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RESLOPING COAL MINE SPOILS AT THE FORDING RIVER OPERATIONS

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INTRODUCTION

Fording Coal Limited operates the Fording River Operations coal mine located in southeastern British Columbia, Canada. The mine site, as shown in Figure 1, is within the medial range of the southern Canadian Rocky Mountains, approximately 136 km north of the United States - Canadian border, and 6 to 12 km west *of* the British Columbia - Alberta provincial border.

The Fording River Operations produces an average of 4 million tons of cleaned coal per annum, primarily for export to Japan. Both thermal and metallurgical coal are produced at the minesite. Mining operations commenced in 1972 and are carried out on a continuous basis. The operations employ both truck/shovel and dragline mining techniques in multiple seam pits. Total material moved annually is approximately 42.6 million bank cubic metres (BCM) of waste and 6.0 million BCM of raw coal.

This report summarizes the rationale and background with respect to resloping spoils at the minesite and describes the spoil resloping project carried out in 1984 in the South Greenhills spoil area.

RATIONALE AND BACKGROUND

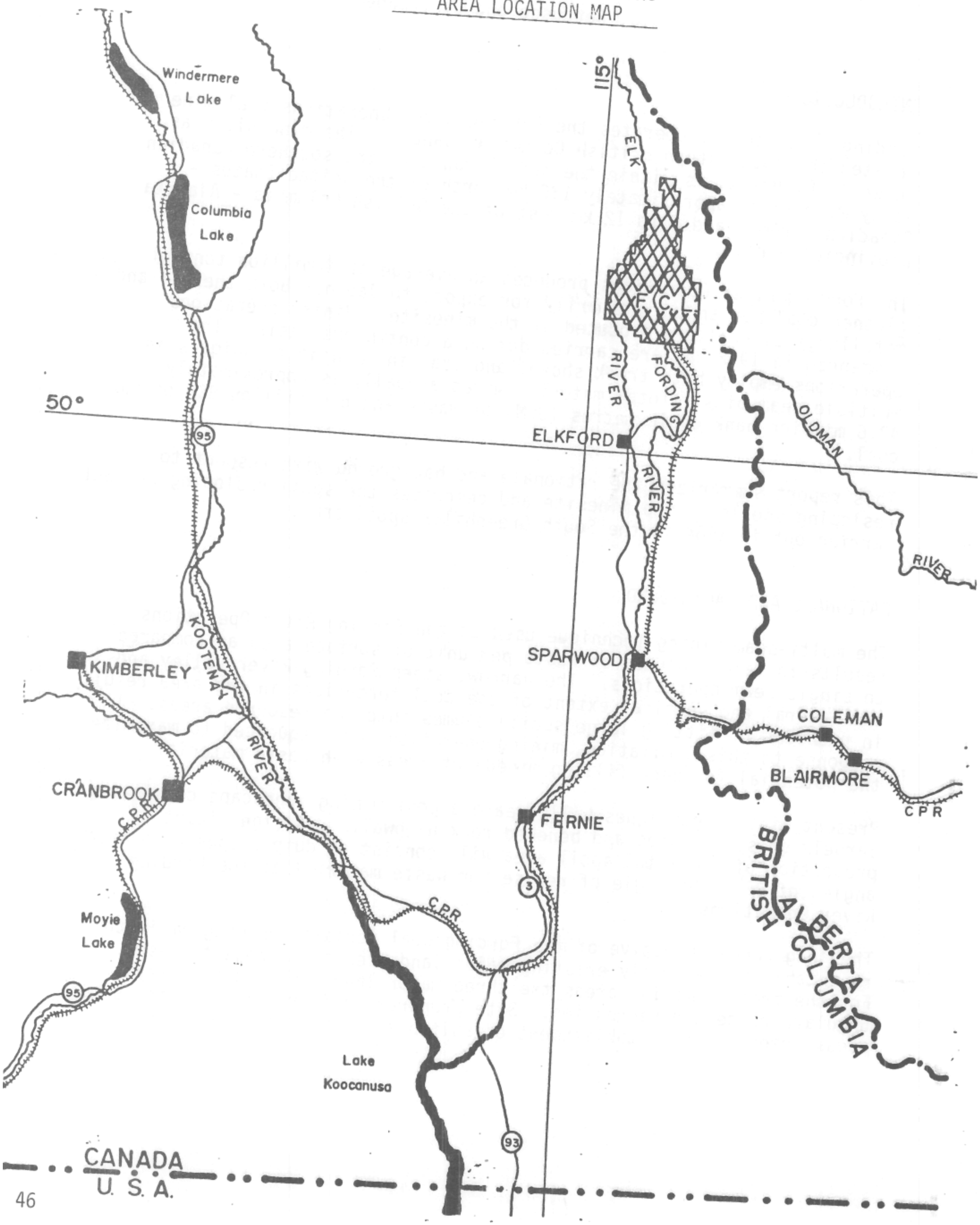
The multi-seam mining technique used at the Fording River Operations results in large volumes of waste per unit of surface area as compared to single seam operations. The narrow, steep Fording River Valley and the lateral and vertical extent of the coal formations in the area result in problems of fitting large spoil volumes into non-resource areas. In response to this limitation, mining operations are sequenced to maximize the potential for back-filling mined-out areas with waste material.

