Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS
In association with:
Sigma Engineering Ltd
Beak Consultants Ltd

REPORT TO B C HYDRO
ON THE
HAT CREEK PROJECT

800 MW SCHEME - MINE DRAINAGE

FINAL REPORT

Distribution:

10	Copies	- B C Hydro and Power Authority Vancouver, B C
6	Copies	- Golder Associates, Vancouver
2	Copies	- Sigma Engineering Ltd
2	Copies	- Beak Consultants

604H-M097

DECEMBER 1982 8221569

HAT CREEK PROJECT

800 MW SCHEME

MINE DRAINAGE

FINAL REPORT

CONTENTS

HAT CREEK PROJECT

800 MW SCHEME

MINE DRAINAGE

CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued..)

LIST OF FIGURES

MANAGEMENT SUMMARY

This report examines the drainage requirements for the proposed 800 MW open pit development at Hat Creek. It identifies potential flows of varying water qualities into the pit and surrounding areas, considers the means of collecting these flows and recommends methods of disposing of the water.

This drainage study is complementary to that carried out by CMJV (1979) for the 2240 MW pit development; hydrological data has been used from that work except where more recent records have permitted re-assessment.

During development of the 800 MW pit, it would be necessary to deal with four qualities of water inflow:

- runoff unchanged in quality by the development which could be channelled to Hat Creek;

- runoff and ground water from the surficial deposits and disturbed land areas, which would exceed limits for suspended solids and which would therefore require detention in sedimentation lagoons before being returned to Hat Creek;

- runoff from coal, vehicle washdown, waste dump and pit coal surfaces; ground water seepage from coal and other in-pit bedrock; which would exceed limits for dissolved solids and which would therefore require treatment if the flows were returned to the creek;

- sanitary sewage.

The hydrology of the various catchments within the Hat Creek basin is assessed and design criteria established for various flow probability levels depending on the sensitivity of the 800 MW Scheme to the particular water courses or engineered structures. Anticipated quantities of surface runoff are calculated. The sources of the surface and ground water for the various water qualities are identified in the report. Figure 4-5 shows schematically the routing of the drainage flows for the 800 MW Scheme.

Hat Creek itself would be diverted through the 800 MW pit by pipeline (Golder Associates, 1982b). Runoff towards the pit or waste dumps and the water yields from dewatering wells capable of being returned directly to Hat Creek would be collected by perimeter drains and diversions. The water directed to the sedimentation system would be collected from within the pit, from the margins of the active slide area, from the waste dump runoff and from the mine services area. Water of leachate quality would arise from runoff and seepage from the coal and other rock exposures in the pit, from the coal blending and coal dump areas, from seepage from the Houth Meadows Dump and from the vehicle washdown areas. Sewage would be generated from the facilities associated with the mine maintenance area.

Because Hat Creek is diverted in a pipe system, most of the clean water diversions would be directed to points either upstream or downstream of the diversion arrangement.

Sedimentation quality water would be diverted to a lagoon located to the north of the pit. The sizing of the lagoon is discussed and design criteria are presented; the seasonal quality variations of the discharges to Hat Creek are discussed.

The waters high in dissolved solids and treated sewage would be diverted to a leachate lagoon between the sedimentation lagoon and the pit rim where they would be held until they could be disposed of by evaporation at the site; this is referred to as the 'Zero Discharge System'. Other methods of disposal would include spray evaporation on the waste dump and dust control. It would be necessary to construct the lagoon to full capacity by year 5 because of the large surface area of coal exposed in the pit in the early years and the fact that the peak runoff precedes the peak demand for water by the dust control system. Ground water seepage from the coal and rock areas in the pit is likely to vary between wide limits because of local variations in hydraulic conductivity. The zero discharge system would be able to cope with the mean seepage flows; temporary storages might be needed for high transient inflows. Monitoring of the flows should be undertaken in the early years. Sewage would be treated and the effluent would be channelled to the leachate lagoon.

Sections are included which discuss the sequence of implementation of the drainage scheme and the abandonment options.

1. INTRODUCTION

1.1 BACKGROUND

The Hat Creek Project is proposed as B C Hydro's first thermal coal power generation project. This power plant would use the vast undeveloped deposits of low grade thermal coal located in the Hat Creek Valley, near Cache Creek. The project is a combined development of an open pit coal mine and associated power station.

The project was initially proposed as a 2240 MW Scheme (2000 MW net power to the grid) and a number of reports were prepared from 1977 to 1980 covering various phases of the mine development. During early 1982, downgraded power forecasts and high cost estimates led to a smaller version of the project being proposed, namely an 800 MW scheme feeding about 720 MW of power to the grid. This scheme was similar in layout to the larger scheme, but most elements were scaled down, including the open pit itself. This report discusses the drainage aspects of the pit area. The diversion of Hat Creek itself around the 800 MW pit is covered in a separate report (Golder Associates, 1982).

1.2 SCOPE OF WORK

The scope of work for the mine drainage study has been detailed in a memo from the B C Hydro Mining Department dated June 22, 1982 and a subsequent proposal from Golder Associates in August, 1982. The main points covered in this work would be similar to those covered in the Mine Drainage Report for the 2240 MW project (CMJV - 1979).

The Terms of Reference were as follows:

- Calculate the flows and size the drainage facilities for the watersheds influencing the 800 MW pit which could be discharged directly to Hat Creek without treatment.

- Calculate flows and pond sizes for runoff with potentially high sediment loads; this water to be stored for a sufficient time to reduce the sediment level to meet the 25 - 75 mg/l range before release to Hat Creek.

- Calculate flows and pond sizes for areas of the 800 MW pit which produce runoff which cannot be discharged to Hat Creek. This water is to be used for dust control and spray evaporation on the waste dump. Quantities of water for dust control also to be estimated, and water balance charts produced.

- Wherever possible, drainage design criteria for these three systems to be adapted from the CMJV Report (1979); where applicable, flows to be provided for years 5, 15 and 35.

- In addition to the stated terms of reference, some comments are to be made on the sewage disposal aspects of the mine project. A means of refinement of the design criteria and staged implementation of the drainage system will be discussed.

1.3 APPROACH

The Mine Drainage Study for the 800 MW Project is intended to provide the basic parameters for use in the more detailed designs which would follow if construction of this reduced capacity thermal power project were to proceed. A study has already been carried out for the mine drainage at the 2240 MW project (CMJV, 1979); this study therefore provides a comparison between the two schemes. Accordingly, much of the background information is drawn from this earlier report, and parameters have not been re-calculated for features of the drainage systems which are common to both projects.

The study has been divided into components which suit the expertise of the various consultants. Golder Associates are providing the study management and are updating the groundwater flows; Sigma Engineering Ltd is providing the input on the surface water hydrology and system design; Beak Consultants Ltd is providing information on the water quality. All three consultants have background experience on the Hat Creek Project.

The contributing consultants to this report used the information contained in the CMJV Report as a basis for the 800 MW Drainage Study. In some instances, where a parameter such as a drainage area is changed from the 2240 MW scheme, the resulting flow is changed accordingly. However, there are some parameters such as runoff coefficients, which in the absence of further research work must be assumed as being correct. Where this information is felt to be insufficient for final design, a recommended method of refinement will be discussed in Section 6.

The layout of the report differs somewhat from the CMJV report in order to assist the development of background information. In particular the various runoff and evaporation parameters are explained as well as the development of the hydrographs. Where drainage systems are described, the major headings have been defined as Collection and Disposal (Sections 4 and 5) with subheadings for the four qualities of water (direct discharges to Hat Creek, sediment, leachate and sewage). Where possible, reference is made to a parameter developed in the CMJV report without further elaboration. A concluding section (Implementation - Section 6) is provided to recommend further work where it is felt that the parameters used in the study could be improved prior to initial construction, and refined as mine development proceeds.

2. SITE DESCRIPTION

2.1 LOCATION

The Hat Creek Valley is located mid-way between Lillooet and Cache Creek. The current project is involved with the exploitation of the No 1 Coal deposit, which is the northernmost of the two coal deposits in the Upper Hat Creek Valley. This study is concerned with the drainage surrounding the development of a pit into No 1 Deposit. Development of the No 2 Deposit would be reserved for future demand or for alternative uses for the coal beyond those envisaged at present.

Hat Creek itself is a relatively small meandering creek flowing through a wide flat valley and having a gradient of about 2 percent in the area of the No 1 Deposit. Tributary creeks, such as Medicine, Ambusten, Anderson, Finney and Harry Creeks flow in the vicinity of Pit 1, but all are diverted, either naturally or with a drainage structure before their waters reach the pit area. Details of the diversions of Hat Creek and its tributaries are discussed in a separate report (Golder 1982).

Closer to the pit itself, the topography is dominated by gradually sloping valley sides of about 8 percent on the west and 5 percent on the east. A few small tributary creeks channel runoffs from these areas. Drainage basins extend from the mine site at about 900 m elevation to 1250 m on the east and to over 1900 m on the west, as shown on Figure 2-1.

2.2 800 MW SCHEME

The 800 MW scheme uses an open pit mine in the valley bottom centered about 2 km south of Highway 12. The location is the same as Pit 1 in previous studies, but the pit is smaller. The power plant is still located on the ridge about 5 km east of the mine and about 500 m higher in elevation.

A series of roads links the various pit levels and surrounds the pit perimeter. An access road switchbacks up the hill to the power plant site. Once coal is mined from the pit, it is trucked to a dump station on the north side of the pit, from where it is conveyed to a coal blending and stockpile area. From the coal blending area, the coal is moved on a conveyor to the power plant.

On the west side of the valley the Houth Meadows waste dump is used as a depository for materials other than coal which are mined from the pit. These materials are moved via truck from the pit to the waste dump. Two earthfill dams are used to contain the waste rock.

The project facilities are serviced by the maintenance complex lying between the north pit rim and Highway 12. This area includes an office, dry room, vehicle repair shop, fuel storage and vehicle washdown area.

The mine facilities mentioned in the preceding paragraphs are all essential to the process of thermal power generation. The facilities themselves occupy about 8 square kilometres of land area, hence the impact of the project on the landscape is significant as is the impact on the existing drainage pattern. The most dramatic impact of the project on runoff patterns is the fact that the open pit itself, which is about 300 m deep, straddles the channel of Hat Creek. This has made a major diversion system necessary, as detailed in the Diversion Study (Golder Associates, 1982).

The other major impact of the project is on the runoff from the various mine facilities and adjacent areas. These areas produce runoff waters of varying qualities which must be collected and treated in different ways. In addition to the networks of collection drains which serve the mine facilities, major treatment facilities such as the leachate and sedimentation ponds are required. The details of these collection and treatment facilities are described in Sections 4 and 5.

2.3 COMPARISON WITH 2240 MW SCHEME

There are few conceptual differences between the 800 and 2240 MW schemes. The problems of coal excavation, coal transportation, waste rock disposal and runoff and seepage control still exist, but the magnitude of the problems is reduced for the 800 MW scheme, because many of the facilities are physically smaller, as described in Table 2 - 1.

There are some significant differences in the schemes, resulting from the reduced pit size for the 800 MW scheme. These include:

- elimination of the Medicine Creek Waste Disposal Area
- reduction in area and depth of the Houth Meadows Waste Dump
- elimination of the low grade coal stockpile
- steeper pit slopes due to the higher proportion of stronger materials in the slopes and the lesser depths.
- for the CMJV Report (1979), a canal was the preferred diversion choice for Hat Creek. For both schemes this is now replaced by a pipeline system during mine operation. For the 800 MW Scheme the pipeline system will also be used after mine abandonment.

TABLE 2 - I

COMPARISON BETWEEN POWER SCHEMES - YEAR 35

Facility		800 MW	2240 MW(1)
Open Pit	- Area (2)	360 ha	750 ha
	- Depth	300 m	400 m
Houth Meadows Waste Dump	- Area	263 ha	580 ha
Medicine Creek Waste Dump	- Area	N/A	410 ha
Mine Maintenance Complex	- Area	20 ha	20 ha
Coal Blending	- Area	15 ha	22 ha
Coal Dump Station	- Area	10 ha	N/A
Drive and Transfer House Mine Conveyor	- Area	N/A	10 ha
Coal Conveyors	- Length(3)	4.5 km	5.5 km
Waste Conveyors	- Length (4)	N/A	6 km(5)
Gravel Roads	- Length	16 km	28 km
Sedimentation Lagoons	- Area	6.8 ha	7.0 ha
	- Volume	225,000 m^3	250,000 m^3
North Valley Leachate Lagoon	- Area	9 ha	9 ha
	- Normal Volume	360,000	700,000 m^3
	- Emergency Volume	900,000	1100,000 m^3
Medicine Creek Leachate Lagoon	- Area	N/A	0.7 ha
	- Volume	N/A	12,000 m^3
Low Grade Coal	- Area	N/A	33 ha
Pipeline Diversion System	- Length	4.5 km	6.0 km

Footnotes:

Note: Areas shown are plan areas

(1) 2240 MW Scheme values obtained from CMJV Drainage Report, 1979

(2) Pit area within perimeter diversion drains

(3) Lengths are approximate and scaled from drawings (CMJV 1979 and B C Hydro 1982)

(4) Does not include conveyors within dump boundaries

(5) Includes Medicine Creek Waste Conveyor

3. DRAINAGE DESIGN CRITERIA

3.1 GENERAL

3.1.1 Constraints

The drainage design criteria of the Hat Creek Project must be established before any conceptual layouts or physical sizes can be determined. For the 800 MW Scheme, the overriding criterion is that there should be no discharge to receiving waters (ie: Hat Creek itself) of water not meeting the quality standards of the Waste Management Branch, British Columbia Ministry of the Environment.

There are four separate water disposal systems outlined in this study, to handle the four categories of water quality which can be expected from the mine development. These systems are defined below:

3.1.2 Runoff Discharged Directly to Hat Creek

Land areas surrounding the mine development which are not altered in any way will produce runoff which is unchanged in quantity and quality from before development conditions. This water would be channelled to Hat Creek or the diversion system and discharged directly without treatment.

3.1.3 Sediment System

Land areas disturbed from their natural condition and surficial groundwaters would produce runoff high in suspended solids but which would be otherwise acceptable. These waters would be detained in sedimentation lagoons north of the pit to settle the suspended solids prior to release of the water into Hat Creek. These flows would include:

- runoff from pit slopes excavated in surficial deposits;

- runoff from disturbed slide areas;
- runoff from service areas;
- seepage flow from pit surficials.

3.1.4 Leachate System

Flows from land areas and groundwaters which would be high in dissolved solids will not be released to Hat Creek. As in the 2240 MW Scheme, it is planned that these waters would be intercepted for use and disposal within the mine area. They thus constitute a "Zero Discharge System". This system would collect the following surface and groundwater flows:

- runoff from coal and other rocks present in the pit slopes below the surficial deposits;
- leachate from the Houth Meadows waste dump;
- runoff from the coal dump station, waste dump surfaces and coal blending areas;
- vehicle washdown water;
- groundwater from the pit coal and other bedrock.

The water collected from the above areas would be stored in a sealed leachate pond for use during the summer season in dust control. Roads and coal blending areas would require most of the dust control water, but excess water could be sprayed and evaporated on the waste dump surface if required.

3.1.5 Sewage System

Sanitary sewage will originate from the showers and washrooms of the Mine Maintenance area in the North Valley Services area. It will be collected in conventional gravity drains, treated in a lagoon and input to the leachate system for disposal via evaporation.

The criteria for assessing the quality of runoff water, and hence defining the land areas from which it originates, are discussed in Section 3.2. The criteria for determining the quantity of runoff, which is a function of climate and topography, are discussed in Section 3.3. Details of the water collection systems are given in Section 4 and details of the disposal systems are given in Section 5.

3.2 WATER QUALITY

3.2.1 Water Quality Objectives

Water quality at the mine site is of primary importance to the overall development of the Hat Creek Project. Despite the impact of the open pit and related facilities on the immediate area, there must be minimal impact on the quality of the water downstream in Hat Creek. The governing criteria for quality of discharges are stated in the British Columbia Ministry of Environment, Waste Management Branch, Effluent Discharge Guidelines for the Mining Industry. (B C Ministry of the Environment, 1979). The discharge objectives are shown in Table IV of the guidelines and objectives for receiving water quality are shown in Table VI.

Projections of water quality from various areas of the mine development were made during earlier sampling programs (Beak, 1978, 1979). These projections have been updated by Beak, together with the latest guidelines from the Waste Management Branch and are shown in Table 3-1.

Sanitary sewage would originate from the Mine Maintenance area. The quality of these flows would be of the normal municipal type, and guidelines for discharge of these flows are contained in Waste Management Branch publications (Guidelines for Municipal Type Discharges, 1975). These flows are to be collected and treated separately from the mine drainage flows, as outlined in Sections 4.4 and 5.4, and then pass through the leachate system prior to disposal by evaporation.

TABLE 3 - 1

PROJECTIONS OF WATER QUALITY OF MINE DRAINAGE

Parameter (mg/l)	Natural Surface Water				Mine Drainage(3)				Discharge Guidelines Range
	Hat(1) Creek	Medicine Creek Area	Finney Lake	Aleece Lake	Mine Waste(2) Leachate	Coal Leachate	Mine Water (Bedrock)	Mine Water (Surficials)	WMB Objectives (1979)
pH (units)	8.4	8.3	8.2	7.6	7.9	5.0(4)	7.8	7.9	6.5 - 10.0
Filterable Residue	336	275	179	--	1340	8400(4)	1950	350	2500 - 5000
Non Filterable Residue	8	0-110	--	--	--	--	--	--	25 - 75
BOD_5	< 1	--	--	--	--	--	--	--	-
TOC	8	19	18	--	51	--	50	21	-
Total hardness (as $CaCO_3$)	219	215	93	185	217	4140	304	214	-
Alkanity (as $CaCO_3$)	212	221	123	217	117	27	1185	270	-
Chloride	1.2	0.4	0.5	< 0.5	26	14	42	3	-
Fluoride	0.14	0.12	0.22	--	0.06	0.10	0.2	0.2	2.5 - 10.0
Nitrate (as N)	< 0.06	0.04	< 0.02	--		--	< 0.06	< 0.2	10.0 - 25.0
Kjeldahl Nitrogen (as N)	0.19	0.26	0.83	--	-	--	14.0	< 0.2	-
Total Nitrogen (as N)	< 0.25	0.30	< 0.85	--	4.3	--	< 14.06	< 0.4	-
Ortho Phosphate (as P)	0.038	0.01	0.025	--	0.29	0.01	< 0.03	< 0.03	2.0 - 10
Sulfate	50	20	5	52	210	3700	321	52	-
Arsenic (Total Dissolved)	< 0.005	< 0.005	< 0.005	--	< 0.07	0.005	0.006	< 0.005	0.1 - 1.0
Boron	< 0.10	< 0.1	< 0.1	--	< 0.07	0.31	0.31	< 0.1	-
Cadmium	0.005	< 0.005	< 0.005	--	< 0.002	--	< 0.005	< 0.005	.01-0.1
Calcium (as $CaCO_3$)	145	130	60	85	99	1900	180	148	-
Chromium	< 0.010	< 0.01	< 0.01	--	0.12	0.01	< 0.01	< 0.01	0.05 - 0.3
Copper	< 0.005	< 0.005	< 0.005	--	1.43(4)	0.03	< 0.008	< 0.005	0.05 - 0.3
Iron	< 0.018	< 0.02	< 0.04	< 0.05	1.19(4)	0.26	< 0.075	< 0.025	0.3 - 1.0
Lead	< 0.010	< 0.01	< 0.01	--	0.02	--	< 0.013	< 0.010	0.05 - 0.2
Magnesium (as $CaCO_3$)	74	85	33	100	115	2240	124	66	-
Mercury	< 0.00038	< 0.0005	< 0.00033	--	0.0014	0.0003	< 0.0003	< 0.0003	0 - 0.005
Sodium	20	11	15	38	67	190	412	39	-
Vanadium	0.005	< 0.005	< 0.005	--	0.01	0.04	< 0.007	< 0.005	-
Zinc	< 0.008	0.009	0.006	--	0.15	0.11	0.52	< 0.03	0.2 - 1.0

SOURCE: Beak 1978, 1979 NOTE: (1) Mean of measurements taken Sept 1976-1977 during a low flow year.

(2) Surface Runoff has been projected to be of this quality (Beak 1981)

(3) Updated for 800 MW Scheme.

(4) Indicates parameter exceeds upper limit of WMB Guidelines range.

3.2.2 Land Areas

The quality of the water from various sectors of the mine site defines the treatment method which would be used for runoff from each area. The four categories of water quality have been identified in Section 3.1, namely: runoff suitable for direct discharge to Hat Creek, runoff high in suspended solids, runoff high in dissolved solids and domestic sewage. The description and size of the land areas contributing to each water quality category are shown in Table 3-2.

Reference to Table 3-2 indicates that most areas contributing runoff near the mine do not change over the life of the mine. However, the areas which are changeable are located within the pit perimeter. These areas increase as the mine expands, and a progressively higher proportion of the flow originates from rock and coal exposed within the pit slopes, resulting in an increasing proportion of flow to the leachate system. This implies that some portions of the drainage scheme must be built to permit expansion as the pit develops.

3.2.3 Groundwater Sources

The quality of the groundwater from various sectors of the mine has been projected in the Impact Assessment of the Revised Project (Beak 1979). The water from the lower pit dewatering and Houth Meadows Waste Dump seepage would contain high levels of dissolved solids and would be directed to the leachate system. Seepage from pit surficials would have varying levels of suspended sediment, as projected from previous sampling programs (Beak, 1978, 1979). To guard against excess concentrations of suspended solids, this water would all be directed to the sedimentation system in conjunction with surface runoff from the same area. The major difference between the groundwater sources in the 2240 MW and 800 MW Schemes is that the slide area underground drainage and most of the pit perimeter wells have been eliminated from the smaller scheme. The pit rim will be further from the slide area, so the slide hazard is reduced. The surface water collection system is retained as described in Section 4.1.4 to reduce ground water recharge.

