IN-TRANSIT CONTROL OF COAL DUST
FROM UNIT TRAINS

by

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ABSTRACT

Effectiveness of chemical binders in controlling coal dust emanating from unit trains was investigated and monitored during 1974 and 1975. The parameters investigated included loading profile, type of chemical binder and spraying technique. A flat loading profile provided maximum retention of binder crust and simplicity of spray application. Oil products were the most effective binders. Almost equally effective were the oil and asphalt emulsions. Latex type chemicals formed brittle crusts that were easily fractured by torsional movement of the cars. A combination of simultaneous flooding and spraying was the most effective technique applied during the study. Coal trains from four mines were monitored for crust retention by measuring the percentage of crust cover remaining over the total car surface when the unit trains reached the terminals. Coverages of up to 95% were obtained; however, the crust coverages which most frequently occurred varied from 86% to 90%, 76% to 80%, 81% to 85% and 61% to 65%, depending on loading profile, type and concentration of chemical binder.

RÉSUMÉ

En 1974 et 1975, on a étudié et contrôlé l'efficacité de certains liants chimiques à éliminer la poussière de charbon se dégageant des trains intégraux. Les paramètres examinés comprenaient le profil de charge, le type de liant chimique et la technique d'arrosage. Le profil plat donnait à la croûte de liant une résistance maximale en même temps qu'il simplifiait l'application. Les produits huileux se sont révélés les liants les plus efficaces et les émulsions d'asphalte ont donné des résultats presque aussi valables. Les produits chimiques à base de latex formaient une croûte cassante que le mouvement de torsion des wagons brisait facilement. C'est le procédé combinant un jet de saturation et l'arrosage superficiel qui s'est révélé le plus efficace. En contrôlant les trains provenant de quatre mines, les techniciens ont mesuré l'adhésion de la croûte qui s'exprime en pourcentage de celle-ci demeurée intacte lorsque le train arrive à destination. Ils ont ainsi mesuré des couches protectrices intactes atteignant 95 p. 100 de la surface. Toutefois, les croûtes superficielles le plus souvent observées ont varié de 86 à 90 p. 100, de 76 à 80 p. 100, de 81 à 85 p. 100 et de 61 à 65 p. 100 en fonction du profil de la charge ainsi que du type et de la concentration du liant chimique.

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1 CONCLUSIONS

(a) Results of the field studies proved that some chemical binders offered an immediate and satisfactory solution to controlling coal dust emanation from en route unit trains.

(b) Coal Spray 100 and Reclamation Oil were the most effective products used to control dust, principally because their regenerative properties were capable of sustaining a cohesive crustal cover which overcame surface cracks caused by torsional stresses of moving rail cars.

(c) Oil emulsion (DS200) and asphalt emulsions (DS100) produced 85% crustal coverage, which met acceptable government and operating mining company criteria.

(d) Properly formulated latex binders used on horizontal surfaces were as effective as oil emulsions, but on sloped surfaces they were less efficient.

(e) The Study Committee had postulated that crustal deficiencies on irregular coal surface profiles may be overcome if increased spraying on sloped surfaces was applied by an improved spraying method. The field test and observed results did not substantiate this theory, particularly in the case of latex products. These compounds are brittle after the curing period and do not re-polymerize on the surface of the coal cars.

(f) Complete dust control depends on a spraying technique which provides complete and controllable spreading of the binder, adequate quantities and concentrations of applied chemical (gallons/car), the use of acceptable and readily available chemicals to the mining industry, and loading techniques which form flat loading profiles.

(g) Extensive monitoring confirmed that when latex products are used, crustal retentions of 85% can be readily achieved if the coal surface configuration is a central horizontal plane bounded by limited sloped ends. Crustal retention can be increased to 95%, if the front-end slope is made level with the horizontal central portion.

2 INTRODUCTION

2.1 Objectives

The study was designed to evaluate chemical methods of eliminating or minimizing wind dispersion of coal dust from open-top rail cars during transportation of coal from mine sites to terminal storage areas. Dust control techniques were to be tested and developed which would be economically acceptable and readily adaptable by mining and railway companies. In addition, the establishment of sound, proven control technology would become available to legislators as guidelines in formulating any necessary environmental control regulations.

2.2 Environmental Concerns

The clouds of wind-blown dust that emanate from moving trains are receiving considerable attention as an environmental issue in many countries. In Canada, concern about the air-borne transport and deposition of coal dust has been expressed by the public as numerous complaints to railway companies, operating mines, municipalities, Members of Parliament and government agencies. Supportive evidence in newspaper articles has also highlighted the pollution aspects.

Figure 1 illustrates the geographical range and monthly frequency distribution of complaints in the study area of British Columbia during 1972 - 1973. The peak of complaints during March to May, possibly reflects the public's tendency to object prior to the onset of the summer outdoor season, a time when their awareness of air-borne dust becomes more acute. Also, moisture deficient coal transported during dry months has lower compaction rates and is more susceptible to wind dispersion than during the wetter months of fall and winter. Evidence of this was observed following compaction tests* on a unit train where only 58% of total compaction had occurred after transportation of 180 miles.

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*Kaiser Resources, Internal Report

Physically, coal is black, nontransparent and relatively lightweight. In populated areas its black colour soils houses, swimming pools, terraces and clothing. The nontransparency creates highway hazards by reducing visibility, while its lower density makes it readily airborne and capable of being carried further than common silicate dust.

