waste piles (see Section 3.3.3).

Geologic investigations willi be required to identify specific sources of riprap to line diversion channels and stabilize the bank. It may also be necessary to conduct leach tests on the riprap materials because of the natural mineralizaticn and acidic woodland soils in the mine area.

Geologic studies will also be needed to identify and assess any local sources of limestone or similar reactive media that could be used for acid neutralization.

8.1.6 Environmental Assessment and Regulatory Compliance

As part of the pre-implementation activities, an environmental assessment (EA) will be required to address impacts of a given abatement program. This assessment, as specified by the National Environmental Policy Act of 1969 (NEPA) requires that the project be evaluated with respect to its impact on the surrounding environment including land, air, and water resources, and socioeconomic issues. Since this will be a regulatory requirement integral to implementation, the assessment process should begin as soon as possible. If construction activities are planned for 1986, the assessment should begin in early 1986.

A formalized program for obtaining necessary state and federal permits (e.g., NPDES, 404 permit, tailings dam, permit, etc.) for implementation will also need to begin in early 1986.

8.2 MONITORING PROGRAMS

Monitoring programs designed to assess the effectiveness of the abatement measures should also be initiated as part of the project. Such programs should be started prior to construction and continue through a number of years of operation. Recommended programs include hydrologic, water quality, and biological monitoring.

8.2.1 Mine Water Level Monitoring

Water levels within the mine should be monitored on a bimonthly basis over a 3- to 5-year period. Rate and amount of water level rise will provide information for the design and installation schedule of bulkheads during any proposed mine sealing activities (Alternative 2). Continued monitoring will provide baseline data for determining the seasonal fluctuation of the water level in the mine.

8.2.2 Water Quality and Quantity Monitoring Program

A water quality monitoring program should be initiated in conjunction with the implementation of the abatement measures. To provide mass loading information, both water quality and quantity information are necessary. Permanent water quality monitoring stations should be established at the following six locations with weekly samplings proposed:

- Mouth of Blackbird Creek
- Mouth of Big Deer Creek
- Panther Creek upstream of Blackbird Creek
- Panther Creek between Blackbird Creek and Big Deer Creek
- Panther Creek below Big Deer Creek
- Mouth of Panther Creek

Existing stations established by the USFS, the University of Idaho, and Noranda Mining Inc. may be suitable for this.

Flow measurement stations are recommended at four of the six water quality monitoring stations. These should include the stations at the mouths of Blackbird and Big Deer creeks as well as two stations on Panther Creek. A cooperative agreement with the USGS may be possible for maintaining gaging stations on Panther Creek. Continuous stage recorders should be installed at the flow measurement stations, and flow measurements should be made monthly so that rating curves can be developed.

8.2.3 Contamination Source Monitoring

Discharge from identified contamination sources should be monitored on a biannual basis for a 3 to 5-year period during and following construction activities. For example, seeps from the base of waste piles should be monitored to determine the effectiveness of abatement measures designed to reduce or eliminate the seepage. This will provide a feedback mechanism for identifying and evaluating alternative design measures as required.

8.2.4 Monitoring of Adult Escapements and Smolt Migrations

Adult escapement to the Panther Creek drainage should be monitored beginning in 1987-88 (the years in which the first steelhead returns are expected). In so doing, information will be obtained regarding the ability of the adults to negotiate through the present water quality condition in Panther Creek (i.e., avoidance response, toxic conditions).

A similar program of monitoring smolt outmigration through the affected reach (smolts planted above Blackbird Creek) would be useful to assess smolt tolerances to present water quality conditions. Such programs will be useful for defining baseline conditions and for evaluating the success rates of migration should accidental releases of contaminants occur. They will also be useful for evaluating the prospects of establishing initial runs of anadromous fish prior to completion of all remedial measures.

8.2.5 Fish Live Car Tests

The fish live car tests that have been periodically conducted in the Panther Creek drainage by the IDF&G should be continued throughout project construction and initial operation. Such tests should be conducted biannually in the spring (May) and fall (August) with sampling points consistent with the IDF&G stations. The tests will be especially useful for biological documentation of changes in water quality coincident with the phased implementation of remedial measures.

8.2.6 Fish Tissue Analysis

Tissue analysis of fish residing above, within, and below the effluent sources should be conducted annually, beginning with construction and extending through initial operation. Such analyses will document metals uptake by fish in the drainage, and hence should provide a useful index for evaluating the success of the remedial measures.

8.2.7 Aquatic Invertebrate Sampling

Aquatic invertebrates are widely distributed in streams and are sensitive to environmental perutrbations including water quality changes. As such,

changes in their density or species composition can be used to monitor aquatic habitat conditions. A monitoring program of aquatic invertebrates is therefore recommended to coincide with the fish live car tests (i.e., biannual sampling). The sampling should occur at stations in close proximity to those used for the live car tests. It should be noted that the USFS has periodically collected and analyzed invertebrate samples in Panther Creek and that a continuation of this program will be important in evaluating the success of the remedial measures and recovery of Panther Creek. This is especially important considering that aquatic invertebrates constitute a major food component of fish.

Section 9: References

Section 9

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Appendix A: Phase II Mine Reclamation/Effluent Abatement Alternatives

APPENDIX A

PHASE II: MINE RECLAMATION/EFFLUENT ABATEMENT ALTERNATIVES

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Section A1

IDENTIFICATION OF POLLUTION SOURCES

To properly formulate and evaluate potential abatement measures, it was necessary to identify and quantify sources of contaminants entering Panther Creek. Therefore, Bechtel conducted a combined hydrology/geology field program in portions of the Panther Creek drainage affected by the Blackbird Mine. The program included separate fall and spring field surveys, the first completed during a l0-day period from September 11-21, 1984, the second during a 5-day period from May 13-17, 1985.

A1.1 FALL FIELD SURVEYS

Field investigations were initially conducted during the fall, when low-flow conditions existed in the streams. The program was designed to:

- Identify and locate low-flow sources of groundwater discharge to Bucktail Creek and the Meadow Creek/Blackbird Creek drainage
- Identify, map, and estimate the volume of tailings and dredged material along Blackbird Creek
- Locate and map mine portals and associated waste piles
- Map geologic structure and lithology in the mine area
- Locate and evaluate sources of clay and talus for use in abatement programs
- Determine discharge, conductivity, and metal concentrations in Bucktail Creek, Blackbird Creek, and Meadow Creek as well as at the mouth of other tributary streams to Panther Creek between the Salmon River and Musgrove Creek.

Field surveys of the Bucktail Creek drainage and Blackbird Creek/Meadow Creek drainage were conducted by systematically walking the entire length of the drainage system. Field stations were established at tributaries or groundwater sources to these creeks, as well as at points where discharge and

water quality measurements were made. Thirty-one stations were established along the Bucktail Creek drainage (Figure A-l), and 45 stations were established along the Blackbird Creek/Meadow Creek drainage (Figure A-2).

At many of the stations, simultaneous measurements of discharge and water quality were made. The major emphasis of the field surveys was to identify and quantify sources of contaminants entering Panther Creek. As such, the measurement of water quality parameters was limited to those that would most likely differentiate clean from contaminated water. Based on a preliminary review of water quality characteristics at the mine site (Platts 1967; Platts et al. 1979; Baldwin et al. 1978), four parameters were selected for analysis. These included copper, iron, conductivity, and pH. These parameters were measured in the field with the following instruments:

Parameter	Instrument
Total copper and iron (mg/l)	Hach DR/EL-4 water chemistry kit
Conductivity (umhos/cm^2)	Myron L - Model EP conductivity meter
pH	Altex/Beckman Model II ion meter; Orion Model 227 pH meter

Stream and seep discharges were determined using a calibrated bucket and stop watch. Higher stream flows were determined using either a Pygmy velocity meter or a Marsh-McBirney model 201 velocity meter. This approach allowed the computation of contaminant concentrations onsite and facilitated locating principal sources of contaminants.

During the survey, tailings and dredge material along Blackbird Creek were located and mapped at a scale of 1:2000. Volumes were computed from the estimated lengths and average thicknesses of each tailings or dredge pile. In addition, the tailings impoundment at the mouth of West Fork was examined and mapped. Drainages leading onto the surface of the tailings impoundment were examined for evidence of flood conditions, and the base of the dam was examined for evidence of discharge or seepage.

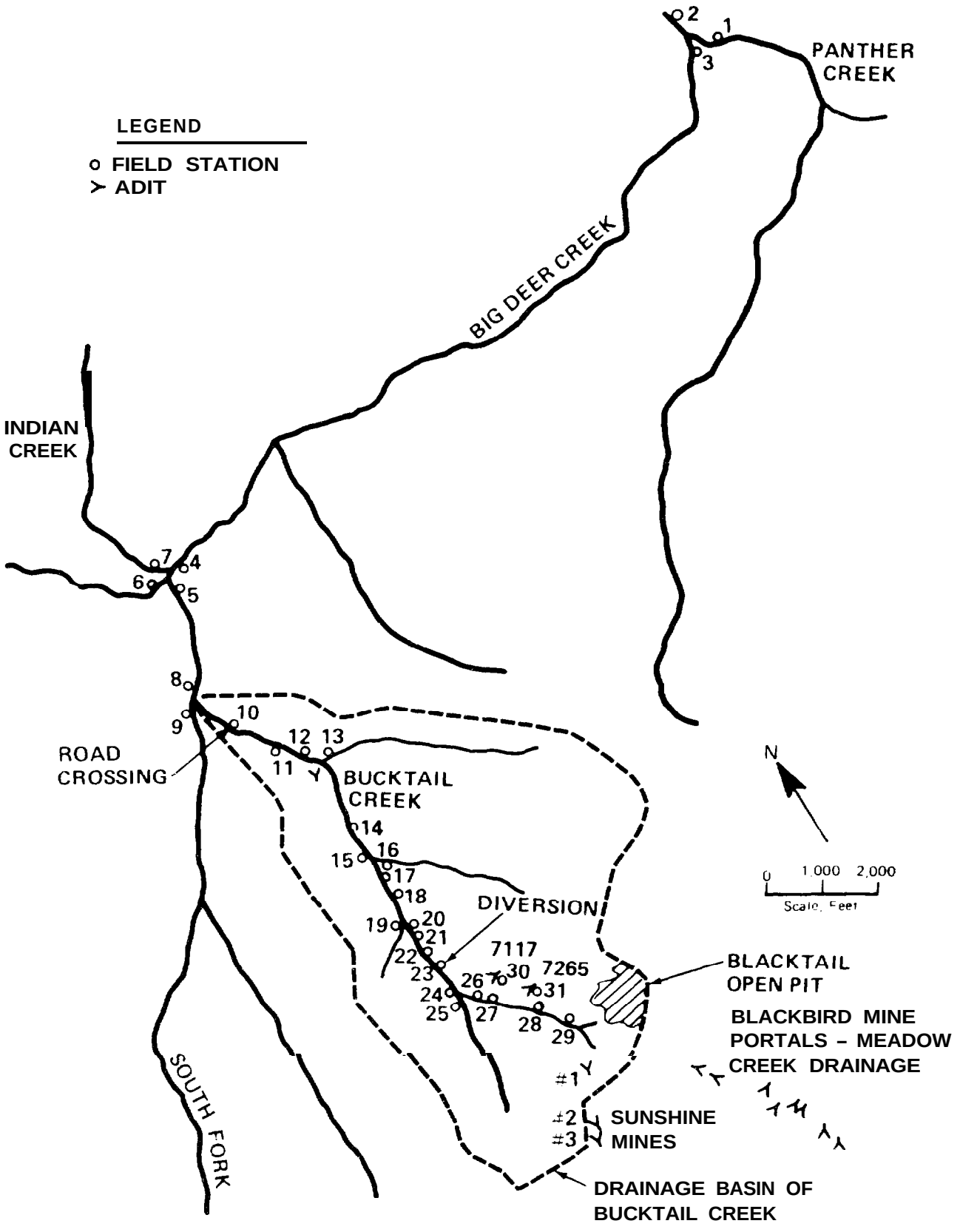


Figure A1-1 BUCKTAIL CREEK DRAINAGE, FIELD SAMPLING LOCATIONS, FALL 1984

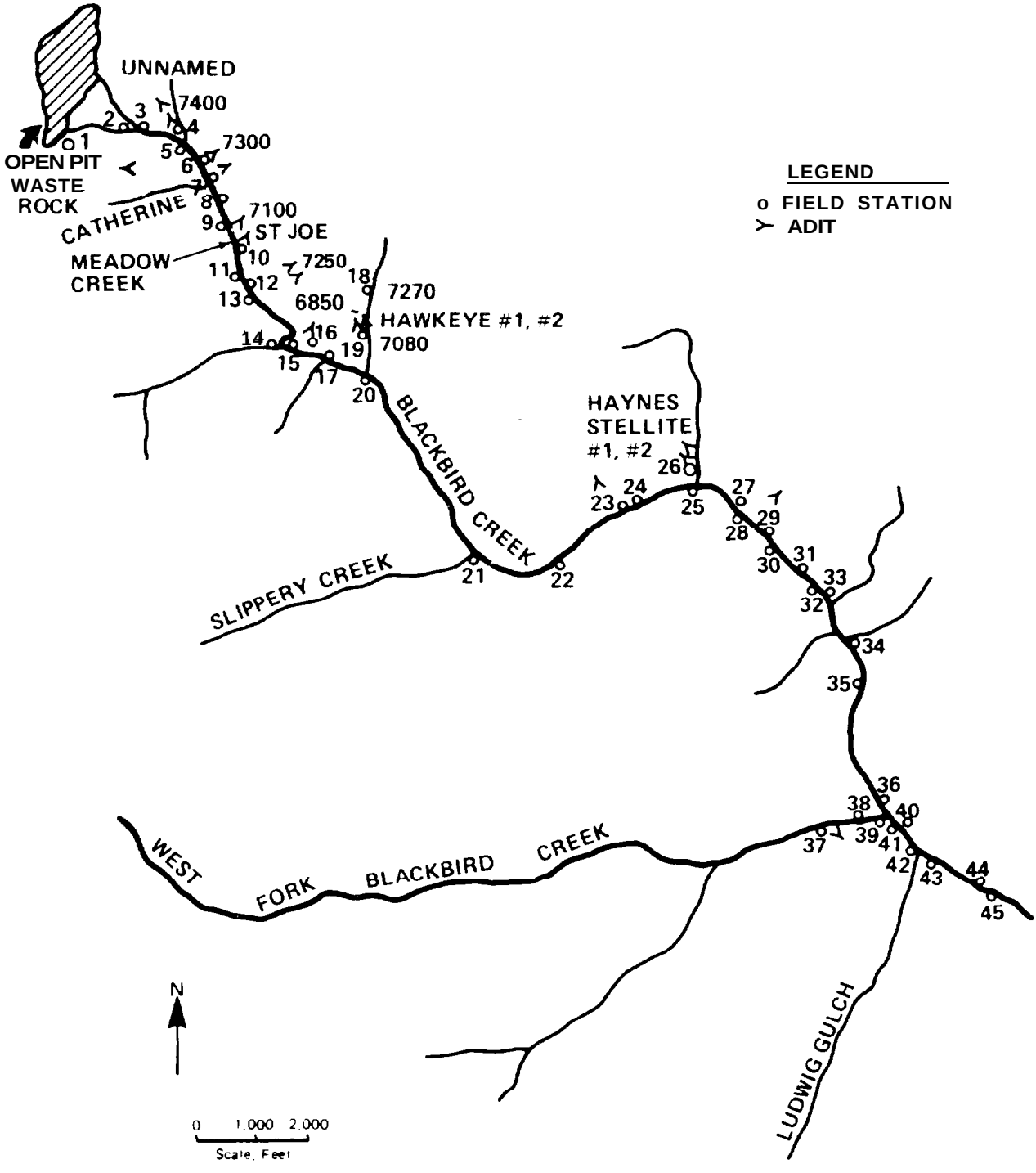


Figure A1-2 BLACKBIRD CREEK DRAINAGE, FIELD SAMPLING LOCATIONS, FALL 1984

Portals and associated waste piles were also located and mapped at a scale of 1:2000. Evidence of flow or seepage from the portals and/or waste piles was noted. Flow was quantified if possible, and water quality was assessed using the Hach portable chemistry kit and the pH and conductivity meters.

The geologic structure and lithology of the Blackbird Mine area was evaluated by reconnaissance field mapping and by using existing mine records on file at the Blackbird Mine office. Field reconnaissance was conducted primarily to obtain general rock descriptions of the principal lithologies in the mine area and to determine fracture/joint density and orientations. The field reconnaissance was also performed to assess average thicknesses of overburden, and areas of talus and clay suitable for use in various remedial alternatives. Mine records were reviewed to obtain detailed information on the distribution of lithologies and faults in the area, and to obtain additional surface and subsurface information on fracture spacing, density, and orientation. The mine records also provided valuable information on the distribution of underground mine workings.

A regional study of water quality also was performed to identify other potential sources of contaminated water to Panther Creek other than the Blackbird mine area. The conductivity of discharges from tributary creeks to Panther Creek (including Beaver Creek, Little Creek, and Copper Creek) between the Salmon River and Musgrove Creek were measured. It was assumed that discharges carrying elevated metal concentrations would exhibit high conductivities relative to clean water in the region; any streams exhibiting high conductivity were to be tested for copper concentrations using the Hach kit. However, none of the tributaries to Panther Creek, other than Blackbird Creek and Big Deer Creek, exhibited higher than normal conductivities.

Al.2 SPRING FIELD SURVEY

A similar, although abbreviated program was conducted in the spring of 1985. The intent of this survey was to sample and evaluate water quality and quantity characteristics of the mine site during high-flow conditions. However, a low snow pack and an early runoff period resulted in below normal streamflow conditions when field measurements were made. The timing of the

survey, which was coordinated with the IDFCG, occurred during their spring 1985 fish live car tests. The spring survey was conducted to:

- Resample selected field stations for water quality and quantity under high-flow conditions
- Visually assess snow melt runoff patterns over and through various waste piles
- Identify potential locations from diversion ditches along the Bucktail and Blackbird drainages
- Review the applicability of preliminary abatement programs and concepts resulting from the fall field data

Specific stations that were resampled included the 7265 and 7117 adits in the Bucktail drainage, and selected adits, springs, and seeps in the Meadow Creek/Blackbird Creek drainages. Measurements were also made directly in Meadow Creek, Blackbird Creek, West Fork of blackbird Creek, Big Deer Creek, and Panther Creek.

A considerable effort was expended to locate and quantify sources of discharge and compare sources above the mine complex with those below. Measurements obtained in the fall had indicated a substantial gain in water occurring somewhere between the mine culvert inflow and the culvert outflow underneath the mine complex. Water quality measurements (copper concentrations, pH, conductivity) were also made to facilitate computation of mass loadings.

Since snowpack had been cited by other investigators (Farmer and Richardson 1980; M. Torf, IDH&W 1984. pers. comm.) as a potential catchment and source of windblown contaminants, several snow samples were collected, melted, and analyzed for copper content, pH, and conductivity. These samples were collected at the ridgelines of the drainages of Bucktail and Blackbird creeks.

Section A2

SOURCES OF CONTAMINATION

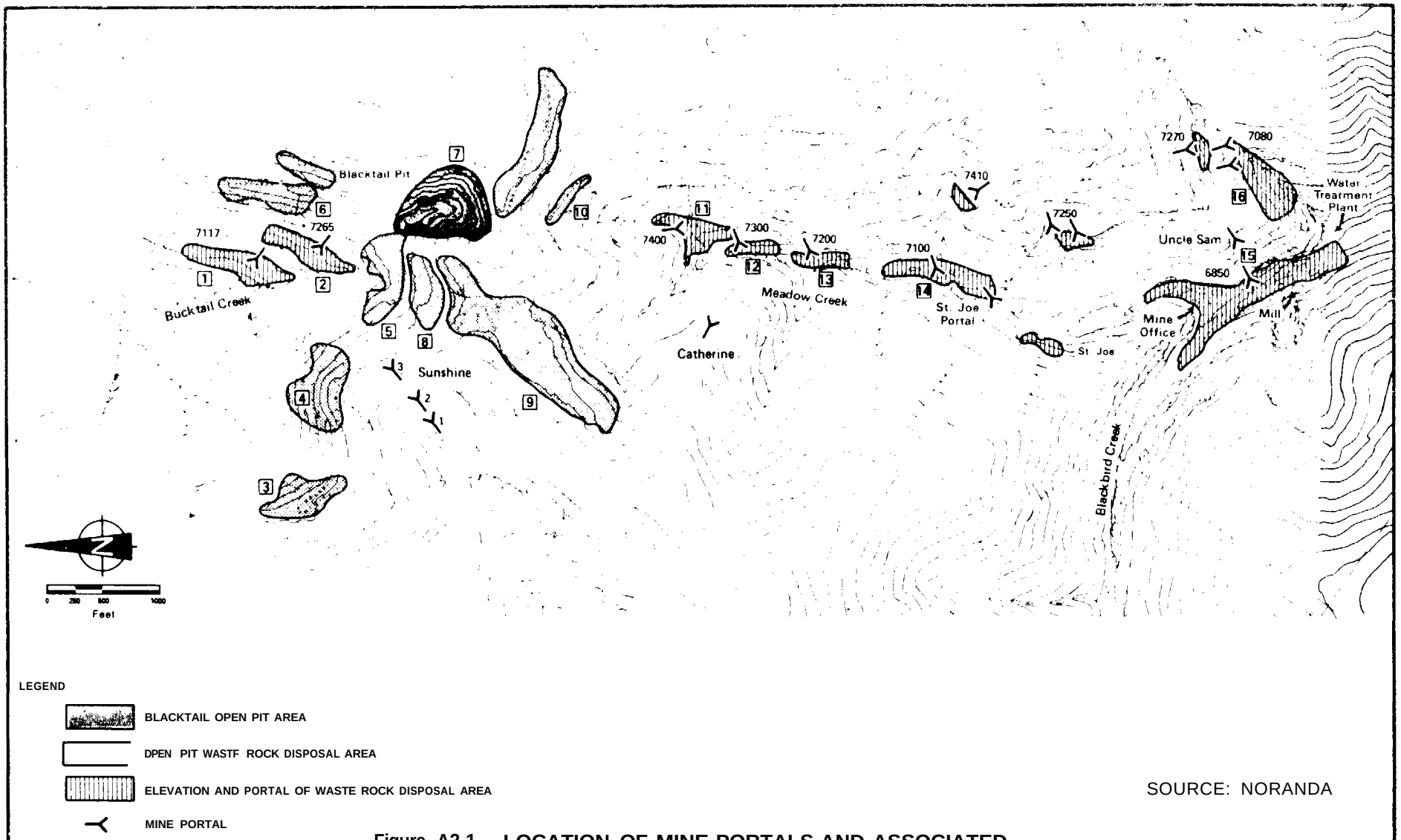
A2.1 BUCKTAIL CREEK DRAINAGE

The Bucktail Creek drainage encompasses the northern portion of the Blackbird Mine workings, which include the open pit, portions of the open-pit waste pile, and the 7265 ft and 7117 ft level adits and associated waste piles (Figure A2-1). Bucktail Creek is a tributary to the South Fork of Big Deer Creek, which flows into Big Deer Creek and ultimately into Panther Creek. Bucktail Creek contains elevated concentrations of copper, cobalt, and iron (See Section 4).

Bucktail Creek is fed from a variety of point and nonpoint sources (Figure A2-1, Table A2-1). These include a spring and culvert at its headwaters immediately below the open-pit waste pile (Station 29), flow from the 7265 and 7117 adits (Stations 30 and 31), two West Fork tributary gullies (Stations 19 and 25), two East Fork tributary streams (Stations 13 and 6), and at least 12 springs located along its course (Stations 14, 19, 22, 26, and 27). Most of these sources have been identified and characterized by Baldwin et al. (1978). In addition, most of the channel banks are seeping, which suggests that the stream is continually gaining water along much of its reach.

The estimated discharge from each source as determined during September 1984 is described in Table A2-1. Total flow in the stream increased from about 5 gpm below the uppermost spring and culvert (Station 29), to 285 gpm at the confluence of Bucktail Creek with the South Fork of Big Deer Creek (Station 10).

Three principal sources of contaminants to the Bucktail Creek drainage have been identified by Baldwin et al. (1978). These sources were verified by field studies during this investigation. These include:



SOURCE: NORANDA

Figure A2-1 LOCATION OF MINE PORTALS AND ASSOCIATED WASTE PILES (See Table 3-2 for details)

Table A2-1

BUCKTAIL CREEK FIELD SAMPLING STATIONS (FALL 1984)
(Refer to Figure A2-2 for Station Locations)

Station	Water	Conductivity (umhos/cm^2)	pH	Cu (mg/l)	Flow	Description
1	Panther Creek 50 ft below Big Deer confluence	100			130 cfs	Bright green moss. No aquatic life.
2	Panther Creek above Big Deer confluence	101	6.5	0.13	112 cfs	Sparse aquatic life.
3	Big Deer Creek above Panther confluence	108	7.0	0.51	24.5 cfs	Slight blue-green ppt. in quiet water. No aquatic life.
4	Big Deer below South Fork confluence	102				Sparse dark green ppt. in quiet water.
5	South Fork above Big Deer confluence	230				Strong blue ppt. in present low-flow channel.
6	Big Deer above South Fork confluence	70	7.0	0.14	18.9 cfs	Clear water. No ppt. Many aquatic invertebrates.
7	Indian Creek above Big Deer	230			50 gpm	Many aquatic invertebrates.
8	South Fork below Bucktail confluence	240	8.0	6.4	3.28 cfs	Strong green ppt.
9	South Fork above Bucktail confluence	160	8.3	0.28	2.7 cfs	Clear, no ppt.

Table A2-1 (Cont'd)

BUCKTAIL CREEK FIELD SAMPLING STATIONS (FALL 1984)
(Refer to Figure A2-2 for Station Locations)

Station	Water	Conductivity (umhos/cm^2)	pH	Cu (mg/1)	Flow	Description
10	Bucktail at lower road crossing above South Fork confluence	650	6.0	32	0.64 cfs	Strong blue ppt. Water was cloudy.
11	Bucktail Creek	690			200 gpm	Strong blue ppt. Water is cloudy.
12	Bucktail below lower east Fork confluence	720				Bluish-green ppt. Small dry adit nearby.
13	Lower east fork above Bucktail confluence	70-120			35 gpm	Many aquatic invertebrates, two channels.
14	Bucktail Creek	950			150 gpm	Pale yellow ppt.
	Small spsing from west bank	140			0.5 gpm	Clear water. Much plant life.
15	Bucktail below upper east fork	920				Very cloudy and yellow ppt.
16	Upper east fork above Bucktail	120		0.08	30 gpm	Good plant life and aquatic invertebrates.
17	Bucktail above upper east fork	1000			150 gpm	Yellow ppt.
18	Bucktail Creek	1000			100 gpm	Bluish white to yellowish-white ppt.
19	Small creek and spring on west bank	160			2 gpm	Clear water. Good plant life.

Table A2-1 (Cont'd)

BUCKTAIL CREEK FIELD SAMPLING STATIONS (FALL 1984)
(Refer to Figure A2-2 for Station Locations)

Station	Water	Conductivity (umhos/cm^2)	pH	Cu (mg/1)	Flow	Description
20	Bucktail Creek	1100			80 gpm	Whitish yellow ppt. Foamy.
21	Bucktail Creek	1100			60 gpm	
22	Large spring from east bank	950	5.2	65	10 gpm	Clear water. Moss, no invertebrates,. No iron ppt.
23	Upper Road crossing	2200	4.2	320	30 gpm	Elemental copper on iron. Yellow-orange ppt.
24	Bucktail below west Fork confluence	2300				Hard iron ppt. Evidence of very high runoff.
25	West Fork above confluence	950	6.3	430	1.0 gpm	Mostly a seep but evidence of higher flows No iron ppt. Much plant life.
26	Bucktail Creek	2550			30 gpm	
	Seep on east bank	2100			0.1 gpm	Evidence of much higher flow.
27	Eight springs at and below base of 7117 waste pile	1700 and 2200 to 2700	4.2	625	2 gpm	No iron ppt. All springs are on east bank and probably include flow from 7117 adit.
	Bucktail Creek above springs	3800	3.6	1120	10 gpm	Good iron ppt. Flows over and through 7117 waste pile.
	Spring from west bank	1450			0.2 gpm	Small seep

Table A2-1 (Cont'd)

BUCKTAIL CREEK FIELD SAMPLING STATIONS (FALL 1984)
(Refer to Figure A2-2 for Station Locations)

Station	Water	Conductivity (umhos/cm^2)	pH	Cu (mg/1)	Flow	Description
28	Bucktail above confluence with 7265 adit water	3900 to 4000			5 gpm	Water has bluish tint. Creek issues from 3 springs at base of 7265 waste pile.
29	Bucktail source above 7265 adit	5000	3.6	1550	5	Two sources: (1) Culvert at base of open pit waste pile, 2 to 3 gpm. Culvert either drains waste pile or drains 7400 adit. (2) Seep 3 ft above culvert, 2 gpm. Evidence of much higher runoff from above. Iron stakes in creek do not plate copper. Creek flows over and disappears into 7265 waste pit. Reappears in springs at station 28. No ppt.
30	7117 adit flow	1500	4.4	220	5 gpm	Flow runs over and disappears into waste pile. Perhaps reappears in springs at station 27. Very orange ppt.
31	7265 adit flow	2500	3.2	140	1 gpm	Adit flow is 1 gpm. Iron visible in water. Very orange ppt. Evidence of higher flow and gullying over face of waste pile.

- Waste piles
- Adit flow
- Contaminated seeps and springs

A2.1.1 Waste Rock Piles

The waste rock piles associated with the open pit and the 7265 and 7117 adits are in the headwater areas of Bucktail Creek and are the major sources of metal loading to the drainage.

The open-pit waste pile contains nearly one million cubic yards of waste rock and potentially low-grade ore that was removed from the Blacktail Pit. This material has been deposited at the head of Bucktail Creek (Baldwin et al. 1978; ESA 1981). Baldwin et al. (1978) indicated that the waste piles cover the upper 500 ft of Bucktail Creek including an area of probable pre-mining groundwater discharge. Groundwater discharge from a seep and culvert at the base of the waste pile (Station 29, Figure A2-2) forms the present-day low-flow headwaters of Bucktail Creek. Baldwin et al. indicated that this groundwater discharge represented the gradual release of water stored in the waste pile from the spring snow melt. Water from the seep and culvert is of poor quality; data from Baldwin et al. (1978) indicate high copper and cobalt concentrations, low iron concentrations, an average pH of 3.9, and discharges ranging from 0 (during the late winter months) to 100 gpm (during spring runoff). In the fall of 1984, this source contributed 5 gpm to Bucktail Creek; water quality characteristics included a conductivity greater than 5000 umhos/cm^2 copper concentrations of 1550 mg/l, and a pH of 3.6 (Table A2-1). These data indicate a copper loading of 27.3 pounds per day under low-flow conditions.

The 7117 and 7265 waste piles represent material mined from the 7117 and 7265 adits, respectively. The 7117 waste pile contains about 51,500 cubic yards of material and the 7265 waste pile contains about 24,800 cubic yards of material (USFS 1982). Both waste piles partially inundate the Bucktail Creek channel. The 7117 waste piles cover about 150 ft, and the 7265 waste pile about 250 ft

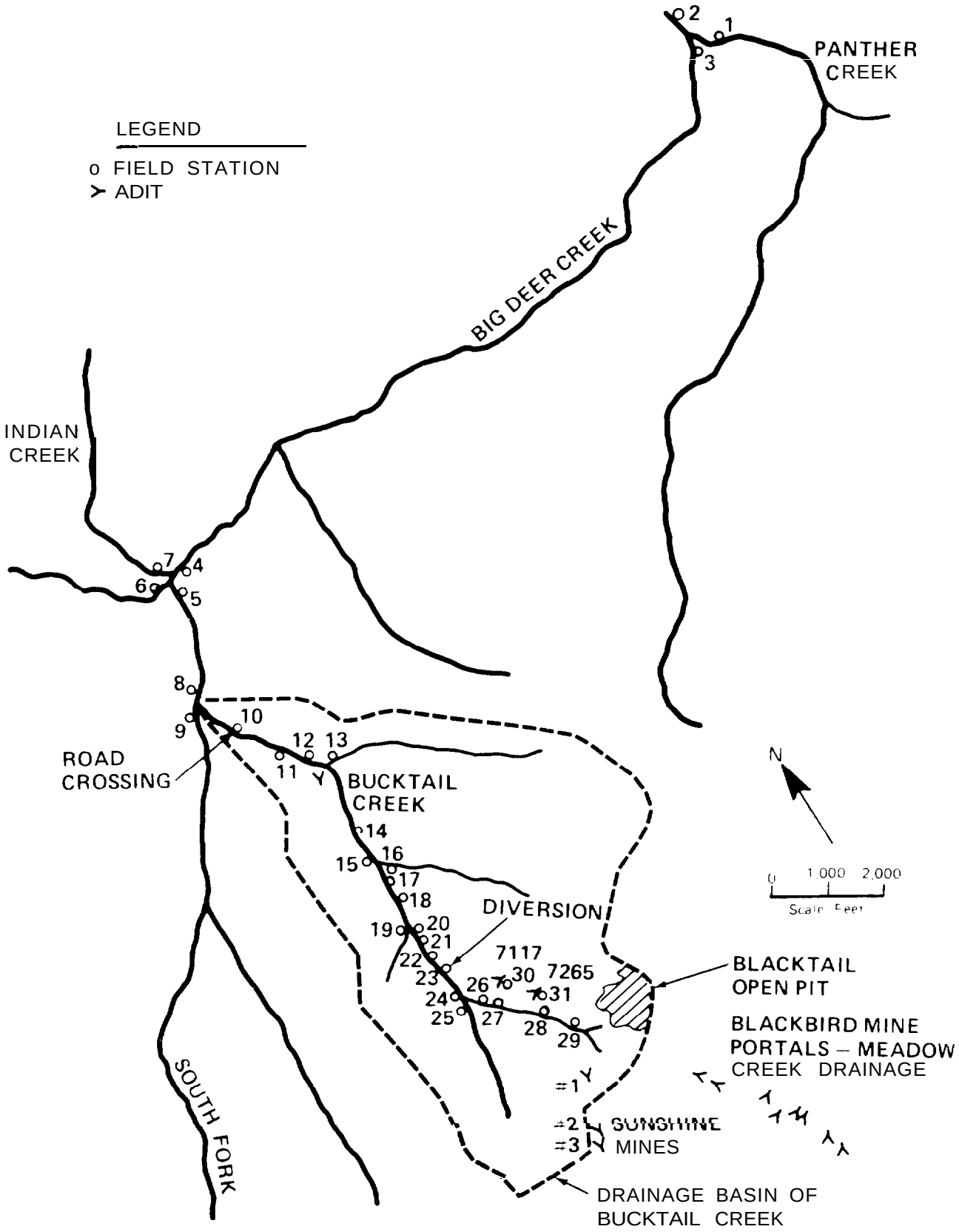


Figure A2-2 BUCKTAIL CREEK DRAINAGE, FIELD SAMPLING LOCATIONS, FALL 1984

of the channel (Baldwin et al. 1978). Bucktail Creek and discharge from the 7117 and 7265 adits flow over and/or through the waste piles. Spring snow melt provides an additional source of recharge under high-flow conditions.

A significant increase in discharge and heavy metals loading occurs in the reach of Bucktail Creek immediately below the 7117 adit (Baldwin et al., 1978). Discharge and copper concentrations recorded during this study (Tables A2-1 and A2-2) indicate that copper loadings increased from 39.8 pounds per day above the 7117 waste pile to 115 pounds per day below the 7117 waste pile during the fall, and from 88 pounds per day to 325 pounds per day during the spring (Figure A2-3). Most of the increase in discharge and copper loading results from seeps and springs near the base of the 7117 waste pile.

A2.1.2 7265 and 7117 Adit Discharge

The 7265 adit extends directly beneath the Blacktail open pit. Tracer tests reported by Baldwin et al. (1978) indicated that the adit receives direct recharge from the pit. Discharge from the portal averages 4.9 gpm with a peak recorded flow of 12 gpm (Baldwin et al. 1978). Field observations during this study show a range in discharge from 1 gpm in the fall to 7 gpm in the spring (Station 31, Figure A2-2, Tables Al-l, and Al-2). The water is acidic with a pH of 3.2, a conductivity of 2500 umhos/cm^2 and contains about 140 mg/l copper.

Discharge from the adit flows over the 7265 waste pile. A thick coating of iron hydroxide was present on the surface of the waste pile, which restricts infiltration during low-flow conditions. The adit discharge enters Bucktail Creek about 40 feet below the waste pile. Conductivity of the water increased to 2650 umhos/cm^2 after flowing over the waste pile, which indicates that the acidic water had leached metals out of the waste rock.

The 7117 adit is connected to the 7265 adit by the 912 raise (Baldwin et al. 1978). Tracer tests reported by Baldwin et al. (1978) suggest that the adit

Table A2-2

BUCKTAIL CREEK FIELD SAMPLING STATIONS (SPRING 1985)
(Refer to Figure A2-2 for Station Locations)

Station	Water	Conductivity (umhos/cm^2)	pH	Copper (mg/1)	Flow (gpm)
23	Bucktail Creek at upper road crossing			225	120
27	Bucktail Creek 7117 waste pile			525	14
31	7265 adit flow				7

Spring sampling done at Elevation 6950 ft above upper road crossing.

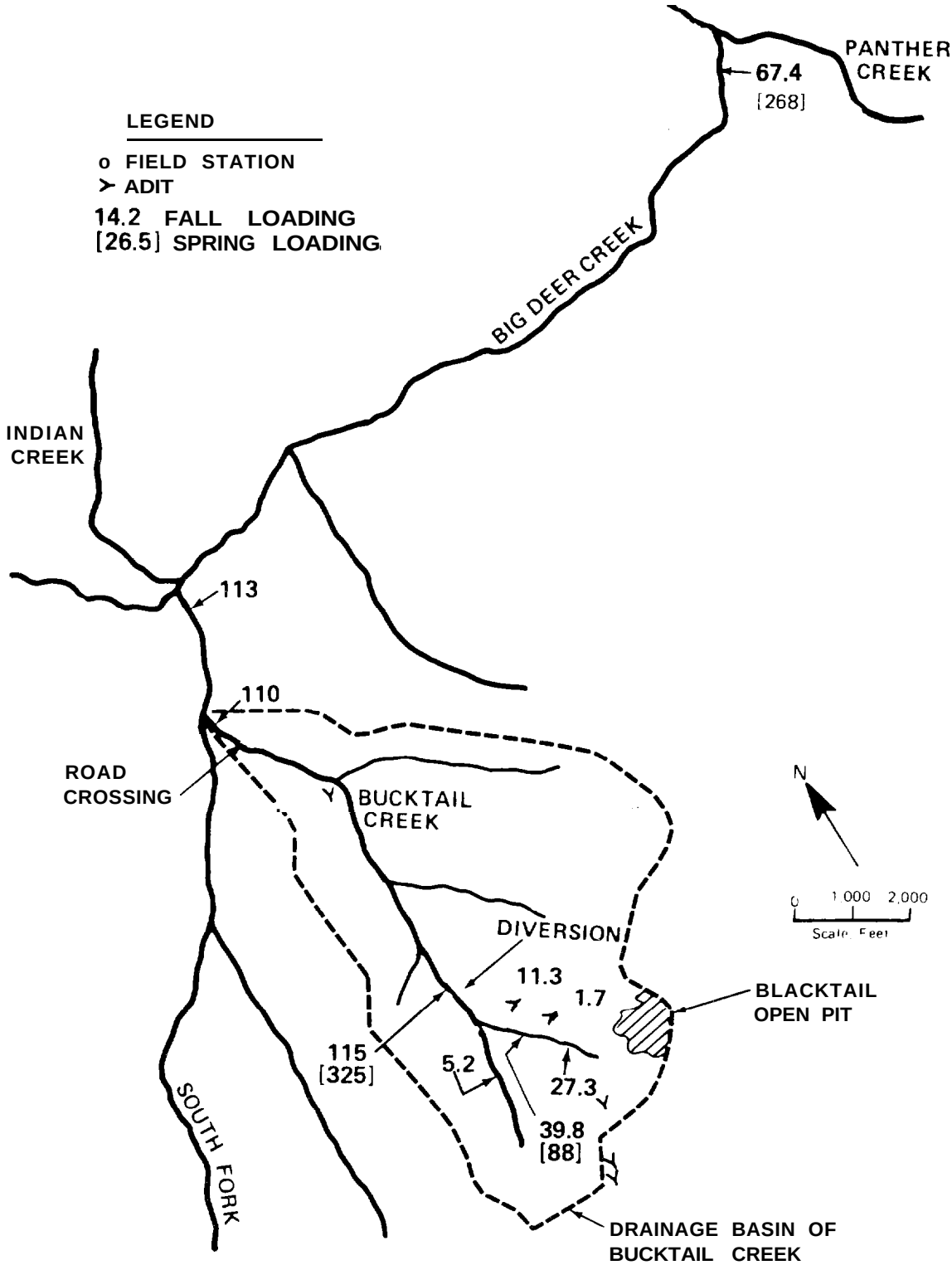


Figure A2-3 BUCKTAIL CREEK COPPER LOADING IN POUNDS PER DAY

receives little if any direct recharge from the Blacktail open pit. Discharge from the adit, therefore, probably comes from:

- Naturally occurring groundwater in the fractured rock
- Recharge to the groundwater system through the Blacktail open pit

Discharge from the 7117 portal ranged from 4 gpm (fall 1984) to 14 gpm (spring 1985) (Table A2-1 and A2-2). The water was of poor quality, with pH of 4.4, conductivity of 500 umhos/cm^2 and a copper content of 220 mg/l in the fall and 500 mg/l in the spring. The discharge flowed over and infiltrated into the 7117 waste pile. The flow probably contributes to the springs and seeps in Bucktail Creek below the 7117 waste pile.

A2.1.3 Seeps and Springs

Contaminated seeps and springs occur at several localities along Bucktail Creek (Stations 22, 26, 27, and 28, Figure A2-2, Table A2-1). At Station 28, water seeps from immediately below the base of the 7265 waste pile at three closely spaced localities in the creek channel. The Bucktail Creek headwaters flow over and infiltrate into the 7265 waste pile, and most of the water in the seeps represents reemergence of this stream flow. In the fall of 1984, however, the seeps had a combined discharge of 5 to 7 gpm - a slightly higher flow than the infiltrated flow of Rucktail Creek into the waste pile. The increase probably represents continued drainage of water stored in the waste pile from spring snow melt, or possibly a contribution from groundwater discharge. Water from the seep is of poor quality, with a conductivity of 3900 to 4000 umhos/cm under low-flow conditions.

Numerous springs and seeps are also present along Bucktail Creek at and immediately below the base of the 7117 waste pile (Station 27). In the fall 1984, eight springs and seeps were identified along a 100 ft reach of the creek below the waste pile. These sources corresponded to "seep zone 1," which is described by Baldwin et al. (1978), as a significant source of metal loading to Bucktall Creek. These sources, each flowing at about 1 to 2 gpm, contributed about 12 gpm to Bucktail Creek under low-flow conditions. Bucktail Creek flows over the 7117 waste pile without significant infiltration

and, thus, these sources probably do not represent discharge from Bucktail Creek. Discharge from the 7117 portal, however, infiltrates into the waste pile and probably contributes to the discharge from the seeps. In the fall of 1984, discharge from the portal was 4 gpm or about one-third of the combined discharge from the seeps. The remaining discharge from the seeps probably represents continued drainage of water stored in the waste pile from spring snow melt. Baldwin et al. (1978) also suggested that groundwater flow along a fault or shear zone may intersect Bucktail Creek at this point. Water quality from the seeps is poor, with conductivities ranging from 1700 to 2700 umhos/cm^2, a pH of 4.2, and a copper concentration of 625 mg/l. This concentration is significantly higher than copper concentrations in the portal discharge (220 mg/l) indicating that metals are being leached from the waste pile.

Data from Baldwin et al. (1978) and this study (Section 4) indicate that the total copper loading in Bucktail Creek increases significantly along the reach immediately below the 7117 waste pile. Most of the additional loading is from seepage from the 7117 waste pile and/or emergence of contaminated groundwater through the seeps and springs at Station 27.

Below these sources of contamination at elevation 6550 feet, water entering Rucktail Creek is apparently not contaminated. Most of this water comes from the upper and lower East Fork tributaries (Stations 13 and 16). Conductivity of these waters ranged from 70 to 120 umhos, and the presence of aquatic plants and aquatic invertebrates in the stream channels suggests that these tributary streams have low metal concentrations. Measured copper concentration in the upper tributary (Station 16) was 0.08 mg/l (Table A2-1), which confirms this interpretation.

Water in the South Fork of Big Deer Creek above Bucktail Creek had a conductivity of 160 umhos/cm^2 and a copper content of 0.2 mg/l (Station 9). The 0.2 mg/l may reflect the natural level of copper in water derived from the Blackbird Mountain area prior to mining activity. No additional work along the South Fork to trace the possible source of this copper was conducted during field investigations for this study. Water quality data reported by Baldwin et al. (1978) indicated that the South Fork above Bucktail Creek was

generally clean with no trace of copper. The South Fork of Big Deer Creek thus provides the opportunity to establish the natural level of copper concentrations in streams and groundwater of the Blackbird Mine region.

Additional sources of metals contamination are from several springs and tributary seeps extending down Bucktail Creek to an elevation of about 6550 feet (several hundred feet below the road crossing/diversion area> (Stations 22, 25, and 26, Figure A2-2). These springs and seeps had conductivities of 950 umhos to 2100 umhos/cm^2 and copper concentrations of 65 mg/l or higher. The largest of these springs, occurs at an elevation of 6550 ft (Station 22) and had a 7 to 10 gpm flow and a copper concentration of 65 mg/l.

A2.2 MEADOW CREEK/BLACKBIRD CREEK DRAINAGE

The Meadow Creek/Blackbird Creek drainages encompass most of the Blackbird Mine workings, which include 15 adits and associated waste piles, about 50 percent of the Blacktail open-pit waste pile, all of the mine buildings and facilities, the tailings pipeline, and the West Fork tailings impoundment (Figure A2-1, Figure A2-4, Table A2-3). Meadow Creek originates in the Blackbird mine area and flows through most of the mine area prior to entering Blackbird Creek. Blackbird Creek flows through the southern part of the mine area and is a tributary to Panther Creek. Meadow Creek is heavily contaminated with copper, cobalt, and iron, which have eliminated aquatic life in Blackbird Creek and greatly reduced or eliminated much of the aquatic biota in Panther Creek below Blackbird Creek (Baldwin et al. 1978; Platts et al. 1979).

A2.2.1 Meadow Creek

Meadow Creek is fed from a number of uncontaminated and contaminated sources. During this study, the discharge in Meadow Creek increased from 15 gpm at its headwaters to 30 gpm at its confluence with Blackbird Creek during low-flow (fall) conditions, and from 20 gpm at its headwaters to 130 gpm at its confluence with Blackbird Creek during high-flow (spring) conditions.

Uncontaminated point sources to Meadow Creek include several springs at its headwaters near the base of the large open-pit waste pile (Figure A2-4,

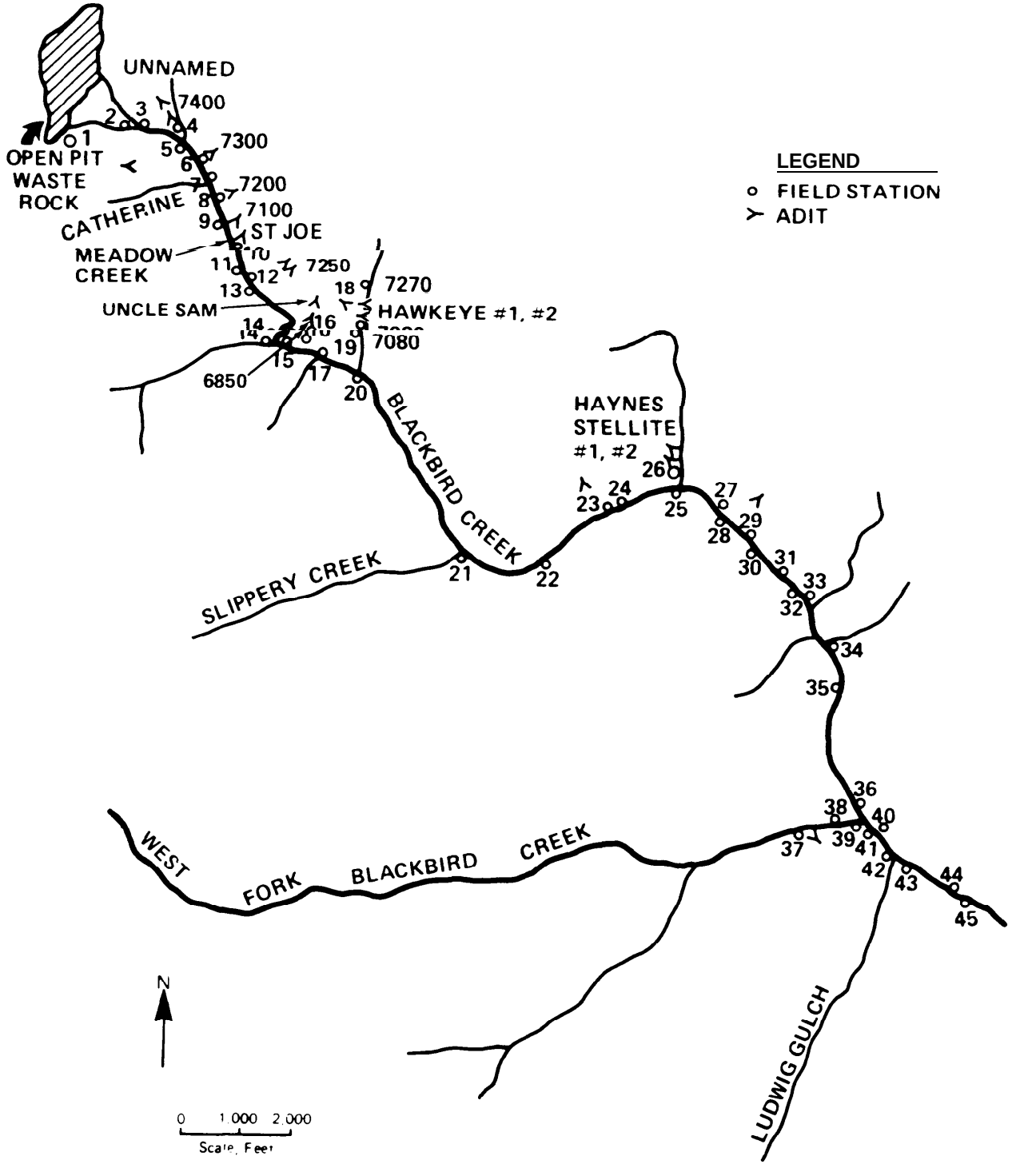


Figure A2-4 BLACKBIRD CREEK DRAINAGE, FIELD SAMPLING LOCATIONS, FALL 1984

Table A2-3

MEADOW CREEK - BLACKBIRD CREEK FIELD SAMPLING STATIONS (FALL 1984)
(Refer to Figure A2-4 for Station Locations)

Station	Water	Conductivity (umhos/cm^2)	pH	Cu (mg/l)	Flow	Description
1	Several springs - source of Meadow Creek. Range from 2 to 10 gpm	42 to 160	5.6 to 6.1	0.19	20 gpm	Springs appear pristine. Much moss. No aquatic invertebrates (perhaps low dissolved oxygen); road cut and some waste on upper slopes.
2	Concentrated spring flow in creek	125 to 160			20 gpm	Pristine headwater section. Much plant life. No invertebrates.
3	Seep at base of debris flow from open-pit waste pile	2750 to 3300	3.25	425		Seep is distributed over 200 ft stretch of Meadow Creek. Vegetation is dead including 60 yr old (est.> trees. Some moss.
	Meadow Creek below seep	550	4.5	37	30 gpm	Water looks clear, some pale blue ppt.
	Meadow Creek above seep	220			0.5 gpm	Clear water. Much moss.
	Seep from north bank 300 ft below main seep	1700			0.5 gpm	
	Meadow Creek below seep	700				Increase in conductivity suggests continuing non-point source.
	Seep from South bank	90			0.5 gpm	Pristine water. Much plant life.

Table A2-3 (Cont'd)

MEADOW CREEK - BLACKBIRD CREEK FIELD SAMPLING STATIONS (FALL 1984)
(Refer to Figure A2-4 for Station Locations)

Station	Water	Conductivity (umhos/cm^2)	pH	Cu (mg/1)	Flow	Description
4	7400 adit. Dry at this time as is unnamed adit upslope					Evidence of high flow out of adit and down North Fork gulch. Large waste pile with ineffective culvert across gulch.
5	Meadow Creek below waste pile of 7400	650				Clear water. No iron or copper ppt.
	Spring from south bank	120	5.9		2 gpm	Heavy iron ppt.
6	Meadow Creek below 7300 waste pile	650			25 gpm	Large 24 in. culvert washed out. Clear water, no ppt. 7300 adit is dry.
7	Meadow Creek below unnamed adit waste pile	670	4.9		25 gpm	Adit is dry.
	West fork of Meadow Creek cut through fresh tailings at mouth	38 to 50	6.5		5 gpm	Water comes through iron pipe l-2 gpm and overland 2-3 gpm.
	Meadow Creek below West Fork confluence	450	4.8 to 5.2			Blue ppt in channel.
8	7200 adit no. 1 and no. 2 currently dry			-		Large adits. Waste pile recently leveled. One adit appears to have had recent flow.
9	Meadow Creek prior to 7100 adit waste pile culvert (effective)	465			50 gpm	Water and channel largely clear, 7100 adit is dry.

Table A2-3 (Cont'd)

MEADOW CREEK - BLACKBIRD CREEK FIELD SAMPLING STATIONS (FALL 1984)
(Refer to Figure A2-4 for Station Locations)

Station	Water	Conductivity (umhos/cm^2)	pH	Cu (mg/1)	Flow	Description
10	Meadow Creek below 7100 waste pile culvert	700	4.0 to 4.3	15	39 gpm	Water has higher conductivity and pH as it passes below waste pile has large gullies suggesting that high flow exceeds culvert capacity.
	St. Joe adit	1450	2.75	25	0.5 gpm	Small flow.
	Seepage from 7100 waste pile above St. Joe	2500			0.1 gpm	Small flow. Evidence of much higher flow.
11	Meadow Creek	690				Much iron ppt. (started at 7100 culvert).
12	Meadow Creek before mine culvert	680				Much iron ppt. Small tailings spill upstream.
	Small seep from west bank	220			0.5 gpm	Clear water. Aquatic invertebrates.
13	Meadow Creek at mine complex	750				Meadow Creek runs overland to Blackbird Creek. Culvert below mine may not be intact.
	Small seeps in channel above culvert	600				Seeps indicate that Meadow Creek is gaining water beneath mine. Quantity not known.
14	Blackbird above Meadow convergence	80	6.5 to 7.0		91 gpm	Clear water. Live fish.
	Meadow above Blackbird convergence	750	3.6		30 gpm	Strong iron ppt.

Table A2-3 (Cont'd)

MEADOW CREEK - BLACKBIRD CREEK FIELD SAMPLING STATIONS (FALL 1984)
(Refer to Figure A2-4 for Station Locations)

Station	Water	Conductivity (umhos/cm^2)	pH	Cu (mg/l)	Flow	Description
15	Spring from north bank	60	6.2	0.22	15 gpm	Pristine water. No invertebrates or plants.
	Blackbird below spring	250	5.95			Strong gray blue ppt.
16	6850 adit					Dry. Waste pile and fill for mine area fills all of stream valley.
17	Small creek from south	45	6.3		10 gpm	Pristine water. Much plant and invertebrate life.
18	Uncle Sam adit					Dry. Waste rock in Hawkeye Gulch. Culvert buried.
19	Hawkeye adits					Dry. Evidence of some flow from no. 2 adit. Large waste pile in gulch. Culvert buried. Evidence of large flow and erosion. Debris flow impacted water treatment plant.
20	Blackbird below culvert and treatment	240	3.9	5.8	0.86 cfs	Yellowish white ppt. No plants.
	Small spring from southwest bank	60			1 gpm	Clear water. Many aquatic invertebrates.
21	Slippery Creek	160			2 gpm	Flow across dredge material at mouth. Pristine above.
	Small spring from west bank above slippery confluence	330			1 gpm	Iron ppt. Seeps through tailings.

Table A2-3 (Cont'd)

MEADOW CREEK - BLACKBIRD CREEK FIELD SAMPLING STATIONS (FALL 1984)
(Refer to Figure A2-4 for Station Locations)

Station	Water	Conductivity (umhos/cm^2)	pH	Cu (mg/1)	Flow	Description
22	Blackbird Creek	210				Clear water. Slight iron ppt.
23	Spring from north bank	135			1 gpm	Much moss.
24	Spring from north bank	60			0.5 gpm	No moss. Seeps through tailings. High copper reported.
25	Spring from south bank	330			1 gpm	Stagnant. Seeps through tailings. Not pristine.
	Blackbird	205				Above Haynes Stellite mine area.
26	Haynes Stellite adits	80			5 gpm	Lower adit small seep. Upper adit is dry. Water seeps into waste pile. Currently dry spring below. Much iron ppt. Ppt on dry spring area.
27	Spring from northeast bank	40			100 to 150 gpm	Much moss.
28	Blackbird Creek	205				Sparse red ppt.
29	Blackbird Creek	195				Sparse red ppt.
30	Spring from south bank	120	4.9	0.55	20 gpm	Moss. Spring at base of talus. Seeps through tailings.
31	Blackbird Creek	195				Sparse red ppt.
32	Spring from southwest bank	125	6.3	0.2	15 gpm	Base of talus. Much moss.
3"	Spring from northeast bank	65			25 gpm	Much moss. Clear water.

Table 3 (Cont'd)

MEADOW CREEK - BLACKBIRD CREEK FIELD SAMPLING STATIONS (FALL 1984
(Refer to Figure A2-4 for Station Locations)

Station	Water	Conductivity (umhos/cm^2)	pH	Cu (mg/l)	Flow	Description
34	Spring from northeast bank	80			1 gpm	Much moss. Aquatic beetles.
35	Blackbird Creek	155				Cloudy white water. White ppt in channel.
36	Blackbird Creek above west fork confluence	160	5.2	2.0	2.17 cfs	Primarily yellowish ppt. Red ppt. on west bank.
37	Ponded water behind tailings dam culvert	90				Clear water. Fish. Adit on south bank is dry.
38	Seep at front of tailings dam	1600			0.2 gpm	Stagnant. Very red-orange ppt.1
39	Dam culvert	80	7.3			Clear water.
	Stream below culvert	120	6.1	0.06		Very orange ppt. From seepage into channel.
40	Springs from northeast bank	140 to 155	4.5	0.8	36 gpm	Clear water. Much moss.
41	Blackbird below west fork/spring confluence	145	5.8	1.19	3.04 cfs	Strong white ppt. Water is cloudy white.
42	Small creek from southwest	135				Pristine clear water. Much plant life and aquatic invertebrates.
43	Blackbird below confluence	140				Strong white ppt. on yellowish orange ppt.

Table A2-3 (Cont'd)

MEADOW CREEK - BLACKBIRD CREEK FIELD SAMPLING STATIONS (FALL 1984)
(Refer to Figure A2-4 for Station Locations)

Station	Water	Conductivity (umhos/cm^2)	pH	cu (mg/l)	Flow	Description
44	Small spring from northeast bank	140			0.5 gpm	Clear water, moss present.
45	Blackbird Creek	140				Dull blue green ppt.

Station 1, Table A2-3), a small tributary stream (Station 7), and several small springs along the west bank of the creek. The headwater springs contributed 15 to 20 gpm combined flow to Meadow Creek in the fall of 1984. The spring water had a conductivity of 42 to 60 umhos/cm^2 a pH of 5.6 to 6.1, and a copper content of 0.19 mg/l (Table A2-3). The tributary stream contributed 3 to 5 gpm surface flow to Meadow Creek with a conductivity of 38 to 50 umhos/cm^2. Under low-flow conditions, total discharge from the west bank springs was less than 1 gpm.

The copper content and relatively low acidity of the headwater springs suggests slight contamination by infiltration through the waste pile, the base of which is about 200 feet away. It is presently unknown whether the discharge is from the waste pile, surficial talus, or the groundwater flow system. However, the similarity of copper content in these waters with the copper content measured in the South Fork of Big Deer Creek suggests that this level of copper may reflect natural, pre-mining conditions. However, a further evaluation of the Meadow Creek springs, the South Fork of Big Deer Creek source waters, and other springs are needed to define the background copper concentrations in waters derived from the Blackbird Mountain area.

The major sources of contaminated water to Meadow Creek include:

- Waste piles
- Adit discharge
- Contaminated seeps and springs

During low-flow conditions, these sources contribute approximately one-quarter to one-third of the total volume of surface flow in Meadow Creek. During high-flow conditions, spring runoff over waste piles and nonpoint seeps produce an unknown percentage of the total flow in Meadow Creek.

A2.2.1.1 Waste Piles

Waste rock from mine workings have been deposited in eight waste piles in the Meadow Creek drainage. These include the open-pit (Blacktail Pit) waste pile (7800 waste pile) at the headwaters of Meadow Creek; the combined 7400 and

7410 waste pile; the 7300, 7250, 7200, 7100, and St. Joe waste piles; and the 6850 waste pile upon which the mill complex is located. The distribution of these waste piles is shown on Figure A2-1.

The open pit waste pile (Station 9, Figure A2-l) consists of about 1.1 million cu yd of waste rock and possibly some low grade ore from the Blacktail Pit (ESA 1981). The upper surface of the waste pile has been graded, terraced, and extensively used by the USFS for revegetation research. The revege tation research program has had mixed but generally positive success. The waste pile covers a surface area of about 42 acres in the headwaters of Meadow Creek (USFS 1982), but does not inundate the Meadow Creek channel. Baldwin et al. (1978) indicated that significant recharge to the waste pile occurs from snow melt during spring runoff.

Although good quality water discharges from springs at the headwaters of Meadow Creek near the southern margin of the waste pile (Station 1, Figure A2-4), the springs discharging from the toe of the pile (Station 3, Figure A2-4) produce poor quality water (Baldwin et al. 1978) A large debris flow originating from the face of the waste pile has traveled about 700 ft down a narrow gully and now is distributed along the northern bank of Meadow Creek. Water presently seeps from nonpoint sources at the toe of the debris over a 200 ft stretch of Meadow Creek. Much of the vegetation in the immediate area is dead, including standing mature trees. The dead vegetation does not appear to be the result of the physical impact of the debris flow but may be a reflection of the contaminated soil and water.

In the fall of 1984, Meadow Creek below the debris flow gained about 5 to 10 gpm, suggesting nonpoint sources of contamination. The surface of the debris flow was dry, indicating that most of the seepage was within or beneath the flow. In the spring of 1985, these seeps contributed about 18 gpm to Meadow Creek (Station 3, Figure A2-4, Table A2-4). Baldwin et al. (1978) Indicated that seepage from the waste site ranges from 1 to 100 gpm and represented the gradual drainage of stored spring snow melt rather than discharge from the bedrock groundwater flow system.

Talbe A2-4

MEADOW CREEK - BLACKBIRD CREEK FIELD SAMPLING STATIONS (SPRING 1985)
(Refer to Figure A2-4 for Station Locations)

Station	Water	Conductivity (umhos/cm^2)	PH	Copper (mg/l)	Flow
3	Seep from open pit waste pile	2150	4.3	650	18 gpm
4	7400 adit waste pile seep	2050			0.5 gpm
8	7200 adit seep	850	3.05	50	1 gpm
9	Meadow Creek 7100 adit waste pile			28	87 gpm
13	Meadow Creek at mine complex			23	0.29 cfs
14	Blackbird above Meadow Creek				4.16 cfs
15	Spring from north bank	80	6.8	0.48	
18	7250 adit	285			3 gpm
19	7080 adit waste pile	350	4.7	28	3 gpm
	Hawkeye Gulch above treatment plant	460	5.1	22	15 gpm
20	Blackbird below mill complex			3.2	5.15 cfs

Seepage from the toe of the debris flow is a significant source of contaminants to Bucktail Creek. During the fall, the water ranged in conductivity from 2750 to 3300 umhos/cm^2, with a pH of 3.25 and a copper content of 425 mg/l (Table A2-3). In the spring, the water had a conductivity of 2150 umhos, a pH of 4.3 and a copper content of 650 mg/l (Table A2-4).

The 7400 waste pile (Station 11, Figure A2-1) consists of about 60,000 cu yd of material deposited across a small North Fork tributary to Meadow Creek (USFS 1982). Poor quality water from runoff and seepage was measured below this pile prior to internal diversion of mine drainage from the 7400 portal to the 6850 level. Under low-flow conditions, no water seeps from this waste pile. Under high-flow conditions, a small seep (0.5 gpm) of poor quality water discharges from the base of the waste pile. In addition, spring runoff down the North Fork tributary to Meadow Creek runs across the surface of the waste pile and down a vertical culvert to Meadow Creek. There is evidence of prior high flows exceeding the capacity of this culvert.

The 7300, 7250, and 7200 waste piles (Stations 12 and 13, Figure A2-1) occur along the east bank of Meadow Creek. The 7300 waste pile consists of 15,400 cu yd of material with its base partially extending into Meadow Creek. The 7250 waste pile consists of 18,600 cubic yards of material and the 7200 waste pile consists of 26,800 cu yd of material (USFS 1982); neither waste pile extends into Meadow Creek.

Meadow Creek does not flow over or through these waste piles and no seeps at their base were observed during this study. In addition, no sources of contamination or acid draiuage from these waste piles have been reported in the literature. However, surface runoff and spring snow melt have caused minor erosion of the surface and may provide a source of subsurface recharge to the Meadow Creek Valley alluvium.

The 7100 waste pile (Station 14, Figure A2-1) consists of about 88,000 cu yd of material (USFS 1982) primarily from the 7100 adit but also from the 7300 and 7200 level adits (Baldwin et al. 1978). The waste pile extends across Meadow Creek over a 350 to 400 ft reach and has been identified as a leading surface source of metals loading to Meadow Creek (ESA 1981). Prior to the

installation of a culvert by Noranda in 1979, Meadow Creek provided a constant direct source of recharge of poor quality water to the 7100 waste pile. In addition, prior to diversion of flow from the 7400 portal (see below), Meadow Creek had a very low pH that facilitated leaching of metals from the waste piles. The culvert installation now diverts the flow of Meadow Creek thereby reducing water contact with waste rock. Observations made during this study indicate that the culvert is susceptible to overflowing.

Current discharge from the 7100 waste pile is limited to small seeps at the downstream base of the pile (Station 10, Figure A2-4). The seeps contribute less than 0.5 gpm during the fall (Table A2-3) and potentially higher flows during the spring as a result of snow melt infiltration into the pile. Water in the seeps is of poor quality having a conductivity of 2500 umhos/cm^2.

The St. Joe waste pile (Station 14, Figure A2-1) consists of 14,000 cu yd of material deposited on the west bank of Meadow Creek above the high flow stream channel. No seeps were present at the toe of the waste pile and none have been described in the literature.

The 6850 waste pile (Station 15, Figure A2-1) consists of about 157,000 cu yd of material deposited in both the Meadow Creek and Blackbird Creek valleys. The waste pile includes material from the 6850 adit as well as stockpiled low-grade ore from other mine levels. The mine complex at the confluence of the Meadow Creek and Blackbird Creek Valleys is constructed on the 6850 waste rock and is mixed with tailings from the mine complex.