TABLE 3-2

LAND AREAS CONTRIBUTING TO WATER DISPOSAL SYSTEMS

I. WATERSHEDS DISCHARGING DIRECTLY TO HAT CREEK (BEFORE MINE DEVELOPMENT)

Description	Reference No (See Dwg 2-1)	Area (km^2) (before mine development)
Pit Region		
Southwest	1	3.0
Northwest	2	5.2
Southeast	3	1.9
Northeast	4	1.9
North Valley	5	2.3
Pit Region Subtotal		**14.3**
Houth Meadows		
South	6	17.6
West	7	8.6
Northwest	8	5.2
North	9	1.9
Northeast	10	0.9
Houth Meadows Subtotal		**28.2**
Harry Creek	11	9.2
Marble Canyon	12	10
Watersheds in Project Area Subtotal		**61.7**
Hat Creek Watershed Upstream (Upstream of Diversion Dam)		
Finney Creek	13	13.2
Anderson Creek	14	36
Anderson Creek North	15	7.4
Medicine Creek	16	61
Medicine Creek North	17	
Ambusten Creek	18	34
Hat Creek Upstream of Anderson Creek	19	198
Hat Creek Upstream of Diversion Dam Subtotal		**350**

TABLE 3-2 (Continued..)

LAND AREAS CONTRIBUTING TO WATER DISPOSAL SYSTEMS

2. WATERSHEDS DISCHARGING DIRECTLY TO HAT CREEK (DURING MINE DEVELOPMENT)

Reference Code (See Fig 3.5, 4.5)	Description	Drainage Area (km^2)
	HAT CREEK	
Q1	Hat Creek u/s of diversion dam	350
Q2	Hat Creek Pipeline diversion capacity	-
	DIVERSION DRAINS	
D1	South West Pit Perimeter Diversion	1.0
D2	Lower Slide Diversion	2.9
D3	Finney Creek Watershed	
D4	Finney Creek Channel Realignment	13.1
D5	Upper North Valley Diversion	0.8
D6	West Houth Meadows Perimeter Diversion	7.8
D7	Upper Slide Diversion	14.8
D8	South Houth Meadows Perimeter Diversion	24.4
D9	North Houth Perimeter Diversion	1.0
D10	North East Houth Meadows Perimeter Diversion	0.3
D11	South East Pit Perimeter Diversion	1.4
D12	North East Pit Perimeter Diversion	1.2
D13	Dewater wells below Diversion Dam	N/A

TABLE 3-2 (Continued..)

LAND AREAS CONTRIBUTING TO WATER DISPOSAL SYSTEMS

3. WATERSHEDS DISCHARGING TO SEDIMENT SYSTEM

Reference Code	Description	Area (ha) Year 5	Year 15	Year 35
S1	Houth Meadows Waste Dump			
	Unstripped land below diversion drains	190	113	67
	Prestripped land	10	17	-
	Active land	25	25	25
	Reclaimed land	N/A	N/A	130
S2	Slide Area Runoff	120	120	120
S3	Pit Surficials	180	120	110
S4	Ground Water from Pit Surficials	N/A	N/A	N/A
S5	North Valley Services Area			
	Buildings, Pavement	20	20	20
	Open areas	190	190	190

4. WATERSHEDS DISCHARGING TO LEACHATE SYSTEM

Reference Code	Description	Area (ha) Year 5	Year 15	Year 35
Z1	Coal Blending Area	15	15	15
Z2	Coal Dump Station	10	10	10
Z3	Runoff from Pit Coal and other Bedrock	180	240	250
Z4	Groundwater Seepage from Pit Coal and other Bedrock	N/A	N/A	N/A
Z5	Vehicle Washdown Area	N/A	N/A	N/A
Z6	Dust Control Consumption	N/A	N/A	N/A
Z7	Evaporative Disposal	N/A	N/A	N/A
Z8	Houth Meadows Waste Dump Leachate	N/A	N/A	N/A
Z9	Houth Meadows Waste Dump (levelled land)	105	175	108

5. DOMESTIC SEWAGE

Reference Code	Description	Capacity (persons/day) Year 5	Year 15	Year 35
Z10	Mine Maintenance Complex	300	300	300

3.3 WATER QUANTITY

3.3.1 Quantity Design Criteria and Methodolgy

Criteria

There are several different criteria used for assessing the design quantity of water to be removed from the mine area. The assessment of which criteria to use in different areas is based on the relative importance of the drainage facility and the potential damage to the mine if the capacity were to be exceeded.

Water quantities are required for peak design flows for the design of collection systems. The pipes, ditches and pumps conveying the four categories of water are assigned design return periods according to Table 3-3. These return periods are based on the importance of the facility and the consequences of failure. The individual criteria for the waters from the mine area are discussed in the following sections.

Runoff Volume

Consistent with the CMJV Report (1979), the 24 hour runoff volume and the peak discharge flows have been obtained using Figures 3-1 and 3-2. For rainstorm events, the 24 hour greatest rainfall was determined from Graph 2 of Figure 3-1. Graph 3 of this figure was then used to obtain runoff volumes, and Graphs 4 to 6 were used to obtain peak discharges.

Graph 2 used to determine the runoff volume is a graphical representation of a runoff relation presented, among others, by Chow (1969) or by the U S Department of Agriculture (1964). This runoff relation assumes average antecedent moisture conditions and is as follows:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

and $$CN = \frac{25400}{S + 254}$$

where:

P	is the total storm rainfall in mm
S	is potential infiltration in mm
CN	is the runoff curve number
Q	is the actual direct runoff in mm

CN values have been obtained for a variety of surface drainage conditions, some of which are shown in Figure 3-1. The actual direct runoff obtained is however very sensitive to the CN value used, and these values should be re-examined for the final design and as the mine development proceeds. The runoff volumes calculated by this method and presented in this report are adequate for preliminary design and were used to size the treatment facilities.

Runoff Peak Discharge

Peak discharge flows were obtained from Graphs 4 to 6 given on Figure 3-1. These graphs were developed by the U S Department of Agriculture (1975) and are applicable for computing peak discharges from agricultural drainage areas less than 10 km^2 in size which have a rainfall distribution common to most of the United States. The peak discharge curves in Figure 3-1 could therefore be applicable to the uniform land areas outside of the pit perimeter. The peak flows obtained for other areas, such as pit benches are calculated in the same manner. The drainage conditions for natural agricultural watersheds may be quite different fromn the drainage conditions within an open pit mine. It is recommended that in the final design stage the peak discharge values should be re-calculated using a different method than the U.S. Department of Agriculture (1975) which was used above and in the CMJV report (1979).

For snowmelt-rainfall events, a regional stream flow analysis was used by the CMJV Report (1979) to obtain Figure 3-2. These curves were used to obtain flows for drainage areas in excess of 10 km^2 in size. Runoff values obtained for areas close to 10 km^2 in size, obtained separately from Figure 3-1 and Figure 3-2, differed considerably and transition values for these areas were developed. It is recommended that the peak flows be reviewed carefully prior to construction.

To assist in obtaining adequate peak discharge values to size the collection systems, intensity duration frequency (I D F) curves would be desirable. Rainfall intensity measuring equipment should therefore be maintained in the Hat Creek valley. Stream flow monitoring should also continue, as well as measurements of discharges from small, low elevation basins. Peak runoff figures obtained from pit benches similar to those at Hat Creek would also be desirable.

3.3.2 Runoff Discharged Directly to Hat Creek

The runoff from the natural land areas surrounding the mine would not be affected by any mining activities. However, the water that would normally have discharged to Hat Creek itself, must avoid the open pit, the waste dump and other facilities, before discharging into Hat Creek or its diversion.

As detailed in Table 3-3, perimeter drains and major diversions are sized for the 100 year rainfall and 1,000 year snowmelt events respectively. The calculation of these flows has been adopted from the previous mine drainage study (CMJV, 1979) which based the tributary runoff on the long term regional data available for Hat Creek and other streams in nearby valleys. At the time of the previous study, there were only partial records available for the tributary streams to Hat Creek, and no conclusions could be drawn. Since 1979, nearly 4 years of record are available on Ambusten, Anderson and Medicine (upper and lower) Creeks, as shown on Table 3-4.

Table 3-4 indicates that there are large differences between the hydrology of the tributary creeks and of Hat Creek. The figures seem to indicate that the

TABLE 3-3

DESIGN CRITERIA FOR PLANNING OF MINE DRAINAGE SYSTEM

Type of Drainage Element	Description	Design Flood	Probability of Exceedance in 35 Year Mine Life (%)
Major Creek Diversions	Hat Creek	1,000 yr F*	3
	Finney Creek	1,000 yr F*	3
	Houth Creek	1,000 yr F*	3
	Upper Medicine Creek	Probable Max. Flood	--
Perimeter Drains	Around Pit Waste Dumps & Slide Area	100 yr R	30
Surface Water Drains within pit	Permanent Major Drains	100 yr R	30
Leachate Collection Systems	Temporary Minor Drains	10 yr R	97
	Field Drains	Max Seepage Rate	--
Dewatering Wells	Collection Systems	Max Pumping Rate	--
Sedimentation Lagoons	Emergency Spillways	1,000 yr R	3
	Treatment Capacity	10 yr R	97
Leachate Storage Lagoons	Emergency Spillways	1,000 yr R	3
	Storage and Disposal Capacity	2 x Mean Annual Flow	--

*Refer BCH/HEDD 1976 and Monenco 1977 for Design Criteria.

<u>**Note:**</u>

1,000 yr F - refers to the 1,000 year average recurrence interval flood during spring freshet caused by rain and snowmelt;

100 yr R - refers to the 100 year average recurrence interval flood caused by high intensity rainfall alone.

TABLE 3-4

RECENT HYDROLOGY IN THE HAT CREEK BASIN

Creek	Year	(1) Peak Instantaneous Flow (m^3/s)	(2) Peak Daily Flow (m^3/s)	(3) Annual Runoff (cm)	(4) Return Period of (1) (Yrs)
Ambusten Creek	79	.05	.048	1.0	1
near mouth	80	.417	.283	2.0	1.5
Stn No 08LF081	81	.982	.847	5.7	2.5
Anderson Creek	79	1.07	.914	9.5	-
above diversions	80	1.94	1.94	12.	-
Stn No 08LF084	81	4.51	2.31	12.	-
Medicine Creek	79	.345	.261	1.1	1
near mouth	80	.545	.502	1.3	1
Stn No 08LF082	81	.510	.444	3.0	1
Medicine Creek	79	-	-	-	-
Diversion near	80	.590	.539	7.4	1
Ashcroft	81	.903	.789	10.0	1.5
Stn No 08LF083					
Near Upper	79	1.16	1.06	2.0	1
Hat Creek	80	10.1	9.55	6.8	10
Stn No 08LF061	81	16.8	12.5	9.0	70
	Mean	-	6.2	5.5	-
Hat Creek	79	1.31	1.23	1.4	1
nr Cache Creek	80	7.67	7.26	3.8	3
Stn No 08LF015	81	18.0	12.8	5.8	30
	Mean	-	6.6	3.8	-

runoffs are larger and more uniform on the western side of the valley than on the eastern side. This information will affect the size of the diversion and perimeter drains, hence the generalized criteria used in this study should be updated at the time of construction, when more flow records would be available.

The other creek shown on Table 3-4, Medicine Creek, has an existing diversion in its upper reaches which complicates the hydrology. The gauge in the diversion measures flows to Cornwall Creek from a drainage basin of 21 km^2, which is all upland flow. The gauge on the lower creek measures flow from a drainage area of about 40 km^2 but if the diversion was no longer in place, the drainage area would be about 61 km^2 and the peak flows would be much larger.

Until further data is available, water quantities from natural drainage areas are based on the graphs on Figures 3-1 and 3-2. The areas around the pit perimeter are all less than 10 km^2 and would use Figure 3-1 while a few larger basins would use Figure 3-2. For comparison, flood frequency curves are also shown in Figure 3-3. A summary of flows for the natural land areas near the open pit mine is shown on Table 3-5.

TABLE 3-5

DESIGN FLOWS FROM WATERSHEDS
DISCHARGING DIRECTLY TO HAT CREEK

Reference Code	Description	YEARS 1-35 Design Flow (m^3/s)	Criteria
	HAT CREEK		
Q1	Hat Creek u/s of Diversion Dam	27	A
Q2	Diversion Capacity	27	1000 F
	DIVERSION DRAINS		
D1	S W Pit Perimeter Diversion	0.9	100 R
D2	Lower Slide Diversion	2.1	100 R
D9	North Houth Perimeter Diversion	1.3	100 R
D10	N E Houth Perimeter Diversion	0.6	100 R
D11	S E Pit Perimeter Diversion	1.4	100 R
D12	N E Pit Perimeter Diversion	1.0	100 R
	CREEK DIVERSIONS		
D3	Finney Creek Watershed	2.0	1000 F
D4	Finney Creek Channel Realignment	2.4	1000 F
D5	Upper North Valley Diversion	0.3	100 R
D6	West Houth Perimeter Diversion	1.6	1000 F
D7	Upper Slide Diversion	2.7	1000 F
D8	South Houth Perimeter Diversion	4.1	1000 F

NOTE: Location of drains shown on Figure 4-1; drainage areas given in Table 3-2(2).

1,000 yr F - refers to the 1,000 year average recurrence interval flood during spring freshet caused by rain and snowmelt;

100 yr R - refers to the 100 year average recurrence interval flood caused by high intensity rainfall alone.

3.3.3 Runoff Discharged to Sediment System

Both the peak runoff and the runoff volume must be accounted for in the design of facilities for the control of water from disturbed land areas which would discharge to the sediment system. Runoff from these areas would include:

a) runoff from the pit slopes below the pit perimeter excavated in surficial deposits;

b) runoff from the slide area;

c) runoff from the North Valley Services Area.

The design criteria for these areas have been outlined in Table 3-3. The flow from these areas must be routed to the sedimentation lagoons, hence the volume of runoff is of importance as it determines the volume of these structures. The peak flow is also important for the design of pipes, channels and pumps (if required). Details of these systems are given in Sections 4.2 and 5.2.

The peak flows from disturbed land areas are approximated from the graphs in Figure 3-1 and are shown on Table 3-6. Groundwater flows are more constant and are discussed in Section 3.3.5. The volume of the runoff from these areas is based on the 10-year 24-hour runoff from Graphs 2 and 3 in Drawing 3-2, and is used for sizing the sedimentation ponds. The mean annual runoff is also shown for comparison, based on 80 mm of annual runoff from the land areas subjected to dust control (ie: within the pit) and 50 mm of annual runoff for areas outside the pit. These runoff values are based on water budget accounting method (modified) developed in the mine drainage study for the 2240 MW pit (CMJV 1979). Projections of the runoff are shown for the 5, 15 and 35 year pit development stages.

TABLE 3-6

DESIGN FLOWS AND VOLUMES FROM WATERSHEDS DISCHARGING TO THE SEDIMENT SYSTEM

Reference Code	AREA	YEAR 5 Design Flow (m^3/s)	YEAR 5 24 hr Volume m^3x10^3	YEAR 5 Annual Volume m^3x10^3	YEAR 15 Design Flow (m^3/s)	YEAR 15 24 hr Volume m^3x10^3	YEAR 15 Annual Volume m^3x10^3	YEAR 35 Design Flow (m^3/s)	YEAR 35 24 hr Volume m^3x10^3	YEAR 35 Annual Volume m^3x10^3
S1	**Houth Meadows Waste Dump**									
	Unstripped land below diversion drains	0.3	2.6	95	0.2	1.6	56	0.1	0.9	33
	Prestripped Land	0.15	1.5	5	0.30	2.5	8	-	-	-
	Active Waste Dump	-	-	-	-	-	-	-	-	-
	Reclaimed Land	-	-	-	-	-	-	1.0	7.5	65
S2	**Slide Area Runoff**	0.85	10.2	60	0.85	10.2	60	0.85	10.2	60
S3	**Runoff from Pit Surfaces**	2.8	27.0	144	2.1	18.0	96	2.0	16.5	88
S5	**North Valley Services Area**									
	Buildings, Pavement	1.3	5.8	10	1.3	5.8	10	1.3	5.8	10
	Open Area	1.6	11.0	95	1.6	11.0	95	1.6	11.0	95

3.3.4 Runoff Discharged to Leachate System

Some land areas within the pit and surrounding facilities produce runoff which contains unacceptable chemical levels and which must be stored in the leachate lagoon. These sources of water include:

a) drainage from coal blending area
b) drainage from coal dump areas
c) runoff from pit coal and other bedrock, other than surficials
d) runoff from the waste dump.

The design criteria for these flows were outlined in Table 3-3. Runoff peak flows and volumes are both important in the design of the collection and treatment facilities. Peak flows from areas producing runoff were approximated using Figure 3-1. and were used to size the collection facilities. Runoff volumes are required for the sizing of the leachate lagoon. The lagoon must store all the water during the spring runoff for gradual release to the dust control system during the summer. The mean annual runoff is the governing criteria, and has been taken as 80 mm (CMJV, 1979) for areas which contribute direct runoff. Groundwater flows have been calculated separately and described in Section 3.3.5. To be conservative, the extreme inflow to the lagoon is taken as twice the mean annual surface inflow plus the mean groundwater inflow which gives a moderate value of the recurrence interval. The runoff values from surface areas are given in Table 3-7.

Hat Creek itself has had some runoff volumes nearly twice the mean in about 20 years of record, hence the probability of the event occurring is realistic. The safety factors inherent in the lagoon design are described in Section 5.3.

3.3.5 Groundwater

Groundwater originates from the diversion dam wells, seepage at the toe of the Houth Meadows Waste Dump and seepage from surficials and bedrock into the pit itself. These flows were previously estimated for the 2240 MW Mine

TABLE 3-7

DESIGN FLOWS AND VOLUMES FROM WATERSHEDS DISCHARGING TO THE LEACHATE SYSTEM

		YEAR 5			YEAR 15			YEAR 35		
Reference Code	AREA	Design Flow (m^3/s)	Mean Annual Inflow m^3x10^3	Extreme Inflow m^3x10^3	Design Flow (m^3/s)	Mean Annual Inflow m^3x10^3	Extreme Inflow m^3x10^3	Design Flow (m^3/s)	Mean Annual Inflow m^3x10^3	Extreme Inflow (m^3x10^3
Z1	Coal Blending Area	0.45	12.0	24.0	0.45	12.0	24.0	0.45	12.0	24.0
Z2	Coal Dump Station	0.35	8.0	16.0	0.35	8.0	16.0	0.35	8.0	10.0
Z3	Runoff from pit coal and other bedrock	2.2	144	288	2.6	192	384	2.7	200	400
Z9	Houth Meadows Waste Dump,Levelled Land	1.5	52	104	2.2	87	174	1.5	54	108

Drainage Study (CMJV, 1979) and they have been updated for the 800 MW Pit using results from the 1982 field work (Golder Associates, 1982) where applicable.

For estimation purposes, groundwater seepage into the pit derived from bedrock is assumed to be constant on a daily and annual basis based on an average hydraulic conductivity of 1×10^{-9} m/s. The magnitude of these flows is shown on Table 3-8; quality is assumed to be poor and the water would be directed to the leachate system. The calculated flows are considerably less than those calculated for the 2240 MW Scheme because of the smaller and shallower 800 MW Pit. However, there is a wide scatter in the field test results of hydraulic conductivity (Golder Assoicates, 1978, 1982) with some indication that higher values are characteristic of shallow depth. This could be due to glacial disturbance or stress relief. It is certain that higher than average short duration inflows would result when fault or highly jointed zones were intersected. Temporary in-pit storage of these flows might be required. It is recommended that surveillance should be undertaken during the early years to verify the inflow prediction because of the variation in tests results.

Water originating from seepage through the surficial deposits should be directed to the sedimentation system; water from the diversion dam wells and dewatering wells would be clean enough to use for irrigation or direct discharge to Hat Creek.

A schematic representation of the ground water flows is shown on Figure 3-5.

3.3.6 Sewage

Sewage flow at the Hat Creek Project originates from the facilities at the mine maintenance area. In the mine drainage study for the 2240 MW Scheme, the flow was estimated at 140 m^3/day for a 700 man-shift crew. This represents a flow of 200 l/c/d, compared with the construction camp flow allowance of 230 l/c/d (R D Lewis, 1980) and the Provincial Health Branch guideline of 90 l/c/d (for factories with showers). For the 800 MW scheme, the estimated sewage flow for the 300 man operation will be 200 l/c/d. Sewage flows and volumes are given in Table 3.9.

3.3.7 Vehicle Washdown Water

The vehicle washdown area will be located in the Mine Maintenance complex. Since the runoff from the vehicle washdown will be high in dissolved solids, it will be discharged into the leachate system.

In consultation with the B C Hydro Mining Department, it was estimated that 20 to 25 major pieces of euqipment would be in operation at the mine and would have to be cleaned every two to three weeks on the average.

A typical high pressure hot water washer used for cleaning heavy equipment has a capacity of about 2.7 m^3/hr and depending on the season it takes from four to six hours (longer if there is snow and ice buildup) to clean a vehicle. The runoff flows and volumes are given in Table 3-9.

TABLE 3-8

DESIGN FLOWS AND VOLUMES FOR SEEPAGE AND GROUNDWATER

Reference Code	AREA	YEAR 5 Mean Flow $m^3/s \times 10^{-3}$	YEAR 5 Mean Annual Volume $m^3 \times 10^3$	YEAR 15 Mean Flow $m^3/s \times 10^{-3}$	YEAR 15 Mean Annual Volume $m^3 \times 10^3$	YEAR 35 Mean Flow $m^3/s \times 10^{-3}$	YEAR 35 Mean Annual Volume $m^3 \times 10^3$
D13	Dewatering Wells downstream of Diversion Dam	3.1	98	3.1	98	3.1	98
S4	Groundwater seepage from pit surficials	2.7	85	3.0	95	3.4	107
Z4	Groundwater seepage from pit coal and other bedrock	.0075	.2	.021	.7	.17	5
Z8	Houth Meadows Dump Leachate	.12	3.8	.19	6.0	.38	12.3

TABLE 3 - 9

DESIGN FLOWS AND VOLUMES FOR SEWAGE AND VEHICLE WASHDOWN

		YEAR 5		YEAR 15		YEAR 35	
Reference Code	Description	Design Flow m^3/s	Mean Annual Volume $m^3 \times 10^3$	Design Flow m^3/s	Mean Annual Volume $m^3 \times 10^3$	Design Flow m^3/s	Mean Annual Volume $m^3 \times 10^3$
Z5	Vehicle Washdown	0.8	7.3	0.8	7.3	0.8	5.8
Z10	Sanitary Effluent	.005	21.9	.005	21.9	.005	21.9

3.3.8 Evaporation

The Hat Creek area has relatively light rainfall and low humidity which give it a high potential evaporation rate. The mine site is required to have a zero discharge of polluted water from the leachate lagoon hence evaporation plays a major role in disposing of wastewater from the site.

