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SURFACE WATER DRAINAGE AND SEDIMENTAL CONTROL PRACTICES AT THE BULLMOOSE COAL MINE

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Introduction

The Bullmoose Mine is located 87 kilometres south of Chetwynd, B.C. within what is generally termed "the Northeast Coal Block." The mine, which commenced production in October 1983, has an annual production rate of 2.3 million tonnes of high quality metallurgical coal.

As part of the B.C. Coal Development Guidelines and as part of the mine reclamation plan, a comprehensive water management plan was developed.

This plan was integrated into the total mine design to ensure environmental protection of the natural aquatic resources and to provide protection for the minesite facilities during the flood events. The general components of this management plan are the subject of this paper.

Planning Strategy

A preliminary assessment of the short and long term aspects of the surface water management problem resulted in adoption of a staged approach in the development of several specific solutions which collectively satisfied a wide variety of mining, land reclamation, and environmental objectives.

The first stage consisted of adopting a strategy directly at the outset of the project to prevent damages to the existing aquatic resources during the construction period.

The second stage of the plan consisted of engineering design and subsequent construction of drainage facilities, flood control structures and sedimentation ponds for long-term control of surface drainage. The third and final phase consists of the ongoing development of the drainage system outlined in the water management plan during the life of the mine, and the compliance with several Waste Management Permits and the Reclamation Permit issued by the Ministry of Environment and the Ministry of Energy, Mines and Petroleum Resources respectively. The main impact of the overall drainage plan on the reclamation plan is the reduction in surface erosion which results from the proper management of surface water. In addition the retention of surface soils in the sedimentation ponds allows future use of this material when the ponds are reclaimed for maintenance or ultimate abandonment. The planning and design work completed in each stage of the plan is discussed in the following sections.

Preservation of Aquatic Resources

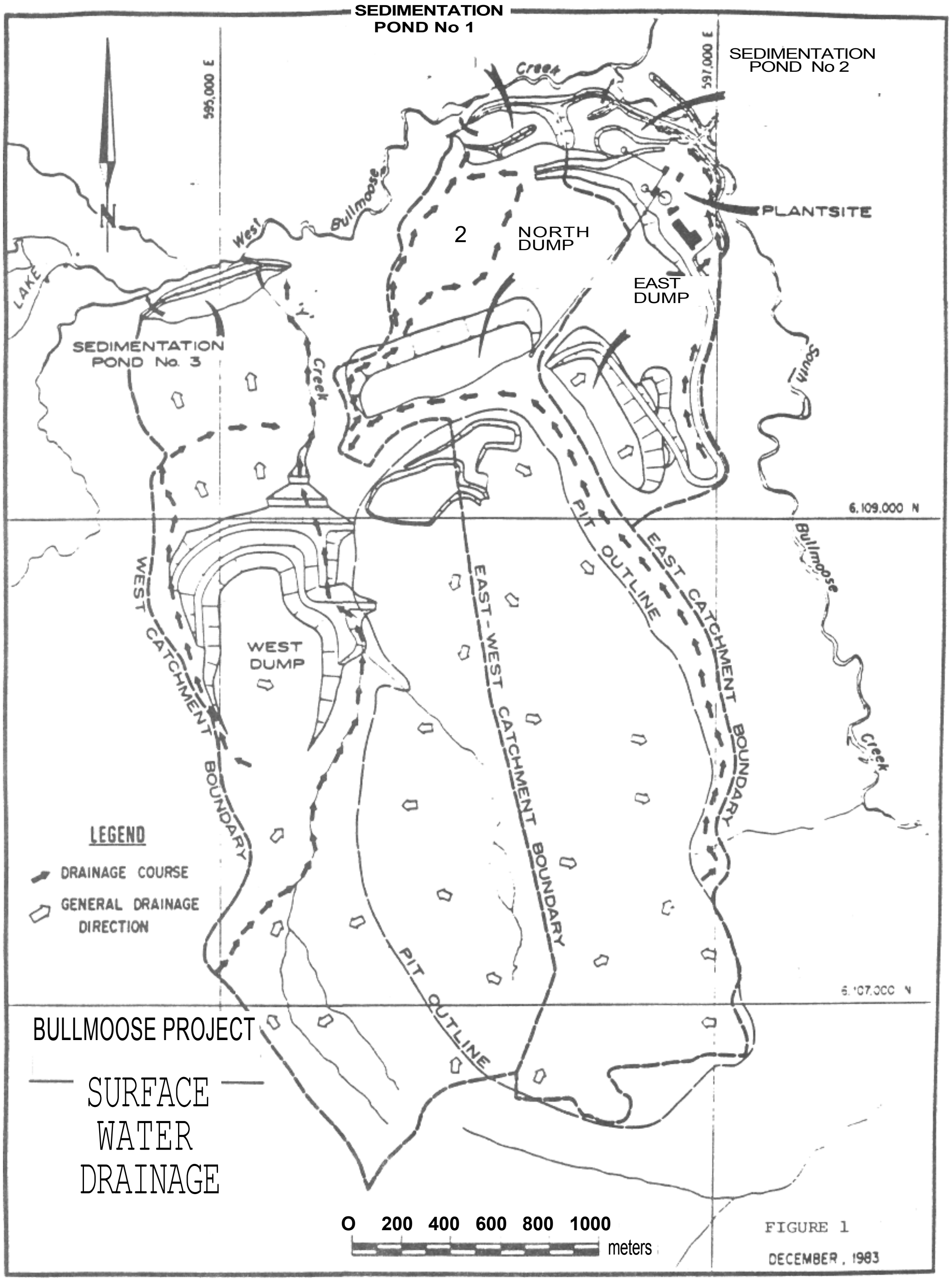
The primary action implemented to prevent damages to the local creeks consisted of restricting construction activities, wherever practical, to within 30 metres of the major creeks. This green belt of preserved, undisturbed vegetation prevented direct erosion of this area, and also prevented the disturbance of the principal spawning, rearing and overwintering habitats of a resident population of Dolly Varden char.