Meadow Creek and Blackbird Creek are presently diverted in a culvert through the waste rock/mill complex area. During the fall of 1984, however, the Meadow Creek culvert was damaged and poor quality Meadow Creek water flowed over and through the 6850 waste pile. Although the culvert was repaired by the spring of 1985, field data collected during this study have identified the 6850 waste pile as a major source of metal loading to the Meadow/Blackbird Creek discharge. During the spring of 1985, water from Meadow Creek entering the culvert above the mill complex carried a copper loading of 36 pounds per day (Figure A2-5). Water leaving the culvert below the mine complex carried a

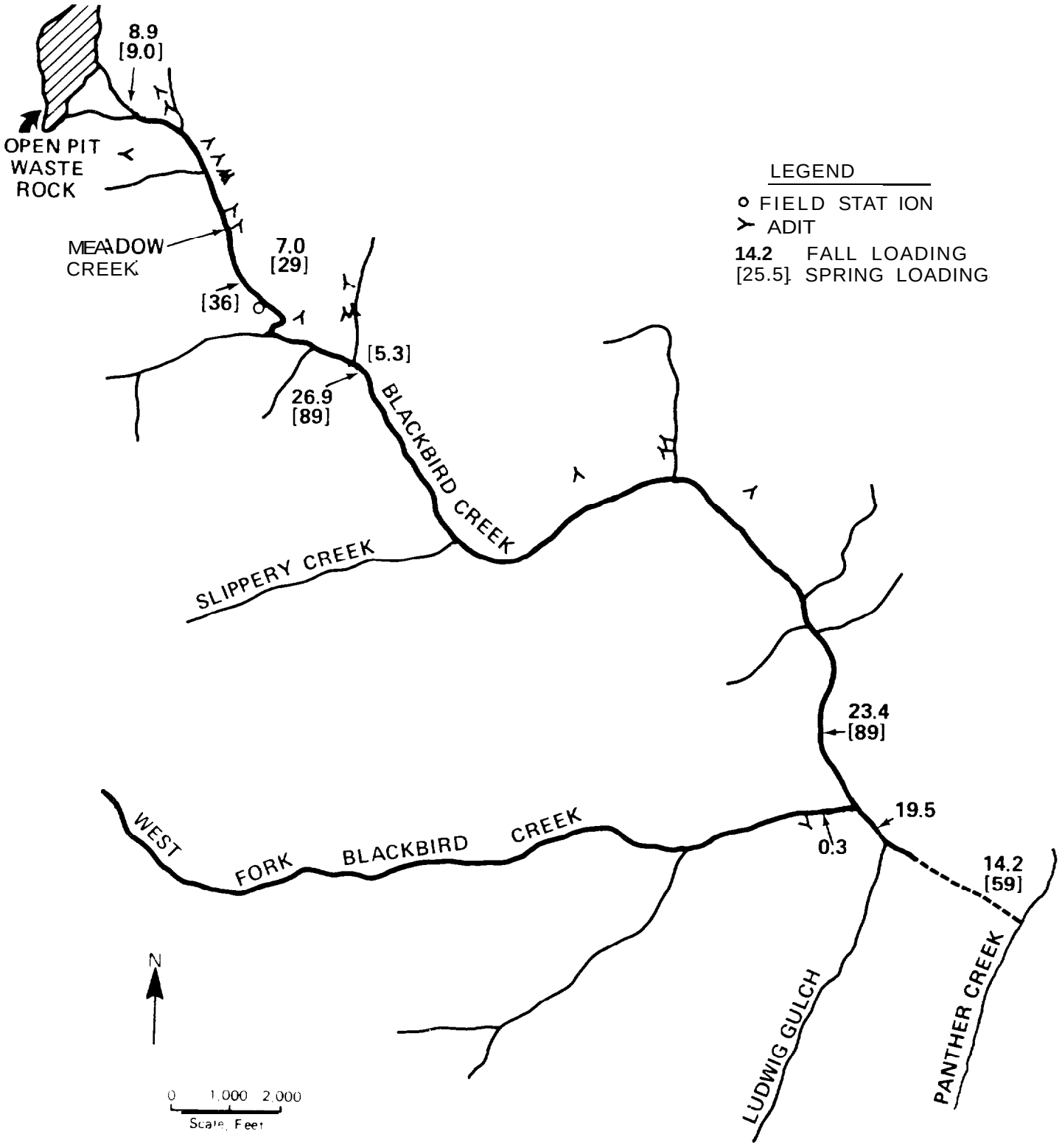


Figure A2-5 MEADOW CREEK-BLACKBIRD CREEK, COPPER LOADING IN POUNDS/PER DAY

copper loading of 89 pounds per day (Figure A2-5). The increase in loading suggests subsurface seepage of poor quality water into the culvert below the mine complex.

A2.2.1.2 Adit Discharge

Discharge of acidic mine water from adits in the Blackbird drainage has represented a significant source of poor quality water. Prior to diversion of water within the mine workings, significant discharge occurred from several portals in the Meadow Creek/Blackbird Creek drainage basin. These included the 7400, 7300, St. Joe, and 6850 portals. Of these, the 7400 and 6850 levels contributed about 95 percent of the total discharge (Baldwin et al. 1978). Subsequent diversions within the mine implemented by Noranda in the late 1970s have redirected water to the 6850 level, except for the St. Joe adit, which is not connected to the inner mine workings. A bulkhead installed in the 6850 adit has eliminated all but seepage discharge from the 6850 portal. The seepage water is currently collected and treated at the existing water treatment facility.

In the fall of 1984, about 0.5 gpm flowed from the St. Joe portal and infiltrated into the toe of the 7100 waste pile. The water was of poor quality with a conductivity of 1450 umhos/cm^2 a pH of 2.75, and a copper content of 25 mg/l. All other adits were dry.

In the spring of 1985, small amounts of water flowed from several adit portals. These included:

- Flow from the St. Joe portal
- About 3 gpm from the 7250 and adit
- About 1 gpm from the 7200 portal (Table A2-4)

A2.2.1.3 Contaminated Seeps and Springs

Contaminated seeps and springs represent a minor source of poor quality water to Meadow Creek. About 300 feet downstream from the open-pit waste pile debris flow, a spring issues from the north bank of Meadow Creek (Station 3, Table A2-3). During the fall of 1984, the spring contributed about 0.5 gpm of

water with a conductivity of 1700 umhos/cm^2. Although the spring was only a minor source of water, it was significant in that it probably represents contaminated groundwater that had infiltrated through the open-pit waste pile (Figure A2-1, Station 9). At least 500 ft of heavily vegetated forest separates the spring from the waste pile. It is likely that this spring and potentially many others undetected along this reach of Meadow Creek produce a significant nonpoint source of contamination.

A spring from the south bank of Meadow Creek opposite and slightly upstream from the 7400 waste pile contributed about 1 to 2 gpm of water to Meadow Creek in the fall of 1984. The quality of water was poor with a pH of 5.9 and a strong, bright-orange iron hydroxide precipitate was present in the channel. The spring is significant in that it represents groundwater flow from the unmined western portion of the Meadow Creek drainage basin and may represent natural conditions.

A2.2.2 Blackbird Creek

The contaminated waters of Meadow Creek flow into Blackbird Creek at the main mine complex. The confluence of these creeks is below ground in a culvert that passes through the 6850 waste pile. In the fall, 1984, however, the culvert was damaged and, as a result, Meadow Creek joined Blackbird Creek at the surface immediately below the Blackbird Creek holding pond (Station 14, Figure A2-4).

Blackbird Creek increased in discharge during the September 1984 study from about 100 gpm above the confluence with Meadow Creek to about 2200 gpm at its confluence with Panther Creek. Above its confluence with Meadow Creek, Blackbird Creek had a conductivity of 80 umhos/cm^2 (Station 14), and it supported abundant aquatic life, including salmonids. Below Meadow Creek, the conductivity was 250 umhos/cm^2 (Station 15), which reflected the contribution of contaminants from Meadow Creek and the 6850 waste pile. Downstream from this point to Panther Creek the conductivity in Blackbird Creek gradually decreased from 250 to 145 umhos/cm^2 indicating that there were no major sources of contaminants to Blackbird Creek during low flow.

In the spring of 1985, discharge in Blackbird Creek increased from 4.2 cfs above the confluence with Meadow Creek to 22 cfs at its confluence with Panther Creek.

Numerous tributaries and springs contribute to the increasing flow of Blackbird Creek. Besides Meadow Creek, the major tributaries to Blackbird Creek include Slippery Creek (Station 21, Figure A2-4), West Fork of Blackbird Creek (Station 37), and Ludwig Gulch (Station 42). Water in Ludwig Gulch had a conductivity of 135 umhos/cm^2 and supported abundant aquatic life. Water in Slippery Creek had a conductivity of 160 umhos/cm^2. It also supported aquatic life upstream from its confluence with Blackbird Creek but flows over dredge material and tailings at its mouth just upstream of Blackbird Creek. Slippery Creek is not contaminated by the tailings during low flows, but erodes and mobilizes the tailings and dredge material during high flows. Water in the West Fork of Blackbird Creek is contaminated by the abandoned tailings pond as described below.

Copper loading in Blackbird Creek generally decreases downstream as a result of partial precipitation along the creek channel, which results from the addition of good quality water (Figure A2-5). Copper loading in the fall of 1984 decreased from 26.9 pounds per day below the mine complex to 14.2 pounds per day at the confluence with Panther Creek. Copper loading in the spring of 1985 decreased from 89 pounds per day below the mine complex to 59 pounds per day at the confluence with Panther Creek.

There are several sources of contaminated water to Blackbird Creek, including:

- Meadow Creek
- Waste piles
- Tailings piles
- West Fork of Blackbird Creek
- Contaminated springs

These sources are located on Figure A2-4 and described in Table A2-3.

A2.2.2.1 Waste Piles

As described earlier, the 6850 waste pile is a significant source of contaminants to the combined flow of Blackbird and Meadow creeks. The source(s) are below the mine complex and cannot be further characterized without additional field investigations.

Waste rock from the 7270 and 7080 adits partially inundate the Hawkeye Gulch, a tributary to Blackbird Creek above the existing water treatment facility. The 7080 and 7270 waste piles consist of about 68,000 and 2,000 cu yd of material, respectively. Portions of this waste rock were excavated from the mine by Noranda during recent exploratory activities. In the fall of 1984, water was not present in Hawkeye Gulch and the waste piles did not represent a source of contaminants. In the spring of 1985, drainage down Hawkeye Gulch passed through portions of the waste piles and contributed about 5.3 pounds per day of copper to Blackbird Creek (Figure A2-5). Additional undetected seepage from the waste pile probably occurs as a result of snow melt and spring runoff over the surface of the piles.

A2.2.2.2 West Fork Tailings Impoundment

The Blackbird Mine tailings impoundment is located in the West Fork of Blackbird Creek immediately above its confluence with Blackbird Creek. Water in the West Fork above the tailings had a conductivity of 90 umhos/cm^2 and supported aquatic life, including salmonids. A 42-inch culvert passes this water beneath the tailings dam and isolates it from the tailings. The culvert is effective during low-flow conditions. However, the culvert is only designed for the 14-year flood event (USFS 1984), and water has ponded behind the tailings dam during high-flow conditions. ESA (1981) reported that a potentially serious problem exists in the possible failure of the culvert with subsequent erosion of tailings and possible dam failure. This potential was not evaluated during this study.

The tailings impoundment has been surfaced with talus to prevent wind and water erosion. The talus, which is not impermeable, allows infiltration into the tailings. The impoundment is approximately 1250 ft long and has a surface

area of about 550,000 ft^2. The southern side of West Fork Valley is heavily vegetated and contains two large gullies that drain onto the tailings. The northern valley slope is sparsely vegetated and mantled by a veneer of loose talus from 1 to 2G ft thick. No active or dry springs were observed on either valley wall. Surface runoff in excess of infiltration is directed away by a vertical culvert located near the upstream margin of the impoundment. This culvert connects to the main west fork culvert beneath the tailings.

Behind the impoundment there is a smaller tailings storage area that was used by Noranda in the early 1980s. These tailings are not covered and, hence, runoff ponds against the backside of the main tailings pile, where it either evaporates or infiltrates.

Downstream from the tailings dam, a heavy precipitation of orange iron hydroxide coats the channel of West Fork prior to entering Blackbird Creek (Station 39). During the fali of 1984, conductivity of this water was 120 umhos/cm^2. Water issuing from the tailings dam culvert, however, was clear and had a conductivity of 80 umhos/cm^2 which is similar to conductivities above the impoundment. This indicates that the culvert is intact and is not contaminated by water infiltrating through the tailings (Station 39).

The iron contamination in West Fork probably results from seepage from the tailings. Acid drainage has been monitored from seeps at the base of the dam (ESA 1981; Baldwin et al. 1978) and a small, stagnant seep along the downstream toe of the dam was observed during this study. In the fall of 1984, water from the seep had a conductivity of 1600 umhos/cm^2 and carried orange iron hydroxide precipitates. Other evidence of seepage through the dam was visible along the western bank of Blackbird Creek above the confluence with West Fork (Station 36). ESA (1981) suggested that a subgrade cutoff was not included in the construction of the dam, so that additional drainage occurs from groundwater flow through alluvium under the tailings.

The relative contribution of acid drainage from the tailings dam to Blackbird Creek is minor. Data reported by Baldwin et al. (1978) indicated that the

water has a moderately low pH, with high iron but low copper concentrations. Data collected during the fall of 1984 indicated that West Fork had a pH of 6.1 and contributes about 0.3 pounds of copper per day to Blackbird Creek.

A2.2.2.3 Tailings and Dredged Material

A potential source of contaminants to Blackbird Creek, primarily during high-flow conditions, are the areas of tailings and dredged waste material deposited along the Blackbird Creek channel. Before construction of the West Fork Tailings Dam, mine waste and tailings were dumped directly into Blackbird Creek (ESA 1981) and deposited downstream as outwash on channel bars and stream terraces. After construction of the tailings dam, a pipeline carried tailings from the mill complex to the impoundment in West Fork (Baldwin et al. 1978). Relatively pure tailings dredged from the creek were deposited on the broad alluvial plain at the confluence of West Fork and Blackbird Creek. Mixed tailings and channel sediment dredged from the creek were placed on the bordering 3 to 5 ft high stream terrace.

Tailings spills and dredged material along Blackbird Creek are shown on Figure A2-6. The volume of material at each locality along the creek was estimated during this study.

Approximately 11,000 cu yd of relatively pure tailings occur in spills and outwash along Blackbird Creek. This estimate does not include the tailings impoundment, but does include the tailings dredge material deposited near the confluence of West Fork and Blackbird Creek. Approximately 9,300 cu yd of mixed tailings and stream sediment have been dredged and deposited on stream terraces along the creek.

Both the tailings and dredged material are potential sources of contaminants. Several springs and tributaries to Blackbird Creek, which seep through this material, had high conductivities and copper and iron concentrations during this investigation (e.g., Figure A2-4, Stations 15 and 21). During high-flow conditions, most of this material is subject to erosion by Blackbird Creek.

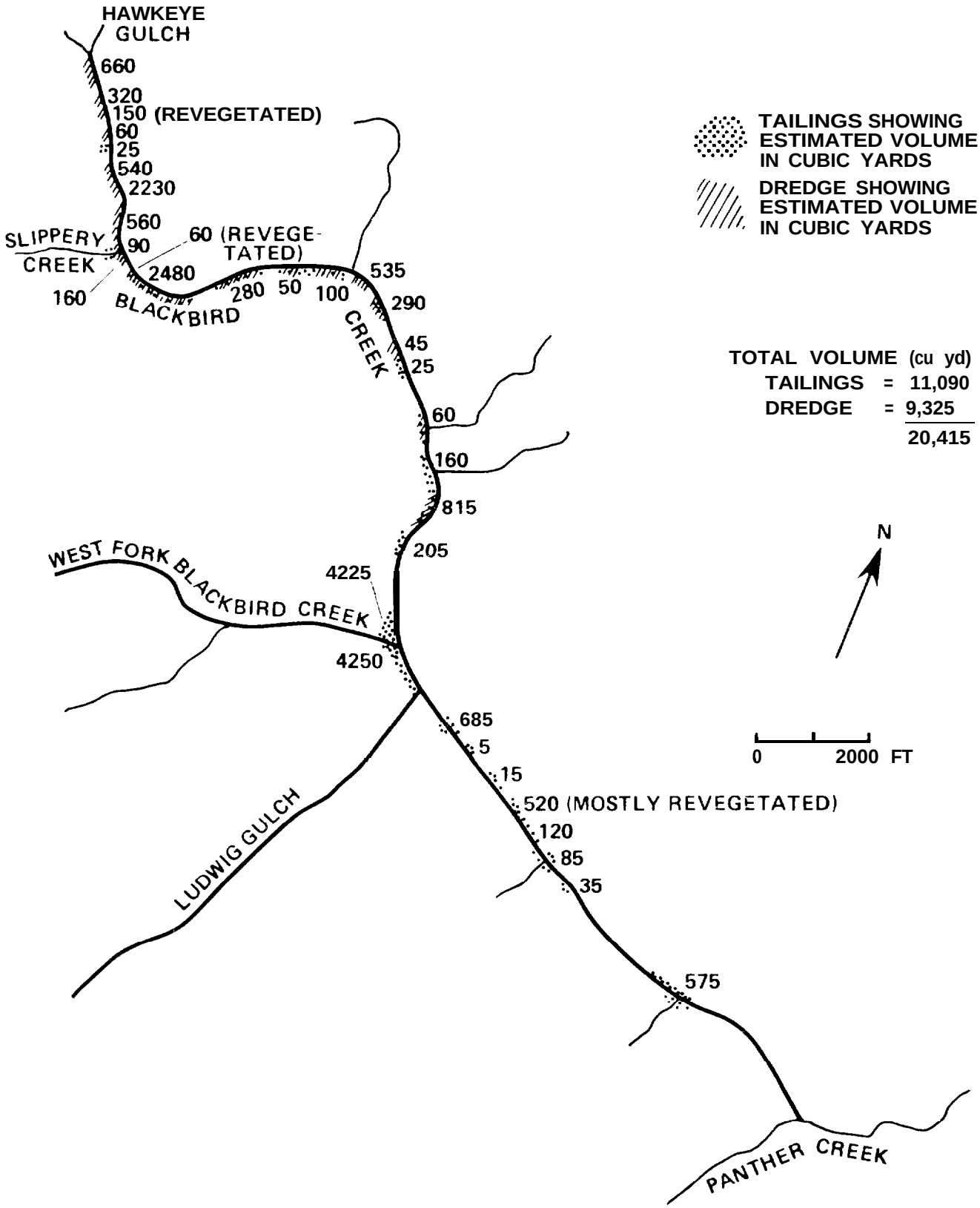


Figure A2.6 APPROXIMATE DISTRIBUTION OF TAILINGS AND DREDGED CHANNEL DEBRIS MIXED WITH TAILINGS, BLACKBIRD CREEK BELOW MINE TREATMENT FACILITY

A2.2.2.4 Contaminated Springs

Blackbird Creek is fed by at least 15 springs along its course between Meadow Creek and Ludwig Gulch. These springs are located on Figure A2-4 and described in Table A2-3. During the fall of 1984, nine of the springs were contaminated. Conductivity of water from the springs ranged from 60 to 330 umhos/cm^2; and copper values ranged from 0.22 to 1.3 mg/l. Several of these springs flow through and are probably contaminated by the tailings and dredge materials along Blackbird Creek (for example Figure A2-4, Station 30). The other contaminated springs appear pristine but probably represent contaminated groundwater flow.

Several of the contaminated springs are significant low-flow contributors of water to Blackbird creek. One spring located immediately below the confluence of Blackbird and Meadow creeks (Figure A2-4, Station 15) was flowing at about 10 gpm and contained 0.22 mg/l copper. The spring flows from the northern channel wall of Blackbird Creek out of an apparently undisturbed hill slope that contains no major mine adits and only a few road cuts. The 0.22 mg/l copper in the spring water was similar to the waters in the South Fork of Big Deer Creek (0.2 mg/l copper) and the springs at the head waters of Meadow Creek (0.19 mg/l copper). These apparently uncontaminated sources suggest that natural copper concentrations during the fall may be about 0.2 mg/l in this area. During the spring of 1984, water from this spring carried 01.48 mg/l, suggesting that contamination of groundwater may fluctuate slightly under seasonal conditions (Table A2-4).

Other major springs include a spring at the confluence of Blackbird and West Fork creeks that flowed in the fall of 1984 at 35 gpm (Figure A2-4, Station 40) and springs along Blackbird Creek near the Haynes Stellite Mine that flowed at rates of 1 gpm, 100 to 150 gpm, and 1.5 gpm (Figure A2-4, Stations 23, 27, and 32, respectively). The spring at Station 40 had a copper value of 0.7 to 0.8 mg/l. Earlier studies by Noranda (1981) indicated copper values of 1.3, 0.5, and 1.1 mg/l for the three springs, respectively. Two hypotheses were suggested by Noranda for the high copper values in these springs. The first, and more probable hypothesis is that the water represents

groundwater flow down gradient from the Blackbird mine workings. The springs are down dip and along strike of the principal local fracture pattern passing through the main ore body that supports groundwater flow from the mine area. The second suggests that the copper is derived from an anomalous band of bedrock that trends northwest along Blackbird Creek between Slipperly Creek and West Fork Creek and contains the Haynes Stellite ore body (Figure A2-4, Station 26). The copper values would thus be considered a natural, premining condition.

Section A3

WATER OUALITY CRITERION FOR FORMULATION OF ALTERNATIVES

The formulation of engineering alternatives required establishing target copper concentrations in Panther Creek that:

- Are acceptable for fish production
- Can be geared to remedial measures

Following a review of the literature and discussions with state and federal agencies, a total copper concentration of 0.05 mg/l was selected as the "not-to-exceed" criterion for the sections of Panther Creek just below the confluence with Blackbird and Big Deer creeks. This total concentration level includes copper in both the dissolved and suspended states, with the relative apportionment of each depending upon the buffering capacity and pH of waters in Panther Creek. This of course, will vary with time (seasonally) as well as with stream distance in the drainage.

With respect to copper toxicity to fish, it is the dissolved component that is the most harmful. Copper toxicities reported in the literature range widely due largely to the characteristics of the different receiving waters. As a result, considerable overlap in the concentrations of copper considered safe versus harmful to aquatic hiota have been reported. For example, McKee and Wolf (1976) noted that copper concentrations of 0.01 to 1.0 mg/l have been reported as nontoxic to most fish; conversely, concentrations of 0.015 to 3.0 mg/l have been reported as toxic. McKee and Wolf (1976) recommend "not-to-exceed" copper concentrations of 0.02 mg/l for waters supporting aquatic biota. The National Academy of Sciences and National Academy of Engineering (1972) recommend that copper concentrations suitable for aquatic biota he estimated by multiplying the 96-h LC50 (concentration killing 50 percent of test fish in 96 hr) by an application factor of 0.1. This suggests that detailed bioassays be conducted for each receiving water. Noranda (1980) had proposed to conduct bioassays in Panther Creek to assess

copper toxicity, but the studies were never implemented. Chapman (1978) indicated the approach of the National Academy results in safe concentration levels similar to his 200-h LC10 values (concentrations killing 10 percent of test fish in 200 hr):

- Steclhead parr - 0.008 mg/l
- Steelhead smolt - 0.007 mg/l
- Chinook parr - 0.017 mg/l
- Chinook smolt - 0.018 mg/l

As noted, the results of Chapman's studies (1978) indicate that chinook salmon are more tolerant of copper concentrations than steelhead, a finding which should be considered in future efforts to restore anadromous fish runs in the Panther Creek system. It should be noted that the recommended copper concentrations by all researchers refer to the dissolved copper component.

The selection of the 0.05 mg/1 total copper criterion was made considering concentrations indicative of background levels of copper. In this respect, several investigators (Platts 1967; Hennes 1980) have noted copper concentrations above Blackbird Creek that have exceeded the levels noted above (range 0.002 - 0.310 mg/l). Platts, et al. (1979) reported an average copper concentration in Panther Creek above the mine area of 0.26 mg/1, but suggest such levels may reflect sampling or analytical errors. Nonetheless, evidence indicates that ambient copper concentration in the Panther Creek drainage may at times naturally exceed recommended limits.

Obviously, the abatement/reclamation measures implemented at the mine site will in no way affect conditions upstream from Blackbird Creek, and it must be assumed such conditions were and can be tolerated by past and future anadromous fish stocks. The selection of the 0.05 mg/1 criterion was made considering this and is supported by the results of them recent water quality andfish live car studies (Table l-2) conducted by the IDH&W (Torf 1985) and IDF&G (Reingold and Latham 1985) in the spring of 1985. For these studies, the tow stations located below Blackbird Creek experienced only 5 and 0 percent mortality (chinook salmon juveniles) asassociated with dissolved

copper levels of 0.05 and 0.02 mg/l, respectively. Overall, it is anticipated that attainment of the criterion (0.05 mg/l total copper) will result in dissolved copper concentrations in the affected reach of Panther Creek in the range of 0.01 to 0.02 mg/l depending on the background levels above Blackbird Creek.

Section A4

SELECTED ABATEMENT/RECLAMATION MEASURES

During the course of this study, specific abatement measures were identified which could provide effective improvements in the water quality of Panther Creek. Abatement programs were then developed which combined some of the abatement measures. The recommended abatement programs are outlined in Section 5. This section provides a description of each of the abatement measures and unit cost information for each. The cost data can be used to evaluate cost implications of alternatives to the proposed abatement programs discussed in Section 5. Although consideration was given to schemes that do not preclude mining, no specific mining plans were considered.

A4.1 RECLAMATION

Reclamation and revegetation activities at the site should be considered as long-term measures designed to help reduce the quantity of acidic leachate and improve the quality of water emanating from the waste piles, roadways and road cuts, tailing depositions, and abandoned equipment yards. Although a well established vegetation cover may not dramatically decrease the concentrations of metals in acidic leachates (Eger and Lapakko 1981; Farmer and Richardson 1981), it will reduce runoff and, ultimately, the volume of drainage percolating through the sulfide wastes (Eger and Lapakko 1981; Eger et al. 1984). In addition, vegetation will reduce surface erosion, deter the movement of wind-borne particulates, and initiate the development of soils through organic build-up and root system action on mineral material. As a soil profile develops, the barrier to rapid oxidation of subsurface sulfide materials will increase in efficiency (Sorensen et al. 1980).

For the Blackbird Project, the type of reclamation measures proposed can be classified as "state-of-the-art," proven techniques. The reclamation plan was based on the site-specific research of Farmer et al. (1976), Richardson and Farmer (1981), Farmer and Richardson (1981), Sorensen et al. (1980), and the published results of similar reclamation research and field scale projects.

The overall objective of the plan is to establish a vegetation cover which is self-sustaining in the long term and which is compatible with the engineering alternatives under consideration for the site.

It should be noted that the need for re-entry to the area was a major consideration in the formulation of the plan. As such, areas essential for future mining/processing operations were excluded from reclamation activities. Cost estimates for the plan were based on today's prices and do not consider future materials availability.

As previously noted, mining of the Blackbird orebody and subsequent disposal of waste materials have occurred in both the Blackbird and Bucktail Creek drainages. Although reclamation goals, procedures, amendments, technologies, and timing are the same for both drainages, they are discussed separately in the plan for the purpose of cost.

A4.1.1 Areas and Acreages

For the combined drainages a total of 85 acres will require reclamation. These acreages include:

- Open pit waste - 46 acres
- Surface waste - 25 acres
- Road cut slopes - 8 acres
- Tailing (including dam face and dredged tails) - 6 acres
- Equipment yards - 2 acres
- Open pit - 12 acres

In addition, the open pit in the Bucktail Creek drainage was estimated at about 12 acres. Of the total acreage, 44 acres were classified as flat or of moderate slope, and 41 acres were classified as having steep to extreme slopes. The acreages were calculated from color aerial photographs (1"=400'), 7-l/2 minute topographic quad maps, and USFS (1982); total acreages are specified in Table A4-1.

Table A4-1

ESTIMATED ACREAGES IN THE BUCKTAIL AND BLACKBIRD DRAINAGES REQUIRING RECLAMATION[a]

Drainage		Flat	Slope	Total
Bucktail Creek				
	Surface waste	3	2	5
	Open pit waste	9	10	19
	Road cuts	0	5	5
	Open pit[b]	--	(12)	--
	Total	12	17	29
Blackbird Creek				
	Surface waste	9	11	20
	Open pit waste	18	9	27
	Tailing	5	1	6
	Road cuts	0	3	3
	Total	32	24	56

[a] Total acreage = 85 acres + 12 acre open pit
[b] Open pit considered separately

The Bucktail Creek drainage, contains about 29 acres that need reclaiming in addition to the 12-acre open pit (Table A4-1). This acreage includes 17 acres of steep slopes and 12 acres of flats and moderate slopes. An estimated five acres have been allotted for road cut slopes.

The Blackbird/Meadow Creek drainage contains approximately 56 acres that require reclamation: 24 acres of steep slopes and 32 acres of flats and moderate slopes (Table A4-1). The largest and most Important single area is the open pit waste pile at the head of Meadow Creek. This dump consists of about 27 acres of flats and slopes.

A4.1.2 Seed Mix and Amendments

The following recommendations for seed mix, amendments (lime, fertilizer, mulch, and netting) and application rates were based on the research of Farmer et al. (1976), Richardson and Farmer (1981), Sorensen et al. (1980), and Brown

et al. (1984). The recommendations were modified considering the short- and long-term results of several successful field scale reclamation programs (Brown 1976; Peters 1984; AMAX Inc. 1981)/

A4.1.2.1 Seed Mixture

The seed mixture recommended for reclaiming the Blackbird Mine area (Table A4-1) was formulated from species that:

- Have a proven track record under harsh environmental conditions
- Have survived and thrived under research situations at the Blackbird site and other similar sites
- Have been used successfully on field scale projects in acid/harsh environments
- Are available commercially. Other seed mix combinations and varieties may also be viable for the Blackbird area

Table A4-2

RECOMMENDED SEED MIXTURE FOR RECLAIMING THE BLACKBIRD MINE AREA

Species	Mix (%)
Smooth Brome (Bromus inermis)	20
Timothv (Phleum pratense)	13
Orchardgrass (Dactylis glomeratus)	12
Intermediate Wheatgrass (Agropyron intermedium (Tegmar var.) -	10
Great Basin Wildrye (Elymus cinereus)	10
Redtop (Agrostis alba)	10
Creeping Red Fescue (Festuca rubra) (Pennlawn var.)	5
White Dutch Clover (Trifolium repens)	5
Balboa Rye (Secale cereale) - nurse crop	15

Because of the extreme harshness and slopes of the Blackbird area, suggested seeding rates are necessarily high. Based on the findings of Richardson and Farmer (1981), recommended rates are:

- 100 lb/acre for broadcast/hydroseeded areas such as slopes
- 50 lb/acre for flat areas where a seeder-packer can be used

A4.1.2.2 Trees and Shrubs

Some tree planting is recommended on the open pit waste pile, but this would not be feasible if the engineering alternative is selected to seal the dump and revegetate over the seal. Nevertheless, if trees are desired at some time, lodgepole pine (*Pinus contorta*) seedlings should be used at a stocking rate of about 500/acre. Where possible, tube-pack rather than bare root seedlings should be used to further encourage survivability. Shrubs such as bitterbrush (*Purshia tridentata*) and wild rose (*Rosa* spp.) are early invaders into disturbed areas in the Blackbird area and should be planted after a grass cover is established.

A4.1.2.3 Lime

The most critical element to revegetation success at the Blackbird site is neutralization of the acidic wastes prior to seed germination. This is needed to eliminate or minimize the impact of phytotoxic reacidification. The application of commercially available agricultural limestone has long been used in reclamation activities to raise and maintain seed bed pH to acceptable levels (Peters 1984). On the Blackbird site, Richardson and Farmer (1981) found that an Initial application of 900 lb/acre of $CaCo_3$ led to reacidification 2 years after seeding. They recommended and applied an additional 4 tons/acre and apparently solved the reacidification problem (for the short term, at least). To more accurately determine lime requirements for the Blackbird site, Sorensen et al. (1980) calculated that approximately 20 to 30 tons/acre of agricultural ground limestone with a neutralizing efficiency of 87 percent pure $CaCo_3$ would be required tc prevent reacidification at the site. Brown et al. (1984) used 1 ton/acre of agricultural limestone (efficiency unknown) on pyritic wastes similar to those of the Blackbird area with excellent results after seven growing seasons.

Although acidities will vary considerably throughout the Blackbird Mine area, the initial application of agricultural ground limestone should be no less than 5 tons/acre. If efficiency is less than 87 percent pure $CaCo_3$,

additional amounts may be necessary. Should reacidification begin to occur after the reclamation program has been completed, maintenance applications of limestone would be needed to ensure long-term success. Suitable limestone, in quantity, may be available from quarry or quarries near Anaconda, Montana.

A4.1.2.4 Fertilizer

The application of inorganic fertilizer is likewise a necessity for successful revegetation at the site. Fertilizer types and application rates vary for different sites based on specific soil testing. Richardson and Farmer (1981) conducted revegetation research on the Blackbird pit wastes using an overall rate of 907 lb/acre of 10-34-0 (N-P-K) fertilizer. Brown et al. (1984) on similar mine wastes used an initial application of 370 lb/acre of (16-40-5) with followup applications at the same rate for 4 years. However, based on herbage production, Brown et al. (1984) concluded that long-term fertilization of revegetation areas on acid spoils is unwarranted. Although site-specific fertilization should be based on actual field testing, the recommended initial fertilization rate is 900 lb/acre of 16-40-5 (N-P-K).

A4.1.2.5 Mulch. Tackifier. and Netting

Mulch, tackifier (organic mulch binder), and netting (for steep slopes) will be required tn enhance and assure seed germination and initial plant establishment and growth. The recommended mulch is Weyerhaeuser Silva-Fiber hydromulch at a rate of 1 ton/acre with 80 lb of tackifier per ton for flats and moderate slopes, and 120 lb of tackifier per ton for steep slopes.

All steep slopes will require netting stapled over the mulch/tackifier. For slopes steeper than 1.5:1, jute netting is recommended. Plastic netting should suffice for those slopes between 1.5:1 and 2:l.

A4.1.2.6 Irrigation

Irrigation of newly seeded areas is a well documented technique which speeds germination and increases productivity. However, irrigation can create problems when seeding directly into limed acid producing spoils. In addition, irrigation is not compatible with the objective of establishng a long-term, self-sustaining vegetation cover. Farmer et al. (1976) found that irrigation

on the Blackbird pit waste increased the rate of reacidification more rapidly than on nonirrigated areas. Therefore, irrigation is not recommended for the Blackbird site.

A4.1.2.7 Amendment Alternatives

Field and laboratory research has been conducted on a number of reclamation amendments that have the potential of either increasing revegetation success or removing metals from mine spoils and stockpiles. Such research has included applications of hay (Richardson and Farmer 1981); xanthated sawdust (Flynn et al. 1980); Sphagnum peat (Farmer et al. 1976; Lapakko and Eger 1981); manure (Brown et al. 1984); low sulfide tailing-glacial till-zeolite (Lapakko and Eger 1981; Eger et al. 1984)); wood chips (Brown 1976; Lapakko and Eger 1981); and sewage sludge (Brown 1976; Peters 1974, 1984). Although the addition of organics to a seed-bed is highly desirable, from a practical field scale perspective, only wood chips and sewage sludge may be applied at the Blackbird site. In addition, this application would only be practical if the chips and sludge were available locally in sufficient quantities (1 to 2 tons per acre) to justify the expense of transportation.

Because of the unknowns of availability and cost, the above alternative amendments were not included in the reclamation plan.

A4.1.3 General Procedures

With the exception of the open pit, reclamation procedures will be the same for all sites in both drainages. Major differences in procedures reflect slope versus flat reclamation. The description of procedures assumes that a11 equipment, supplies/amendments, and personnel are available as soon as snow melts in the spring and that physical stabilization of erosion areas and capping or sealing has been completed prior to revegetation activities.

The procedures recommended for the Blackbird Project have been proven under both research and field scale conditions. Seed bed preparation should begin in the spring as soon as the snow clears and the ground will support equipment. The general procedures include:

- Spread limestone on flats/moderate slopes (includes roadways) and harrow/rip to a depth of 8 to 12 in. (the deeper the better).

- Spread limestone on steep slopes and roughen thoroughly with heavy chains and a Klodbuster harrow.

- Allow areas to rest after liming for approximately 60 days.

- After 60 days, harrow/klodbuster all areas a second time before the seeding process begins (seeding activities should commence in the late summer and autumn).

- On flats/moderate slopes, seed with a seeder-packer (such as a Brillion Culti-Packer). On areas that cannot be reached with a seeder-packer and on steep slopes, seed hydraulically with a hydromulcher.

- After an area has been seeded, apply fertilizer and mulch/tackifier together with a hydromulcher in a single step process (this completes the process on flat/moderate slope areas).

- On steep slopes, plastic or jute netting must be placed over the mulch and stapled in place. Jute netting will be used only for the steepest slopes and areas of highest erosion potential (once netting is in place, the process on steep slopes is complete).

- If trees are planted, it should be done during the second or third growing season as soon as the snow clears in the spring. Trees should not be planted over impermeable seals.

- Since re-entry to the area is a major consideration, the location and acreage of roadways to be reclaimed is unknown at this time. Procedurally, roadway reclamation is approached in the same manner as flats/moderate slope reclamation. For this project, roadway acreage was roughly calculated as follows: main roads - 1 acre = 1,000 ft linear; secondary roads - 1 acre = 2,000 ft linear; lesser roads (drill site roads, etc.) - 1 acre = 3,000 ft linear. Road cuts are included in the steep slope acreage.

- When equipment yards and/or areas that contain structures are specified for reclamation activity, equipment and structures should be removed and foundations and pads broken and removed or buried. Once the site has been cleared, it can be treated procedurally as either flats/moderate slope or steep slope.

A4.1.3.1 Bucktail Creek Drainage

The areas within the Bucktail Creek drainage include the open pit and approximately 17 acres of steep slopes with severe erosion gullies. Relative to the overall Blackbird Project area, the sites within the Bucktail Creek drainage will probably be the most difficult to reclaim,

After physical stabilization of erosion areas has been completed, the first priority for reclamation should be the open pit waste areas, followed by the waste sites at the 7265 and 7117 portals, and the steeply sloped road cuts.

In general, little can be done with the open pit from the perspective of revegetation. Pit walls should be physically stabilized, and hazards such as hanging boulders eliminated. Seeding should only be attempted on areas within and around the pit where the slope is moderate, erosion paths have been stabilized, and enough fines exist to create a suitable seed bed. However, if the pit is backfilled with waste and sealed with a cap (see Section A4), revegetation can be accomplished if 24 in. of suitable material is placed over the seal.

A4.1.3.2 Blackbird/Meadow Creek Drainage

The largest contiguous area for reclamation activity is the open pit waste pile located at the top of Meadow Creek (see Section A2). This dump is the top priority for stabilization and reclamation. The site has been used for reclamation research for more than 10 years and contains varying amounts of topsoil material, lime, fertilizer, vegetation, and associated organics. If the engineering alternative is selected to cap this pile with a clay or synthetic liner (see Section A4.5), the top 24 in. of material should be salvaged and replaced over the cap as a seed bed. Reclamation can then proceed in the manner previously described.

After reclamation activities are complete on the open pit waste dump, site activities should proceed down-gradient at the various adit portals, including the 7400, 7300, 7200, 7410, 7100, St. Joe, 7250, 7270, 7080, and 6850 portals, Following this, the tailings pond and remaining tails dredged from Blackbird Creek below the tailing dam can be reclaimed.

Realizing the re-entry consideration, reclamation at portal sites, including the existing office/mill complex at 6850, should be directed toward specific areas that will not be reused in the future. These areas may include road cuts, abandoned equipment yards, portal slopes and flats, and areas where structures have been removed or buried.

The existing tailing pond located on the West Fork of Blackbird Creek has been covered with talus to stabilize fines and reduce wind erosion. Two small areas of tailing below the dam (approximately l/4 acre pond directly below the main dam, and approximately l/2 acre of tails dredged from the creek) and one above the dam (tailings from Noranda's pilot operation) remain uncovered. These three areas should be stabilized and covered with talus or other material to prevent airborne particulate movement. Revegetation should follow procedures discussed previously with one exception: that seeding on the flats/moderate slopes should be accomplished with a hydromulcher rather than a seeder-packer. If it is determined that wood chips and/or sewage sludge are available for use on the Blackbird site, the tailing area(s) should be the priority area for application.

A4.1.3.3 Maintenance

Annual site inspections will be necessary for several years following project completion to determine the success and rate of revegetation and to apply corrective actions where needed. Such actions may consist of stabilizing new erosion areas, reseeding/mulching failed sites, reliming if phytotoxic reacidification occurs, and refertilization. Other than stabilization of erosion, it is recommended that two full growing seasons be completed before any major corrective action is taken.

A4.1.3.4 Major Equipment Requirements, Requirements for equipment were based on the needs of other field scale mined land reclamation projects and on the research conducted at the Blackbird site by Farmer et al. (1976) and Richardson and Farmer (1981). Equipment availability was not considered. However, if the implementation of the program is contracted to a specialized reclamation firm, availability should not present a problem. Individual pieces of equipment, particularly agricultural equipment such as

seeder-packers, harrows and tractors, can be leased or purchased from Salmon, Idaho or surrounding communities. Hydromulchers can be leased or purchased from a number of firms in the western United States, or they might be leased from larger mines in the region (e.g., Cyprus Mine near Challis, Idaho).

Major items of equipment needed-to complete the project include:

- Agricultural ground limestone spreader - 1
- Small front-end loader - 1
- Farm tractors - 2
- Harrow (Triple-K type) for flats - 1
- Harrow (Klodbuster type) w/chain for slopes - 1
- Truck mounted, 2500 gallon, Hydromulcher (Bowie type) - 1
- Water pump and hoses

A4.1.4 Cost Estimates

Costing a reclamation program for the Blackbird Mine was difficult due to uncertainties such as material, equipment and manpower availability; transportation costs; site access; changing site environmental conditions; and ultimate arrangements for implementation. If field implementation of the reclamation plan is contracted to a professional reclamation firm, cost estimates may change significantly based on negotiations and various contractual arrangements. Likewise, material and labor costs in the land reclamation industry can change rapidly and significantly based on timing, local and regional supply and demand functions, and volumes. For example, jute netting quoted at $80/roll today may be totally out of stock next week because of disruption of cverseas supply. For this reason, the reclamation program for the Blackbird Mine was costed on a per-acre basis, based on the acreages outlined in Table A4-1.

The overall estimated cost of the reclamation program is $327,840, which includes $124,320 for the Bucktail drainage, and $203,520 for the Blackbird drainage (Table A4-3). Costs of additional acreages for roadways, etc. are not included, but can be calculated on a per-acre basis and added

Table A4-3

ESTIMATED COSTS BY DRAINAGE AND TOTAL COSTS FOR RECLAMATION AT THE BLACKBIRD MINE

	No. Acres (cost)						
	Bucktail Drainage			Blackbird Drainage			
Unit and Cost (per acre>	Flat	Slope	Total cost	Flat	Slope	Total cost	Total Cost
Materials (seed mix, fertilizer, netting, etc.)							
Flats, $1,300/acre	12 ($15,600)	17 ($62,900)	$78,500	32 ($41,600)	24 ($88,800)	$130,400	$208,900
Slope, $3,700/acre							
Equipment/Manpower (hydromulcher, harrowing etc.)							
Flats, $560/acre	12 (86,720)	17 ($39,100)	$45,820	32 ($17,920))	24 ($55,200)	$73,120	$118,940
Slope, $2,300/acre							
Total	$22,320	$102,000	$124,320	$59,520	$144,000	$203,520	$327,840

accordingly. As noted, changes in per-acre costs vary between flats and slopes but do not change between the Bucktail Creek drainage and the Blackbird Creek drainage. Cost estimates were based on 1985 prices as generally quoted for moderate to high reclamation materials volume and do not include transportation costs or contingency.

The specific assumptions, rationale, and basis for the costs in Table A4-3 include:

- Materials and amendments:

  Seed mix - $3/lb (50 lb/acre - flats; 100 lb/acre - slopes

  Agricultural ground limestone - $100 lb/ton (5 tons/acre)

  - Fertilizer - $.30/lb (900 lb/acre)

  Hydromulch - $300/ton (1 ton/acre - flats; 2 tons/acre - slopes

  Tackifier - $l.05/lb (80 lb/acre - flats; 240 lb/acre - slopes

  Jute net - $80/roll, 56 rolls/acre; 5 acres in each drainage

  Plastic net - $480/acre (12 acres - Bucktail drainage; 19 acres - Blackbird drainage)

  Net staples - $120/acre (11 gauge; all slopes)

  Trees (not included in totals) - $0.30/tree

  Total cost/acre

  Flats = $1,300/acre

  Slopes = $3,700/acre

  Limestone application (including loader costs) - $160/acre (Equipment costs: Tractor/spreader = $250/day; Loader = $300/day; 17 days equipment; 34 man days)

  Flats harrowing - $l00/acre (Equipment costs = $200/day; 14 days equipment; 14 man days)

Slope harrowing - $340/acre
(Equipment costs = $250/day; 28 days equipment; 54 man days)

Hydromulcher (includes all applications) - $300/acre
(Equipment costs = $300/day; 43 days equipment; 86 man days)

Slope netting (jute and plastic) - $1500/acre
(Minimum 6-man crew, l/ acre/day = 12 man days/acre>

Manpower estimates based on $125/manday (no overtime)

- Equipment costs used general hourly rates

  No time allocated for mobilization, downtime, or transport

  Costs for use of hydromulcher assume good quality water source nearby (e.g., Blackbird Creek water storage pond)

  Limestone application costs assume stockpiles located near reclamation sites

- Equipment/manpower

  Total cost/acre; flats = $560/acre; slopes = $2,300/acre

- Total project cost estimate

  Flats = $1,860/acre

  Slopes = $6,000/acre

A4.1.5 Constraints

Constraints to successful reclamation of the Blackbird Mine area are numerous, and ultimately may hinder complete site revegetation. The physical and chemical characteristics of the waste dumps, coupled with site topography and lack of topsoil, probably make the Blackbird site one of the harshest environments in the United States in which to undertake reclamation efforts.

A4.1.5.1 Topography

As previously discussed, site topography is extremely steep, narrow, rocky, and confined (USFS 1982). Slopes commonly range between 30 and 90 percent (ERT 1981), making the use of heavy equipment difficult. The surface and pit

waste dumps and road cuts have slopes ranging from near vertical to less than 2:l. The majority of road cuts and dump slopes are between 1:l and 1.5:1 with slope distances up to 200 feet in places. It will therefore not be possible to contour the dumps to more moderate slopes due to the steepness and confines of the deposition areas. Because of these extreme slopes, sheet and gully erosion of the dumps and road cuts is pervasive and severe. Successful revegetation of slopes such as these will therefore be difficult.

A4.1.5.2 Topsoil

Along with problems related to topography and erosion, the lack of topsoil for site reclamation may be a major constraint to reclamation success. Topsoil was not salvaged during past operations of the Blackbird Mine, and therefore, unless soil is borrowed from other areas (creating additional acreages requiring reclamation), there is no topsoil available for the project. Although forest soils surrounding the site have been inventoried and described as marginal at best for topdressing material (ERT 1981), any amount of topsoil will enhance the chances of success. Therefore, as part of the pre-implementation studies, a survey should be conducted to delineate suitable borrow sources of top soil. In addition, as part of the construction activities at the site (earth-moving, ditching), all topsoil material should be meticulously salvaged and stockpiled near the open pit waste pile for use on that particular area.

Even if topsoil material is not available, successful revegetation is not precluded if proper technologies are applied. Although even a nominal amount of topsoil will reduce the time needed for establishment of a good vegetation cover, Brown (1982) stated that topsoil is not always necessary for plant growth. However, he indicated that additional maintenance fertilization will probably be needed when topsoils are not used.

On field scale projects, both Brown (1976) and Peters (1974, 1984) have reported excellent results in establishing extensive plant covers without the use of topsoils. In the case of the former, however, organics in the form of wood chips and sewage sludge were applied over non-acidic waste rock as part of seed bed preparation. Peters (1984) established extensive high quality

vegetation cover on highly acidic polymetallic tailings by liming and seeding directly into the tails. Both projects have required periodic maintenance fertilization.

The small plot research conducted by Farmer et al. (1976) on the Blackbird site resulted in establishment of a vegetation cover by direct seeding into the pit waste. Although herbage production was only 25 percent of those plots with topsoil dressing, applications of lime, fertilizer, and mulch resulted in a successful cover. Similar results were obtained by Brown et al. (1984) on the highly acidic wastes of the McLaren Mine site north of Cooke City, Montana.

A4.1.5.3 Acidic/Phytotoxic Zones

Wastes at the Blackbird site are highly acidic, and will not grow or support plant life without neutralization. The application of adequate amounts of lime as part of the seed bed preparation process will minimize the general acidity problem. However, as documented by Farmer et al. (1976), small areas of leached salts/acidic "hotspots" exist on and in the,waste piles. These hotspots are phytotoxic and must be identified and either excavated and reburied (such as in the pit), covered in-situ (e.g., clay cap), or neutralized using other measures (Caruccio and Geidel 1984).

A4.2 DIVERSION OF SURFACE FLOWS

The diversion of surface flows away from waste rock piles is a primary remedial measure required at the Blackbird Mine. As discussed in Sections 4 and A2, the waste piles contribute the majority of metal-laden acid drainage to Panther Creek. Recharge of these waste piles takes place in the form of direct infiltration of snow melt, as well as infiltration of surface flows that originate higher in the drainage basin. Surface flows, associated with spring snowmelt and rainstorm activity, can be observed passing over waste piles and permeating the surface of the waste piles. The mine-related deposits, as well as the native talus and alluvial materials, are quite pervious, allowing surface flows to enter the ground and then reappear at the base of a waste pile or even further downstream.

To reduce the recharge of waste piles, diversion channels must be constructed to intercept and direct these surface flows. Observations of the performance of roadside ditches at the Blackbird Mine during the spring of 1985 indicate that water intercepted by the ditches often disappears into the channel bed and travels subsurface in a manner similar to the overland flows observed on the waste piles. Consequently, in order to be effective, these diversion ditches must be lined with an impermeable material to prevent the loss of any intercepted flows. Although this significantly increases the cost of the diversion ditches, it is necessary to prevent surface flows from recharging the waste piles.

The steep terrain and the extensive amount of disturbed land associated with the mining activities will make flow diversion very difficult to maintain, regardless of the design of the diversion facilities. Debris flows associated with thunderstorm activity and peak runoff from snowmelt can block channels and plug culverts. In general, culverts should be used at as few locations as possible. Where culverts are used at road crossings, the crossing should be designed so that when the road is overtopped, the flow' is directed back into the diversion ditch.

A design criterion for the diversion facilities was selected which would provide a minimum capacity of the 25-year flood.

The ditch dimensions required to carry a 25-year flood are relatively small due to the small drainage areas and the steep slopes involved. The erosion potential of high velocity water and the problems associated with debris dictate the design of these channels.

The following materials were considered for the selection of an appropriate lining material for the diversion channels:

- Concrete
- Asphalt
- Half-round corrugated metal sections
- Clay lining with riprap protection

The concrete and asphalt channel alterations are susceptible to cracking and damage due to ground movement and freeze-thaw processes. In addition, the steepness of the terrain requires that energy dissipation structures be incorporated at numerous locations in the diversion system.

Half-round sections of corrugated metal pipe provide a cost-effective means to transport water, but they are susceptible to undermining from lateral inflow. In addition, corrosion and erosion problems complicate the use of this corrugated metal pipe. Therefore, corrugated metal sections were selected only for steep chutes where there was minimal lateral inflow and where steep slopes make the installation of alternate channel materials difficult.

Clay-lined channels with riprap protection were chosen as the primary method of flow diversion. Clay borrow material is available about 13 mi from the mine (see Section 3.1.2), and the talus slopes in the immediate vicinity of the mine are a source of riprap material. This channel design will prevent surface water from entering the groundwater system and should also require the least maintenance of all alternatives. To prevent erosion of the fine grain clay material and loss of riprap into the clay, a filter fabric must be used as a separation barrier.

Conceptual layouts of the flow diversion system for specific abatement programs are discussed in Section 5. Where possible, the ditches are located where the natural hillside meets the waste rock pile (see Figure A4-1). Although cutting the channels into the hillside would improve their interception capabilities, it would be difficult to stabilize the cut slopes and sloughing of the hillside into the channels would be a persistent problem.

The layout of the diversion system is conceptual, with the intent of providing sufficient information to obtain cost estimates. The final layout must be determined from detailed field investigations in which numerous factors will be considered. These include:

- Existing flow patterns when surface runoff occurs
- The road system necessary to maintain access to mine facilities

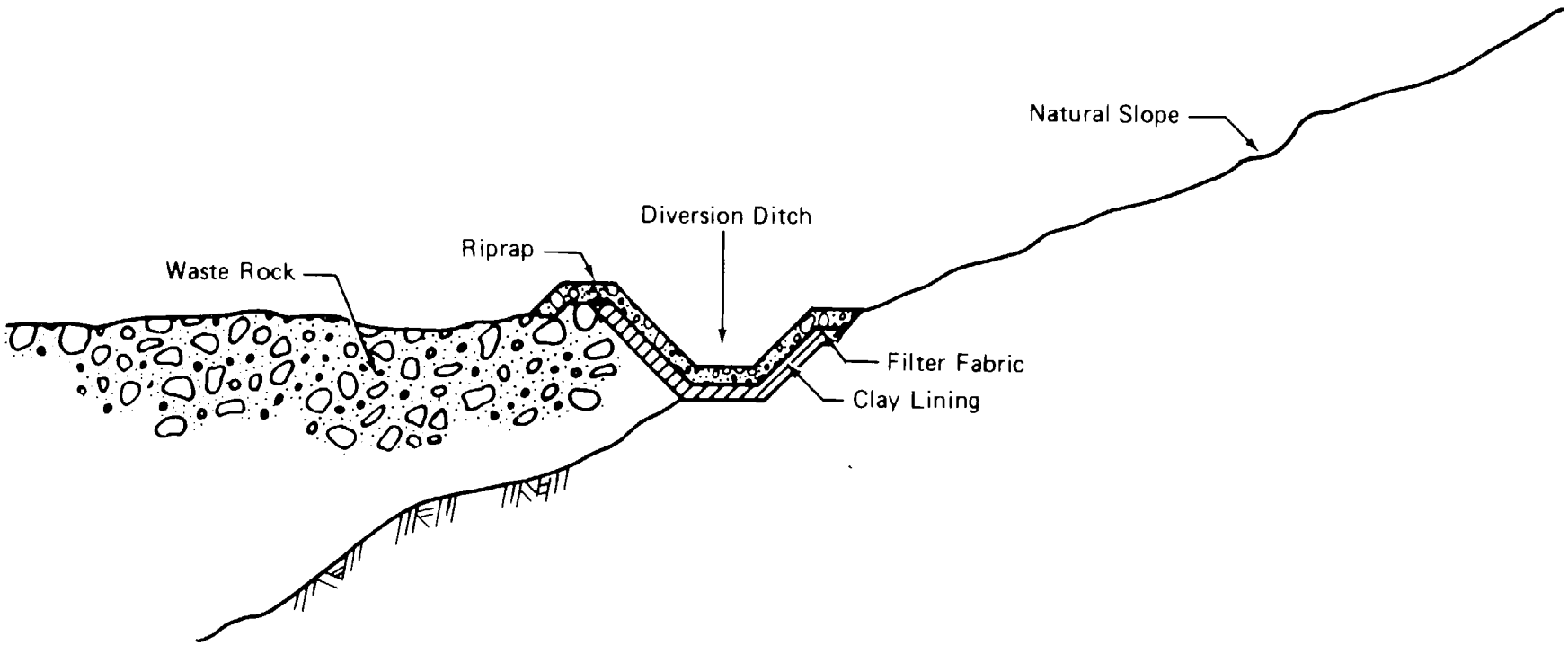


Figure A4-1 DIVERSION DITCH AT UPHILL SIDE OF WASTE-ROCK PILES

- The location of adits, buildings, or other mine facilities
- Slope requirements of ditches

Six channel. types were selected for the design of the diversion channel system. Five of the six are clay-lined channels and the sixth is a half-round corrugated metal section. The channel cross-sections are shown in Figures A4-2 to A4-3, and their application is described below:

- Type A. V-ditch, 18 in. deep, lined with 6 in. of riprap with a 4 in. d_{50} underlain with filter fabric and an 8 in. clay layer. Application - high in drainage basin and channel bottom slope less than 5 percent. Estimated costs per ft installed: $14.

- Type B. 2 ft bottom width ditch, side slopes 1.5:1, minimum depth of 2 ft, lined with 18 in. of riprap with a d_{50} of 12 in., underlain with filter fabric and 12 in. of clay. Application - moderate drainage area, and channel bottom slopes to 15 percent. Estimated cost per ft installed: $62.

- Type C. 2 ft bottom width ditch, side slopes 1.5:1, minimum depth of 2 ft, lined with 9 in. of riprap with a d_{50} of 6 in., underlain with filter fabric and a 12 in. clay layer. Application - moderate drainage area, channel bottom slopes to 5 percent. Estimated cost per foot installed: $52.

- Type D. 3 ft bottom width ditch, side slope 1.5:1, minimum depth of 2 ft, lined with 30 in. of riprap with a d_{50} of 18 in., underlain with filter fabric and 12 in. of clay. Channel bottom slopes to 35 percent. Estimated cost per ft installed: $115.

- Type E. 3 ft bottom width ditch, side slope of 1.5:1, minimum depth of 2 ft, lined with 18 in. of riprap with a d_{50} of 12 in., underlain with a filter fabric and 12 in. of clay. Channel bottom slopes to 15 percent. Estimated cost per ft installed: $79.

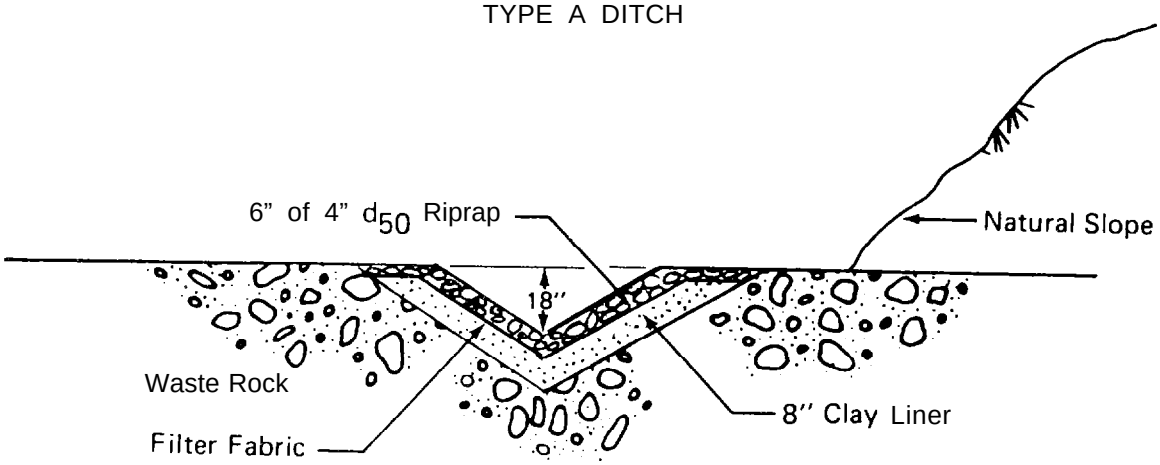
- Type F. Half-round corrugated metal chute, 24- to 36 in. diameter, with concrete headwall. Full round section for last 4 diameters. Tee at bottom of chute fur energy dissipation. Estimated cost per ft installed: $30.

- Total estimated cost of diversion channels:
  (See Section 5 for layout of ditches for each alternative)

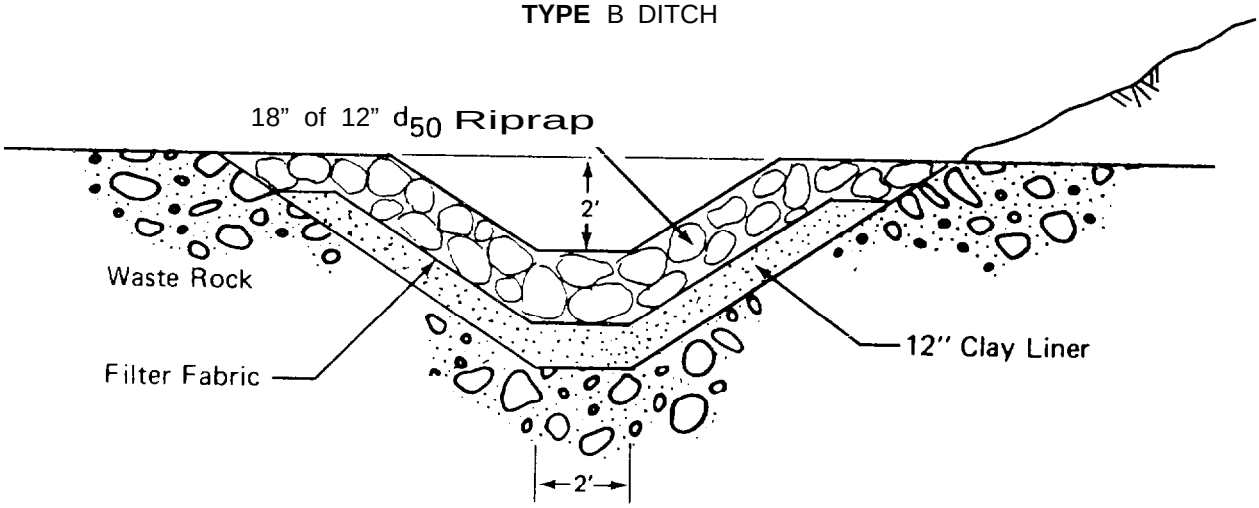
  Blackbird drainage excluding Meadow Creek improvement. Estimated cost: $796,000.

  — Bucktail drainage. Estimated cost: $714,000.

TYPE A DITCH



TYPE B DITCH



TYPE C DITCH

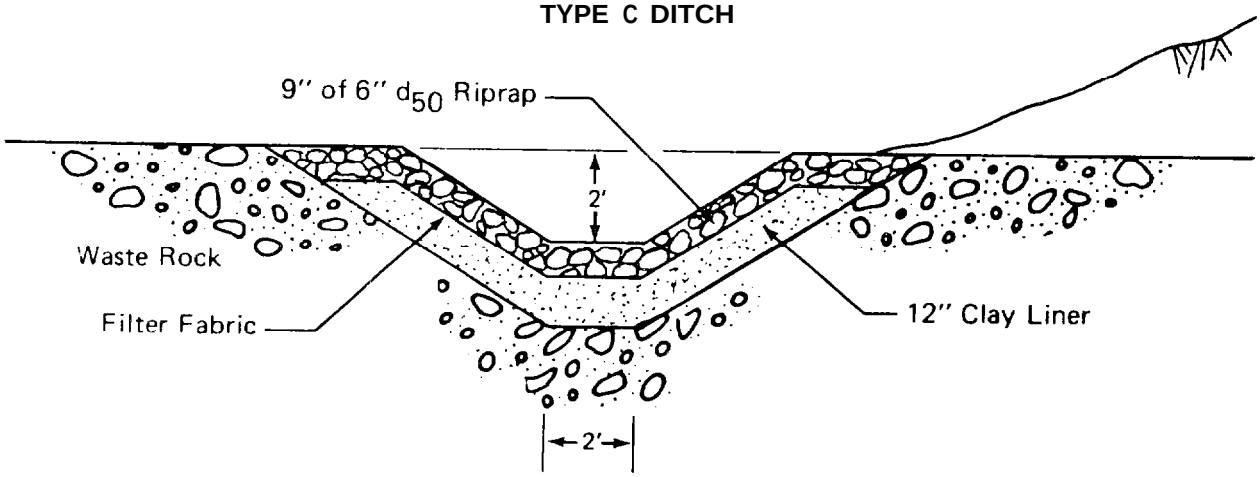
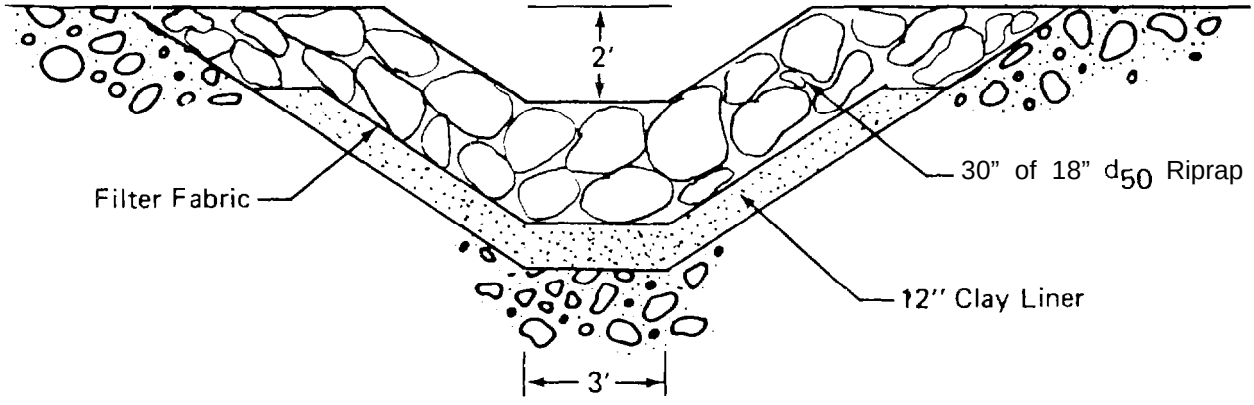
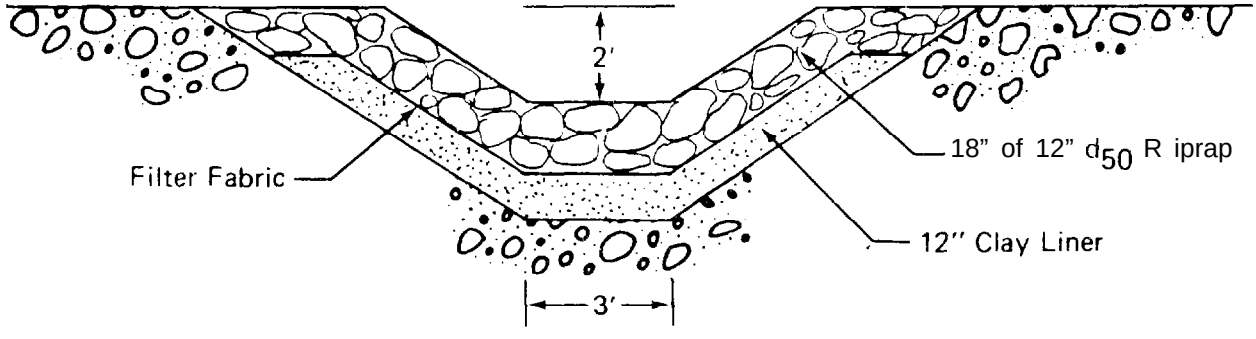


Figure A4-2 DIVERSION DITCH TYPES A, B, AND C
(See Text for Descriptions)

TYPE D DITCH



TYPE E DITCH



TYPE F DITCH

Corrugated Metal Chute

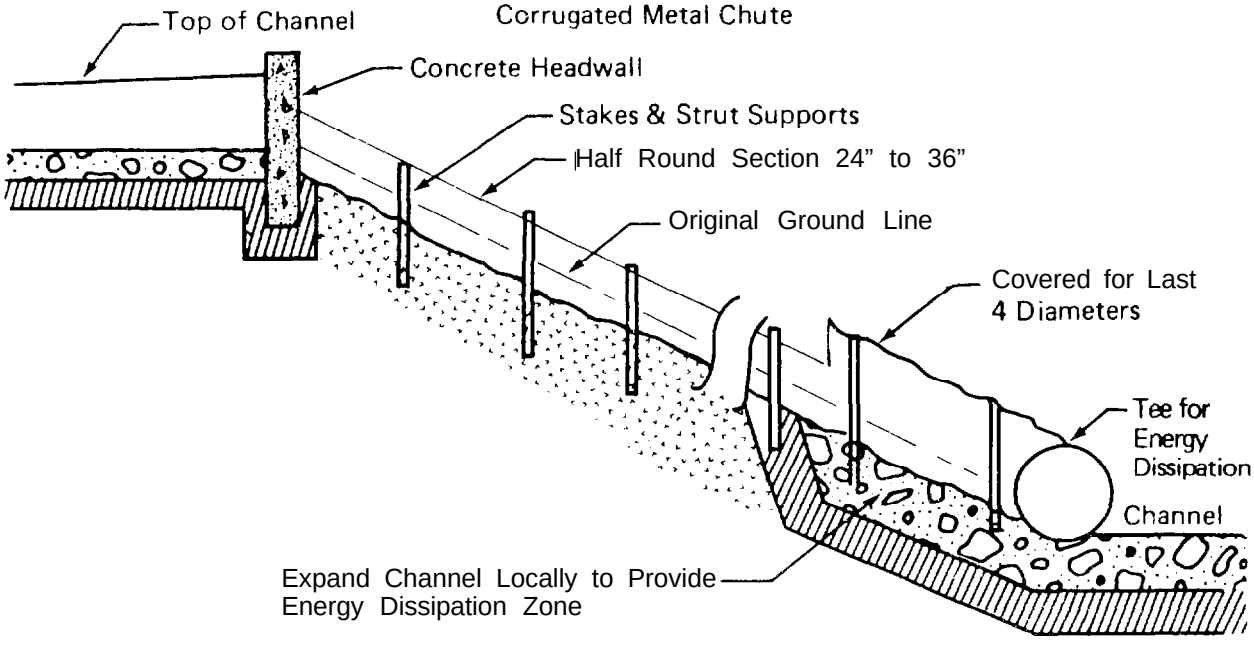


Figure A4-3 DIVERSION DITCH TYPES D, E, AND F
(See Text for Descriptions)

A4.3 MEADOW CREEK CHANNEL IMPROVEMENT

Meadow Creek has been identified as a source of groundwater recharge to the mine workings and valley fill material (Baldwin et al. 1978). The elimination of this source of recharge is an important part of the overall scheme to reduce the metal loading to Panther Creek. The proposed scheme uses the clay-lined channel design outlined in the previous section. As proposed, an 18 in. deep V-ditch (Type A) picks up Meadow Creek flows below the open pit waste pile. At its confluence with diversion flows from the 7,400 and the 7,300 waste piles, Meadow Creek is expanded to a 2 ft bottom width channel. This channel continues through the 7,100 waste pile, replacing the existing culvert. A 36 in. half-round corrugated metal chute carries Meadow Creek flows down the face of the 7,100 ft waste pile where more diversion flows join Meadow Creek. Culverted road crossings will be required both on top of the 7,100 waste pile and at the base of the pile. These road crossings must be designed so that flow overtops the road and re-enters the ditch if the culverts become clogged. Below the 7,100 waste pile, the Meadow Creek channel becomes a 3 ft bottom width ditch (Type E) which continues to the mine yard area.