The water is disposed of at a number of areas on the site. Dust control is the largest water user, with discharges onto roads and the coal blending area. There is also direct evaporation from the leachate pond surface and direct losses to the air in the dust control sprays (assumed as 15 percent of the total). In years where there was too much water for dust control, the surface of the Houth Meadows waste dump would be sprayed to evaporate the excess water.

The mean evaporation rate in the area is about 250 mm/year as shown on Figure 3-4. This figure is used as a design value for spray irrigation areas and is increased to 400 mm on areas of high dust potential, such as roads and coal blending areas. The remaining area, the pond surface, is assigned a more conservative evaporation rate of 125 mm/year. The evaporation rates and areas for various stages of mine development are shown in Table 3-10.

TABLE 3-10

EVAPORATIVE DISPOSAL AREAS

Reference Code	AREA	Evaporation Rate mm/yr	YEAR 5		YEAR 15		YEAR 35	
			Area ha	Evaporation Volume $m^3 \times 10^3$	Area ha	Evaporation Volume $m^3 \times 10^3$	Area ha	Evaporation Volume $m^3 \times 10^3$
Z6	**Dust Control**							
	-Roads	400	19.5	78	22.5	90	24.0	96
	-Coal Blending	400	15	60	15	60	15	60
	-Coal Dump Station	400	10	40	10	40	10	40
	-Pond Evaporation	125	9	11	9	11	9	11
	-Other (Spray Loss)			15		15		15
Z7	**Evaporative Disposal**							
	-Houth Meadows Waste Dump (potential Volume shown)	250	105	262	175	437	238	595
Total Potential Evaporation				**466**		**653**		**817**

4. COLLECTION SYSTEMS

4.1 COLLECTION OF DIRECT DISCHARGES TO HAT CREEK

The collection system for runoff from the undisturbed land areas involves a combination of watercourses, channels and pipes. These features use different design criteria, depending on the tributary area (and hence the volume of runoff) involved. Design flows for the areas less than 10 km^2 are based on the 100 year rainfall event, while flows for larger areas are based on the 100 year snowmelt event. This approach, which was used in the mine drainage study for the 2240 MW pit (CMJV, 1979) is inconsistent at the boundary between large and small catchments (10 km) so transition flows were derived. The drainage areas and system layout are shown in Figure 4-1. The system schematic is shown in Figure 4-5, along with the sediment and leachate systems. The disposal of the water is described in Section 5.1.

4.1.1 Land Areas Upstream of Diversion Dam

The runoff from the Hat Creek watershed upstream of the diversion dam located at Finney Creek, would be conveyed around the open pit mine through the Hat Creek pipeline diversion. This major Hat Creek diversion system is described in detail in the Diversion Report (Golder, 1982).

Typical sizing of the open drains for the collection system is given in Table 4-1. The maximum velocities in the drains are mainly determined by the channel slope, and for steeper sections riprap protection would be required to prevent excessive erosion.

Finney Creek would discharge into the main diversion just upstream of the diversion dam. Because of its proximity to the pit boundary, and because the present channel is not well defined in the flat terrain near the existing airstrip, the channel would be realigned slightly to the south of its present location and sized to accommodate the 1000 year flood.

As part of the diversion and dewatering programme for the slide area, described in Section 4.1.4, drainage of Finney Lake is not considered essential at the onset of the project. Monitoring of the slide area during mining should give indications whether to drain Finney Lake at a future date. Some of the runoff from the southern half of the slide area would also be diverted into the Finney Creek watershed.

4.1.2 Pit Perimeter Diverson Drains

The proposed open pit mine would be surrounded by approximately 6 km of open drainage ditches which would intercept small amounts of local surface runoff. Where possible, they will be located adjacent to the perimeter access roads. The drainage ditches will cross under the roads as required through culverts.

The southeast and the southwest perimeter diversion drains will drain south from the high point along the pit rim to the diversion dam of the main Hat Creek Diversion system.

The northeast perimeter diversion drain will drain the northeast sector above the pit. To avoid contamination from mining activities, runoff from the drain will be conveyed in the lower sections by a 0.5 meter diameter pipeline since runoff from the northwest perimeter drain will be high in suspended sediments from the slide area. Slide area drainage is discussed in Section 4.2.

To avoid moving the pit perimeter diverson drains as the pit expands in size, the pit perimeter diversion drains are located on the basis of the 35 year pit rim boundary. Runoff from land areas between the perimeter drains and the expanding pit will be handled by the sediment system described in Section 4.2.

4.1.3 Upper North Valley Diversion Drain

The watershed above the North Valley mine services area will be drained by an 800 m long diversion ditch discharging into the Northeast pit perimeter diversion drain.

TABLE 4 - I

SIZING OF OPEN DRAINS

	SLOPE											
	.002			.005			.01			.05		
Flow m^3/s	b (m)	h (m)		b (m)	h (m)		b (m)	h (m)		b (m)	h	
.5	.8	.45		.8	.39		.8	.30	R	.8	.20	R
1.0	.8	.60		.8	.50	R	.8	.42	R	.8	.27	R
1.5	1.0	.70		1.0	.56	R	1.0	.47	R	1.0	.31	R
2.0	1.4	.73		1.4	.58	R	1.4	.48	R	1.4	.32	R
3.0	1.4	.88	R	1.4	.71	R	1.4	.60	R	1.4	.40	R
5.0	1.6	.98	R	1.6	.78	R	1.6	.66	R	1.6	.43	R

Notes:

b = bottom width of drain

h = depth of flow

R = riprap required

Bank side slope for drains is 2 horizontal : 1 vertical

4.1.4 Slide Area Diversion and Drainage

The area immediately to the west of the open pit has been identified as a slide area and an adequate drainage system must be maintained to ensure slide stability. A smaller portion of this area, immediately above the pit can be classified as an active slide area, while a larger area surrounding and above the active slide area can be classified as a past or potential slide area. The runoff from the surface of the active slide itself will be high in suspended solids and is discussed in Section 4.2.

To assist in the lowering of the ground water table of the area, and to prevent recharge of the ground water system, Aleece Lake and numerous small ponds in the area would be drained. A monitoring programme of the slide area during mining should give indications of whether Finney Lake should also be drained.

To minimize infiltration of surface runoff from the small creeks and watersheds above the slide area, and to provide drainage to the potential slide area, two slide diversion drains and several secondary drains would be constructed. The largest drain, the upper slide diversion drain, starts at elevation 1150 m and follows north, along the stable slope-slide debris contact zone. The upper slide diversion drain is approximately 2 km long and empties into the South Houth perimeter diversion drain. Also at high elevation, will be a short secondary drain flowing south into the Finney Creek watershed.

At lower elevation, draining most of the potential slide area immediately above the active slide, will be the lower slide diversion drain. It will be 2 km long and will travel from approximately the Aleece Lake location, south into the Finney Creek watershed. Several secondary drains would feed into the lower slide diversion drain. The northern section of the potential slide area will be drained by additional secondary drains, emptying into the South Houth perimeter diversion drain. The southwest pit perimeter diversion drain will also assist in the drainage of the slide area.

4.1.5 Houth Meadows Perimeter Diversion Drains

The Houth Meadows waste dump would be surrounded by approximately 6 km of perimeter diversion drains. The largest of these drains would be the West Houth perimeter diversion drain, which would divert the runoff from the large watershed to the west of Houth Meadows dump, and South Houth perimeter diversion drain which would convey the runoff from the upper slide diversion drain in addition to the West Houth perimeter diversion. This drain would discharge into the main Hat Creek diversion via a 0.8 meter diameter pipeline. The smaller North Houth and Northeast Houth perimeter diversion drains would carry runoff from the northern sides of the Houth Meadows dump. They would discharge onto level ground spreaders into the Marble Canyon watershed.

The Houth perimeter diversion drains would be constructed in locations as required for the 35 Year dump boundary. Runoff from the land areas between the perimeter diversion drains and the expanding pit would be handled by the drainage system described in Section 4.2

4.2 SEDIMENT COLLECTION SYSTEM

The collection system for waters directed to the sediment system involves wells, drains and pipes. All of the runoff from disturbed land areas is passed through the sedimentation lagoons as described in Section 5.2. The areas include the maintenance yard, pit surficials, reclaimed waste dump surface, slide area and pit seepage from surficials. The collection systems for each of these areas is described below and shown on Figures 4.2, 4.3 and 4.4..

4.2.1 Pit Surficials

The groundwater seepage and runoff from in-pit surficials includes the area between the pit perimeter drains and the upper level of coal strata. It would be desirable to separate the runoff from the surficials which would be high in suspended solids from the runoff contaminated by coal on lower benches. The practicality of this division would be determined in the final design stage or during mine operation. If a separate drainage system were used, the contact zone between surficials and bedrock would not follow a pit bench exactly, so that some adjustment of the drain system would be needed to ensure that coal leachates would not be collected. The system will have to be adjusted whenever the bench changed during expansion of the pit.

The runoff from the pit surficials would be conducted around the pit in ditches. The benches would be sloped such that the flow would be from the northern part of the pit towards the southern exit of the pit. The ditches would be lined where required, and in some areas a closed conduit may be suitable. With present mine plans a gravity flow system would be adequate and no pumps would be required.

4.2.2 Groundwater Seepage in Surficials

Groundwater seepage entering the pit from the surficials will mainly occur at the contact between the surficials and bedrock. This water will be of sediment water quality or better. Since the surficial bedrock contact may occur on a bench draining into the leachate system, a separate collection system for the groundwater seepage would be desirable. Alternatively, the groundwater seepage could be discharged directly into the pit bench ditches and into the leachate system. The relative costs of each alternative would be examined in the final design stage and the appropriate alternative chosen.

4.2.3 Active Slide Area Drainage

Runoff from the active slide area would be high in suspended sediment and would be directed into the sediment system. With the smaller 800 MW pit size no dewatering wells for the slide area would be required.

The surface flow from the active slide area would be collected by the northwest pit perimeter diversion drain, and a slide area drain located on the active slide material. The flow would then be conveyed through the waste material haul road embankment, connecting to the rest of the sediment system.

4.2.4 Waste Dump Surfaces

The Houth Meadows waste dump surface area can be divided into five areas: unstripped land below the perimeter diversion drains, prestripped land, active waste dump, levelled land and reclaimed land. Although runoff from only some of these areas would be high in suspended solids, to keep the collection system simple all runoff except that from the levelled dump area would be directed into the sediment system. The runoff curve numbers (Figure 3-1) corresponding to the individual surface conditions, were used to determine the total flows.

The Houth Meadows waste dump would be sloped and runoff would be collected by drainage ditches. The active dump itself would not contribute to runoff since it would consist of ridges and furrows. The active area would be subsequently levelled and may contribute significantly to runoff which would be collected separately and conveyed to the leachate system. Because of uncertainties in the final dump design, the sizing and location of the drainage ditches should be incorporated into the final design stage. This is particularly true of the drainage behind the expanding dump because its lower elevation, in relation to the main body of the dump, precludes the use of simple drains to convey the water to the sediment system.

4.2.5 North Valley Services Area

Much of the natural cover of the North Valley Services Area would be disturbed, and all runoff with the exception of that specifically designated as leachate quality, would be directed into the sediment system.

The North Valley Services Area is bounded on the north by the pit, on the south by lower sedimentation lagoons, on the west by Houth Meadows waste dump, and on the east by the coal blending area and the mine maintenance complex. Drains would be placed at various locations to direct the waters into the sedimentation lagoon.

4.3 LEACHATE COLLECTION SYSTEM

4.3.1 Definition

The collection system for flows to the leachate system would involve several different systems. The design criteria are consistent with the other collection systems except that groundwater or seepage flows are taken as constant while surficial runoff would vary both in distribution throughout the year and in total annually. The water collected by these systems must be conveyed to the leachate lagoon for storage and eventual evaporation. The sources of water include runoff from the coal blending area, runoff from coal and rock in the pit, runoff from the levelled waste dump, seepage from the coal exposed in the lower part of the pit vehicle washdown water and leachate from the Houth Meadows Waste Dump. The collection systems are shown on Figures 4-2, 4-3 and 4-4.

4.3.2 Runoff from Coal and Rock in the Pit

Runoff in the lower part of the open pit where coal would be exposed would be collected in bench drains much as in the upper pit area where surficials are present. These drains would also collect groundwater seepage. The drains would lead to the north end of the pit, where the gravity catchment from several levels would be collected in small storage basins for pumping. Several pumps at each collection level would be used (for capacity and security). The flow would join other flows which would be piped to the leachate lagoon.

4.3.3 Runoff from the Coal Blending Area and Coal Dump Area

Runoff from the coal blending and dump areas would consist of natural runoff plus water residual from the dust control sprays. The water would be collected in several drains in the areas located at the edge of the area if the surface is impervious. Depending on the relative elevations of the coal blending area and the leachate lagoon, a pump might be required to direct the runoff from the drains to the discharge.

4.3.4 Runoff from the Levelled Area of the Houth Meadows Waste Dump

This runoff will be collected by ditches, similar to the adjoining areas of the waste dump. The collected water will be pumped over the top of the embankment and carried in a conduit to the leachate lagoon.

4.3.5 Vehicle Washdown Area

The water collected by floor drains in the vehicle washdown area will be carried by a pipe to the outside of the maintenance area where it will join other wastewater flows and be carried by gravity to the leachate lagoon.

4.3.6 Seepage from Houth Meadows

The toe of the embankment defining the eastern edge of the Houth Meadows Waste Dump would be provided with drains and possibly seepage control wells to collect the groundwater emerging from the dump. These flows would be collected and pumped to the leachate lagoon. The wells would serve to collect contaminated groundwater and prevent it from flowing towards Hat Creek.

4.4. SEWAGE

Sewage collection would be by conventional means to gather the effluent from the facilities associated with the mine maintenance area. The environmental services building location has not been decided yet but its contribution would be small and it would likely be located away from the maintenance area and served by a small sewage disposal system. The location of the sewage treatment facility has not been fixed, but once the effluent has been collected from the maintenance area a single pipe would convey the flow and there would be few conflicts in routing the pipe to any of the potential treatment sites.

5. DISPOSAL SYSTEMS

5.1 DIRECT DISCHARGES TO HAT CREEK

There are no quality control constraints with direct discharges, as by definition only water of an acceptable quality could be discharged to Hat Creek. Complications in design arise because for most of its length in the pit area, Hat Creek would be directed in a pipeline (Golder Associates, 1982). Only when it is downstream of the sedimentation lagoon would the Creek return to an open channel, making simple discharges possible. Energy dissipation would only be required where large flows were discharged to unprotected sections of Hat Creek.

There are a limited number of locations where it would be feasible to discharge runoff water directly to Hat Creek. The southern half of the pit would have its perimeter drains flowing towards the south, where the water could enter the diversion intake pond upstream of the diversion dam. Water collected in the northern half of the pit perimeter would be directed to the north, where it would be close to the Hat Creek Diversion, so that it would be feasible to return the direct runoff flows back to the system by means of a junction. Further downstream, tributary flows from the North Valley services area would originate from disturbed land areas and these flows would be directed to the sedimentation lagoons.

5.2 SEDIMENTATION LAGOON

5.2.1 General

The sedimentation lagoon accepts water from disturbed land areas as outlined in Section 4.2. The purpose of the lagoon is to settle out suspended solids from the incoming water and release the water after a suitable detention time so that it has less than 25 to 75 mg/l of nonfilterable residue to meet the Waste Management Branch objective.

5.2.2 Design

In order to establish the settlement rate and hence the lagoon size, a number of column settling tests were performed on a variety of samples from the Hat Creek area. These are shown in Tables 5.1, 5.2 and 5.3, duplicated from the drainage study for the 2240 MW Scheme (CMJV, 1979). The test results indicate that long settling times are required if the use of coagulant (aluminum sulfate) is to be avoided. As indicated in the tables, the use of coagulant greatly speeds the settling time.

The critical settling velocity was selected as 9 cm/hr (2.5×10^{-5} m/s) to meet the guidelines and provide additional detention time for the fraction of the runoff which should have gone to the leachate lagoon. (CMJV, 1979).

The sedimentation lagoons are sized on the basis of the critical settling velocity and the design inflow rate. For the 800 MW Scheme, the design inflow rate is equivalent to the 10 year 24 hour mean runoff of 0.88 m^3/s while the settling velocity of 2.5×10^{-5} m/s is used. The following formula is used as the basis of design:

$$\textbf{Lagoon Area} = \frac{\textbf{Flow rate} \times \textbf{1.2}}{\textbf{Settling Velocity}}$$

The factor of 1.2 accounts for nonuniform settling rates (Waste Management Branch 1980). The calculated lagoon area is then 4.2 ha. In actual practice, there are typically 2 types of lagoons provided; the first type of lagoon (primary) is for flow regulation and settling of the course fraction of sediment, while the secondary lagoon is for settling of finer suspended solids. In the previous study, two secondary lagoons were used with a total area of 4.5 ha while the primary lagoon area was 2.5 ha. For the design of the 800 MW Scheme, the required area of the primary lagoon is taken as 2.1 ha while the required area of the secondary lagoons is 2.1 ha each. Actual areas are slightly larger. Inflows to

TABLE 5 - 1

COLUMN SETTLING TESTS IN 2 - 1 GRADUATE CYLINDERS WITHOUT FLOCCULANT

Material	Time (hr)	Suspended Solids (mg/L) 0 cm	11 cm depth	28.5 cm	Particle Size (%) Clay + Silt (sample)*	Sand	pH
Glaciofluvial sand/gravel	0.25	188	404	428	2	98	7.4
	4.5	120	132	132			
	24	76	56	60			
Glacial till	0.25	2,600	5,643	5,893	19	81	8.1
	4.5	510	1,980	2,670			
	24	45	1,040	1,360			
Slide Debris	0.25	5,798	10,040	11,218	36	64	8.2
	4.5	560	2,760	4,130			
	24	60	65	70			
Waste (1)	0.25	10,000	15,000	16,640	2	98	8.5
	4.5	840	9,480	10,160			
	24	133	5,800	7,020			
Waste (2)	0.25	12,500	17,080	19,160	6	94	8.3
	4.5	2,410	9,400	10,960			
	24	120	5,400	6,920			
Low-grade coal	0.25	13,280	17,080	19,060	N/A	N/A	6.9
	4.5	1,680	9,860	11,789			
	24	90	6,040	8,100			
Composite	0.25	7,700	10,820	12,260	N/A	N/A	8.1
	4.5	2,060	5,980	7,040			
	24	53	3,200	4,340			

<u>NOTE:</u> 50 g of original solids (coarse plus fine) per litre distilled water

* B C Research (1978) Golder (1978)

(1) Golder Sample

(2) Acres Sample

TABLE 5 - 2

COLUMN SETTLING TESTS IN 15 CM X 180 CM CYLINDERS
WITH ALUMINUM SULPHATE

Material	Time (hr)	Suspended Solids (mg/L)	Turbidity NTU	Interface Depth (cm)	Sample Depth (cm)
Glacial till	0.3	44	21.0	61	48
	0.6	19	7.5	81	48
Slide debris	0.3	144	48.0	43	20
	0.6	68	29.0	67	36
	1.6	42	21.0	78	65
Waste (1)	0.9	105	32.0	8	6
	2.5	66	23.0	22	20
	5.3	5	3.2	48	37
	6.7	4	2.2	53	52
Waste (2)	0.7	28	11.0	7	5
	4.1	2	2.5	38	20
	4.2	21	7.5	38	36
	21.4	25	8.2	69	52
Low grade coal	0.6	11	7.2	85	
	1.9	21	8.8	24	20
	4.7	8	5.2	51	36
	6.2	2	2.4	59	51
Composite	0.3	20	16.0	9	7
	0.9	9	6.5	28	22
	1.8	7	4.5	47	36
	3.7	3	4.2	67	53
	5.1	5	2.8	70	66

(1) Golder (2) Acres

NOTE: Alum dosages are described in Table 3-13.

Source: B C Research (1978)

TABLE 5 - 3

COLUMN SETTLING TESTS IN 15 CM X 180 CM CYLINDERS

WITH ALUMINUM SULPHATE (ALUM)

	Alum Dosage mg/L	Free Interface Settling Rate cm/hr	Time to Achieve Suspended Solids 50 mg/L at 50 cm depth hours	SO_4 mg/L
Glacial till	100	253	1	74
Slide debris	120	143	2	138
Composite waste	206	30	4	106
Low grade coal	125	12	6	171
Waste (1)	206	9	6	152
Waste (2)	206	9	21	178

(1) Golder (2)Acres

Source: B C Research (1978)

the lagoons are shown on Tables 5-4, 5-5, and 5-6 based on flow figures established earlier in this report. The flows change little throughout the mine development period, so the lagoon is built to its ultimate capacity in Year 1.

5.2.3. Construction

The sedimentation lagoons are located in the valley bottom just north of the leachate lagoons described in Section 5.3. They would be constructed of a compacted fill core with a sand and gravel outer shell. Lining of the lagoon would be required if the underlying soils were found to be too pervious.

The primary lagoon dam would be built with an upstream crest in common with the leachate lagoon dam. The downstream crest would be common with the secondary sediment lagoons and the sides would be raised above the valley bottom where required. The secondary lagoons, because the valley elevation continues to fall, would be built above the valley bottom. The plan of the lagoons is shown in Figures 4.2 through 4.4, showing a primary lagoon 150 m x 150 m x 5 m and secondary lagoons 70 m x 325 m x 2.5 m.

The control structures would be similar to those proposed for the 2240 MW Scheme, with an inlet manifold feeding the primary lagoon, 2 outlets feeding the secondary lagoons and overflow outlets from the secondary lagoons. The lagoon outlets would be sized for the 1000 year flood, although the lagoons themselves are sized for detaining the 10 year flood. Extreme floods will pass through the lagoons with little detention. The combined secondary lagoon volumes would total 115,000 m^3 to provide a 36 hour average detention time. During peak storms, pH and coagulant facilities would have to be used to adjust for higher sediment loads and shorter detention times.