A second action taken was to direct site drainage from the plantsite area, which experienced extensive site grading work, to an existing natural swamp adjacent to the plantsite. This practice was effective during low precipitation periods, and prevented major sediment losses during significant storm events. This interim sedimentation/ swamp area was ultimately included in the area of Sedimentation Pond 2.

Drainage System Design

A conceptual minesite drainage system was laid out for the mine plan to demonsrate drainage feasibility, to allow calculation of sedimentation pond design flows, and to provide guidance for the development of a detailed mine drainage plan (Figure I).

Figure I


SEDIMENTATION POND No 1
SEDIMENTATION POND No 2
SEDIMENTATION POND No. 3
595,000 E
597,000 E
Creek
West Bullmoose
LAKE
Creek
2
NORTH DUMP
EAST DUMP
PLANTSITE
South Bullmoose Creek
6,109,000 N
6,107,000 N
WEST CATCHMENT BOUNDARY
EAST-WEST CATCHMENT BOUNDARY
EAST CATCHMENT BOUNDARY
PIT OUTLINE
PIT OUTLINE
WEST DUMP
LEGEND
DRAINAGE COURSE
GENERAL DRAINAGE DIRECTION
BULLMOOSE PROJECT
SURFACE WATER DRAINAGE
O 200 400 600 800 1000
meters
FIGURE 1
DECEMBER, 1983

The fully developed mine plan (to be achieved in approximately 1996) was divided into three drainage basins with areas roughly in the proportion to the surface areas of the three corresponding sedimentation ponds. The drainage ditch system was laid out to divert runoff away from steep terrain to the west, south and east of the minesite where collection and settling of runoff were not feasible. Existing natural stable channels were identified and used in the plan to economically convey the runoff down steep gradients to the sedimentation ponds. Flexibility was incorporated in the drainage layout by allowing runoff from the upper mine area to be routed to either of the two larger ponds (Nos. I and 3).

Geotechnical studies conducted during the early field assessment period revealed a problem of constructing the planned waste dumps on steep terrain adjacent to the pit area. This problem was resolved in conjunction with the drainage problems by employing a major ravine located on the west perimeter of the mine for both purposes. This design involved installation of a rock drain which utilized competent coarse waste material as the foundation material for the dump.

The location of the dumps in this area will result in a significantly shorter haul distance of waste material while maintaining a virtually level haulage route as the mine development progresses up the mountain. A further major benefit of this structure will be the smoothing effect on the storm hydrograph (Figure 2) which results from the water retention capability of the drain. This reduction in peak flow allowed a corresponding reduction in the cost of the spillway for Pond No. 3. In addition, the storm flows, which are routed to Pond No. 3 for sediment removal, will have a longer retention time and consequently more effective treatment.

Sedimentation Pond Design

The hydrologic design required in stage 2 of the plan was complicated by the lack of long term local meteorologic and streamflow data. Consequently, a network of rain gauges and stream gauges was set up in the early phase of the project. Estimations of minesite runoff flows were achieved by a careful review of available regional rainfall intensity data and integration of local data collected during 1981 and 1982. A rainfall runoff model was then used to estimate the sedimentation pond inflow hydrographs. The sizes of the sedimentation ponds were determined by the ten year return period flow estimates, and the designs of the spillways were based on estimates of 200 year return period flows.