Through the mine yard area, the canyon is quite narrow. Given the requirements for access roads and the mine buildings, the continuation of Meadow Creek as an open channel is prohibited. Noranda recently installed a new 18 in. culvert through the mine yard to deliver Meadow Creek flows to Blackbird Creek. The capacity of this Meadow Creek culvert is unknown since a detailed layout was not available. Noranda personnel indicate that the major problem with this culvert in the past has been caused by debris plugging the intake. To remedy this situation, Noranda has installed two sedimentation basins in series. The first basin has two outlets in the event that one becomes plugged. These outlets discharge directly into the lower pond. The outlet of the lower pond connects directly to the meadow Creek culvert. This design should be effective in keeping the culvert intake clear. To prevent recharge to the mine yard area, these debris basins should be lined with clay.

The estimated cost of a Meadow Creek channel improvement is $337,000.

A4.4 BLACKBIRD CREEK DIVERSION CULVERT

Blackbird Creek flows in a culvert from the fresh water reservoir to the mine gate. Noranda personnel reported that this culvert was installed in the 1950s. For the majority of its length, it is a 42 in. concrete tile pipe. In the vicinity of the mill, a 120 ft long section of the culvert is a 5 ft by 5 ft wooden crib conduit. It was installed to collect groundwater which would show up as numerous springs in the mine yard. This culvert and wood collection gallery are believed to be the source of poor quality water (see Section 4). Future field studies should confirm this finding.

Abatement schemes that incorporate the collection and treatment of poor quality groundwater in the Blackbird Creek drainage will require this culvert to be replaced. This will prevent the exchange of water to and from the culvert and thus facilitate the isolation and collection of this poor quality water.

The estimated cost of replacing Blackbird Creek culvert with 48 in. reinforced concrete pipe is $284,000.

A4.5 CAPPING OF WASTE ROCK PILES

The direct infiltration of rainfall and snowmelt into the top surfaces of the waste piles is a major source of recharge to these piles. The placement of an impermeable material on the flat surfaces of the waste piles would significantly reduce this source of recharge. Since capping of the steep slopes of the waste piles is not feasible, complete elimination of direct infiltration as a source is not possible. It will also be difficult to provide an effective cap in the mine yard area due to the numerous buildings and access roads.

The installation of the impermeable liner is accomplished by excavating 24 in. of waste rock, placing the impenetrable liner over the flat surface of the pile, and backfilling the waste rock (Figure A4-4). The procedures discussed in Section A4-1 may then be used to neutralize and revegetate the top of the waste rock piles.

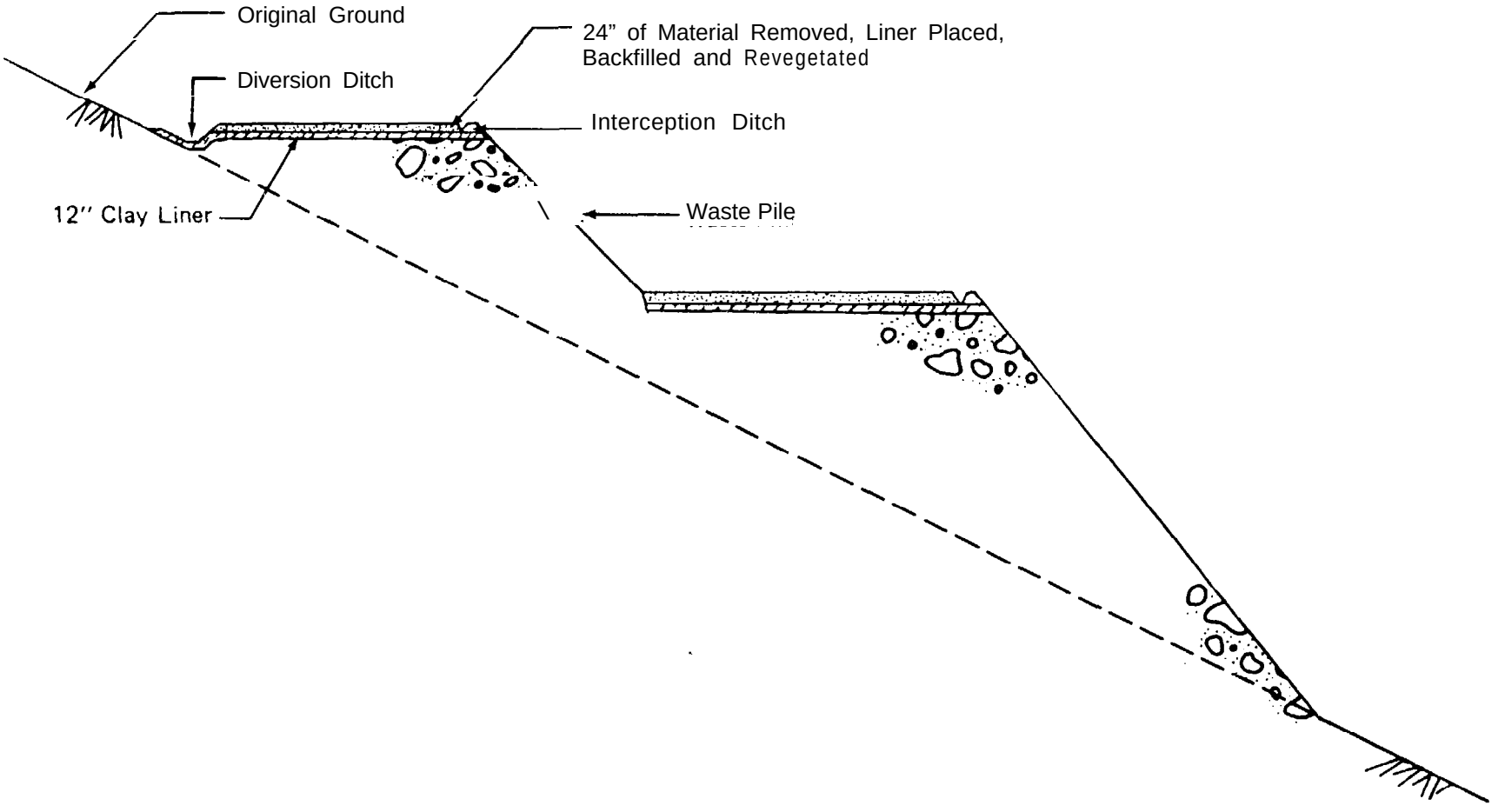


Figure A4-4 WASTE PILE CAP AND DIVERSION DITCHES
(See Text for Description)

Two impermeable materials were considered for capping the waste piles: a 12 in. clay layer and a synthetic impermeable geomembrane. Both types of materials would provide satisfactory performance if properly installed. The moisture conditions during installation of the clay liner must be tightly controlled. Cracks in the clay can quickly fill with windblown sand which can drastically reduce the effectiveness of the clay liner. The synthetic geomembranes would be susceptible to tearing during the waste rock backfilling process. Heavy machinery could also damage this membrane. For this reason, clay lining is the preferred material.

This abatement measure can be used on existing portions of the waste rock piles with slopes less than 3:l. Approximately 42 acres of land are suitable for this application, which includes 30 acres in the Blackbird drainage and 12 acres in the Bucktail drainage.

As discussed in Section A2, several springs were buried by waste rock in the headwaters of Bucktail Creek. In addition, the copper loading in Bucktail Creek is high. Therefore, capping the waste rock pile at the headwaters of Bucktail Creek may not sufficiently reduce copper loading to achieve acceptable levels.

It is difficult to assess the effectiveness of capping the waste rock piles. Although the majority of the water that directly infiltrates the top surface of the waste rock piles would be eliminated, subsurface flows and water infiltrating the steep slopes would continue to recharge the waste piles.

The cost for installing the clay cap was based on a 15 mi haul from the clay source along Panther Creek:

- Installed cost per acre $44,750
- Blackbird drainage, 30 acres – $1,342,000
- Bucktail drainage, 12 acres - $537,000
- Total cost $1,879,000

A4.6 COLLECTION OF MINE ADIT FLOWS FOR TREATMENT

Flows from all adits in the Blackbird drainage that connect to the main mine workings have been directed to the 6850 level by Noranda. However, the St. Joe adit on the Blackbird side and the 7117 and the 7265 adits on the Bucktail side continue to release acid mine drainage to the surface waters. Raises presently connect both the 7117 and the 7265 adits to the 6850 level and diversion of these flows should be relatively simple, although an investigation into the present condition of these mine workings has not been made. Depending on the elevations of the interconnections between mine levels, low-pressure mine bulkheads may be required to direct these flows back to the 6850 level. Inspection of the inner mine workings would be necessary to evaluate the most effective means for diversion. Collection of the St. Joe mine adit flows must be done in connection with the collection of flows from waste rock piles.

The estimated cost of two bulkheads at $10,000 each is $20,000.

A4.7 COLLECTION OF CONTAMINATED WATER FROM WASTE PILES IN THE BLACKBIRD DRAINAGE

The diversion scheme discussed in Section A4.2 will significantly reduce the recharge of the waste piles by surface flows. However, poor quality water will continue to emerge from the base of these waste piles. The diversion scheme will also facilitate the isolation and collection of the poor quality water. In the Blackbird drainage, a catch basin below each waste pile can be installed to collect surface runoff. Subsurface flows are intercepted by the catch basin's perforated riser. The catch basin design is shown in Figure A4-5. Local grading in the vicinity of the catch basin directs the runoff from the waste pile toward the basin entrance. A 15 in. PVC pipe interconnects all of the catch basins and directs the flow to the treatment plant.

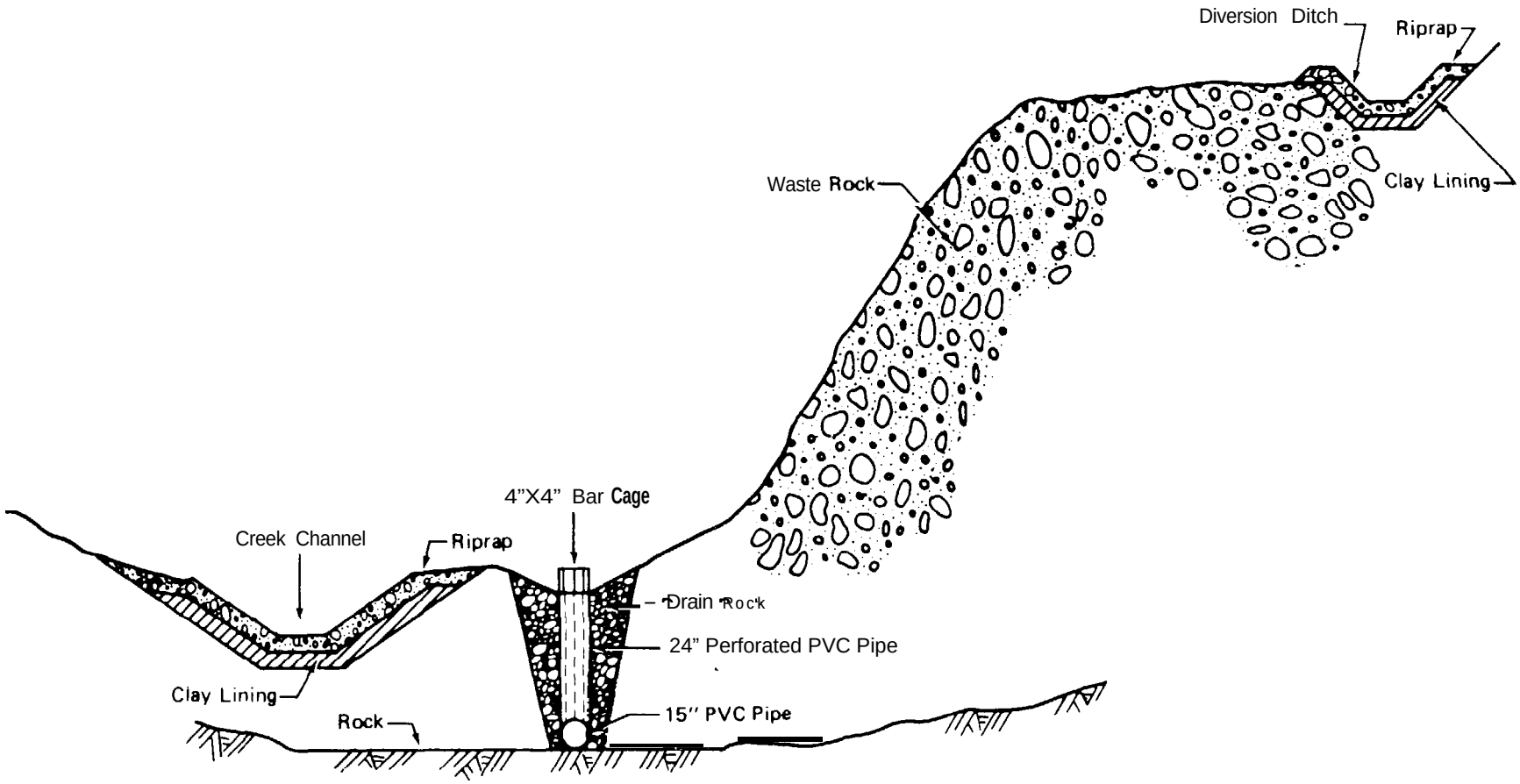


Figure A4-5 COLLECTION SYSTEM FOR INTERCEPTING CONTAMINATED WATER FROM WASTEPILES, BLACKBIRD DRAINAGE

Design flow rates for the collection system are discussed in Section A4.13. Sizes of the facilities were dictated by maintenance considerations instead of capacity requirements.

The estimated cost of the collection system is $229,000.

A4.8 DIVERSION OF BUCKTAIL CREEK TO THE 6850 LEVEL VIA BORE HOLE

The majority of the poor quality water in the Bucktail drainage enters Bucktail Creek above elevation 6950 ft according to detailed studies by Baldwin et al. (1978). Since the majority of this flow is associated with seepage from waste piles or adit flows, the diversion of the entire stream has been suggested as a possible means to improve Panther Creek water quality. The concept entails boring a hole from the Bucktail Creek stream at approximately elevation 6950 to the 6850 level (Figure A4-6). Bucktail Creek flows can then be treated using treatment facilities in the Blackbird drainage.

An intake structure, similar to that shown in Figure A4-7, would be constructed in the Bucktail Creek channel bed. The inclination of the proposed borehole and the geology in the Bucktail drainage require that specialized directional drilling equipment be used. It may prove to be cost-effective to drive a tunnel from the 6850 level to the Bucktail drainage, particularly if the mine is in operation. An adit in the Bucktail drainage would also provide access to the diversion structure. Cutoff walls that tie the structure into bedrock are used to minimize flow past the structure. A 12 in. pipe leads from the intake structure to the borehole that carries Bucktail Creek to the 6850 level. Within the 6850 level, the flow is contained in a 12 in. pipe that leads to the treatment facilities. Release of the flow within the mine would leach additional metals from the interior of the mine and increase treatment costs. Consequently, direct transfer of water to the treatment building is preferable to allowing it to travel along the mine floor.

The steep terrain in the Bucktail drainage and the large amount of disturbed land result in high debris and sediment loads in the creek during high flow events. For this reason, the intake structure is relatively large for the

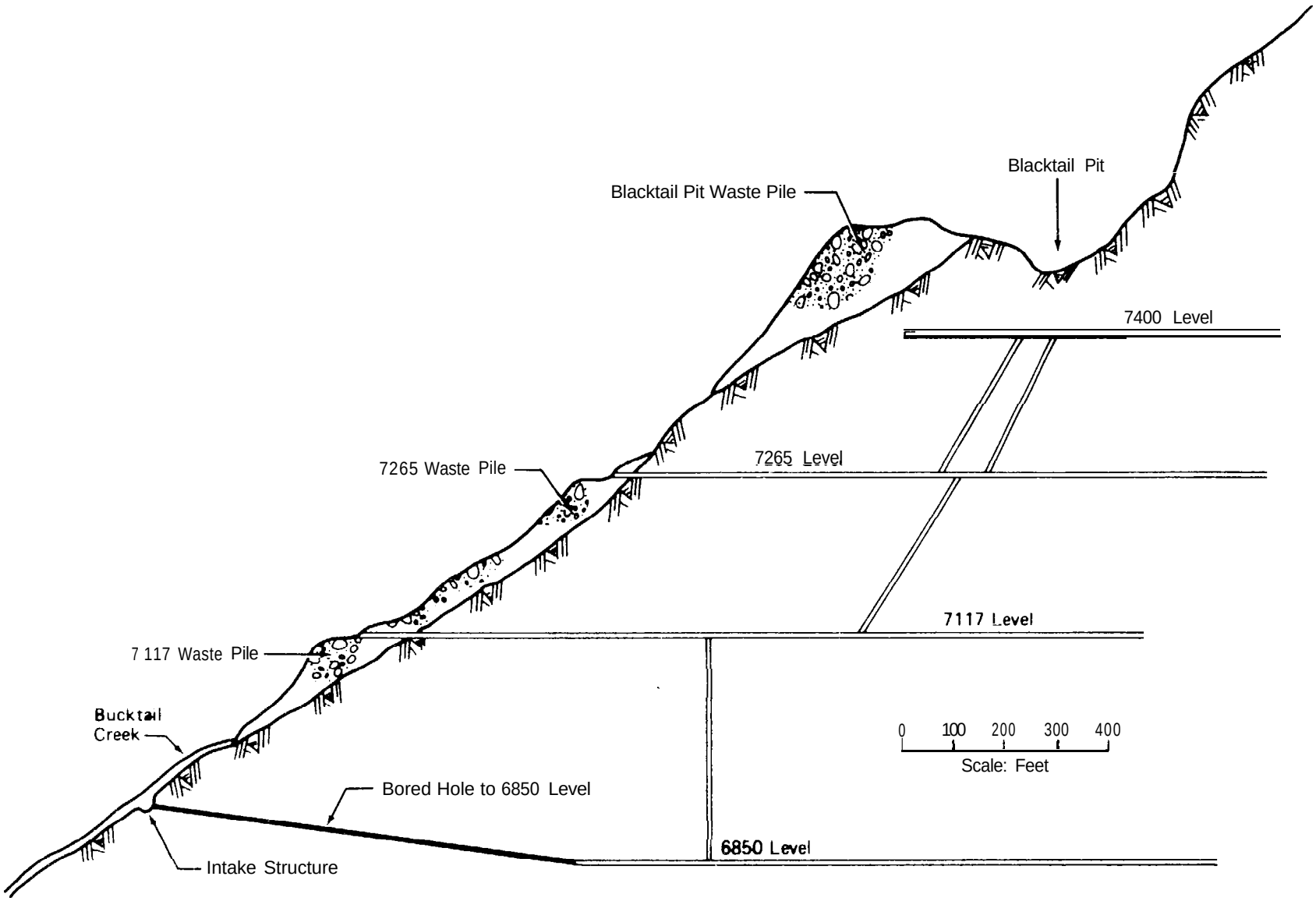


Figure A4-6 BORE HOLE DIVERSION OF CONTAMINATED BUCKTAIL WATER TO 6850 LEVEL FOR SUBSEQUENT TREATMENT

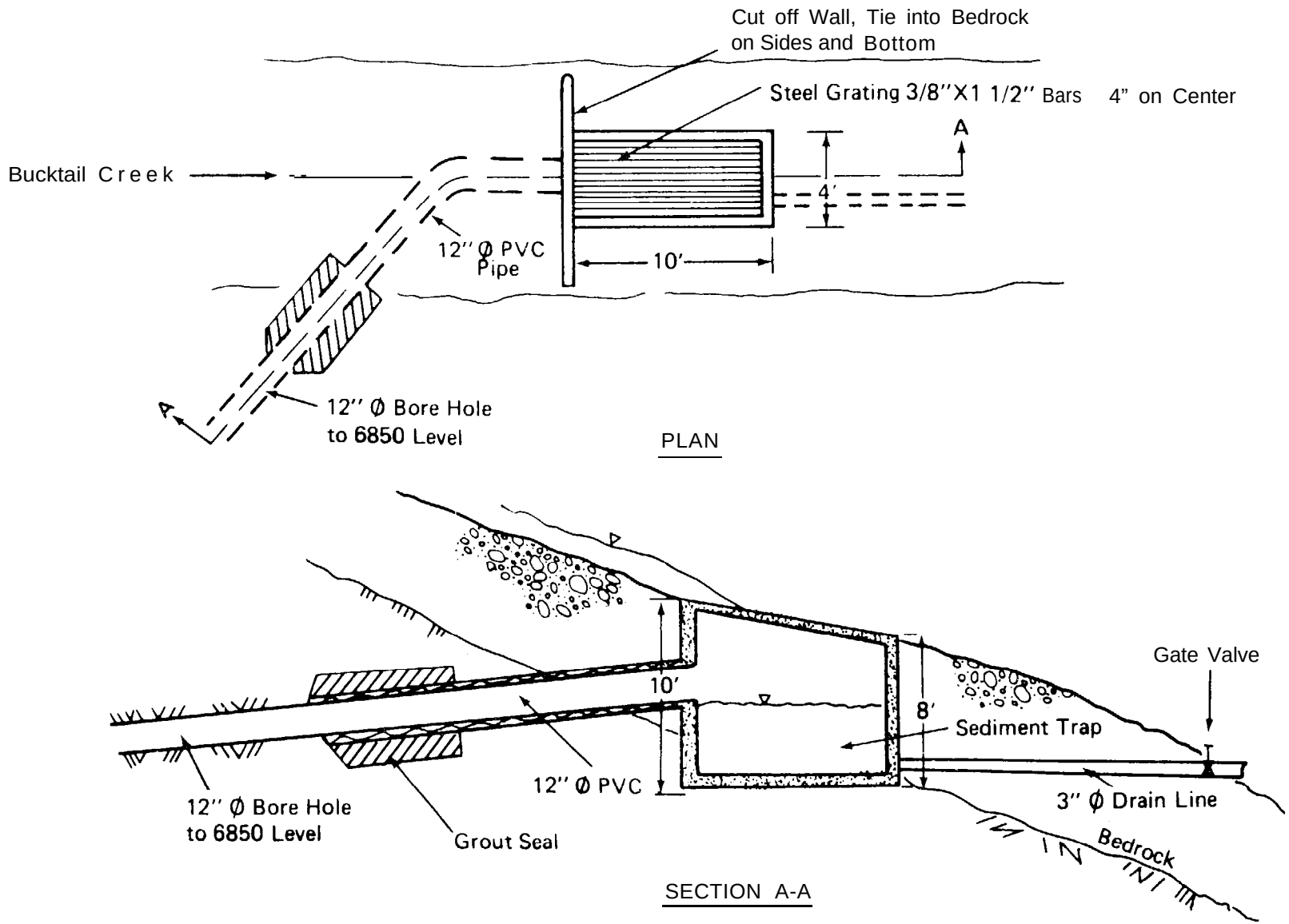


Figure A4-7 DETAIL OF THE INTAKE STRUCTURE FOR THE BUCKTAIL CREEK DIVERSION SYSTEM

small flow in the creek. In addition, the bar screen covering the top of the structure should be aligned with the flow direction to facilitate self-cleaning,

Bucktail Creek is presently inaccessible for at least 6 months of the year, and it will be difficult to maintain the intake structure if it fills with sediment or the intake is covered with debris. Consequently, a sedimentation pond should be constructed upstream of the intake structure. This can most easily be accomplished by excavating material from the 7117 waste pile and forming a small sedimentation basin (500 cu yd). The basin should be lined with clay and protected with riprap. An outlet similar to that used in sedimentation basins in Blackbird Creek should be provided. A riprapped overflow channel should be included in the event of overtopping of the basin. Annual maintenance of the sedimentation basin will be required and experience may dictate that additional sediment storage is needed. If this occurs, a similar detention basin may be constructed in the 7265 waste pile.

The estimated cost of a Bucktail diversion to the 6850,via borehole is $845,000. This cost would be reduced if the mine were in operation.

A4.9 DIVERSION OF UPPER BUCKTAIL THROUGH THE 7117 ADIT

To increase ventilation within the mine, Noranda drilled a raise that connects the 7117 level to the 6850 level. This raise provides a path that could be used to divert upper Bucktail Creek flows through the mine for treatment. The intake structure would he similar to that discussed in the previous section. The sill elevation, where the raise connects to the 7117 level, was not determined for this study but it is probably at about elevation 7150 ft based on its location within the mine. Consequently, the diversion structure must be built below the 7265 waste pile at about elevation 7175 ft. A sedimentation basin should be constructed in the 7265 waste pile similar to that proposed in the previous section.

Based on water quality data collected by Baldwin et al. (1978), and confirmed by measurements conducted in conjunction with this study, less than one-third of the total copper loading of Bucktail Creek has entered the stream at the

location where this diversion must be made. Consequently, large metal loadings would probably continue to flow into Big Deer Creek if additional measures were not taken.

The estimated cost of diversion of Bucktail Via 7117 adit is $318,000.

A4.10 PUMPING OF BUCKTAIL CREEK FROM 6950 LEVEL TO 7117 ADIT

A significant amount of poor quality water enters Bucktail Creek below the 7117 adit. This additional flow can be collected and pumped back up to the 7117 level and piped through the mine to the treatment facilities in Blackbird Creek. Three pumps with a total capacity of 500 gpm would satisfy the requirements to direct the mean annual flood for the drainage area not intercepted by the diversion above the 7117 adit. One of the three pumps should be sized for about 20 gpm to handle flow during the low flow season.

A pump structure similar to the intake structure discussed in Section A4.8 must be constructed, and a sedimentation pond should be built in the 7117 waste pile. Power lines must also be installed. It is not known whether sufficient power is available within the mine in the vicinity of the 7117 adit. Consequently, it was assumed that power can be obtained from the existing power lines at the top of the ridge.

The estimated cost of pumping facilities is $122,000.

A4.11 OPEN PIT DRAIN

The open pit (Blacktail Pit) has been identified as a major source of recharge to the mine workings. Baldwin et al. (1978) reported that sand-filled workings beneath the pit collapsed subsequent to cessation of mining activity. Surface water, which previously ponded in the pit, now discharges directly to the subsurface workings.

This source of recharge can be eliminated by providing a drain for the Blacktail pit. This can be accomplished by drilling a 6 in. diameter slant borehole from the bottom of the pit to the Bucktail drainage as shown in Figure A4-8. To prevent infiltration through the bottom of the pit, a 12 in.

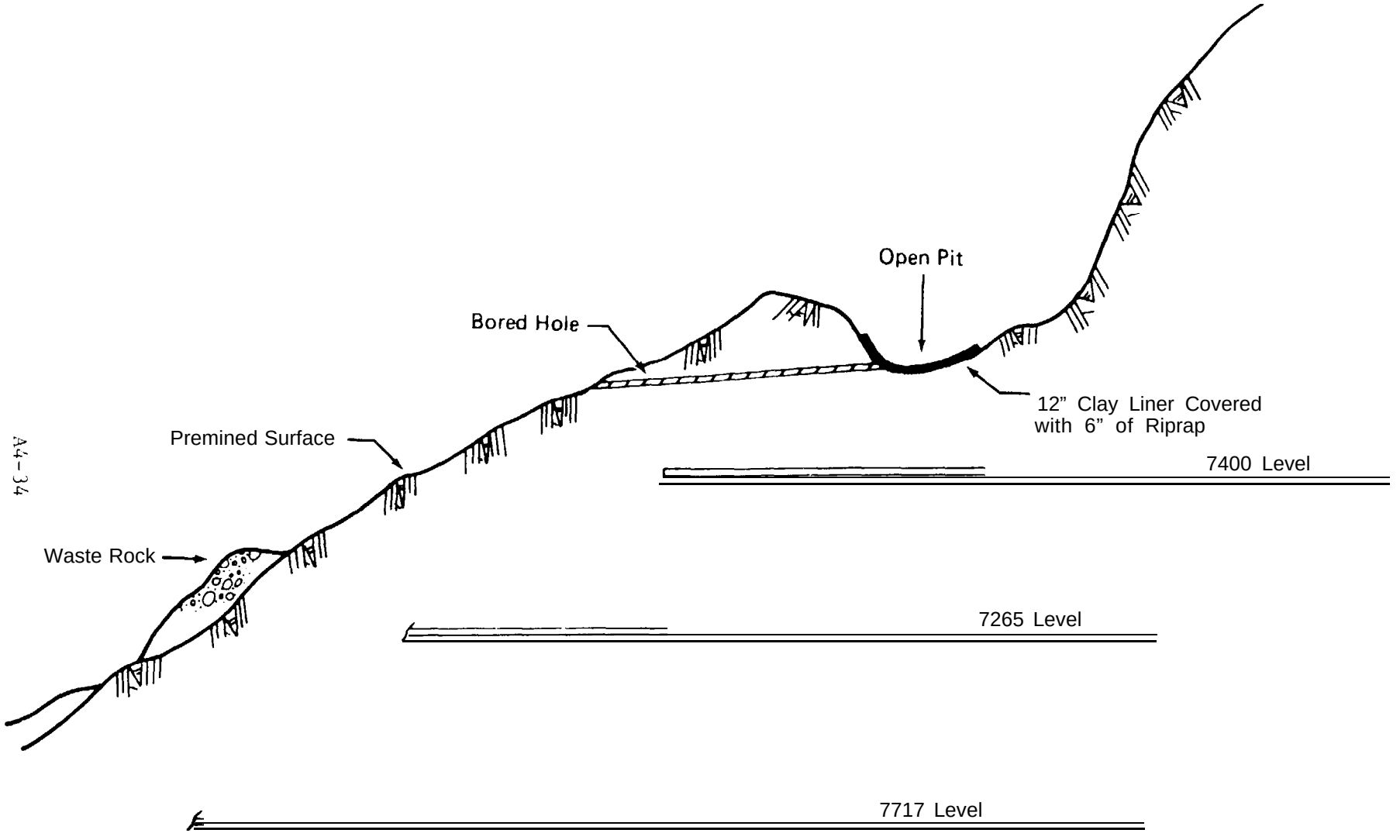


Figure A4-8 OPEN PIT DRAIN AND CLAY LINER

clay liner is proposed. The clay liner is protected by a 6 in. layer riprap with a filter cloth separating the two layers. It was assumed that approximately one acre of the pit bottom would require clay lining. An above-ground 6 in. PVC pipe is used to carry the pit drain discharge to Bucktail Creek.

The estimated cost of pit drain including borehole, drain pipe, clay liner, and discharge pipe is $217,000.

A4.12 BACKFILL OPEN PIT WITH WASTE ROCK AND CAP

The waste rock deposited at the headwaters of Bucktail Creek produce very poor quality water, with copper concentration as high as 1,500 mg/l measured below the waste pile. As a result, capping of this waste pile may not provide a sufficient reduction in copper concentration in Panther Creek, and it may be necessary to more effectively isolate this waste material.

The size of the waste rock pile in the headwaters of Bucktail Creek was estimated by Baldwin et al. (1978) to be about l,000,000 cu yd. It could be more effectively isolated by excavating this waste and placing it in the open pit (Figure A4-8). The top surface of the waste pile should be graded to a 3:1 slope. A 12 in. thick clay liner should then be placed over the pile and covered with 24 in. of neutralized waste rock. The top surface can then be revegetated using methods discussed in Section A4.1.

The estimated cost of backfilling and capping the pit, and revegetating the disturbed area is $2,706,000.

A4.13 TREATMENT OF POOR QUALITY WATER

Sections A4.6 through A4.10 discussed the methods necessary to isolate and collect poor quality water associated with the Blackbird mine area. These schemes entail the diversion of flows from Bucktail Creek, the Meadow Creek waste piles, and the mine adit flows to the water treatment facility.

The treatment of poor quality water is only a part of the overall abatement scheme that would include flow diversion and revegetation. Therefore, it is

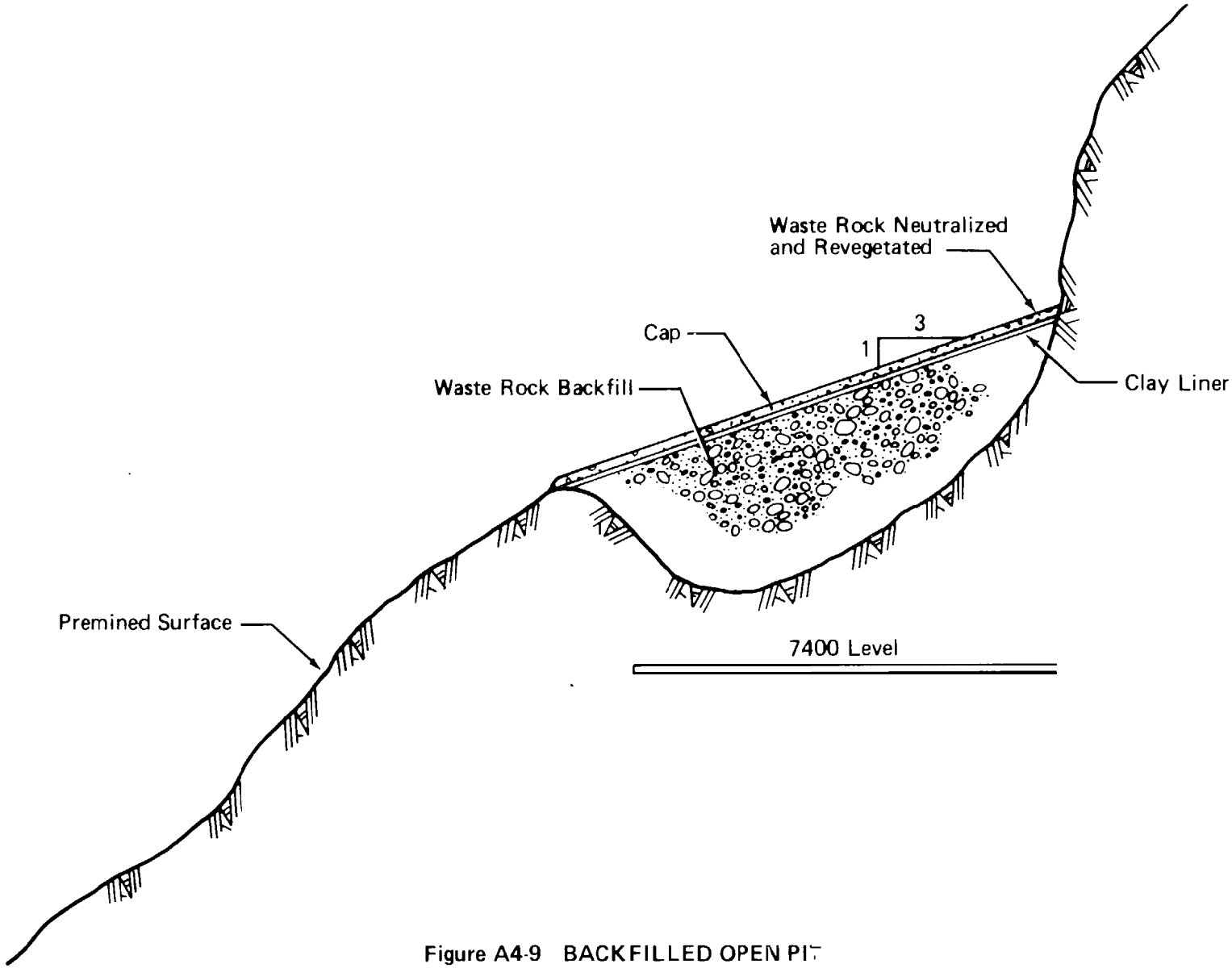


Figure A4-9 BACKFILLED OPEN PIT

difficult to determine how much water must be treated to maintain a certain water quality in Panther Creek. During flood events, it is anticipated that the flow diversion and revegetation of waste piles will result in a major reduction in the metal loadings compared to existing conditions. However, during a major part of the year when groundwater flows are the major contributor to stream flow, these measures would have no effect.

The quantity of water to be treated has a major impact on the required facilities to treat and store the water. Given the uncertainty in predicting the level of treatment required during varying hydrologic conditions, a phased approach to the implementation of water treatment should be considered.

The field conditions observed during May 1985 were representative of conditions more typically occurring in late June. Although the streams were partially fed by direct snowmelt runoff, the majority of the water entered the ground and emerged as springs. Therefore, the treatment facility must treat the majority of this poor quality water. The following flows are estimates of the quantities applicable during the latter part of the spring runoff:

o Meadow Creek collection system	200 gpm
o Bucktail Creek diversion	100 gpm
o Main adit flows (drained mine)	150 gpm
Total	450 gpm

The present capacity of the existing water treatment facilities is also approximately 450 gpm. It could, therefore, be used without modification to provide full treatment for flows up to those representative of the latter part of spring runoff. During peak snowmelt periods and severe thunderstorm activity, the flows would exceed the capacity of the treatment facility.

With the uncertainties involved, a reasonable approach is to size the collection facilities for a minimum capacity of the mean annual flood and to not increase the treatment capacity unless subsequent monitoring dictates it. The corresponding mean annual floods for the collection system were estimated as:

o Meadow Creek collection system	650 gpm
o Bucktail Creek diversion	1350 gpm
o Mine adit flow	200 gpm
Total	2200 gpm

Collected mine water and runoff from waste piles can be treated to remove copper and other dissolved metals by a number of methods. These include the following:

- o Lime Neutralization. Hydrated lime is added in a mixed tank to increase the pH to around 9.0, and the wastewater is aerated to oxidize metal ions. This causes most heavy metals to precipitate as hydroxide particles that are subsequently removed in a continuous gravity thickener or clarifier. This treatment process is used in the mine water treatment plant presently owned and operated by Noranda Mining.

- o Limestone Neutralization. Attempts have been made to neutralize acid mine wastes by placing porous barriers containing limestone directly in the affected streams. This has been largely unsuccessful because the calcium carbonate particles become coated with reaction products that decreases further chemical activity. Rotating porous drums containing limestone have also been used (Zurbach 1984). The tumbling effect tends to keep the surface of the limestone particles chemically active. Continuous feeding of limestone into streams has also been used. It should be noted that all three methods are only partially effective in neutralizing acidity because there is little or no control over the amount of limestone actually reacted and the resultant pH. Also, the metal hydroxides that do precipitate are not removed but are simply carried downstream.

- o Sulfide Precipitation. This consists of a lime neutralization process as described previously, followed by a sulfide precipitation step. Sodium sulfide, or a similar reagent, is added to further reduce the solubility of heavy metals in solution, followed by a gravity clarifier or filter for removal of solids. Since the lime neutralization process itself removes copper to less than 0.1 mg/l concentration, a sulfide precipitation step is needed only for very stringent discharge requirements. Also, any residual sulfide will consume dissolved oxygen in the receiving stream.

- Reverse Osmosis. In a reverse-osmosis (RO) system, water flows under high pressure through a membrane, but most ions ate retained by the membrane. An RO system usually requires extensive pretreatment of the wastewater to protect the membrane from fouling, including neutralization. The RO unit produces a high-quality effluent, but it also produces a concentrated blowdown stream containing the ions removed, and this must be further treated to remove heavy metals before discharge.

- Electrochemical Precipitation. This method employs an electric current imposed across consumable iron electrodes to generate ferrous ions which coprecipitate heavy metals in the wastewater. The precipitate is subsequently removed in a gravity clarifier. Incoming water must be neutralized using a lime neutralization process as described above.

- Ion Exchange. There are several processes involving ion exchange resins for treatment of acid mine drainage water. These include the Desal process, the Sul-biSul process, the Modified Desal process, and the Two Resin system. Generally, these have been applied in situations where potable drinking water was to be produced from contaminated surface water supplies. Exchange resins must be regenerated with strong acid and/or caustic solutions, The aqueous regeneration wastes (which contain the metal ions) must be further treated in a chemical precipitation step to remove the heavy metals prior to discharge.

- Biological Treatment. Some research has been performed on the use of microorganisms to treat acid mine drainage. Generally, these methods are only partially successful in removing heavy metals and do not, in themselves, neutralize acids. A lime neutralization step is usually a part of the biological treatment processes.

The lime neutralization process is recommended for treatment of the collected runoff and mine water. It produces a fairly neutral pH water with a low copper concentration and has the important virtues of low cost and simplicity. Lime treatment is by far the most commonly used method, and it is generally recommended in the literature. It should be noted that all of the treatment methods described previously, except for limestone neutralization, include some sort of lime neutralization step as an integral part of the treatment.

The present mine water treatment plant owned by Noranda is routinely operated at 400 gpm, but can be used for flows up to 450 gpm. This plant was completed

in 1980 and presently treats seepage from the 6850 plugged adit. There is an obvious economic advantage in using this plant for treating the collected acid mine drainage rather than building a new treatment plant. This possibility would undoubtedly be affected by any plans for reopening the mine at some time In the future.

The Noranda plant presently contains the following equipment items:

- Surge tank
- Storage tank
- Hydrated lime silo
- Hydrated lime feeder
- Lime slurry tank and mixer
- Two lime slurry pumps
- Recycle mix tank and mixer
- Two reactor tanks and mixers
- Air blower
- Lamella thickener
- Two recycle sludge pumps
- Two waste sludge pumps
- Polymer feeding/wetting unit
- Polymer solution mix tank and mixer
- Polymer solution transfer pump
- Polymer solution holding tank with mixer
- Two polymer solution feed pumps

In this plant, lime is manually added to control the pH between 8.5 and 9.5. Air is added to oxidize ferrous ions to ferric. The metal hydroxide particles that are formed settle out in the thickener. Most sludge is recycled to build a large particle size, but a small stream is wasted to a sludge-holding pond.

A polyelectrolyte solution is added to promote settling and to reduce the effluent solids concentration.

Since the closing of the mine, the treatment plant has been operated on an intermittent schedule to treat mine water leaking from the plugged mine adit. Most recently, the plant has been operating at a 400 gpm rate and has treated water collected over 48 hours in an 8-hour shift. The copper concentration in the plant effluent has averaged 0.08 mg/l in the past year. This is considerably higher than the copper solubility range of 0.008 to 0.016 mg/l expected between pH 8.5 to 9.5. This high copper concentration indicates either carryover of copper precipitate in the clarifier effluent or low pH excursions that allowed greater concentrations of copper to remain in solution.

The Noranda treatment plant was originally constructed to handle mine drainage and mill wastewater after the mill was reopened. As such, the treatment plant was designed to handle a fairly steady and predictable flow quantity. However, if it is to be used for treatment of surface drainage as well as mine drainage, it should be recognized that the flowrate will vary considerably with rainfall and snowmelt rates. Also, a high surface drainage rate will carry grit, stones, and debris that must be removed before the water can be treated.

A grit collector would be needed to allow gritty particles to settle out before entering the treatment plant. The grit collector would consist of a long, narrow concrete channel fed at one end and overflowing a weir at the other.

After overflowing the weir in the grit separator, the acid mine drainage would flow into the present storage tank if the Noranda treatment plant is used. The storage tank has two submersible pumps that feed an elevated head tank. Gravity flow from the head tanks to the Lamella thickener is controlled by a flow control valve, and excess water flows back to the storage tank by gravity. This provides flow control and equalization for the treatment system. If the storage tank fills completely, any excess influent would flow to Blackbird Creek through an overflow line (overflows of untreated acid mine drainage do not occur in the present treatment plant operation).

Figure A4-10 shows a simplified flow diagram of the proposed treatment system, which differs from the present treatment plant in several respects.

A4.13.1 Treatment Plant Criteria

The combined flow rate into the treatment plant is expected to average 150 gpm with a 450 gpm maximum, and will contain about 80 mg/l copper, 20 mg/l cobalt, and 40 mg/l iron. The pH will average about 3.4. Based on experience from the present treatment plant, roughly 1 g/l of lime will be required to neutralize the water, but this should be determined by oxidizing and neutralizing representative samples of acid drainage after the recommended collection/diversion system is in place. The pH should be controlled to between 8.5 and 9.5 to minimize the effluent copper concentration, with a target pH value of 9.00.

As stated previously, the average copper concentration in the present treatment plant effluent has been reported as 0.08 mg/l, which is considerably higher than the solubility of copper in the 8.5 to 9.5 pH range. A review of recent plant operating data (pH and suspended solids concentration of the effluent) would indicate that this is due to low pH excursions that allowed greater concentrations of copper to remain in solution or to carryover of copper precipitate from the clarifier. Closer control of pH and polymer dosage might reduce the average effluent copper concentration to below 0.02 mg/l without the need for modifications such as an automatic pH control loop or a gravity sand filter after the clarifier,

A4.1.13.2 Sludge Disposal

There will be a large amount of sludge produced from a continuous neutralization process, much more than is produced in the present intermittent operation. A rough estimate of average sludge production is 2 tons of dry solids per day; but this can best be established after changes are implemented that will produce a representative acid mine drainage to be treated. At that time representative samples should be oxidized and adjusted to pH 9.0 with lime Then, the suspended solids should be filtered, dried and weighed to dete mine the sludge solids concentration.

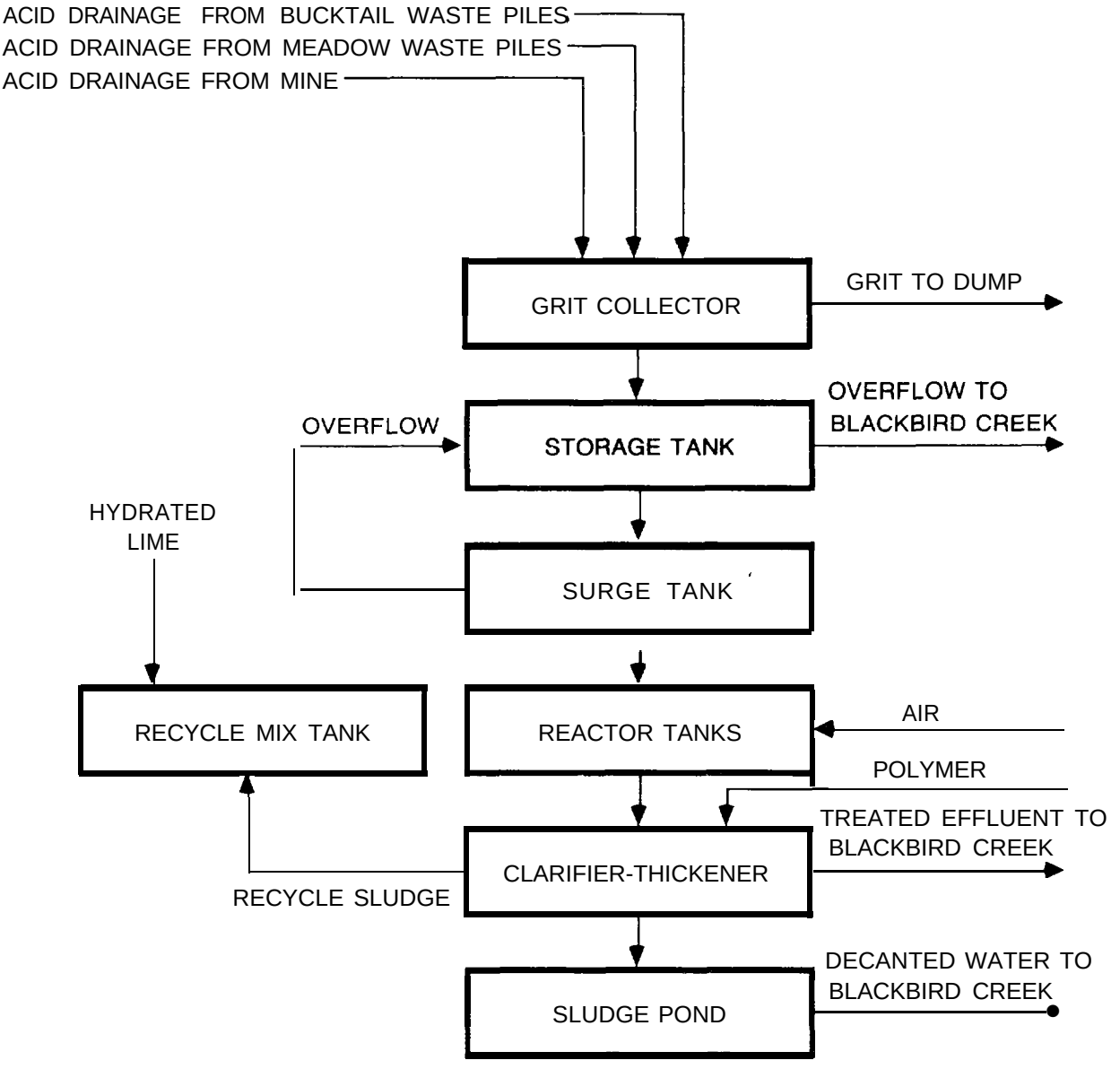


Figure A4-10 MINE WATER TREATMENT PROCESS
SIMPLIFIED FLOWSHEET

Sludge from the present treatment plant operation is now sent to a pond lined with a synthetic geotextile filter fabric. The fabric allows the sludge to dewater in the pond. Water seeps through the bottom of the pond until the sludge attains a dewatered appearance with large cracks in the top surface.

This method of sludge dewatering could be used if the treatment plant is operated continuously. A second pond would be required to allow one pond to dewater while the other pond was filling. An existing "sedimentation pond" near the present sludge pond could likely be converted to that purpose. After excavation from the ponds, the dewatered sludge could be hauled by truck to an area behind the tailings dam for final disposal. The volume of dewatered sludge is roughly estimated at 2,000 cu yd per year.

If the mine and mill were in operation, the sludge could be processed through the mill for removal of metals. Noranda has found that the sludge has characteristics approximately equal to those of the concentrated ore.

A4.1.13.3 Treatment Plant Capital Costs

The present treatment plant owned by Noranda Mining was designed for and is routinely operated at a flow rate of 400 gpm, but it reportedly can treat up to 450 gpm. If this facility can be used to treat the collected acid mine drainage, then the only major capital expenditures required would be to purchase the grit collector, and to modify the present sedimentation pond to serve as a second sludge pond.

The present 400 gpm treatment plant cost about $1.5 million when it was completed in 1980, or about $1.8 million in present dollars. A new 500 gpm plant is estimated to cost $2.1 million in present dollars.

A4.1.13.4 Treatment Plant Operating Costs

Operator manpower costs are the largest single operating cost because the plant must be attended 24 hours per day. Staffing may be difficult since the mine is situated in a remote location. Using a manpower cost of $25/hour, (which includes employee benefits, supervision, etc.) operator staffing costs are estimated at $219,000 per year.

Chemical costs are also high. Because of the remote location, lime presently costs about $200/ton delivered. This would result in an annual cost of about $66,000. At $2.10/lb, polymer is estimated to cost an additional $7,00O/year. This assumes an average flow of 150 gpm.

Other operating costs such as maintenance, sludge hauling, and electric power are estimated to cost an additional $72,000.

The total estimated treatment plant operating and maintenance costs are $364,00 per year.

If the mine were operating, part of the costs of the treatment plant would be offset through recovery of metals from the sludge. Personnel costs could probably also be reduced.

A4.14 MINE SEALING

Sealing the mine to eliminate portal discharge of acidic mine water is an optional remedial measure at the Blackbird Mine. As discussed in Section A2, acid water discharge from mine portals that seeps thrdugh surface waste piles is an important contributor to surface water contamination.

Sealing the mine would involve placing bulkheads in mine workings that approach the surface, including adit portals and raises. Based on preliminary information, a total of 17 portals and 5 raises may require bulkheads depending on the elevation to which groundwater stabilizes after flooding.

Flooding the mine would allow groundwater to rise to an unknown level at or below the pre-mining groundwater table and may have the following effects:

- Significantly reduce the discharge from the mine
- Reduce oxidation of sulfide minerals and thus limit the production of acids by an unquantified amount
- Cause an unquantified increase in fracture-controlled groundwater flow and thus discharge of poor quality water through nonpoint sources

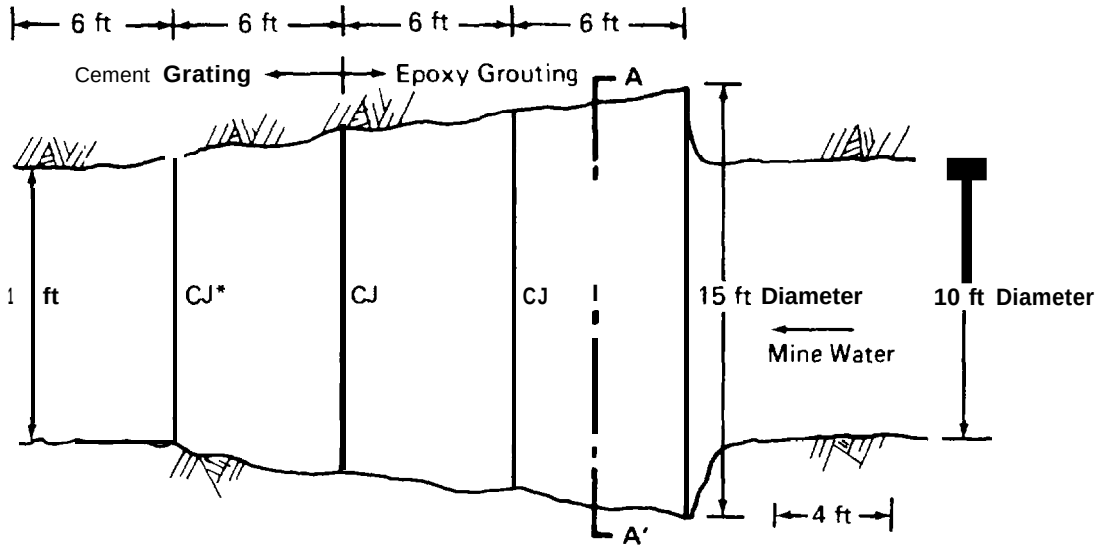
- Create safety hazards related to destabilization of slopes and mine workings
- Not allow concurrent mining without prior draining and maintenance of the mine

However, because flooding will produce a passive condition, reduce operating cost, and innibit oxidation and production of acidic mine water, it has major advantages regarding the long-term reclamation of the Blackbird mine. Installation of the bulkheads would be phased to coincide with the rising water table. After groundwater stabilizes under natural condition, portals above that elevation would not be sealed.

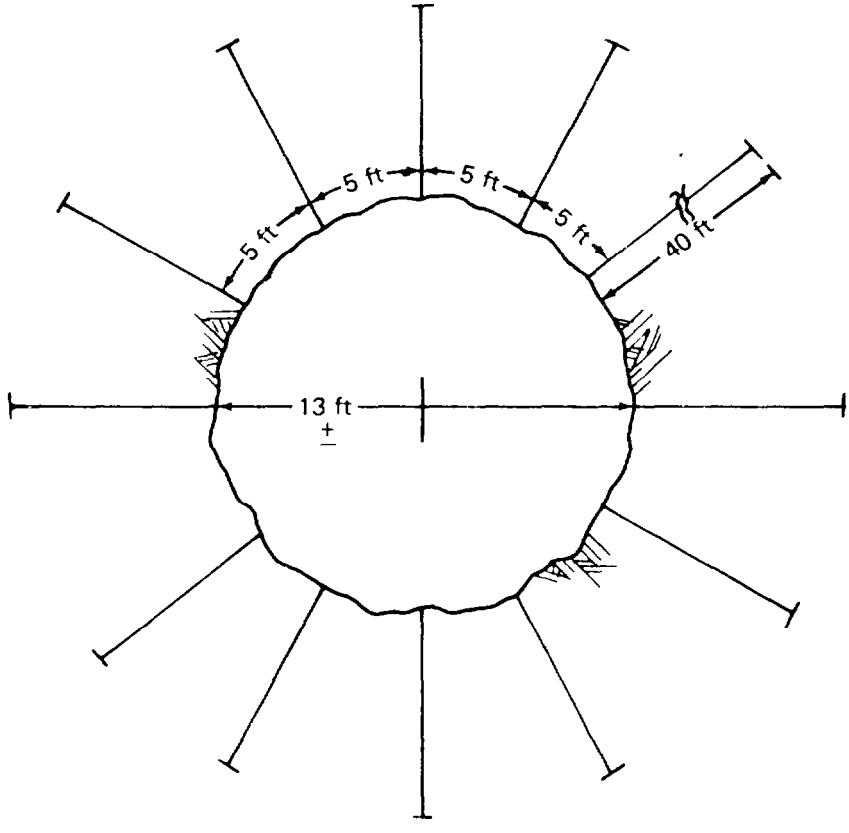
A preliminary bulkhead design is shown on Figure A4-11. The bulkhead is designed to withstand an average pressure of 175 psi (400 feet of water) and acidic mine water with pH less than 4.0. The concrete bulkhead should be constructed in four 6 ft long sections, The surface of each section should be coated with epoxy resin to reduce deterioration of the cement by acidic water. The bulkhead proposed should be placed well within the adit (at least 100 ft) to avoid surface fracturing. The bulkhead design tapers from 15 to 10 ft to provide adequate frictional resistance. To reduce flow through fractures in the rock around the bulkhead, a 50 ft radius grout curtain around the bulkhead is included in the design. The grout material is an epoxy resin around the inner two bulkhead sections, and a sand-cement mixture around the outer bulkhead sections. The estimated cost for each portal bulkhead is $72,000, and for each raise bulkhead is $36,000.

Sealing of the adits would preclude underground mining operations and is, thus, not applicable if the mine were to be operated.

The estimated cost for sealing the mine (17 portals and 5 raises) is $1,400,000.



***Construction Joints Treated With Epoxy Resin and Coating.**



SECTION A-A

SECTIONAL ELEVATION OF BULK HEAD

Figure A4-11 PRELIMINARY BULKHEAD DESIGN FOR MINE SEALING

Appendix A5

ESTIMATE COST SHEETS

PROJECT IDAHO PANTHER CREEK

NO _____ ITEM _____

JOB NO 17020-005

SHEET 1 OF 9

DATE 7/27/85

BY Longoria

H&CE DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN HOURS	MAN HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
A BLACKBIRD SIDE																
1 DIVERSION DITCHES																
TYPE - A	5200	LF													14	72800
B	5500	✓													62	341,000
C	2200	✓													52	114,000
D	1400	✓													115	161,000
F	1000	✓													30	30,000
2 CULVERT CROSSINGS																
30" ϕ CMP w/flare	120	LF													50	6000
ends - (2 x 60') = 120'																
SUBTOTAL																724,800
CONTINGENCIES 10%																72,480
TOTAL - DIVERSION DITCHES																797,280
														SAY	$	797,000

PROJECT PANTHER CREEK

JOB NO 17020-005
SHEET 2 OF 9
DATE 7/27/85
BY [illegible]

H&CE DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN HOURS	MAN HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUBCONTRACTS UNIT COST	SUBCONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
B MEADOW CREEK IMPROVEMENTS																
1 DRAINAGE DITCHES																
TYPE A	1200	LF													14	16,800
" B	2200	✓													62	136,400
" E	1700	✓													79	134,300
" F	250	✓													30	7,500
2 CULVERT CROSSINGS																
2-24"ϕ - 60' long	120	LF													40	4800
3 Sedimentation Basin w/outlet works	2	Ea													3400	6800
SUBTOTAL																306,600
CONTINGENCIES - 10%																30,660
TOTAL																337,260
														SAY		$ 337,000

C. EME

PROJECT PANTHER CREEK

NO. ____ ITEM ____

JOB NO. 17020-005

SHEET 3 OF 9

DATE 7/27/85

BY Kongonia

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN HOURS	MAN HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
C BLACKBIRD SIDE																
CONTAMINATED WATER COLLECTION SYSTEM																
1. 24" CMP Risers perf. 10' long	12	Ea													300	3600
2. Excavation & Backfill	16,700	CY													4.50	75,150
3. Riprap	170	CY													33	5610
4. 15" ϕ PVC @ 10' deep.	6000	LF													16	96,000
5. Grading to Catch Basin	1	LS													LS	1200
6. Grit Removal Basin	1	LS													LS	22000
7 Connection to exist treatment plant.	1	LS					ALLOWANCE									5000
SUBTOTAL																206560
CONTINGENCIES	10%															20656
TOTAL																229,416
														SAY		229,400

A5-4

PROJECT PANTHER CREEK

NO. _____ ITEM _____

JOB NO. 17020-005

SHEET 4 OF 9

DATE 7/27/85

BY Longoria

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
REPLACEMENT BLACKBIRD CREEK CULVERT																
1. Remove 42" RCP	2000	LF													25	50,000
2. Install new 48 RCP	2000	LF													90	180,000
3. Excavation & Backfill	4000	CY													4.70	19,740
4 New Concrete Headwall incl riprap apron.	2	EA													4000	8000
SUBTOTAL																257,740
CONTINGENCY	10%															25774
TOTAL																283,514
														SAY		283,500

JOB NO. 17020-005
SHEET 5 OF 9
DATE 7/23/85
BY Longoria

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB CONTRACTS UNIT COST	SUB CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
B BACKTAIL SIDE																
DIVERSION DITCHES																
TYPE A	1700	LF													14	23800
B	2900	LF													62	179,800
C	1300	LF													52	67,600
D	1200	LF													115	138,000
E	700	LF													30	21,000
SUBTOTAL																644,400
CONTINGENCIES																64,600
TOTAL															$	709,000
2 CULVERT CROSSINGS																
24" ϕ CMP (2x60')	120	LF													40	4800
CONTINGENCIES 10%																480
SUBTOTAL																5280
TOTAL DIVERSION DITCHES																714,280
														Say		714,000

PROJECT GAITHER CREEK

NO. _____ ITEM _____

JOB NO. 17020-005

SHEET 6 OF 9

DATE 7/27/85

BY Longoria

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN HOURS	MAN HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
BLACKTAIL PIT DRAIN																
Bore 6"ϕ horizontal hole	500	LF													260	130,000
6"ϕ PVC Pipe - Above ground	1500	LF													10	15,000
Clay Liner - 12" (40,000#)	1500	CY													26	39,000
Filter Fabric	4500	SY													2.50	11,250
Waste pile - 6" layer	750	CY														2250
SUBTOTAL																197,500
10% CONTINGENCY																19,750
																217,250
														SAY		217,000

PROJECT PANTHER CREEK

NO. _____ ITEM _____

JOB NO. 17020-005

SHEET 7 OF 9

DATE 7/27/85

BY Holgonia

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
BUCKTAIL DIVERSION VIA BORE HOLE - 6850																
1. Access Road - Dirt Rd	1200	LF													20.00	24,000
2. Bore 12" ϕ Hole	1500	LF													420	630,000
3. Diversion Structures	1	Ea													10,000	10,000
4. 12" ϕ PVC Pipe @ 6850	10,000	LF													10.00	100,000
5. Sedimentation Basin @ 7117 waste pile	1	Ea													4000	4,000
SUBTOTAL																768,000
CONTINGENCY	10%															76,800
TOTAL																844,800
														Say		845,000

PROJECT: PANTHER CREEK

NO. _____ ITEM _____

JOB NO. 17020-005

SHEET 8 OF 9

DATE 7/27/85

BY JL

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
BUCKTAIL CREEK FLOWS @ 6950 TO 7117 ADIT																
INTAKE STRUCTURE	1	LS													LS	34,000
8" Φ - 200PS PVC Pipe	1000	LF													16.00	16,000
Pumps - 20 HP	2	EA													20,000	40,000
Pump - 2 HP	1	EA													EA	3000
Power & Controls	2500	LF													5.00	12,500
Pre-Engineered Metal Bldg - 6x12'	1	LS													LS	6,000
Sedimentation Pond	1	LS													LS	4,000
SUBTOTAL																110,500
CONTINGENCY 10%																11,050
TOTAL																121,550
														SAY		122,000

PROJECT PANTHER CREEK

NO. _____ ITEM _____

JOB NO. 17020-005

SHEET 9 OF 9

DATE 7/27/85

BY [illegible]

H&CE DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUBCONTRACTS UNIT COST	SUBCONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
UPPER BUCKTAIL DIVERSION TO 7117 LEVEL THRU MINE																
Diversion Structure	1	Ea													LS	10,000
12"Ø PVC Pipe - 200#	11,000	LF													25	275,000
Sedimentation Basin	1	Ea													LS	4,000
SUBTOTAL																289,000
CONTINGENCY																28,900
TOTAL																317,900
														SAY		318,000

JOB NO. 17020-005

SHEET 1 OF 3

DATE 7/22/85

BY JI

JOB NAME PANTHER CREEK

ITEM

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
WASTE PILE CAP - 42 ACRES																
Excavation 24"	135,600	CY													1.70	230,520
Clay Liner - 12"	67,800	CY													20.00	1,356,000
Backfilled - Light compaction	135,600	CY													0.90	122,040
SUBTOTAL																1,708,560
CONTINGENCY 10%																170,856
TOTAL																1,879,416
														SAY		1,879,000
Breakdown as follows:																
BLACKBIRD SIDE	30	AC														1,342,000
BUCKTAIL SIDE	12	AC														537,000

PROJECT PANTHER CREEK

NO. ____ ITEM ____

J.B NO. 170 20-005

SHEET 2 OF 3

DATE 7/27/85

BY U.