5.2.4 Hydrographs

The design flow hydrograph for the lagoon system is shown in Figure 5.1. The inflow is based on a simulated 24 hour, 10 year storm, peaking linearly after

TABLE 5 - 4

ESTIMATED SEDIMENTATION LAGOON INFLOW

YEAR 5

Ref Code	Source	Area (ha)	Runoff Curve CN	Mean Annual Runoff mm	Mean Annual Runoff $m^3 x 10^3$	10 Yr 24 Hr Runoff $m^3 x 10^3$
S1	Houth Meadows Waste Dump					
	Unstripped land below diversion drains	190	70	50	95	2.6
	Prestripped land	10	90	50	95	1.5
	Active Waste Dump	25	-	50	0	0
	Reclaimed Dump	0	80	50	0	0
S2	Slide Area Runoff	120	65	50	60	10.2
S3	Runoff from Pit Surficials	180	90	80	144	27
S4	Ground Water Seepage from Pit Surficials	N/A	N/A	N/A	85	0.2
S5	North Valley Services Area					
	Buildings, Pavement	20	98	50	10	5.8
	Open Area	190	80	50	95	11.0
				Total	584	58.3

NOTE: Runoff Curve Numbers should be updated in the early stages of mine development.

TABLE 5 - 5

ESTIMATED SEDIMENTATION LAGOON INFLOW

YEAR 15

Ref Code	Source	Area (ha)	Runoff Curve CN	Mean Annual Runoff mm	Mean Annual Runoff $m^3 x 10^3$	10 Yr 24 Hr Runoff $m^3 x 10^3$
S1	**Houth Meadows Waste Dump**					
	Unstripped land below diversion drains	113	70	50	56	1.6
	Prestripped land	17	90	50	8	2.5
	Active Waste Dump	25	-	50	0	0
	Reclaimed Dump	0	80	50	0	0
S2	**Slide Area Runoff**	120	65	50	60	10.2
S3	**Runoff from Pit Surficials**	120	90	80	96	18
S4	**Ground Water Seepage from Pit Surficials**	N/A	N/A	N/A	95	0.3
S5	**North Valley Services Area**					
	Buildings, Pavement	20	98	50	10	5.8
	Open Area	190	80	50	95	11.0
				Total	**420**	**49.0**

NOTE: **Runoff Curve Numbers should be updated in the early stages of mine development.**

TABLE 5 - 6

ESTIMATED SEDIMENTATION LAGOON INFLOW

YEAR 35

Ref Code	Source	Area (ha)	Runoff Curve CN	Mean Annual Runoff mm	Mean Annual Runoff $m^3 x 10^3$	10 Yr 24 Hr Runoff $m^3 \times 10^3$
S1	**Houth Meadows Waste Dump**					
	Unstripped land below diversion drains	67	70	50	33	0.9
	Prestripped land	0	90	50	0	0
	Active Waste Dump	25	-	50	0	0
	Reclaimed Dump	130	80	50	65	7.5
S2	**Slide Area Runoff**	120	65	50	60	10.2
S3	**Runoff from Pit Surficials**	110	90	80	88	16.5
S4	**Ground Water Seepage from Pit Surficials**	N/A	N/A	N/A	107	0.3
S5	**North Valley Services Area**					
	Buildings, Pavement	20	98	50	10	5.8
	Open Area	190	80	50	95	11.0
				Total	**458**	**52.2**

NOTE: Runoff Curve Numbers should be updated in the early stages of mine development.

3 hours. The resulting outflow hydrograph is based on the lagoon characteristics. The primary lagoon is allowed to fluctuate 4 m at the design 1000 year outflow, while the secondary lagoon is allowed to fluctuate 2 m.

In Figure 5.1 the effects of controlling the discharge of the primary pond are shown. With an available variable storage depth of 4 m, it would be possible to store much of the peak flow within the primary lagoon. The examples shown give the range between the situations of:

1) No flow control - all flow goes through emergency spillway, which is sized to pass the 1000 year flood at 4 m head.

2) Decant towers control flow such that the 10 year peak runoff (from Figure 3-1 : 5.2 m^3/s) is passed when the pond is at 4 m head.

The secondary lagoons would receive the water from the primary lagoon and route it through the spillway with little modification, because the hydrograph was based on a discharge curve of a broad crested weir passing the 1000 year flood at a head of 2 metres. Additional storage could be provided by using a compound weir section, but this detail would be left to final design.

The mean annual discharge hydrograph is shown on Figure 5-2. This is based on the variable inflow from surface runoff and the nearly constant supply from the groundwater collection systems. The surface water inflow is based on the annual runoff of the spring thaw as being between 50 and 80 mm, depending on surface conditions. It is expected that about 20 percent of this runoff would occur in March, 70 percent in April and 10 percent in May. After April, most of the snow would be gone from the lower valley, although the flood peak of Hat Creek would not occur until early June. Surface runoff is expected to be negligible in the average summer and winter, but 10 percent runoff from the mixed rain and snow of October and November has been allowed.

5.2.5 Water Quality

The water quality of the discharge has been estimated by Beak Consultants using Table 3-1 and the flow data. Three situations have been analyzed to provide a range of typical effluent types, as shown in Tables 5-7, 5-8 and 5-9 and discussed below.

Table 5-7 - Dry Weather - Case I

This table describes the quality parameters when Hat Creek flows are at a minimum and the lagoon flow is steady from groundwater. There would be a marginal increase in most water quality parameters in Hat Creek after mixing of the sedimentation lagoon effluent, but the effluent meets all Waste Management Branch Guidelines.

Table 5-8 - Spring Runoff - Case II

This table describes the water quality parameters when the sedimentation lagoon flow is dominated by collected surface runoff in April. Hat Creek itself would be rising, but below its peak. An increase in all parameters, but within the guidelines, could be expected.

Table 5-9 - Summer Rainstorm - Case III

This table describes the parameters when a localized storm affects the mine area but not the rest of Hat Creek Valley. High surface runoffs can be expected, discharging into relatively low Hat Creek flows. Most parameters would be elevated in concentration, especially iron and copper, but would remain within the discharge guidelines. However, there is a possibility that copper would exceed the upper limit of the guidelines range.

Conclusion

It is concluded that the sedimentation lagoon discharge will not alter the background levels of Hat Creek sufficiently to raise any parameter, including toxic chemicals, above the Effluent Discharge Guidelines for the Mining Industry (BC Ministry of Environment, 1979).

TABLE 5 - 7

PROJECTED QUALITY OF LAGOON DISCHARGE AND HAT CREEK - CASE I*

Parameter (mg/l)	Projected North Lagoon Effluent	Existing Hat Creek	Projected Hat Creek
pH (units)	7.9	8.4	8.4
Filterable Residue	350	342	342
Non-Filterable Residue	**50	6	7
TOC	21	9	9.3
Total Hardness (as $CaCO_3$)	214	224	224
Alkalinity (as $CaCO_3$)	270	226	227
Chloride	3	1.1	1.2
Fluoride	0.2	0.16	0.16
Total Nitrogen (N)	< 0.4	0.24	< 0.24
Phosphorous (P)	< 0.03	0.043	< 0.043
Sulfate	52	54	54
Arsenic	< 0.005	< 0.005	< 0.005
Boron	< 0.10	< 0.10	< 0.10
Cadmium	< 0.005	< 0.005	< 0.005
Calcium (as $CaCO_3$)	148	143	143
Chromium	< 0.01	< 0.10	< 0.01
Copper	< 0.005	< 0.005	< 0.005
Iron	< 0.025	< 0.026	< 0.026
Lead	< 0.010	0.010	< 0.010
Magnesium (as $CaCO_3$)	66	77	77
Mercury	< 0.0003	< 0.0004	< 0.004
Sodium	39	20	21
Vanadium	< 0.005	< 0.005	< 0.005
Zinc	< 0.03	< 0.007	< 0.008

* Dry Weather Condition (Year 35). The only discharge to Hat Creek via the sedimentation lagoons is the groundwater flows from the pit surficials. Hat Creek discharge was assumed to be 0.12 m^3/s.

** The non-filterable residue level of the WMB Guidelines is given as a range of 25 - 75 mg/l. Therefore it has been assumed that the middle of the range (50 mg/l) will be attained by the lagoons performance.

(Source Beak)

TABLE 5 - 8

PROJECTED QUALITY OF LAGOON DISCHARGE AND HAT CREEK - CASE II*

Parameter (mg/l)	Projected North Lagoon Effluent	Existing Hat Creek	Projected Hat Creek
pH (units)	8.3	8.4	8.4
Filterable Residue	487	342	367
Non-Filterable Residue	**50	12	19
TOC	15	9	10
Total Hardness (as $CaCO_3$)	223	224	224
Alkalinity (as $CaCO_3$)	233	226	227
Chloride	6	1.1	2.0
Fluoride	0.15	0.16	0.16
Total Nitrogen (N)	< 0.8	0.24	< 0.34
Phosphorous (P)	< 0.07	0.043	< 0.048
Sulfate	74	54	58
Arsenic	< 0.013	< 0.005	< 0.006
Boron	< 0.10	< 0.10	< 0.10
Cadmium	< 0.005	< 0.005	< 0.005
Calcium (as $CaCO_3$)	138	143	142
Chromium	< 0.024	< 0.010	< 0.012
Copper	< 0.186	< 0.005	< 0.037
Iron	< 0.174	< 0.026	< 0.052
Lead	< 0.01	< 0.010	< 0.01
Magnesium (as $CaCO_3$)	81	77	78
Mercury	< 0.0005	< 0.0004	< 0.0004
Sodium	27	20	21
Vanadium	< 0.006	< 0.005	< 0.005
Zinc	< 0.026	< 0.007	< 0.010

* Spring Runoff Condition (Year 35). Discharges to Hat Creek via the sedimentation lagoon include prorated mean surface runoffs and groundwater flows. Hat Creek discharge was assumed to be 0.48 m^3/sec.

** The non-filterable residue level of the WMB Guidelines is given as a range of 25 - 75 mg/l. Therefore it has been assumed that the middle of the range (50 mg/l) will be attained by the lagoons performance.

(Source Beak)

TABLE 5 - 9

PROJECTED QUALITY OF LAGOON DISCHARGE AND HAT CREEK - CASE III*

Parameter (mg/l)	Projected North Lagoon Effluent	Existing Hat Creek	Projected Hat Creek
pH (units)	8.3	8.4	8.4
Filterable Residue	579	342	418
Non-Filterable Residue	**50	95	81
TOC	19	9	12
Total Hardness (as $CaCO_3$)	222	224	223
Alkalinity (as $CaCO_3$)	200	226	218
Chloride	7.0	1.1	3.0
Fluoride	0.14	0.16	0.15
Total Nitrogen (N)	< 1.20	0.24	< 0.55
Phosphorous (P)	< 0.10	0.043	< 0.06
Sulfate	91	54	66
Arsenic	< 0.020	< 0.005	< 0.010
Boron	< 0.09	< 0.10	< 0.10
Cadmium	< 0.004	< 0.005	< 0.005
Calcium (as $CaCO_3$)	133	143	140
Chromium	< 0.036	< 0.010	< 0.018
Copper	< 0.34	< 0.005	< 0.112
Iron	< 0.30	< 0.026	< 0.11
Lead	< 0.01	< 0.010	< 0.01
Magnesium (as $CaCO_3$)	86	77	80
Mercury	< 0.0006	< 0.0004	< 0.0005
Sodium	31	20	24
Vanadium	< 0.006	< 0.005	< 0.005
Zinc	< 0.041	< 0.007	< 0.02

* <u>Summer Rainstorm Condition (Year 35)</u>. Discharges to Hat Creek via sedimentation ponds include surface runoff caused by a 10 year return period, 24 hour rainfall of 35 mm and ground water flows from pit surficials. Hat Creek discharge was assumed to be 1.68 m^3/sec. The projected outflow hydrographs are shown on Figure 5-1.

** The non-filterable residue level of the WMB Guidelines is given as a range of 25 - 75 mg/l. Therefore it has been assumed that the middle of the range (50 mg/l) will be attained by the lagoons performance.

(Source Beak)

5.2.6 Operation

Operation of the sedimentation lagoons would require attention to ensure that the control works remained clear and that the water quality of the discharge was maintained. Addition of coagulant might be required as well as pH control, and these factors could change on a daily basis. Routine structure checks would need to be made on the lagoon embankments and control works.

The most uncertain part of the lagoon operation would be the sediment removal frequency. Previous studies for coal mining operations (EPA, 1976; Steele, 1976; James, 1977) give a wide range of values for the sediment carried by runoff. Variations would exist with the rainfall of the site, surface condition (road, waste dump etc), slope and geology. In the drainage study for the 2240 MW Scheme (CMJV, 1979) a value of 17 tonnes/km^2/year was given as the residual sediment load (after sedimentation) for the entire mine development. At an 80 percent removal efficiency, four times this value would be retained in the settling ponds. However 17 tonnes/km ^{2}/year at an average 50 mm annual runoff produces a concentration of 340 mg/l suspended solids which exceeds the guidelines. Accordingly 100 percent removal will be assumed, so that sediment accumulations will amount to 272 m^3/year from the 7.7 km^2 of mine area. (Sediment density assumed at 2.4 tonnes/m^3).

If the predicted sediment accumulation rate was not exceeded, a total of 9500 m^3 would be stored by the end of Year 35, to an average depth of 0.14 m in the ponds. This amount of sediment would be easily retained, however experience at other mine sites would suggest much higher accumulations. Until the rates of sediment accumulation can be verified, provision should be made to clean out the sedimentation lagoons at intervals of about 1 - 2 years.

5.3 LEACHATE LAGOON

5.3.1 General

The leachate lagoon is the intermediate element of the zero discharge system, holding water high in dissolved solids until it could be disposed of by evaporation at the mine site. Water sources to the lagoon include in-pit coal and rock leachate, Houth Meadows Waste Dump leachate, coal blending area runoff, coal dump station runoff, levelled waste dump runoff, vehicle washdown water and sewage effluent. The water collection systems are described in Section 4.3.

The leachate lagoon would be located roughly midway between the north pit rim, the maintenance area, the Houth embankment and Highway 12. The Hat Creek diversion would pass just above the leachate lagoon level on the east side, as described in the Hat Creek Diverson Study (Golder Associates, 1982).

5.3.2 Design

Unlike the proposal in the previous drainage study, (CMJV, 1979), the leachate lagoon would be constructed to its ultimate capacity at the start of the project. In the early years, the pit and waste dumps would be relatively small, hence the flow to the lagoon and the required lagoon storage would be small. However by Year 5 a significant amount of the pit surface is coal and the runoff could be appreciable. The total leachate flow would only increase by 35 percent from Year 5 to Year 35.

The governing criteria for lagoon sizing is the required storage which would be necessary because the peak runoff precedes the peak demand for water by the dust control system. The value of the storage in year 35 is determined from the hydrographs on Figure 5-3. These hydrographs present the mean and "extreme" monthly flows as determined for the system on Table 3-7. It is assumed that the groundwater flow is constant, but that flow originating from surface areas varies with the seasons. Mean runoffs of 80 mm are assumed to be distributed with 20 percent of the flow in March, 70 percent in April and 10 percent in May to correspond with the lower valley snowmelt pattern. A further 10 percent of the mixed rain and snow falling in October and November is assumed to run off based on the range of previously established runoff coefficients (Beak 1978).

5.3.3 Hydrographs

The hydrograph analysis results in a peak storage volume of 361,000 m^3 in Year 5, 490,000 m^3 in Year 15 and 458,000 m^3 in Year 35. The increase in storage is only 35 percent from Year 5 to Year 15, hence it is suggested that the lagoon be built to its maximum expected capacity at the start of the project. There is some uncertainty in the flows at the present stage of development, so a possible increase in capacity should be provided for.

Table 5-10 also indicates that in Year 5, with 20% below normal rainfall, there could be a deficit for dust control activities. This amount could be made up by adding water from the sedimentation lagoon. In Year 5 with an extreme flow, up to 261,000 m^3 of excess water would be sprayed on the Houth Meadows waste dump, representing an average land use of 104 ha. The land use would range from 38 ha to 147 ha for the mean and extreme flows of Year 35.

5.3.4 Construction

The lagoon would be constructed partially by excavation and partially of embankment construction. Side slopes in cut and fill would be at 3 horizontal to 1 vertical. To minimize leakage, the entire pond would be lined with an impervious membrane; potential seepage would be monitored. The initial size would be 300 m x 300 m x 5 m deep, with a provision for expansion in depth to 10 m. A freeboard of 2 m would be provided.

There are several safety features inherent in the system. The pond itself is oversized and capable of expansion. Much of the inflow results from pumped water from the lower levels of the pit; a limited amount of excess runoff could therefore be stored within the pit. Finally there is provision for an emergency overflow spillway which would return water to the pit for storage and eventual pumping. The desirability and practicability of this feature would need to be assessed during the early phases of operation when the designs and hydrological data have been refined.

5.3.5 Disposal System

Disposal of the leachate would be by evaporation during the months of May through September. The disposal areas and amounts of water used in this way have been shown in Table 3-9. A water balance for the leachate system is shown in Table 5-10. The water for dust control would be piped to the coal blending area, but disposal of water for dust control on mine roads would be by truck. Several small reservoirs and filling stations would be required. The water for spray evaporation would be piped to Houth Meadows, but the system might not need to be installed in the early years as there would be insufficient water available, except in extreme inflow years. The distribution of evaporative flows is based on monthly potential evapotranspiration calculated by Environment Canada. The pump capacity for the lagoon discharge would be based on three times the maximum monthly outflow, and would be increased from 140 l/s in Year 5 to about 180 l/s in Year 15.

5.3.6 Operation

Maintenance of the system would be relatively simple involving annual inspection of the lining and routine pump overhaul. Sediment removal might be required every few years as the annual sediment load from active surface areas could be excessive, depending on the erosion rate. The only potential conflict in the system would arise when spray evaporation was required at the waste dump. Water should be kept away from the waste placement operation, but considering the size of the dump area and the seasonal nature of spray evaporation, it is considered that there is sufficient space to separate these activities.

5.4 SEWAGE

Sewage wastes in the pit area include the effluent from the mine maintenance area, but the effluent from the power plant itself and other smaller facilities would be treated separately and are not included here. In previous studies there have been different recommendations for the sewage disposal system. The first study (CMJV 1979) recommended that the effluent be treated in a sewage treatment plant prior to discharge to the leachate lagoon and eventual use in

TABLE 5 - 10

ANNUAL WATER BALANCE FOR LEACHATE SYSTEM

Reference Code		YEAR 5 $m^3 \times 10^3$		YEAR 15 $m^3 \times 10^3$		YEAR 35 $m^3 \times 10^3$	
		Mean	Extreme	Mean	Extreme	Mean	Extreme
	Inflow						
Z1	Coal Blending Area	12.0	24.0	12.0	24.0	12.0	24.0
Z2	Coal Dump Station	8.0	16.0	8.0	16.0	8.0	16.0
Z3	Runoff from Pit coal and other leachate	144	288	192	384	200	400
Z4	Groundwater Seepage from pit coal and other bedrock	0.2	0.2	0.7	0.7	5.4	5.4
Z5	Vehicle Washdown Water	7.3	7.3	7.3	7.3	5.8	5.8
Z8	Houth Meadows Waste Dump leachate	3.8	3.8	6.0	6.0	12.3	12.3
Z9	Houth Meadows Levelled Waste Runoff	52	104	87	174	54	108
Z10	Sanitary Effluent	22	22	22	22	22	22
	TOTAL	**249**	**465**	**335**	**634**	**319.5**	**593.5**
	Outflow						
Z6	**Dust Control**						
	Roads	78	78	90	90	96	96
	Coal Blending Area	60	60	60	60	60	60
	Coal Dump Station	40	40	40	40	40	40
	Net Pond Loss	11	11	11	11	11	11
	Other (Spray Loss)	15	15	15	15	15	15
Z7	**Spray Evaporation**						
	Houth Meadows (Required Volume)	45	261	119	418	97.5	371.5
	Houth Meadows (Potential Volume)	262	262	437	437	595	595
	TOTAL	**466**	**466**	**653**	**653**	**817**	**817**

NOTE: **Extreme flows based on 2 x mean annual flow. All flows to be confirmed following field investigation.**

dust control. The second study (R D Lewis, 1980) recommended treatment in a facultative lagoon followed by discharge to the leachate lagoon. Chlorination of the combined effluent prior to road discharge for dust control as well as screening of the spray irrigation area (waste dump) were also advised in the Lewis study.

In reviewing the sewage disposal options another system is also considered to be feasible, that of using the lagoon and exfiltration basins proposed for the construction camp on a permanent basis. Mine operations would produce much less effluent than the construction camp system was designed for, hence the effluent could be easily treated. The remoteness of the site from the mine maintenance area would mean about 1.5 km of pumped discharge line would be required.

The sewage treatment system recommended in this report is similar to the second scheme proposed (R D Lewis 1980). The effluent from the mine maintenance area could be treated in a facultative lagoon with provision for aeration. A lagoon size of 630 m^3 could be provided to ensure 7 day retention and 2 days of reserve storage at a depth of 5 - 6 m. Aeration would be added if odours became a problem. From the treatment lagoon, the effluent would pass through a chlorination tank to provide 30 minutes of contact time and a 1 mg/l chlorine residual prior to discharge to the leachate lagoon. Storage in the leachate lagoon would be at least 3 months before the effluent was used for dust control. Testing of the leachate, prior to disposal in the early stages of the mine (when the sewage component would be at its highest fraction) could determine if further treatment was necessary.

5.5 ABANDONMENT

This section briefly describes the status of the waste water disposal systems after the projected 35 year mine life. There are two possible scenarios:

- the mine would be kept in operation after year 35 by expanding the pit; or
- the mine site would be totally abandoned.

In the case of continued mine operation new sources of coal would be required. One option would be to expand the 800 MW pit towards the size of the proposed 2240 MW pit or even to exploit the total resource. If this were done sediment and leachate flows would increase, requiring expansion of the sedimentation and leachate systems to the sizes proposed for the 2240 MW scheme and beyond.

A second mining option could be to develop the No 2 Deposit south of Pit No 1. Waste rock could be disposed in Pit No 1 thus precluding further development of the pit, or a separate disposal area could be constructed. If Pit No 1 were filled in, the need for the disposal systems would gradually diminish. If a new waste dump were constructed, separate wastewater disposal systems would need to be constructed and the effect on the existing system would be the same as total abandonment, described below.