The surface areas of the three ponds meet the British Columbia Government design guidelines for treatment of runoff from the entire area resulting from the 13 year life of the South Fork deposit. The design criteria are outlined in Table I. In addition, the ponds incorporated baffle dykes to maximize the actual retention time and improve settling, and roughing ponds to facilitate cleanout maintenance procedures. The final discharge structures for Ponds I and 3 consist of economical rock weir spillways, constructed of competent coarse rock, while the discharge structure for Pond 2 consists of corrugated steel pipe arches with an outflow stilling basin composed of large riprap.

Available areas for sedimentation ponds were restricted to the West Bullmoose Creek Valley bottom immediately northwest of the plantsite. The pond dykes were built on a foundation of dense, silty sands and gravels and were constructed as compacted, impermeable, earthfill structures. The general pond areas also consist of glaciofluvial deposits, and as such are expected to initially exfiltrate varying portions of the pond inflows to the groundwater table.

Flood Control

The data derived from the hydrologic surveys employed in the mine drainage design was also utilized to predict the 200 year flood flow rates in the adjacent Bullmoose and West Bullmoose Creeks. These flow rates, which occurred during spring freshet and summer storm events, were used to predict the corresponding flood levels in the area of the plantsite, the access bridge, and

Figure 2

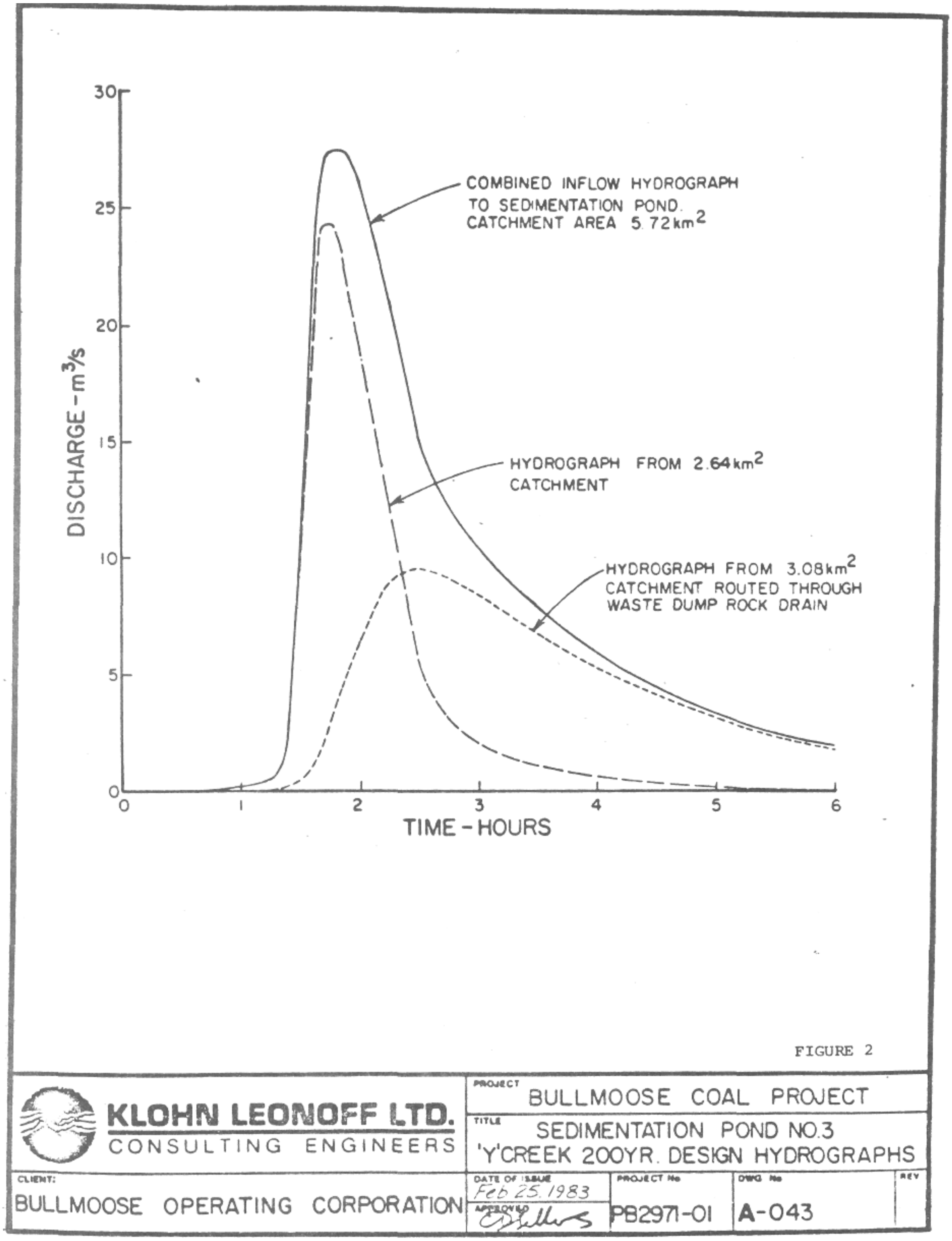

30
25
20
15
10
5
0
DISCHARGE - m³/s
0
1
2
3
4
5
6
TIME - HOURS
COMBINED INFLOW HYDROGRAPH
TO SEDIMENTATION POND.
CATCHMENT AREA 5.72 km2
HYDROGRAPH FROM 2.64 km2
CATCHMENT
HYDROGRAPH FROM 3.08 km2
CATCHMENT ROUTED THROUGH
WASTE DUMP ROCK DRAIN
FIGURE 2
KLOHN LEONOFF LTD.
CONSULTING ENGINEERS
PROJECT
BULLMOOSE COAL PROJECT
TITLE
SEDIMENTATION POND NO.3
'Y'CREEK 200YR. DESIGN HYDROGRAPHS
CLIENT:
BULLMOOSE OPERATING CORPORATION
DATE OF ISSUE
Feb 25 1983
APPROVED
PROJECT No
PB2971-01
DWG No
A-043
REV

Table I

Sedimentation and Pond Design

Item		Pond No 1	Pond No 2	Pond No 3
1.	**Design Flows**			
	a) Year 13 drainage area	300 ha	95ha	348 ha
	b) 10 year, max. mean daily flow	1.25 m^3/s	0.40 m^3/s	2.16 m^3/s
	c) 200 year, peak inflow	12.1 m^3/s	5.6 m^3/s	28 m^3/s*
	d) 200 year, peak outflow	8.0 m^3/s	2.7 m^3/s	15.3 m^3/s*
2.	**Pond Sizing Data**			
	a) Surface area	5.3 ha	3.3 ha	5.0 ha
	b) Pond volume	115,000 m^3	34,600 m^3	185,000 m^3
	c) Retention time for 10 year, max. mean daily flow	25 hours	24 hours	24 hours
	d) Critical settling velocity for 10 year event	2.8×10^{-5} m/s	1.5×10^{-5} m/s	5.2×10^{-5} m/s
	e) Critical particle size for 10 year event	.007 mm (fine silt)	.005 mm (fine silt)	.009 mm (fine silt)
	f) Sediment storage capacity (above a minimum of 10 hours retention time)	67,500 m^3	20,200 m^3	107,000 m^3
3.	**Design Features**	- roughing pond to remove coarse silt and sand	- baffle dyke to improve length/width ratio	- 5:1 length to width ratio