Present mining techniques will create a post mining landscape consisting largely of spoil dumps and benched rock highwalls. A significant proportion of the total spoil area will consist of dump slopes with face angles of 37 , the angle of repose for waste material at the Fording River Operations.

The long range objective of the Fording Coal reclamation program is to re-establish previously existing major land-uses on a property basis. For the present mining areas the three major land-uses are forestry, ungulate range and recreation. Site preparation is required on the spoil areas prior to the establishment of suitable vegetation to achieve the

FIGURE 1

FORDING RIVER OPERATIONS
AREA LOCATION MAP



proposed post-mining end land-use. Spoil dump tops are ripped to break compaction, where necessary, and regraded to smooth the contours. Spoil dump slopes are generally resloped to reduce face angles from 37° to an angle more suitable for revegetation. Lower portions of waste rock slopes are characterized by large boulders and the absence of fines necessary to support plant life. Resloping spreads the fine waste material (mudstones and shales), which accumulates in the crest region of the dump, over the whole dump face, thus improving the physical characteristics of the lower spoil faces to aid in revegetation. Resloping the dump face also allows for revegetation activities such as tree and shrub planting which require personnel to work on the dump face.

The present guidelines for the reclamation of coal mine spoils in B.C. suggest that the final slope of waste dumps shall be 27°. Currently, all the waste dumps at the Fording River Operations have been designed for resloping to 26 and 28 . Resloping to face angles that are as steep as practical has several benefits at the Fording River Operations. The area of land required for waste disposal and the costs of mining and reclamation can be reduced. In addition, the steeper face angles are more desirable for reclaiming to ungulate winter range.

In 1977, pilot-scale waste dump slopes were constructed with varying angles and aspects on the Turnbull and Greenhills spoils to determine optimum reslope angles. Slope angles ranged from 24° to 34°, slope aspects varied from NW through W to SW on Turnbull and NE through E to SE on Greenhills, and slope face lengths ranged from 16 m to 64 m on Turnbull and 16 m to 50 m on Greenhills. The slopes at both sites were fertilized and seeded to a grass-legume mixture in October, 1977. The test sites have been monitored yearly beginning in 1978.

The observations to-date on both test sites have indicated that the erosion on waste rock slopes is minimal. Surface slopes at angles exceeding 26 were not unstable or more prone to rill erosion. Surface runoff from resloped waste rock slopes was negligible. Waste rock slopes generally have a loose, open structure. The resultant high infiltration rate minimizes surface runoff during rainstorms and spring snow melt.

The assessment of vegetative growth to-date has indicated that slope steepness influences density, composition and productivity of vegetation on regraded spoil dumps. In general, vegetative cover and grass cover decreased as slopes increased in steepness while legume cover, legume content and biomass increased. However, it remains obvious that a plant community of agronomic grass and legume species can establish and sustain satisfactory growth and cover on mine waste slopes as steep as 32° to 34° .

1984 RESLOPING PROJECT

In 1984, operational resloping of the Greenhills spoil was started at the southern end. A total of 5.6 hectares of spoil face was resloped during the period of July to September 1984 and December to early January 1984-85. The layout of the completed dump is shown in Figure 2. The dump has two levels with average heights of 75 m and 110 m. There are no berms on the completed slopes, with the result that there are two face lengths, 190 m and 255 m. The in-situ volume of spoil moved during the project was 141,000 cubic metres. The total dozed volume was in excess of 260,000 cubic metres.