ALT 2E

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
CONCRETE ADITS																
Exc of slots	1															0
Forms	600	SF													5.00	3000.00
Concrete	101	CY													150	15,150
Grouting																
a) Epoxy	18	CY													700	2600
b) Concrete	68	CY													500	34,000
Epoxy @ Const. Jts	600	SF													2.00	1200
SUBTOTAL																65,950
CONTINGENCY																6595
TOTAL																72,545
														SAY		72,000
SEAL MINE ADITS																
ADITS	17	EA													72000	1,224,000
RISERS	5														36000	180,000
TOTAL - SEAL MINE ADITS																1,404,000
													SAY			1,400,000

PROJECT PANTHER CREEK

NO. _____ ITEM _____

JOB NO. 17020

SHEET 3 OF 3

DATE 7/27/85

BY L

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	AP-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
BACKFILL BLACKTAIL PIT																
1. Remove Waste Piles & place in pit	1,000,000	cy													2.30	2,300,000
2. Clay Liner	9700	cy													20	194,000
3. Seal Adits	2	Ea														144,000
SUBTOTAL																2,638,000
CONTINGENCY	10%															263,800
TOTAL																2,901,800
														SAY		2,900,000
LESS CLAY LINER																<194,000>
TOTAL -																2,706,000

A5-13

JOB NO. 17020-005
SHEET 1 OF
DATE 7/25/85
BY

H&CE DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN HOURS	MAN HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
DRAINAGE DITCHES																
1. TYPE A = 5200 LF																
Excavation	2340	CY													2.00	4680
Clay	1092	CY													26.00	28392
Filter Fabric	0	SY														Ø
Sack-Fill - Berm	2340	CY													1.50	3510
Rip-rap	624	CY													33	20,592
TYPE A :	5200	LF														57174
O.H. & Profit			25%													14293
																71,467
Cost/LF -													13.74	SAY →		14.00/LF
2. TYPE B - 5500 LF																
Excavation	11000	CY													2.00	22000
Clay	3300	CY													26.00	85800
Filter Fabric	9350	SY													2.50	23375
Back-Fill - Berm	11,000	CY													1.50	16,500
Rip-rap	3850	CY													33	127,050
									C.H & PROFIT 25%							274725
																68681
	5500	LF														343,406
														SAY →		62.00/LF

PROJECT PANTHER CREEK

NO. ____ ITEM ____ . ____ ---

JOB NO 17020-005

SHEET 2 OF ____

DATE 7/27/85

BY - ____

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
DRAINAGE DITCHES																
3. TYPE-C - 1300 ft																
Excavation	1690	CY													2.00	3380
Clay	780	CY													26.00	20280
Filter Fabric	3510	SY													2.50	8775
Backfill - Berm	1690	CY													1.50	2535
Rip-rap - 9" Thick 6"	585	CY													33	19,305
																54275
									O.H. & PROFIT 25%							13569
																67,844
									COST/LF							52.19
														SAY		52.00/LF
4. TYPE-D - 1400 ft																
Excavation	3780	CY													2.00	7560
Clay	1260	CY													26.00	32760
Filter Fabric	3920	SF													2.50	9800
Backfill - Berm	3780	CY													1.50	5670
Rip-rap - 30" Thick 18"	2240	CY													33.00	73,920
																129710
									O.H. & Profit 25%							32427
																162,137
									Cost/LF							115.81
														Say		115.00/LF

JOB NO. 17020-005
SHEET 3 OF
DATE 7/27/85
BY Longoria

CREEK

NO. ITEM

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
DRAINAGE DITCHES																
5. TYPE E - 1700 ft																
Excavation	4420	CY													2.00	8840
Clay	1360	CY													26.00	35360
Filter Fabric	2465	SY													2.50	6162
Backfill - Berm	4420	CY													1.50	6630
Rip-rap	1530	CY													33.00	50490
																107,482
										O-H & PROFIT			25%			26,870
																134,352
										COST/LF						79.00/LF
6. TYPE F - 1000 ft																
Excavation	120	CY													2.00	240
Clay	60	CY													26.00	1560
Filter Fabric	Ø														-	
Backfill - Berm	Ø														-	
Rip-rap	40														33	1320
Half Round CMP 24"Ø	952	LF			5.00								10		15	14280
CMP - 36"Ø - 12Ga	48	LF			13								30		43	2064
CMP - 36" T	4	EA			50								250		300	1200
Struts @ 20' o.c.	52	EA			20								50		70	3640
																24304
										O-H & PROFIT			25%			6076
																30380
																30.00/LF

A5-16

PROJECT IDAHO PANTHER CREEK

NO. ____ ITEM ____

JOB NO. 17020-005

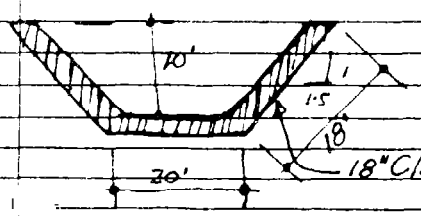
SHEET ____ OF ____

DATE ____

BY Longoria

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
SEDIMENTATION BASIN																
																
Clay = $\frac{(18+18+20)30'}{27}$	63	CY													26	1638
Excavation (Waste)	63	CY													5	315
Outlet Structure (Timber)	1.5	LS													500	750
SUBTOTAL																2703
CONTINGENCIES																677
TOTAL																3380
														SAY		3400

PROJECT IDAHO PANTHER CREEK

NO. _____ ITEM _____

JOB NO L 7020-005

SHEET ____ OF ____

DATE _____

BY Koogorie

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
CLAY LINER																
Excavate	1	CY													0.52	0.52
Haul & Dump	1	CY		(15 Mile Haul											20.00	20.00
Place & Shape	1	CY													0.30	0.30
TOTAL DIRECT COST																20.82
O.H. & PROFIT - 25%																5.20
TOTAL																26.02
														SAY		26.00/CY

- AHO

PROJECT PANTHER CREEK

NO. _____ ITEM _____

JOB NO. 11020-005

SHEET ____ OF ____

DATE _____

BY Hoggard

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN HOURS	MAN HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
RIPRAP																
1-F E Loader 931B	1	HR				1		3		5						12
1-Rear Dump - 8CY	1	✓				1		4		10						18
1-25 Ton Crane	1	✓				16		10		16						42
1-Foreman	1	HR			20.00	20										20
2-Operators	2	✓			19.50	39										39
8-Laborers	8	✓			16.50	132										132
SUBTOTAL CREW COST						215		17		31						263
Assume a production of 10 CY/Hr Riprap from waste piles at no cost	1	CY				21.50		1.70		3.10						26.30
O.H. & Profit - 25%																6.58
TOTAL COST	1	CY														32.88
														SAY		33.00/CY

JOB NO. 17020-005

SHEET ____ OF ____

DATE ____

BY ____

PROJECT ____

NO. ____ ITEM ____

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
DIVERSION STRUCT.																
· Forms	600	SF													7	4200
· Concrete	14	CY													100	1,400
· Re-bar	1400	lbs													.60	840
· Grating 20#/SF @ 1#/ft	40	SF													20	800
· 3" Cap	30	LF													14	420
· 3" Stl. Pipe	30	LF													8	240
· 3" Gate Valve	1	Ea													300	300
Total Direct Cost	1	LS														8,700
O.H. & Profit	25%															2,050
																10,750
										Over						$ 10,000

JOB NO. 17020-005

SHEET ___ OF ___

DATE ___

BY ___

ITEM ___

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
15" ϕ CMP																
1- BACKHOE 215	1	HR				15-		9-		13-						37-
1- DOZER D-7	1	✓				16		12-		18						46
[illegible]	1	✓			20-	20-										
[illegible] OPERATORS	2	✓			19.50	39-										112-
[illegible] PIPEFITTER	1	✓			20-	20-										
[illegible] LABORERS	2	✓			16.50	33-										
TOTAL CREW COST	1	HR				143-		21		31						195
PRODUCTION 20 LF/HR	1	LF			7.15		1.05				1.55				9.75	
PIPE	1	LF									8-				8-	
SUB-TOTAL DIRECT	1	LF			7.15		1.05				9.55				17.75	
CATCH BASINS																
$500 ÷ 100' =	1	LF													5-	
TOTAL DIRECT	1	LF													22.75	
O.H. & PROFIT	25	%													5.68	
BID COST	1	LF													28.43	
USE	1	LF													30.00	

JOB NO. 17020-005

SHEET ___ OF ___

DATE ___

BY ___

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
REM. WASTE PILES																
SPREAD & ROAD MAINT.																
1 - D8	1	✓				21		15		25						61
1 - CAT GRADER	1	✓				14		9		17						40
2 - OPERATORS	2	✓			19.50	39										49
1/2 - F. MAN	1/2	✓			20	10										
TOTAL CREW	1 HR					84		24		42						150
FUEL, 500 GAL	1	Gal.				.17		.05		.08						.30
RECAP:																
EX. & LOAD	1	Cy				.28		.09		.15						.52
HAUL	1	✓				.39		.15		.25						.69
SPREAD & RD. MAINT	1	✓				.17		.05		.08						.30
TOTAL DIRECT	1	Cy														1.51
CONTR. OH & PROFIT	25	%														.38
									TOTAL	2.15						1.89
									Say							$1.90/yd

JOB NO. 17020-005

SHEET ____ OF ____

DATE ____

BY ____

PROJECT ____

NO. ____ ITEM ____

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
REM. WASTE PILES																
EXC. & LOAD:																
1 - EXCAVATOR 235	1	HR				31		17		28						76-
1 - DOZER D-8	1	✓				21-		15-		25-						61-
1 - F.E. LOADER 980C	1	✓				19-		14-		25-						58-
½ F-MAN	½	✓			20-	10-										10-
3 OPERATORS	3	✓			19.67	59-										59-
TOTAL CREW HR	1	HR				140-		46-		78-						264-
PRODUCTION 500 cy/HR	1	cy				.28		.09		.15						.52
HAUL ½ MILE R.T.																
· TRAVEL 4																
· LOAD 1 } 7 min																
· U-LOAD 1 } say 10 min																
· TURN & SPOT 1																
5 - 769 C TRUCKS	5	HR			12-	60	15-	75	25-	125					52-	260
5 - DRIVERS	5	-			17.6	88										88
TOTAL CREW	1	HR				148		75		125						348
PRODUCTION 500 cy/HR	1	cy				.29		.15		.25						.69

IDAHO

PROJECT FANTHER CREEK

NO. _____ ITEM _____

JOB NO. 17020-005

SHEET _____ OF _____

DATE _____

BY Hongoria

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
HORIZONTAL																
6" ϕ BORE																
1 - 25 TON CRANE	1	HR				16.38		10.13		15.59						42.10
1 - GAS WELDER	1	✓				1.31		.54		3.32						5.17
1 - HORIZ BORING MACH.	1	✓				20-		15-		25-						60-
1 - HYDR. JACKS	1	SET				10-		5-		5-						20-
1 - FMAN	1	HR			20-	20-										
4 - LABORERS	4	✓			16.50	66-										144.50
1 - WELDER	1	✓			19.50	19.50										
2 - OPERATORS	2	✓			19.50	39-										
TOTAL CREW HR COST	1	HR				192.19		30.67		48.91						271.77
PRODUCTIVITY 1.75 /HR																
USE	1	LF				110		18		28						156
6" ϕ ½" XTRA STRONG 40 lbs/LF @ .50	1	LF								20						
JACKING PIT Say 1 15,000.00/500	1	LF				10-		10-		10-						30-
TOTAL DIRECT COST	1	LF				120		28		58						206
CONTR. O.H. & PROFIT	25	%														52
TOTAL BID COST	1	LF														258.00
																$ 260.00

A5-24

IDAHO

PROJECT PANTHER CREEK

NO. _____ ITEM _____

JOB NO. 17020-005

SHEET ____ OF ____

DATE _____

BY Pontoria

H&CF DIVISION

ESTIMATE WORK SHEET

DESCRIPTION	QUANTITY	UNIT	MAN-HOURS	MAN-HOURS	LABOR (ALL INCL.) UNIT COST	LABOR (ALL INCL.) AMOUNT	EQUIPMENT UNIT COST	EQUIPMENT AMOUNT	SUPPLIES (INCL. S.T.) UNIT COST	SUPPLIES (INCL. S.T.) AMOUNT	SUB-CONTRACTS UNIT COST	SUB-CONTRACTS AMOUNT	PERMANENT MATERIALS (INCL. S.T.) UNIT COST	PERMANENT MATERIALS (INCL. S.T.) AMOUNT	TOTAL DIRECT COST UNIT COST	TOTAL DIRECT COST AMOUNT
15" ϕ CMP																
1 - BACKHOE 215	1	Hr				15-		9-		13-						37-
1 - DOZER D-7	1	✓				16		12-		18						46
1 - FOREMAN	1	✓			20-	20-										
2 - OPERATORS	2	✓			19.50	39-										112-
1 - PIPEFITTER	1	✓			20-	20-										
2 - LABORERS	2	✓			16.50	33-										
TOTAL CREW COST	1	HC				143-		21		31						195
PRODUCTION 20 LF/HR	1	LF			7.15		1.05				1.55				9.75	
PIPE	1	LF									8-				8-	
SUB-TOTAL DIRECT	1	LF			7.15		1.05				9.55				17.75	
CATCH BASINS																
#500 ÷ 100' =	1	LF													5-	
TOTAL DIRECT	1	LF													22.75	
O.H. & PROFIT	25	%													5.68	
BID COST	1	LF													28.43	
USE	1	LF													30.00	

Appendix B: Phase III: Fisheries Habitat Surveys

APPENDIX B

PHASE III: FISHERIES HABITAT SURVEYS

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Section Bl

METHODS

As part of the Panther Creek Rehabilitation study, detailed habitat surveys were conducted in portions of streams within the Panther Creek drainage. The majority of the field studies were completed during a 20-day period from September 11-30, 1984. Supplemental studies involving fish tissue analysis and additional habitat surveys were conducted during September 9-11, 1985. The streams evaluated all have potential for anadromous fish production should the toxic mine effluent problem be resolved. Results of the surveys were used to estimate potential smolt production and the economic value of restoring chinook and steelhead runs to the drainage.

The habitat surveys were coordinated with fisheries biologists from the LJSFS (Bruce May) and the IDF&G (Mel Reingold, Herb Pollard, and Terry Holubetz). In particular, the IDF&G had recently completed several qualitative fish surveys at stations throughout the Panther Creek drainage (T. Holubetz, IDFCG 1984, pers. comm.) To the extent possible, habitat stations were selected in close proximity to the IDF&G stations.

B1.l STUDY SITE SELECTION

Following a review of existing aquatic ecology information and a site visit, portions of eight streams were selected for detailed studies (Figure Bl-1). Specific reaches included five sites on Panther Creek, two sites on Moyer Creek, and single sites on Musgrove, Deep, Big Deer, Beaver, Napias, and Clear creeks (Table Bl-1). The number of reaches assigned to each stream and the type of assessment made (quantitative and/or qualitative) were based on:

- Relative potential of the stream for providing fisheries habitat
- Topographic and morphologic characteristics of the streams (elevation, slope)
- Stream size and discharge

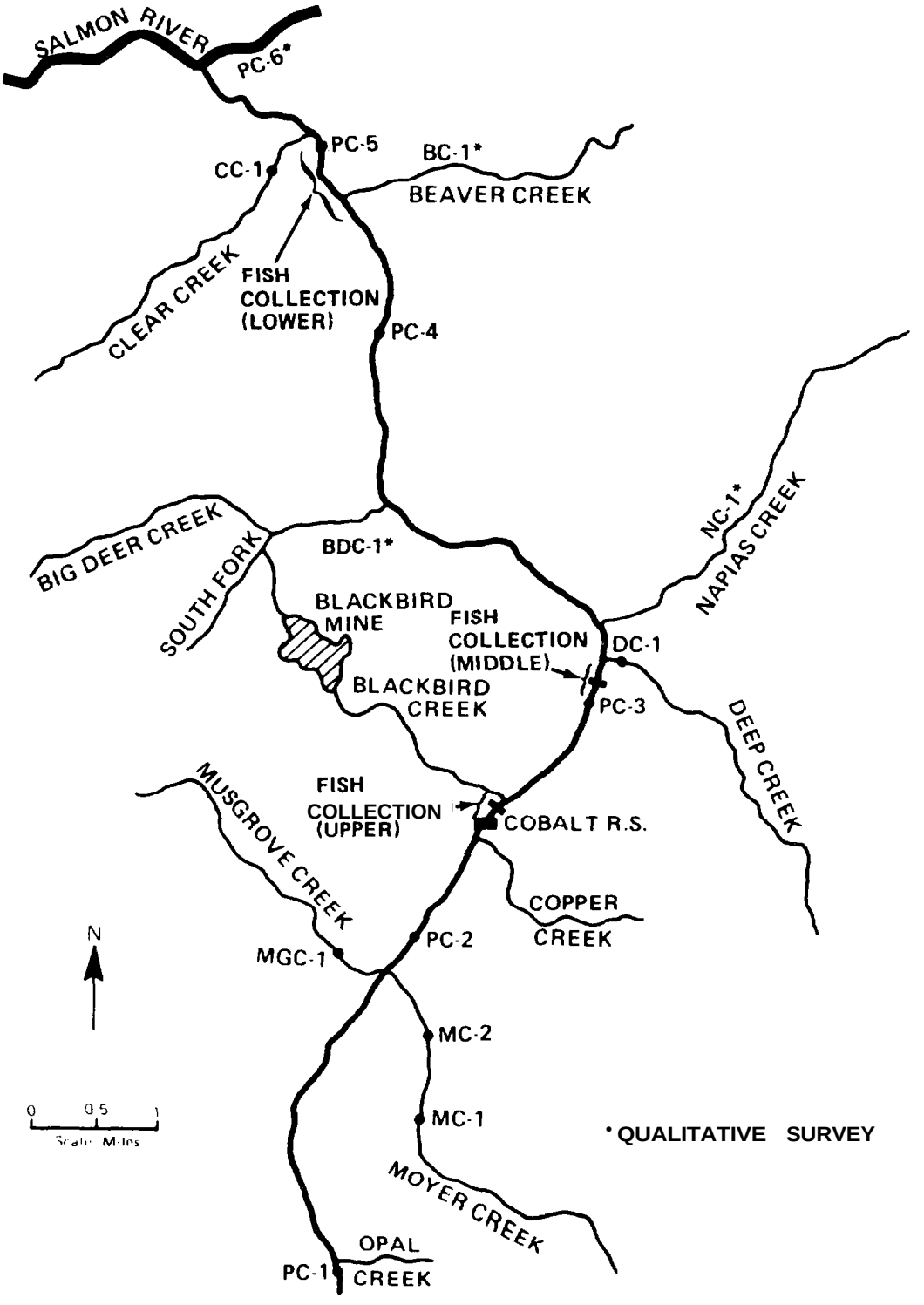


Figure BI-1 FISHERIES HABITAT STUDY STATIONS AND FISH COLLECTION SITES LOCATED IN THE PANTHER CREEK DRAINAGE, FALL 1984 AND 1985

Table Bl-1

NUMBER OF REACHES, STREAM LENGTH SURVEYED
AND SURVEY TYPES FOR STREAMS EVALUATED IN THE PANTHER CREEK DRAINAGE, 1984-1985

Stream (Designation)	No. Reaches	Length Surveyed (mi)	Survey Type Qualitative	Survey Type Quantitative
Panther Creek (PC-l through PC-5)	5	42.5	X	X
Musgrove Creek (MGC-1)	1	2.7	X	X
Moyer Creek (MC-l and MC-2)	2	2.4	X	X
Deep Creek (DC-l)	1	1.2	X	X
Napias Creek (NC-l)	1	1.3	X	
Big Deer Creek (BDC-1)	1	2.5	X	
Beaver Creek (BC-1)	1	1.0	X	
Clear Creek (CC-l)	1	2.5	X	X

Table Bl-2

PANTHER CREEK HABITAT TYPES

Habitat type	Description	Length (mi)	Total (%)
A	Pool-Cascade-Boulder	9.8	23.1
B	Spawning (Class 1) - Small Substrate	2.25	5.3
C	Spawning (class 2) - Large Substrate	6.65	15.6
D	Riffle - ripple - run	9.25	21.8
E	Riffle - ripple	14.55	34.2
		42.5	100.0

- Presence of fish barriers
- Variety of habitat types

The select ion of study reaches on Panther Creek was made following three complete surveys of the stream from mouth to headwaters, a distance of 42.5 mi. The entire stream was stratified into five discrete habitat types representing varying stream lengths as shown in Table Bl-2.

Five study sites were selected on Panther Creek to allow detailed assessments of each habitat type. The stream was stratified by major tributary and study stations randomly located using an HP-11C random number generator. Final stations included sites above and below Blackbird and Big Deer creeks (Figure Bl-1).

Reach lengths surveyed in the tributary streams ranged from 1.0 mi in Beaver Creek to 2.7 mi in Musgrove Creek (Table Bl-1).

B1.2 PEDESTRIAN HABITAT SURVEYS

Prior to the selection of study stations and site-specific analyses, a pedestrian habitat survey was conducted on each of the eight study streams. The surveys were used for characterizing fish habitats, evaluating physical and hydraulic conditions, and assessing potential use of the streams by anadromous salmonids. The surveys were also used for selecting representative study reaches for detailed quantitative and qualitative habitat assessments.

The surveys were conducted in an upstream direction beginning at the stream mouth. The general procedure used involved a qualitative-semiquantitative assessment of habitat characteristics at 300 ft stream intervals (transects). The reach of stream surveyed was variable and depended on the habitat conditions encountered and the potential value of the stream to anadromous salmonids.

Information collected at each transect included:

- Habitat type - classified as pool, riffle, cascade, ripple, run, or glide (USFS 1976)
- Water depth (ft) and velocity (fps)
- Stream width (ft)
- Substrate composition (visual characterization)
- Imbededdedness (%) - defined as the relative degree to which the largest sized bottom elements are surrounded and partially covered by smaller substrate
- Stream bank stability (%)

In addition, any important habitat areas (e.g., spawning, rearing habitats) and limiting factors, such as fish barriers or areas where fish passage may be a problem, were noted. Several photographs were taken during each stream survey. All data were recorded on specially prepared field forms; completed copies are included in Volume II, Section 1 of this report.

B1.3 OKJALITATIVE HABITAT ASSESSMENT

A qualitative evaluation of existing aquatic habitats within each study reach. was made using procedures modified after the General Aquatic and Wildlife System (GAWS) methodology (USFS 1976) and the Stream Reach Inventory and Channel Stability Index (SRICSI; Pfankuch 1975). The evaluation included an assessment of the following parameters:

- Substrate composition - ocular percentage estimates of boulder, cobble, rubble, gravel, sand, and silt
- Imbeddedness (%) - the relative degree to which the largest sized bottom elements of a stream segment are surrounded and partially covered by smaller substrate
- Riffle quality - related to substrate composition and water depths
- Pool quality - related to pool length, depth, and abundance of cover

- Percentage cover of overstory and understory riparian vegetation
- Bank composition and stability

All data were recorded on specially prepared stream habitat survey forms; copies of all completed forms are presented in Volume II, Section 2 of this report.

As part of this assessment, various water quality parameters were also measured including:

Parameter	Instrument
Dissolved oxygen (mg/l)	Altex/Beckman Model II Specific Ion Meter System; Yellow Springs Instrument (YSI) Model 54-ARC
Air and Water Temperature (°C)	Altex/Beckman Model II Specific Ion Meter System; YSI Model 54-ARC
Conductivity (umhos/cm^2)	Altex/Beckman Model II Specific Ion Meter System; Myron L - Model EP conductivity meter
pH	Altex/Beckman Model II Specific Ion Meter System; Orion Model 221 pH meter

Bl.4 QUANTITATIVE HABITAT ASSESSMENT

Over 15 different methods are available for use in habitat surveys. These range from rapid, largely subjective techniques such as the General Aquatic and Wildlife System (GAWS, USFS 1976) and the Stream Reach Inventory and Channel Stability Index (SRICSI, Pfankuch 1975), to more sophisticated, objectively based methods such as the Habitat Ouality Index (HOT, Binns 1979) the Habitat Suitability Index model (HSI, Raleigh et al. 1984), and the USFWS Instream Flow Incremental Methodology (IFIM, Bovee 1982; Milhous et al. 1984). Wesche (1984) provided a general review and comparison of the above techniques. Based on the need for an objective assessment of habitat in the Panther Creek drainage, the IFIM was selected for making quantitative habitat estimates.

As noted by Milhous et al. (1984) and Bovee (1982), the IFIM comprises both hydraulic and habitat models that, when interfaced, provide a means of estimating habitat as a function of streamflow. This is accomplished through the use of the Physical Habitat Simulation System (PHABSIM). Operationally, PHABSIM uses habitat suitability curves very similar to the suitability index graphs used in the HSI model. The curves represent the physical and hydraulic parameters preferred by a particular fish species and life stage. Because the method employs hydraulic simulation models, habitat can be incrementally projected with changes in streamflow.

The IFIM is based on establishing a stage-discharge relationship that allows the determination of various hydraulic and physical parameters at streamflows other than those at the time of field studies. This relationship is then used for quantifying habitat at the varying flows.

With respect to habitat and efforts to calculate smolt production, it can be generally assumed that the summer-fall low flow conditions limit fish production. This assumption, as noted by Chapman (1966) is generally valid, although other investigators (Chapman and Bjornn 1969; Mason 1976) have reported that winter habitat conditions can also be limiting. For the Panther Creek Project, all field data were collected in September during low flow conditions. The use of the IFIM provided a means for evaluating habitat availability at a range of flows extending from approximately 0.4 to 2.5 times the field measured flow (Milhous et al. 1984).

B1.4.1 Hydraulic Parameters

Within each study reach several cross-channel transects were located and surveyed-in to characterize prevailing physical, hydraulic and habitat conditions (see Section B3 for transect locations at each station). Such transects were generally located at hydraulic controls and major changes in channel configuration, and in areas representing different habitat types including spawning and juvenile rearing. Each transect was marked with a permanent headstake (l/2 in. rebar).

Headstake elevations were determined by differential leveling techniques (using an automatic level), with station numbers assigned to each headstake based on distance between adjacent transects. A staff gage was installed in close proximity to each reach to allow periodic monitoring of water levels during field measurements.

As part of the data collection, a streambed cross-sectional profile was measured at each transect using an automatic level and Philadelphia rod. Vertical elevations (Y-coordinates) and horizontal distances (X-coordinates) referenced from each station headstake were taken at specific increments across the transect (Figure Bl-2). The number and spacing of measurements was based on the width of the stream, with consideration for sufficient measurements (minimum of 10) for an accurate determination of stream discharge (BOR 1975). Water-surface elevations were measured near the right and left banks of each transects.

Water depths and mean column velocities were measured along each transect at the same locations as the vertical profile measurements (Figure Bl-2). Water velocities were measured at 0.6 of the depth when depths were less than 3.0 ft, and at 0.2 and 0.8 when depths exceeded 3.0 ft. Water velocities were measured with either a Marsh-McBirney Model 201 or a Pygmy current meter. Water depths were measured with a top setting rod and a Philadelphia rod. All data were recorded on specially prepared field forms. Copies of all completed data forms are included in Volume II, Section 3 of this report.

Bl.h.2 Physical Parameters

In conjunction with the hydraulic measurements, the substrate and cover characteristics present within a 0.5 ft radius of each vertical were assessed and recorded as noted above.

Substrate was coded using a two-digit coding format patterned after the AEIDC (1982) code (Table Bl-3). Substrate was characterized by assigning two index values representing the dominant and subdominant size materials present. The integer in the l's place denoted the dominant size; the decimal point, the

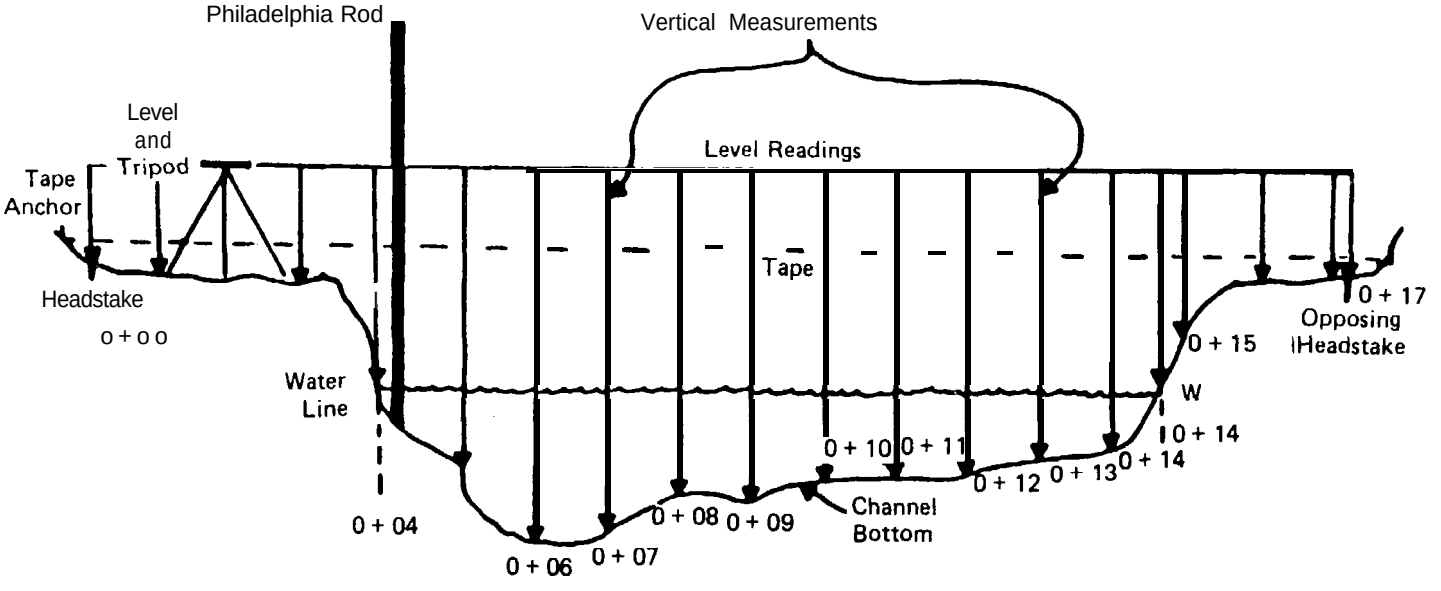


Figure B1-2 CROSS-SECTIONAL PROFILE OF A HYPOTHETICAL TRANSECT 0+00 SHOWING LOCATIONS OF HEADSTAKES AND VERTICAL MEASUREMENTS AS UTILIZED DURING THE PANTHER CREEK QUANTITATIVE HABITAT ASSESSMENT

subdominant size. As an example, a mixture of large cobble and coarse gravel is represented by 7.5; a mixture of sand and fine gravel, in order of dominance, is coded as 2.3.

Table Bl-3

SUBSTRATE CODES USED FOR DESCRIBING SIZE CLASSES OF BED MATERIALS FOR THE PANTHER CREEK PROJECT

Substrate Index Value	Classification	Particle Size (In.)
9	Bedrock	
8	Boulder	>9.8
7	Large cobble	5.0-9.8
6	Small cobble	2.5-5.0
5	Coarse gravel	1.3-2.5
4	Medium gravel	0.25-1.3
3	Fine gravel	0.08-0.25
2	Sand	0.002-0.08
1	Silt/Clay	co.002
0.1	Detritus/Vegetation	

Adapted from AETDC 1982

Cover was evaluated and classified as grass, overhead vegetation, submerged vegetation, undercut banks, boulders, rubble, and logs.

Photographs were taken of each transect to compare habitat types. In addition, representative upstream and downstream photographs were taken to depict general site and flow conditions as well as areas of special concern (e.g., passage problems, sediment deposition, effluent inflow etc.). A generalized schematic drawing of each study reach was prepared in the field (copies presented in Section B3) reflecting transect locations and orientations, and important stream and habitat components (e.g., riffles, pools, runs, spawning areas, cover, etc.).

B1.5 DATA ANALYSIS/COMPUTER MODELING

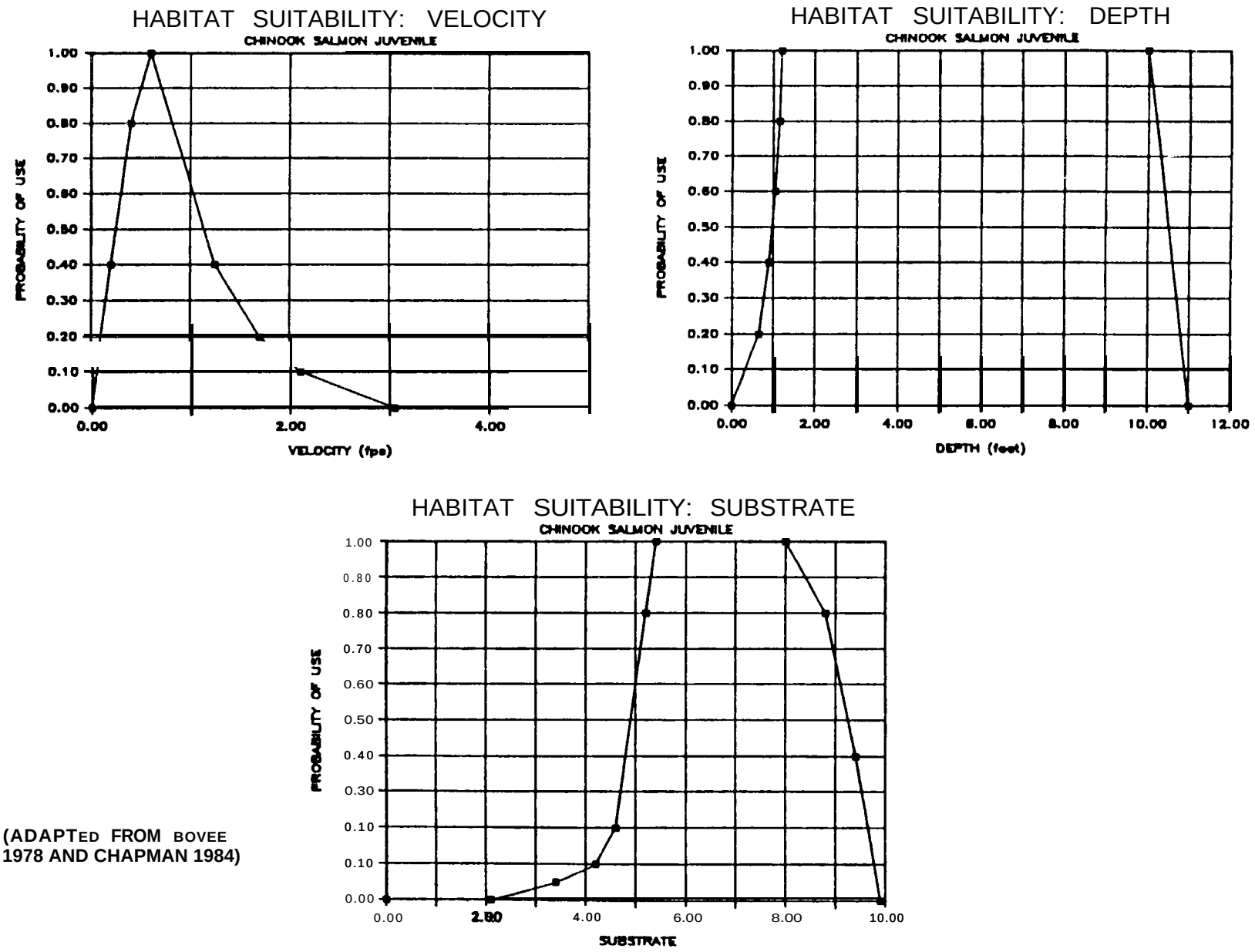
The quantitative habitat data were analyzed using the Physical Habitat Simulation (PHABSIM) model on file at Bechtel. Detailed descriptions of the theory and use of this system are provided in Milhous et al. (1984), Bovee and Milhous (1978), and Bovee (1982).

Hydraulic data were calibrated using a two-step procedure described by Milhous (1984). Initially, all data were calibrated to water surface elevations (WSE) using the IFG-2 model. This model was then used to predict water surface elevations (WSEs) for two input discharges that bracketed flows of interest. The predicted WSEs were then input to a personal computer version of the IFG-4 model (Payne 1985) and hydraulic simulations made at selected flow increments. This approach was relatively quick and yet afforded a level of calibration deemed sufficient for this type of study (Bovee, USFWS 1985, pers. conml.).

The IFG-3 (HABTAT) model was then used to translate the hydraulic data into available fish habitat, termed Weighted Usable Area (WUA), for each species and life history stage of concern. For the Panther Creek Project, the following fish species and life history stages were evaluated:

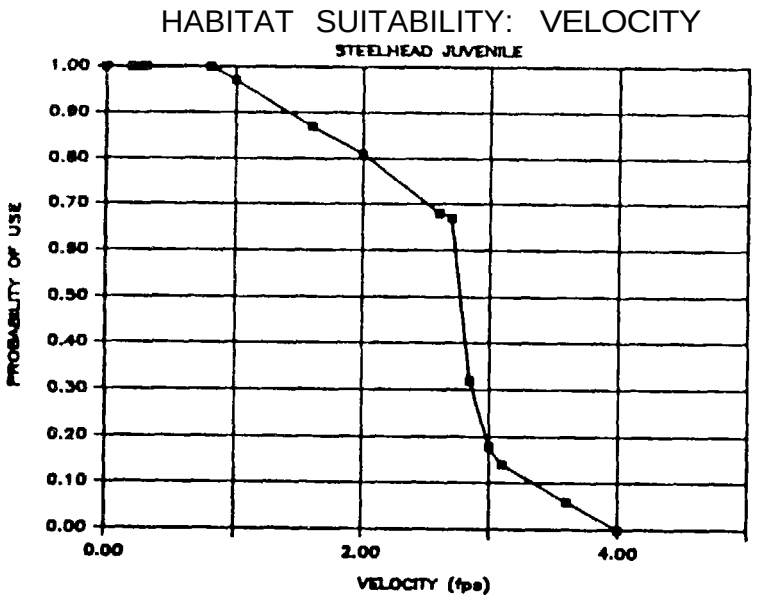
Species	Life History Stage
Chinook salmon	Spawning Juvenile
Steelhead trout	Spawning Juvenile

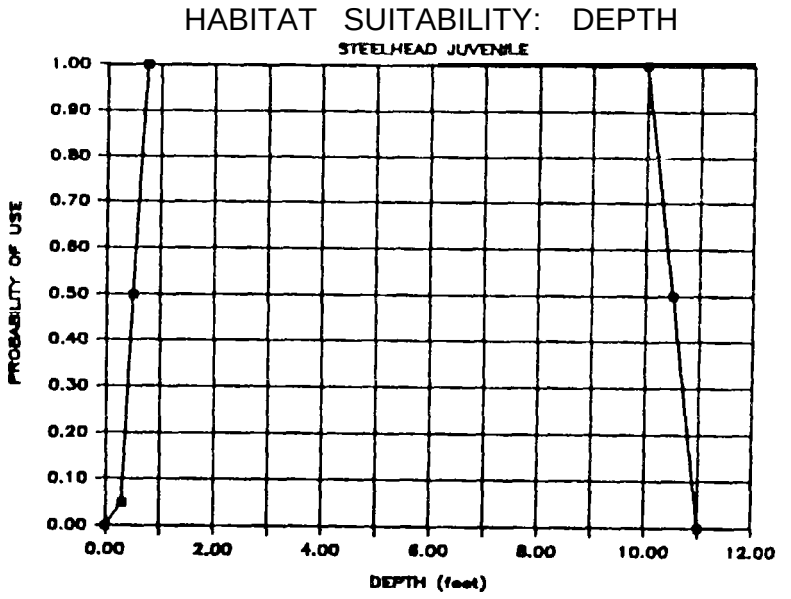
The habitat suitability curves used in the modeling of juvenile habitat were adapted from curves prepared by Bovee (1978) and Chapman (1984) based largely on data collected by Everest and Chapman (1972) (Figures Bl-3 and Bl-4). Steelhead and spring chinook spawning curves were modified from Bovee (1978) using data collected by Reiser and White (1981) (Figures Bl-5 and Bl-6). Reiscr and White measured over 150 chinook salmon redds and 84 steelhead redds in streams within the Salmon River drainage. The above curves depict the suitability flow-dependent variables (depth, velocity, and substrate) with respect to habitat requirements of the target species.

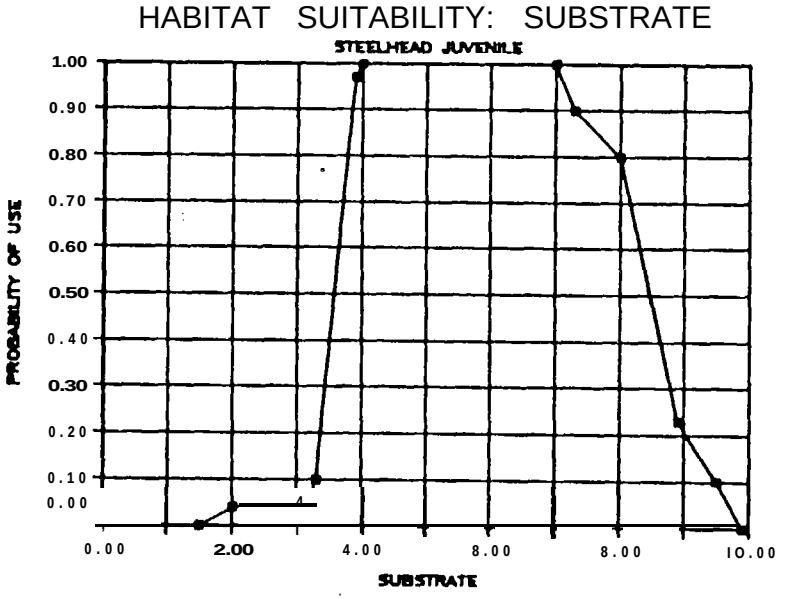


(ADAPTED FROM BOVEE 1978 AND CHAPMAN 1984)

figure **B1-3 CHINOOK SALMON JUVENILE HABITAT SUITABILITY CURVES USED ON PANTHER CREEK PROJECT**

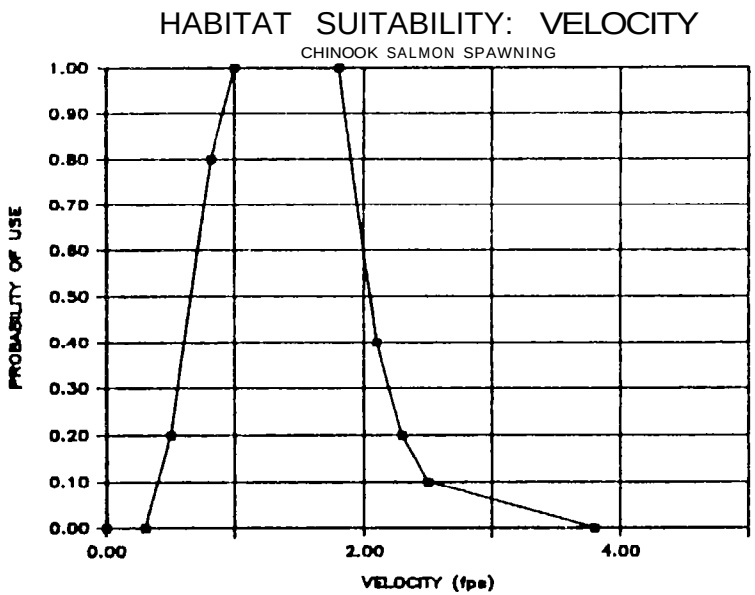


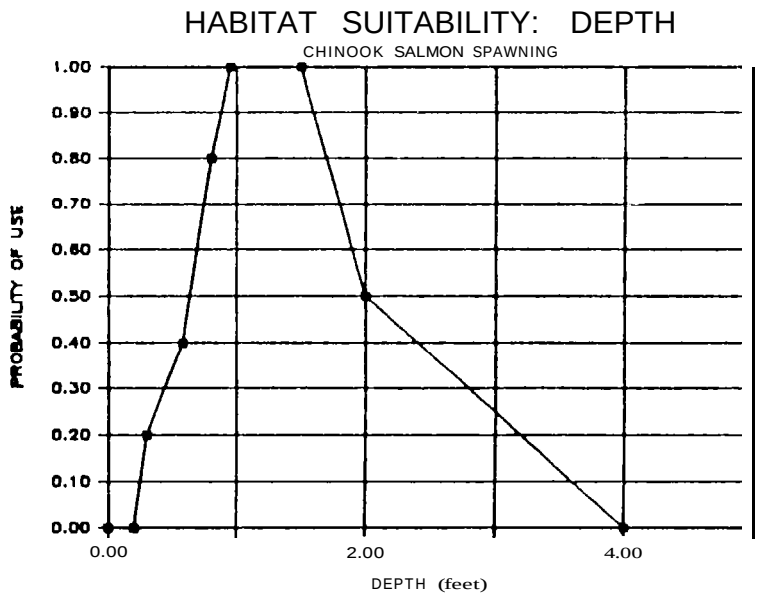


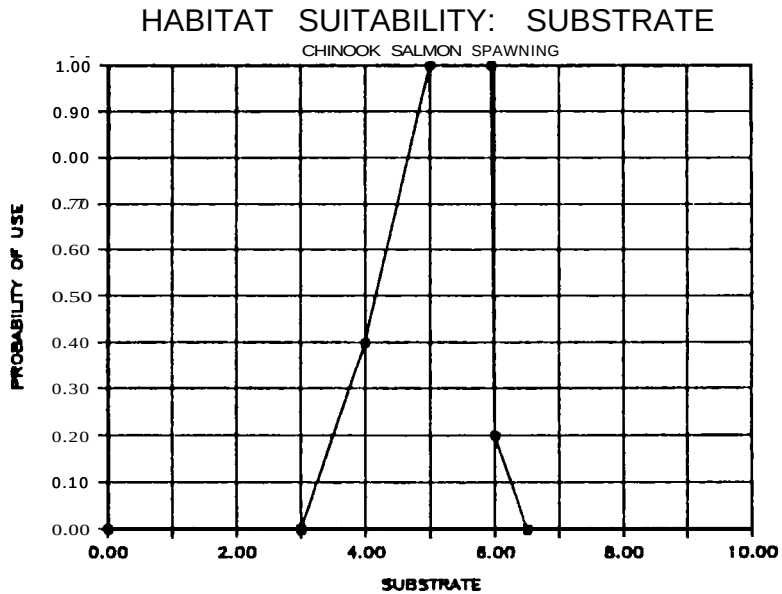


(ADAPTED FROM BOVEE 1978 AND CHAPMAN 1984)

Figure B1-4 **STEELHEAD JUVENILE HABITAT SUITABILITY CURVES USED ON THE PANTHER CREEK PROJECT**







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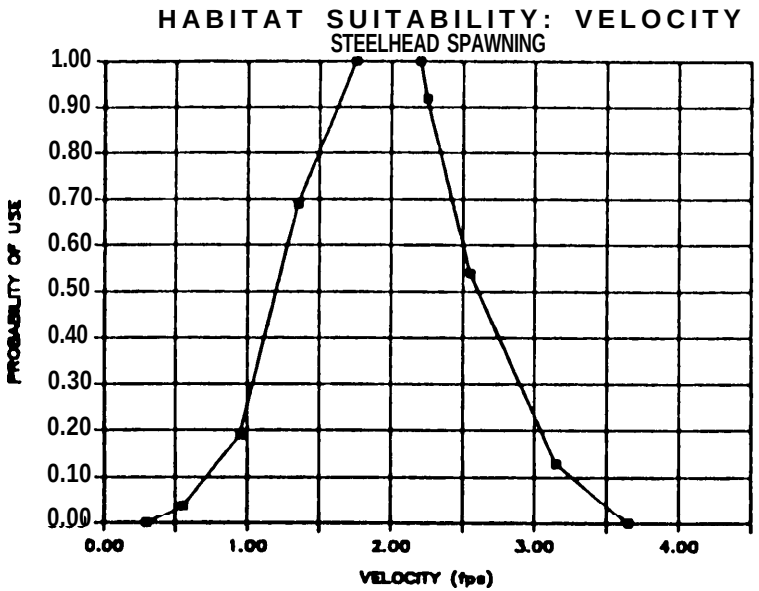
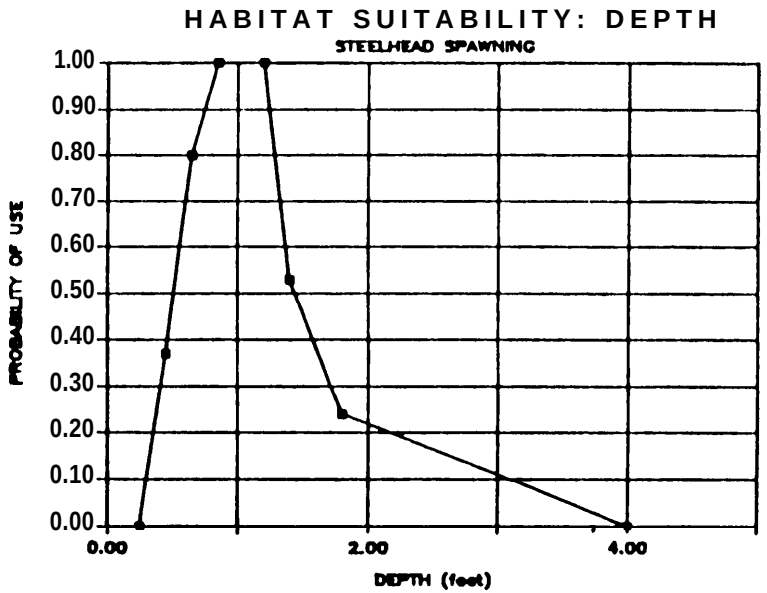
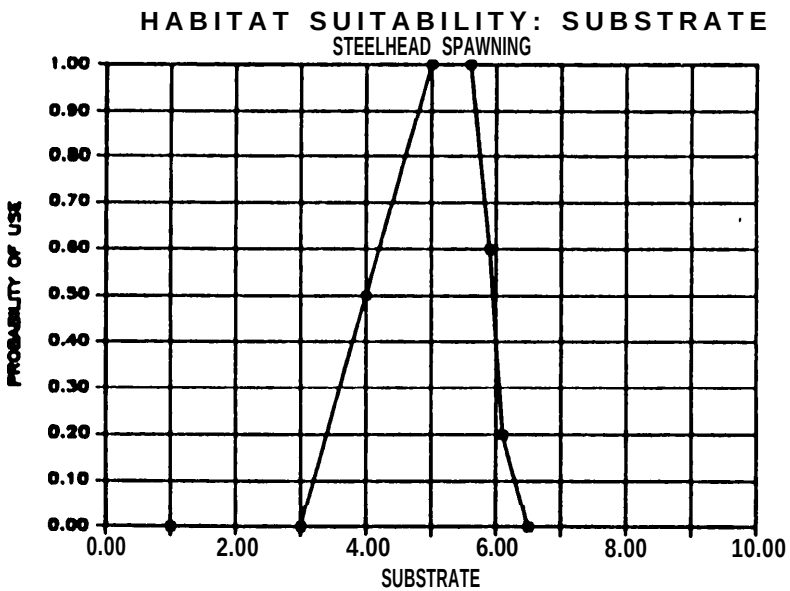
1978 AND REISER AND WHITE 1981)

Figure B1-5 CHINOOK SALMON SPAWNING HABITAT SUITABILITY CURVES USED ON THE PANTHER CREEK PROJECT







(ADAPTED FROM BOVEE 1978
AND REISER AND WHITE 1981)

Figure B1-6 STEELHEAD SPAWNING HABITAT SUITABILITY CURVES USED ON THE PANTHER CREEK PROJECT

Habitat-flow simulations were subsequently made for each stream at flow increments ranging from 1 to 20 cfs (depending on stream size). The resulting WUA per species life history stage per stream were plotted against flow.

For streams in which only one reach was measured, the total habitat available for a given life stage for a specified flow was determined by:

$$HA = WA \times L$$

where,

HA = Total stream segment habitat area (ft^2)

WA = Weighted Usable Area (ft^2/mi)

L = Length of stream representative of the study reach having suitable water quality and temperatures

Thus, the habitat present in the representative reach was extrapolated to include other stream segments having similar habitat characteristics.

Because multiple reaches were present in Panther and Moyer creeks, the determination of total available habitat was computed as:

$$HA = WUA_l \times L_1 + WUA_2 \times L2 + . . . WUA_n \times L_n$$

Where,

WUA_l = Weighted Usable Area per unit length of stream represented by the upper study reach

Ll = Length of stream represented by the upper study reach

WUA_n = Weighted Usable Area per unit Length of stream represented by the nth study site

L_n = Length of stream represented by the nth study site

For Panther Creek, this was done for each of the five modeled habitat types. This required adjusting the habitat-flow relationships developed at the stations representing each habitat type to compensate for differences in stream discharge and morphology upstream and downstream from the stations. For example, a type A habitat-flow relationship developed in the upper section of Panther Creek could not be automatically applied to the lower type A reaches since streamflows may be 5 to 10 times greater. To compensate for this variation, the habitat (rearing or spawning) present at each modeled station for the selected flows was expressed as a percentage of the total stream area available. These same percentages were then applied to other sections of stream having the same habitat types; total surface areas were computed from reach lengths and estimated widths. This determination can be expressed as a simple ratio of WUA:Total Area (TA) for the flow selected:

$$\frac{WUA_{A-1}}{TA_{A-1}} = \frac{WUA_{A-n}}{TA_{A-n}}$$

Where,

WUA_{A-1} = Weighted Usable Area of habitat type (A) at the first (1, modeled) station

TA_{A-1} = Total Surface Area within modeled station

WUA_{A-n} = Weighted Usable Area of habitat type (A) at the nth section (Unknown)

TA_{A-n} = Total Surface Area at the nth section (computed from estimated reach Length and width)

Total habitat was estimated for a band of flows centered around the field calibration flow measured in September. Such flows were typical of summer-fall low flow conditions that are generally considered limiting to salmonid production.

Bl.6 SMOLT PRODUCTION ESTIMATES

Estimates of smolt production were based on availability of both juvenile and spawning habitat and on fish spatial requirements (see Section 7). For juvenile habitat, smolt production for both species was estimated for each stream as:

Total juvenile habitat at limiting flow (ft^2) x spatial needs of smolt ($smolt/ft^2$) = Total no. smolts

Steelhead spatial needs were estimated at 0.0057 $fish/ft^2$, which is the average density of age I+ and II+ fish as reported for several Idaho Streams by Reiser and Bjornn (1979). Chinook salmon space requirements were estimated at 0.096 $fish/ft^2$.

For spawning, smolt production estimates were based on the following:

- Average redd spatial needs (area) per spawning pair (based on Burner 1951; Orcutt et al. 1968; Reiser and Bjornn 1979):

Species	Average area of redd (sq ft)
SH	35.5
CH	58.1

- Fecundity of the female (no. of eggs) Estimated at:

  Steelhead - 3,500 (Bell 1973)

  Chinook - 5,000 (Bell 1973)

- Percent survival - egg to alevin

  25 percent survival (0.25)

- Percent survival - alevin to fry

  50 percent survival (0.50)

  Percent survival - fry to juvenile (smolt)

  25 percent survival (0.25)

The above fecundity and survival estimates result in an estimated number of smolts/redd for steelhead and chinook of 109 and 156, respectively.

B1.7 ECONOMIC ANALYSIS (see Section 7, Main Report)

B1.8 FISH TISSUE ANALYSIS

The fish tissue analysis study was conducted to determine the potential human health hazards from the consumption of fish taken from Panther Creek below Blackbird and Big Deer creeks. Three collection sites were selected corresponding to the following locations (see Figure 2-3):

- Above Blackbird Creek (upper)
- Below Blackbird Creek but above Big Deer Creek (middle)
- Below Big Deer Creek (lower)

Large, "wild" fish were collected since these fish would spend the longest time in the stream and thus would have the greatest exposure to the toxic effluent. Fish were collected either by angling or electrofishing techniques using a Coffelt backpack electrofishing unit.

A total of 20 fish were collected from the three areas including 6 from the upper, 5 from the middle, and 9 from the lower site. All fish were labelled and shipped on ice to the laboratory for analysis.

Laboratory analysis of the fish was limited to muscle tissue, which represents the consumable portion of the fish. Analysis included the evaluation of five metals (copper, cobalt, iron, lead, and zinc) selected on the basis of their relatively high concentration In mine drainage waters (see Platts et al. 1979). Metals analyses followed methods specified by the U.S. Department of Agriculture's Food and Drug Administration (FDA).

Section B2

RESULTS

B2.1 QUALITATIVE AND QUANTITATIVE SURVEYS

Qualitative assessments, which included pedestrian habitat surveys, were conducted on portions of eight streams in the Panther Creek drainage (Table Bl-1). The surveys were made during a 20-day period extending from September 11 to September 30, 1984 and during a 3-day period from September 9 to 11, 1985.

Estimates of the quantity of habitat available in the Panther Creek drainage were based on the results of the HABTAT modeling described in Section B1.5. Estimates of both spawning and rearing habitat were made from which independent estimates of smolt production could be derived. This enabled a determination of the limiting habitat component in the drainage (i.e., spawning on rearing habitat);' Habitat estimates were made for five streams in the system including Panther Creek, Clear Creek, Deep Creek, Moyer Creek, and Musgrove Creek. No estimates were made for Napias, Big Deer, or Beaver creeks since they contained limited fish production potential as determined by the qualitative surveys (see below). Detailed results of the quantitative survey, including all hydraulic and habitat computer printouts, are presented in Volume II, Section 5.

B2.1.1 Panther Creek

Following the completion of the pedestrian habitat survey that covered 42.5 mi of stream, discrete parcels of Panther Creek were classified into one of the five habitat types (Table B2-1). The total length of stream representing each type was then summed. Overall, about 34 percent of Panther Creek consisted of riffle-ripple habitat, 23 percent of pool-cascade, 22 percent of riffle-ripple-run, and collectively about 21 percent of spawning habitat. Of this latter amount, the majority of the Class I spawning habitat (5 percent of total) was above Blackbird Creek.

Table B2-1

STREAM HABITAT SURVEY OF PANTHER CREEK, SEPTEMBER 1984

Reach Begin (miles)	Reach End (miles)	Reach Length (miles)	Habitat Type [a]	Comments/Tributaries
0	0.26	0.20	A	Survey begins at Mouth of Panther Creek
0.20	0.25	0.05	D	(Confluence with Salmon River)
0.25	0.50	0.25	A	
0.50	1.00	0.50	D	0.9 - Pretty Gulch/l.00 - Bear Gulch
1.00	1.65	0.65	E	1.60 - Braided
1.65	1.70	0.05	A	
1.70	2.00	0.30	E	
2.00	2.20	0.20	D	
2.20	2.35	0.15	E	
2.35	2.45	0.10	D	2.40 - Braided
2.45	2.50	0.05	A	
2.50	2.80	0.30	D	
2.80	3.00	0.20	E	3.00 – Hot Springs Creek
3.00	3.20	0.20	D	
3.20	4.70	1.50	C	3.40 - Clear Creek/4.00 - Lower End
4.70	5.00	0.30	E	PC-5/4.10 - Upper End PC-5 (Modeled Type C)
5.00	5.35	0.35	C	
5.35	5.60	0.25	D	5.20 - Beaver Creek
5.60	5.80	0.20	E	
5.80	6.50	0.70	D	
6.50	6.70	0.20	A	6.50 - Birch Creek
6.70	7.45	0.75	D	
7.45	8.60	1.15	A	
8.60	8.90	0.30	D	8.85 – Squaw Camp Creek
8.90	9.00	0.10	A	
9.00	9.30	0.30	A	9.25 - PC-4 (Modeled Type A)
9.30	9.45	0.15	C	
9.45	9.90	0.45	D	
9.90	10.6	0.70	A	
10.60	11.10	0.50	D	10.8 - Fritzer Gulch
11.10	11.50	0.40	A	11.35 - Very Steep Reach
11.50	11.60	0.10	E	
11.60	11.85	0.25	A	
11.85	12.00	0.15	E	
12.00	12.20	0.20	A	
12.20	12.60	0.40	D	12.55 - Big Deer Creek
12.60	12.80	0.20	A	
12.80	12.40	0.60	D	
13.40	13.55	0.15	A	13.45 - IDF&G Flag
13.55	13.85	0.30	D	13.75 - Little Deer Creek
13.85	13.90	0.05	A	
13.90	14.30	0.40	D	

Table B2-1 (Cont'd)

STREAM HABITAT SURVEY OF PANTHER CREEK, SEPTEMBER 1984

Reach Begin (miles)	Reach End (miles)	Reach Length (miles)	Habitat Type [a]	Comments/Tributaries
14.30	14.65	0.35	A	
14.65	15.05	0.40	D	
15.05	15.55	0.50	A	15.55 - Little Jureano Creek
15.55	15.95	0.40	D	
15.95	16.15	0.20	A	16.1 - Big Jureano Creek
16.15	16.25	0.10	D	
16.25	17.20	0.95	A	17.15 - Quartz Gulch
17.20	17.35	0.15	D	
17.35	17.50	0.15	A	
17.50	17.65	0.15	D	
17.65	17.75	0.10	A	
17.75	17.90	0.15	D	17.85 - White Horse Basin Trail
17.90	17.95	0.05	A	
17.95	18.45	0.50	D	
18.45	18.65	0.20	C	18.6 - Napias Creek
18.65	18.85	0.20	E	
18.85	19.35	0.50	A	
19.35	19.65	0.30	D	19.4 - Deep Creek
19.65	19.75	0.10	A	
19.75	20.25	0.50	D	20.2 - PC-3 Station (Modeled Type D)
20.25	20.70	0.45	B	
20.70	21.30	0.60	E	21.2 - IDF&G Station
21.30	21.95	0.65	C	
21.95	22.65	0.70	E	22.1 - Colbalt Townsite
22.65	23.15	0.50	A	Road construction has resulted in a
23.15	23.35	0.20	D	narrowing of the channel.
23.35	23.65	0.30	A	
23.65	24.75	1.10	E	23.7 - Fawn Creek/24.15 - Blackbird
24.75	24.80	0.05	C	Creek/24.55 - IDF&G Station
24.80	25.25	0.45	E	25.05 - Dummy Creek/25.2 - Copper Creek
25.25	25.35	0.10	D	
25.35	26.15	0.80	E	25.4 - IDF&G Station/25.65 -
26.15	26.25	0.10	A	IDF&G Station
26.25	26.25	0.40	E	
26.25	26.75	0.10	A	26.8 - Woodtick Creek
26.75	29.00	2.25	E	27.75 - USFS Reach (Boulders)/27.8 -
29.00	29.75	0.75	C	McDonald Gulch/27.9 - Habitat
29.75	30.20	0.45	B	Improvement/28.1 - PC-2 Station (Modeled Type E)
30.20	31.75	1.55	C	28.9 - Moyer Creek/29.15 - Musgrove
31.75	32.05	0.30	E	Creek - 30.8 - Porphory Creek
32.05	32.65	0.60	C	32.2 - 4th July Creek

Table B2-1 (Cont'd)

STREAM HABITAT SURVEY OF PANTHER CREEK, SEPTEMBER 1984

Reach Begin (miles)	Reach End (miles)	Reach Length (miles)	Habitat Type [a]	Comments/Tributaries
32.65	33.60	0.95	A	33.3 - Coral Creek
33.60	34.45	0.85	C	34.0 - Cabin Creek
34.45	34.85	0.40	E	
34.85	35.25	0.40	A	
35.25	35.45	0.20	E	
35.45	36.05	0.60	B	
36.05	36.35	0.30	E	
36.35	36.95	0.60	A	Forest cover, debris jam (Barriers)/
36.95	38.30	1.35	B	excellent spawning grave1/37.9 -
38.30	39.10	0.80	E	beaver dams/extensive activity
39.10	39.85	0.75	B	forest cover, debris jam/39.25 -
39.85	42.50	2.65	E	Opal Creek/39.5 - PC-1 (Modeled Type B) Forest Canopy (Deadfall) some good pools/access probably a problem/some good pockets of spawning gravel/ 42.3 - Otter Creek/43.7 - Panther Creek very small - Meadow Area/ 43.85 - Panther Creek goes underground

[a] Habitat Type Classification (USFS 1976):

Type	Classification
A	Pool/Cascade/Boulder
B	Spawning - Class I
C	Spawning - Class II
D	Riffle - Ripple - Runs (Lower)
E	Riffle - Ripple (Upper)

On a mileage basis, the first 10 mi of Panther Creek contained primarily D and E type habitats, although A habitat dominated in the upper portions of the reach. The section was characterized by relatively wide spread-out channels with large substrate and little instream cover. The USFS has completed and monitors several habitat enhancement projects (boulder placement) that have added instream cover (May, USFS 1984 pers. comm.). Two major tributaries to lower Panther Creek - Clear Creek and Beaver Creek - enter the system at miles 3.4 and 5.2, respectively.

The next 5 mi of the stream are primarily pool-cascade habitat with large boulders and fast water velocities. Slopes in this section often exceeded 3 to 4 percent. The steepest reach of main Panther Creek extends from mile 11.1 to 11.5; the reach is boulder laden and could pose some passage problems (excessive velocity) at high flows. Big Deer Creek, which is a major conveyor of toxic effluent to the system, enters at mile 12.55.

From mile 15 to 20, the stream alternates between type A and D habitat. This section contains many boulders that create deep pools (exceed 5 to 6 ft) and resting areas. Napias Creek and Deep Creek enter the stream at mile 18.6 and 19.4.

The next 10 mi of Panther Creek are dominated by type E habitat that often extends in reaches over 1 mi in length, This section includes the Cobalt townsite (mile 22.1). Blackbird Creek enters at mile 24.1, Moyer Creek at 28.9, and Musgrove Creek at 29.2.

Habitat types C and A are dominant in the next 5 mi (miles 30 through 35) of Panther Creek, which extends from just above Musgrove Creek to above Cabin Creek. This section of stream flows through wide alluvial valleys that are used for livestock grazing. The Fomey Clay pits (see Section 3) border the reach of stream.

The upper 5 mi of Panther Creek (prior to headwaters) contain the best quality spawning grounds found in the stream. These are found in meadow areas and are characterized by relatively slow, meandering sections containing clean, 2 to

3 in. gravel. The reaches are bordered by willows and ridges, and include deep pool (3 to 4 ft deep) and backwater areas.

From the survey, five stations, one to represent each habitat type, were selected on Panther Creek for detailed modeling.

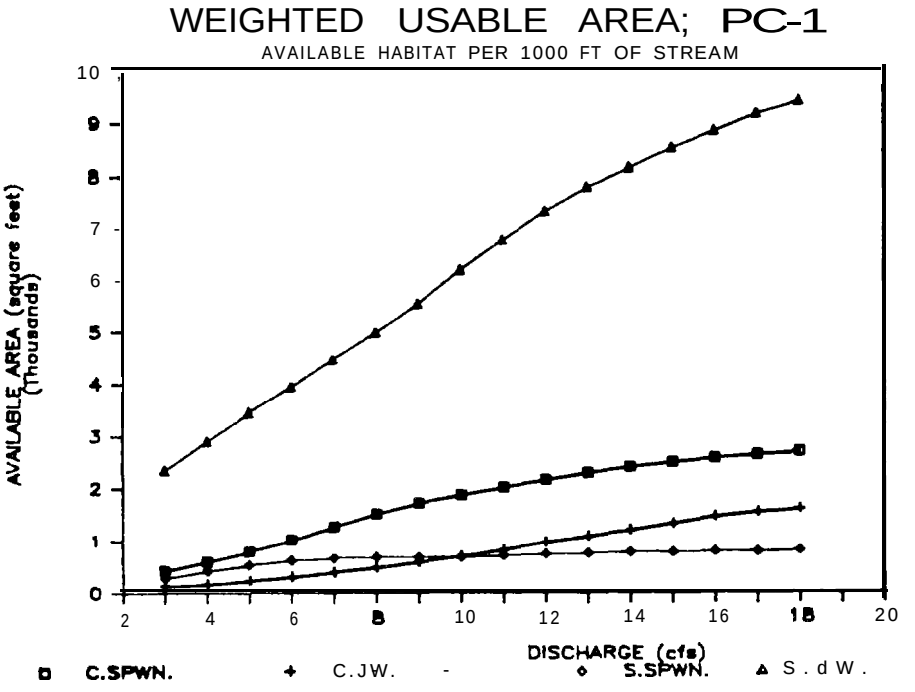
The habitat-streamflow relationships developed for the five stations are presented in Figures B2-1 through B2-3. The flows depicted encompass a range of 0.4 and 2.5 times the calibration flow measured at each site. In all cases and for all flows, more chinook spawning area is available than for steelhead, while the reverse is true for rearing habitat. However, these trends do not automatically apply with respect to smolt production estimates since spatial requirements for chinook and steelhead smolts differ widely.

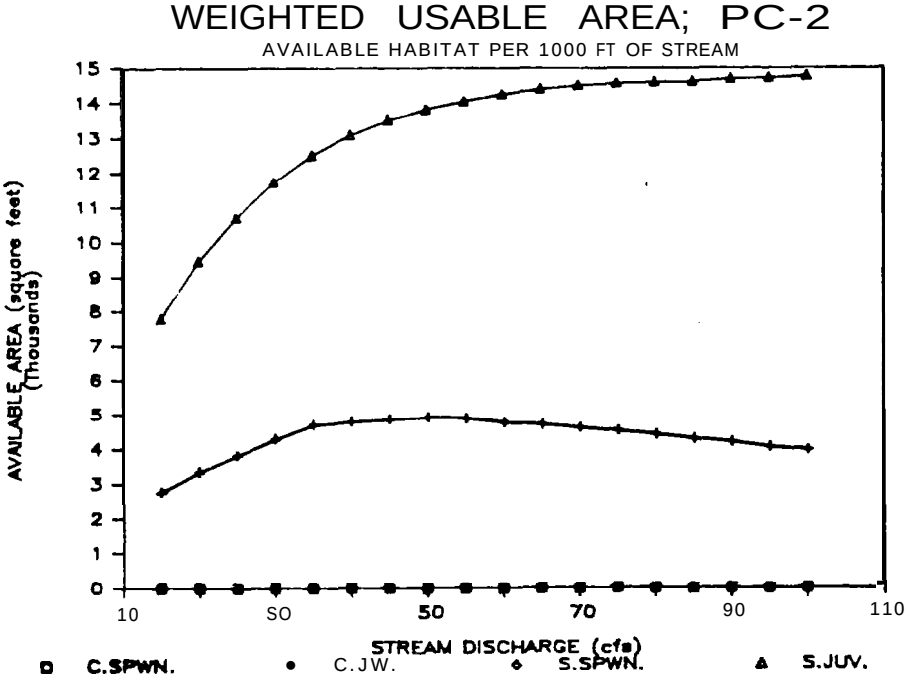
B2.1.1.1 Panther Creek - 1 (PC-l): Habitat Type - B

The uppermost (about 39 mi above the mouth) station on Panther Creek, PC-l, was the representative reach used to characterize Type B habitat. This station was located in a large meadow area just upstream from Opal Creek. The reach was bordered by an even mix of grass and shrubs (primarily willow, *Salix sp.*) (Table B2-2) and had a bottom composition comprised of coarse and fine gravels (Table B2-3). Although cattle activity was noticeable, the gravel interstices were well-washed; imbeddedness was about 10 percent.