		- baffle dyke to improve length/width ratio	- pipe arch culvert spillway with rip rap stilling basin	- economical rock weir spillway
		- economical rock weir spillway		- roughing pond

* 200 year flows estimated for a drainage area of 572 ha.

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the main Bullmoose valley. Consequently dykes were designed to protect the plantsite, the sedimentation ponds, and the tailings pond. These dykes, constructed of compacted native materials, were armoured with quarried rock riprap which was installed to a level below the scour depths of the creeks. Similarly the plantsite bridge across Bullmoose Creek was designed as a single span with adequate clearance for the predicted floodwaters and floating debris. The bridge abutments were also extensively armoured with riprap material.

The construction work required for all of these facilities was performed during low flow periods and specified "time windows" which avoided seasonal fish spawning periods. Thus direct contact with the creek was prevented, and any impact on the adjacent fishery resources was minimized.

Operation and Performance of the Ponds

Ponds No. I and 2 were completed and operational in the fall of 1982. It must be emphasized that the design criteria adopted is firstly intended to treat runoff from the ultimate area of disturbance (1996 mine area) and secondly, is intended to accommodate large storm events which may occur during the spring snowmelt period or early summer. The flows during 1983 were low due to the limited area draining to the ponds and the absence of a significant freshet or major storm event. Hence no positive discharge occurred from either pond, as the exfiltration capacity was sufficient to process the entire inflow volume.

Pond No. 3 was completed in the late fall of 1983 and hence has limited operating data. Similar to the other two ponds, the entire inflow is initially expected to exfiltrate to the adjacent ground water table.

Conclusions

The Bullmoose Mine Surface Water Management plan was successfully implemented by first following a strategy of preserving the natural stream conditions and secondly, designing appropriate structures for the control and treatment of surface drain age prior to discharging water to the adjacent creeks. The design of the components of this system was based on a limited knowledge of post startup conditions with respect to detailed mine layout, the runoff response from developed areas, expected sediment yields and sediment settling characteristics. Downslope drainage is economically conveyed to sediment ponds either through stable natural channels or through a rock drain located in the base of a major waste dump. Flood protection dykes were installed to control flood waters in Bullmoose and West Bullmoose Creeks and to protect the adjacent plantsite facilities.

Implementation of this water management plan will ensure that erosion losses are minimized and sediment discharges are controlled, thereby preventing removal of the basic resource material necessary for a successful land reclamation program.