The original design for res loping the dump was to res lope the dump to face angles of 28° and 30° in order to compare the performance of various dozers and the construction costs for these two face angles. The 30 slope was dropped from the design during the project because of field results. The maximum sloge that the tracked dozers were able to construct was 30° . However, 28° was the reclaimed slope that the dozers were able to construct consistently. It was not possible to sustain the 30° slope angle as the resloping progressed down the dump face largely due to the increasing content of coarse rock in the spoil material in going from the top of the dump downward. The greater the content of coarse rock (0.3 m plus diameter fragments), the more difficulty the dozers had backing up the slope.

Five different tracked dozers were used during the project. Table 1 lists these dozers and gives some of their general specifications as an indication of their relative capabilities. The method used to reslope the spoils is illustrated schematically in Figure 3. The spoil is moved in successive layers or slices beginning at the top of the dump and progressing downwards. The dozer used a slot dozing technique, pushing downhill at an optimum grade (approximately 5%) to the edge of the spoil. The last cut for each slice is made at the reslope angle which requires the dozer to be able to back up the resloped face above the slice. This method is used until the total push length becomes too short for the dozer to operate. Generally this occurs close to the bottom of the spoil where the dozer can push downhill at the reclaim angle to complete the resloping process.

The project required 731 hours of dozer time, with 517 hours spent actually resloping. A total of 42 hours of dozer time was required for access construction, site leveling for surveying and other miscellaneous work related to the project. This results in an efficiency equivalent to 46 minutes of work per hour of charged dozer time. The cost per total dozed volume for the project was $\$.30/m^3$. The project cost on an area basis was $14,157/ha ($5,728/acre).

The productivities and cost effectiveness of the dozers were found to be variable (Table 2). The average productivities for the various dozer types ranged from 362 m^3/hr for the D9H to 898 m^3/hr for the Dl0. The maximum measured productivity achieved with any dozer was the Dl0 where one trial gave a productivity of 1,127 m^3/hr. The average cost per cubic metre of material dozed ranged from a high of $.29 for the D9H to a low of $.13 for the Dl0. It should be noted that these costs and productivities are calculated on the basis of dozer hours actually spent resloping and not the total dozer hours actually spend resloping and

TABLE 1

MAKE, MODEL AND GENERAL SPECIFICATIONS OF THE CRAWLER-TYPE TRACTORS USED IN THE 1984 SPOIL RESLOPING PROJECT[1]

MAKE	MODEL	RATE HP (FLYWHEEL)	BLADE TYPE	BLADE CAPACITY(m^3)
Caterpillar	D8L	335	U	13.6
Caterpillar	D9L	460	U	18.29
Caterpillar	D10	700	U	29.07
Caterpillar	D9H	410	U	14.5
Komatsu	D355A	410	U	23.7[2]

1 - Information taken from manufacturers' handbooks.

2 - Fording Coal Limited's units have blade extensions to give this capacity. The blade capacity for this model reported in the manufacturer's handbook is 16.7 m^3.

TABLE 2

1984 RESLOPING PROJECT
DOZER PRODUCTIVITIES AND COSTS[1]

DOZER TYPE	AV. TOT. M^3 DOZED/HR (RANGE)	AV. $/TOT. M^3 DOZED
D8L	412[2]	.26
D9L	718[3] (635-800)	.15 (.17-.13)
D10	898 (741-1127)	.13 (.16-.10)
D9H	362 (314-409)	.29 (.34-.26)
D355A	516 (390-642)	.21 (.27-.17)

1 - The cost and productivities are calculated on the basis of dozer hours actually spent resloping and not the total dozer hours charged to the project.

2 - These results based on only 20.5 hours of resloping.

3 - The higher productivity rate based on only 4.5 hours resloping under ideal resloping conditions at the start of cutting the original dump.