At this location, the stream was relatively narrow and shallow having an average width of 17 ft, a depth of 0.6 ft, and water velocity of 0.73 fps (Table B2-4); discharge averaged 7 cfs. All measured water quality parameters were within acceptable limits for salmonid production (Table B2-5). However, dissolved oxygens were comparatively low (6.4 mg/l) with respect to the other stations.

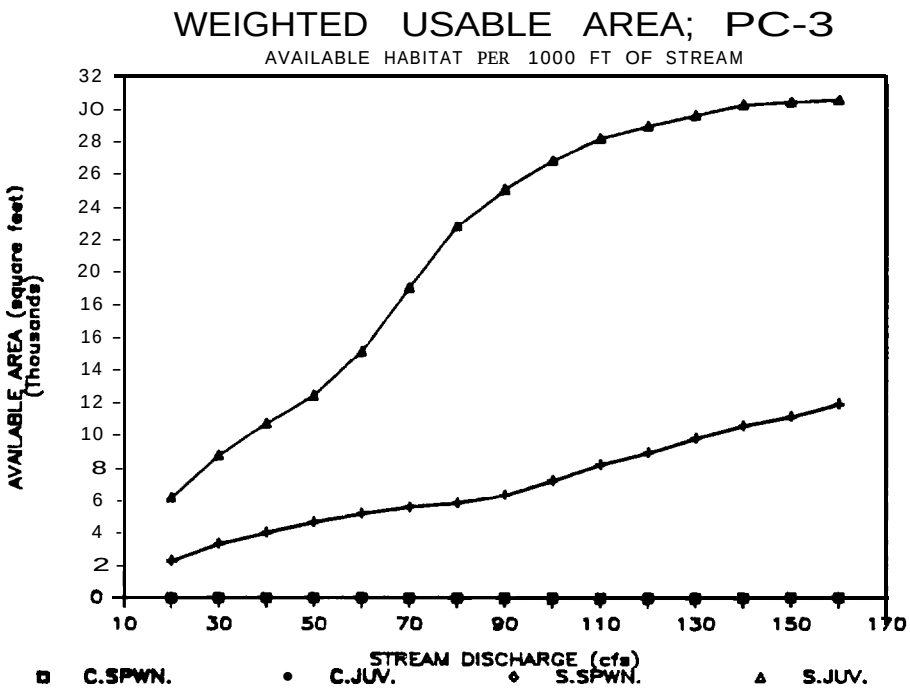
This station contained the greatest amount of chinook and steelhead spawning habitat per length of stream of all five Panther Creek stations (Figure B2-1). For the calibration (field measured) flow of 7 cfs, a total of 1,265 ft^2 and 663 ft^2 of chinook and steelhead spawning area were available per 1,000 ft of stream. These values represent 6 and 4 percent of

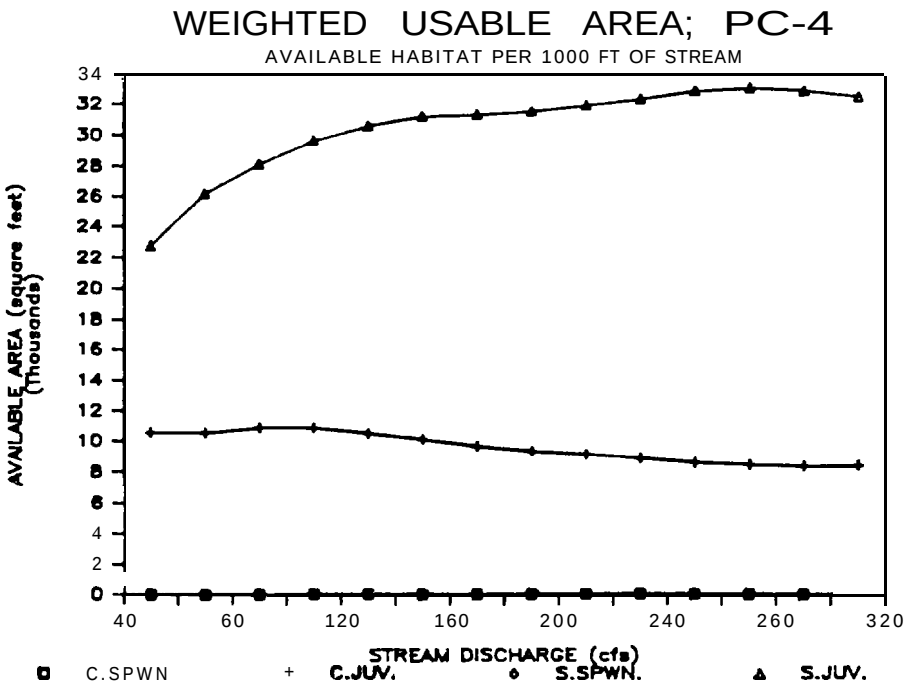




C = CHINOOK, S = STEELHEAD

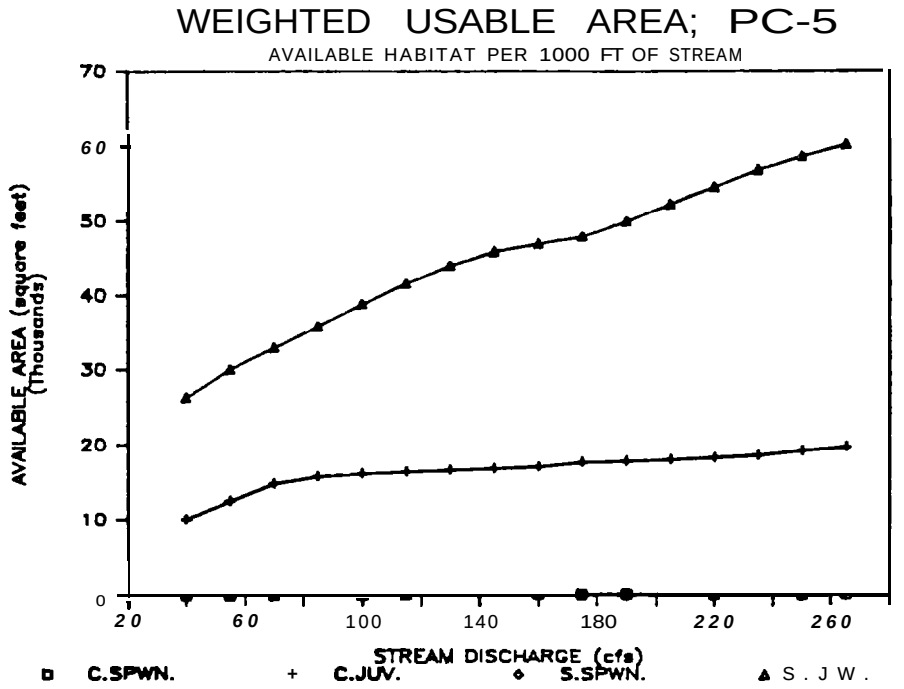
Figure B2-1 SPAWNING AND JUVENILE HABITAT – STREAMFLOW RELATIONSHIPS FOR CHINOOK SALMON AND STEELHEAD TROUT AS DEVELOPED FOR STATIONS PC-1 (UPPER) AND PC-2 (LOWER) ON PANTHER CREEK

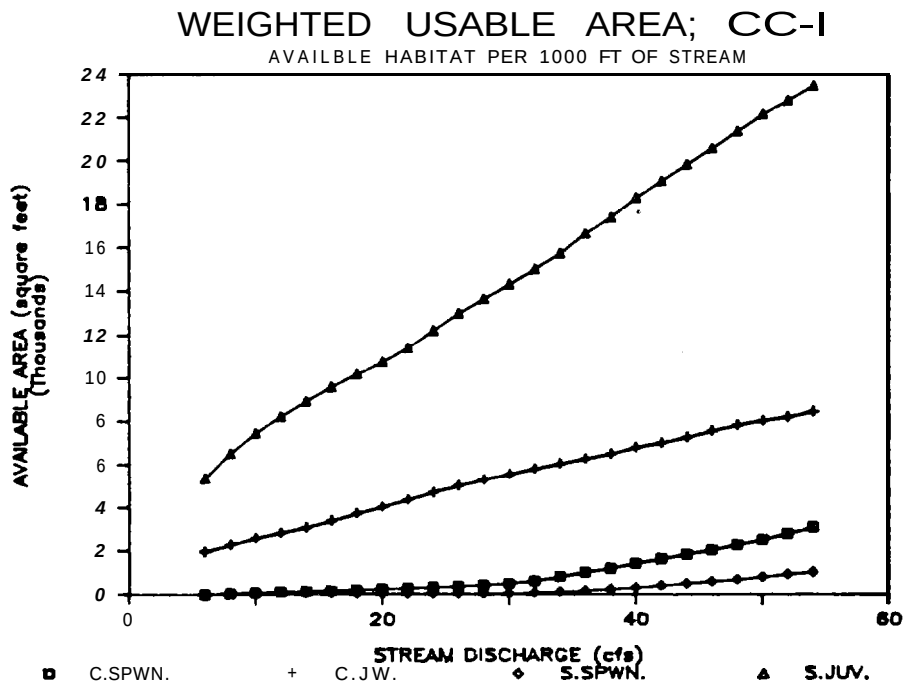




C = CHINOOK, S = STEELHEAD

Figure B2-2 SPAWNING AND JUVENILE HABITAT – STREAMFLOW RELATIONSHIPS FOR CHINOOK SALMON AND STEELHEAD TROUT AS DEVELOPED FOR STATIONS PC-3 (UPPER) AND PC-4 (LOWER) ON PANTHER CREEK





C = CHINOOK, S = STEELHEAD

Figure B2-3 SPAWNING AND JUVENILE HABITAT · STREAMFLOW RELATIONSHIPS FOR CHINOOK SALMON AND STEELHEAD TROUT AS DEVELOPED FOR STATIONS PC-5 (UPPER) ON PANTHER CREEK AND CC-1 (LOWER) ON CLEAR CREEK

Table B2-2

BANK-CLASS CHARACTERISTICS AT 15 STUDY STATIONS
WITHIN THE PANTHER CREEK DRAINAGE

Class	PC-1[a] (L/R)	PC-2 (L/R)	PC-3 (L/R)	PC-3A (L/R)	PC-4 (L/R)	PC-5 (L/R)	PC-6 (L/R)	DC-1 (L/R)	NC-1 (L/R)	BDC-1 (L/R)	MC-1 (L/R)	MC-2 (L/R)	MGC-1 (L/R)	BC-1 (L/R)	CC-1 (L/R)
Rock				25/10	25/40	-	-	0/60		10/10		60/0	20/0		
Gravel					0/5										
Sand					5/0	10/0	-	0/10							
Soil		10/0	0/5		5/0	20/10	20/0			5/0		0/10			
Grass	50/60	10/0	20/20	15/10	15/5	40/40	60/0	0/10	0/20	5/0	10/40	10/10	10/30	70/70	60/80
Shrub	50/40	50/50	70/40	30/60	20/40	30/40	10/0	80/20	70/80	20/30	80/50	20/40	30/20	25/25	40/20
Tree		30/50	10/35	30/20	30/10	0/10	10/0	20/0	30/0	60/60	10/10	10/40	40/50	5/5	

[a] L - Left bank facing downstream
R - Right bank facing downstream

Table B2-3

VISUAL CHARACTERIZATION OF SUBSTRAT t COMPOSITION AT 15 STUDY STATIONS
WITHIN THE PANTHER CREEK DRAINAGE

Stream-Station		Substrate Compostion (Percent)								
		Boulders >12 In.	Rubble 3-11 in.	Coarse Grave; 1-3 in.	Fine Gravel 0.1-1 in.	SalId	Silt	Shal e	Red rock	Imbeddcdness
Panther Creek	PC-1	0	0	60	20	10	10	0	0	10
Panther Creek	PC-2	20	70	5	5	0	0	0	0	10
Panther Creek	PC-3	15	50	15	5	5	10	0	0	50
Panther Creek	PC-3A	20	60	10	10	0	0	0	0	60
Panther Creek	PC-4	40	40	10	10	0	0	0	0	25
Panther Creek	PC-5	10	40	40	10	0	0	0	0	30
Panther Creek	PC-6	30	50	10	10	0	0	0	0	30
Deep Creek	DC-1	20	40	30	10	0	0	0	0	15
Napias Creek	NC-l	30	50	15	5	0	0	0	0	10
Big Deer Creek	BDC-1	30	40	20	5	5	0	0	0	20
Moyer Creek	MC-1	10	60	20	5	5	0	0	0	10
Moyer Creek	MC-2	0	20	60	10	10	0	0	0	10
Musgrove Creek	MCC-1	0	20	60	10	0	0	10	0	10
Beaver Creek	BC-1	20	70	5	5	0	0	0	0	15
Clear Creek	CC-1	10	20	50	10	10	0	0	0	0

Table B2-4

PHYSICAL AND HYDRAULIC CHARACTERISTICS OF 15 STUDY STATIONS
WITHIN THE PANTHER CREEK DRAINAGE

Station	Date	Total Stream Length (mi)	Total Length Surveyed (mi)	Reach Length (ft)	Gradient (%)	Average Width (ft)	Average Depth (ft)	Average Velocity (ft/s)	Average Discharge (cfs)	Fish Passage Problems	Spawning Area
PC-1	9/11/84	11.4	14.4	137.6	2.5	17.3	0.63	0.73	7.01	N	Y
PC-2	9/13/84	7.9	7.9	234.5	1.6	30	0.94	1.43	39.84	N	N
PC-3	9/15/84	10.9	10.9	421.5	1.5	47	0.98	1.37	57.60	N	Y
PC-3A										N	N
PC-4	9/17/84	5.2	5.2	243.5	2.1	55	1.54	1.58	122.21	N	Y
PC-5	9/22/84	4.0	4.0	519.5	1.2	72.5	1.24	1.13	101.56	N	Y
PC-6										N	N
Total		42.5	42.5								
DC-l	9/20/84	12	1.2	115.4	4.0	13.3	0.81	0.91	9.74	Y	Y
NC-1		14.4	1		3.8					Y	N
BDC-1			2.5		6.6					Y	N
MC-1	9/27/84	11.4	2.4	147	2.5	12.5	0.92	1.39	15.72	N	Y
MC-2	9/26/84			196	2.4	15.5	0.72	1.50	15.94	N	Y
MCN-1	9/29/84	11.1	2.7	165	3.4	15.3	0.66	0.96	8.91	Y	Y
BC-1		9.4	1.0		9.7					Y	N
CC-1	9/24/84	16.2	2.5	148.5	4.6	20.5	0.80	1.34	21.98	N	Y

Table B2-5

WATER QUALITY CHARACTERISTICS OF 15 STUDY STATIONS
WITHIN THE PANTHER CREEK DRAINAGE

Stream	Station Number	Date	Time	Air Temperature (°C)	Water Temperature (°C)	Conductivity (umhos/cm^2)	Dissolved Oxygen (mg/l)	pH	Comments
Panther Creek	PC-1	9/19/84		24	9.5	95	6.4	6.7	Good invertebrate productions
Panther Creek	PC-2	9/14/84	0900	3.3	3.3	100	9.7	7.1	Good invertebrate productions
Panther Creek	PC-3	9/19/84	1600	19	7.2	115	10.5	6.6	Sparse invertebrate productions
Panther Creek	PC-3A - above Big Deer Creek	9/18/84	1030	13	10	101	10.5	7.0	Moderate invertebrate productions
Panther Creek	PC-4	9/14/84	1330	20	12	90	11.3	6:9	No Invertebrate productions
Panther Creek	PC-5	9/19/84	1100	20	12	102	11.5	7.1	Good invertebrate productions
Panther Creek	PC-6 - Mouth	9/19/84	1015	14	11	95	9.7	7.2	Good invertebrate productions
Deep Creek	DC-1	9/19/84	1330	20	9	80	11.45	6.5	Good invertebrate productions
Napias Creek	NC-l	9/19/84	1930	20	12	40	10.4	6.9	
Big Deer Creek	BDC-1	9/18/84	1030	13	7.2	108	11.4	6.5	No invertebrate productions
Moyer Creek	MC-1	9/18/84	1730	20	10.5	70	10.2	6.7	Good invertebrate productions
Moyer Creek	MC-2	9/18/84	1645	26	11	65	11.3	6.8	Good invertebrate productions
Musgrove Creek	KC-2	9/18/84	1530	23	10	140	9.8	6.7	Good invertebrate productions
Beaver Creek	BC-1	9/20/84	0930	17	11	58	9.5	6.4	
Clear Creek	CC-1	9/20/84		17	12.5	75	10.2	6.8	Good invertebrate productions

the total area available in the reach. The greatest gains in spawning habitat were associated with flow increases between 5 to 9 cfs; spawning habitat would probably be maximized at flows of 19 to 20 cfs.

Rearing habitat in the section showed a steady increase with flows. The calibration flow provided 399 ft^2 and 4,466 ft^2 of chinook and steelhead rearing habitat per 1,000 ft of stream, which represented 2.5 and 2.7 percent of the available area.

B2.1.1.2 Panther Creek - (PC-2): Habitat Type-E

Panther Creek PC-2 station was representative of habitat Type E. This station was located 28 mi above the mouth of Panther Creek and traverses through the USFS McDonald Flat campground. The reach is a strict riffle-ripple habitat that contains almost no instream cover. The USFS has recently initiated an enhancement project (boulder placement) just downstream from PC-2.

The study station was bordered by an even mix of shrubs and trees, primarily conifers. The reach had an average width of 30 ft, an average depth of 0.9 ft, and an average velocity of 1.4 fps (Table B2-4). No spawning size gravels were present; substrate was primarily rubble and boulder (70 and 20 percent). Stream discharge measured on 9/13/84 was 39 cfs. Measured water quality characteristics were suitable for salmonids, and invertebrate production was noticeably high.

The station contained essentially no spawning habitat (Figure B2-1). This was a function of the relatively large substrates and fast velocities typical of the reach.

Rearing habitat was provided by the slack water areas created by boulders and rubble, and the calm sections associated with the edge of the stream. For chinook, rearing habitat is maximized at a flow of 50 cfs (4931 ft^2), for steelhead, flows in excess of 95 cfs continue to show positive gains in area (Figure B2-1). For the calibration flow of 40 cfs, the chinook rearing habitat was estimated at 4,803 ft^2/l,000 ft stream, while that for steelhead

was 13,095 ft^2/l,000 ft of stream. These values represented 15 and 41 percent of the total area available at that flow.

The amount of rearing habitat in the entire length of Panther Creek provided by Type E habitat was 371,478 ft^2 for chinook and 960,839 ft^2 for steelhead (see Section B7). On a strict area basis, there was about 2.5 times more steelhead rearing area than for chinook.

~2.1.1.3 Panther Creek - (PC-3): Habitat Type-D

Station PC-3 was located 20 mi upstream from the mouth of Panther Creek, about 1 mi above Deep Creek and 4 mi below the mouth of Blackbird Creek. Hydraulically, the reach encompassed an entire riffle-ripple-run complex (Type D habitat). Instream cover was again noticeably absent.

The substrate in this section was blanketed with a brownish-grayish organic material which filled-in interstitial spaces (imbeddedness estimated at 50 percent). The underlying material was comprised, in order of abundance, of rubble, boulder, and coarse gravel (Table B2-3). Some areas suitable for spawning were present in the mid-portion of the reach. Invertebrates were present, although production was sparse.

Overall, the stream reach averaged 47 ft wide, 0.98 ft deep and had an average water velocity of 1.4 fps; streamflow was 57 cfs on 9/15/84 (Table B2-4). The water quality parameters measured were all within acceptable limits (does not include dissolved metals; see Section 4) for salmonids, although pH values (6.6) were the lowest for all of Panther Creek (Table B2-5).

The habitat-streamflow relationships for the station are depicted in Figure B2-2. Spawning areas were again essentially absent in the reach. Some, albeit negligible, spawning area became available only for flows in excess of 130 cfs. This is not surprising given the dominance of larger substrates and high velocities in the section.

Rearing habitats were provided in backwater areas behind boulders and rubble, and in conjunction with overhanging vegetation and instream debris. For the

flows modeled (20 to 160 cfs), rearing habitat continued to increase for both chinook and steelhead, even at the highest flows. The greatest gains in area for chinook were in conjunction with flow increases of 100 to 120 cfs; for steelhead, this occurred with flow increases from 50 to 80 cfs. The available rearing area at the field measured (calibration) flow for chinook and steelhead was 5,204 and 15,104 ft^2/l,000 ft of stream, representing 11 and 33 percent of the total area, respectively.

Collectively Type D habitats at the field measured flow provided 388,437 and i,127,540 ft^2 of chinook and steelhead rearing area, respectively, in Panther Creek (see Section B7).

B2.1.1.4 Panther Creek - (PC-3A)

This station was located just upstream from Big Deer Creek and was strictly a qualitative assessment site. As in other D Type habitats, the flow in the reach was spread out, and there was little instream cover present. Substrate composition was primarily rubble (60 percent) and boulder (20 percent), which was about 60 percent imbedded with organic material (same material as at PC-3). Water quality parameters were similar to PC-3, although a noticeable increase in invertebrate production was apparent. This suggested further biological recovery from the input of Blackbird Creek upstream.

B2.1.1.5 Panther Creek - (PC-4): Habitat Type-A

This station (PC-4) was representative of pool-cascade-boulder habitat (Type B) present in Panther Creek. The station was located 9.2 mi above the mouth of the Panther Creek, about 3 mi downstream of the confluence of Big Deer Creek. The reach was characterized by deep, fast water flowing over large boulders and rubble creating a series of cascade-pool areas. Many of the pool areas were in excess of 4 to 5 ft deep. The average depth and velocity in the reach were 1.54 ft and 1.58, fps respectively (Table B2-4); streamflow was 122 cfs as gaged on 9/17/84.

About 80 percent of the substrate at this station was comprised of boulders and rubble (Table B2-3). However, essentially no invertebrate production was

noted even though this size material generally produces large numbers of organisms The substrate was covered with thick mats of filamentous algae. The lack of invertebrates was probably a function of the toxic effluent that enters from Big Deer Creek upstream. The IDF&G likewise found no fish in the reach of Panther Creek immediately below Big Deer Creek (Figure Bl-2). General water quality characteristics (not including dissolved metals), including pH, were within acceptable salmonid limits (Table B2-5).

As expected, the station contained only a sparse amount of spawning habitat (Figure B2-2). The large boulder-rubble substrate and excessive velocities characteristic of the reach provided few suitable areas for spawning. The spawning areas that are available were maximized at flows of 190 cfs for both chinook (51 ft^2) and steelhead (49 ft^2). At the calibration flow of 130 cfs, only 31 ft of habitat/ 1,000 ft of stream were provided for chinook and 29 ft^2/l,000 ft of stream for steelhead. Such amounts do not even provide for the minimal spatial needs for spawning chinook and steelhead, and hence become insignificant for smolt production (see Section B7).

In contrast, the Type A habitat provided an abundance of juvenile rearing habitat (Figure B2-2). This resulted from the many long, deep pool areas created by the cascading water, and the abundance of large boulders throughout the reach. The habitat-streamflow relationships for chinook indicate that habitat is maximized at the low flow (90 cfs = 10,917 ft^2) with a general decline in habitat as flows increase thereafter. Steelhead rearing habitat was maximized at a much greater flow (270 cfs = 33,077 ft^2/1,000 ft of stream) before decreasing. For the field measured flow of 130 cfs, 1,052 ft^2/1,000 ft of stream of chinook and 30,598 ft^2 of steelhead rearing area was provided. These amounts represent 23 and 66 percent, respectively, of the total area available.

When adjusted for different flows in the system, a total of 569,995 ft^2 of chinook and 1,655,590 ft^2 of steelhead rearing area was provided by the Type A habitat (see Section B7). This was the greatest total amount of rearing area provided by any of the five Panther Creek habitat types.

B2.1.1.6 Panther Creek - (PC-5): Habitat Type-C

The fifth Panther Creek station (PC-5) was located 4 mi above the mouth, about 0.6 mi above Clear Creek and 1.2 mi below Beaver Creek. The reach was characteristic of spawning areas used by steelhead and chinook, although substrates were markedly larger than in the spawning habitats at PC-l. Substrate composition consisted of a 40:40 mix of rubble, coarse gravel (Table B2-3).

This section of Panther Creek was the widest of those measured (average width 72 ft) (Table B2-4). Water depths and velocities averaged 1.2 ft and 1.1 fps respectively; streamflow was gaged at 101 cfs on 9/22/84. Water quality parameters were conducive to salmonid production, and good invertebrate populations were noted (Table B2-5). During the summer of 1984, the IDF&G observed fish in close proximity to this station. In addition, several adult steelhead were observed by local fishermen in September 1984 in the reach just below the confluence of Clear Creek with Panther Creek. In the fall of 1985, several rainbow/steelhead trout were captured from this area for fish tissue analysis.

Although representing Type C (spawning-Class II) habitat, little usable spawning area was provided by any of the flows modeled. The areas that were provided were maximized at flows of 190 cfs for chinook (157 ft^2) and 265 cfs for steelhead (18 ft^2). As for PC-4, such low amounts become insignificant when redd spatial requirements are considered.

The paucity of spawning areas in the reach was a function of the larger substrates present as noted above. This was demonstrated through a sensitivity analysis of this parameter in which the substrate habitat suitability curves (Figures Bl-5 and Bl-6) were modified. It was noted that a one digit higher shift in the curves (i.e., large cobble now considered as suitable spawning substrate) resulted in a lo-fold increase in the spawning area. This confirmed that the hydraulic parameters of the reach (water velocity and depth) were conducive to spawning, but that the size of the substrate was limiting.

The rearing habitat-flow relationships provided in this reach were the greatest of any in Panther Creek. For the range of flows modeled (40 to 265 cfs), rearing areas continued to increase for both chinook and steelhead. The greatest gains in habitat for both occurred in the flow range 40 to 100 cfs. The amount of juvenile rearing habitat provided by the calibration flow of 100 cfs, was 16,188 ft^2/1,000 ft of stream for chinook and 38,919 ft^2/l000 ft of stream for steelhead. These represented 26 and 65 percent of the total area. This type of habitat collectively provided 391,251 ft^2 of chinook, and 983,953 ft^2 of steelhead rearing area (see Section B7).

B2.1.1.7 Panther Creek - (PC-6)

Station PC-6 represented the lowermost station on Panther Creek located at its confluence with the Salmon River. Only qualitative assessments were made at this station. In general, the reach is representative of Type A habitat consisting of pool-cascade areas. Substrate was large (80 percent rubble and boulder) and no spawning areas were present (Table B2-3). Water quality conditions were similar to PC-5, and invertebrates were abundant (Table B2-5).

B2.1.2 Musgrove Creek

A 2.7 mi section of Musgrove Creek was evaluated at 300 ft intervals (Figure B2-4). The section extended from the mouth, upstream to where the stream enters a large meadow area; a total of 42 transects were evaluated (Table B2-6). The reach was dominated by riffle-ripple type habitat with water depth and velocities ranging from 0.5 to 1.5 ft and 1.0 to 3.0 fps, respectively. The section surveyed had little available spawning gravel with the majority of subtrates comprised of coarse gravel and rubble. Stream gradients in the lower mile of stream averaged 3.4 percent; gradients in the next 3 mi, 2.7 percent (Table B2-6). At least three separate areas in the section contained extensive beaver dam activity that would create passage problems for upstream migrating salmonids. These were located at 1,200 ft, 1.5 mi, and 1.8 mi, respectively, above the mouth of Musgrove Creek (Figure B2-4). Beaver dam development within each of these areas exceeded 600 ft in stream length.

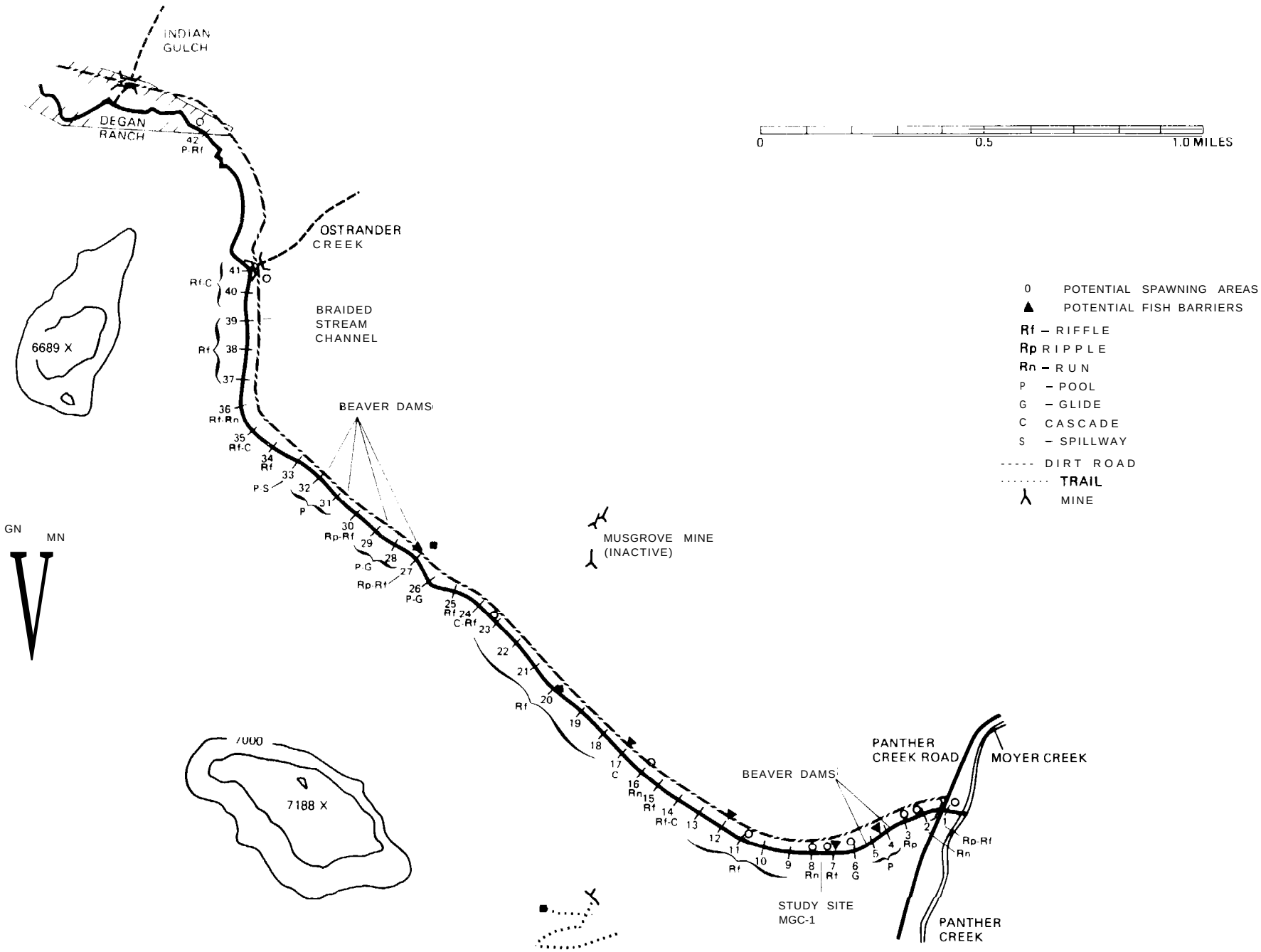


Figure B2-4 AQUATIC HABITAT MAP OF A 2.7-MILE REACH OF MUSGROVE CREEK, SEPTEMBER 1984

Table B2-6

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 2.7-MILE REACH OF MUSGROVE CREEK, SEPTEMBER 1984

Transect No.	Habitat[b] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft^2)	Comments
1	Riffle/Ripple	0.5	0.5-1.0	15	CG/FG	5	50	50	Y 20x30	Spawning gravel. Some bank sloughing.
2	Run	2.5	0.5	12	R/CG	5	80	50	Y	Spawning gravel upstream. Good riparian cover.
3	Ripple	1.0	0.5	12	R	5	80	80	Y	Spawning gravel upstream and downstream. Passage could be a problem at decreased flows.
4	Pool	2.0-3.0	0	40	St	100	80	40	N	Beaver dam just downstream. Begins ponding. Small spring enters just upstream.
5	Pool	3.0-4.0	0	40	St	100	$0	80	N	Beaver dam is extensive. Passage problems for upstream adults.
6	Glide	2.0	0.5	15	R/CG	25	50	80	Y	Creek is above beaver dam. Narrow. Some spawning gravel present.
7	Riffle	0.5	1.0-2.0	20	CG/R	10	80	80	Y	This section spread out. Could have passage problems at decreased flows. Spawning gravel present. Location of Study Station MG-1.
8	Run	1.0	1.0-1.5	12	CG/R	10	80	50	Y	Well canopied; riffle upstream; decreasing spawning gravel. Log is a potential barrier.
9	Riffle	0.5	1.0-2.0	10	CG/R	10	50	80	N	Narrow, no spawning gravel. Increasing canopy.
10	Riffle	0.5	2.0-3.0	15	R/CG	10	100	80	N	Long riffle area upstream. No spawning gravel.
11	Riffle	0.5	1.0-1.5	15	CG/R	10	90	80	Y	Shallow; thick bank vegetation; limited spawning gravel. Small cascade upstream.
12	Riffle	0.5	1.0-2.0	30	R/CG	10	50	90	N	Large debris jam present. Good cover but is a potential barrier.
13	Riffle	0.5	2.0-3.0	15	CG/R	10	80	70	N	Flow pools upstream and downstream. No spawning gravel.

Table B2-6

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 2.7-MILE REACH OF MUSGROVE CREEK, SEPTEMBER 1984 (Cont'd)

Transect No.	Habitat[b] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft^2)	Comments
14	Riffle/ Cascade	0.5	2.0-3.0	10	R/CG	10	80	50	N	Enters steep valley; increasing debris; no spawning gravel.
15	Riffle	0.5-1.0	1.0-2.0	15	R/CG	10	90	90	N	2 ft log drop 50 ft downstream. No spawning gravel.
16	Run	1.0-1.5	0.5-1.0	10	CG/FG	10	70	90	Y 10x15	Spawning gravel present on right bank. Increasing debris.
17	Cascade	1.5	2.0-3.0	20	ST/R	50	10	90	N	Log barrier and plunge pool. Some rearing habitat.
18	Riffle	1.0	2.0-3.0	15	R/CG	10	10	90	N	Enters small meadow with willows. No spawning gravel; high velocity,
19	Riffle	0.5-1.0	1.5-2.0	20	CG/R	10	10	90		
20	Riffle	0.5	2.0-3.0	20	CG/R	10	90	90	N	Adjacent to collapsed old cabin. Flow spread out. No spawning gravel or rearing habitat.
21	Riffle	0.5	2.0-3.0	20	R/CG	10	90	70	N	High velocity; flow spread out.
22	Riffle	1.0	1.0-2.0	10	R/B	10	90	90	N	High velocity. No spawning gravel. No rearing habitat.
23	Riffle	1.0	2.0-3.0	10	B/R	30	80	50	N	Narrow - fast reach. No spawning gravel upstream; no rearing habitat; large talus on right bank.
24	Cascade/ Riffle	1.0-1.5	2.0-3.0	12	B	10	80	60	N	Increasing debris instream. Little rearing habitat; no spawning gravel.
25	Riffle	0.5	1.0-2.0	15	R/CG	10	50	80	N	No spawning gravel; no rearing habitat; high velocity.
26	Pool/Glide	2.0	0.5-1.0	20	CG/FG	50	50	80	N	Good pool area - 20 x 15 ft. Good rearing habitat. Log dam Just downstream.
27	Ripple/Riffle	1.0	0.5-1.0	10	CG/R	10	70	80	N	Large beaver dam 30 ft upstream; complete passage barrier. Large pool 3 x 4 ft deep upstream. Would be good rearing habitat but is inaccessible.

Table B2-6

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 2.7-MILE REACH OF MUSGROVE CREEK, SEPTEMBER 1984 (Cont'd)

Transect NO.	Habitat[b] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbed-dedness (%)	Bank Stability (X3 Left	Bank Stability (X3 Right	Spawning Gravel (Yes/No) (ft^2)	Comments
28	Pool/Glide	3.0	0.5	25	CG/R/St	80	50	50	N	Upper border of pond. Another dam 100 ft upstream.
29	Pool/Glide	3.0	0.5	20	SD/St	100	40	80	N	Upper border of beaver dam. 3 ft drop at dam. Increasing aquatic habitat. Good rearing habitat but limited access.
30	Ripple/Riffle	0.5	1.0-2.0	20	R/CG	10	80	80	N	Increasing velocity; no spawning gravel; little rearing habitat.
31	Pool	3.0	0.5	60-70	Sd/St	100	80	80	N	Beginning of extensive beaver activity. Limited access.
32	Pool	3.0-4.0	0.5	40	Sd/St	100	90	90	N	Beaver dam continues; good rearing habitat.
33	Pool/ Spillway	l-0-3.0	0.5	50	Sd/St	100	90	90	N	Good rearing habitat; some free flowing water.
34	Riffle	0.5	0.5-1.0	20	R/CG	10	90	90	N	Free flowing water; spread out and shallow.
35	Riffle/ Cascade	1.0	2.0-3.0	15	B/R	10	40	40	N	Steep, fast water; no spawning gravel.
36	Riffle/Run	1.0-1.5	2.0-3.0	10	R/CG	10	90	90	N	Narrow, fast water; no spawning gravel.
37	Riffle	0.5	2.0-3.0	15	CG/R	10	50	90	N	Narrow, fast water; no spawning gravel.
38	Riffle	0.5	2.0-3.0	15	CG/R	10	90	50	N	Very shallow and fast; increasing debris jams.
39	Riffle	0.5-1.0	2.0-3.0	40	R/CG	10	30	40	N	Braided section; increasing undercut banks and slumping. Increasing debris jam.
40	Riffle/ Cascade	0.5	2.0-3.0	8	R/B	10	80	80	N	Just above 4 x 4 ft stream crossing. Narrow and fast.
41-2.4 ml	Riffle/ Cascade								Y 10x15	Ostrander Creek enters on right bank. Excellent spawning and rearing habitat. Very similar to Upper Panther Creek. Estimate R:P at 40:60 within 300 ft with spawning gravel.

Table B2-6

AQUATIC HABITAT CHARACTERISTICS WITHIN A 2.7-MILE REACH OF MUSGROVE CREEK, SEPTEMBER 1984 (Cont'd)

Transect No.	Habitat Type[b]	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft^2)	Comments
42-2.7 mi	Pool/Riffle	3.0-4.0	1.0-2.0	10-15	CG/FG	10	90	90	N	Stream enters extensive meadow area; excellent chinook spawning, and rearing habitat, provided accessible.

[a] Visual observations used to evaluate all parameters.

[b] USFS Classification (1976)
- Pool = area of stream with reduced velocity
- Riffle = shallow section of stream with turbulent flows and/or swift velocity
- Cascade = turbulent, broken surface flow of water over a steeply inclined streambed
- Ripple = slower moving water exhibiting minor surface agitation or waves as a result of wind or velocity action
- Run = a stretch of relatively deep, fast, flowing water with the surface essentially nonturbulent
- Glide = a calm stretch of water flowing smoothly and gently

[c]
- B = boulder (>12 in.)
- R = rubble (3-12 in.)
- CG = coarse gravel (1-2 in.)
- FG = fine gravel (0.08-1.0 in.)
- Sd = sand
- St = silt

Above Ostrander Creek (mile 2.4), the stream enters a large meadow that contains extensive spawning and rearing habitat. However, access to the area is questionable owing to upstream passage problems (e.g., beaver dam). This area is representative of the Type B habitat found in Panther Creek.

B2.1.2.1 Musgrove Creek (MGC-1)

The station selected for detailed quantitative analysis on Musgrove Creek was located about 2,000 ft above the mouth, adjacent to Transect 7. The station was comprised largely of riffle-run type habitat; spawning gravel was present. The study reach was heavily canopied with a variety of conifers.

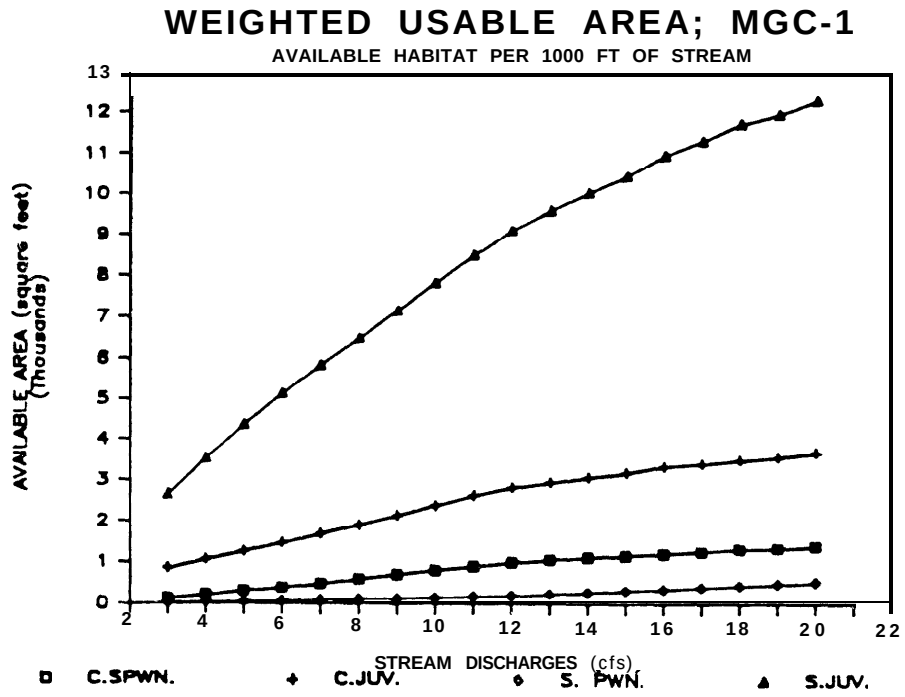
Stream substrate within the section was well washed (10 percent imbeddedness) and was comprised, in order of abundance, of coarse gravel, rubble, and fine gravels (Table B2-3). A large gravel bar located mid-stream at the upstream end of the section was exposed during the field measured flow, resulting in stream braiding.

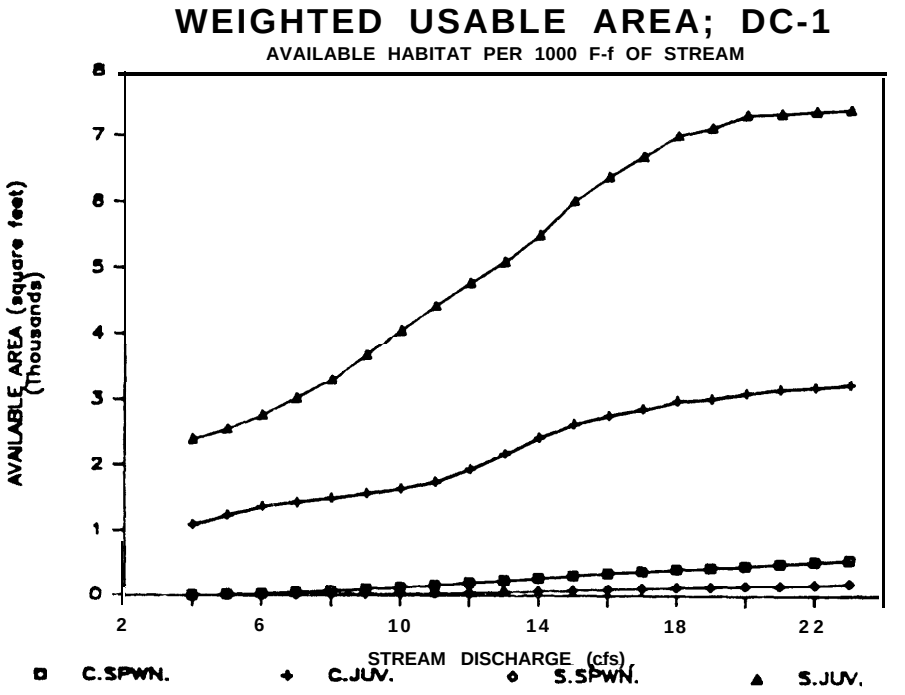
The water quality parameters of Musgrove Creek (measured 9/18/84) were all within limits for salmonid production (Table B2-5). The reach studied had an average width and depth of 15 ft and 0.66 ft, and a velocity of 0.96 fps; average discharge (measured 9/29/84) was 8.9 cfs (Table B2-4).

The spawning and rearing habitat-flow relationships for the station are depicted in Figure B2-5. In general, both spawning and rearing areas continued to increase for the range of flows modeled (3 to 20 cfs). As for Panther Creek, more chinook spawning area was present than steelhead, while the reverse was true for rearing habitat.

At the calibration flow of 8 cfs, 603 and 106 ft^2 of spawning area were provided per 1,000 ft of stream for chinook and steelhead. These represented 3 and 0.6 percent of the total area present.

Based on channel slope and topography, an estimated 4 mi of Musgrove Creek were considered as providing similar spawning habitat conditions. This





C = CHINOOK, S = STEELHEAD

Figure B2-5 SPAWNING AND JUVENILE HABITAT - STREAMFLOW RELATIONSHIPS FOR CHINOOK SALMON AND STEELHEAD TROUT AS DEVELOPED FOR STATIONS MGC-1 (UPPER) ON MUSGROVE CREEK AND DC-I (LOWER) ON DEEP CREEK

results in a total spawning area estimate of 12,735 ft^2 for chinook and 2,218 ft^2 for steelhead (Table B2-7).

Rearing habitat likewise exhibited a steady increase in area with flow (Figure B2-5). An estimated 1,924 and 6,510 ft^2/1,000 ft of stream of rearing area was provided for chinook and steelhead at the calibration flow. Such areas represented 11 and 37 percent of the total area available. For all of Musgrove Creek, an estimated 7 mi of stream provided similar rearing conditions. This results in a total estimate of chinook and steelhead rearing habitat of 71,098 ft^2 and 240,624 ft^2, respectively (Table B2-8).

B2.1.3 Moyer Creek

The pedestrian habitat survey on Moyer Creek encompassed a reach extending from its mouth, 2.3 mi upstream (Transect 45) (Figure B2-6). An additional 3.1 mi of stream were evaluated to note major changes in habitat type and channel morphology.

The reach surveyed contained a variety of habitat types including pools, riffles, and cascades (Figure B2-6, Table B2-9). Stream gradients ranged from 2.4 percent in the lower section to over 5 percent in the headwaters (Table B2-4).

Stream substrates were likewise variable and included mixtures of fine and coarse gravel, rubble, and boulders. Most substrates were well-washed as evidenced by low imbeddedness ratings (Table B2-3). Spawning gravels were abundant in some sections of the stream. Excellent rearing habitat was likewise provided by pool areas and instream cover created by debris and log jams. Several of the pools had depths exceeding 3 ft; addtional rearing habitat was provided in a slough area located at Transect 35.

As for Musgrove Creek, beaver activity was also present in Moyer Creek in its lower section (Transect 9, about 2,700 ft above mouth). The beaver dam located at this point ponds water 300 ft upstream and could present passage problems for upstream migrating salmonids. A second beaver dam complex was located 4.2 mi upstream within a large meadow area.

Table 82-7

ESTIMATED TOTAL CHINOOK AND STEELHEAD SPAWNING AREA (FT^2) PROVIDED IN THE PANTHER CREEK DRAINAGE

Stream	Length (Miles)	Length (Feet)	Measured Flow (cfs)	Estimated Spawning Area (ft^2)					
				0.4 x Measured Flow		Measured Flow		2.5 x Measured Flow	
				Chinook	Steelhead	Chinook	Steelhead	Chinook	Steelhead
Clear Creek (CC-1)	4.0	21,120	22.0	1.223	1,794	6,804	1,026	65,988	22,299
Deep Creek (DC-1)	4.0	21,120	9.7	283	53	2,869	668	11,796	3,867
Lower Moyer Creek (MC-2)	2.1	11,088	15.7	2,334	1,066	10,751	4,568	10,103	3,043
Upper Moyer Creek (MC-1)	3.6	19,008	15.9	10,672	5,961	27,124	17,930	46,778	14,409
Musgrove Creek (MGC-l)	4.0	21,120	8.9	2,892	484	12,735	2,218	29,577	11,063
Panther Creek	42.0	221,760	Variable	57,847	38,727	128,563	66,694	187,540	55,804
Total				72,251	48,085	188,846	93,104	351,782	110,485

Table B2-8

ESTIMATED TOTAL CHINOOK AND STEELHEAD REARING AREA (FT^2) PROVIDED IN THE PANTHER CREEK DRAINAGE

Stream	Length (Miles)	Length (Feet)	Measured Flow (cfs)	Estimated Spawning Area (ft^2)					
				0.4 x Measured Flow		Measured Flow		2.5 x Measured Flow	
				Chinook	Steelhead	Chinook	Steelhead	Chinook	Steelhead
Clear Creek (CC-1)	7.0	36,960	22.0	85,927	241,801	163,641	421,661	314,061	866,011
Deep Creek (DC-1)	4.0	21,120	10	23,161	50,724	34,617	85,994	68,915	156,847
Lower Moyer Creek (MC-2)	2.1	11,088	16	25,633	77,162	43,523	115,145	57,975	148,729
Upper Moyer Creek (MC-1)	7.5	39,600	16	98,621	215,500	154,458	349,538	199,639	496,477
Musgrove Creek (MGC-1)	7.0	36,960	9	32,105	98,375	71,098	240,624	136,575	455,728
Panther Creek	42.0	221,760	Variable	1,618,551	4,174,579	1,752,013	5,218,210	1,834,602	6,033,529
Total				1,883,998	4,858,141	2,219,345	6,431,172	2,611,267	8,157,321

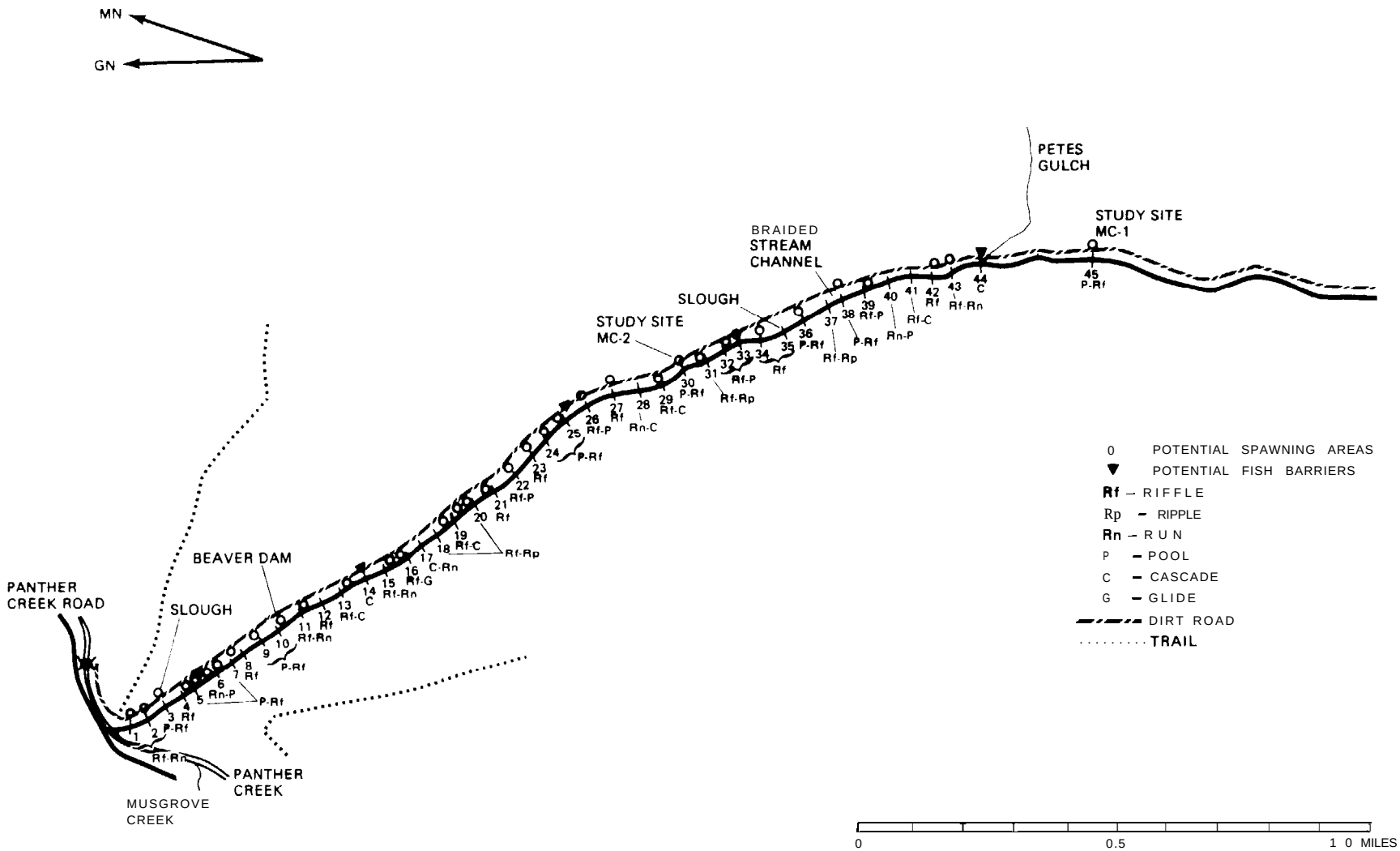


Figure B2-6 AQUATIC HABITAT MAP OF A 2.3-MILE REACH OF MOYER CREEK, SEPTEMBER 1984

Table B2-9

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 2.3-MILE REACH OF MOYER CREEK, SEPTEMBER 1984

Transect No.	Habitat[b] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate'	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft2)	Comments
1	Riffle/Run	1.0	2.0-3.0	15	R/B	10	78	80	Y 20x20	Small cascade just upstream. Spawning gravel above cascade.
2	Riffle/Run	2.0	1.0-2.0	15	CG/FG	10	70	50	Y 20x15	Good spawning gravel on right bank. Downstream area also has useable spawning gravel.
3	Pool/Riffle	2.0	0.5-1.0	20	R/CG	10	90	90	Y 10x20	Spawning gravel on left - dry. Side channel off of right with some sloughwater for chinook rearing.
4	Riffle	0.5	2.0-3.0	20	CG/R	10-15	70	90	Y 10x20	Fast water; channel splits above. Spawning gravel present above.
5	Pool/Riffle	2.0	0.5-2.0	20	CC/R	10	80	70	Y	Adjacent to new USFS station. Good spawning gravel upstream and downstream; water spreads; passage problems at this flow.
6	Run/Pool	2.5	1.0	12	CG/FG	10	40	50	Y 20x30	Good spawning gravel upstream and downstream. Mostly high and dry at this flow. Some rearing habitat pools.
7	Pool/Riffle	1.5	1.0-2.0	15	CG/FG	10	40	80	Y	Increase of spawning gravel upstream. Fairly good rearing pools.
8	Riffle	0.5	1.0-2.0	20	FG/R	10	80	80	Y	Good spawning gravel downstream. Good undercut bank on left bank; rearing habitat.
9	Pool/Riffle	1.5	0.5-2.0	40 split	CG/FG	10	40	80	Y	Good spawning gravel and rearing habitat in pools; good habitat. Beaver dam (100 ft long); good spawning gravel below; undercut bank.
10	Pool/Riffle	1.0-3.0	0.5-2.0	70	R/CG/St	10	80	80	Y	Upper end of beaver activity. Many channels throughout reach; good spawning gravel above.
11	Riffle/Run	2.0	2.0-3.0	15	R/B	10	50	60	Y	Increased gradient; increased substrate; decreased spawning gravel. Some pools for rearing; undercut bank.
12	Riffle	1.0	2.0-3.0	12	R/B	10	50	80	N	Increased velocity; narrow. No spawning gravel; undercut bank.

Table B2-9

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 2.3-MILE REACH OF MOYER CREEK, SEPTEMBER 1984 (Cont'd)

Transect No.	Habitat Type[b]	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbeddedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft^2)	Comments
13	Riffle/ Cascade	1.0	2.0-3.0	10	B/R	10	80	80	N	Small cascade upstream; approximately 1-2 ft drop. No spawning gravel; decreased rearing habitat.
14	Cascade	2.0	3.0-4.0	10	B	10	80	80	N	Approximately 100 ft cataract section with increase in gradient. Velocity increases at high flows; potential velocity barrier.
15	Riffle/Run	0.5	2.0-3.0	15	CG/R	10	80	50	Y	Increase in debris jams; some spawning gravel upstream; decreased rearing habitat.
16	Riffle/Glide	2.0	1.0-2.0	15	CG/FG	10	80	80	Y 15x30	Excellent spawning gravel just downstream; some good rearing habitat in pools.
17	Cascade/Run	3.0	1.0-3.0	10	B/Sd	10	80	60	N	Fast and narrow with increased run; deep water. Some good rearing habitat in backwaters; cascade just downstream.
18	Riffle/Ripple	1.0	1.0-2.0	15	CG/R	40	60	40	Y	Stairstep section; small pockets spawning gravel; undercut bank provides some rearing habitat.
19	Riffle/ Cascade	0.5	3.0-4.0	12	R/B	10	80	50	Y	Increased gradient; small amount spawning gravel downstream. Some undercut bank provides cover; good spawning gravel upstream. Undercut right bank.
20	Riffle/Ripple	0.5	0.5-1.0	25	CG/R	10	60	80	Y	Log jam downstream; good spawning gravel downstream. Upstream is a long ripple; some undercut bank for rearing habitat.
21	Riffle	1.0	1.0-2.0	20	R/CG	10	80	70	Y	Fast water; shale substrate. Small pocket s of spawning gravel downstream; good rearing habitat in pocket water.
22	Riffle/Pool	0.5	2.0-3.0	25	R/CG	10	40	40	Y	Excellent rearing habitat. Some small pockets spawning gravel; pool created by log roller downstream.
23	Riffle	1.0-1.5	1.0-2.0	30	CG/FG	10	80	80	Y	Excellent spawning gravel on left and upstream. Good undercut bank and debris provides edgewater for rearing habitat.

Table B2-9

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 2.3-MILE REACH OF MOYER CREEK, SEPTEMBER 1984 (Cont'd)

Transect No.	Habitat Type[b]	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft^2)	Comments
24	Pool/Riffle	2.0	0.5-2.0	20	R/CG	25	50	50	Y	Increased log jam creates nice rearing pools; good spawning gravel upstream. Good rearing habitat upstream also.
25	Pool/Riffle	2.0	0.5-2.0	20	CG/FG	10	50 UCB	50	Y	Excellent habitat for spawning and rearing. Debris jam upstream; approximately 2 ft drop. Good pool and backwater. Potential barrier.
26	Riffle/Pool	1.0	2.0-3.0	25	CG/R	10	70	80	Y	Some spawning gravel on perimeter. Excellent pool; approximately 150 ft upstream, 3-4 ft deep.
27	Riffle	0.5	1.0-2.0	30	CG/FG	10	80	80	Y	Flow spreads out. Some spawning gravel present, but mostly fast water; no rearing habitat.
28	Run/Cascade	3.0	2.0-3.0	20	B/R	40	68	80	N	Rock dam creates good pool at toe; 1-2 ft drop of water, 2-3 ft deep; good backwater. Rearing habitat. Undercut right bank.
29	Riffle/ Cascade	1.5	2.0-3.0	15	CG/FG	10	80	70	Y	Entering thick forest cover. Increased debris jams. Good pockets of spawning gravel; some rearing habitat in undercut bank and behind root wads. Deep plunge pool approximately 4 ft deep; excellent habitat.
30	Pool/ Riffle -	2.0	1.0-3.0	20	CG/FG	10	80	80	Y	Excellent spawning gravel and rearing habitat in pools and sloughs. Enters meadows.
31	Riffle/Ripple	1.0	0.5-1.0	25	CG/R	10	60	80	Y	Has some spawning gravel but flows spread out. Undercut bank downstream with good rearing habitat.
32	Riffle/Pool	2.5-3.0	1.0-3.0	20	CG/B	10	68	50	Y	Boulders create plunge pools; increased turbulence. No rearing habitat; some spawning gravel upstream; undercut bank.
33	Riffle/Pool	1.0-2.0	1.0-2.0	20	CG/R	10	70	70	Y	Meadow area; spawning gravel common.

Table B2-9

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 2.3-MILE REACH OF MOYER CREEK, SEPTEMBER 1984 (Cont'd)

Transect No.	Habitat[a] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft^2)	Comments
34	Riffle	1.0	1.0-2.0	15	R/CG	50	80	80	N	Increased gradient but still has backwater for rearing habitat. Small pockets spawning gravel; small debris jam approximately 200 ft upstream.
35	Riffle	1.0	2.0-3.0	15	R/CG	10	80	80		No longer in meadow.
38	Riffle	2.0-3.0	0.5	10	St/debris	100	92	80	N	Slough area adjacent to main channel; extends into meadow approximately 80 ft. Excellent rearing habitat for chinook.
36	Pool/Riffle	2.0-2.5	1.0-2.0	25	CG/R	25	80	80	Y	Good pool/riffle habitat approximately 30 x 70 ft for rearing habitat. Good spawning gravel upstream and downstream; good pool downstream.
37	Riffle;Ripple	0.5	1.0-2.0	20	R/CG	10	70	70	N	Increased gradient, No spawning gravel in immediate area.
38	Pool/Riffle	1.5	1.0-2.0	25	CG/FG	10	50	70	Y	Good spawning gravel and undercut bank for rearing habitat. Stream braids - one channel has beaver activity; Good gools and rearing habitat.
39	Riffle/Pool	1.0-4.0	2.0-3.0	10	R/B	10	60	90	Y	Pool is approximately 3-4 ft deep. Excellent rearing habitat and holding water; some spawning gravel upstream.
40	Run/Pool	2.5	2.0-3.0	15	B/R	10	80	80	N	Increased debris jam. Good edgewater and pools upstream for rearing habitat.
41	Riffle/ Cascade	1.0	3.0-4.0	10	B/R	10	80	60	N	Increased gradient; steep and fast. Decreased pools; no spawning gravel or rearing habitat.
42	Riffle	1.0	2.0-3.0	15	R/CG	10	70	80	Y	Some undercut banks upstream; no rearing habitat, Decreased spawning gravel,
43	Riffle/Run	1.5	1.0-2.0	15	R/CG	10	80	80	Y	Gradient somewhat decreased. Some spawning gravel upstream; some backwater area for rearing habitat; good overhead vegetation.

Table B2-9

AQUATIC HABITAT CHARACTERISTICSa WITHIN A 2.3-MILE REACH OF MOYER CREEK, SEPTEMBER 1984 (Cont'd)

Transect No.	Habitatb Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft²)	Comments
44-2.5 mi	Cascade	2.0-3.0	3.0-4.0	15	B	10	80	80	N	Stream enters steep canyon with cascades; Potential velocity barrier at higher flows.
45-2.7 mi	Pool/Riffle	1.0-2.0	1.0-2.0	15	CG/RG	10	80	80	Y	Excellent site for spawning. Detailed modeling - MC-l.
3.2 mi	Riffle/ Cascade/Pool									Salt Creek - increased debris jams and deep pool. Similar habitat to MC-Z.
3.4 mi										Good spawning habitat.
3.5 to 4.2 mi										Large meadow (good pool-riffle and spawning).
4.2										Large beaver complex-barrier.
4.4 to 5.3 mi										Meadow (Moyer basin); spawning pool/riffle habitat; stream getting narrow.
5.4 to 5.6 mi										Timber. Increased gradient.
5.6 to 5.8 mi										Meadow and bridge (end)/culvert approximately 1/2 upstream - meadow continues.

[a] Visual observations were used to evaluate all parameters.

[b] USFS Classification (1976)
- Pool = area of stream with reduced velocity
- Riffle = shallow section of stream with turbulent flows and/or swift velocity
- Cascade = turbulent, broken surface flow of water over a steeply inclined streambed
- Ripple = slower moving water exhibiting minor surface agitation or waves as a result of wind or velocity action
- Run = a stretch of relatively deep, fast, flowing water with the surface essentially nonturbulent
- Glide = a calm stretch of water flowing smoothly and gently

[c] B - boulder (>12 in.)
R - rubble (3-12 in.)
CG = coarse gravel (1-2 in.)
FG - fine gravel (0.08-1.0 in.)
Sd = sand
St = silt

Two stations were selected on Moyer Creek for detailed assessment of habitat, the first located about 1 mi upstream (MC-2), the second 2.3 mi upstream (MC-l). These two stations were selected as representative of habitat types in the lower and upper portions of the stream.

B2.1.3.1 Mover Creek - (MC-l)

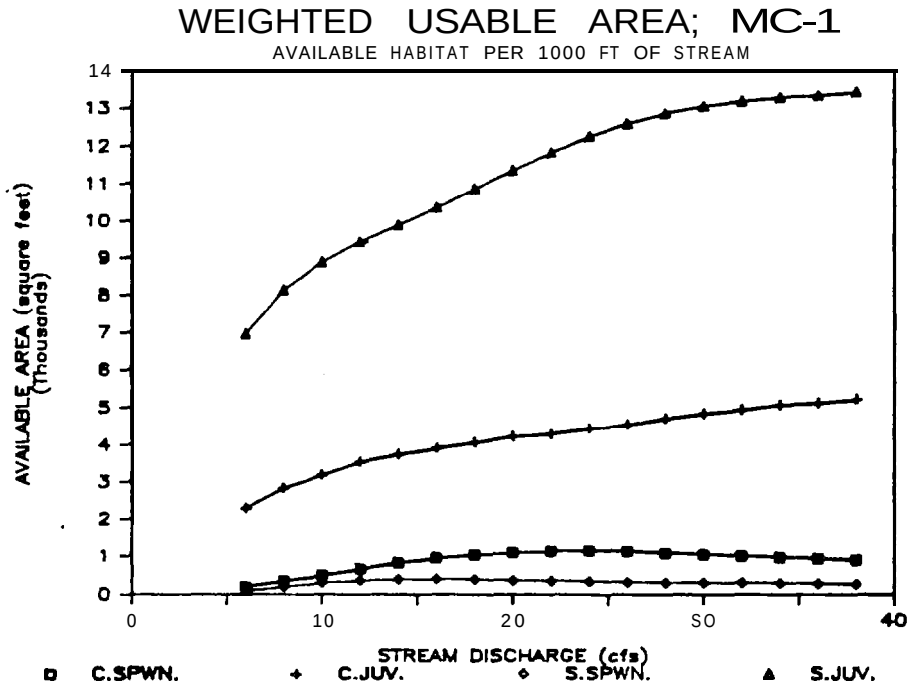
The upper Moyer Creek station (MC-I) was located 2.7 mi upstream from the mouth at Transect 45 of the pedestrian habitat survey. The reach was comprised of pool-riffle habitat that provided excellent physical and hydraulic conditions for spawning. This reach typified many of the spawning areas present in Moyer Creek.

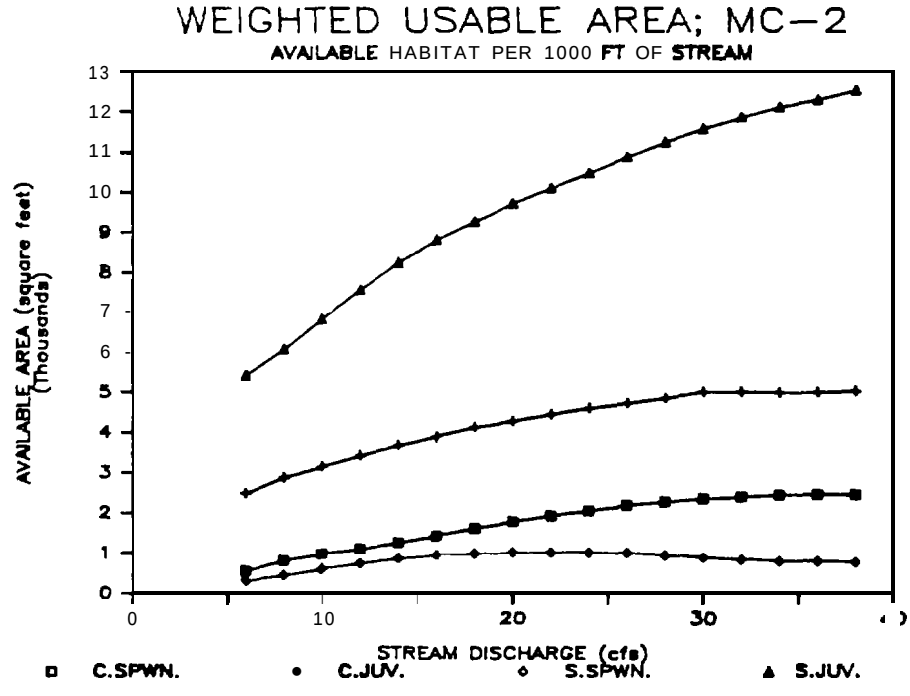
The substrate composition consisted primarily of coarse gravels intermixed with rubble and fine gravel. Most spawning gravel was located in the lower portion of the reach. The gravels were clean of fine sediments and had an imbeddedness of about 10 percent (Table B2-3).

