SELECTIVE HANDLING COSTS FOR STRIP MINE RECLAMATION

BY

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ABSTRACT

One of the major tasks facing the coal mining industry today is dealing with environmental concerns. The requirement of selectively handling topsoil and subsoil for reclaiming plains strip mines is causing significant expenditures in overall mining costs. CMRC has developed a report to provide a reference for industry and government that outlines the technical feasibility and comparative costs for six major methods of selective materials handling. Specific systems covered include dragline, scraper/dozer, shovel/truck, bucket wheel excavator/truck, BWE/cross-pit conveyor and BWE/round-the-pit conveyor. Evaluations are based on removal and placement of layers 1, 2 and 3 metres deep.

INTRODUCTION

A number of coal strip mines in western Canada are located in areas where the surficial geology includes problem soils. One of these is sodic soil. Sodium adsorption and migration cause problems with revegetation when these materials remain at the top of the reconstructed soil profile. To aid in reclaiming such areas, the sodic material, after being graded to the approximate final land contours, is covered with sodic-free soils to provide a suitable rooting medium for vegetation re-establishment. These soils usually are obtained from the upper portion of the original soil profile.

Since draglines are still the most common primary stripping machines used in plains surface coal mines, this non-sodic material must be removed before the dragline excavates the rest of the overburden, otherwise it will be lost at the bottom of the spoil piles. Research is still inconclusive as to what the required depth of cover should be. Therefore, three depths were chosen for evaluation: 1, 2 and 3 metres.

This paper is a summary of the original study done by CMRC. The economics of handling those depths using six alternatives are presented here, and in greater detail in the original report.

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APPROACH TO THE STUDY

The study took into account conditions normally encountered in the Ardley coal zone of Alberta. However, since the major part of the work was concerned with only the top 3 metres of material, the results of the investigation should apply to any strip mining operation in the plains. Cost analyses which follow are simplified to a certain degree. True economics can only be evaluated on a site-specific basis. Since no particular site was being studied and since the study concentrated on the top few metres only, some parameters are very important, while others are less critical.

Pit Configuration/Material Properties

For the purposes of the study the following parameters were chosen as being typical of a western Canadian plains coal surface mine.

Coal production :	2 million tonnes/year
Coal density :	1.3 tonnes/m³
Seams :	one, 2.7 m thick
Coal recovery :	85%
Land area required :	67 hectares (ha)

Coal recovery and seam thickness obviously have an effect on the amount of land area to be stripped annually. This one fact alone, means that any of the figures which follow will be specific to this particular site, and not necessarily applicable to any others. Pit parameters were chosen as follows:

Total overburden depth :	17.2 m
Pit width :	35 m
Pit length :	3.7 km
Highwall angle :	60°
Spoil angle :	37°
Overburden density :	2145 kg/m³ (bank)
Overburden swell factor :	30%

From these sets of values the quantities of overburden to be moved annually are as follows:

Total overburden volume :	11,500,000 bank m³ OR 15,000,000 loose m³
Overburden volume/m of depth :	670,000 bank m³/year

Operating Schedule

The amount of time that was available in which to operate equipment during the year was calculated as follows:

Hours/shift	: 7.5
Shifts/day	: 3
Days/week	: 7
Weeks/year	: 50
Scheduled Hours/year	: 7875

Deductions for weather and equipment availability must also be allowed for:

Weather factor	: 0.9 (10% lost time)
Equipment availability	: 0.8

This results in 7875 x 0.9 x 0.8 = 5670 operating hours per year.

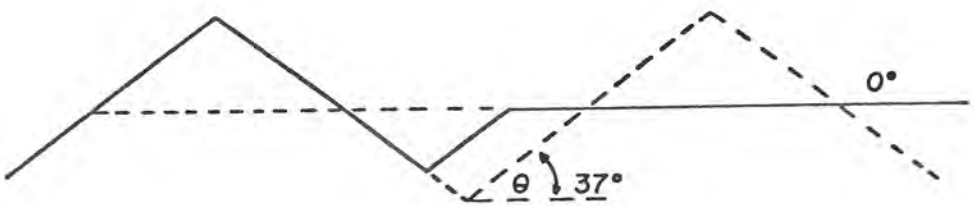
Labor rates/Costs

All equipment operators and oilers were paid at $17/hour with the exception of dragline and bucket wheel/cross-pit conveyor operators who were paid $20/hour.