If the mine site were totally abandoned, the various disposal systems could remain intact. The diversion system and perimeter drainage systems should continue to operate if they received routine maintenance.

The sediment system could continue to operate. Much of the gravity flow into it would remain unchanged, except that reclamation of the waste dump would result in cleaner water.

The leachate system would be left with few sources of water. All of the inputs to the leachate system which did not require pumping would be reclaimed, while the pumped water inputs would cease when pumping ceases. The sewage flow into the lagoon would also be eliminated.

The components of the flow to the leachate and sedimentation systems which were pumped from the lower pit would no longer be a part of any treatment system, but ground water seepage would continue to infiltrate into the lower pit, and runoff would continue to accumulate. The runoff and seepage would continue to fill the pit until a balance is made with the annual evaporation, or the pit fills to overflowing and returns water to the original Hat Creek channel.

6. IMPLEMENTATION

6.1 STAGES OF MINE DEVELOPMENT

The Hat Creek 800 MW Scheme involves the development of the open pit gradually over 35 years. Most of the development above elevation 900 m on the east side of the pit would be completed by Year 10, when the pipeline diversion arrangement would be in its final location (Golder Associates, 1982). Below elevation 900 m, and on the west side, excavation would continue through Year 35 and pit benches would continue to move.

The Houth Meadows waste dump would be developed slowly in this more limited scheme so that runoffs and seepages would increase yearly. Other mine facilities, with the possible exception of the leachate and sedimentation lagoons, would attain their final configuration in the early stages of operation, so that their respective drainage facilities will remain fixed.

6.2 STAGES OF DRAINAGE SYSTEM DEVELOPMENT

Portions of the mine drainage system must be established early in the project life, as there is sediment laden water to collect as soon as any excavation proceeds. It might be necessary to install some dewatering wells around the east pit perimeter prior to excavation, to reduce excess pore pressure. There is also perimeter drainage to intercept to prevent excess runoff into the excavation. Most other drainage systems would have to be established before coal mining began.

The following facilities would have to be constructed at each stage of development:

1. Preliminary Development

   - Major tributary creek diversions
   - Hat Creek Diversion

- Pit Perimeter Diversion Drains
- Leachate Lagoon
- Mine Maintenance sewage treatment
- Sedimentation lagoons
- Pit Slope Drains and Dewatering (First Stage)
- Dust control for roads

2. Prior to coal being mined and stored, and shortly after the waste dump is used:

   - Leachate collection drains (First Stage)
   - Coal blending drains
   - Houth Meadows waste dump runoff drains

3. During mining:

   - Relocation and lengthening of pit bench drains
   - Groundwater drain development
   - Pit pumping system expansion and possible relocation

Of the various drainage systems used, the ones involving pit slope drains for leachate and sediment quality water would require the most careful planning and design, because they would be part of a movable system which would change continuously as excavation proceeds. The design parameters also require verification in some cases.

6.3 MONITORING

Much of the drainage design information in this report and in previous reports is based on the Hat Creek Regional hydrology and on preliminary estimates of runoff and sediment yields from other mining operations, not necessarily similar to Hat Creek. It is felt that the regional hydrologic information for Hat Creek is adequate for preliminary design, but the smaller basins would require more on site information.

In the pre-development stage, several monitoring programmes should be maintained. To assist in obtaining adequate peak discharge values to size the collection systems, intensity duration frequency (IDF) curves would be required. Rainfall intensity measuring equipment should therefore be maintained in the Hat Creek valley.

To expand the data base it is recommended that stream flow monitoring continue, as well as additional hydrologic measurements from small low level basins. Information would include mean flows, peak flows, monthly flow distribution and snowpack. This would assist in design of the collection systems and sizing of the lagoons.

In the pre-development years, it would also be desirable to obtain some peak runoff figures from pit benches similar to those at Hat Creek. Also desirable would be improved values for sediment yield.

During mine development several monitoring programmes should continue. Particularly groundwater flows should be monitored carefully and compared to the capacity of the zero discharge leachate system. The slide area would be monitored to see if additional stablization measures are required, such as the drainage of Finney Lake.

Stream flow and rainfall information should continue to be collected to be used in drainage design as the pit expands.

We thank you for the opportunity of carrying out this interesting study.

Yours truly
GOLDER ASSOCIATES

G. E. Rawlings

G E RAWLINGS, P ENG

7. REFERENCES

BEAK CONSULTANTS LIMITED, 1978, **Hat Creek Project** Water Resources Subgroup - Hydrology, Drainage, Water Quality and Use, Volume 2, Inventory Report - Final Report, June 1978.

BEAK CONSULTANTS LIMITED, 1978, **Hat Creek Project** Detailed Water Quality and Use, Volume 3, Impact Assessment - Final Report June 1978.

BEAK CONSULTANTS LIMITED, 1979, **Hat Creek Project** Detailed Environmental Studies, Water Resources Subgroup - Hydrology, Drainage Water Quality and Use, Volume 3A, Impact Assessment of the Revised Project, July 1979.

BEAK CONSULTANTS LIMITED, 1979, **Hat Creek Project** Detailed Environmental Studies, Water Resources Subgroup - Hydrology, Drainage Water Quality and Use, Volume 3B, Impact Assessment of the Revised Project, Flue Gas Desulphurization Option, May 1981.

B C HYDRO AND POWER AUTHORITY, 1978, **Hat Creek Project**, Diversion of Hat and Finney Creeks, Preliminary Design Report, Hydroelectric Design Division, Report No 913, March 1978.

B C HYDRO AND POWER AUTHORITY, 1979, **Hat Creek Project**, Mining Report, 2 Volumes, Mining Department - Thermal Division, December, 1979.

B C HYDRO AND POWER AUTHORITY, 1982, **Hat Creek Project**, Report on 1981 Site Investigations for Hat and Finney Creek Diversion and Access Road, Hydroelectric Generation Projects Division, Report No H1478, March 1982.

B C HYDRO AND POWER AUTHORITY, 1980, **Hat Creek Project**, Station Design Manual, Diversion of Hat and Finney Creeks, Hydroelectric Design Division, February 1980.

B C MINISTRY OF ENVIRONMENT, 1980, **Guidelines for the Design and Operation of Settling Ponds used for Sediment Control in Mining Operations**, Preliminary Draft, Victoria, B C

B C MINISTRY OF THE ENVIRONMENT, 1979, **Pollution Control Objectives for The Mining, Smelting and Related Industries of British Columbia,** Pollution Control Board, Victoria, B C.

CHOW, VEN TE, Editor, **Handbook of Applied Hydrology**, McGraw-Hill, Toronto, 1964.

COMINCO-MONENCO JOINT VENTURE, **Hat Creek Project**, Mining Feasibility Report, Volume IV, Section 3A, Mine Drainage, October 1979 (Revision)

ENVIRONMENT CANADA, 1980, **Historical Streamflow Summary**, British Columbia to 1979. Water Resources Branch, Ottawa, 1980.

ENVIRONMENTAL PROTECTION AGENCY, 1976. **Erosion and Sediment Control, Surface Mining in the Eastern U S, Vol 1 - Planning, Vol 2 - Design EPA** Technology Transfer Seminar Publication.

GOLDER ASSOCIATES, 1982a, **Report to B C Hydro and Power Authority on Hat Creek Construction Water Supply**, April 1982.

GOLDER ASSOCIATES, 1982b, **Hat Creek Project - Diversion Study**, Review of Alternatives, 800 MW and 2240 MW Schemes, Report No 822-1523B.

GOLDER ASSOCIATES, 1982c, **Hat Creek Project - Geotechnical and Hydrological Update,** Fall 1982. Report No 822-1524B.

JAMES, I C., STEELE, T D, June 1977. **Application of Residuals Management for Assessing Impacts of Alternative Coal-Development Plans on Regional Water Resources.** Third International Hydrology Symposium. Fort Collins, Colorado.

LEWIS, R D AND ASSOCIATES LTD, **Hat Creek Project - Construction Phase Sewage Treatment and Disposal, Conceptual Design Report**, November 1980. (B C Hydro Environmental Impact Statement, Reference No 62)

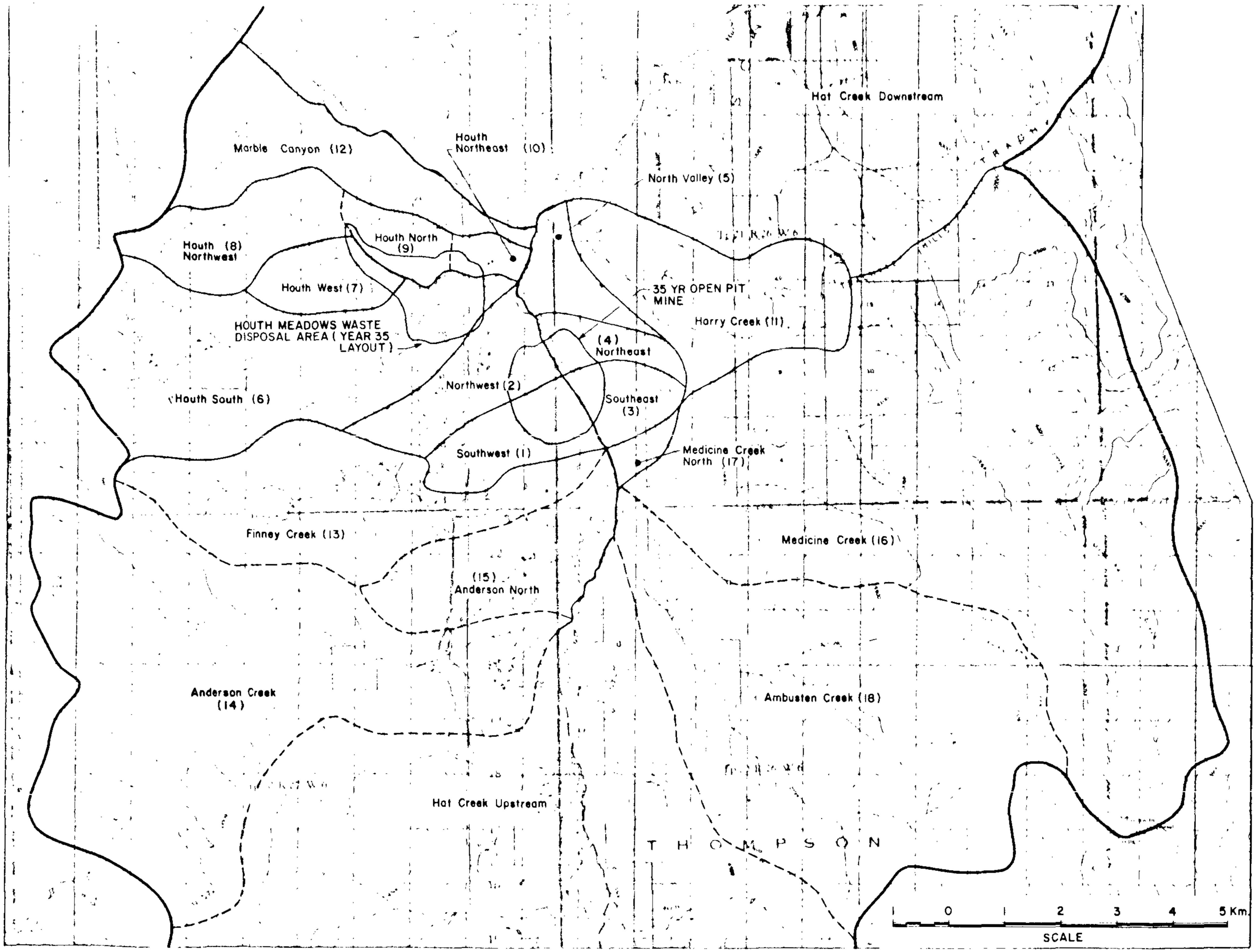
MONENCO CONSULTANTS, 1977, **Hat Creek Diversion Study.** Report to B C Hydro and Power Authority, January 1978.

STEELE, T D September, 1976. **Coal-Resource Development Alternatives, Residuals Management and Impacts on the Water Resources of the Yampa River Basin, Colorado and Wyoming.** Symposium on Water Resources and Fossil Fuel Production. Dusseldorf, Germany.

U S DEPARTMENT OF AGRICULTURE, 1964, **National Engineering Handbook Section 4, Hydrology.** Soil Conservation Service Reprinted 1969.

U S DEPARTMENT OF AGRICULTURE, 1975 **Urban Hydrology for Small Watersheds:** Technical Release No 55 Soil Conservation Service, January 1975.

FIGURES



LEGEND

————	Watersheds within project area.
- - - - -	Watersheds upstream of dam.
━━━━	Hat Creek watershed

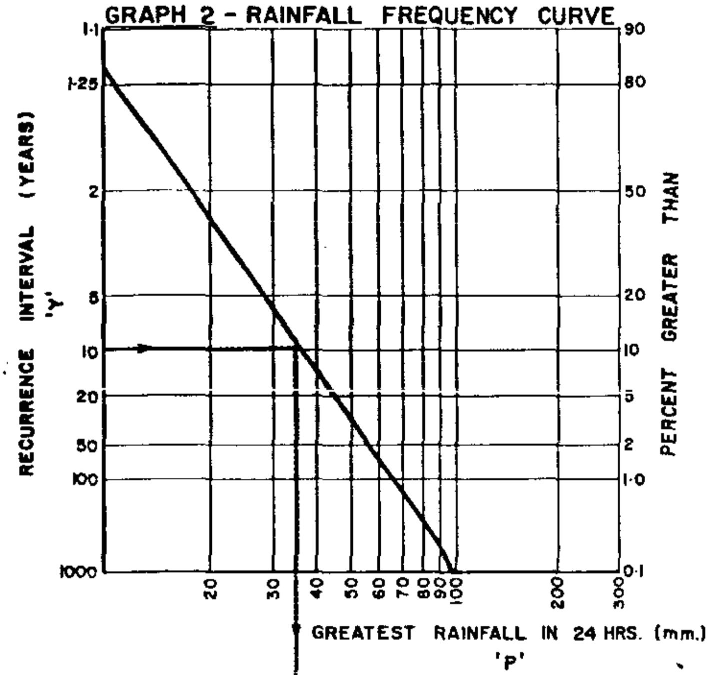
Golder Associates / Sigma Engineering Ltd.		
B.C. Hydro		
HAT CREEK DRAINAGE STUDY 800 MW SCHEME NATURAL WATERSHEDS WITHIN PROJECT AREA		
Drawn:	Checked:	Reviewed:
Date: OCT. 1982	Scale: AS SHOWN	Drawing: FIG. 2 - 1

TABLE 1 - SOIL COVER COMPLEXES

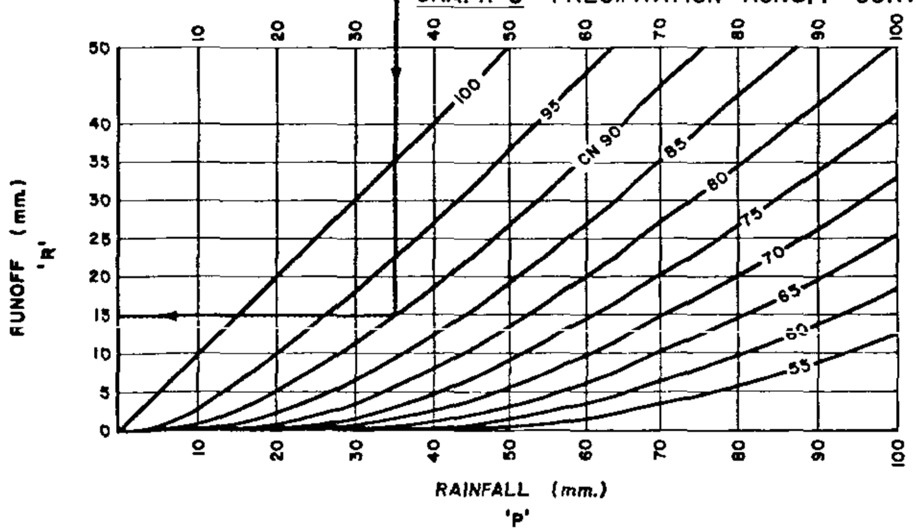
CURVE NUMBERS (CN)

NATURAL WATERSHEDS	=	60 - 70
REVEGETATED AREAS	=	70 - 80
DUMP SURFACE	=	90 (Surface storage not accounted for by this parameter)
PIT SLOPE	=	90
STORAGE YARDS	=	90
PAVED AREAS	=	98

GRAPH 2 - RAINFALL FREQUENCY CURVE



GRAPH 3 - PRECIPITATION RUNOFF CURVES

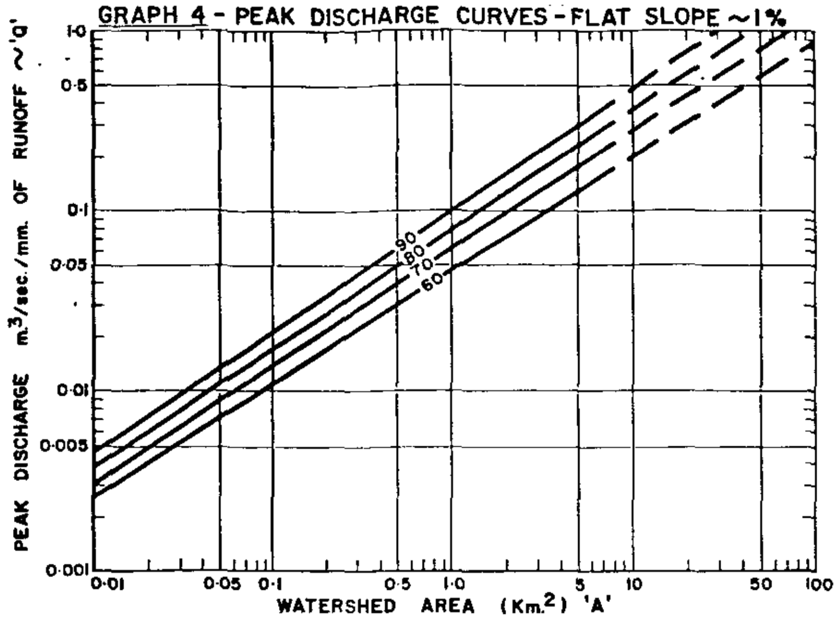


ASSUMPTIONS:

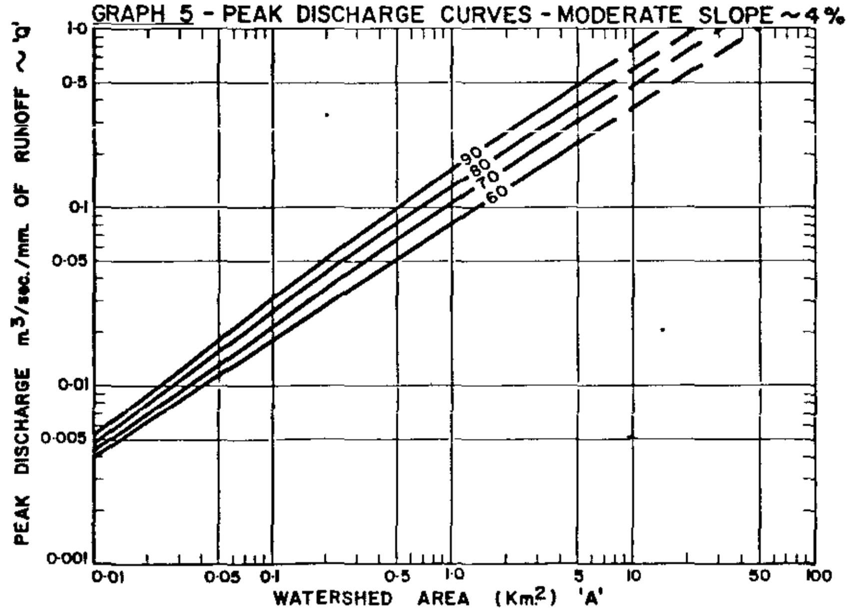
Antecedent Moisture Condition AMC = II

Initial Abstraction Ia = 0·2S~ Potential Abstraction

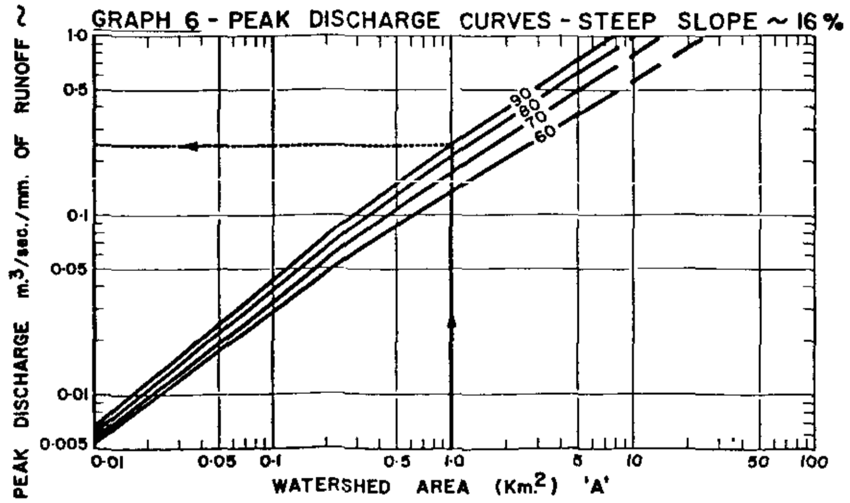
GRAPH 4 - PEAK DISCHARGE CURVES - FLAT SLOPE ~1%



GRAPH 5 - PEAK DISCHARGE CURVES - MODERATE SLOPE ~4%



GRAPH 6 - PEAK DISCHARGE CURVES - STEEP SLOPE ~16%



EXAMPLE CALCULATION

DATA:

DESIGN STORM

Recurrence Interval	10 Yrs.
Duration	24 Hrs.

WATERSHED

Area	1 Km²
Slope	Steep (16%)
Surface	Pit Slope

CALCULATION:

(i) From Table 1

CN = 90

(ii) From Graph 2

Design Rainfall 'P' = 35 mm.

(iii) From Graph 3

Runoff 'R' = 15 mm.