The stream had an average discharge of 15.9 cfs as measured on 9/27/84 (Table B2-4). Overall the reach averaged 15.5 ft wide and 0.72 ft deep, and had an average water velocity of 1.5 fps (Table B2-4). Water quality characteristics were suitable for salmonids, and invertebrate production was noticeably high (Table B2-5).

For the station, chinook spawning area exhibited a steady increase in habitat with increasing flow, while steelhead spawning habitat peaked at 22 cfs with a value of 1,000 ft^2/1,000 ft of stream (Figure B2-7). The calibration flow of 16 cfs provided 1,427 ft^2 (chinook) and 943 ft^2 (steelhead) of spawning area, respectively. For the 3.6 mi of stream representive of this habitat, a total of 27,124 ft^2 and 17,930 ft^2 of chinook and steelhead spawning area is provided at the calibration flow (Table B2-7).

The calibration flow provided 3,900 ft^2/1,000 ft of stream of chinook rearing area, and 8,826 ft^2/1,000 ft. of area for steelhead. An estimated 7.5 mi of Moyer Creek were considered as having similar rearing conditions.





C = CHINOOK, S = STEELHEAD

Figure B2-7 SPAWNING AND JUVENILE HABITAT – STREAMFLOW RELATIONSHIPS FOR CHINOOK SALMON AND STEELHEAD TROUT AS DEVELOPED FOR STATIONS MC-1 (UPPER) AND MC-2 (LOWER) ON MOYER CREEK

Thus, a total of 154,458 ft^2 and 349,538 ft^2 of chinook and steelhead habitat was available at the calibration flow (Table B2-8).

B2.1.3.2 Moyer Creek - (MC-2)

The lower station on Moyer Creek (MC-Z) was situated about 1 mi above the mouth. This station was also comprised of pcol-riffle habitat, although substrates were dominated by larger materials (rubble-coarse gravel/fine gravel). A deep pool (greater 3 ft) was located mid-way in the reach, and debris and log jams were located both upstream and downstream from the station. Some cattle grazing activity occurred in the reach, although no problems with bank instability were evident.

The physical, chemical, and hydraulic characteristics at MC-2 were similar to those of MC-l, stream flow, 15.7 cfs; average width, 12 ft; average depth, 0.92 ft; and average velocity, 1.4 fps (Tables B2-4 and B2-5).

The lower station of Moyer Creek (MC-2) contained less than half the available spawning area as for MC-l. This, as noted above was a result of the larger substrates. For the flows modeled, chinook spawning habitat was maximized at a flow of 24 cfs (1,158 ft^2/1,000 ft stream), while the maximum steelhead spawning area (412 ft^2/1,000 ft stream) occurred at a flow of 16 cfs, (which was the field measured flow) (Figure B2-7). The total amount of chinook and steelhead spawning area in a 2.1 mi section of stream was 43,523 ft^2 and 115,145 ft^2, respectively (Table B2-7).

The rearing habitat-flow relationships were simiiar to those of MC-l. Total rearing habitat available in a 2.1 mi section was estimated at 43,523 ft^2 (chinook) and 115,145 ft^2 (steelhead) (Table B2-8).

B2.1.4 Deep Creek

The survey of Deep Creek encompassed a 1.2 mi reach of stream extending from the mouth to a point midway within a large meadow area (Figure B2-8). The stream has a relatively steep gradient averaging 4 percent. As a result, the section was dominated by riffle-cascade habitat with velocities in excess of

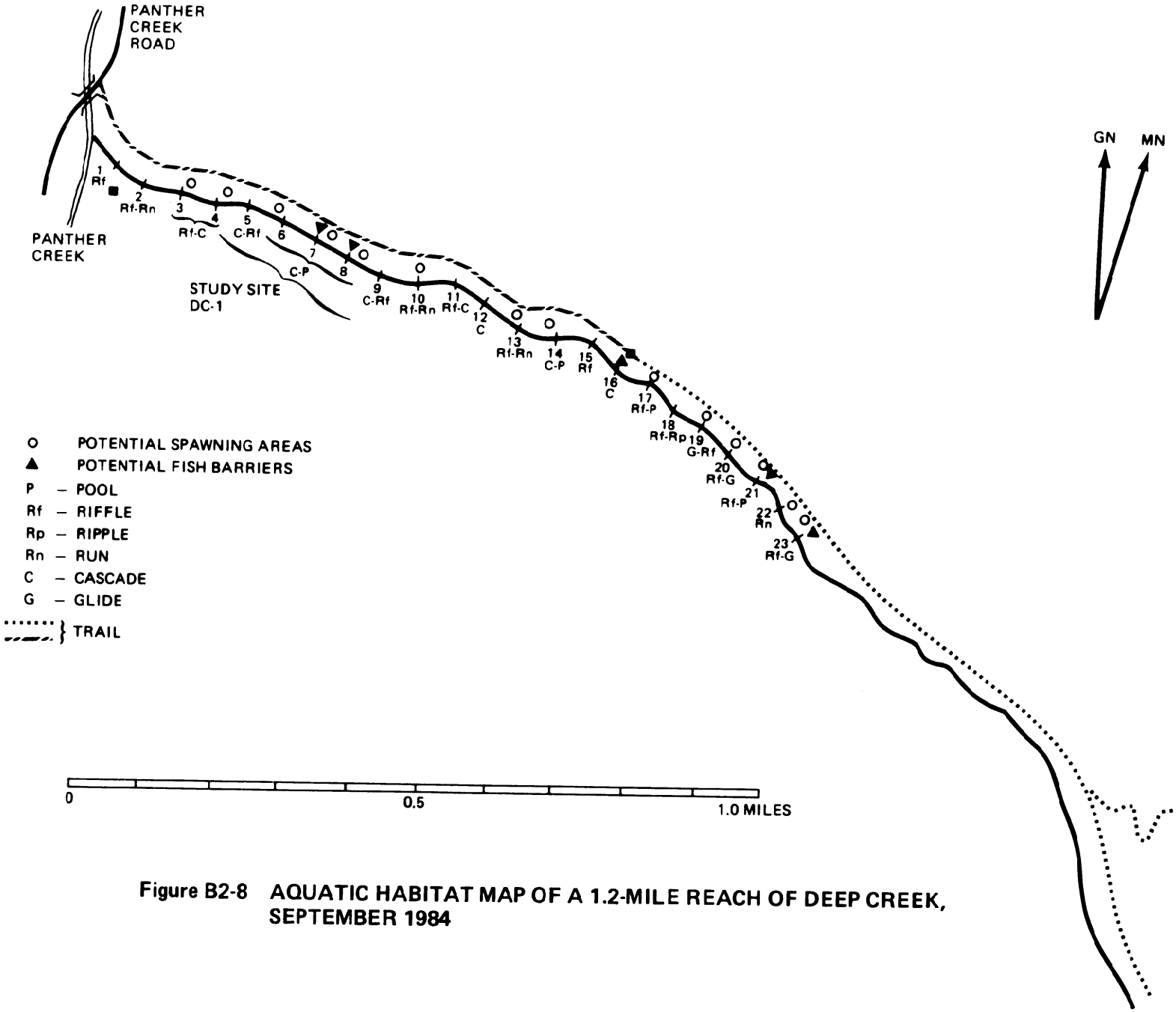


Figure B2-8 AQUATIC HABITAT MAP OF A 1.2-MILE REACH OF DEEP CREEK, SEPTEMBER 1984

3-4 fps (Table B2-10). The substrate in the lower portion of the stream was correspondingly dominated by boulder and rubble; little spawning habitat was available.

At Transect 17, the stream entered a meadow area and gradients were reduced. Some spawning gravel was present and water velocities ranged from 0.5 to 2.0 fps. Under present conditions, fish passage to the meadow may be prevented due to a series of debris jams/cascades extending from Transects 12 to 16. Foremost of these is the debris jam and cascade at Transect 16. This area is characterized by a 5 to 10 ft drop over a 30 ft section of stream, which contains a mixture of boulders and debris jams. For the low flows measured in September this would prove a formidable passage area. However, higher flows in the spring would decrease the elevational difference and successful passage may be possible.

From the meadow area, Deep Creek enters and remains within a forested zone. The stream gradient increases and riffle-cascade habitat again dominates. Beaver activity was noticed about 3 mi upstream where an offsite dam had been constructed. The stream is laden with downed trees and debris jams that help to decrease water velocities and create rearing habitat. The stream passes through two culverts before entering a densely forested zone in which gradients become extremely steep (estimated greater than 7 percent). Presently, both culverts provide free-falling water under low flow conditions, which may result in difficult fish passage; high velocities in the culverts during high flows may also impede passage.

B2.1.4.1 Deep Creek - (DC-l)

The Deep Creek detailed study station was located about 2,000 ft upstream within a riffle-cascade-pool habitat type. Although boulder-rubble substrates were dominant, some spawning gravels were present in the upper portion of the reach. Stream gravels were generally clean; imbeddedness was estimated at 15 percent (Table B2-3). A small debris jam (2.3 ft drop) served as the downstream limit of the reach.

Table B2-10

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 1.2-MILE REACH OF DEEP CREEK, SEPTEMBER 1984

Transect No.	Habitat[c] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft^2)	Comments
1	Riffle	0.5	2.0-3.0	8	R	10	80	80	N	Thick bank cover. Small pool upstream.
2	Riffle/Run	1.0	1.0-2.0	12	R/B	10	70	80	N	Thick willow bank cover. Small pool upstream. Some rearing habitat. No spawning gravel.
3	Riffle/ Cascade	0.5	1.0-2.0	20	CC/R	10	80	80	N	Some spawning gravel just upstream. Steep cascade of 1-2 ft. Generally fast water.
4	Riffle/ Cascade	1.0	2.0-3.0	20	R/B - water on left bank	30	80	80	N	Some spawning gravel just upstream. Steep, fast. No resting pools. Decreasing rearing habitat.
5	Cascade/ Riffle	1.0	3.0-4.0	15	B/R/Bedrock	10	80	70	N	Log jam upstream. Steep cascade of 1-2 ft deep. No spawning gravel. No rearing habitat. No pools.
6	Riffle/ Cascade/Pool	1.0	2.0-3.0	12	B/R	10	80	80	Y	2-3 ft pool downstream; fast water; 2 ft drop; debris jam downstream.
7	Cascade/Pool	2.0	3.0-4.0	14	B	10	9	90	N	Very steep segment; 4 ft drop over 20 ft. Could be a velocity barrier at increased flows. Little rearing habitat; no spawning habitat.
8	Cascade/Pool	2.5	3.0-4.0	10	B	20	50	90	N	Another steep reach with Cascade pool; 4 ft drop after 15 ft. Potential velocity barrier at increased flows.
9	Cascade/ Riffle	1.0	3.0-4.0	12	B	10	40	80	N	Steep; increasing debris; pool 2-3 ft downstream; no spawning gravel.
10	Riffle/Run	0.5	2.0-3.0	20	CC/R	30	50	60	Y 5x20	Somewhat decreasing gradient; spawning gravel available on left bank at increased flows; 10 x 20 ft rearing habitat.
11	Riffle/ Cascade	1.0	2.0-3.0	15	R/B	10	90	90	N	Steep, fast; increasing debris; flow spread out.

Table B2-10

AQUATIC HABITAT CHARACTERISTICS[d] WITHIN A 1.2-MILE REACH OF DEEP CREEK, SEPTEMBER 1984 (Cont'd)

Transect No.	Habitat[c] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbeddedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft^2)	Comments
12	Cascade	0.5	3.0-4.Q	8-10	B/R	10	90	80	N	Very steep and narrow; 6 ft drop over 30 ft. No spawning gravel; decreasing rearing habitat; fast.
13	Riffle/Run	1.0	2.0-3.0	10	R/B	10	90	60	Y 10x20	Gradient decreasing; still narrow and fast. Some spawning gravel downstream.
14	Cascade/Pool	0.5-3.0	0.5-3.0	25	CG/R	50	90	90	Y	Large debris jam across stream; pool 2-3 ft deep downstream. Access problem; 2-3 ft drop. Some spawning gravel downstream. Flow splits at debris jam; two spillways.
15	Riffle	1.0	2.0-3.0	15	R/CG	10	90	80	N	Fast steep.
16	Cascade	1.0	3.0-4.0	20	B	10	40	40	N	Steep cascade. Debris jam. Probable barrier.
17	Riffle/Pooh	0.5	1.0-2.0	20	CG/R	20	90	90	Y 10x10	Gradient decreasing. Entering meadow. Small patches spawning gravel; pool 8 x 10 ft.
18	Riffle/Ripple	1.0	1.0-2.0	15	R/CG	20	90	30	N	Fast water. No spawning gravel.
19	Glide/Riffle	1.0	0.5	12	CG/R	10	90	90	Y 10x20	Spawning gravel present below riffle; some rearing habitat.
20	Riffle/Glide	0.5	0.5-1.0	10	CG/R	10	50	30	Y 10x10	Spawning gravel present in fast water.
21	Riffle/Pool	0.5	0.5-1.5	40	CG/FG	10	70	20	Y 20x30	Increasing spawning gravel but flow spread out and shallow. Passage problem at existing flow due to depth.

Table B2-10

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 1.2-MILE REACH OF DEEP CREEK, SEPTEMBER 1984 (Cont'd)

Transect No.	Habitat[c] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft^2)	Comments
22	Run	1.0	1.0-1.5	8	CG/FG	10	80	50	Y 40x8	Good spawning gravel on right bank. Usable at higher flows.
23	Riffle/Glide	0.5	1.0-2.0	25	R/CG	10	80	30	Y 10x10	Spawning gravel downstream. LOW flow and depth. Could be a passage problem.

[a] Transect length = 300 ft

[b] Visual observations used to evaluate all parameters.

[c] USFS Classification (1976)
- Pool - area of stream with reduced velocity
- Riffle = shallow section of stream with turbulent flows and/or swift velocity
- Cascade - turbulent, broken surface flow of water over a steeply inclined streambed
- Ripple - slower moving water exhibiting minor surface agitation or waves as a result of wind or velocity action
- Run - a stretch of relatively deep, fast, flowing water with the surface essentially nonturbulent
- Glide = a calm stretch of water flowing smoothly and gently

[d]
- B = boulder (>12 in.)
- R = rubble (3-12 in.)
- CG = coarse gravel (1-2 in.)
- FG = fine gravel (0.08-1.0 in.)
- Sd = sand
- St = silt

The reach studied averaged 13 ft wide and 0.81 ft deep, and had an average water velocity of 0.91 fps; stream flow on 9/30/85 was 9.7 cfs (Table B2-4). Water quality characteristics were suitable for salmonids, and invertebrate production was high.

The flow-habitat relationships for DC-1 are presented in Figure B2-5. Overall, only small amounts of spawning habitat were present; areas ranged from 13 to 558 ft^2/1,000 ft of stream for chinook, and from 2-183 ft^2 for steelhead. Only 135 and 32 ft^2/1,000 ft of stream were provided for these species by the calibration flow of 10 cfs. The relative scarcity of spawning area in Deep Creek was anticipated since it was primarily a riffle-cascade-pool habitat containing boulder-rubble substrated. For the 4.0 mi of stream representative of the modeled reach, a total of 2,869 ft^2 and 668 ft^2 of spawning area existed for chinook and steelhead (Table B2-7). This was the smallest amount of spawning area of the four tributary streams.

Rearing habitat was more plentiful in the reach, but overall, still represented the smallest quantity of the four streams. Available rearing area for the calibration flow (10 cfs) was 1,639 ft^2/1,000 ft of stream for chinook and 4,072 ft^2/1,000 ft for steelhead; total amount estimated for the 4.0 mi section was 34,617 and 85,994 ft^2, respectively (Table B2-8).

B2.1.5 Napias Creek

The habitat survey on Napias Creek extended from its mouth to 1.5 mi upstream; the reach included measurements on 26 transect. The upper terminus of the survey was located just above a steep inclined falls (gradient 7.9 percent), which extended for about 300 to 400 ft (Figure B2-9, Table B2-11). The vertical drop within this distance was estimated at 50 to 75 ft. The falls are a definite barrier to upstream migration. As a consequence, potential salmonid production would be limited to the lower 1.2 mi of stream. Should passage facilities be installed, an additional 8.5 mi would be available for production, extending up to Devlin Falls.

Most of the stream in the lower reach contains a mix of riffle-cascade habitat; substrates are rubble and boulder and water velocities frequently

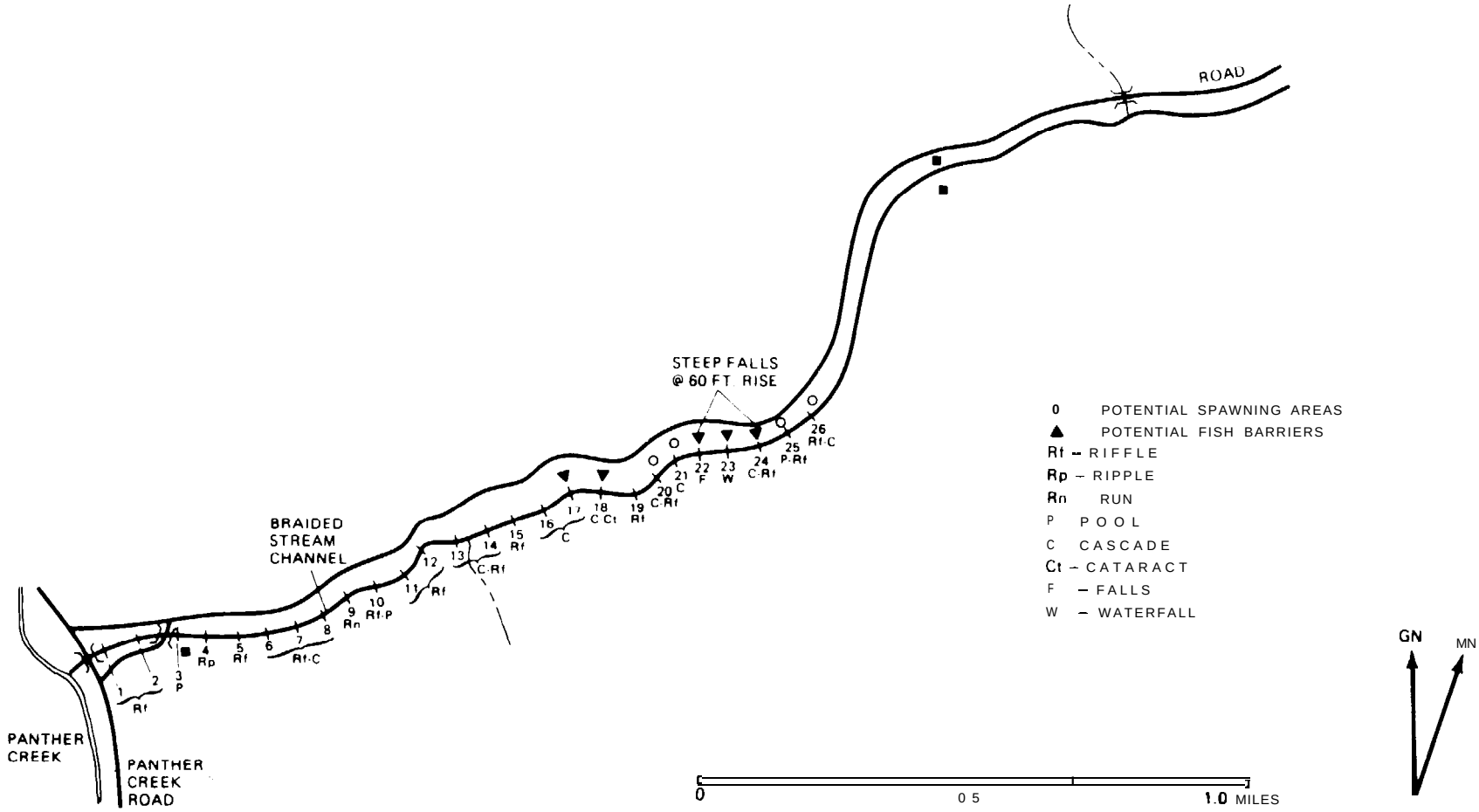


Figure B2-9 AQUATIC HABITAT MAP OF A 1.5 MILE REACH OF NAPIAS CREEK, SEPTEMBER 1984

Table B2-11

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 1.5-MILE REACH OF NAPIAS CREEK, SEPTEMBER 1984

Transect No.	Habitat Type[b]	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft^2)	Comments
1	Riffle	1.5	2.0-3.0	25	B/R	10	100	100	N	Fast water and large substrate.
2	Riffle	1.0	2.0-3.0	25	B/R	10	70	70	N	Steep gradient.
3	Pool	3.0	0.5-1.0	15	B/R	40	50	40	N	Across from homestead, by old footbridge.
4	Ripple	1.0-1.5	1.0-2.0	50	R/B	10	100	100	N	No spawning gravel; transect just above braided section.
5	Riffle	1.0	2.0-3.0	30	B/R	10	80	70	Y 10x10	Small patch of spawning gravel on left bank.
6	Riffle/ Cascade	2.0	3.0-4.0	20	B/R	10	80	80	N	No spawning gravel; fast water. Pool approximately 45 ft upstream.
7	Riffle/ Cascade	1.0-1.5	2.0-3.0	20	R/B	10	50	80	N	No spawning gravel; log jam just downstream.
8	Riffle/ Cascade	1.0	2.0-3.0	25	R/B	10	60	60	N	No spawning gravel; fast and steep. Braided section 50 ft upstream.
9	Run	1.5-2.6	2.0	15-20	B	10	60	80	N	No spawning gravel; cascade 10 ft upstream.
10	Riffle/Pool	3.0-4.0	1.0-2.0	25	B	10	80	80	N	Cascade; riffle upstream with pocket water; no spawning gravel.
11	Riffle	1.0-1.5	2.0-3.0	40	R/B	10	80	60	N	Flow spreads out; no spawning gravel.
12	Riffle	1.0-2.0	2.0-3.0	30	R/B	10	80	50	N	Flow spreads out; no spawning gravel; log debris.
13	Cascade/ Riffle	1.0-2.0	3.0-4.0	30	R/B	10	80	50	N	Heavy canopy.
14	Cascade/ Riffle	2.3	3.0-4.0	30	B/R	10	80	70	N	Fast with some pocket water.
15	Riffle				B/R	-			N	
16	Cascade		3.0-4.0		B/R				N	Fast water with pockets; no spawning gravel.
17	Cascade	2.3	3.0-4.0	40	B	10	70	70	N	Some passage problems likely; very little rearing habitat.

Table B2-11

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 1.5-MILE REACH OF NAPIAS CREEK, SEPTEMBER 1984 (Cont'd)

Transect No.	Habitat Type[b]	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft^2)	Comments
18	Cascade/ Cataract	3.4	4.0-5.0	40	B	10	70	70	N	Some passage problems likely. Deep pocket water.
19	Riffle	1.2	3.0-4.0	30	B/R	10	80	40	N	Small slide on left bank.
20	Cascade/ Riffle	2.3	3.0-4.0	15	B/R	20	80	80	N	No spawning gravel; series of pools; cascades; steep falls approximately 100 ft upstream.
21	Cascade	3.4	3.0-4.0	25	B	10	90	80	N	Large boulders, pools, steep cataracts; passage problems. Probably good for resident trout in some pocket areas. No spawning gravel.
22	Falls	3.4	4.0-5.0	25	B	10	90	90	N	At toe of falls; definite passage barriers.
23	Waterfall	2.3	4.0-5.0	40	B	10	90	90	N	Mid-falls estimated rise approximately 60 ft.
24	Cascade/ Riffle	2.3	3.0-4.0	35	B	10	70	90	N	Top of falls; steep. No spawning gravel.
25	Pool/Ripple	2.3	1.0-2.0	40	B/C & FG	20	70	90	Y	Some patches spawning gravel; cascade upstream.
26	Riffle/ Cascade	1.2	3.0-4.0	20	B/R	10	70	90	N	Adjacent to road; no spawning gravel. Survey end at Transect No. 26. Falls are a complete barrier to upstream passage. Steep gradient throughout stream. Some pocket water behind boulders with deep pools.

[a] Visual observations were used to evaluate all parameters.

[b] USFS Classification (1976)
- Pool = area of stream with reduced velocity
- Riffle = shallow section of stream with turbulent flows and/or swift velocity
- Cascade = turbulent, broken surface flow of water over a steeply inclined streambed
- Ripple = slower moving water exhibiting minor surface agitation or waves as a result of wind or velocity action
- Run = a stretch of relatively deep, fast, flowing water with the surface essentially nonturbulent
- Glide = a calm stretch of water flowing smoothly and gently

[c] B = boulder (>12 in.)
R = rubble (3-12 in.)
CG = coarse gravel (1-2 in.)
FG = fine gravel (0.08-1.0 in.)
Sd = sand
St = silt

exceed 3 to 5 fpa. Essentially no spawning gravel is present in the reach and few pool or resting areas are available. Thus, the reach has limited value for anadromous salmonid production. As such, no detailed habitat assessment (hydraulic and habitat modeling) of the stream was made and no estimates of smolt production were computed.

B2.1.6 Big Deer Creek

Big Deer Creek is located about 12 mi downstream from Blackbird Creek, and like Blackbird Creek, is presently transporting contaminants into Panther Creek (see Section 4.4). The majority of this material enters Big Deer Creek via the South Fork of Bucktail Creek (Figure B2-10).

The habitat survey on Big Deer Creek was conducted to determine its anadromous fish production potential should the toxic effluent problem be rectified. The survey encompassed a 2.5 mi reach of stream extending from its mouth upstream to the confluence of the South Fork of Bucktail Creek (Figure B2-10). At this juncture, the South Fork waters entering Big Deer Creek are aqua-blue in color, a result of copper precipitates, and a noticeable discoloration of Big Deer Creek occurs for about 75 to 100 yd downstream.

The lower 1 to 1.5 mi of Big Deer Creek is very steep with gradients exceeding 6 percent. Substrates within this area are comprised almost exclusively of boulder-rubble (Table B2-12). Spawning gravels are sparse and are limited to small pocket areas sheltered from high water velocities; water velocities often exceed 5 fps. Adult passage through this area would be impossible, owing to several debris jams (Transect 3, 4) and cascade/falls (Transects 8 through 12 and 19). The most prevalent of these has a vertical drop exceeding 50 ft that extends over 300 ft. The falls are comparable to those on Napias Creek.

Upstream from this, the stream assumes a more moderate gradient, although boulder-rubble substrates are still dominant. A light green precipitate was found beginning at Transect 14. In this reach, Big Deer Creek traverses several meadow areas that contain usable spawning habitat. Debris jams are prevalent, which would add to passage problems in the stream.

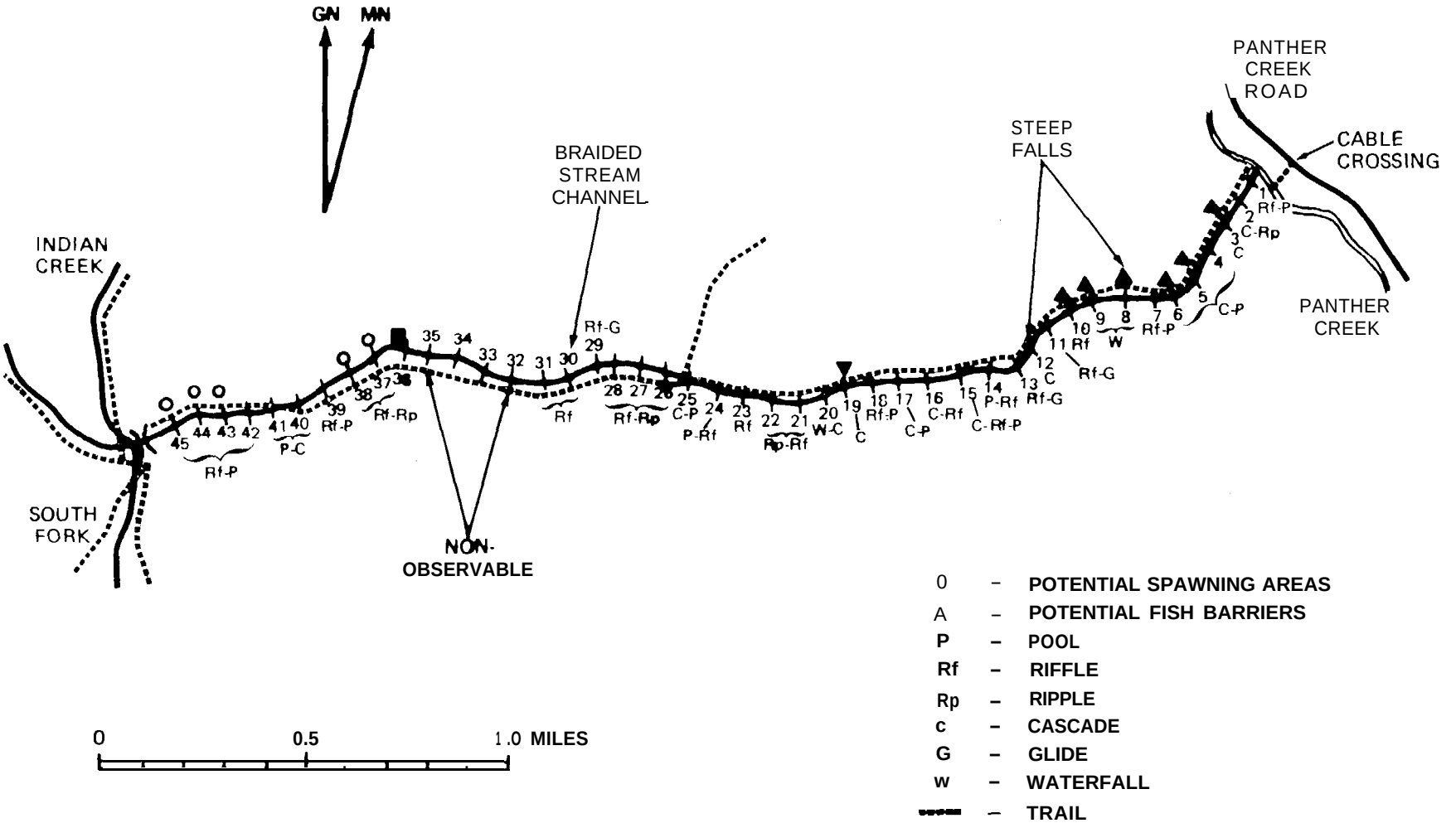


Figure B2-10 AQUATIC HABITAT MAP OF 4 2.5-MILE REACH OF BIG DEER CREEK, SEPTEMBER 1985

Table B2-12

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 2.5-MILE REACH OF BIG DEER CREEK, SEPTEMBER 1985

Transect No.	Habitat[b] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	SubstrateC	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft2)	Comments
1	Pool/Riffle	1.0	1.5-2.0	15	B/R	10	50	50	Y 6x6	Debris jam, upstream; some spawning gravel on left bank.
2	Cascade/ Ripple	1.0	3.0-4.0	12	B/R	5	90	95	Y	Steep cascade upstream (drop 5 ft); spawning gravel on left bank at high flow.
3	Cascade	3.0	4.0-5.0	25	B	5	90	95	N	Debris jam (4 ft drop); passage problem; pool area upstream.
4	Cascade/ Pool	2.0	3.0-4.0	12	B	5	95	95	N	Continues steep; cascade Well upstream; 4-5X gradient.
5	Pool/ Cascade	2.0	2.0-4.0	40	B	10	90	60	Y	2-3 ft passage problems; some spawning gravel on left bank.
6	Cascade/ Pool	3.0	1.0-4.0	35	B	30-40	90	90	Y	Passage problems; some spawning gravel on left bank; steep.
6.5	Cascade									30 ft drop over 20 ft distance; barrier problem.
7	Riffle/Pool	0.5	1.0-3.0	30	R/FG	25-30	75	75	Y	Moderate gradient; some spawning gravel on right bank; end of steep section.
8	Water Fall	1.4	3.0-6.0	20-25	B	20	80	80	N	Base of 50 ft falls; passage barrier.
9	Falls	5-10	5.0-10.0	20	B	0	95	95	N	3/4 up falls; 5-6 ft vertical drop; falls upstream.
9.5	Falls									Upper end of falls; moderate gradient.
10	Riffle	2.0	1.0-3.0	25	B/R/CG	10-20	80	50	Y	Tree roots/big downfall; some spawning gravel mid-stream.
11	Riffle/ Glide	2.0	1.0-2.0	20	B/R	10	90	90	N	Downstream debris jam; 3 ft falls upstream.
12	Cascade	2.0	3.0-5.0	12	B	5	90	90	N	Debris jam upstream/downstream.
12.5	Cascade									5 ft vertical drop,

Table B2-12

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 2.5-MILE REACH OF BIG DEER CREEK, SEPTEMBER 1985 (Cont'd)

Transect No.	Habitat[h] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft^2)	Comments
13	Riffle/ Glide	1.5	0.5-1.0	15	R/G/FG	30	90	90	Y	Some spawning gravel on right bank; substrate covered with green brown precipitate.
13.5	Cascade								N	4 ft vertical drop.
14	Pool/Riffle	1.0	1.0-2.0	20	B/CG/FG	15-20	90	90	N	Green precipitate on substrate.
15	Cascade/ Riffle/Pool	1.0	1.0-4.0	20	B/R/CG	20	90	90	Y	Some spawning gravel mid-stream; debris jam upstream.
16	Cascade/ Riffle	0.5	2.0-4.0	25	B/R/CG	20	90	90	N	Root wad-debris jam upstream.
16.5	Cascade								N	Increased gradient.
17	Cascade/ Pool	2.3	3.0-5.0	10	C/B	20	90	90	N	Very steep.
18	Riffle/Pool	2.3	1.0-3.0	25	B	10	90	90	N	Some green precipitate.
19	Cascade	1.0	2.0-4.0	20	B	10	90	90	N	Debris jam upstream.
19.5	Falls								N	Increased gradient.
20	Falls/ Cascade	2-3	2.0-5.0	20	B	10	90	60	N	Base of falls.
21	Ripple/ Riffle	1.0	1.0-2.0	15	R/CG/FG	20	85	90	N	Green precipitate.
22	Ripple/ Riffle	0.5	1.0-3.0	15	R/CG	40-50	90	90	N	Green precipitate.
23	Riffle	0.5	2.0-3.0	15	B	20	90	90	N	
24	Pool/Riffle	1.0	1.0-3.0	20	R/B	30	75	90	N	
25	Cascade/ Pool	3.0	3.0-5.0	35	B	15	75	60	N	Extensive debris jam.
26	Riffle/ Ripple	0.5	1.0-3.0	25	R	30	90	90	N	Change in character; decreased gradient.

Table B2-12

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 2.5-MILE REACH OF BIG DEER CREEK, SEPTEMBER 1985 (Cont'd)

Transect No.	Habitat[b] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	SubstrateC	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft2)	Comments
27	Riffle/ Ripple	0.5	1.0-3.0	15	R	30	90	90	N	Smooth reach; open meadow.
28	Riffle/ Ripple	0.5	1.0-3.0	15	R	30	90	75	N	Small debris jam downstream (2 ft drop).
29	Riffle/ Glide	1.0	1.0-2.0	15	R/CG	30	90	80	N	
30	Riffle	1.0	2.0-3.0	40	R/CG/B	20	80	90	N	Braided; some under cut bank slumping.
31	Riffle	1.0	2.0-3.0	15	R/B	20	90	90	N	
32									–	Nonobservable; similar meadow-marsh.
33							–		–	Nonobservable; similar meadow-marsh.
34						–	–		–	Nonobservable; similar meadow-marsh.
35									–	Abandoned cabin.
36	Riffle	1.0	2.0-3.0	15	R/CG	20	75	75	Y	debris jam downstream; some spawning gravel on right bank.
37	Riffle/ Ripple	1.0	1.0-2.0	25	R/CG	20-30	90	90	N	
38	Riffle/Ripple				B/R				N	
39	Riffle/Pool	2.0	2.0-4.0	20	B/R	15	90	90	N	
40	Pool/ Cascade	1.2	3.4	20	R/CG	15	80	80	N	
41	Pool/ Cascade					–	–		N	
42	Riffle/ Ripple	0.5-1.0	0.5-2.0	15	CG/FG	10	90	90	Y	

Table B2-12

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 2.5-MILE REACH OF BIG DEER CREEK, SEPTEMBER 1985 (Cont'd)

Transect No.	Habitat Type[b]	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft^2)	Comments
43	Riffle/Pool	-							Y	Good spawing habitat.
44	Riffle/Pool	-							Y	Meadow; excellent spawning gravel.
45	Riffle/Pool	-							Y	Good spawning gravel.

[a] Visual observations used to evaluate all parameters.

[b] USFS Classification (1976)
- Pool = area of stream with reduced velocity
- Riffle = shallow section of stream with turbulent flows and/or swift velocity
- Cascade = turbulent, broken surface flow of water over a steeply inclined streambed
- Ripple = slower moving water exhibiting minor surface agitation or waves as a result of wind or velocity action
- Run = a stretch of relatively deep, fast, flowing water with the surface essentially nonturbulent
- Glide = a calm stretch of water flowing smoothly and gently

[c]
- B = boulder (>12 in.)
- R = rubble (3-12 in.)
- CG = coarse gravel (1-2 in.)
- FG = fine gravel (0.08-1.0 in.)
- Sd = sand
- St = silt

Thus, even excluding the water quality problems of Big Deer Creek, the existing physical and hydraulic conditions would effectively prevent its habitation by anadromous salmonids. The Big Deer Creek system can therefore be considered of limited production potential.

B2.1.7 Beaver Creek

Beaver Creek is a small, relatively narrow (width range 6 to 20 ft.) stream Located in the lower Panther Creek drainage. A 1.0 mi reach of stream was evaluated to determine its potential value for salmonid production. The reach extended from its mouth to mid-way within a large meadow area (Figure B2-11 and Table B2-13).

The entire reach of Beaver Creek was characterized by riffle-cascade habitat, large substrate (boulder-rubble) and fast water velocities (range of 2 to 5 fps) (Tables B2-3 and B2-4). Overall, the stream is 9.4 mi long and has an average gradient of 9.7 percent. The stream reach studied was bordered by a dense riparian zone that contained many debris and log jams. The abundance of such materials would create difficult conditions for fish passage.

Because of its small size and prevailing physical and hydraulic conditions, the reach was considered of limited value for salmonid production. Therefore, detailed habitat assessments and smolt estimates were not made.

B2.1.8 Clear Creek

The mouth of Clear Creek is located about 1 to 2 mi downstream from Beaver Creek. This stream extends over 16 mi in length from its mouth to its headwaters located in the River of No Return Wilderness Area. A 2.5 mi reach of stream was assessed for potential salmonid production (Figure B2-12). This section had an average gradient of 4.6 percent, while the upper reaches had a gradient of 6.0 percent.

In general, the lower 22 transects had riffle-pool type habitat, the upper 22 transects were primarily cascade-pool (Table B2-14). Most of the suitable spawning areas (substrate primarily coarse and fine gravels) were located in

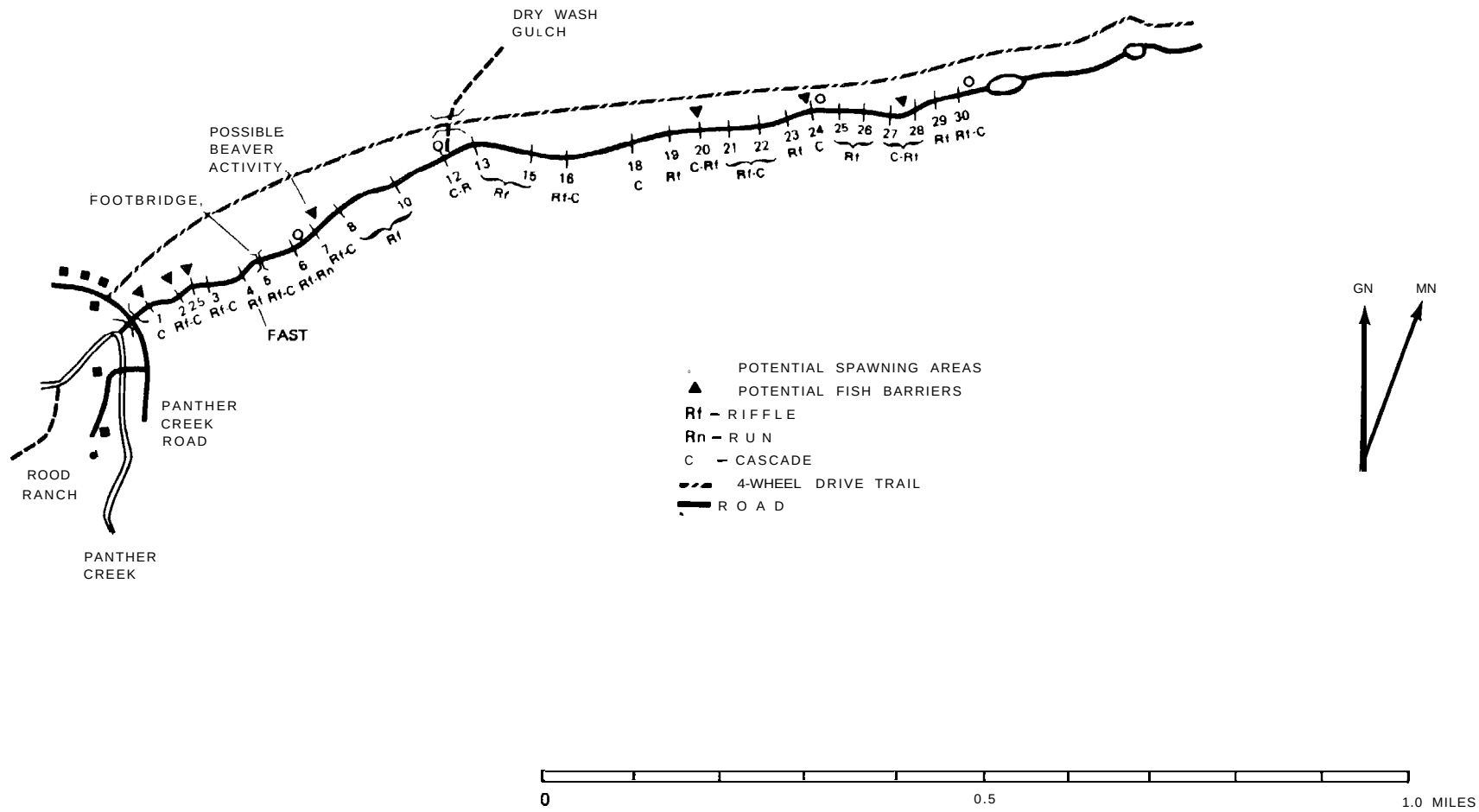


Figure B2-11 AQUATIC HABITAT MAP OF A 1.0-MILE REACH OF BEAVER CREEK, SEPTEMBER 1984

Table B2-13

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 1.0-MILE REACH OF BEAVER CREEK, SEPTEMBER 1984

Transect No.	Habitat[b] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate'	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft²)	Comments
1	Cascade	2.0	3.0-4.0	8.0	R/B	20	100	100	N	Possible barrier; log dam; fast water.
2	Riffle/ Cascade	1.0	3.0-4.0	9	B/R	10	100	100	N	Possible barrier; 4 ft foot dam.
2.5	Cascade	1.5	4.0-5.0	12	B/R	10	100	100	N	Possible barrier; dam.
3	Riffle/ Cascade	0.6	4.0-5.0	6	R/B	20	100	100	N	Fast, turbulent.
4	Riffle/Fast	0.6	3.0-4.0	10	R/CG	50	60	80	N	Complete canopy cover, dense vegetation.
5	Riffle/ Cascade	1.0	4.0-5.0	10	R/CG	30	100	90	N	Complete canopy cover, bridge 30 ft below.
6	Riffle/Run	1.5	2.0-3.0	6	R/CG	30	90	100	N	Dense canopy, fast water; spawning gravel upstream.
7	Riffle/ Cascade	0.6	4.5	12	B/R	30	50	50	N	Log jam; Cascade; thick canopy.
+ 20 paces	-								N	Barrier, log jam. Possible beaver activity.
8	Riffle	0.6	3.0-4.0	15	R/CG	20	80	80	N	Open area and undercut 20 ft below.
10	Riffle	0.6	3.0-4.0	8	R/CG	20	80	80	N	Thick canopy, steep, fast.
12	Cascade/ Riffle	0.6-1.0	4.0-5.0	15	R/R/Bedrock	20	80	SO	N	Thick canopy, steep, fast water, many Cascades.
13	Riffle	0.6	3.0-4.0	10-12	R/B	20	80	80	N	Dense vegetation, fast water.
15	Riffle	0.6	3.0-4.0	10	B/R	20	100	100	N	Dense vegetation, fast water.
16	Riffle/ Cascade	0.6	3.0-4.0	12	R/B	20	20	80	N	Dense vegetation, fast Water.
18	Cascade	1.0	4.0-5.0	10	B/R		80	20	N	Thick canopy.
19	Riffle	1.0	3.0-4.0	10	R/B		80	80	N	Dense, thick, debris jam.
20	Cascade/ 'iff le	0.6	4.0-5.0	10-12	B/R	20	50	80	N	Log barrier 10 ft below with 3 ft drop; thick.

Table B2-13

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A l.0-MILE REACH OF BEAVER CREEK, SEPTEMBER 1984 (Cont'd)

Transect No.	Habitat[b] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substratec	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft^2)	Comments
21	Riffle/ Cascade	1.0	3.0-4.0	12	R/CG	20	20	50	N	Slumping on right bank. Thick and dense.
22	Riffle/ Cascade	0.6	4.0-5.0	8	R/CG	20	50	80	N	Fast; thick canopy; clumping on right bank.
23	Riffle	0.6	3.0-4.0	8	R/CG		80	80	N	Fast, thick canopy.
24	Cascade	0.6	4.0-5.0	8	CG/Willows	20	80	80	N	Thick; barrier; fast velocities.
25	Riffle	0.4	2.0-3.0	20	R-CG	30	80	80	N	Thick canopy.
26	Riffle	0.6	3.0-4.0	12	R/B	20	80	80	N	Thick canopy, fast water.
27	Cascade/ Riffle	0.6	4.0-5.0	6	B/Bedrock	10	50	80	N	Thick canopy, fast water; log jams.
27.5	Cascade	0.6-1.0	4.0-5.0	7	B/Bedrock	10	80	60	N	Cascade; barrier 2-3 ft.
28	Cascade/ Riffle	0.8	3.0-6.0	10	B/Bedrock	10	60	80	N	Cascade
29	Riffle	0.8	4.0-5.0	12	R/CG	10	80	60	N	Cascade
30	Riffle/ Cascade	0.6	4.0-5.0	12	R/CG	20	60	80	N	End of survey. Stream conditions unsuitable for anadromous salmonid production. High velocities, deadfalls, debris jams, rock Cascades. Small size, 6-15 ft wide. Boulder and rubble substrates; no good spawning gravels in 1 mile surveyed. Entire reach fast and steep. Very difficult passage corridor.

[a] Visual observations used to evaluate all parameters.

[b] USES Classification (1976)
- Pool = area of stream with reduced velocity
- Riffle = shallow section of stream with turbulent flows and/or swift velocity
- Cascade = turbulent, broken surface flow of water over a steeply inclined streambed
- Ripple = slower moving water exhibiting minor surface agitation or waves as a result of wind or velocity action
- Run = a stretch of relatively deep, fast, flowing water with the surface essentially nonturbulent
- Glide = a calm stretch of water flowing smoothly and gently

[c]
- B = boulder (>12 in.)
- R = rubble (3-12 in.)
- CG = coarse gravel (l-2 in.)
- FG = fine gravel (0.08-1.0 in.)
- Sd = sand
- St = silt

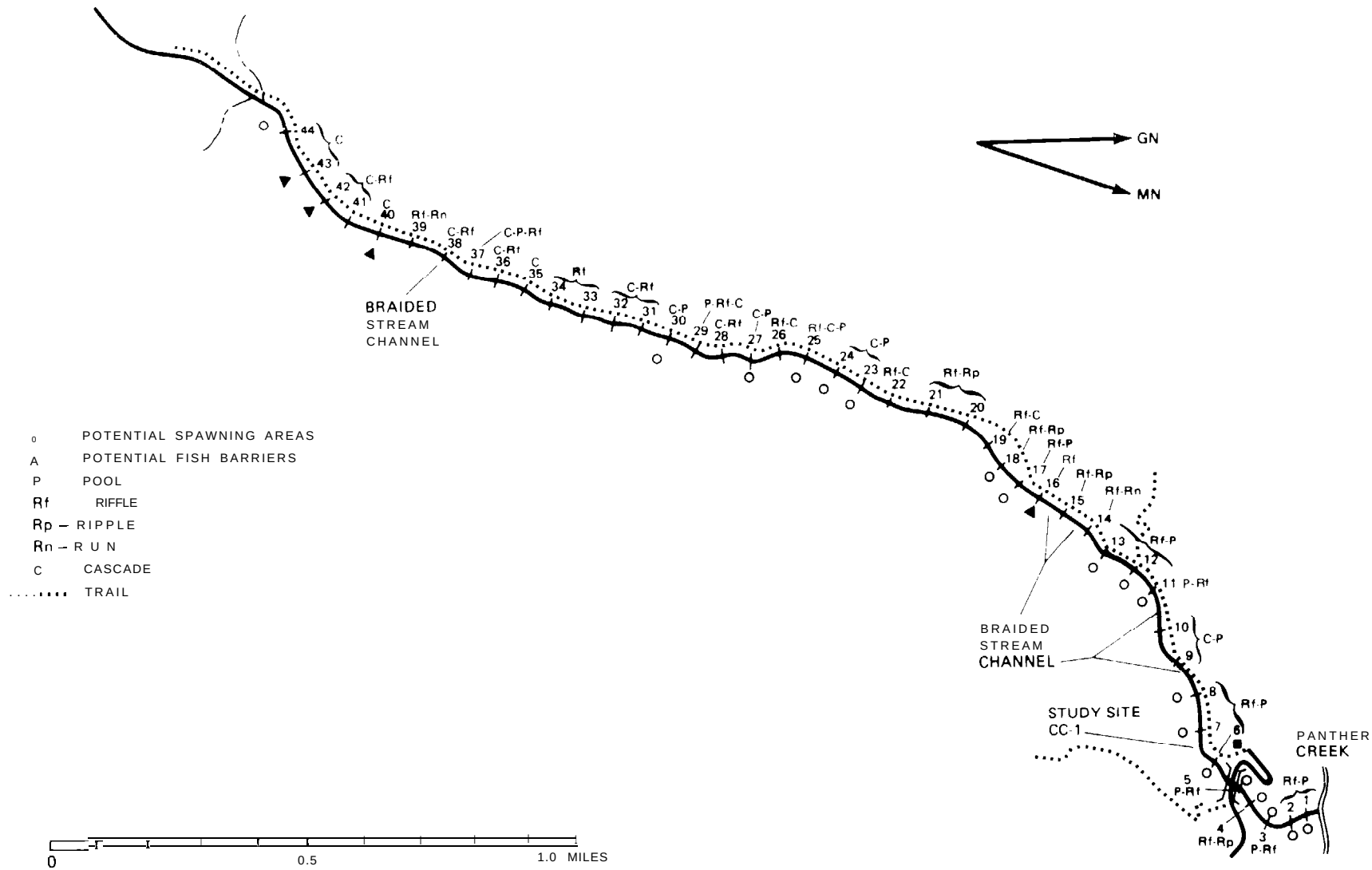


Figure B2-12 AQUATIC HABITAT MAP OF CLEAR CREEK FROM CONFLUENCE WITH PANTHER CREEK TO UPSTREAM 2.5 MILES, SEPTEMBER 1984

Table B2-14

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 2.5-MILE REACH OF CLEAR CREEK, SEPTEMBER 1984

Transect No.	Habitat[b] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate'	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft2)	Comments
1	Riffle/Pool	1.0-2.0	0.5-1.0	15	CG/FG	40	70	40	Y	Stream splits; good spawning gravel upstream at increased flow.
2	Riffle/Pool	1.0	0.5-1.0	20	CG/FG	40	20	20	Y	At point of split, good spawning gravel on right because of increased flow.
3	Pool/Riffle	2.0-3.0	1.0-2.0	12	CG/FG	40	70	60	Y	Good rearing habitat in pool and spawning gravel at riffle. Increased invertebrate production.
4	Riffle/Ripple	0.5	2.0-3.0	25	CG/FG	20	80	80	Y	Braided; good spawning gravel. Decreased depth at this flow; passage problems.
5	Pool/Riffle	1.0	2.0-3.0	10	CG/FG/Sd	40	70	70	Y	At bridge; good spawning gravel above and below. Rearing habitat in pools.
6	Riffle/Pool	2.5	2.0-3.0	20	CG/R	20	25	80	Y	Hydraulic model site CC-l. Good spawning gravel at flow. Good rearing habitat with undercut bank. Upper end just below IDF&G site.
7	Riffle/Pool	2.0	1.0-3.0	15	CG/FG	25	60	60	Y	Pipe crossing; good spawning gravel and rearing habitat.
8	Riffle/Pool	1.0	1.0-2.0	15	CG/FG/R	25	80	80	Y	Increased canopy; small falls upstream, good spawning gravel.
9	Cascade/Pool	2.0-3.0	1.0-2.0	20	CG/FG	25	60	60	N	At small falls, l-2 ft; maybe beaver activity. Good rearing habitat in pools. Flow spread out and braided.
10	Cascade/Pool	2.0-3.0	1.0-2.0	20	CG/FG	25	60	60	N	
11	Pool/Riffle	1.0	2.0-3.0	10	CG/FG	25	80	80	Y	Good spawning gravel.
12	Riffle/Pool	2.0-3.0	2.0-3.0	25	CG/FG	10	80	40	Y	Increased canopy cover; good spawning gravel and rearing habitat.
13	Riffle/Pool	2.0-3.0	1.0-3.0	20	CG/FG	10	80	80	Y	Excellent rearing and spawning; slough on left bank.
14	Riffle/Run	1.0	2.0-3.0	8	CG/FG	10	70	60	N	Increased gradient, narrow. Some overhead vegetation and undercut bank with run area.

Table B2-14

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 2.5-MILE REACH OF CLEAR CREEK, SEPTEMBER 1984 (Cont'd)

Transect No.	Habitat[b] Type	Water Depth (ft)	Water Velocity (ft)	Stream Width (ft)	Substrate'	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft2)	Comments
15	Riffle/Ripple	0.5-1.0	2.0-3.0	40	R/CG/Sd	20	50	70	N	Braided section; pool downstream with overhead vegetation; fast.
16	Riffle	0.5	2.0-3.0	20	R/CG	20	80	80	N	Increased substrate size and gradient; passage problems at this flow. + 180 ft to wilderness area.
17	Riffle/Pool	1.5	2.0-3.0	15	CG/FG	10	80	80	Y	Just within wilderness; 100% canopy. Debris jam upstream; some spawning gravel and pools for rearing habitat.
18	Riffle/Ripple	1.0	1.0-2.0	15	CG/FG	10	80	80	Y	Spawning gravel in riffles; pools for rearing habitat.
19	Riffle/ Cascade	0.5	2.0-3.0	15	R/CG	10	80	80	N	Increased gradient.
20	Riffle/Ripple									
21	Riffle/Ripple									
22	Riffle/ Cascade	0.5	2.0-3.0	12	B/R	10	60	80	N	Increased gradient; narrow and fast. No spawning gravel; limited rearing habitat.
23	Cascade/Pool	2.0	0.5-3.0	12	B/R	10	80	80	N	Small falls l-2 ft; increased gradient. Pools for rearing habitat; no spawning gravel.
24	Cascade/Pool	3.0	2.0-3.0	15	R/CG/FG	10	80	80	Y	Increased downfalls; some spawning gravel on right bank. Good plunge pools for rearing habitate.
25	Riffle/ Cascade/Pool	3.0	2.0-3.0	25	R/CG	20	70	70	Y	Second plunge pool. Rearing habitat by log jam; no spawning gravel.
26	Riffle/ Cascade	1.0	2.0-3.0	25	R/B	20	70	70	N	Steep; no spawning gravel.
27	Cascade/Pool	3.0	2.0-3.0	15	R/B	10	80	50	N	Increased gradient; increased debris jams; good pools; no spawning gravel.
28	Cascade/ Riffle	1.0	2.0-3.0	20	R/CG		80	80	N	Gradient still steep. Decreased pools, no spawning gravel.

Table B2 -14

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 2.5-MILE REACH OF CLEAR CREEK, SEPTEMBER 1984 (Cont'd)

Transect No.	Habitat[b] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	SubstrateC	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft²)	Comments
29	Cascade/Pool/ Riffle	1.0	2.0-3.0	10	R/B	10	80	80	N	Some pocket water. Stairstepped; narrow; no spawning gravel.
30	Cascade/Pool	2.0	1.0-3.0	15	R/CG	10	80	80	Y	More debris jams. Pockets of spawning gravel; some pools for rearing.
31	Cascade/ Riffle	1.0	2.0-3.0	10	B/R	10	80	50	N	Steep and narrow chute; very high velocities at increased flow.
32	Cascade/ Riffle	2.0	3.0-4.0	20	B/R	10	80	50	N	Increased log dams; fast water with some pools; no spawning gravel.
33	Riffle	1.0	2.0-3.0	15	R/CG	10	80	80	N	Long stretch of fast, shallow water; no spawning gravel or pools.
34	Riffle								N	
35	Cascade	1.0	3.0-4.0	12	R/B	10	80	80	N	Increased gradient, fast; decreased pools and no spawning gravel.
36	Cascade/ Riffle	2.0	3.0-4.0	20	R/B	10	80	80	N	Debris jam upstream; l-2 ft drop.
37	Cascade/Pool/ Riffle	2.0	2.0-3.0	10	R/B	10	80	80	N	Narrow and fast; some rearing habitat in pools, no spawning gravel.
38	Cascade/ Riffle	1.0	1.0-3.0	45	CG/R	10	70	70	N	Large debris jam; channel is braided.
39	Riffle/Run	1.0	2.0-3.0	10	R/B	10	70	70	N	Narrow and fast; no pools or spawning gravel.
'40	Cascade	2.0-3.0	3.0-4.0	10	B/R	10	80	80	N	Very steep and fast; falls upstream approximately 2-3 ft at increased flow; may pose velocity barrier.
41	Cascade/ Riffle	2.0-3.0	3.0-4.0	12	B/R	10	80	80	N	Continues steep and fast.
42	Cascade/ Riffle	2.0-3.0	3.0-4.0	8	B/R	10	80	80	N	Transect crosses cataract 2-3 ft steep; no spawning gravel. Decreased pools and rearing habitat; passage problems.

Table B2-14

AQUATIC HABITAT CHARACTERISTICS[a] WITHIN A 2.5-MILE REACH OF CLEAR CREEK, SEPTEMBER 1984 (Cont'd)

Transect No.	Habitat[b] Type	Water Depth (ft)	Water Velocity (fps)	Stream Width (ft)	Substrate[c]	Imbed-dedness (%)	Bank Stability (%) Left	Bank Stability (%) Right	Spawning Gravel (Yes/No) (ft2)	Comments
43	Cascade	2.0-3.0	3.0-4.0	12	B/R	10	70	70	N	Steep, narrow, and fast; passage problem at increased flow.
44	Cascade	1.0-2.0	3.0-4.0	12	B/R	10	80	60	N	Increased debris jam; steep. same morphology.

[a] Visual Observations used to evaluate all parameters.

[b] USFS Classification (1976)
- Pool = area of stream with reduced velocity
- Riffle = shallow section of stream with turbulent flows and/or swift velocity
- Cascade - turbulent, broken surface flow of water over a steeply inclined streambed
- Ripple - slower moving water exhibiting minor surface agitation or waves as a result of wind or velocity action
- Run - a stretch of relatively deep, fast, flowing water with the surface essentially nonturbulent
- Glide - a calm stretch of water flowing smoothly and gently

[c]
- B - boulder (>12 in.)
- R - rubble (3-12 in.)
- CG - coarse gravel (1-2 in.)
- FG = fine gravel (0.08-1.0 in.)
- Sd - sand
- St - silt

the lower sections of the stream. Stream gravels were well-washed with imbeddedness ratings generally ranging from 10 to 20 percent (Table B2-3).

Although no beaver activity was observed there were many debris and log jams in the upper portions of the reach that could impede fish passage at certain flows. Many of these structures have resulted in the scouring-out of pool areas thereby providing excellent rearing habitat.

From the assessment, It appears that most viable spawning habitat would be provided in the lower 4.0 mi of Clear Creek. Rearing habitat is available throughout the stream, but in places this also becomes marginal owing to the steep gradient and fast water velocities.

B2.1.8.1 Clear Creek - (CC-l)

For modeling purposes, a single station was located about 1800 ft upstream from the mouth of Clear Creek, adjacent to Transect 6 (Figure B2-12). The station was comprised of riffle-pool habitat and contained excellent spawning gravels. The station also contained excellent rearing habitat in the form of undercut banks and pool areas.

Stream substrates were comprised, in order of abundance, of coarse gravel, rubble, and fine gravels, which were all clean and sediment-free (Table B2-3). Some slumping of undercut banks had occurred mid-reach.

The stream had an average width of 20.5 ft and an average depth and velocity of 0.80 and 1.34 fps, respectively (Table B2-4). Stream discharge, as gaged on 9/24/85, was 21.9 cfs. All water quality parameters were conducive to salmonid production.

The available spawning habitat in Clear Creek ranged from 18 to 3,124 ft^2 (chinook) and from 36 to 1,056 ft^2/1,000 ft stream (steelhead) (Figure B2-3). For the field measured flow of 22 cfs, 322 and 49 ft^2 of spawning area/ 1,000 ft of stream were available for chinook and steelhead, respectively. Steelhead spawning habitat showed two peaks with flow, the first at 10 cfs, the second at over 50 cfs. This type of situation can occur

in conjunction with a stepped-gravel bar that becomes overtopped, thereby providing additional habitat. For the 4 mi of Clear Creek containing similar habitat, a total of 6,804 ft^2 (chinook) and 1,026 ft^2 (steelhead) of spawning habitat was provided (Table B2-7).

It is of interest to note the large increases in spawning habitat that occur when flows are increased in Clear Creek. An almost lo-fold increase results in chinook spawning habitat when flows are increased from 22 to 54 cfs (6,804 ft^2 to 65,988 ft^2); a 20-fold increase occurs for steelhead (1,026 ft^2 to 22,299 ft^2). Such changes were the largest of any of the tributary streams (Table B2-7).

There was abundant rearing habitat in Clear Creek in pools, undercut banks, and debris jams. The Clear Creek system collectively provides the greatest amount of rearing area of the four tributary streams. A total of 163,641 ft^2 of chinook rearing area and 421,661 ft^2 of steelhead were made available at the calibration flow (Table B2-8).

B2.1.9 Panther Creek Drainage - Summary

For the entire Panther Creek Drainage, a total of 188,846 ft^2 and 93,104 ft^2 of chinook and steelhead spawning habitat existed at the field measured flows (Table B2-7). Total rearing habitat provided at these flows were 2,219,345 ft^2 for chinook and 6,431,172 ft^2 for steelhead (Table B2-8).

With respect to spawning area, the next step prior to estimating smolt production was to estimate the potential number of redds resulting from a given area. Table B2-15 presents a summary of the redd capacity of the Panther Creek system. Such estimates reflect conditions in which escapement is high and all spawning areas are fully seeded. This condition has been documented by many investigators who have observed high spawning densities of salmon and steelhead when space is at a premium. In these instances, the required area per redd can be small and may result in redd superimposition (Stuart 1953; Hobbs 1937).

Table B2-15

ESTIMATED CHINOOK AND STEELHEAD REDD CAPACITY IN THE PANTHER CREEK DRAINAGE

Stream	Length (Miles)	Length (Feet)	Measured Flow (cfs)	Estimated Number of Redds					
				0.4 X Measured Flow		Measured Flow		2.5 X Measured Flow	
				Chinook'	Steelhead[b]	Chinook[a]	Steelhead[b]	ChInook[a]	Steelhead[b]
Clear Creek	4.0	21,120	22.0	34	30	191	17	1,858	383
Lower Mover Creek	2.1	11,088	16	62	18	302	78	284	52
Upper Moyer Creek	3.6	19,008	16	300	102	764	308	1,317	248
Musgrove Creek	4.0	21,120	9	81	8	488	52	804	190
Deep Creek	4.0	21,120	9	7	0	80	11	332	66
Panther Creek	42.0	221,760	Variable	1,628	664	3,605	1,128	5,275	944
Total				2.112	822	5,430	1,594	9.870	1,883

a Nnumbers derived from chinook redd area estimates of 35.5 ft^2/redd

b Numbers derived from steelhead redd area1 estimates of 58 ft^2/redd

For the calibration flows, the potential number of chinook redds per stream ranged from 80 in Deep Creek to over 3,600 in Panther Creek. Moyer Creek offers the greatest amount of potential spawning area of the tributary streams, providing space for over 1,000 chinook redds. Musgrove Creek also contains substantial chinook spawning habitat that is equivalent to 488 redds. Overall, the Panther Creek drainage contains spawning area sufficient for over 5,400 chinook salmon redds.

Steelhead spawning area and redd equivalents are markedly lower than for chinook, although the order of numerical abundance in the systems is the same (i.e., Panther Creek contains the greatest number of redds, Deep Creek the least). For the calibration flows, the Panther Creek drainage has the potential for providing over 1,500 steelhead redds (Table B2-15).

Figures B2-13 and B2-14 present graphic depictions of the cumulative number of redds as a function of distance upstream from the mouth of Panther Creek (see Section B8). From these, it is apparent the majority of spawning habitat present in Panther Creek is above both Big Deer and Blackbird creeks. As noted, space is available below Big Deer Creek at the measured flow to provide only 248 chinook and 23 steelhead redds, which includes redds in Clear Creek. Below Blackbird Creek (including Deep Creek) space exists for 1,066 chinook and 267 steelhead redds. In contrast, over 4,300 chinook and 1,300 steelhead redds, each representing about 80 percent of the total numbers of potential redds, exist in the upper reaches of Panther Creek and the tributaries Moyer Creek and Musgrove Creek.

From a biological perspective, it is easy to understand the demise of the anadromous fish runs in Panther Creek since the toxic effluent from Blackbird and Rig Deer creeks effectively isolated the majority of spawning habitat from use.