SPOIL GRADING

Before any selective handling can be done, the raw spoil must be levelled to the approximate final contour. Two slopes were chosen: 0° and 10°, as shown in Figures 1 and 2. The work was done using two dozers of the sizes represented by a Cat D8K and Cat D9L. Hourly rates of $82.33 for the D8 and $119.54 for the D9 (including operator) were used. The quantities of earth moved and costs for each configuration are shown in Table 1.

0° SLOPE FINAL GRADE

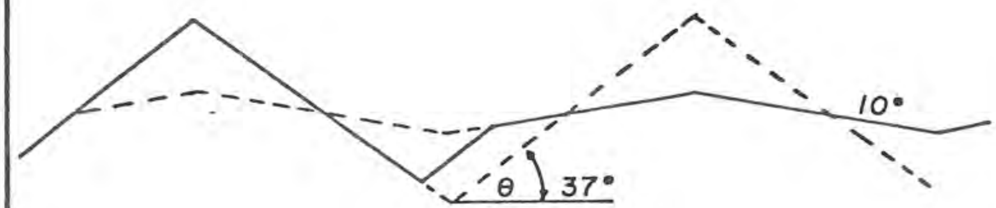


ANNUAL VOLUME : 1.109×10^6 m^3

		D8	D9
ANNUAL TIME (hrs)	:	1572	1027
COST ($/ha)	:	1945	1841

FIGURE 1

10° SLOPE FINAL GRADE



ANNUAL VOLUME : 0.858×10^6 m^3

		D8	D9
ANNUAL TIME (hrs)	:	1366	891
COST ($/ha)	:	1680	1589

FIGURE 2

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TABLE 1

SPOIL GRADING REQUIREMENTS AND COSTS

		FINAL SLOPE	
		0°	10°
Annual volume * (lm³)		1,109,000	858,000
Annual time (hr)	D8	1572	1366
	D9	1027	891
Unit cost ($/lm³)	D8	0.27	0.13
	D9	0.11	0.12
Cost ($/ha)	D8	1945	1680
	D9	1841	1589
% increase (0° over 10°)	D8	16	-
	D9	16	-

*Based on a yearly stripped area of 67 ha (lm³ = loose cubic metres)

DRAGLINE

The dragline chosen to meet the total annual stripping requirement was one equivalent to a BE 2570W using a 79 m³ bucket and a 102 m boom with an operating radius of 100 m. A range diagram for this configuration is shown in Figure 3. This particular dragline has the ability to handle a yearly volume (based on 6000 operating hours) of 14,740,000 bank m³ or a depth of 22 m in this case. The 17.2 m depth shown would require only about 4750 hours, and when handled exclusively by the dragline is considered a base case in this study. The costs associated with any selective handling of the 17.2 metres will be compared to this base cost. Included with the dragline in the base costs is a dozer equivalent to the size of a Cat D8K. This machine would be used for pad preparation, clean-up etc.

The total cost for the dragline and dozer to excavate the 17.2 m depth of overburden over 67 ha is about $8,093,000 or approximately $120,800/ha. As some of the overburden is taken away from the dragline by some other means (e.g. scrapers) the cost per loose m³ increases slightly, but the volume decreases. This concept of taking material away from the dragline when it has the capacity to handle the material, thus increasing unit costs, is used later when cost comparisons of the various handling systems are made. The dragline and dozer total costs (ownership and operating) for the depths under consideration are given in Table 2.