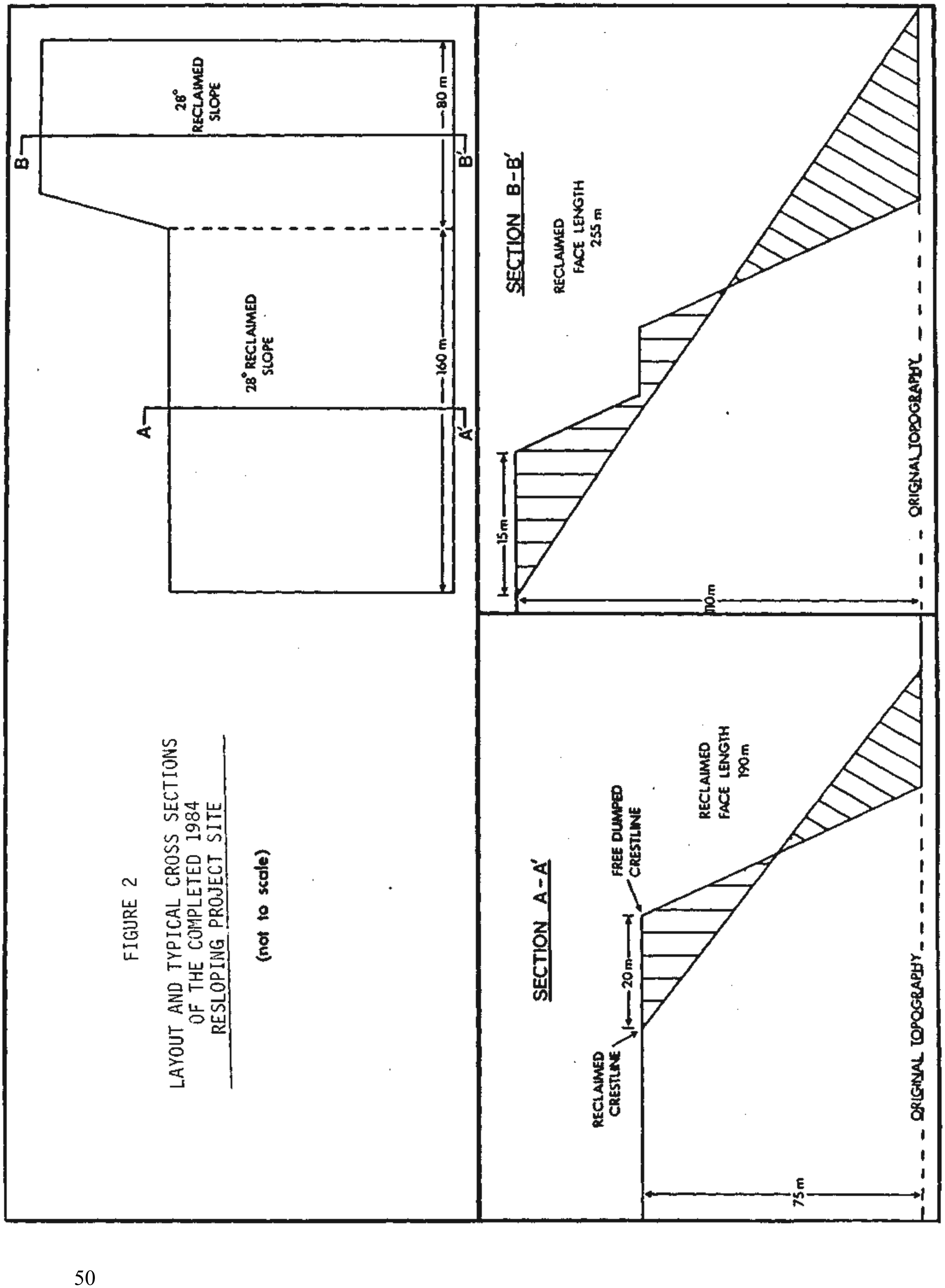


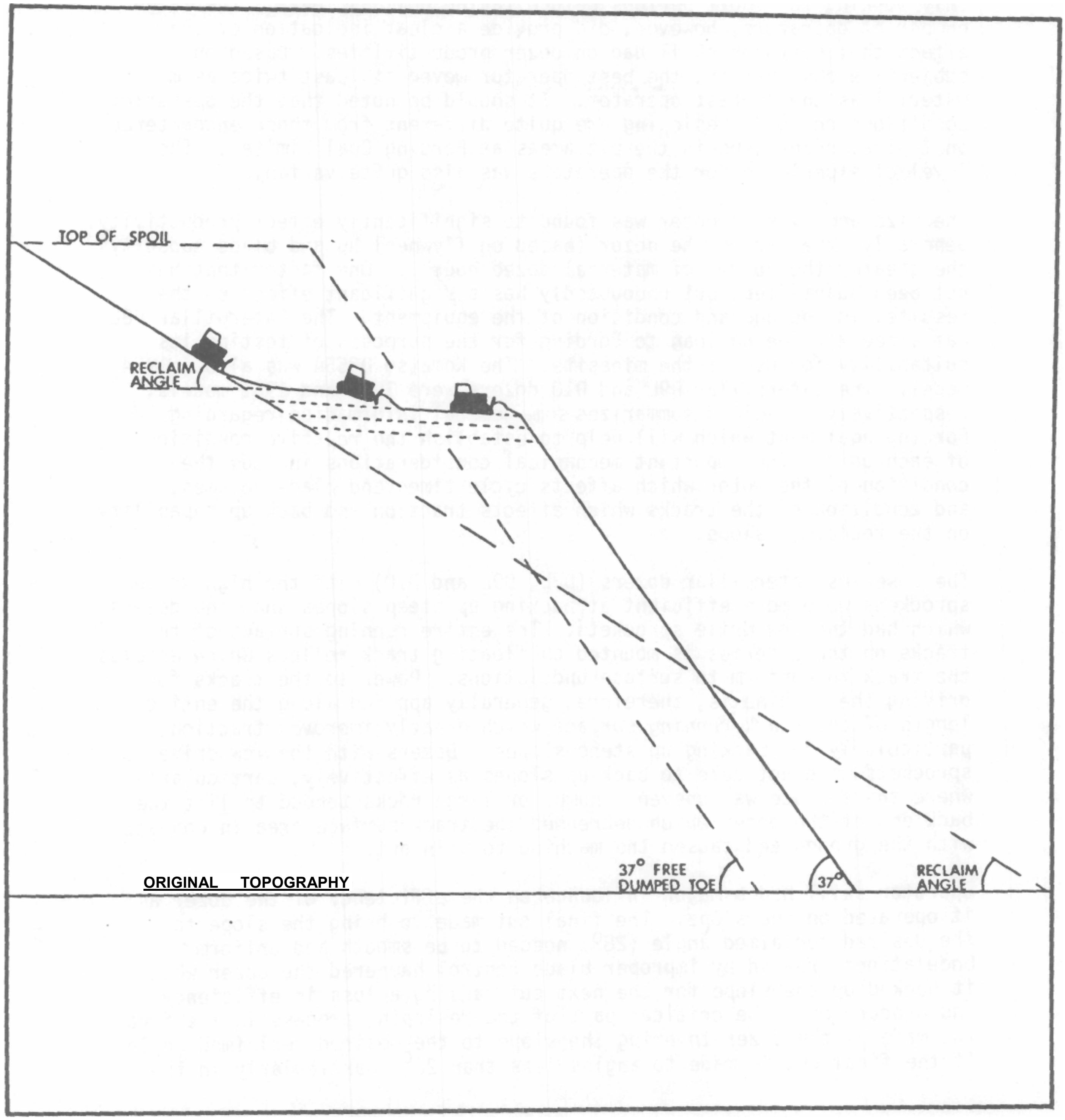
FIGURE 2

LAYOUT AND TYPICAL CROSS SECTIONS OF THE COMPLETED 1984 RESLOPING PROJECT SITE

(not to scale)

FIGURE 3

SCHEMATIC DRAWING OF RESLOPING TECHNIQUE USED IN THE 1984 RESLOPING PROJECT UN THE GREENHILLS SPOIL



and not the total dozer hours charged to the project.

The data in Table 2 show large ranges for the productivities of the various dozers. These differences are largely related to operator efficiency, the type of dozer and the spoil material being dozed. During the month of July, when the project was half completed, 15 different dozer operators worked on the project. This large turnover of operators was due to the fact that July was a vacation shutdown and operators were only working for short periods before taking holiday leave. The large number of operators, however, did provide a clear indication of the effect that operator skill had on dozer productivities. Based on subjective observation, the best operator moved at least twice as much material as the poorest operator. It should be noted that the operating conditions on spoil resloping are quite different from those encountered on typical dozer jobs in the pit areas at Fording Coal Limited. The level of experience for the operators was also quite variable.