B2.2 SMOLT PRODUCTION ESTIMATES

From the above analysis, two independent estimates of smolt production were made for the Panther Creek drainage: one based on spawning habitat, the other on rearing. These estimates enabled a determination of the limiting habitat

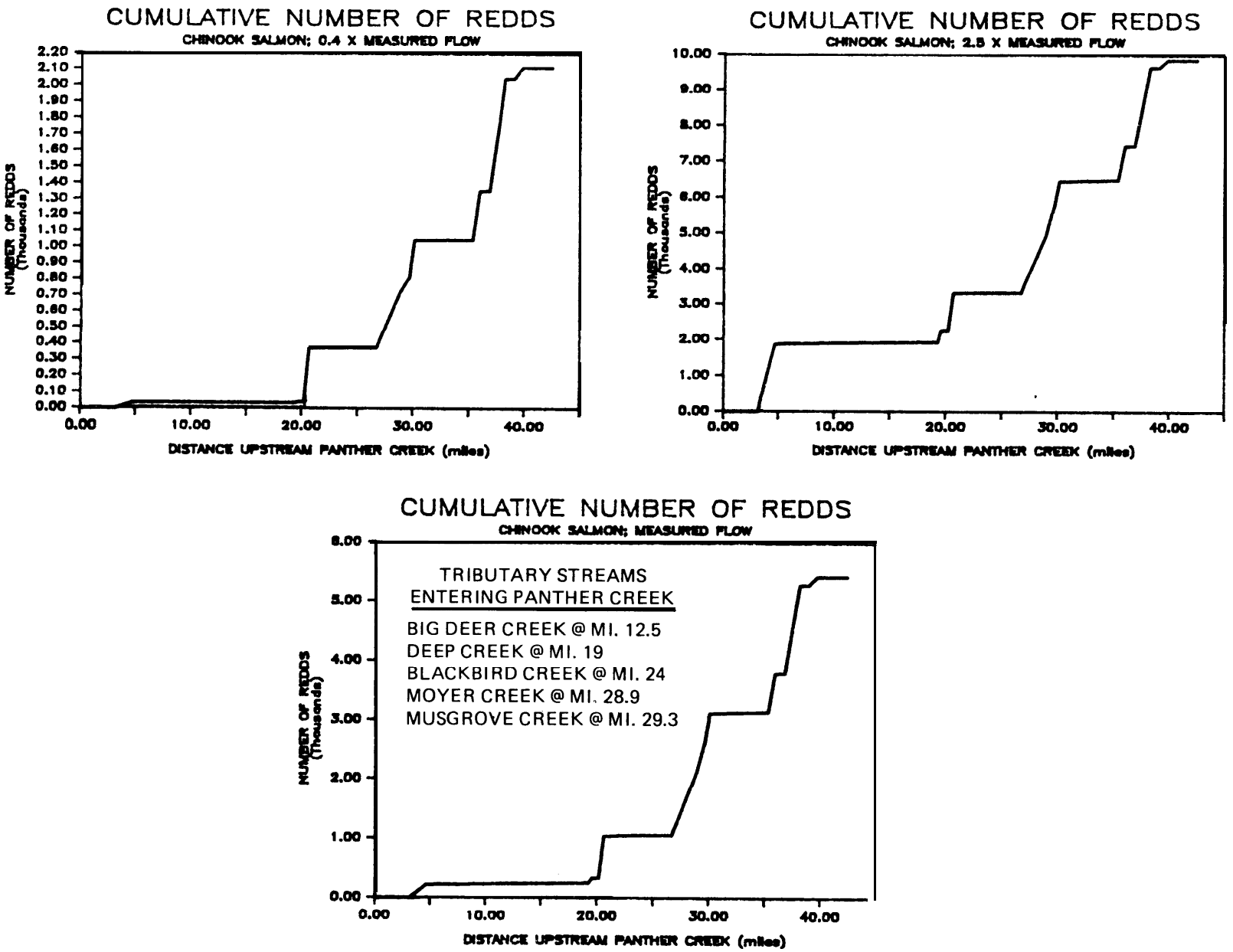


Figure B2-13 CUMULATIVE CHINOOK REDD CAPACITY FOR THREE FLOW CONDITIONS AS A FUNCTION OF DISTANCE UPSTREAM FROM THE MOUTH OF PANTHER CREEK

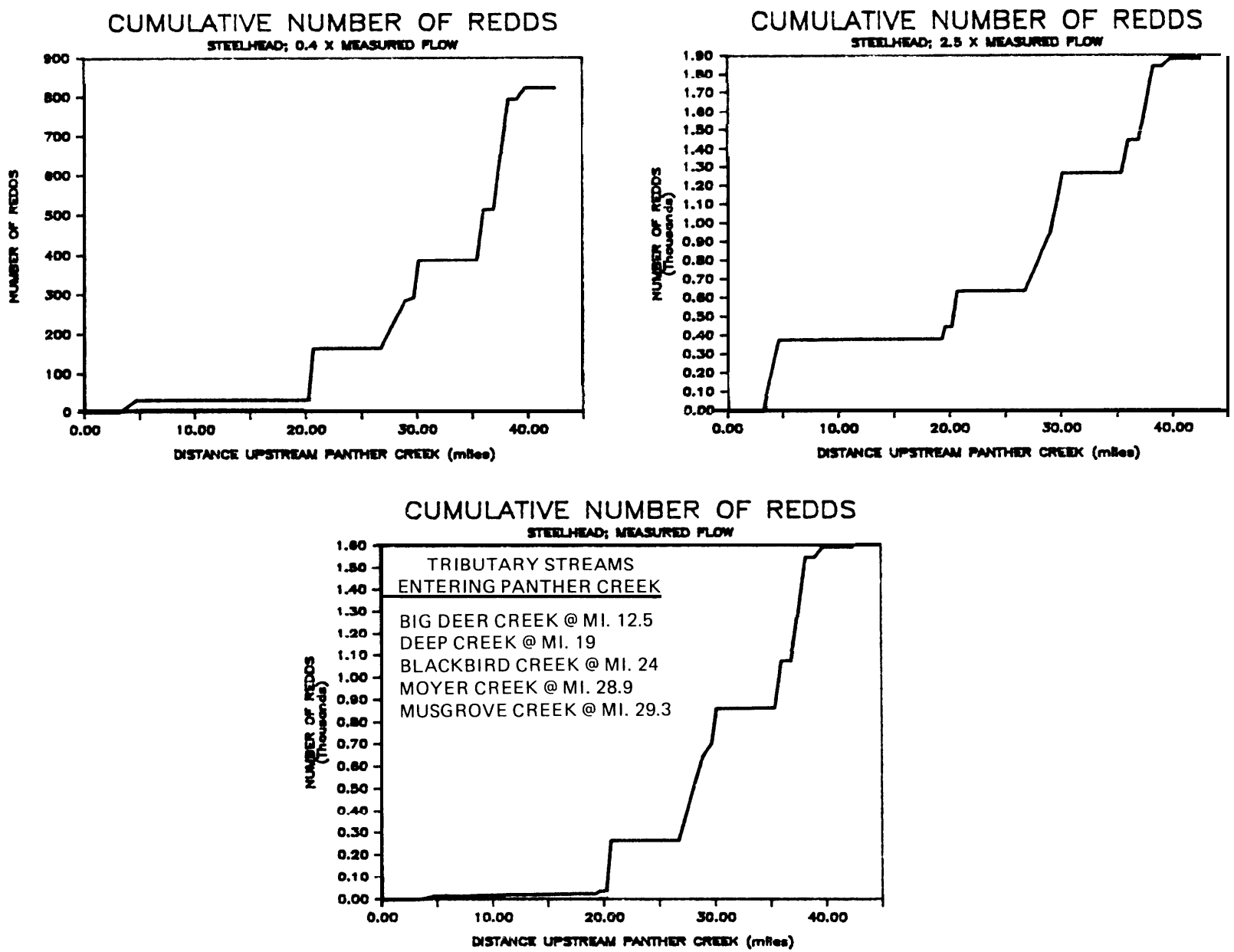


Figure B2-14 CUMULATIVE STEELHEAD REDD CAPACITY FOR THREE FLOW CONDITIONS AS A FUNCTION OF DISTANCE UPSTREAM FROM THE MOUTH OF PANTHER CREEK

component in the system. The estimates were made for four different flows to demonstrate the variability in production levels at different base flow conditions. For spawning, the estimates were made corresponding to the redd-area estimates previously described; 36 ft^2 for chinook and 58 ft^2 for steelhead. The chinook rearing estimates were made based on spatial needs of 0.096 $fish/ft^2$. The steelhead estimates were based on average density information for yearling I+ and II+ age fish.

B2.2.1 Spawning Habitat Estimates

Based on spawning area and number of redds for the field measures flow, an estimated 847,080 chinook and 173,746 steelhead smolts could be produced in the Panther Creek Drainage (Table B2-16).

The 847,080 chinook smolt estimates included a contribution of 562,380 from Panther Creek and 284,700 smolts from the four tributary streams. Of this latter amount, Moyer Creek contributed 166,296 smolts, clearly indicating it is the most important tributary system of Panther Creek for spawning. Next, in order of abundance was Musgrove Creek, followed by Clear and Deep creeks.

Steelhead smolt production estimates followed a similar trend. Of the 173,746 smolts, Panther Creek provided 122,952, and the tributaries 50,794, of which Moyer Creek's contribution was 42,074.

As depicted in Figure B2-15 the majority of smolt production potential for the field measure flow based on spawning occurs upstream from Big Deer and Blackbird creeks (see Volume II, Section 6 for tabular results). The contribution of chinook smolts below Big Deer Creek is only about 38,376 (4.5 percent of total), which includes Clear Creek. Below Blackbird Creek, which includes Deep Creek, an estimated 166,140 smolts (20 percent of total) could be produced. Thus, about 80 percent of the chinook production from spawning would occur above Blackbird Creek, over 95 percent above Big Deer Creek. For steelhead, only 1.5 percent (2,507 smolts) and 17 percent (29,103) of smolt production potential exists below Big Deer and Blackbird creeks, respectively.

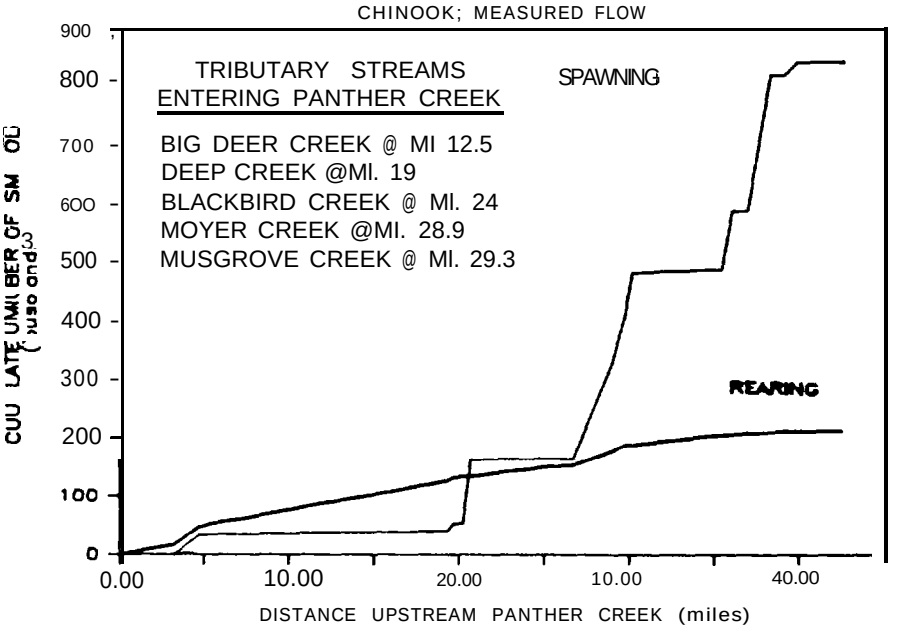
Table B2-16

ESTIMATED TOTAL *CHINOOK* AND STEELHEAD SMOLT PRODUCTION IN THE PANTHER CREEK DRAINAGE BASED ON SPAWNING HABITAT AT THREE FLOWS

Stream	Length (Miles)	Measured Flow (cfs)	Estimated Number of Smolts from Redds					
			0.4 X Measured Flow		Measured Flow		2.5 X Meaured Flow	
			Chinook[a]	Steelhead[b]	Chinook[a]	Steelhead[b]	Chinook[a]	Steelhead[b]
Clear Creek	4.0	22	5,304	3,270	29,796	1,853	289,848	41,747
Lower Moyer Creek	2.1	16	9,672	1,962	47,112	8,502	44,304	5,668
Upper Moyer Creek	3.6	16	46,800	11,118	119,184	33,572	205,452	27,032
Musgrove Creek	4.0	9	12,636	872	76,128	5,668	125,424	20,710
Deep Creek	4.0	10	1,092	0	12,480	1,199	51,792	7,194
Panther Creek	42.0		253,968	72,376	562,380	122,952	822,900	102,896
Total			329.472	89,592	847,080	173,746	1,539,720	205,247

[a] Numbers derived from chinook redd area estimates of 35.5 ft^2/redd

b Numbers derived from steelhead redd area1 estimates of 58 ft^2/redd



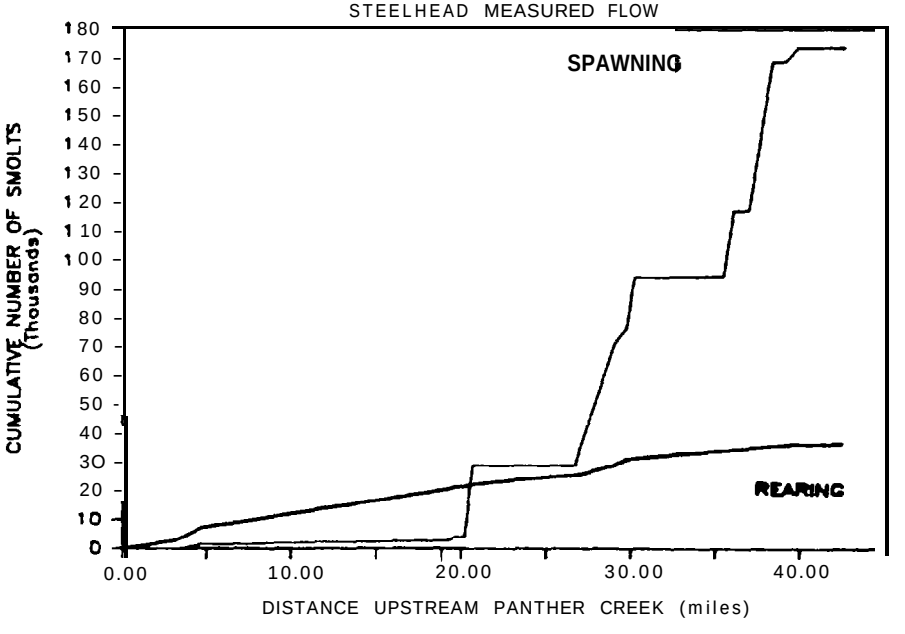


Figure B2-15 CHINOOK AND STEELHEAD SMOLT PRODUCTION POTENTIAL BASED ON SPAWNING AND REARING HABITAT, AS A FUNCTION OF DISTANCE UPSTREAM FROM THE MOUTH OF PANTHER CREEK

B2.2.2 Rearing habitat Estimates

Smolt production estimates based on rearing habitat were remarkably close to those for spawning when made for the field measured calibration flow. Overall, the estimates for chinook were slightly higher (215,539) than those for spawning, while those for steelhead were slightly lower (36,609). The chinook estimates Included a contribution of 170,677 from Panther Creek and 44,862 from the four tributaries (Table B2-17). The contribution of chinook smolts from the tributaries was dominated by Moyer Creek (19,005) and Clear Creek (15,709). Estimates of steelhead production followed a similar trend, with Panther Creek contributing 29,697 and the tributaries 6,912. Moyer and Clear Creeks again constituted the bulk of the tributary estimate.

The difference in smolt estimates noted above for spawning and rearing implies that chinook production is limited by spawning habitat while steelhead production is limited by rearing habitat. In reality,it is likely that rearing habitat (probably winter rearing habitat) is the limiting factor for both chinook and steelhead. This is because the estimates presented for spawning were minimum values based on large redd spatial requirements. The actual smolt production potential would likely exceed the minimum estimates and may range to over 840,000 (Table B2-16). In addition, mention has been made to the general lack of instream cover (e.g., boulders, debris jams, logs, etc.) throughout much of Panther Creek. Such material creates good rearing habitat by providing needed cover and resting areas. The Salmon National Forest has recognized this and has implemented several habitat enhancement projects in Panther Creek designed to increase the amount of available rearing habitat. Such projects could, in the future, significantly increase the smolt production potential in the Panther Creek drainage.

In contrast to the estimates derived from spawning, the majority of smolt production potential based on rearing occurs downstream from Big Deer and Blackbird creeks (Figure B2-15). For chinook, 42 percent (92,260) of the smolt production would occur below Big Deer Creek, and 69 percent (149,929) below Blackbird Creek. The steelhead estimates were similar: 41 percent (14,863) of the production below Big Deer Creekand 68 percent below Blackbird Creek. These estimates illustrates the significance of the lower reaches of

Table B2-17

ESTIMATED TOTAL CHINOOK AND STEELHEAD SMOLT PRODUCTION IN THE PANTHER CREEK DRAINAGE BASED ON AVAILABLE REARING HABITAT AT THREE FLOWS

Stream	Length (Miles)	Measured Flow (cfs)	Estimated Number of Smolts					
			0.4 x Measured Flow		Measured Flow		2.5 x Measured Flow	
			Chinook	Steelhead	Chinook	Steelhead	chinook	Steelhead
Clear creek (CC-l)	7.0	22	8,248	1,378	15,709	2,403	30,149	4,936
Lower Moyer Creek (MC-2)	2.1	16	2,460	439	4,178	656	5,565	847
Upper Moyer Creek (MC-l)	7.5	16	9,467	1,228	14,827	1,992	19,165	7,829
Musgrove Creek (MGC-1)	7.0	9	3,082	560	6,825	1,371	13,111	2,597
Deep Creek (DC-l)	4.0	10	2,223	289	3,323	490	6,567	894
Panther Creek	42.0	Variable	153,209	23,751	170,677	29,697	175,003	34,160
Total			178,689	27,645	215,539	36,609	249,560	42,263

Panther Creek for production. In addition, they emphasize the need for reclamation/abatement measures on the Blackbird mine to attain the necessary water quality levels to allow complete habitation of fish throughout Panther Creek. Simply providing passage through the affected reach will only open the system to spawning and will not provide sufficient rearing habitat.

B2.2.3 Effects of Flow on Smolt Estimates

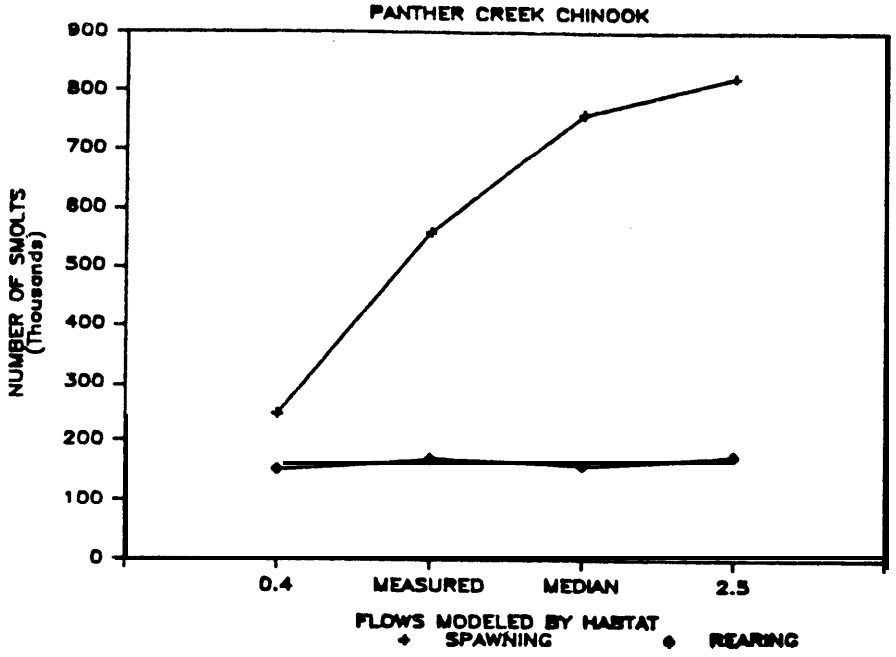
Figures B2-16 through B2-20 depict the variability in smolt production estimates as influenced by changes in baseflow and shifts in the limiting habitat component. In general, for the flows modeled, a positive relationship exists between number of smolts and streamflow, which reflects the positive habitat flow relationship previously described. The degree of change in smolt numbers does vary depending on whether it is based on spawning or rearing habitat. Compare the following. Based on rearing area, at 0.4 and 2.5 of the calibration flow, the estimated chinook smolt production is 153,000 smolts and 175,000 smolts, respectively, which is only a l.l-fold increase. Based on spawning areas, these flows would result in estimates ranging from about 253,900 to 823,000 smolts, which represents a 3-fold increase. A similar trend occurs for steelhead. Thus, smolt production potential could range widely depending on the existing baseflow conditions and general flow regime.

B2.3 ECONOMIC ANALYSIS

(See Section 7, Main Report)

B2.4 FISH TISSUE ANALYSIS

Results of the fish tissue analysis are presented in Table B2-18. In general, the metals in the tissues of ail fish were concentrated above ambient levels that have been reported for waters in the Panther Creek drainage (Platts et al. 1979, Hennes 1980, Noranda 1980, Torf 1985). However, none of the concentrations exceeded values considered deleterious to human health (David Bingham 138.5, U.S. Food and Drug Administration FDA, San Francisco, Calif, pers. comm.). In tact, for the metals analyzed the FDA presently only has upper concentration limits specified for lead (7ug/g). The remaining metals have no set standards for human consumption. This is based on the assumption



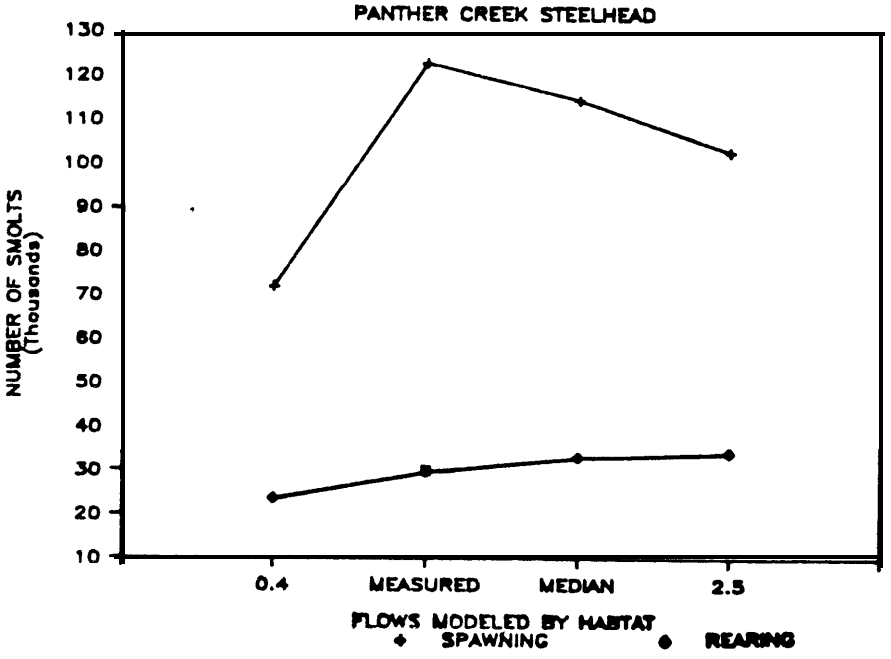
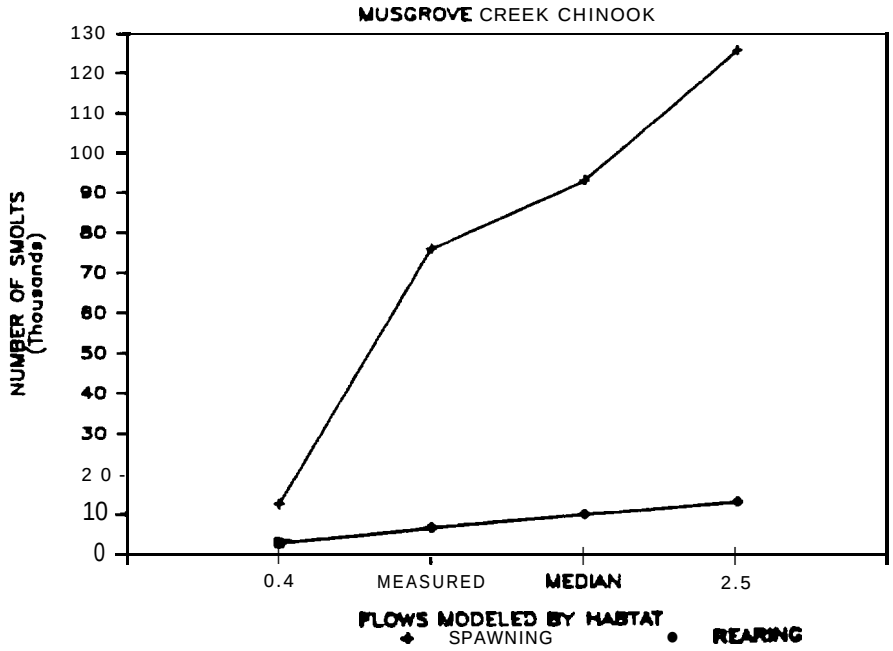
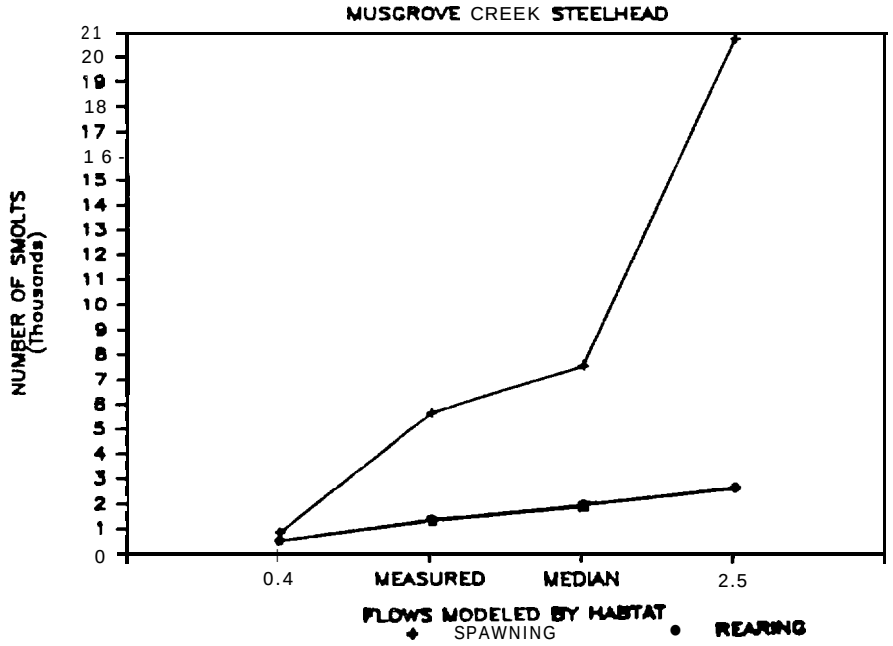


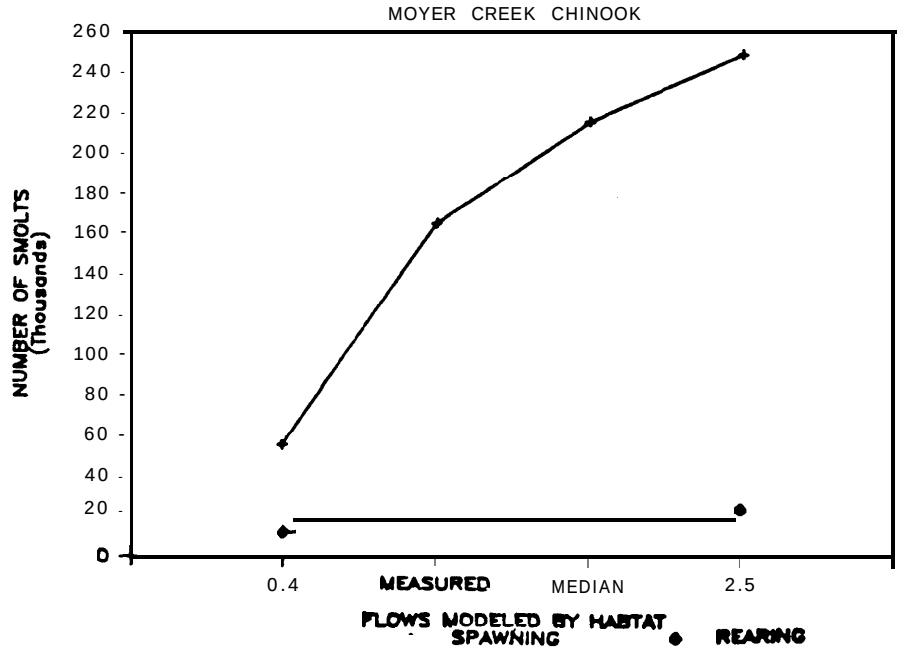
FIGURE B2-16 PANTHER CREEK CHINOOK AND STEELHEAD SMOLT PRODUCTION ESTIMATES BASED ON SPAWNING AND REARING HABITAT AT FOUR FLOWS

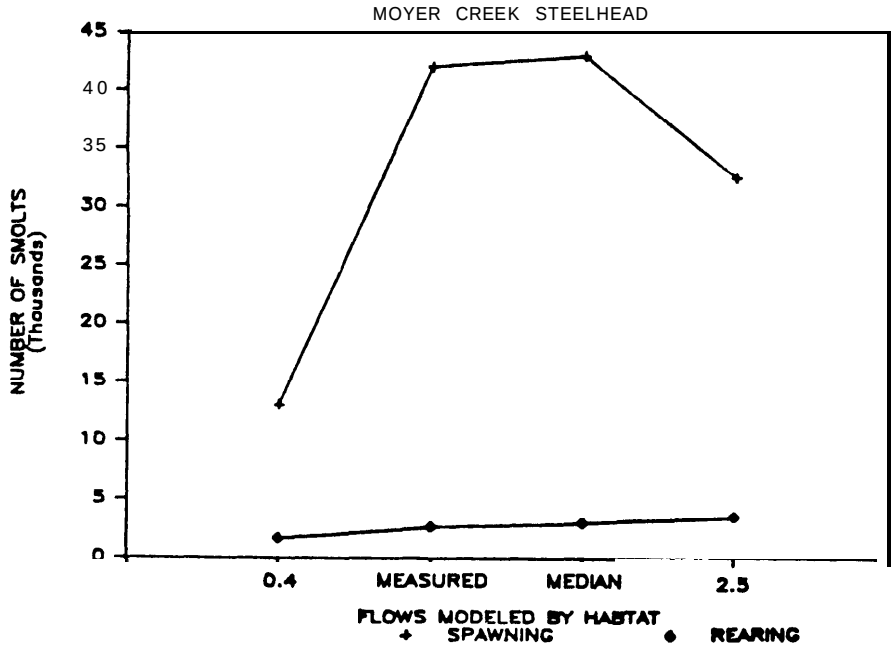




FIELD MEASURED FLOW = 8.0 cfs

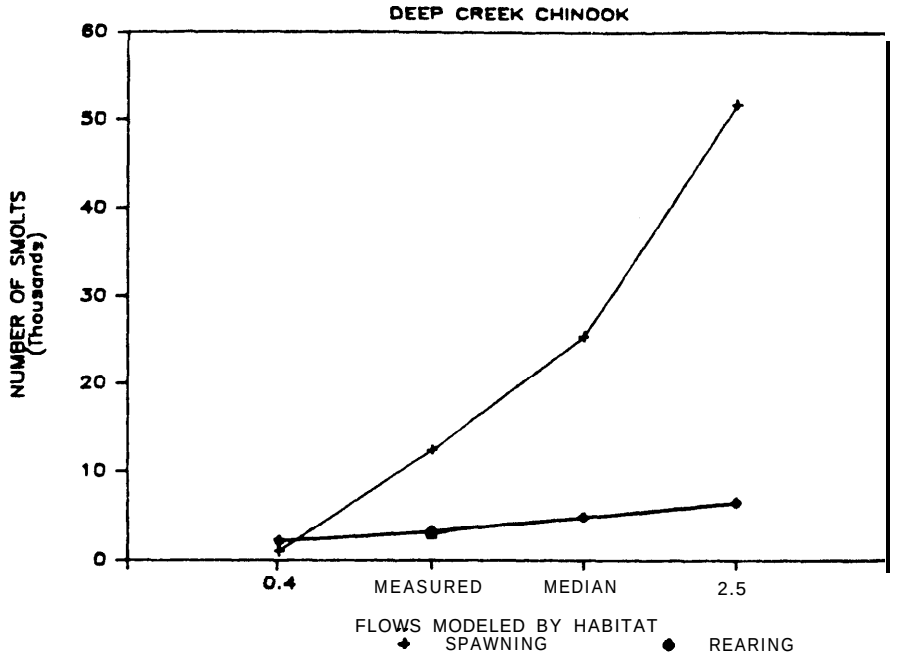
Figure B2-17 MUSGROVE CREEK CHINOOK AND STEELHEAD SMOLT PRODUCTION ESTIMATES BASED ON SPAWNING AND REARING HABITAT AT FOUR FLOWS

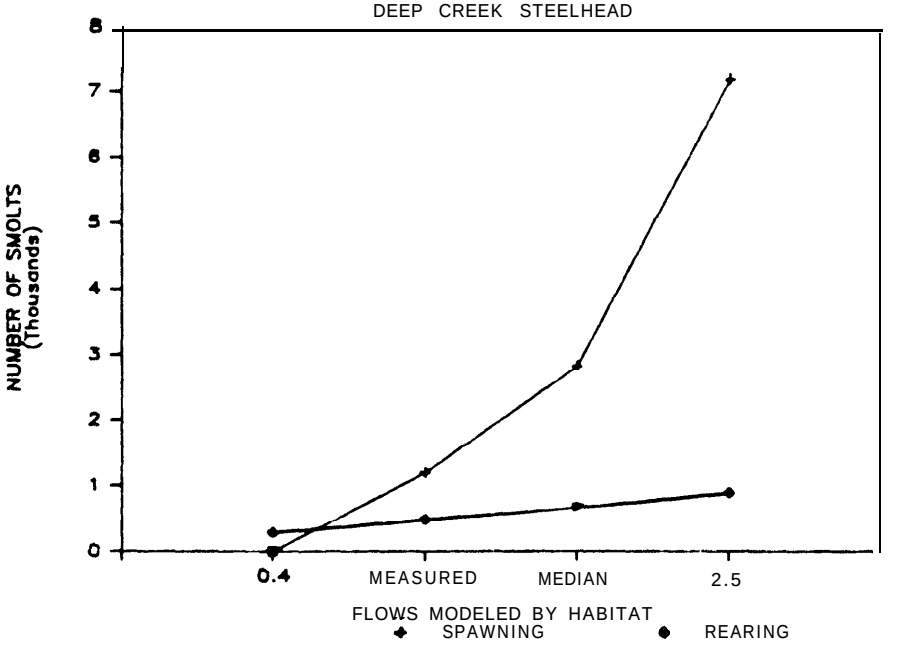




FIELD MEASURED FLOW = 16 cfs

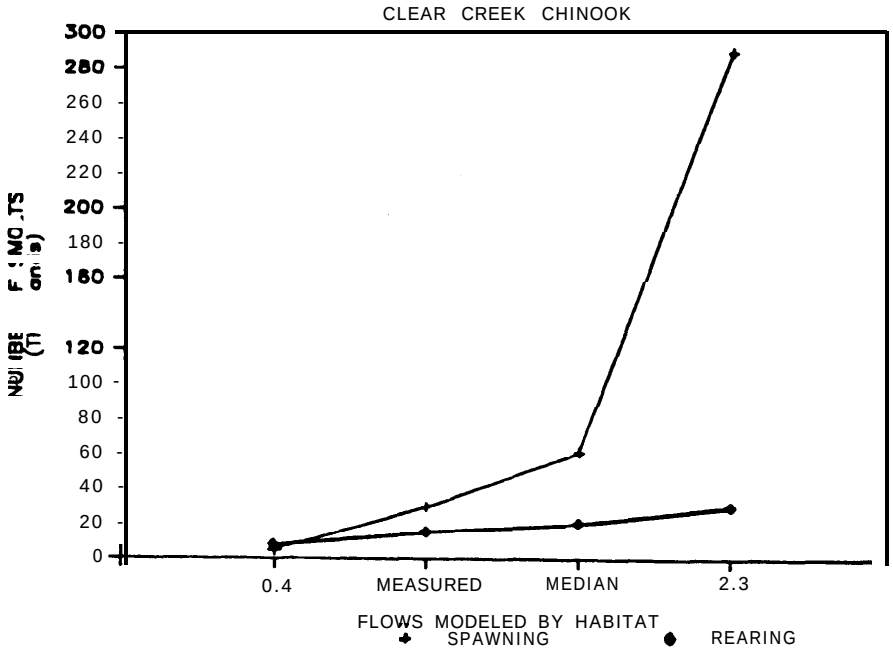
Figure B2-18 MOYER CREEK CHINOOK AND STEELHEAD SMOLT PRODUCTION ESTIMATES BASED ON SPAWNING AND REARING HABITAT AT FOUR FLOWS

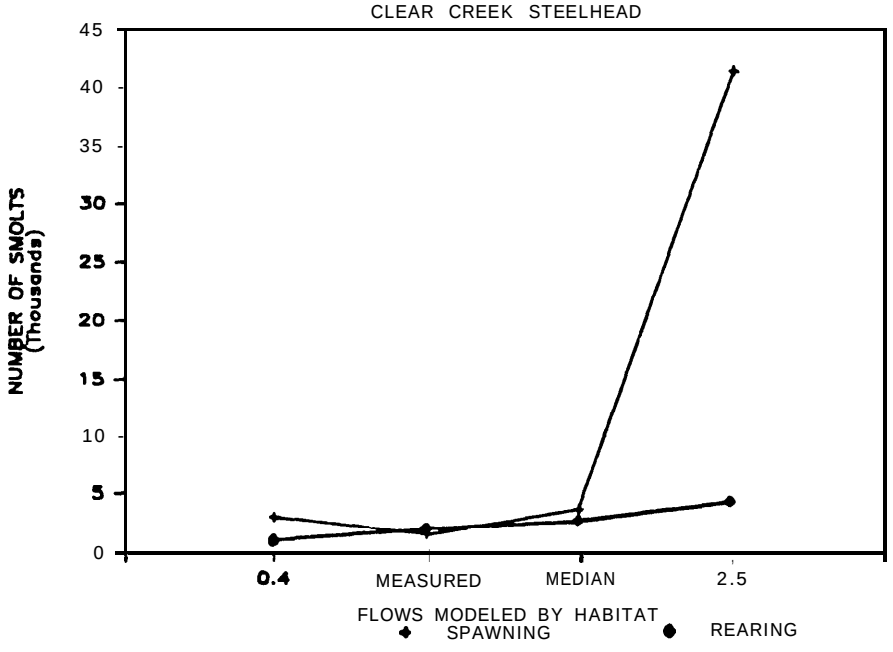




FIELD MEASURED FLOW = 10 cfs

Figure B2-19 DEEP CREEK CHINOOK AND STEELHEAD SMOLT PRODUCTION ESTIMATES BASED ON SPAWNING AND REARING HABITAT AT FOUR FLOWS





FIELD MEASURED FLOW = 22 cfs

Figure B2-20 CLEAR CREEK CHINOOK AND STEELHEAD SMOLT PRODUCTION ESTIMATES BASED ON SPAWNING AND REARING HABITAT AT FOUR FLOWS

that concentrations of these materials could never be bioaccumulated to levels harmful to humans since the necessary concentrations would already be toxic to the fish. Thus, consumption of fish from the Panther Creek drainage should pose no human health hazard.

Of the five metals analyzed, only copper and cobalt exhibited any trend indicative of metals contamination from mine drainage. Mean (x) copper concentrations in fish were 0.76 ug/g above Blackbird Creek, 0.95 ug/g below Blackbird Creek, and 1.13 ug/g below Big Deer Creek; mean cobalt concentrations were 0.25, 0.54, and 0.46 ug/g respectively (Table B2-18). However, only the cobalt concentrations were found to be significantly different; concentrations above Blackbird Creek were significantly less than below the creek (Kruskal-Wallis test, $\alpha = 0.05$, df = 2, k = 3, Table B2-19). Thus, the copper, iron, zinc, and lead concentrations in tissues of fish from contaminated areas (below Blackbird Creek) were not significantly higher than those from control areas (above Blackbird Creek).

The variability in concentrations depicted in Table B2-18 was anticipated and reflects species differences between and within the specimens captured (e.g., age, length, weight, diet). Additionally, salmonids migrate frequently within a given stream system and would be expected to move to and from the contaminated reach of Panther Creek. As such, metals uptake could be sporadic, which would also contribute to the observed variability.

Table B2-18

METALS CONCENTRATIONS IN MUSCLE TISSUES OF FISH
COLLECTED ABOVE AND BELOW BLACKBIRD AND BIG DEER CREEK,
SEPTEMBER 1985

Collection Site	Location	Species[a]	Length (in.)	Weight (g)	Metals Concentration (ug/g) Cobalt	Copper	Iron	Zinc	Lead[b]
Upper	Above Blackbird Creek	Bull trout	8.62	87.03	0.27	0.45	4.5	5.9	<0.1
	Above Blackbird Creek	Rainbow trout (W)	8.62	114.23	0.24	0.65	5.4	5.1	<0.1
	Above Blackbird Creek	Rainbow trout (W)	7.00	46.96	0.36	0.59		5.4	<0.1
	Above Blackbird Creek	Brook trout	6.87	49.35	0.21	1.07	23.5	7.8	<0.1
	Above Blackbird Creek	Bull trout	6.62	45.38	0.17	1.06	10.7	7.4	<0.1
	Above Blackbird Creek	Mountain whitefish	9.00	120.06	0.25	0.76	9.2	4.9	<0.1
				Mean ($\bar{x}$)	0.25	0.76	9.7	6.1	-
Middle	Below Blackbird Creek, above Deep Creek	Rainbow trout (W)	7.87	80.82	0.54	1.1	11.4	6.5	<0.1
	Below Blackbird Creek, above Deep Creek	Rainbow trout (W)	7.44	71.29	0.51	0.69	6.8	5.8	<0.1
	Below Blackbird Creek, above Deep Creek	Rainbow trout (W)	7.50	70.50	1.05	1.59	13	5.7	<0.1
	Below Blackbird Creek, above Deep Creek	Rainbow trout (W)	7.00	50.12	0.3	0.49	6.2	5.2	<0.1
	Below Blackbird Creek, below Deep Creek	Rainbow trout (W)	8.50	80.62	0.28	0.89	6.8	5.4	<0.1
				Mean ($\bar{x}$)	0.54	0.95	8.8	5.7	-
Lower	Below Big Deer Creek, above Clear Creek	Rainbow trout (W)	7.37	53.20	0.55	1.14	5.1	6.1	<0.1
	Below Big Deer Creek, above Clear Creek	Rainbow trout (H)	10.50	189.63	0.41	0.65	4.2	4.1	<0.1
	Below Big Deer Creek, above Clear Creek	Rainbow trout (W)	8.87	99.79	0.39	1.16	7.3	7.4	<0.1
	Below Big Deer Creek, above Clear Creek	Rainbow trout (H)	10.12	147.50	0.51	1.61	9.4	5.1	<0.1
	Below Big Deer Creek, above Clear Creek	Rainbow trout (W)	7.25	57.22	0.62	1.32	6.8	6.4	<0.1
	Below Big Deer Creek, above Clear Creek	Rainbow trout (W)	8.00	88.78	0.5	0.95	5.3	5.2	<0.1
	Below Big Deer Creek, above Clear Creek	Rainbow trout (W)	8.75	104.30	0.36	0.6	6.1	4.9	<0.1
	Below Big Deer Creek, above Clear Creek	Rainbow trout (W)	8.75	97.00	0.49	1.92	11.6	6.8	<0.1
	Below Big Deer Creek, above Clear Creek	Rainbow trout (W)	10.00	129.78	0.32	0.84	8.2	7.0	<0.1
				Mean ($\bar{x}$)	0.46	1.13	7.1	5.9	-

[a]W = wild fish
H = hatchery fish
[b]Detection limit = 0.1 ppm

Table B2-19

RESULTS OF KRUSKAL-WALLIS MULTIPLE COMPARISON TESTS OF METALS CONCENTRATION IN FISH TISSUES COLLECTED IN UPPER, MIDDLE, AND LOWER PANTHER CREEK

Metal	Comparison[a]	Computed T Value	Tabled X^2 Value[b]	Result
Cobalt	Upper vs Middle	11.185	5.99	Significant = Upper < Middle
	Upper vs Lower	11.185	5.99	Significant = Upper < Lower
	Middle vs Lower	11.185	5.99	Not Significant = Middle = Lower
Copper	All	4.46	5.99	Not Significant Upper = Middle = Lower
Iron	AL1	1.60	5.99	Not Significant Upper = Middle = Lower
Zinc	A11	0.063	5.99	Not Significant Upper = Middle = Lower

a Upper = Above Blackbird Creek
Middle = Below Blackbird Creek but above Big Deer Creek
Lower = Below Big Deer Creek

b $\alpha = 0.05$
$k = 3$, df = 2

Section B3

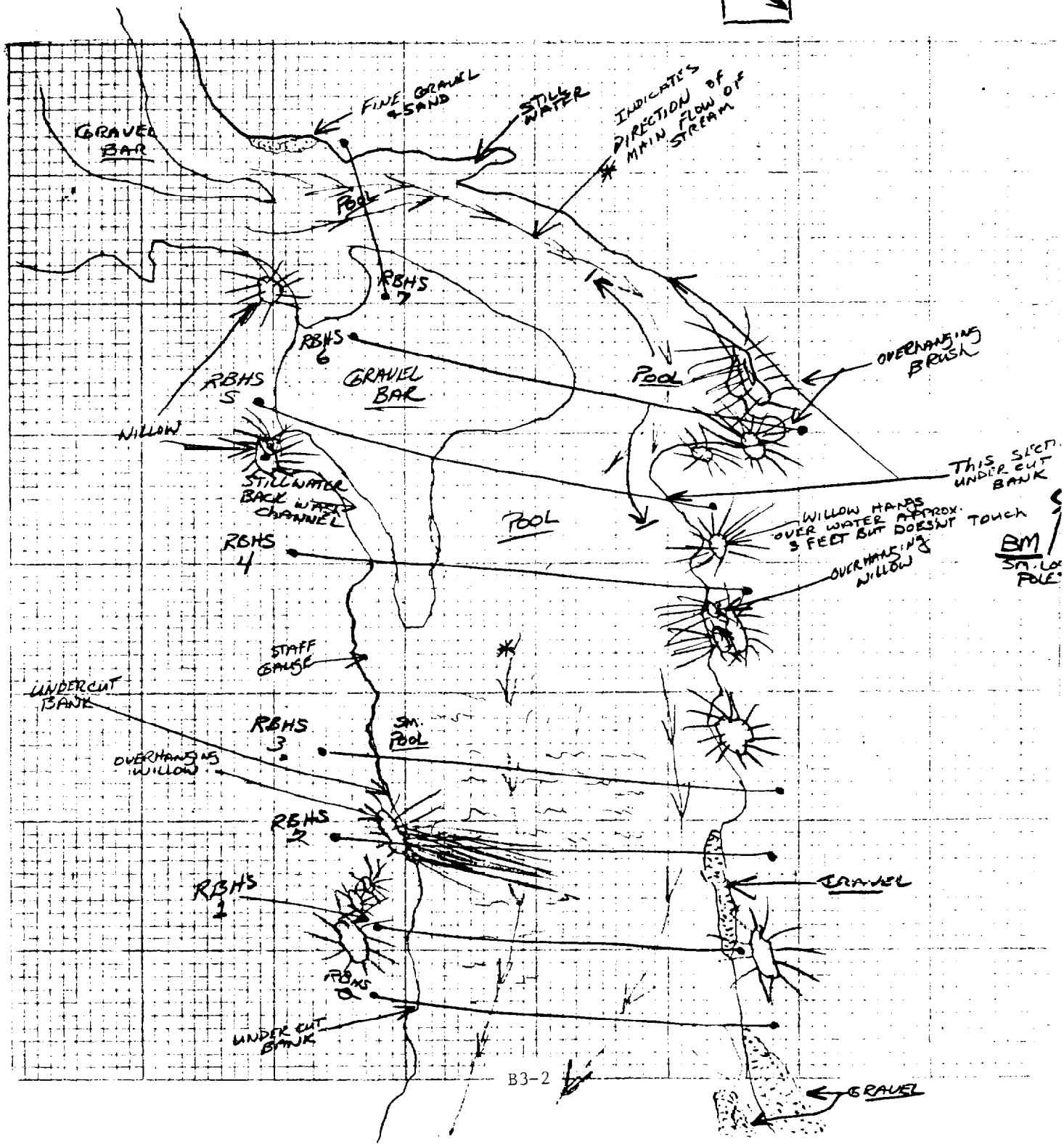
SCHEMATIC FIELD DRAWINGS OF QUANTITATIVE HABITAT STATIONS, PANTHER CREEK DRAINAGE

MAP OF STUDY AREA

Date 9-11-84
River PANTHER CREEK
Study Area UPPER STANWING

Cartographer OALE

Direction of Magnetic North:

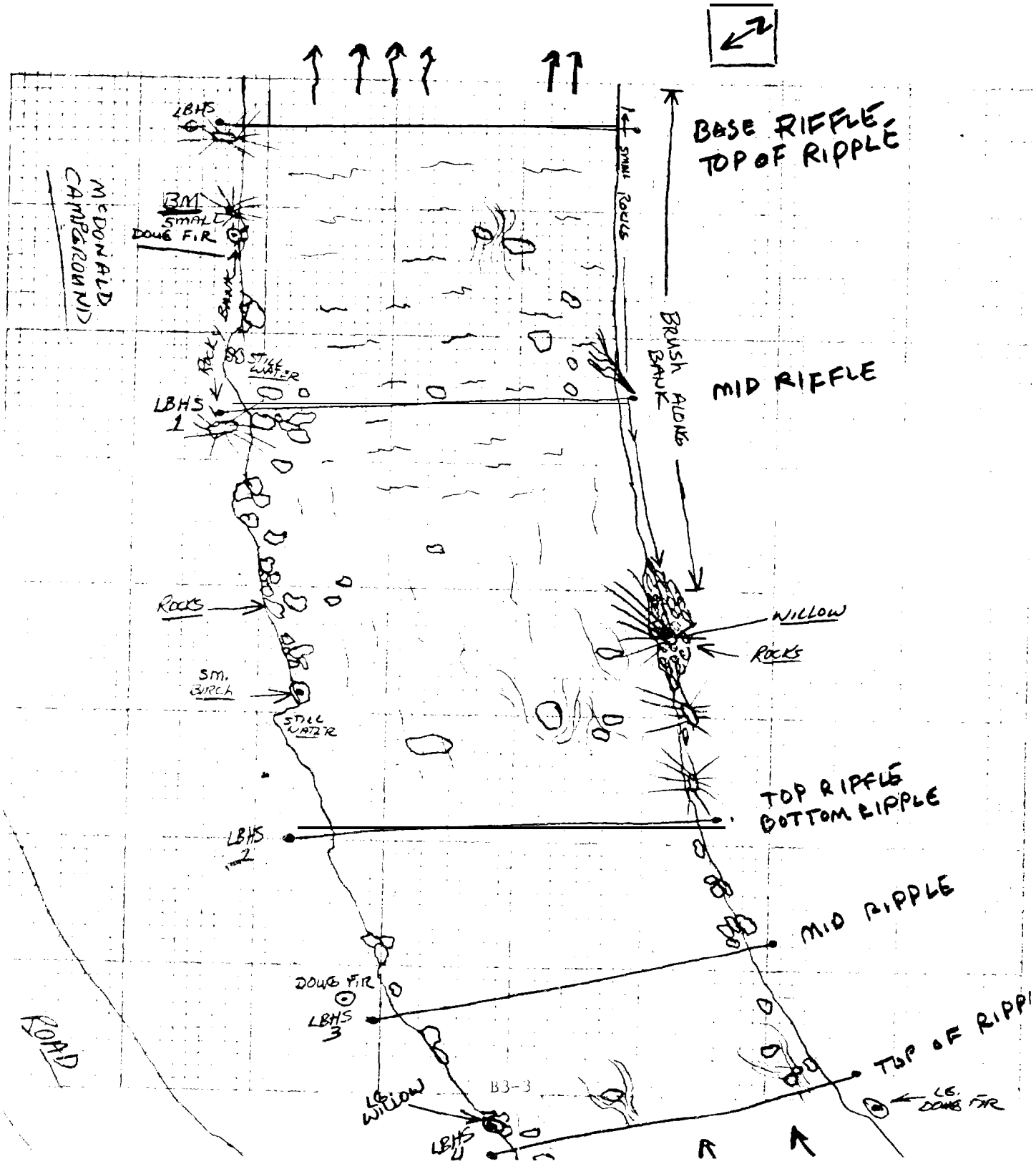


MAP OF STUDY AREA

Date 9-12-84
River PANTHER CRK.
Study Area RIPPLE - RIFFLE

Cartographer COLE

Direction of Magnetic North:

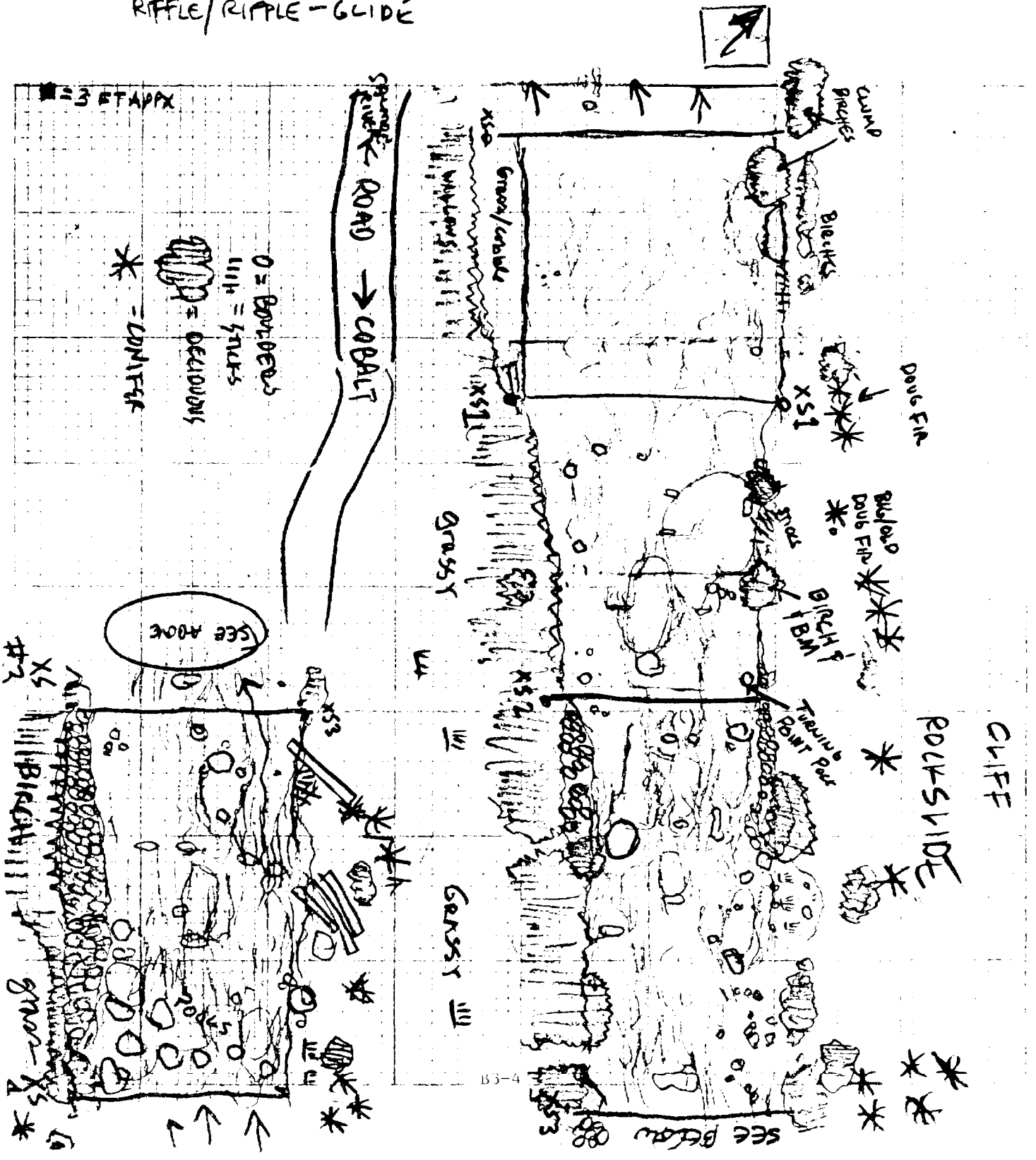


MAP OF STUDY AREA

Date 9/ /84
River PANTHER
Study Area BELOW COBALT
RIFFLE/RIPPLE-GLIDE

Cartographer C. Brown

Direction of Magnetic North:



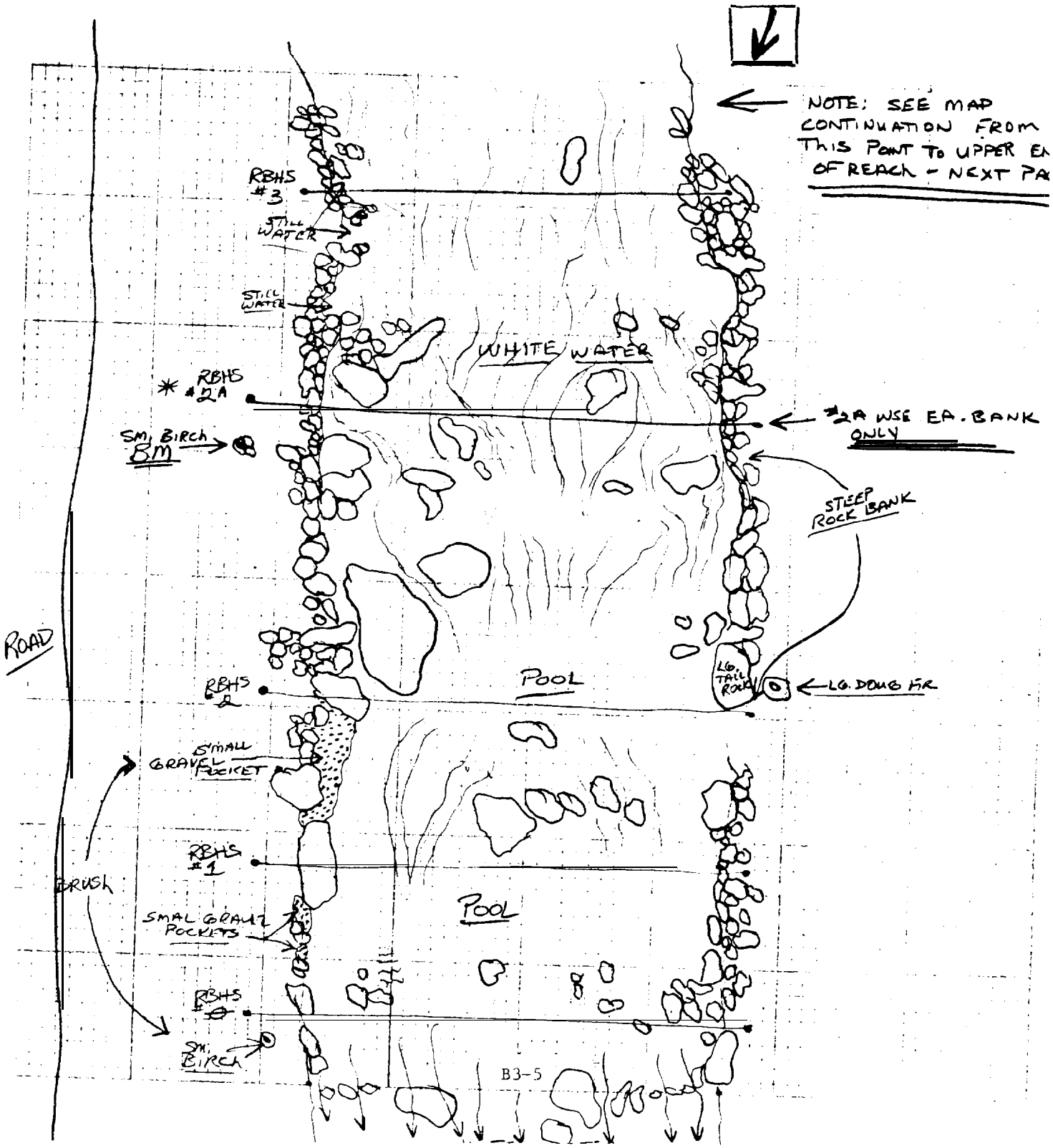
Pg. 1

MAP OF STUDY AREA

Date 9-16 84
River PANTHER CRK
Study Area CASCADE/POOL

Cartographer OGLE

Direction of Magnetic North:



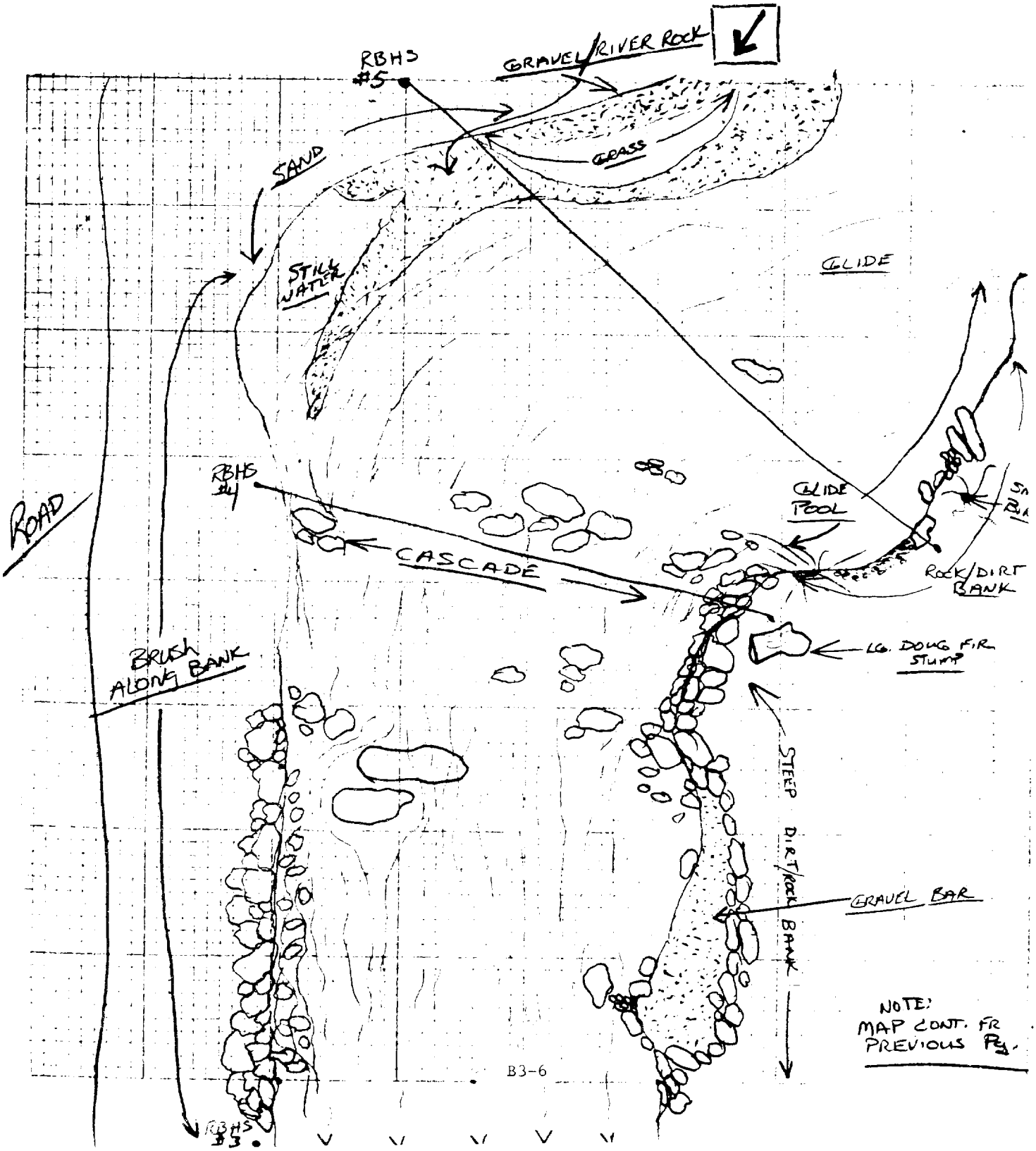
Pg. 2

MAP OF STUDY AREA

Date 9-16-84
River PANTHER CRK.
Study Area CASCADE/POOL

Cartographer OGLE

Direction of Magnetic North:



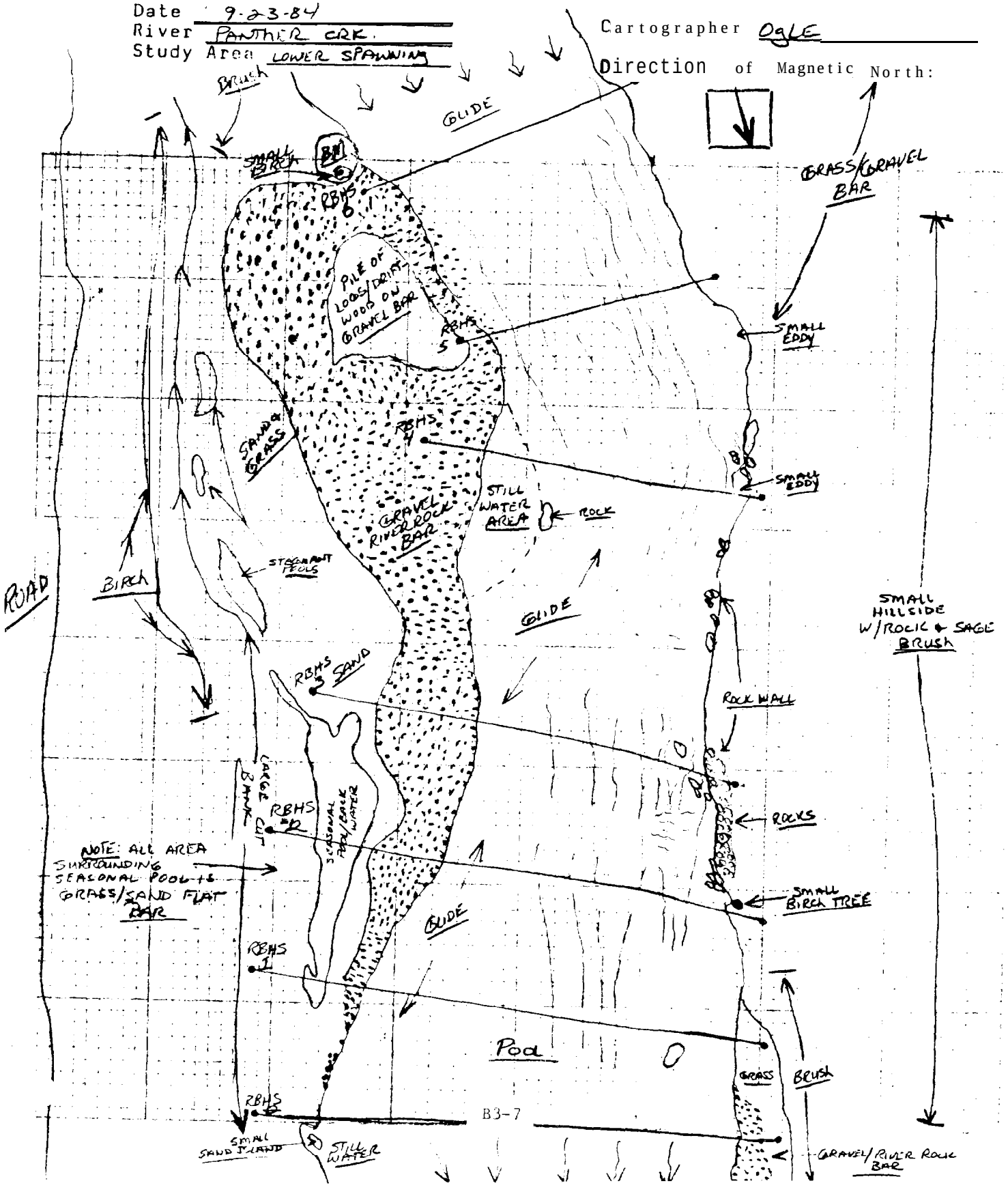
NOTE: MAP CONT. FR PREVIOUS PG.