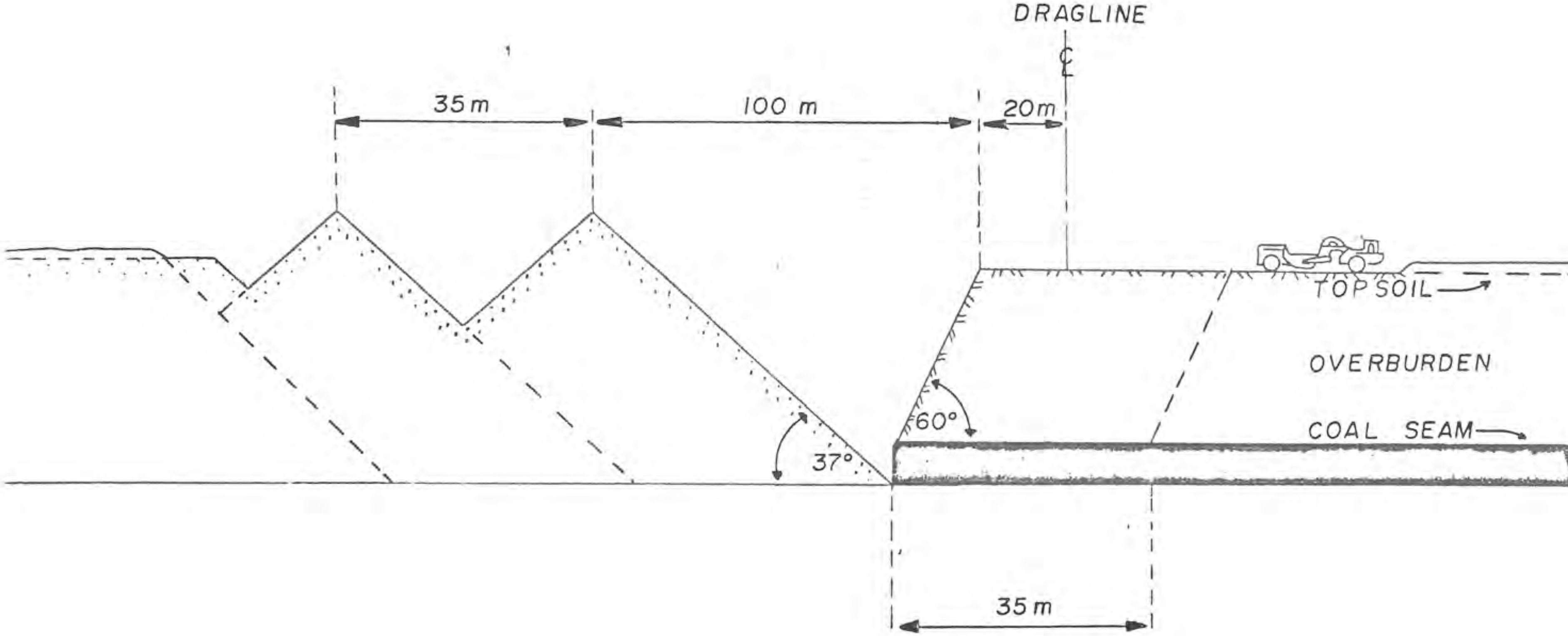


FIGURE 3
BASE CASE for DRAGLINE MINING

*note: N.T.S.

TABLE 2

DRAGLINE/DOZER
OWNERSHIP AND OPERATING COSTS

DEPTH (m)	VOLUME (bm^3)*	TOTAL COST ($ / year)	UNIT COST ($/$bm^3$)	COST ($ / ha).
17.2	11,538,000	8,093,000	0.70	120,800
16.2	10,868,000	7,906,000	0.72	118,000
15.2	10,197,000	7,720,000	0.76	115,200
14.2	9,526,000	7,535,000	0.79	112,500

* bm^3 = bank cubic metre

SELECTIVE HANDLING SYSTEMS

The choice of equipment for selectively handling topsoil and subsoil may be determined by the equipment already on site for an existing operation. Reducing the number of different types of equipment has advantages. The need for flexibility for other uses may also be important. Planning a new operation has the benefit of allowing for such special measures from the beginning and may allow a wider choice of methods, particularly before the primary stripping machine has been selected. Having a dragline in place might preclude the choice of a BWE/conveyor system since such a method would probably require the system to also remove a large part of the overburden to be economically feasible. The usual factors of nature of the overburden, life and production rate of the operation, the geological structure, size and distribution of the coal deposit, topography, etc. must all be considered. Since no two mines are identical, the equipment selected for one site may not be the best choice for another.

The capital investment required is another major factor. The method having the lowest cost per cubic metre may not be the ultimate choice if the investment required is such that cash flow or financing is not suitable. The discussions that follow are a brief summary of the detailed descriptions and costs provided in the original study.

Scraper/Dozer System

The capability of scrapers to selectively remove and place different materials is relatively good. They are versatile, highly mobile machines that can be used for road construction, parting removal, coal cleaning, removal and stockpiling of topsoil and recontouring raw spoil to a finished grade.