(iv) From Graph 6

Unit Peak Discharge 'Q' = 0·25 m³/sec./mm.

(v) Peak Watershed Discharge = 'R' x 'Q' = 3·75 m³/sec.

NOTE:

This nomograph is for preliminary estimates of flows from watersheds in mine area < 10 Km²

SOURCE:

Table 1 and Graphs 3,4,5 & 6

Adapted from U.S. Soil Conservation Service, National Engineering *Handbook, Section 4, Hydrology (1964)* & Technical Release No. 55, Urban Hydrology For Small Watersheds. (1975)

Graph 2

B.C. Hydro, H.E.D.D., Report No. 913. (1978)

Golder Associates/Sigma Engineering Ltd.

B.C.Hydro & Power Authority

HAT CREEK DRAINAGE STUDY

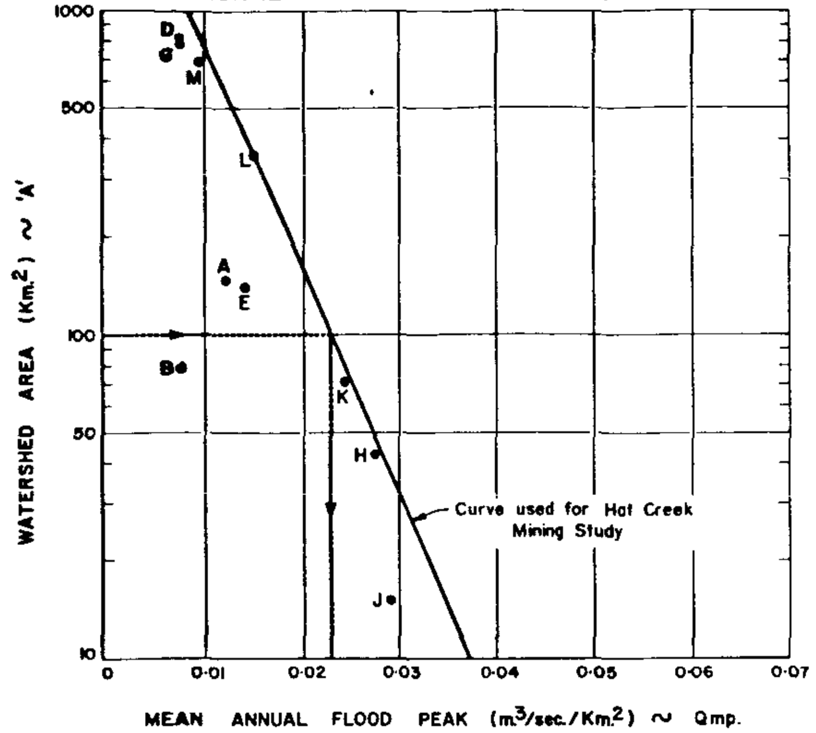
800 MW SCHEME

RAINSTORM FLOOD NOMOGRAPH

Drawn	J. NG	Checked	B.B.C.	Reviewed	G.S.M.
Date	SEP 1982	Scale	N.T.S.	Figure	3 - 1

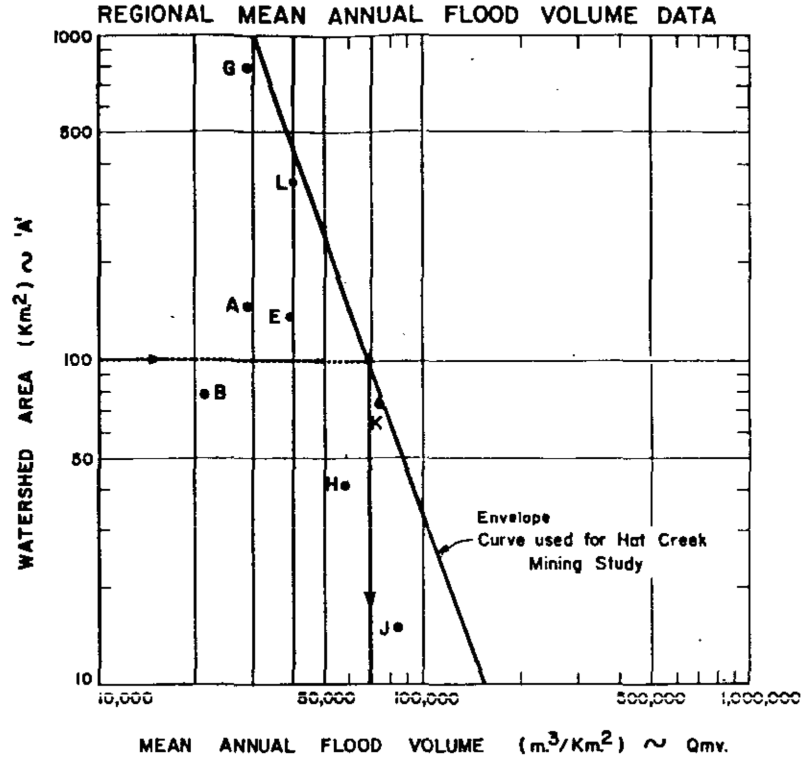
GRAPH 1

REGIONAL MEAN ANNUAL FLOOD PEAK DATA



GRAPH 2

REGIONAL MEAN ANNUAL FLOOD VOLUME DATA



EXAMPLE CALCULATION

DATA:

Watershed Area = 100Km^2

Design Recurrence Interval = 10 Yrs.

CALCULATION:

From Graph 1, Qmp = 0·023m^3/sec./Km^2

From Graph 3, Mp = 1·9

Flood Peak Discharge = 1·9 x ·023 m^3/sec./Km^2 x 100Km^2

= 4·4 m^3/sec.

From Graph 2, Qmv = 70,000 m^3/Km^2

From Graph 3, Mv = 1·7

Flood Volume = 1·7 x 70,000 m^3/Km^2 x 100 Km^2

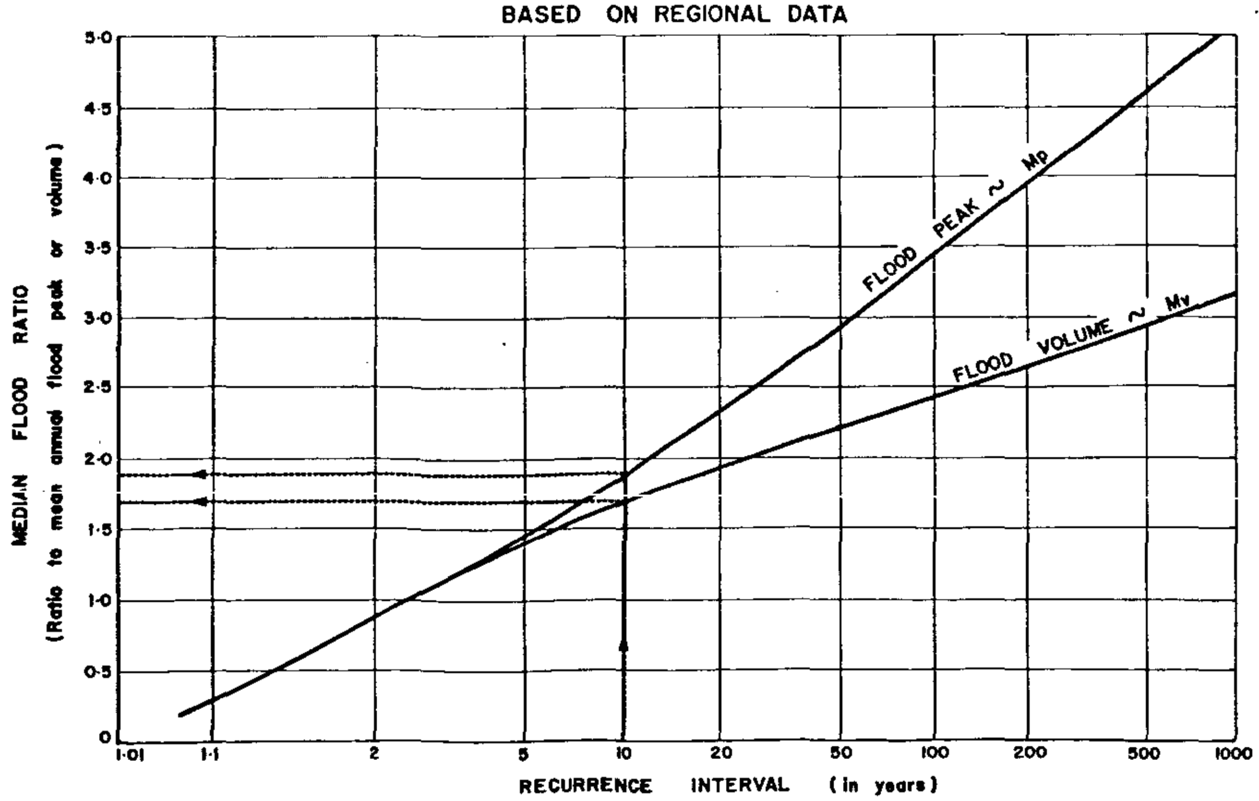
= 11·90 x 10^6 m^3

NOTE:

For preliminary estimates of floods from natural watersheds 10Km^2 or greater in mine area.

GRAPH 3

FREQUENCY AND RATIO OF ANNUAL FLOODS TO MEAN ANNUAL FLOODS BASED ON REGIONAL DATA



KEY	WATER SURVEY OF CANADA GAUGE STATION	
A	08LF036	
B	08LF038	
C	08LF069	
D	08LG003	
E	08LG009	
F	08LG014	
G	08LG032	
H	08LG033	
J	08LG055	
K	08LF013	Stations in Hat Creek valley
L	08LF061	Stations in Hat Creek valley
M	08LF015	Stations in Hat Creek valley

SOURCE:

Adapted from Regional Analysis Of Streamflow Data in B.C. Hydro, H.E.D.D. Report No. 913.
"Hat Creek Project - Diversion of Hat and Finney Creeks."

Golder Associates/Sigma Engineering Ltd.

B.C. Hydro & Power Authority

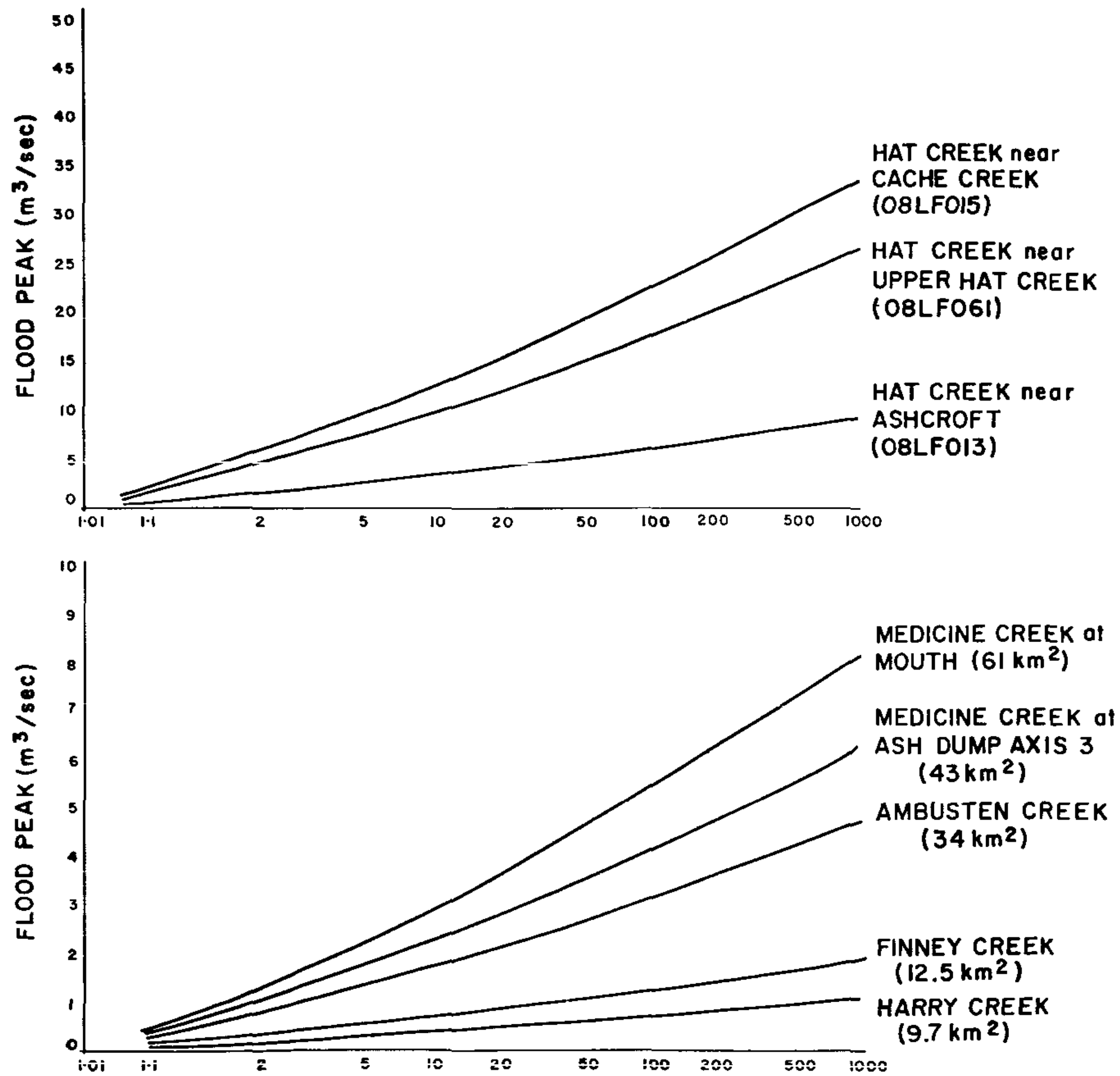
HAT CREEK DRAINAGE STUDY

800 MW SCHEME

RAIN - SNOWMELT NOMOGRAPH

Drawn J. NG	Checked B.C.R.	Reviewed G.S.M.
Date SEP 1982	Scale N.T.S.	Figure 3-2

FLOOD FREQUENCY CURVES
DERIVED FROM REGIONAL DATA

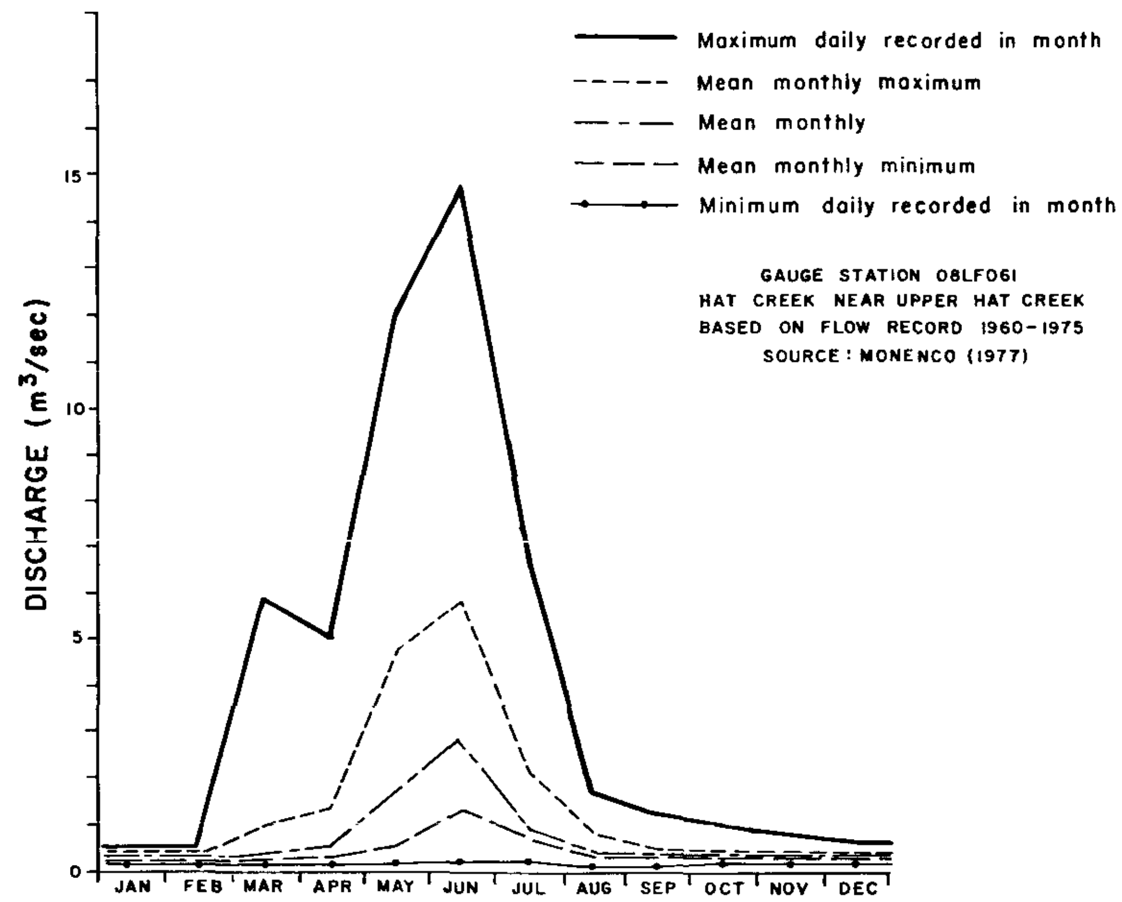


NOTE :

CURVES SHOWN ARE FOR ANNUAL SNOWMELT FLOODS

Source: B.C. Hydro H.E.D.D. Report 913, 1978

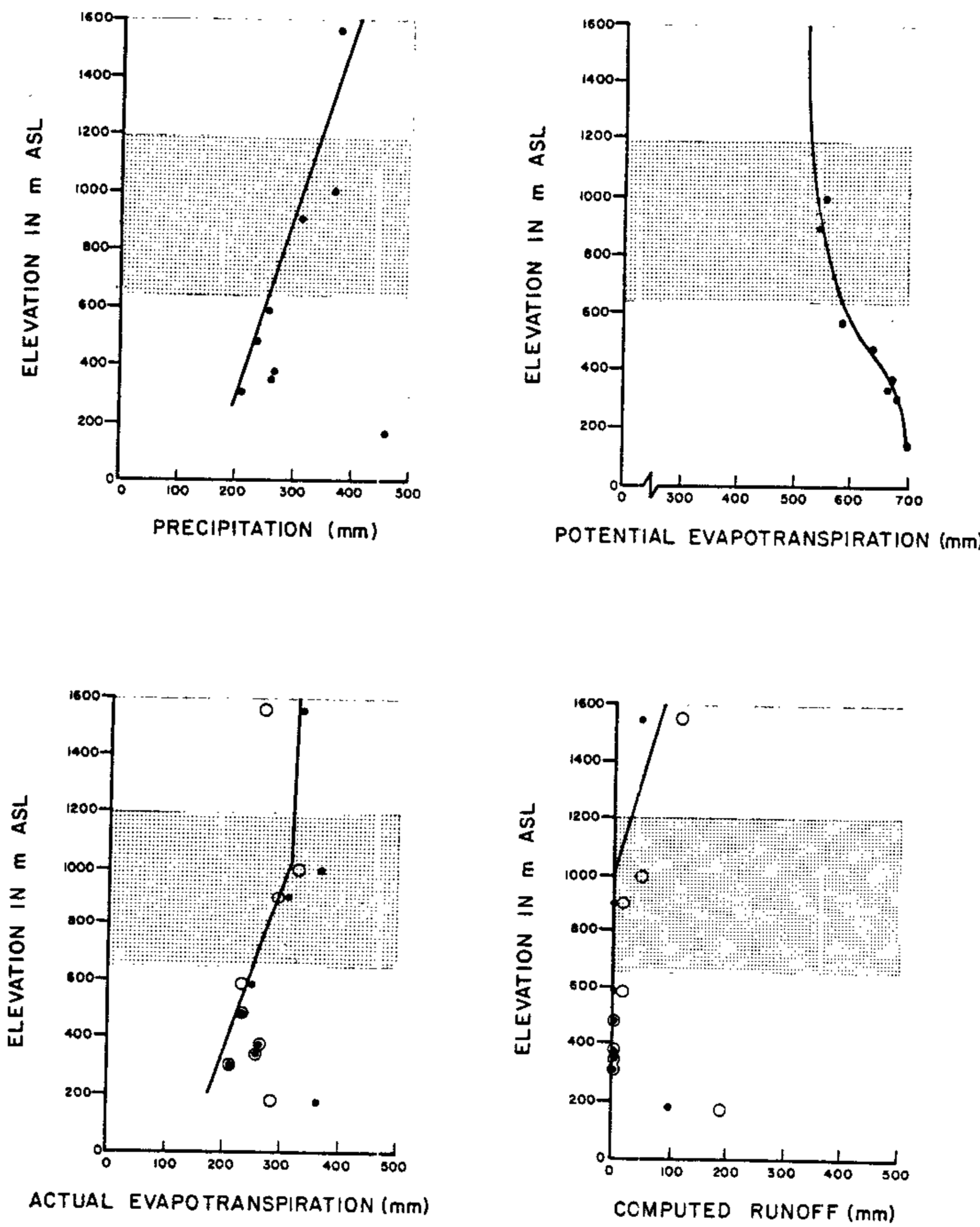
MONTHLY FLOW IN HAT CREEK
JUST ABOVE THE MINE SITE



Golder Associates / Sigma Engineering Ltd		
B.C. Hydro		
HAT CREEK DRAINAGE STUDY 800 MW SCHEME **STREAMFLOW DATA**		
DRAWN:	CHECKED: B.R.C.	REVIEWED: G.S.M.
DATE: October 198	SCALE: N.T.S.	FIGURE: 3-3