MAP OF STUDY AREA

Date 9-23-84
River PANTHER CRK.
Study Area LOWER SPAWNING

Cartographer OGLE

Direction of Magnetic North:

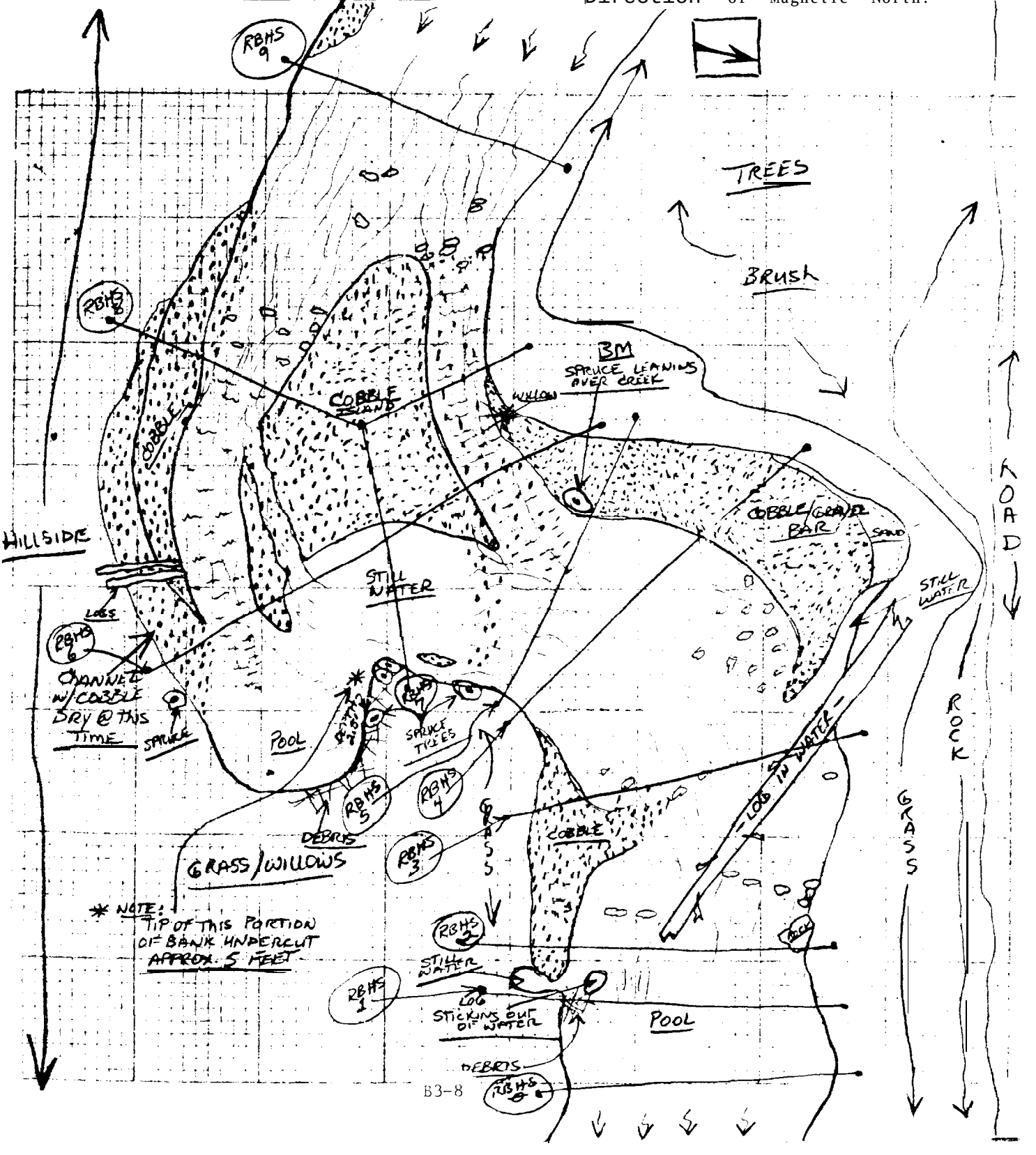


MAP Of STUDY AREA

Date 9-28-84
River PANTHER CREEK
Study Area MUSGROVE CRK.

Cartographer RON OGLE

Direction of Magnetic North:

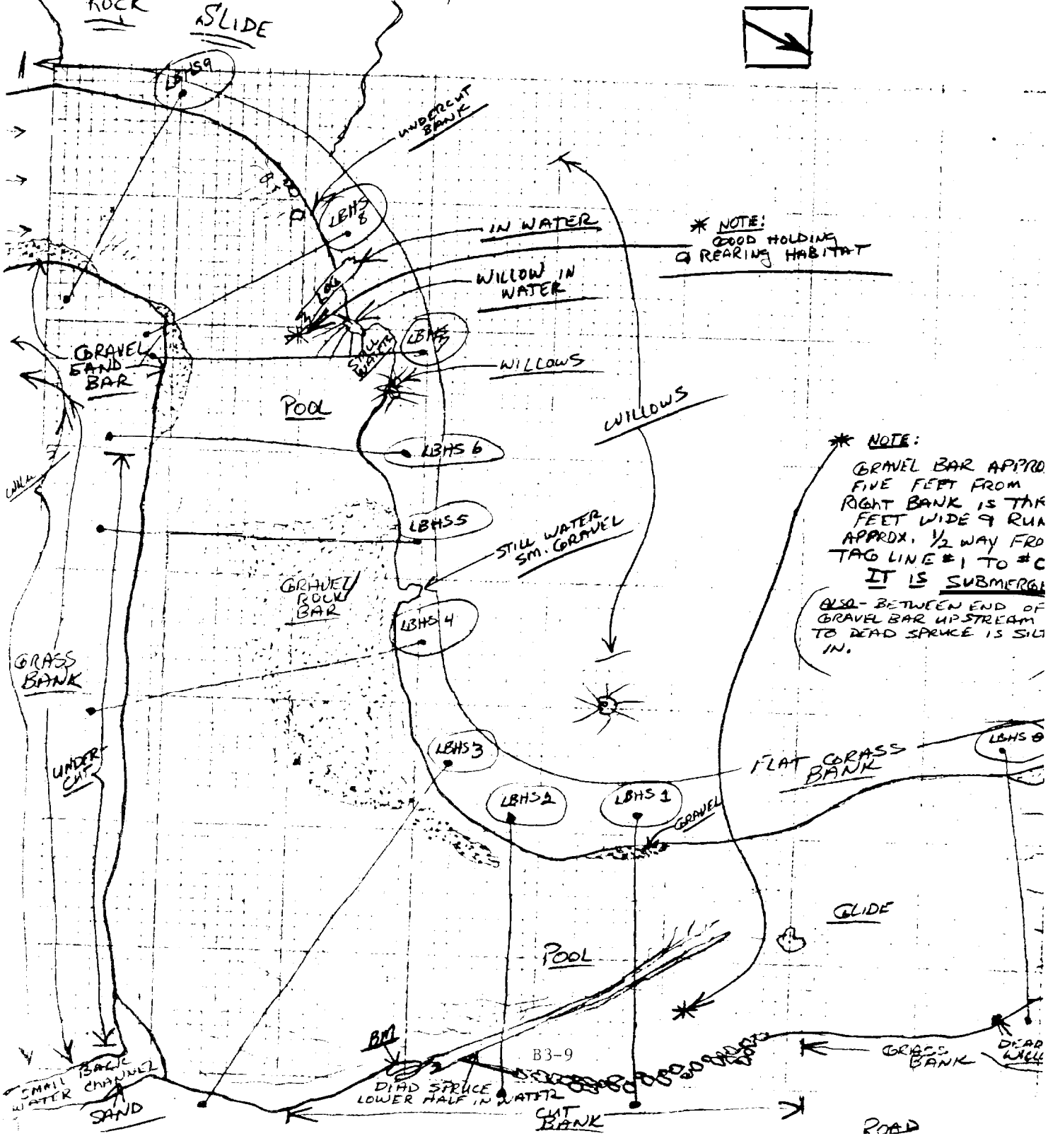


HAP OF STUDY AREA

Date 9-26-84
River PANTHER CRK.
Study Area MOYER CRK. #1 UPPER
MC-1

Cartographer RON OGLE

Direction of Magnetic North:

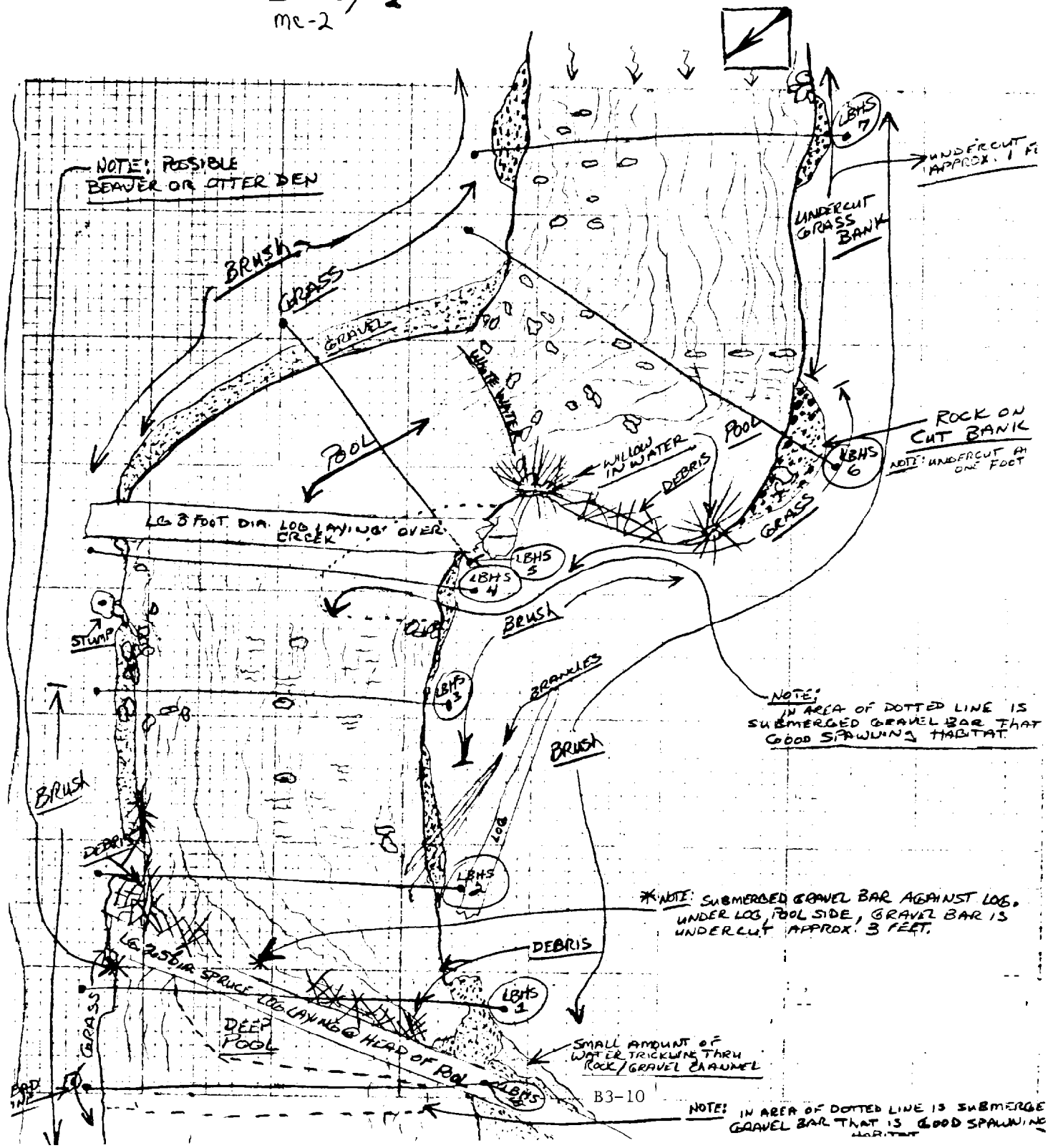


MAP OF STUDY AREA

Da' 7-27-84
Ri ver PANTHER CREEK
Study Area MOYER CRK. LOWER / #2
MC-2

Cartographer Ron Ogle

Direction of Magnetic North:

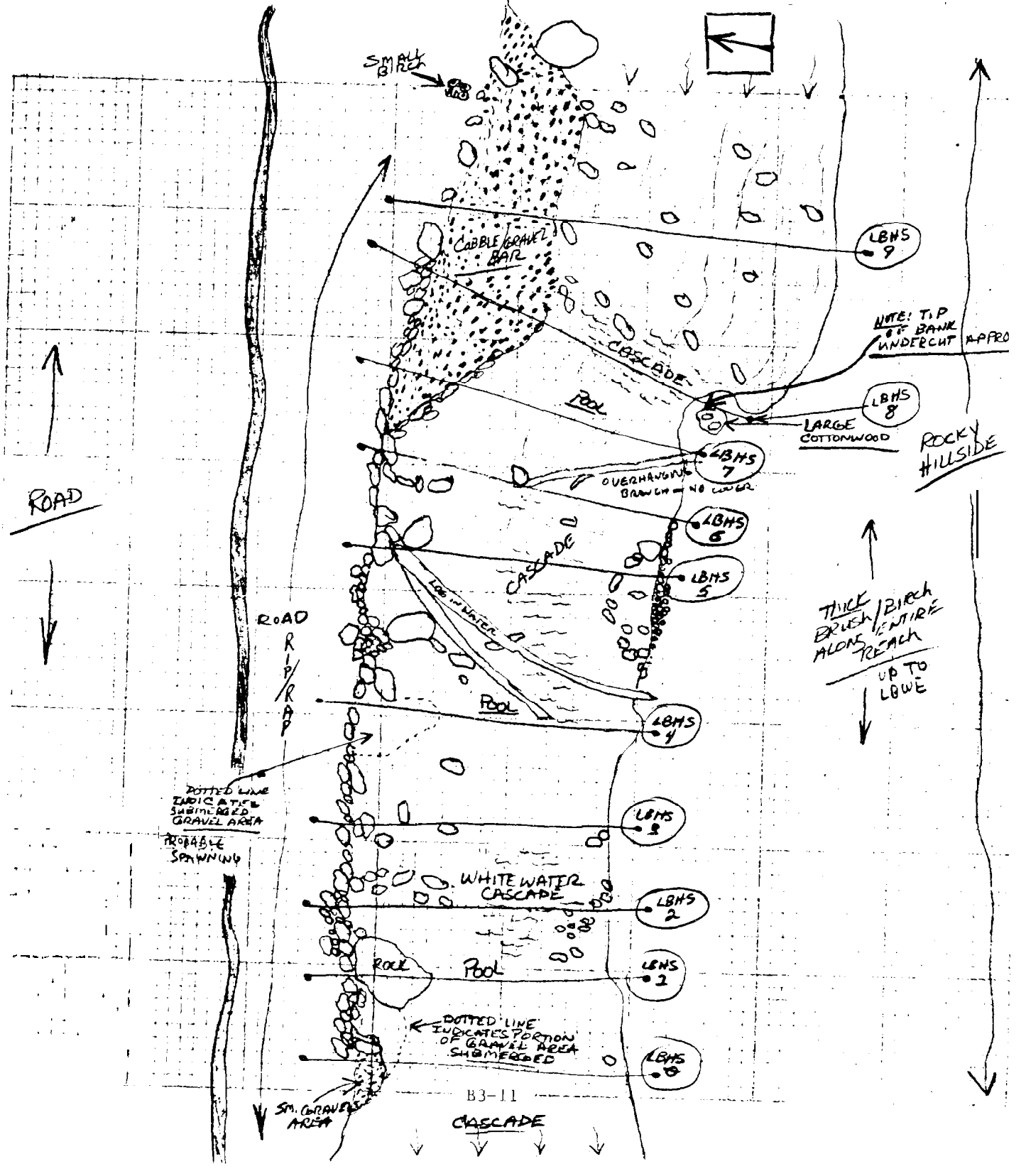


MAP OF STUDY AREA

Date 9-29-84
River PANTHER CREEK
Study Area DEEP CREEK

Cartographer RON OGLE

Direction of Magnetic North:

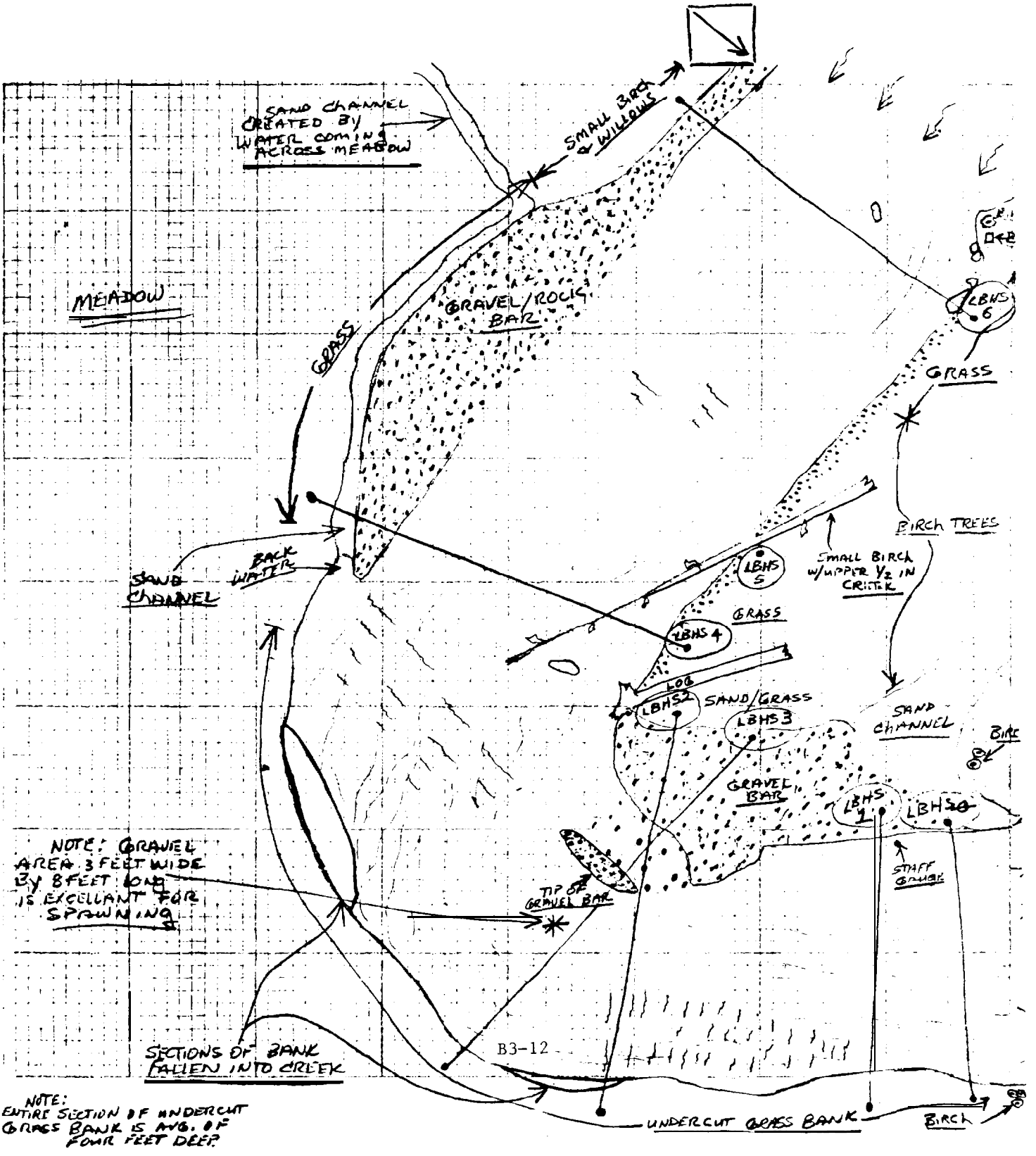


MAP OF STUDY AREA

Date 9-24-84
River PANTHER CRK.
Study Area CLEAR CRK. 1

Cartographer RON OGLE

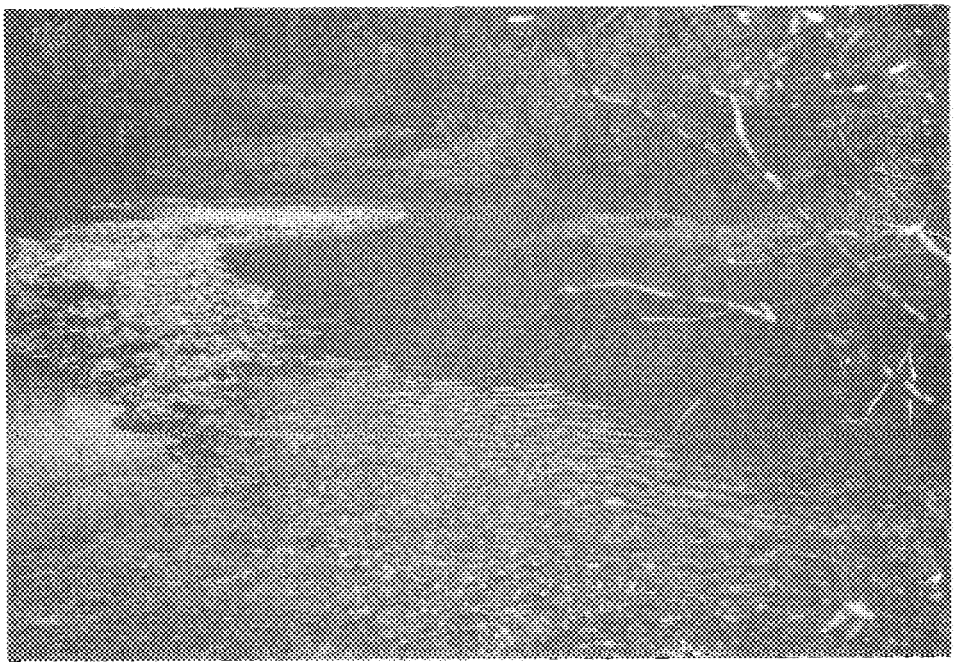
Direction of Magnetic North:



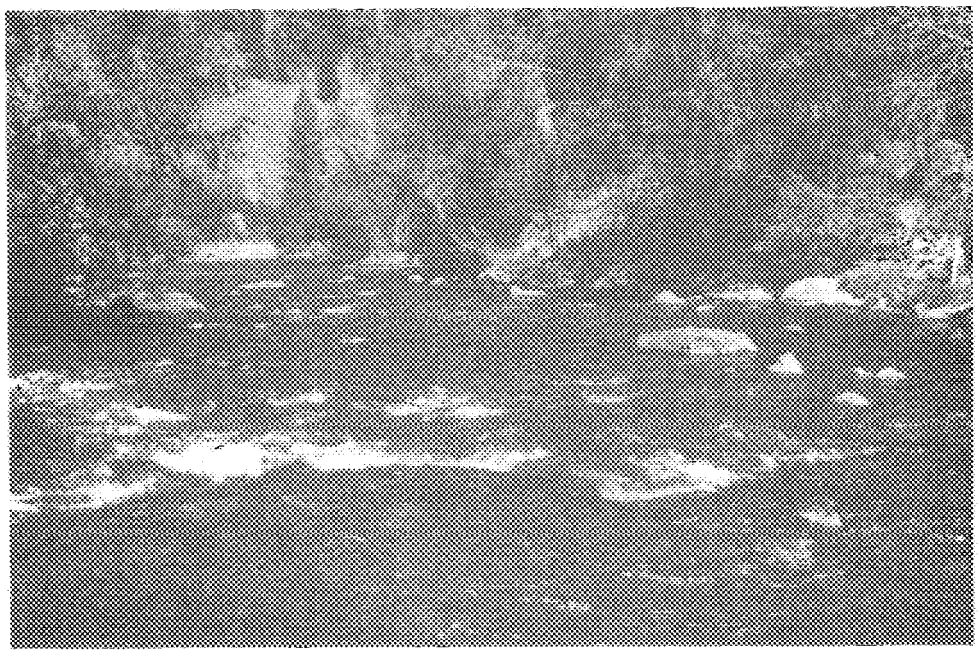
NOTE: ENTIRE SECTION OF UNDERCUT GRASS BANK IS AVG. OF FOUR FEET DEEP.

Section B4

PHOTOGRAPHS OF STUDY STREAMS IN THE PANTHER CREEK DRAINAGE

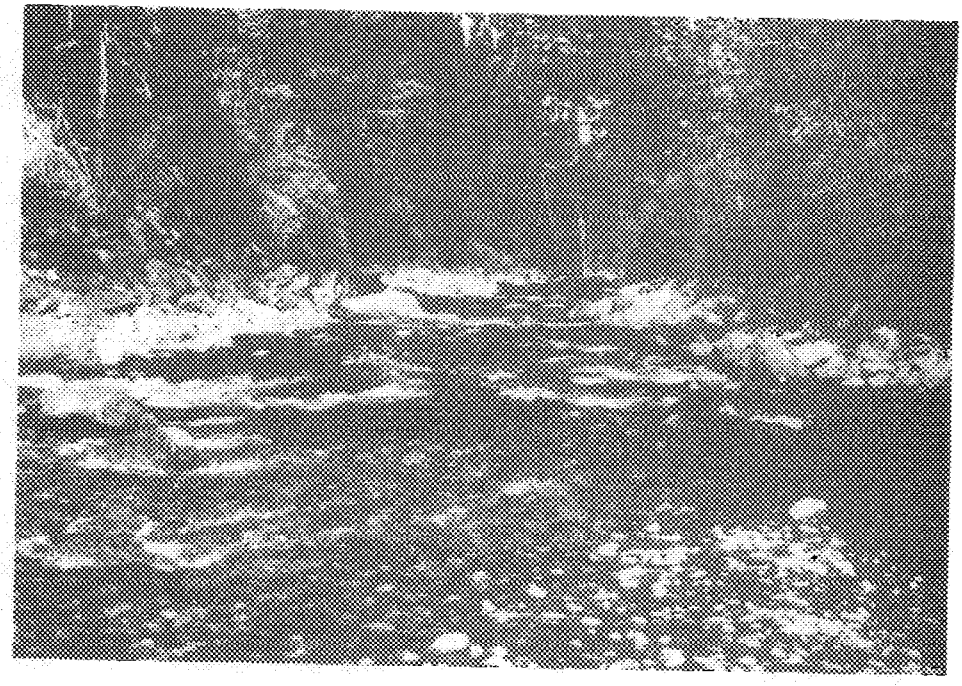


PANTHER CREEK – STATION PC-1
SPAWNING HABITAT (CLASS I)

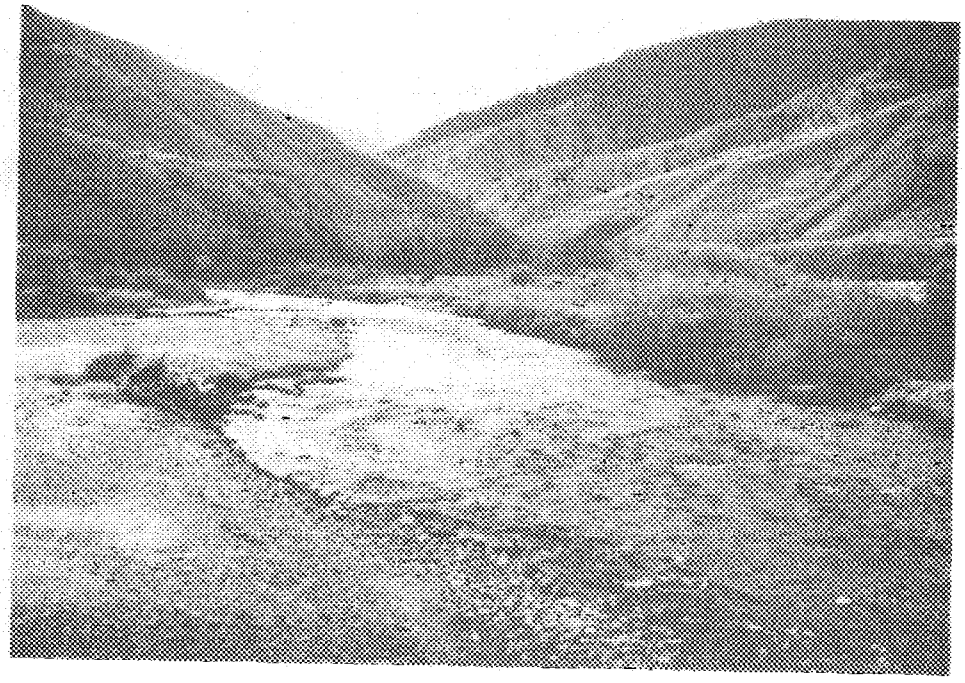


PANTHER CREEK – STATION PC-3
RIFFLE – RIPPLE – GLIDE HABITAT

Figure B4-1 PANTHER CREEK FISHERIES HABITAT STATIONS PC-1 (UPPER) AND PC-3 (LOWER), SEPTEMBER 1984



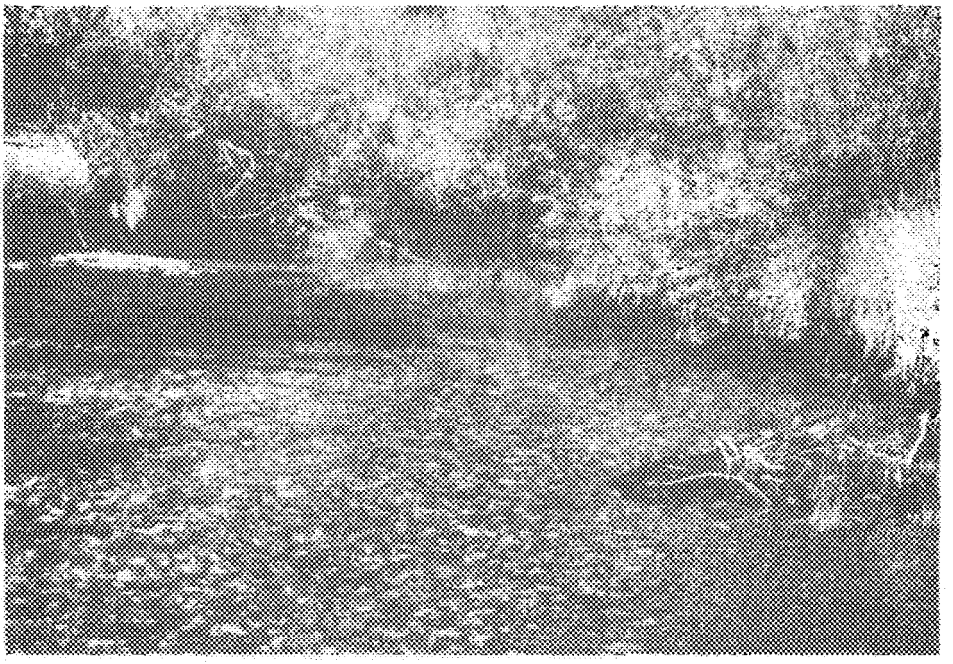
PANTHER CREEK – STATION PC-4
POOL – CASCADE HABITAT



PANTHER CREEK – STATION PC-5
SPAWNING HABITAT (CLASS II)

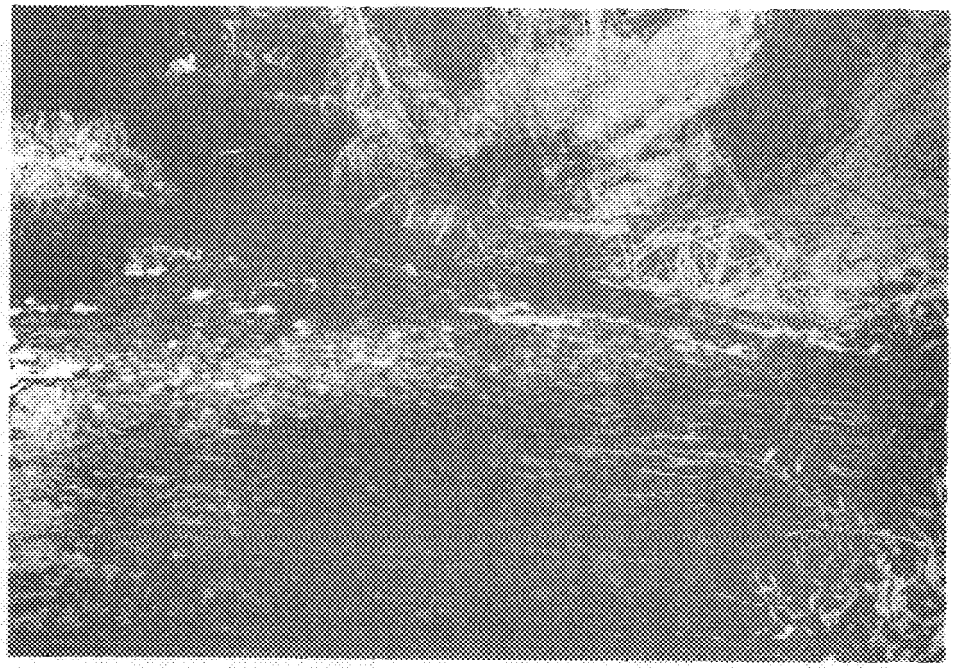
Figure B4-2 PANTHER CREEK FISHERIES HABITAT
STATIONS PC-4 (UPPER) AND PC-5 (LOWER),
SEPTEMBER 1984

EXCELLENT SPAWNING HABITAT IN
UPPER REACHES OF MUSGROVE CREEK

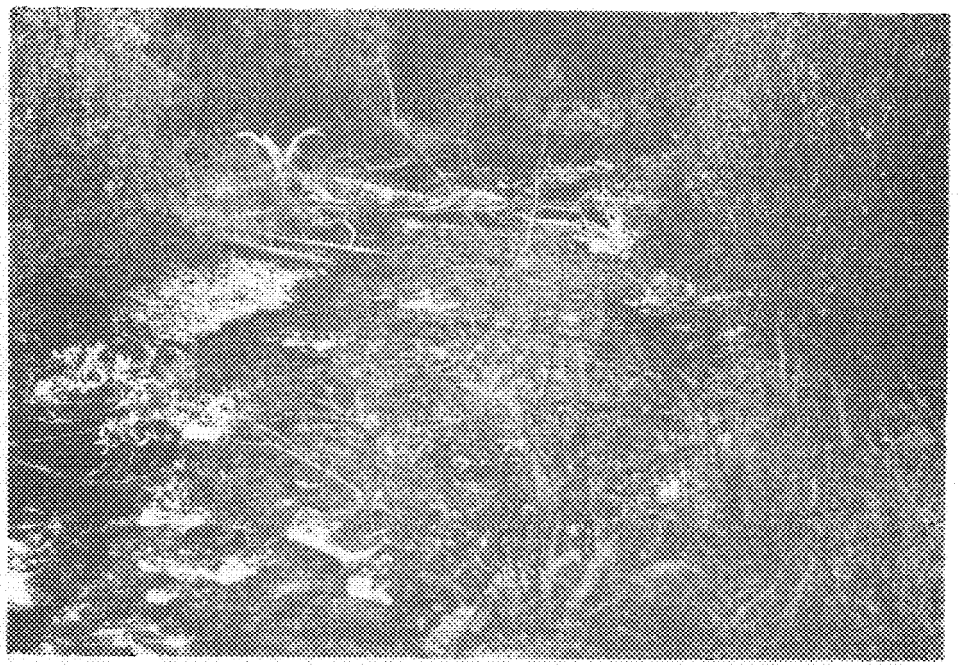


TYPICAL HABITAT CHARACTERISTICS OF
LOWER MUSGROVE CREEK

Figure B4-3 REPRESENTATIVE HABITAT TYPES LOCATED IN UPPER AND LOWER MUSGROVE CREEK, SEPTEMBER 1984

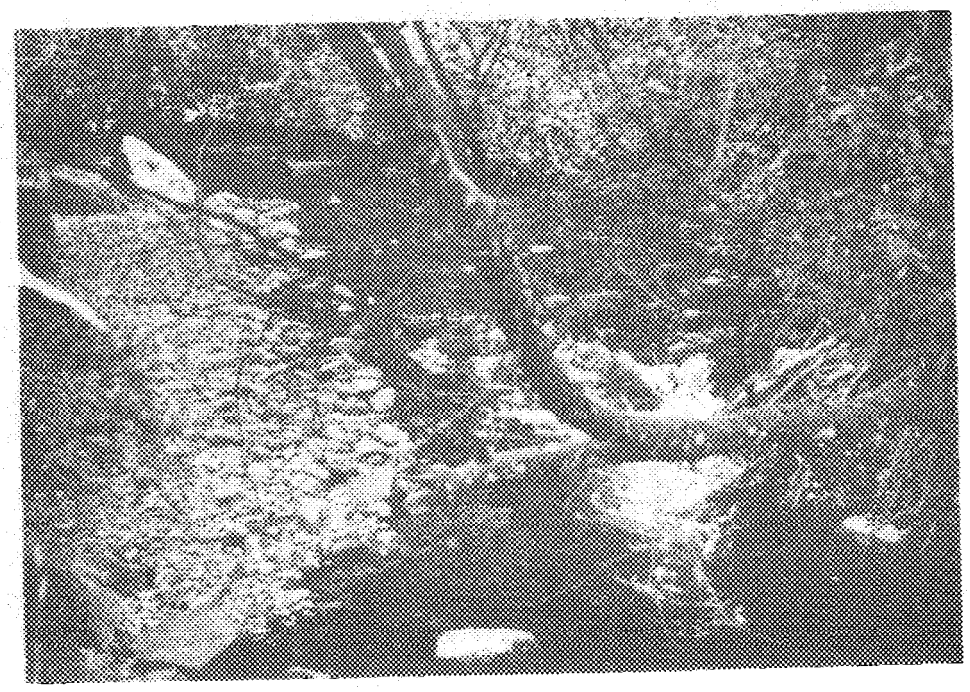


MOYER CREEK – STATION MC-'!

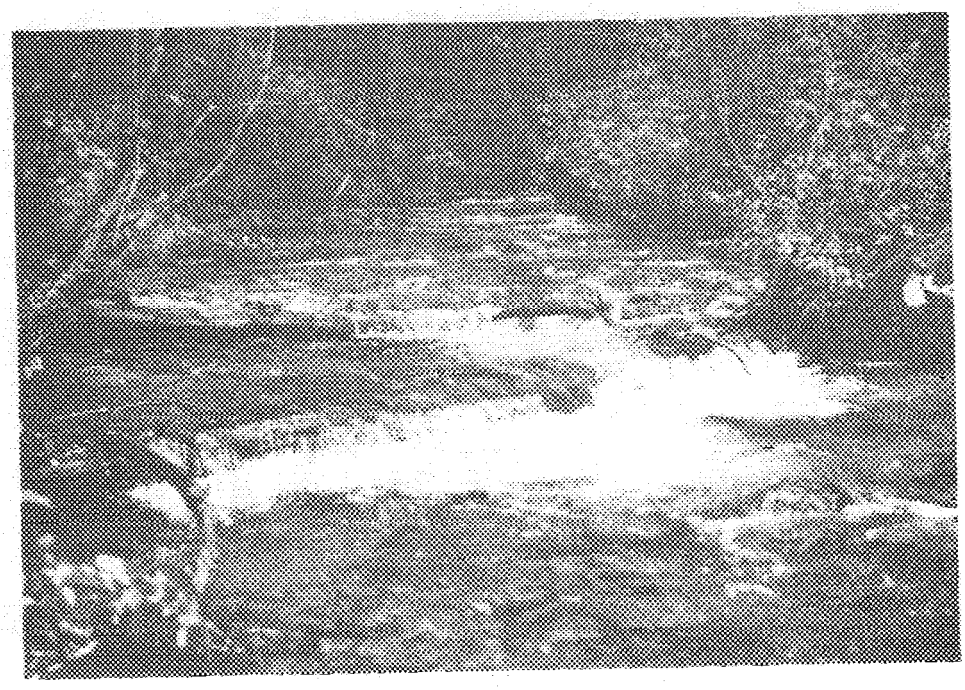


MOYER CREEK – STATION MC-2

Figure B4-4 MOYER CREEK FISHERIES HABITAT STATIONS MC-1 (UPPER) AND MC-2 (LOWER), SEPTEMBER 1984



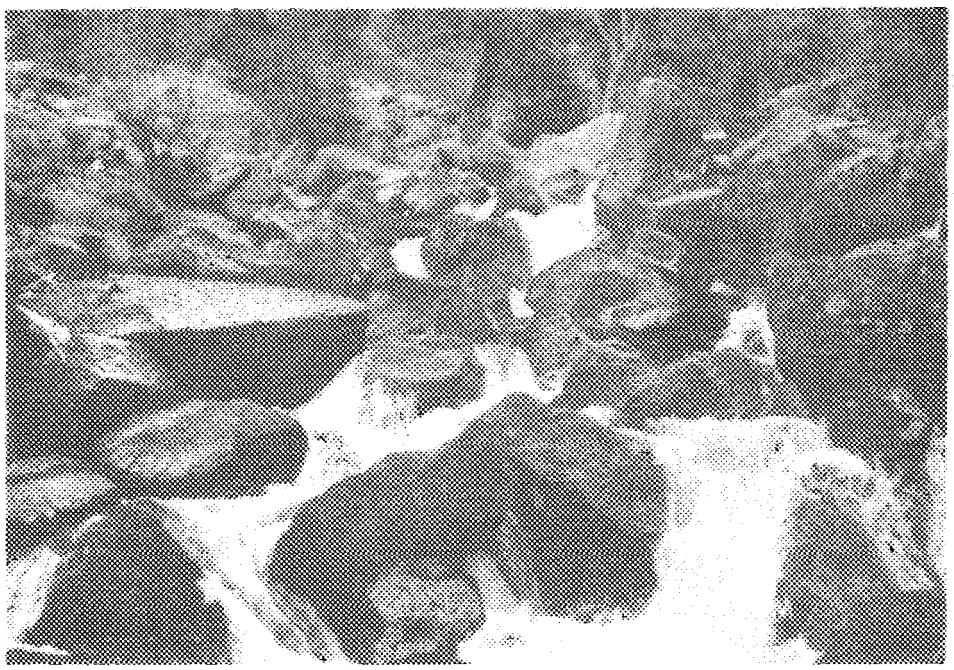
DEEP CREEK – STATION DC-1



TYPICAL HABITAT CHARACTERISTICS OF
CLEAR CREEK ABOVE CC-1

Figure B4-5 REPRESENTATIVE HABITAT TYPES IN DEEP CREEK AND CLEAR CREEK, SEPTEMBER 1984

BEAVER CREEK



NAPIAS CREEK AT FALLS AREA

Figure B4-6 REPRESENTATIVE HABITAT TYPES IN BEAVER CREEK AND NAPIAS CREEK, SEPTEMBER 1984

Appendix C: Correspondence

The SHOSHONE-BANNOCK TRIBES

FORT HALL INDIAN RESERVATION
PHONE (208) 238-3748
(208)238-3900

FISHERIES DEPARTMENT
P. 0. BOX 306
FORT HALL, IDAHO 83203

DUDLEY W. REISER

NOV 0 8 1985

5 November 1985

Bechtal Group, Inc.
Attn: Dr. Dudley W. Reiser
Environmental Technology Department
Fifty Beale Street
San Francisco, CA 94119

Re: Review of the Panther Creek, Idaho Habitat Rehabilitation

Dear Dr. Reiser:

After a careful review of the Draft Plan for the Panther Creek, Idaho Habitat Rehabilitation, we feel that the alternative selected for enhancement should be implemented to a point of obtaining the preferred level of results (0.05 mg/l or lower of copper) and not to a point of exausted funding. We also feel that approaching a problem of this magnitude with only X amount of dollars and not the initiative, power, or dedication to reaching some endpoint product would be a mistake.

Although past experience has usually shown that an initial high capital outlay with low operations/maintainence over time is a good approach to a problem of this type, the large number of unknowns associated with this type of approach (Alternative 2) with this particular problem neutralizes gains that might normally be appreciated. We would, at this time and utilizing only Draft information, support Alternative 1 (A or B) for implementation since diversion, collection, and treatment will actively deal with the water quality problem and, over time, a correlation between water quality and time will demonstrate the effects treatment has had on the original levels of pollution. Alternative 1 will give a partial answer as to what or how long it will take to achieve a 0.05 mg/l level of copper. At that time, a reassessment of the problem may provide more insight as to the amount of time still necessary to solve the problem. At the time of reassessent just as at the beginning of the project, a continuing commitment from funding sources must be reaffirmed.

Alternative 2 assumes that the mine will fill and not leak appreciably. Alternative 2 also leaves only Alternative 1 if mining operations resume at some future date.

In addition, we agree that whatever approach is used that the Alternative be phased and work should start in the Bucktail drainage (Page 8-l). We concur with the approach of the Water Quality and Quantity Monitoring Program (Page 8-4). We caution the use of aquatic invertebrate sampling as a response indicator unless sampling is done in sufficient number (statistically supported), with small enough mesh nets, and using state-of-the-art methods (i.e., modified Hess sampler, 160-250 micron mesh netting, removal method). Invertebrate sampling can be a very expensive and useless indicator tool if used incorrectly. Correlation between other physical (water quality variables) and/or biological variables (fish absence/presence, change in fish numbers, live car test results) may yield better information at less cost.

Thank you for this opportunity to review and comment on the Draft product. If you wish to pursue any of the above points further, please call me at (208) 238-3748.

Sincerely,

Dr. Richard C. Konopacky
Tribal Biologist

Sincerely,

Kesley Edmo, Sr.
Chairman, Fort Hall
Business Council

CC: FHBC (7)
File

DUDLEY W. REISER

NOV 0 8 1985

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TELEPHONE
(208) 233-0845

November 15, 1985

Mr. Dudley W. Reiser
Project Manager
Research and Engineering
Bechtel Group, Inc.
P.O. Box 3965
San Francisco, CA 94119

Re: Draft Report

Dear Dudley:

Thank you for your courtesy in providing us a copy of the "Panther Creek, Idaho Habitat Rehabilitation, Prepared for the U. S. Department of Energy, Portland, Oregon." I understand that you have asked for comments on the report by this date.

As I know you are aware, the State of Idaho is currently suing our client, The Hanna Mining Company, over the mine site. Settlement negotiations concerning that suit are currently in progress.

Because of the pending litigation and the pending settlement negotiations, we would, therefore, defer making comments at this time. I would reserve the opportunity to make comments in the future if a more appropriate occasion arises. Our defferal of comments at this time implies neither approval nor disapproval of the report or any of its contents.

Sincerely,

HAWLEY TROXELL ENNIS & HAWLEY

Don Olowinski

Don A. Olowinski

DAO:cf

DUDLEY W. REISER

NOV 19 1985

Noranda Inc.
Envionmental Services
12640 W. Cedar Dr.
P.O. Box 15638
Denver. Colorado 80215

DUDLEY REISER

NOV 19 1985

Tel.: (303) 988-6456
Telex: 45-4375
Noranda DVR

noranda

November 11, 1985

Dudley W. Reiser
Bechtel National Inc.
P.O. Box 3965
50 Beale Street
San Francisco, California 94119

Ref: Draft Panther Creek Project Report CERTIFIED MAIL

Dear Sir:

We have reviewed the draft of the report on the above referenced project and would offer the following comments.

Introduction - Section 1

Considering the multitude of unknowns, it may be worthwhile to evaluate the return run in 86-87 prior to committing large amounts of money. Stocking of Panther Creek with steelhead has occurred yearly since 1982 (p. l-13). Return runs will be evaluated in 1986-87 to determine whether lower Panther Creek is, in fact, a barrier to spawners (p. l-8). However, even if spawners are successful in passing through this area, the majority of smolt habitat occurs downstream of Big Deer (chinook 42%, steelhead 41%) (p. 7-G). Fish mortalities below Big Deer seem to confirm unsuitability of water quality for'rearing juveniles (p. l-10, p. B2-65).

Alternatives - Section 5

During the course of this investigation, other alternatives were discussed. Among these was that of the mine being in operation. Noranda does not currently have plans for mine operation, however, Inspiration Mines Inc. is considering an option on the property and has submitted a preliminary plan of operation to the State of Idaho for review. We believe all available alternatives should be included in the report for review. It remains Noranda's position that the mine represents the largest reserve of cobalt in North America and that this reserve must be protected for future demand.

Reclamation and Revegetation - Section 5.1-1

The USFS through the SEAM project has done extensive work at the site in this regard. Their work has indicated that this is a very slow, labor intensive process due to climate and other conditions. The areas that the report focuses on for this action are principally the low grade stockpiles which in the future can be millable material. We would be concerned about spending resources on tasks which may later be disturbed.

Is the project prepared to spend the money with no quarantee of achieving any improvements or even whether vegetation can, in fact, be established (p. A4-14)? The total cost of $330,000 (p. A4-12) does not take into account any follow-up work, "touch-ups", etc.

Procedures seem to take into account physical differences (i.e., slope vs. flat) but do not consider different amendment needs for different areas, i.e., tailings area vs. waste rock. Growth room tests would likely reduce some of these unknowns.

Subsequent fertilization will likely be required based on similar approach to other programs conducted elsewhere (p. 4-15). Is greater use of legume not possible? Concern here is that seed selection may not lead to self sustaining cover as quickly as may otherwise be achieved.

Diversion of Surface Flow - Section 5.1-2

Noranda has employed this technique at other mine sites with varying success. We believe that there are some areas at the site which may be amenable for this measure where there is a significant watershed above the area and a proper diversion area. We do not think the report indicates an adequate maintenance cost for such a system based on our current experience with such maintenance. Also, corrugated metal sections are not appropriate construction materials.

Meadow Creek Channel Improvement - Section 5.1-3

Because of the number of diversion sites that Noranda considers cost effective for the Meadow Creek drainage, it is not considered necessary to effect improvements to the channel at this time. When the operation is reactivated, there are possible modifications which may improve this area.

Blackbird Creek Diversion Culvert - Section 5.1-4

During investigations for Noranda's feasibility study, it was decided that during mill construction or relocation the culvert would be repaired in this area to guarantee access through the mill to the mine. This work will

however, inhibit access to the mine and the report schedule does not appear to provide for this interruption.

Capping of Waste Rock Piles - Section 5.1-5

As indicated in Sec. 5.1-1, the top of the low grade rock piles has been revegetated by the USFS. Capping the piles with clay and revegetating seems redundant at this point, particularly if the material will be later milled.

Collection of Mine Adit Flows for Treatment - Section 5.1-6

We do not believe cost estimates for sealing the 7117 and 7265 adits are realistic, particularly since access to these areas will require rehabilitation before sealing.

Collection of Contaminated Water from Waste Piles - Section 5.1-7

Cross contamination is a concern when trying to isolate flows.

Great cost of implementation (about $2 million for Bucktail and Blackbird, p. 5-21), long term maintenance and cost of the diversion, collection system without knowning whether this work will make a significant contribution to the overall objective does not seem to make much sense.

The design does not appear to be scaled adequately. Also see Sec. 5.1-2 comment.

Diversion of Bucktail Creek to the 6850 Level via Borehole- Section 5.1-8

The suggested design layout for this task is not appropriate for geologic conditions in the Bucktail drainage. The angle of penetration and length of the proposed hole are not practical for the strike and dip of the formations. A hole drilled at that attitude in a homogeneous strata would still require special equipment and technique and probability of success might be relatively low. Maintenance of such a system would be high on account of run-off impact, access and freezing.

Gravity Diversion of Bucktail Creek to 7117 Adit - Section 5.1-9

Again, as in the previous section, maintenance for this diversion will be very high due to access and freezing.

Pumping of Bucktail Creek from Elevation 6950 to 7117 Adit - Section 5.1-10

Maintenance again will be very high due to access, lack of

power and freezing.

Blacktail Pit Drain - Section 5.1-11

Geologic conditions and ground fractures due to proximate underground openings would make the installation of this system very costly. Installation of the clay liner in the pit would also be hazardous on account of the weathered condition of pit walls.

Backfill Blacktail Pit With Waste Rock and Cap - Section 5.1-12

The term "waste rock" is inappropriate particularly in this scheme. The low grade stockpiles in the Meadow Creek drainage represent a potential cobalt reserve. To use this material as backfill precludes alternate uses. The report identifies the Bucktail drainage as the major contributor of metal loading and the Meadow Creek as secondary. We question the advisability of moving this material from Meadow Creek into Bucktail and increasing the possibility of impact. It will be very expensive to place and compact the clay cap in the pit area with the near surface fractures at the perimeter which may serve as conduits to the pit. The material in Meadow Creek is now well consolidated with restricted exposure and disturbance may create additional risks.

Treatment of Poor Quality Water - Section 5.1-13

The report does not address treatment process problems when comingled flows from surface diversions and mine openings at varying flow rates will be the influent. Without analytical analysis of probable turbidity, pH and metal concentration, it is likely that plant capacity may be reduced and additional equipment required. Also during mine operation, the existing plant capacity will be required to treat mine and mill flows.

Implementation Schedule - Section 6

The schedule as proposed by the report does not present sufficient time for required permitting. The impact to the cobalt reserve under the proposed alternatives will require extensive review by the USFS, USGS, USBM, GSA and Defense. The design of water diversions will require extensive review by State agencies.

Following are comments on the text of above referenced report.

1. p. 1-6, last paragraph: Incorrect treatment plant capacity: should be 450 qpm instead of 550 gpm. The mine produced 90 qpm prior to the installation of the 6850 adit plug in 1983.

2. pp. 3-2 to 3-6: The discussion on p. 3-l is about the mine in general, the pictures show problem areas only. The pictures are biased in this context.

3. PP. 3-8 to 3-9, Table 3-l is incorrect. The statement that storms produce high peak flows of small volume is historically incorrect.

4. p. 3-16, fourth paragraph: The statement that, "...ground water flow is from the mine workings to the springs through fractures", is unfounded. There are considerable indigenous metals in the surface and ground waters of the area: and to say the mine is feeding these springs is reckless.

5. p. 3-17, second paragraph: Implies that the mine is going to overflow, resulting in discharges. Noranda will manage water elevation by releasing water through the water treatment plant.

6. p. 3-17, third paragraph: The Hawkeye Gulch adits do not discharge.

7. P. 3-18, figure 3-9: This is a Noranda map or an EIS map and should be referenced.

8. pp. 4-2: The existing data as we understand it does not indicate redisolution of precipitates.

9. p. 4-8, fourth paragraph: Additional concentration and flow data is available through the EPA for the mine gate.

10. p. 4-12, first paragraph: Again it is suggested that water will overflow the mine. Noranda will manage the water level.

11. An objective of .05 mg/l total copper for Panther Creek below Blackbird and Big Deer is selected (p. 2-5). If the water treatment plant eventually treats the Bucktail Creek flows then we may expect some modifying effect from hardness due to the plant's operation at greater flows (the streams are quite soft). Previous data collected in Panther exceeds .05 mg/l above Blackbird (p. A3-2). For these reasons the .05 mg/l is probably unreasonable and unrealistic.

12. It is suggested that the natural background for the mine area drainages may be approximately .2 mg/l (p. A2-3, A2-4, A2-13, A2-23, A2-36). This seems quite reasonable based on data from natural springs. The report does not address the contribution of the springs and non-point sources below the mine gate.

13. Plant site contributes 50% of loading in May 1985 (p. 4-20), but no specific proposal on how this can be

controlled. General statements only (p. 5-4, A4-23).

14. Collection system shown on p. A4-28 suggests going down to bedrock. Variability in bedrock profile and depth to bedrock may complicate this proposal.

15. pp. A4-36 to A4-37: Due to field conditions in 1985, the flow estimates are believed to be understated.

16. pp. A4-40 to A4-43: The descriptions of plant operation and products are not accurate.

Noranda considers some of the proposed actions feasible under the proper design criteria. Our current focus is to minimize site maintenance and treatment costs while protecting the integrity of the cobalt reserve. Implementation and maintenance of mitigation projects would be facilitated by operation of the mine.

Respectfully,

BLACKBIRD MINING COMPANY

Joseph Scheuering
Manager

JS:sr

United States Department of Agriculture
Forest Service
Salmon National Forest
P.O. Box 729
Salmon, ID 83467

Reply to: 2810

Date: November ~~15~~ 18, 1985

DUDLEY W. REISER

NOV 20 1985

Mr. Dudley Reiser
Bechtel Group, Inc.
PO Box 3965
San Francisco, California 94119

Dear Mr. Reiser:

The Forest has reviewed tire Draft Plan for the Rehabilitation of the Panther Creek Drainage. This review included Regionai Office Staff as well as Inter-mountain Station Researchers, Bland Richardson and Eugene Farmer. This letter incorporates their comments as well as that of Salmon Forest personnei.

We feel that the Draft Plan presents a good framework for resolving the poliution problems which exist in the Panther Creek drainage. While we will offer some specific comments pn portions of the study, we believe the following general procedural steps will facilitate the implementation of any treatment strategy:

1. The next step in proceeding further with the selection and implementation of any alternative should be the establishment of an interagency workgroup. This would include the landowners involved as well as agencies which are involved due to technical expertise or legally responsible by law for some aspect of the proposal. Although the players may have been involved through the review of tire study to this point, their role has been passive, consisting of providing information and reviewing documents. To proceed will require active negotiation of the roles and responsibilities involved in implementing any reclamation alternative.

2. Following the establishment of the workgroup described above, the initial effort should be tow rd establishing common ground for agreement on those act ivit ies, studies, and monitoring programs which are common to all alternatives of are necessary in order to evaluate them. This would help to maintain tile momentum the study has established.

3. Finally responsibilities for the conduct of the construction, operation and maintenance of the alternative selected will have to be negotiated. This involves funding and manpower requirements for all aspects of the alternative selected, on both National Forest and private land. There are opportunities in this process to realize cost savings by utilizing existing facilities, personnel and expertise.

FS-6200-28(7-82)

These three steps are important to stress and are the keys to proceeding with the work items described in Chapter 6. It would be very worthwhile to include some discussion of them in that chapter to focus attention on the fact that the next and active phase of the project will require a good deal of negotiation prior to the time on the ground activities can commence.

The following are comments on specific portions of the study:

Chapter 2. There is no mention of a treatment strategy for the tailings dam located in the West Fork of the Blackbird drainage. While this facility may not contribute significantly to the current pollution problem, its long term stability is a very serious consideration for the success of the rehabilitation project.

Chapter 3.

Page 3-7 : The Intermountain Station did collect precipitation data at the nine site. The information is attached to this letter.

Page 3-9: We have some questions about the assumptions used regarding flood sources. Couid you have used the rainfall event for the 100 year period instead of increasing snowmelt event by 50% Our feelings are that the figure that gives the most safety in a long-term program like this is the most desirabie.

Page 3-14: We would like to clarify that the topsoil availability discussed in the Blackbird EIS was limited to that which might be used to reclaim the new tailings dam which would be constructed if the nine was reopened. We do believe that there is suitabie material which could be used as a growing medium for the reclamation of the waste rock and that it could be salvaged f rom the more gently sloping areas of the drainage without serious resource damage. We suggest that a survey to deiineate suitable borrow sources could be added as an additional preliminary study. Any clean suitable growing medium would be preferable to using contaminated waste rock.

Chapter 4. We believe that it is important to have some idea of the degree of success which could be expected for each option and alternative. It seems that at this point some additional generalizations could be made from the existing ins data. If this is not the case, then obtaining the additional Gata to make these predict ions should be assigned a high priority as pre-implementation studies.

Chapter 5.

Page 5-l: The relationship of future mining acitvities and the nlternative selected seems to be an important issue. Uon-treatment opt ions, such as backf ill ing the Blacktail Pit and capping the waste piles, would (or at least should) preclude disturbance of those areas by future operations. On both public and private lands, rpotecting the improvements constructed will require the cooperation of the landowners and should anticipate the possibility that the demand for cobalt, a strategic metal, may increase in the future.

FS-6200-28(7-82)

Page 5-2: We suggest that the decision to treat waste rock as a growing medium should be made only as a last resort. There may be sufficient material in the area to be used as a growth medium.

Page 5-4; Has Bechtel considered using a graded gravel material below the clay liner to serve both as a capillary barrier and a good even base for the clay layer? In addition, if an impermeable clay barrier is formed that will conduct lateral f Lows, then the entire treated surface will need to be shaped to conduct f iows away from the untreated slopes of the waste piies, perhaps towari the surface diversions. In general the clay layer option seems to be prohibitively expensive, especially compared to the potential benefits.

Chapter 6. We agree with emphasizing those options which are common to all alternatives, are necessary for evaluating alternatives, or which have the highest cost/benefit ratios. To proceed with this approach it will be necessary to establish an interagency Workgroup to begin the process of definingthe roles each will play in designing, reviewing, approving, constructing, operating and maintaining the treatment options.

Chapter 3. As was noted earlier, we suggest that Bechtel consider a survey to identify and evaluate the available sources of material which could be used as a growing medium. In fact, it should be easy to provide this information based on existing information. In addition, we would like to see a treatment strategy developed for the West Fork Tailings Dam based on the probability that the concrete culvert will eventually fail, causing the drainage to backup behind the tailings.

Section A4. Has Bechtel considered the possibility of combining some clay with the soil material which may be found in the areas Volumes could be considerably less than that needed for a cap yet it may dramatically increase the success of the revegetation effort.

On very steep slopes which prove to have little chance of revegetation, would it be desirable to armor them with clean talus materiel? This type of material is available and could at least prevent surface erosion caused by wind and water.

We would like to emphasize that reclamation and revegetation of all bare areas is a high priority for a project such as this. The best hope for accomplishing the goal of reestablishing Panther Creek as an anadromous fishery seems to be some combination of treatment in the short term which buys the time for reclamation efforts to effect long term reductions of metal loadings to the area streams.

Conclusion Although there is not enough information to support selection of treatment options and alternatives, it seems that some generalizations can be made .

First, the treatment alternatives involve a facility which is aiready in place and will provide the most dependabie reduction of copper concentrations in Panther Creek. It is by far the most cost effective solution in the short run. In the long run, it may be possible to reduce the operating costs by taking advantage of personnel and facilities already in place and by phased implementation of the non-treatment alternatives which are determined to be

cost effective through the pre-implementation, and monitoring studies. The first step in implementing this option is to negotiate with the owners on the use of the facility. They can be expected to have serious concerns, especially in relation to the effects on future mining activities.

Secondly, as stated in the rreport treatment of the Eucktail drainage will yield the greatest benefits in both the short and long term.

Finally, we are talking about a iong-term investment and involvement in the rec lamat ion process. Once started, we are committed to a program of indeterminate length even after the anadromous fishery becomes reestablished. It will be very important to have a stable source of funding and personnel to ensure the integrity of the program which is inplemented.

Bechtei and the Bonneville Power Administration are to be commended in bringing the study to this point. We look forward to working to implement a successful rehabilitation project.

Sincerely,

RICHARD T. HAUFF
Forest Supervisor

Enclosure

PRECIPITATION RECORDS AT THE BLACKBIRD MINE

Period of Record		Accumulated Precip (inches)	
START DATE	END DATE	Lower Bench 7645'	Mouth of Meadow Ck. 7275'
8/28/75	9/9/76	25.5	27.9
9/9/76	10/18/77	20.0	20.9
10/18/77	9/9/78	22.6	28.3
9/9/78	9/26/79	17.0	18.0
9/26/79	9/3/80	19.1	22.3
9/3/80	9/13/81	22.2	22.8
	MEAN =	21.1	23.4

Both gauges fitted with Alter wind shields.

The lower gauge (Mouth of Meadow Ck) was in a more favorable exposure with respect to wind than was the upper gauge (Lower Waste Bench).

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION X
IDAHO OPERATIONS OFFICE
422 WEST WASHINGTON STREET
BOISE, IDAHO 83702

DUDLEY W. REISER

NOV 21 1985

November 18, 1985

I00

Dudley W. Reiser, Project Manager
Bechtel National, Inc. (45/15/A20)
P. 0. Box 3965
50 Beale Street
San Francisco, California 94119

RE: Draft Panther Creek Project Report

Dear Mr. Reiser:

We have reviewed the above draft report and generally feel it is quite thorough and well done. As you are aware, EPA is quite committed and supportive of efforts to rehabilitate polluted, once productive streams. We are uncertain as to the implementation of this project. Is the Bonneville Power Administration planning any phase of implementation at this point or is their commitment only for this study? We most certainly encourage implementation as a logical mitigation measure.

Cost is obviously a major factor in implementation. Coincidently, we have received some information from Senator McClure's office which indicates a local and potential source of lime for a neutralizing agent. Such a source may reduce the costs you projected for neutralization, and make the opportunity for implementation more feasible.

We appreciate the opportunity to comment on the draft report and would like to be kept informed of the progress of this project.

Sincerely,

Donald M. Martin

Donald M. Martin,
Nonpoint Source Coordinator

Enclosure

cc: Senator James McClure, Washington, D.C., w/att

JAMES A. MCCLURE
IDAHO

United States Senate

WASHINGTON. DC 205 10

September 10, 1985

AR
R10
10
OP/OCR
AA

Environmental Protection Agency
Director of Hazardous Waste Division
401 M. Street sw
D.C. 20460

Dear Mr. Stiehl:

I am enclosing a letter I received from a constituent, David Burk from Challis, Idaho.

The letter concerns the possibilty of altering a chemical, used to neutralize the acidity in soil, to neutralize acid lakes. I would appreciate having EPA's opinion on whether Mr. Burk's idea has possibilities. Any information you can provide will be appreciated.

Thank you for handling this matter.

Sincerely,

Jim McClure

James A. McClure
United States Senator

McC: c h v

RECEIVED
9/19/85

301 Constitution Ave.
Washington D.C.
20510

September 3 1985

Dear Mr. Haywood and McClure

Enclosed you find a soil sample that has been analyzed.

We are presently using this product as an additive in cattle feed to aid in digestion of their feed, works somewhat like Rolaids if you will pardon the expression. This product is also used to neutralize acid soils.

Our question to you and your chemist is this. Would this product, as it is, a detriment in some way help the Acid Lakes? We presently have access to millions of tons of this material. The product is easily mined without any environmental damage.

If this product can help you in any way let my attorney know or myself, we will be glad to send samples or any other information we can.

Sincerely
Charles E. Beck
H.C. 63 Box 163
Challis Idaho
83226
208-879-2438

Attorney
R.L. Sniffen
525 9th St.
Idaho Falls Idaho
832
208 524-4952

Section Line, Point North

GRAVIMETRIC RESULTS

Crude Protein, %	
Digestible Protein, %	
Lipids, %	< 0.1
Crude Fiber, %	
Crude Fibre, %	
Ash, %	
Nitrogen Free Extract (NFE), %	
Total Digestible Nutrients (TDN), %	
Dry Matter, %	
Moisture, %	
Nitrogen, ppm N	
Phosphorus, %	< 0.1
Potassium, %	< 0.2
Calcium, %	20.1
Magnesium, %	13.1
Sulfur, %	< 0.05
Sodium, %	< 1.0
Lime % (by acid titration	95.5
Zinc, ppm	8
Iron, ppm	320
Manganese, ppm	55
Copper, ppm	15
Boron, ppm	
Molybdenum, ppm	
Cobalt, ppm	
Selenium, ppm	

Five other Claims ranging in Min. Contents from: Calc volume Cal 20.6 - 26.0 Mag 6.0 - 13.7

Zl4 Cal - 26.0
Mag - 6.0

n/ Calcium 20.4
Mag 12.3

4 Cal 20.5
2. Mag 12.6

21 3 Cal 22.9
Mag 13.7

Based on sample moisture plus dry matter as 100%. All other results are reported on a dried sample basis. Parts per million

This is for the exclusive use of the client(s) to whom it is addressed. Its communication or disclosure to others or use in advertising is not [illegible]. These results refer only to the specific sample tested and not to other apparently similar material. Unused sample portions are to be [illegible] for a period of 30 days unless other arrangements are agreed to.

IDAHO DEPARTMENT OF FISH AND GAME
600 South Walnut • Box 25
Boise • Idaho • 83707

DUDLEY W. REISER

JAN 02 1986

December 11, 1985

Dudley Reiser, Project Manager
Bechtel National, Inc.
P.O. Box 3965
San Francisco, CA 94119

Subject: Panther Creek Draft Report, September, 1985

Dear Dudley:

This letter is to confirm to you our general support of your September, 1985, Draft Report on Panther Creek Habitat Rehabilitation, and to offer a few specific comments that Terry Holubetz and I had on estimates of smolt production potential and economic value.

Section 2.3 - Fisheries Habitat Surveys:

The assumed value of 0.0057 fish/ft^2 (6.1 fish/100m^2) for spatial requirements for steelhead rearing seems conservative. These average densities from Idaho streams were determined during years that steelhead runs were depressed. The spatial requirements for chinook rearing (0.096 fish/ft^2; 103 fish/100m^2) appear appropriate. For these analyses, we think that "average area of redd" is more appropriate than "area recommended per pair."

Section 7.1 - Smolt Production Estimates:

We favor your approach of calculating ranges of smolt production potential, based on the various assumptions of spatial needs for spawning and rearing. However, we would like to see the discussion and analysis focused in a few areas.

Unless you have strong indications that spawning habitat is limiting, we would prefer to see rearing capacity in late summer emphasized for both species. In all cases, potential smolt production estimated from rearing was lower than that from spawning (based on "average area of redd"). We think that this points to rearing as a more likely limiting factor. Emphasis on estimates based on rearing capacity would also compliment ongoing project evaluations in other Idaho streams.

Effects of flows on smolt production potential (Section 7.1.3) appear to be somewhat overemphasized as presented. No changes in flow are proposed for

• EQUAL OPPORTUNITY EMPLOYER •

Panther Creek, and late-summer flows are not as variable as the range covered in the analysis. If rearing capacity is the limiting factor, potential smolt production was estimated to be fairly constant throughout the range of flows.

Section 7.2 - Economic Analysis:

A range of survival rates should be incorporated into this analysis to account for improved survival of downstream migrants after full implementation of the Fish and Wildlife Program.

Otherwise, the report looks good. If you have any questions regarding our comments, feel free to contact either Terry or me.

Sincerely,

Charlie Petrosky
Fishery Research Biologist

CP:mm

CC: Larry Everson
Mel Reingold
Rick Konopacky

Appendix D: References Reviewed but Not Cited

Appendix D

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