They have drawbacks as well. In wet conditions, spreading thin, even lifts of material becomes almost impossible. Rutting is also a problem.

Compaction of the placed materials, particularly clayey soils can create revegetation problems. Congestion of the site if a large number of units are used may arise. Costs increase as haul distances increase, and ramps or bridges may be needed to reduce overall cycle times.

Three scrapers were evaluated equivalent to the Cat 627B, 637D and 657B. The following factors were applied in calculating production:

Haul distance 2.1 km

Effective grade 4%

Fill factor 0.9

Teamed with the push-pull scrapers were the following push dozers:

627B/1-D8K

637D/1-D9L

657B/2-D9L's

Included with scraper fleets of three units or more were a water truck and grader for road maintenance. All calculations were based on 5670 hours of operation per year. Any excess time not required for the selective handling job was assumed to be used productively elsewhere on the site.

Table 3 shows the lowest ownership and operating costs of the three scraper models. The selective handling cost is lower than the total earthmoving cost for each incremental depth (1 m, 2 m, 3 m). This reflects the fact that although the scrapers are selectively handling that particular depth of material, not all of that work is selective handling, since the overburden is also being mined for the purpose of obtaining coal and part of the cost must be attributed to that activity. For example, when 3 m is removed by scraper, this leaves 14.2 m for the dragline. From Table 2, the dragline cost for 14.2 m is $112,500/ha. From Table 3, 3 m by scraper costs $45,600/ha for a total cost of $158,100/ha for the 17.2 m. The dragline could have handled the entire 17.2 m for $120,800/ha (Table 2) so the additional cost of $37,300/ha (158,100 - 120,800) is attributed to selective handling.

TABLE 3

SCRAPER SELECTIVE HANDLING COSTS

DEPTH (m)	LOWEST EARTHMOVING COST ($/bm³)	LOWEST EARTHMOVING COST ($/ha)	SELECTIVE HANDLING COST ($/ha)
1	1.63	16,300	13,500
2	1.38	27,600	22,000
3	1.52	45,500	37,300

Truck/Loader System

A truck/loader or truck/shovel system can also be used to remove and selectively place materials. Segregation of materials is reasonably good, particularly with the loader as the excavator. Again the equipment is versatile and highly mobile. The higher loading times and problems with traction in wet weather may be of some concern.

Three loader/truck combinations were studied, as well as one shovel/ truck combination. There were represented by the following:

LOADER		TRUCK	
Model	Size (lm^3)	Model	Size (lm^3)
980C	4.0	769C	23.5
988B	5.4	773B	34.1
992C	10.3	777	51.3
D241	14.0	120C	67.0

The maximum and minimum earthmoving costs are shown in Table 4. The selective handling cost is derived in the same fashion as for the scraper operation.

TABLE 4

TRUCK/LOADER COSTS

DEPTH (m)	EARTHMOVING COST ($/bm³)	($/ha)	SELECTIVE HANDLING COST ($/ha)
1	1.34 (min)	13,400	10,600
	1.85 (max)	18,500	15,700
2	1.34	26,800	21,200
	1.64	32,800	27,200
3	1.34	40,200	31,900
	1.64	49,200	40,900

The shovel/truck combination had the capacity to remove about a 7 m depth of overburden for each shovel. At that rate the costs for 1, 2 and 3 metres are shown in Table 5. As before, it was assumed that of the total time available during the year, any excess time over that required for the selective handling task would be spent productively elsewhere on the site. Otherwise, costs will be somewhat higher than shown. A dozer and auxiliary equipment are also included.

TABLE 5

SHOVEL/TRUCK COSTS

DEPTH (m)	EARTHMOVING COST ($/bm³)	($/ha)	SELECTIVE HANDLING COST ($/ha)
1	0.91	9,100	6,300
2	0.91	18,200	12,600
3	0.91	27,300	19,000

Bucket Wheel Excavators

Bucket wheel excavators (BWE's) are still unproven in western Canadian coal mines. When used as part of a major stripping operation, BWE's can be utilized at their full potential. A BWE has a number of advantages. It is usually smaller than a comparable shovel or dragline of equal production capability. The BWE digs continuously which means no cycle times and lower instantaneous power requirements. Thin layers such as topsoil would need to be windrowed for the wheel to pick up the material efficiently. The BWE is not versatile or very mobile, and extremely hard materials may be difficult to handle without ripping or blasting.