WATERSHED YIELD - 800 MW SCHEME

Figure 3-4



LEGEND

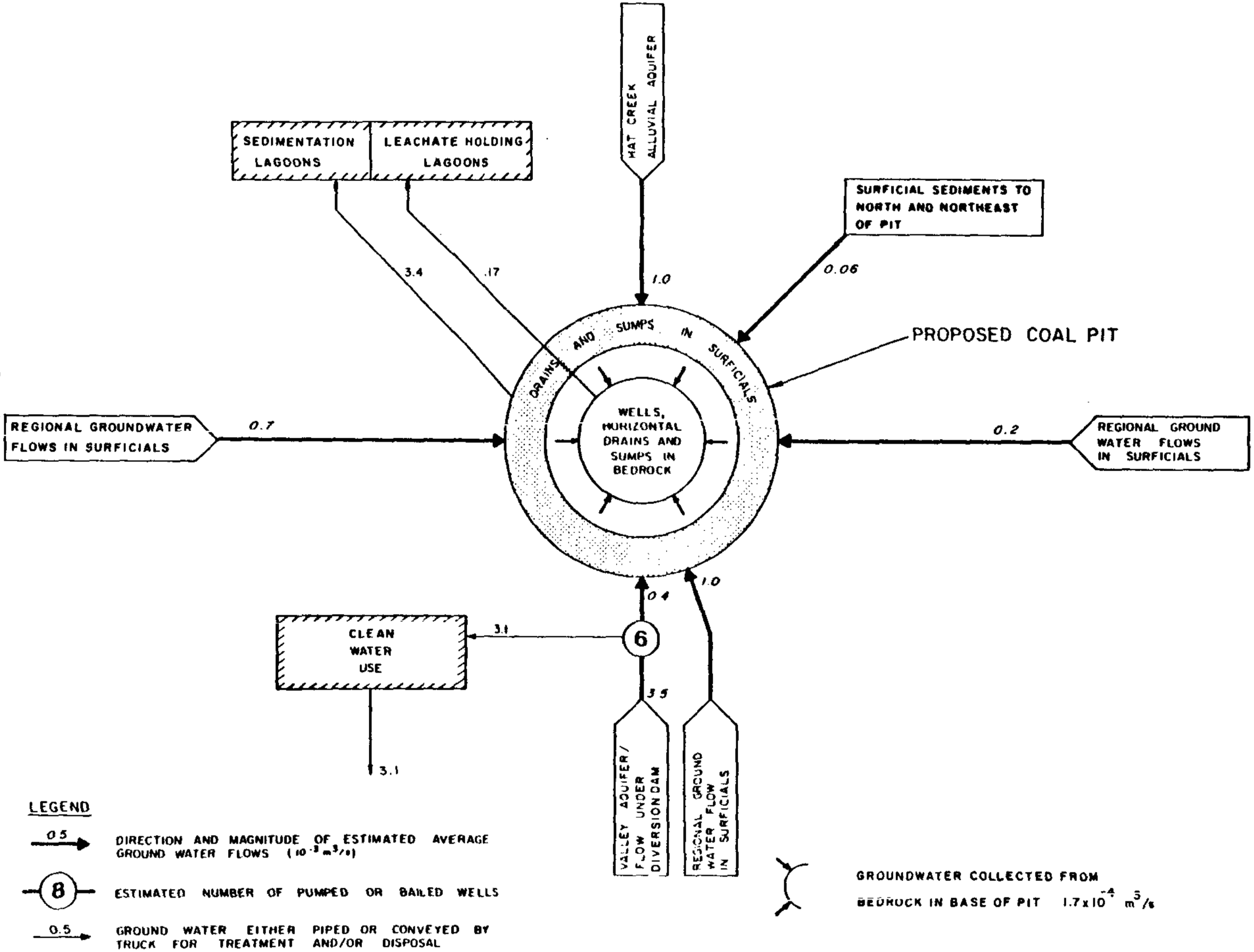
○ 100 mm SOIL STORAGE

• 200 mm SOIL STORAGE

MINE SITE ELEVATION

Source : Beak 1978

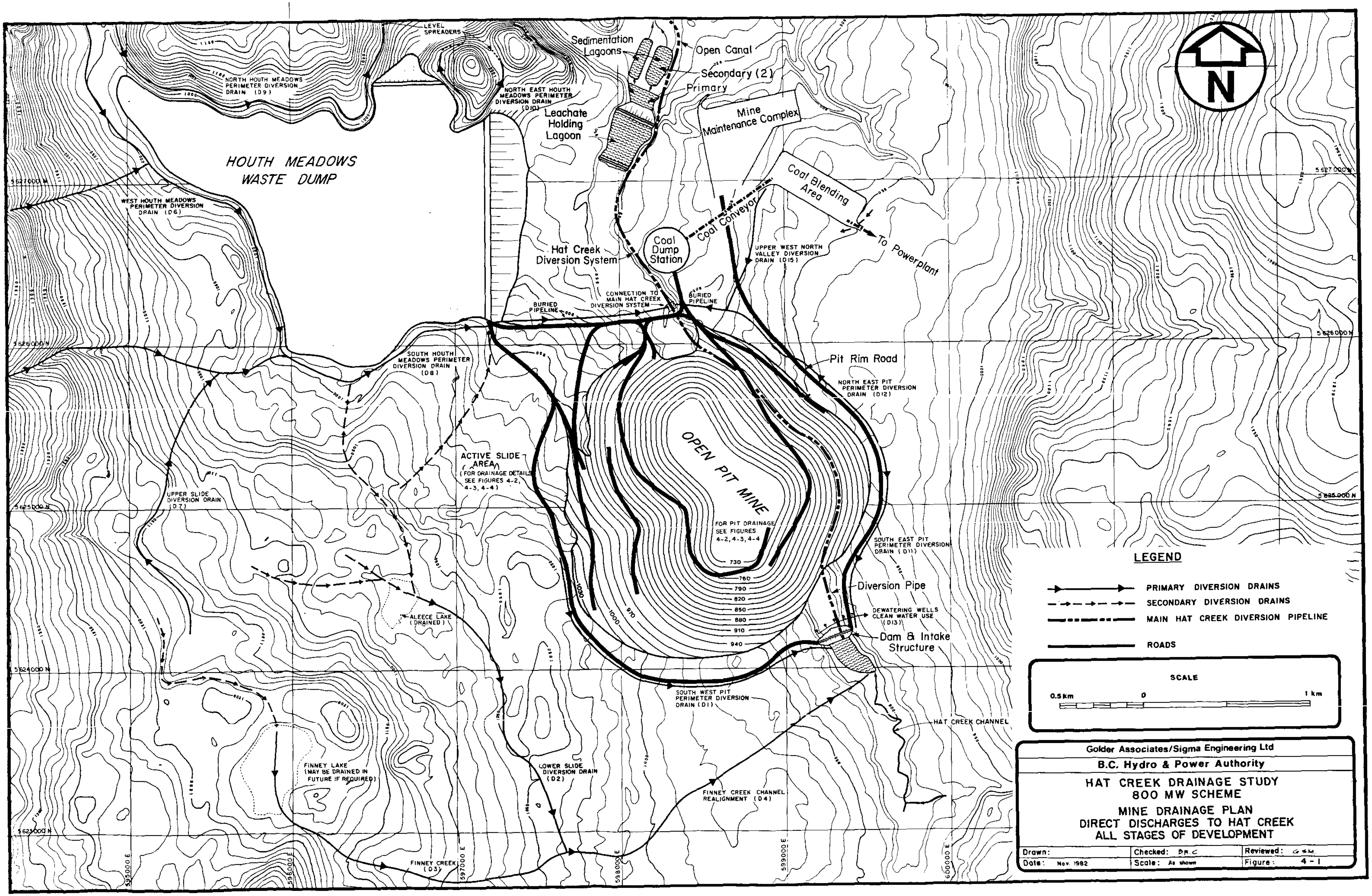
Project No ______ Drawn ______ Reviewed ______ Date ______



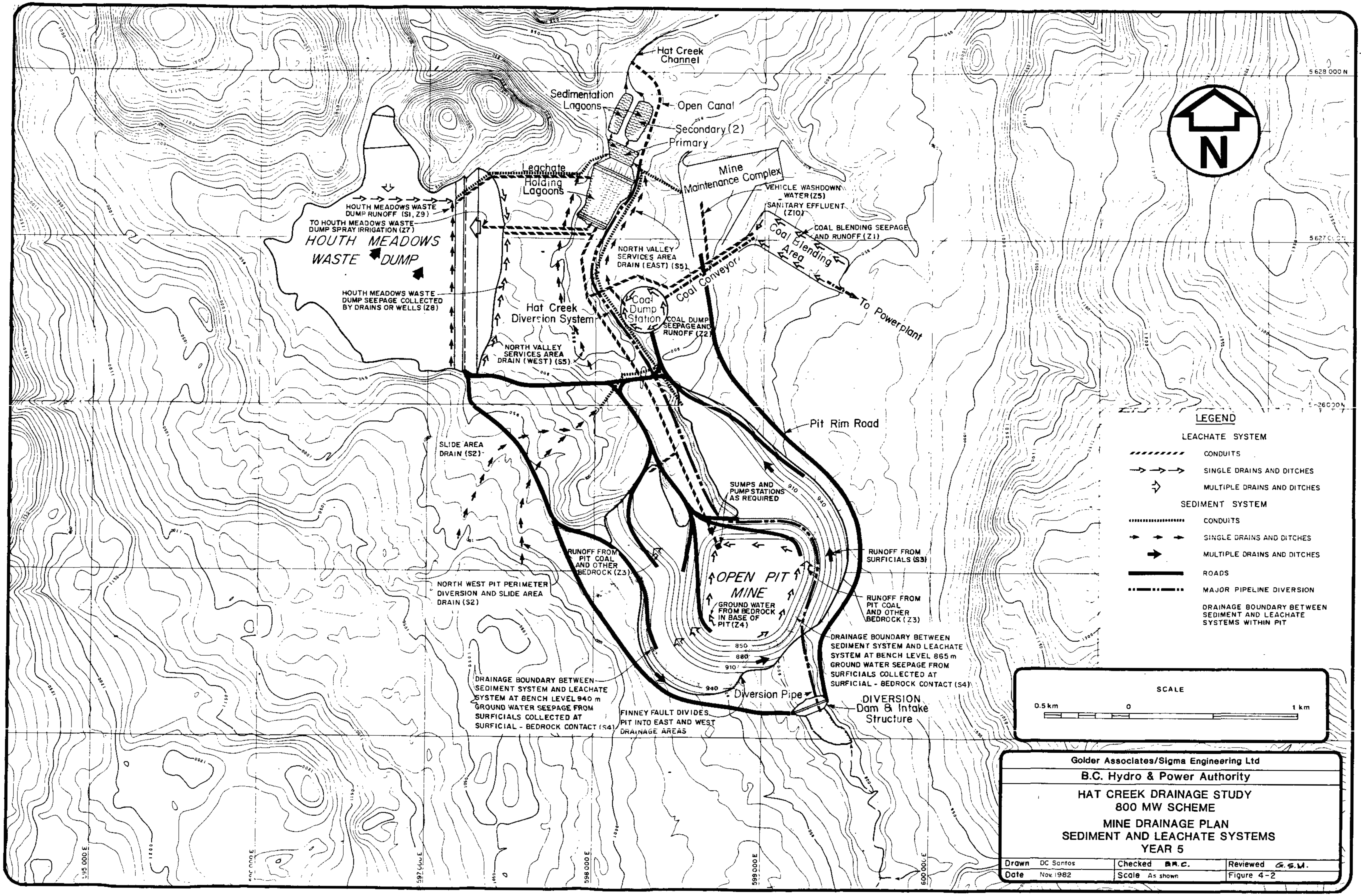
Golder Associates

MINE SEEPAGE AND DEWATERING FLOW CHART
800 MW SCHEME

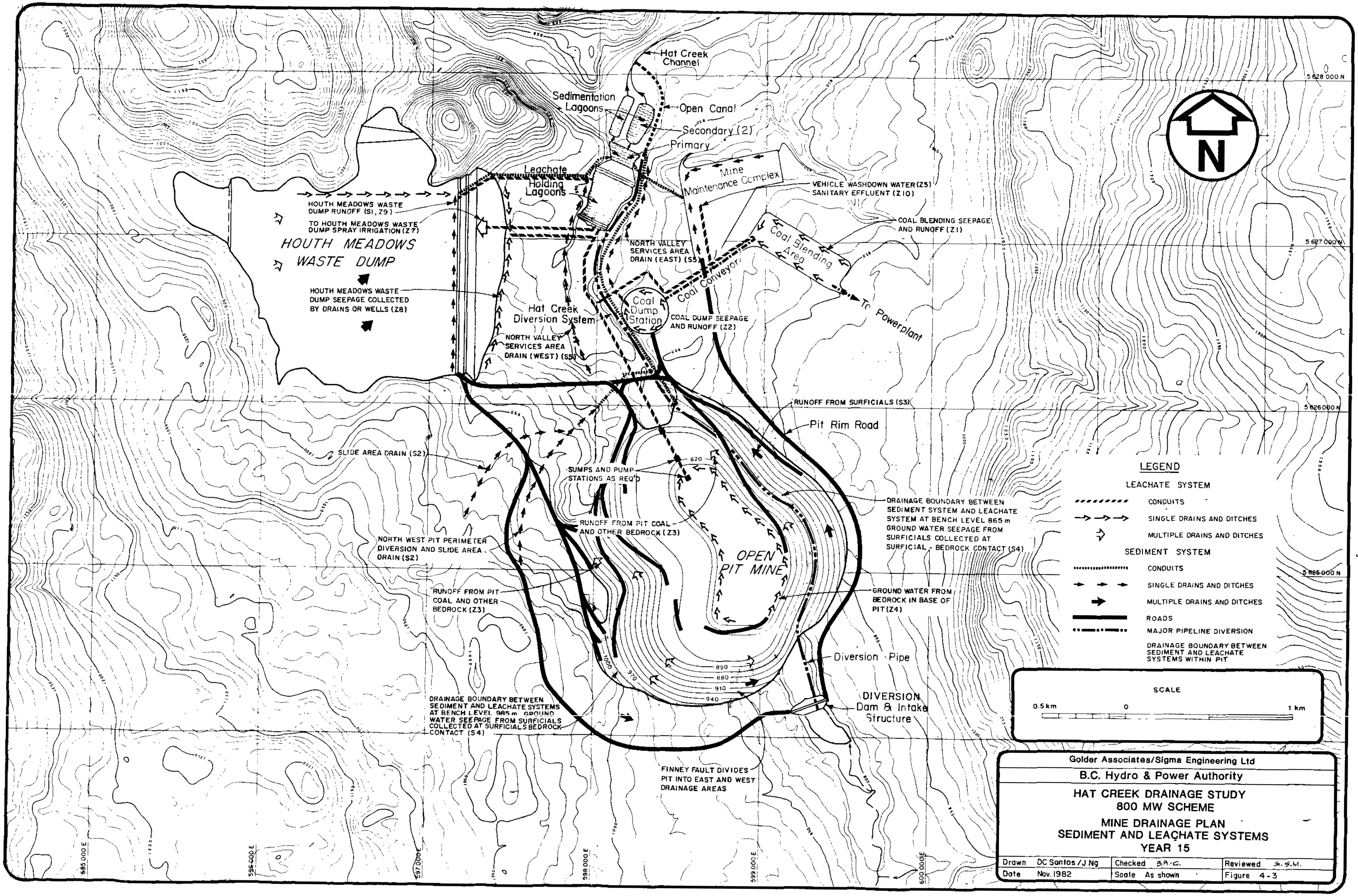
Figure 3-5

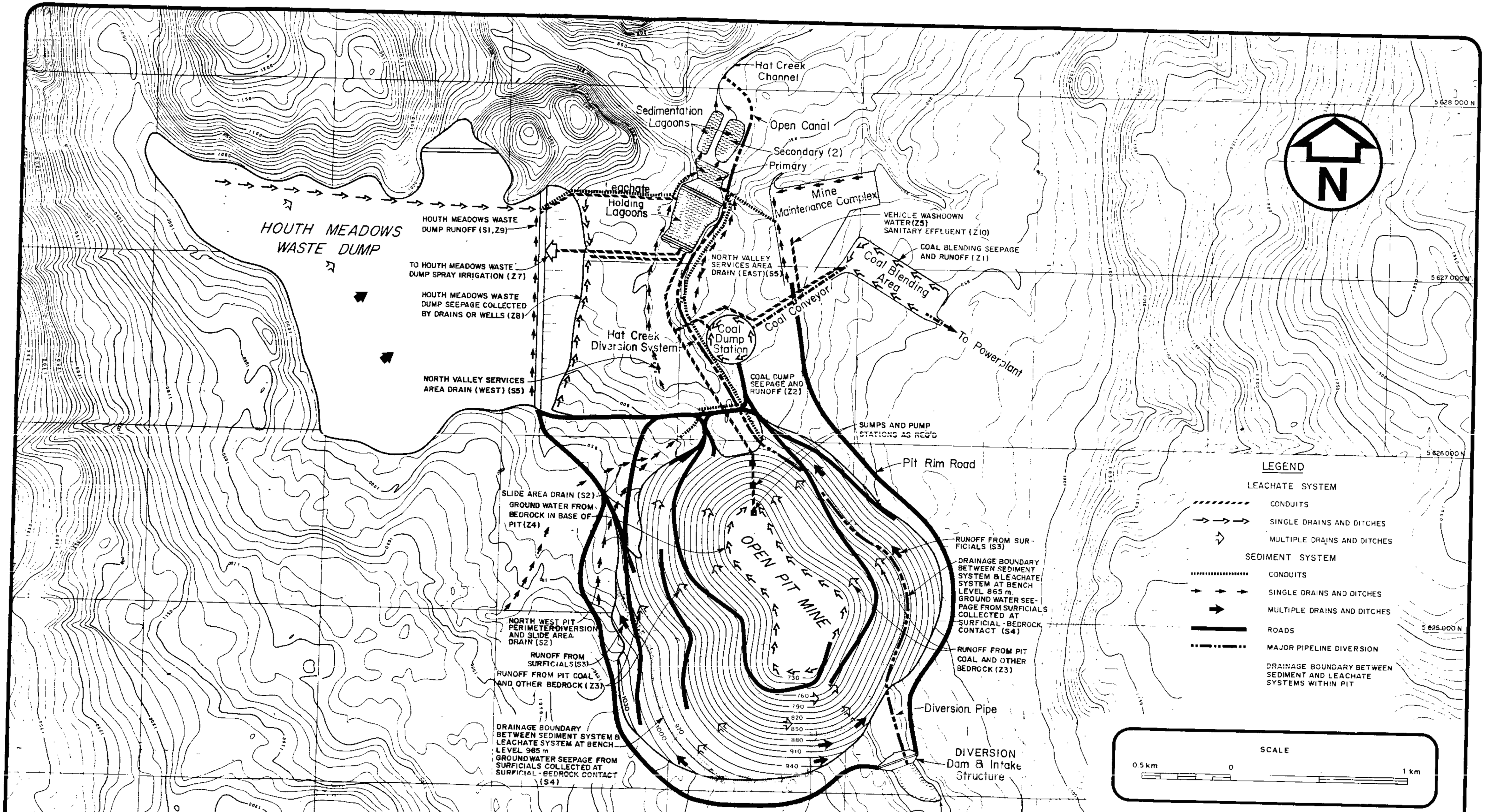


HOUTH MEADOWS WASTE DUMP
LEVEL SPREADERS
NORTH HOUTH MEADOWS PERIMETER DIVERSION DRAIN (D9)
NORTH EAST HOUTH MEADOWS PERIMETER DIVERSION DRAIN (D10)
Sedimentation Lagoons
Open Canal
Secondary (2)
Primary
Leachate Holding Lagoon
Mine Maintenance Complex
Coal Blending Area
Coal Conveyor
To Powerplant
Coal Dump Station
Hat Creek Diversion System
CONNECTION TO MAIN HAT CREEK DIVERSION SYSTEM
BURIED PIPELINE
BURIED PIPELINE
UPPER WEST NORTH VALLEY DIVERSION DRAIN (D15)
WEST HOUTH MEADOWS PERIMETER DIVERSION DRAIN (D6)
SOUTH HOUTH MEADOWS PERIMETER DIVERSION DRAIN (D8)
Pit Rim Road
NORTH EAST PIT PERIMETER DIVERSION DRAIN (D12)
ACTIVE SLIDE AREA (FOR DRAINAGE DETAILS SEE FIGURES 4-2, 4-3, 4-4)
OPEN PIT MINE
FOR PIT DRAINAGE SEE FIGURES 4-2, 4-3, 4-4
UPPER SLIDE DIVERSION DRAIN (D7)
SOUTH EAST PIT PERIMETER DIVERSION DRAIN (D11)
Diversion Pipe
DEWATERING WELLS CLEAN WATER USE (D13)
Dam & Intake Structure
ALEECE LAKE (DRAINED)
SOUTH WEST PIT PERIMETER DIVERSION DRAIN (D1)
HAT CREEK CHANNEL
FINNEY LAKE (MAY BE DRAINED IN FUTURE IF REQUIRED)
LOWER SLIDE DIVERSION DRAIN (D2)
FINNEY CREEK CHANNEL REALIGNMENT (D4)
FINNEY CREEK (D3)
730
760
790
820
850
880
910
940
970
1000
1030
5627000 N
5626000 N
5625000 N
5624000 N
5623000 N
595000 E
596000 E
597000 E
598000 E
599000 E
600000 E
N
LEGEND
PRIMARY DIVERSION DRAINS
SECONDARY DIVERSION DRAINS
MAIN HAT CREEK DIVERSION PIPELINE
ROADS
SCALE
0.5 km
0
1 km
Golder Associates/Sigma Engineering Ltd
B.C. Hydro & Power Authority
HAT CREEK DRAINAGE STUDY
800 MW SCHEME
MINE DRAINAGE PLAN
DIRECT DISCHARGES TO HAT CREEK
ALL STAGES OF DEVELOPMENT
Drawn:
Checked: B.R.C.
Reviewed: G.S.M.
Date: Nov. 1982
Scale: As shown
Figure: 4-1