The size and type of dozer was found to significantly effect productivity. Generally, the larger the dozer (based on flywheel hp and blade capacity), the greater the volume of material dozed hourly. One factor that has not been quantified, but undoubtedly has a significant effect on the results, is the age and condition of the equipment. The Caterpillar D8L was *a* new machine on loan to Fording for the purposes of testing its suitability for use at the minesite. The Komatsu D355A was also a 1984 model. The Caterpillar D9L and D10 dozers were 1983 and 1981 models, respectively. Table 3 summarizes some general information regarding the Fording equipment which will help to establish the relative condition of each unit. The important mechanical considerations include the condition of the motor which affects cycle times and blade volumes, and condition of the tracks which affects traction and back up capability on the reclaimed slope.

The L series Caterpillar dozers (D8L, D9L and D10) with the high drive sprockets were more efficient at backing up steep slopes than the dozers which had the low drive sprockets. The entire running surface of the tracks on the L series is mounted on floating track rollers which enables the track to conform to surface undulations. Power to the tracks for driving the machine is, therefore, generally applied along the entire length of the track running surface which greatly improves traction, particularly for backing up steep slopes. Dozers with the low drive sprockets were not able to back up slopes as effectively, particularly where the surface was uneven. Humps or large rocks tended to lift the back end of the dozer which decreased the track surface area in contact with the ground and caused the machine to spin out.

Operator skill had a major influence on the efficiency of the dozer as it operated on the slope. The final cut made to bring the slope to the desired reclaimed angle (28°) needed to be smooth and uniform. Undulations created by improper blade control hampered the dozer when it backed up the slope for the next cut causing a loss in efficiency and production. The critical part of the resloping process is the cut made by the dozer to bring the slope to the desired reclaimed angle. If the final cut is made to angles less than 28^{U}, particularly in the

TABLE 3

HOURS AND CONDITION (AS OF JULY 1, 1984)
OF FORDING COAL LIMITED'S TRACKED DOZERS
USED IN THE 1984 SPOIL RESLOPING PROJECT

DOZER TYPE	UNIT NUMBER	CONDITION AND HOURS ON ENGINE	CONDITION AND HOURS ON TRACKS
D355A	98060	new unit*	
	98062	new unit*	
D9H	98005	441 hours on engine; 100% of power	2964 hours on tracks and frames; 90% wear left
	98009	6041 hours on engine; 25% of available life left	3986 hours on tracks and frames; 80% wear still left
D9L	98040	7561 hours on engine; 25% of its available life left	7561 hours on tracks and frames; tracks due for regrousering
D10	98050	2832 hours on engine; 80% of its available life left	616 hours on tracks and frames; 100% of wear still left
	98051	3600 hours on engine; 75% of its available life left	4306 hours on tracks with 35% wear left; 2797 hours on frames with 80% wear left

*units purchased subsequent to July 1, 1984. Were in new condition when used on the project.

upper cuts, then the volume of fill material will be reduced with the risk that dozers will not be able to complete the resloping process.

A balanced cut/fill design was used to determine the distance back from the 37° dump crest where the dozers would start resloping to construct the reclaimed slope (Figure 2). The line where the dozers started cutting forms the crest for the reclaimed slope (reclamation crest) and it is parallel to the free-dumped (37°) crestline. During this project, the actual constructed reclamation crest was behind the design crest which gave the advantage of having extra material which made up for material lost for portions of the slope which were constructed to an angle less than 28°. A disadvantage to this was the extra costs incurred by having to move the extra material. Further testing is required to determine the amount of extra material which should be added to the balanced cut/fill design to provide an adequate buffer to ensure that the dozers can complete the resloping process.

The use of vertical panels along the spoil to carry out the resloping process is not the most effective method. When the dozers finished the first panel and began resloping the adjacent panel, spoil material spilled over onto the first panel necessitating reworking of the completed slope. Also, significant dozer time was required to maintain access to the dozer's working pad. Future resloping programs will start at the highest point of the dump arid work down, resloping the whole face of the dump.

SUMMARY

Resloping of spoils at the Fording River Operations will generally be required in order to establish suitable vegetation to meet end land-use objectives. Field trials at the minesite have indicated that spoil slopes from 260 to 34° can be satisfactorily revegetated with agronomic grasses and legumes. The spoil resloping project carried out in 1984 at the minesite indicated that the maximum reslope angle that tracked dozers can economically construct is 28°. Resloping costs on a total project basis were $14,157/ha ($5,728/acre) or $.30 per m3 on a total dozed volume basis. The range of costs for the dozers was between $.10/m3 and $.34/$m^3$ depending on the type, size and condition of the machine and operator skill.