Three wheels were evaluated with capacities from 3 to 8 million loose cubic metres per year. These were represented by Weserhutte models SR250, SR400, and SR 630. Some means of removing material from the BWE must be provided, which, unlike the dragline, cannot cast spoil material back far enough. Three methods were examined: trucks, cross-pit conveyors, and round-pit conveyors. Using trucks matched to BWE production, costs were found to be as follows:

Depth : 3 m

Unit cost : $1.34 to 1.60/bm³

Earthmoving cost : $40,200 to $48,000/ha

Selective handling cost : $31,900 to 39,700/ha

Conveyors

Two types of conveyor were evaluated - round-the-pit shiftable conveyors and cross-pit bridge conveyors. Adequate capacity for each

FIGURE 4
BWE/SHIFTABLE CONVEYOR SYSTEM for 1400 mm and 1050 mm BELT WIDTHS O & O COST vs. DEPTH

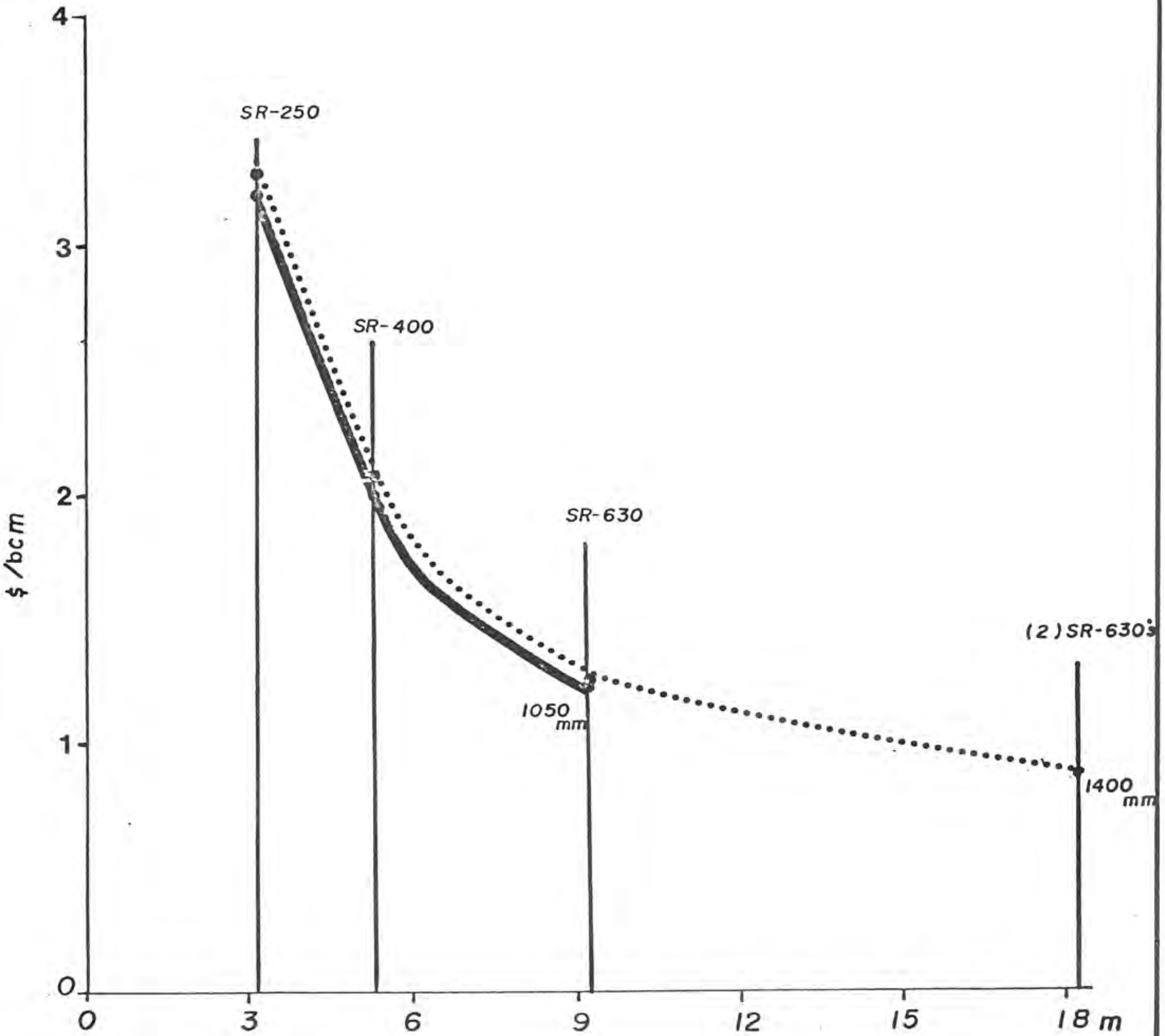
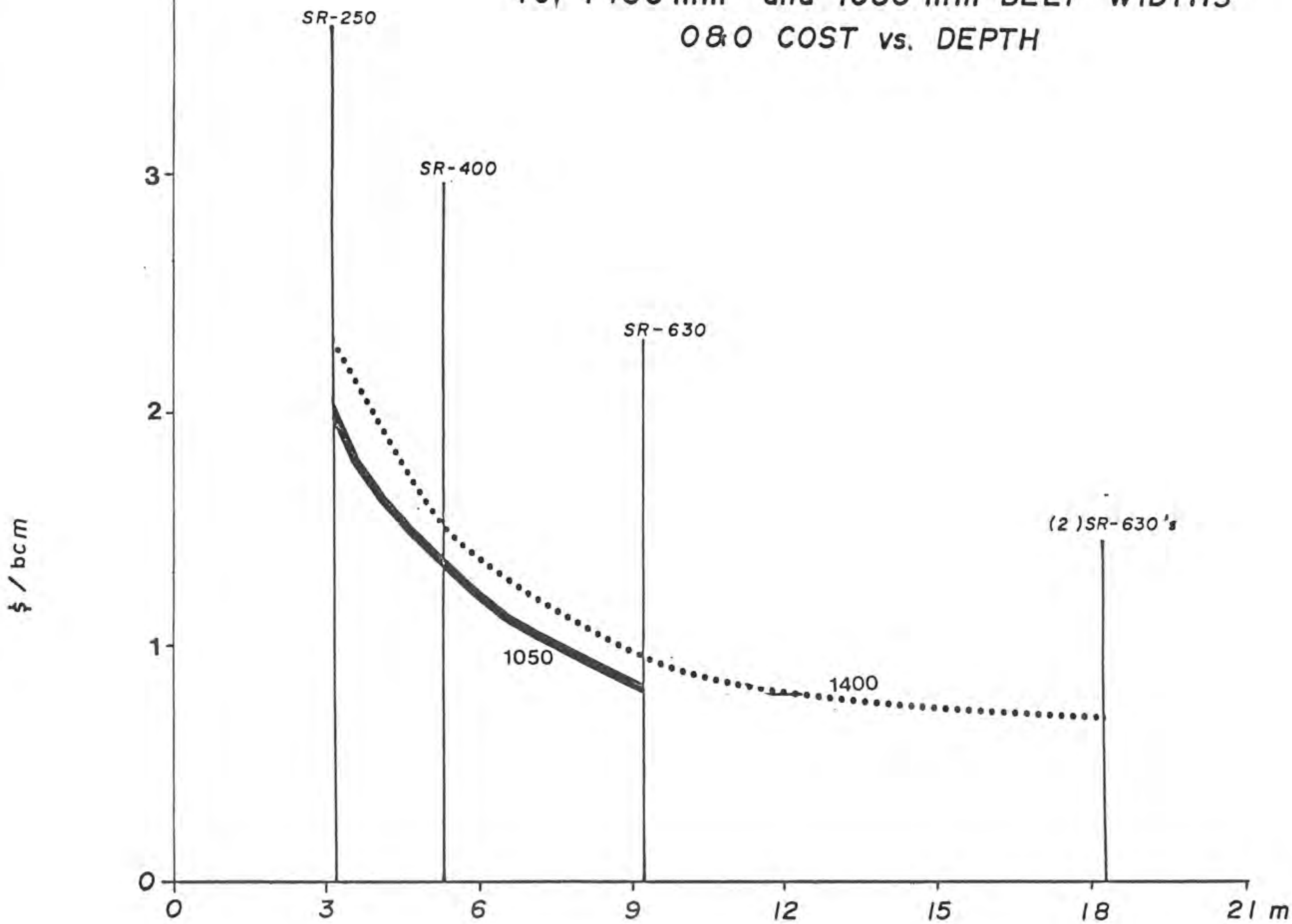