Hat Creek Channel
Sedimentation Lagoons
Open Canal
Secondary (2)
Primary
Leachate Holding Lagoons
Mine Maintenance Complex
VEHICLE WASHDOWN WATER (Z5)
SANITARY EFFLUENT (Z10)
COAL BLENDING SEEPAGE AND RUNOFF (Z1)
Coal Blending Area
Coal Conveyor
To Powerplant
HOUTH MEADOWS WASTE DUMP RUNOFF (S1, Z9)
TO HOUTH MEADOWS WASTE DUMP SPRAY IRRIGATION (Z7)
HOUTH MEADOWS WASTE DUMP
HOUTH MEADOWS WASTE DUMP SEEPAGE COLLECTED BY DRAINS OR WELLS (Z8)
NORTH VALLEY SERVICES AREA DRAIN (EAST) (S5)
Hat Creek Diversion System
Coal Dump Station
COAL DUMP SEEPAGE AND RUNOFF (Z2)
NORTH VALLEY SERVICES AREA DRAIN (WEST) (S5)
Pit Rim Road
SLIDE AREA DRAIN (S2)
SUMPS AND PUMP STATIONS AS REQUIRED
RUNOFF FROM PIT COAL AND OTHER BEDROCK (Z3)
RUNOFF FROM SURFICIALS (S3)
OPEN PIT MINE
GROUND WATER FROM BEDROCK IN BASE OF PIT (Z4)
NORTH WEST PIT PERIMETER DIVERSION AND SLIDE AREA DRAIN (S2)
RUNOFF FROM PIT COAL AND OTHER BEDROCK (Z3)
DRAINAGE BOUNDARY BETWEEN SEDIMENT SYSTEM AND LEACHATE SYSTEM AT BENCH LEVEL 865 m GROUND WATER SEEPAGE FROM SURFICIALS COLLECTED AT SURFICIAL - BEDROCK CONTACT (S4)
DRAINAGE BOUNDARY BETWEEN SEDIMENT SYSTEM AND LEACHATE SYSTEM AT BENCH LEVEL 940 m GROUND WATER SEEPAGE FROM SURFICIALS COLLECTED AT SURFICIAL - BEDROCK CONTACT (S4)
FINNEY FAULT DIVIDES PIT INTO EAST AND WEST DRAINAGE AREAS
Diversion Pipe
DIVERSION Dam & Intake Structure
850
880
910
940
5 628 000 N
5 627 000 N
5 626 000 N
595 000 E
596 000 E
597 000 E
598 000 E
599 000 E
600 000 E
N
LEGEND
LEACHATE SYSTEM
CONDUITS
SINGLE DRAINS AND DITCHES
MULTIPLE DRAINS AND DITCHES
SEDIMENT SYSTEM
CONDUITS
SINGLE DRAINS AND DITCHES
MULTIPLE DRAINS AND DITCHES
ROADS
MAJOR PIPELINE DIVERSION
DRAINAGE BOUNDARY BETWEEN SEDIMENT AND LEACHATE SYSTEMS WITHIN PIT
SCALE
0.5 km
0
1 km
Golder Associates/Sigma Engineering Ltd
B.C. Hydro & Power Authority
HAT CREEK DRAINAGE STUDY
800 MW SCHEME
MINE DRAINAGE PLAN
SEDIMENT AND LEACHATE SYSTEMS
YEAR 5
Drawn DC Santos
Checked B.R.C.
Reviewed G.S.M.
Date Nov. 1982
Scale As shown
Figure 4-2


Hat Creek Channel
Sedimentation Lagoons
Open Canal
Secondary (2)
Primary
Leachate Holding Lagoons
Mine Maintenance Complex
VEHICLE WASHDOWN WATER (Z5) SANITARY EFFLUENT (Z10)
COAL BLENDING SEEPAGE AND RUNOFF (Z1)
Coal Blending Area
To Powerplant
Coal Conveyor
Coal Dump Station
COAL DUMP SEEPAGE AND RUNOFF (Z2)
NORTH VALLEY SERVICES AREA DRAIN (EAST) (S5)
Hat Creek Diversion System
NORTH VALLEY SERVICES AREA DRAIN (WEST) (S5)
HOUTH MEADOWS WASTE DUMP RUNOFF (S1, Z9)
TO HOUTH MEADOWS WASTE DUMP SPRAY IRRIGATION (Z7)
HOUTH MEADOWS WASTE DUMP
HOUTH MEADOWS WASTE DUMP SEEPAGE COLLECTED BY DRAINS OR WELLS (Z8)
RUNOFF FROM SURFICIALS (S3)
Pit Rim Road
SLIDE AREA DRAIN (S2)
SUMPS AND PUMP STATIONS AS REQ'D
RUNOFF FROM PIT COAL AND OTHER BEDROCK (Z3)
NORTH WEST PIT PERIMETER DIVERSION AND SLIDE AREA DRAIN (S2)
RUNOFF FROM PIT COAL AND OTHER BEDROCK (Z3)
OPEN PIT MINE
DRAINAGE BOUNDARY BETWEEN SEDIMENT SYSTEM AND LEACHATE SYSTEM AT BENCH LEVEL 865 m GROUND WATER SEEPAGE FROM SURFICIALS COLLECTED AT SURFICIAL - BEDROCK CONTACT (S4)
GROUND WATER FROM BEDROCK IN BASE OF PIT (Z4)
Diversion Pipe
DIVERSION Dam & Intake Structure
DRAINAGE BOUNDARY BETWEEN SEDIMENT AND LEACHATE SYSTEMS AT BENCH LEVEL 985 m GROUND WATER SEEPAGE FROM SURFICIALS COLLECTED AT SURFICIALS BEDROCK CONTACT (S4)
FINNEY FAULT DIVIDES PIT INTO EAST AND WEST DRAINAGE AREAS
820
850
880
910
940
970
1000
5 628 000 N
5 627 000 N
5 626 000 N
5 625 000 N
595 000 E
596 000 E
597 000 E
598 000 E
599 000 E
600 000 E
N
LEGEND
LEACHATE SYSTEM
CONDUITS
SINGLE DRAINS AND DITCHES
MULTIPLE DRAINS AND DITCHES
SEDIMENT SYSTEM
CONDUITS
SINGLE DRAINS AND DITCHES
MULTIPLE DRAINS AND DITCHES
ROADS
MAJOR PIPELINE DIVERSION
DRAINAGE BOUNDARY BETWEEN SEDIMENT AND LEACHATE SYSTEMS WITHIN PIT
SCALE
0.5 km
0
1 km
Golder Associates/Sigma Engineering Ltd
B.C. Hydro & Power Authority
HAT CREEK DRAINAGE STUDY
800 MW SCHEME
MINE DRAINAGE PLAN
SEDIMENT AND LEACHATE SYSTEMS
YEAR 15
Drawn DC Santos / J Ng
Checked
Reviewed
Date Nov. 1982
Scale As shown
Figure 4-3



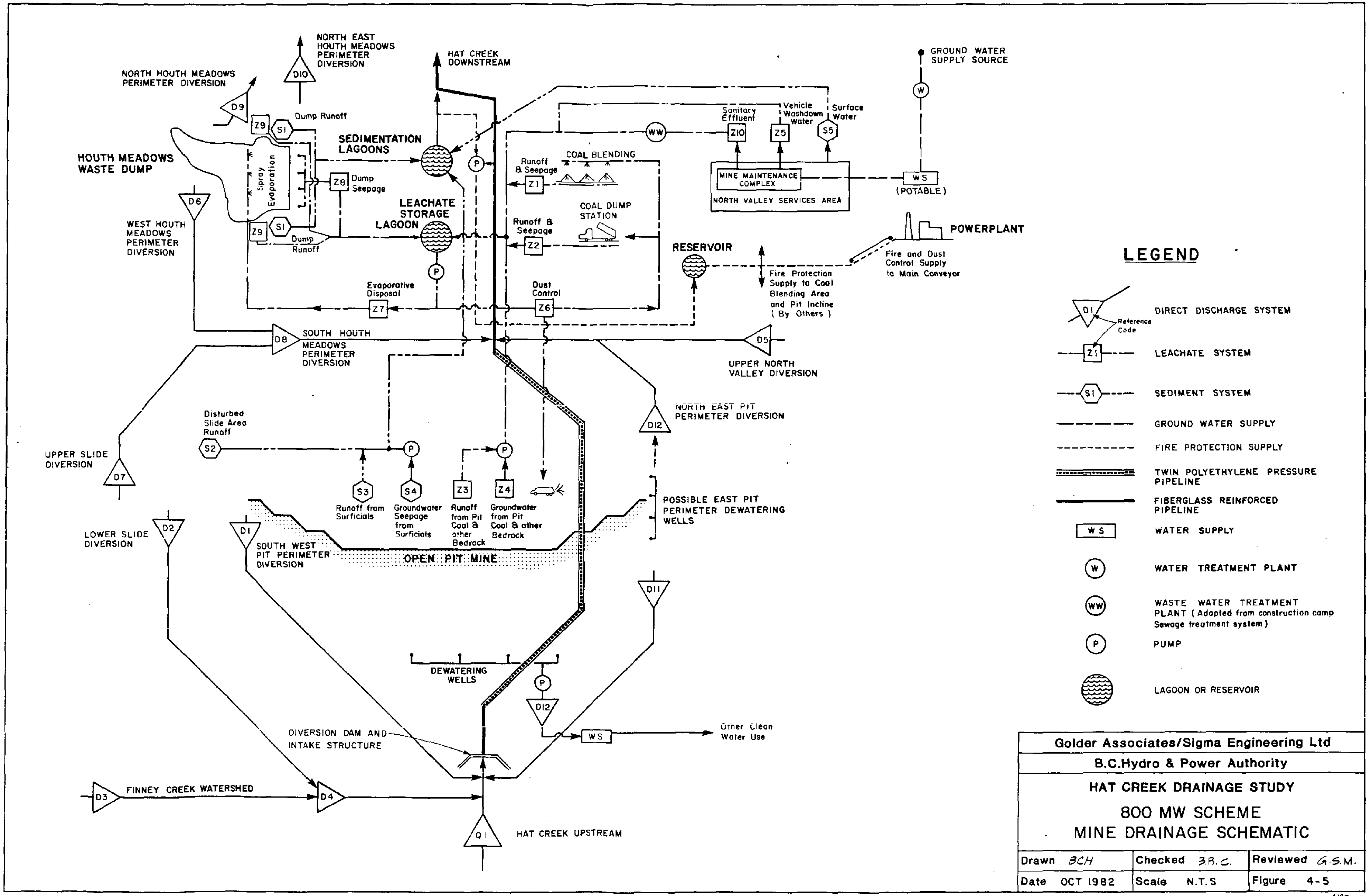
Golder Associates/Sigma Engineering Ltd

B.C. Hydro & Power Authority

HAT CREEK DRAINAGE STUDY
800 MW SCHEME

MINE DRAINAGE PLAN
SEDIMENT AND LEACHATE SYSTEMS
YEAR 35

Drawn DC Santos	Checked BR.C.	Reviewed G.S.M.
Date Nov 1982	Scale As shown	Figure 4-4



Golder Associates/Sigma Engineering Ltd

B.C.Hydro & Power Authority

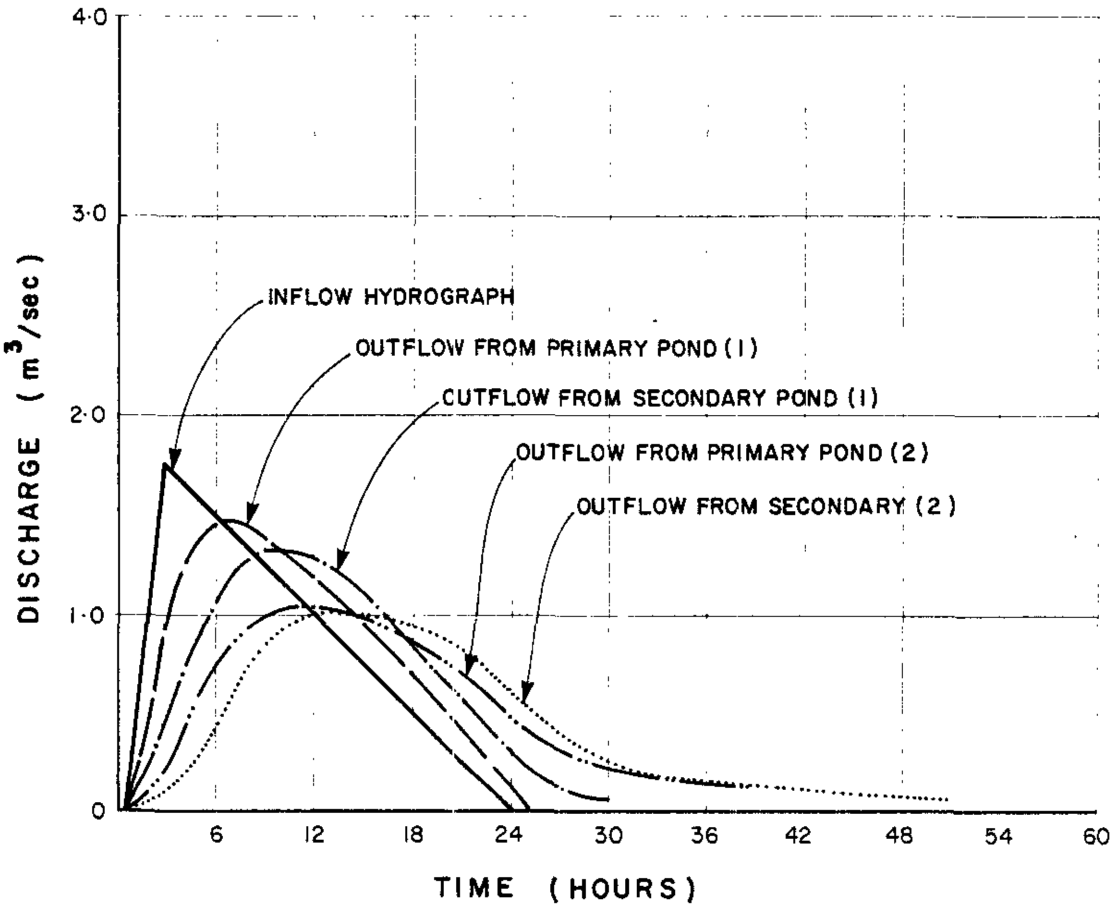
HAT CREEK DRAINAGE STUDY

800 MW SCHEME
MINE DRAINAGE SCHEMATIC

Drawn BCH	Checked B.B.C.	Reviewed G.S.M.
Date OCT 1982	Scale N.T.S	Figure 4-5

SEDIMENTATION LAGOONS - 800 MW
10 YEAR 24HOUR FLOOD DISCHARGE HYDROGRAPH

Figure 5-1

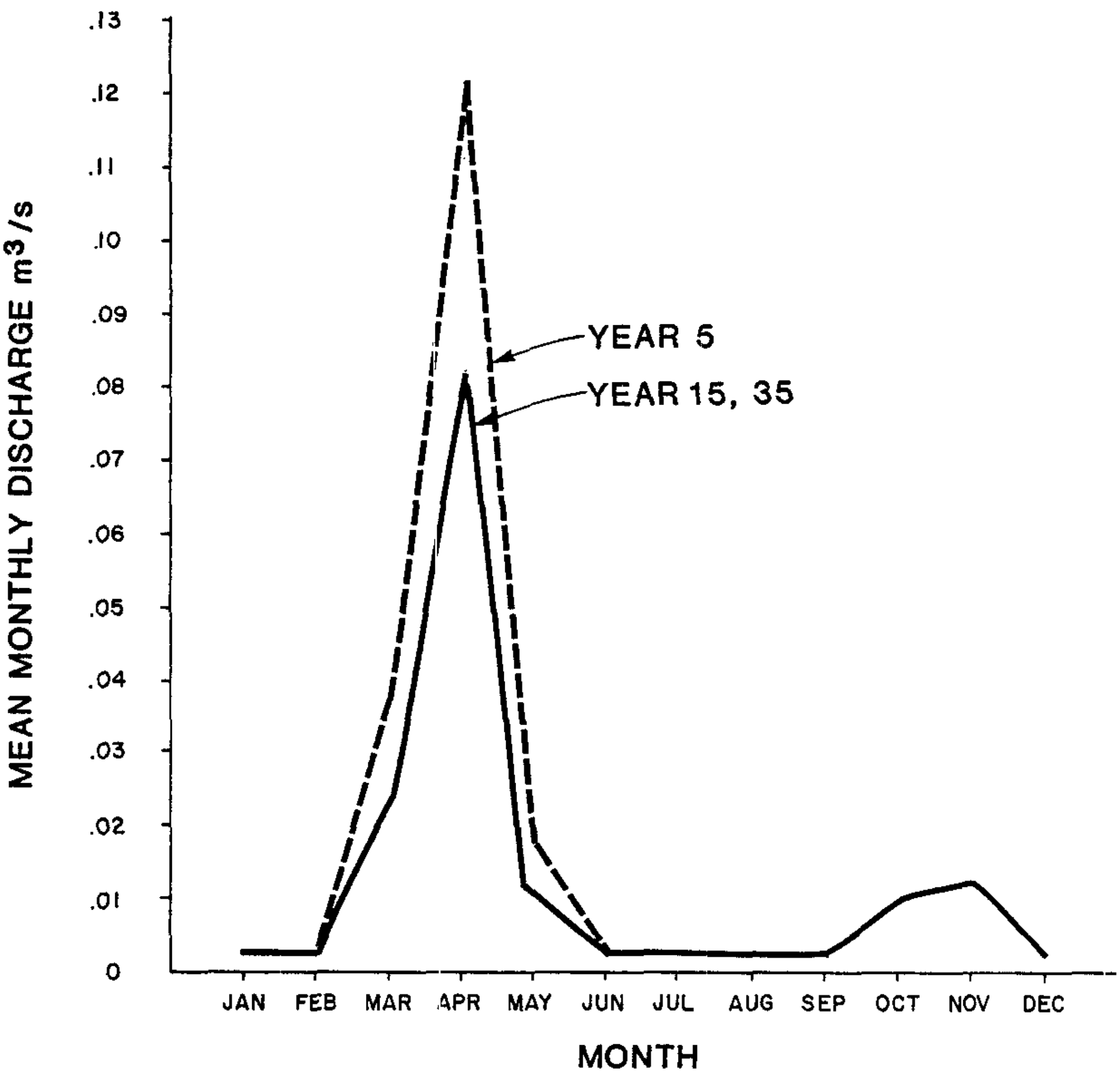


1. Uncontrolled outflow from emergency spillway

2. Controlled outflow from decant tower sized to release 10 year peak flow at 4m of storage

SEDIMENTATION LAGOONS - 800 MW
MEAN DISCHARGE HYDROGRAPH

Figure 5-2

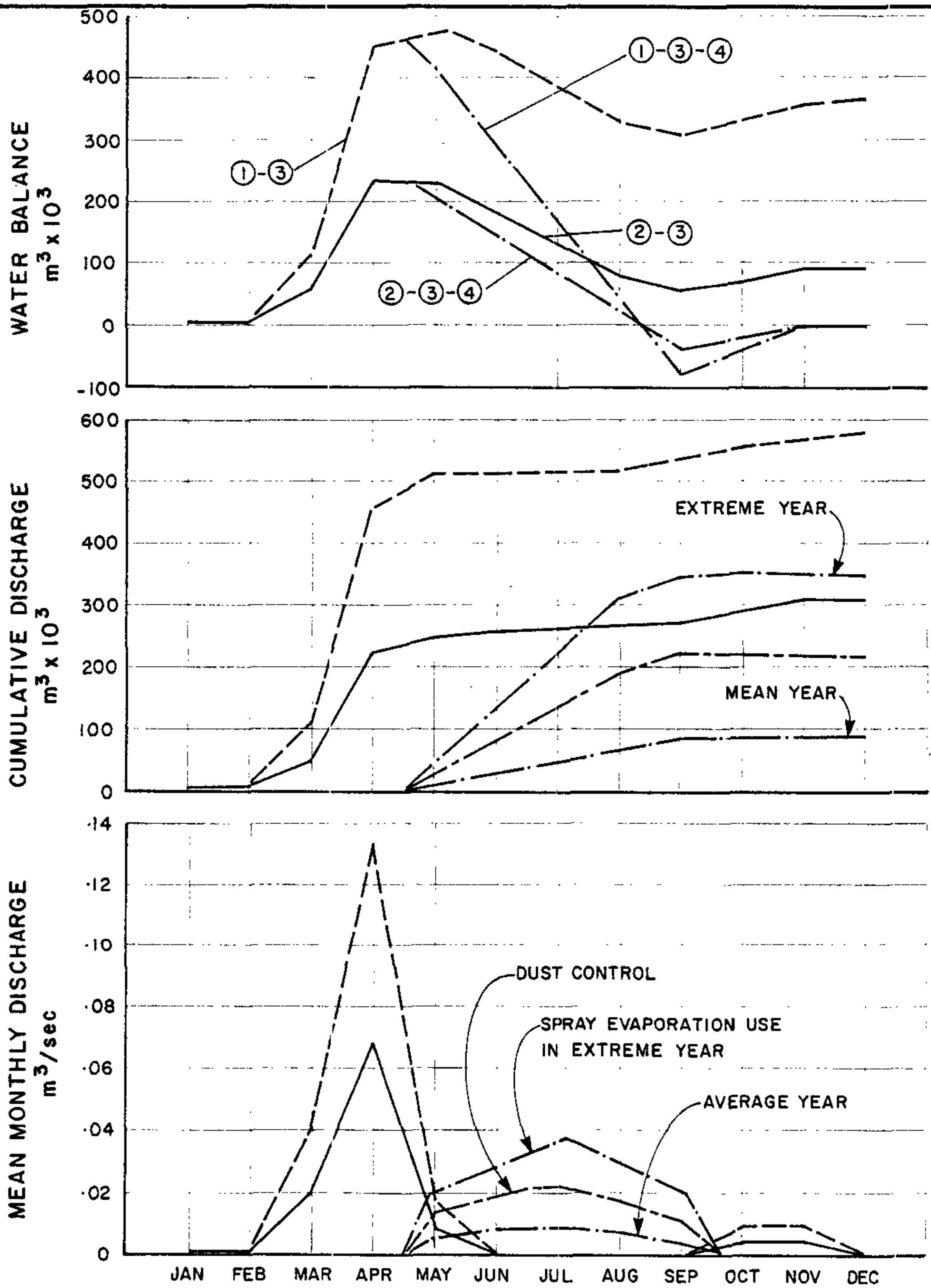


5280 DCS

Golder Associates/Sigma Engineering Ltd

LEACHATE SYSTEM HYDROGRAPHS - 800 MW
YEAR 35

Figure 5-3



KEY

① ——— Extreme inflow

② ——— Mean inflow

③ ——— Dust control outflow

④ ——— Spray evaporation outflow

Golder Associates/Sigma Engineering Ltd

5280

J.NG NOV 1982