FIGURE 5
BWE / CROSS-PIT CONVEYOR SYSTEM
for 1400 mm and 1050 mm BELT WIDTHS
O&O COST vs. DEPTH



Cost to the Consumer

As a final note, it is interesting to examine how such costs might be interpreted. If the coal mining operation supports a thermal generating station, for example, the cost could be expressed as an increase in the price of electricity. Assume a typical power plant can generate and distribute 1500 kWh/tonne of coal. In our example of a single 2.7 m thick seam and an 85% recovery, about 29,835 tonnes/ha are available to fuel the plant. Using a selective handling cost of $37,300/ha for 3 metres results in an additional cost of $0.000833/kWh.

If an average residential consumer uses 7000 kWh annually, the increase in his electricity bill for this example would be about $5.83 per year. This does not include grading costs of $1900/hectare which would add another $0.30 per year. Varying coal seam numbers and thickness and different overburden depths can change these figures, but when expressed in this manner, the differences become negligible.

Conclusions

A number of different systems may be used for selectively handling topsoil and subsoil as an aid to reclamation. The methods used and costs incurred are site-specific and not necessarily applicable from mine to mine. Generally speaking, selectively handling thin layers with a dragline is not practical.

Scraper and truck/loader operations are reasonably well-suited to such tasks and may be the best choice for existing operations where a dragline is already in place as the primary excavator.

BWE/conveyor systems have a relatively high investment requirement and are, therefore, usually too expensive to operate as auxiliary equipment for handling topsoil and subsoil only. However, if such systems are brought in as the primary stripping machines, it may be possible to realize lower total costs overall for mining and selective handling, (particularly with the cross-pit conveyors) compared to the dragline system. Such BWE/conveyor systems are still unproven in western Canadian coal mines, however.

Acknowledgement

The original study, which outlines in detail the costs and productivities of the various alternatives, was financially supported by the Alberta/ Canada Energy Resources Research Fund; this support is gratefully acknowledged.

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PROCEEDINGS:

ALBERTA RECLAMATION CONFERENCE

Edmonton, 1982

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CANADIAN LAND RECLAMATION ASSOCIATION

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INTRODUCTION

Last Spring the Provincial Government's Reclamation Research Technical Advisory Committee presented a two day Reclamation Research Seminar at the Chateau Lacombe. We were surprised by the large turnout and an overwhelming majority of those in attendance indicated the desirability of an Annual Reclamation Conference for Alberta which would focus on Policy and Practice as well as Research and which would include industry, academic and government participation.

These were very sensible suggestions though their implementation would exceed the mandate and manpower of the Reclamation Research Technical Advisory Committee. So various groups were contacted to sponsor and help organize the Conference. Positive responses where received from the Canada Land Reclamation Association (CLRA) The Alberta Government's Land Conservation and Reclamation Council, The Coal Association of Canada and The Oil Sands Environmental Study Group (OSESG).

The CLRA authorized formation of an Alberta Chapter to serve as the umbrella organization with a Program Committee consisting of representatives of the Government and the two Industry groups. Through this Conference and perhaps other functions the Alberta Chapter of the CLRA can fulfill two important roles:

1. To provide an opportunity for members of the Reclamation community to meet, exchange experiences or argue and otherwise improve communications among its industry, government and academic factions.

2. To provide a public forum for reclamation activities, capabilities, issues and challenges.

This was the first function of its kind in Alberta. Special thanks are due the Sponsors, Speakers and the other Members of the organizing Committee: Jennifer Hansen, Malcolm Ross and Al Fedkenheuer. Their talents and efforts made the Conference a success.

One final word on the Speakers: they were given very short notice of the Conference and not only responded enthusiastically but prepared presentations which were of remarkable quality and consistency. We are fortunate to have individuals of this caliber working in the Field of Reclamation in Alberta.

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