From a chemical viewpoint, coal mined in Western Canada has not been demonstrated to be acutely toxic to salmonids. Bioassays conducted by B.C. Research proved that liquid extracts from East Kootenay coal are acutely nontoxic to fish.[(1)]

Pollution by coal dust, then appears to be confined to some aesthetic values and to physical hindrance where excessive quantities of coal are deposited.

2.3 Coal Transportation in the Study Area

Coal is transported to British Columbia terminals by Canadian National Railways (CNR) and by Canadian Pacific Rail (CPR). CNR moves coal from two major mines located in Alberta (McIntyre Mines Limited and Cardinal River Coal) to Neptune Terminals Ltd. in North Vancouver. CPR transports coal from the East Kootenay (Kaiser Resources Ltd. and Fording Coal Ltd.) to Westshore Terminal, the superport at Roberts Bank in the Municipality of Delta.

Figure 1 shows the major coal mine locations and railway routes to the Vancouver terminals. During 1973, 11,303,539 short tons of coal were transported over the railway system, 8.3 million tons by CPR and approximately 3 million by CNR. Table 1 details the coal movements to British Columbia terminals during 1973. Future coal industry development will greatly increase the tonnages transported, particularly from the northeastern area of British Columbia. Such development will emphasize the need for effective en route coal dust control.

3 THE STUDY PROGRAMME

In February 1974, a committee of representatives from Kaiser Resources Ltd., Fording Coal Ltd., Canadian Pacific Rail and the Federal Government formulated a study and test programme to determine the relative effectiveness of available chemical binders as an immediate solution to the problem of coal dust control on moving unit trains.

3.1 Phase I - Planning and Preliminary Field Investigations (During 1974)

(a) Planning involved technical and logistic considerations to determine the following:

- The most economical and effective location to apply chemical spraying.
- The minimum number of rail cars per train required to obtain a conclusive test programme.
- The number and types of tests to be conducted to obtain base data for Phase II.
- Allocation of test sites, based on in-transit settling characteristics, where tests would be carried out.
- What test evaluation procedures and criteria would yield reliable data.
- Preliminary screening and assessment of available chemical products to be used in the field test work.

(b) Field Work

Initially, spraying locations other than the mine sites at Fort Steele, were considered to evaluate the possible advantages of spraying after coal compaction had taken place. Eventually all trains were sprayed at the mine sites (Kaiser and Fording) to avoid all pollution problems.

Each chemical product was tested on a maximum of five cars, with each car selected on the basis of representative profile and location at, or near, the head-end of the train, to avoid possible accumulation of coal dust escaping from other cars. Binding performance at the departure point, at Kamloops, and at the Vancouver terminal was recorded by each committee member on a Visual Observation Form (see Table 2). The final rating for each series of tests reflecting the opinion of the total group was recorded on Tables 3 to 10.

3.2 Phase II - Extension of Field Investigations to Complete Unit Trains

In order to confirm the test results and analyses obtained in the limited (five cars per train) Phase I work, B.H. Levelton and Associates Ltd. were contracted by Environment Canada to carry out control tests on complete unit trains during the period August 28th to September 30th, 1975. A synopsis of Levelton's report entitled, "Measurement of Crust Remaining on the Surface of Coal Cars on Arrival at Dumping Terminals - Results of Monitoring 30 Trains", is presented in Sections 9 and 10 of this report.

4 COAL LOSSES BY WIND FROM UNTREATED CARS

Early in the study it became evident that the loading profile, that is, the geometrical configuration of the exposed surface of the coal, had a large influence on the coal lost in transit (Plate 1). Beshketo[2] reported heavy losses of coal at high train speeds. According to his data, the best "hood" height, based on car capacity and winds losses, is 200 mm (8") above the sill of the coal cars (Figure 2). He observed that 6 mm of coal was lost at 60 km/h (40 mph) and 13 mm (1/2") lost at 100 km/h (approx 60 mph). A parallel study on dust losses from mineral concentrates was carried out by Schwartz.[5] He observed that losses from concentrates were up to 2.1% for speeds up to 60 mph.

Screen analyses of the various coals transported to British Columbia terminals are presented in Figure 3. Even though the coal from Alberta is somewhat coarser than the coal from British Columbia, both types readily become airborne at low speeds.

Exact measurements of coal losses during transportation were difficult to determine with a high degree of confidence. Some problems experienced during the study included: inconsistencies in weigh scale calibration, variations of existing moisture content of the coal, addition of flying debris deposited in cars en route, and the inclusions of rain and/or snow. Thus calculations of coal lost en route as a measurable difference between car weight at the departure point and its weight at the terminal were somewhat unreliable.

Previous studies[2 and 3] suggest losses in the order of 1.5 tons/car or 1.5% for a 100-ton car capacity. Even if we assume that losses of western coal are only 0.5% or 1/2 ton/car per 700 mile journey, it is relatively easy to justify a reasonable expenditure to keep coal in the cars and, at the same time, reduce public concern over pollution.

In economic terms, prevention of the assumed Western Canada coal losses represent a saying, based on $60/ton of $30/car or over <u>$3 million annually</u>.

5 LOADING PROFILE

5.1 <u>Effects on Crust Retention During Transit</u>

Loading profiles had a profound influence on crust retention (Plates 1, 2). A surface particle is affected by the vertical force of gravity and by horizontal forces of linear and centrifugal acceleration and/or deceleration. The magnitude of each component depends on whether the particle rests on a horizontal surface or on an inclined plane and on the resistance to shear offered by the substrate. Furthermore, if the independent particle is chemically bound to other surface particles, the strength of the chemical bond is an additional force that increases the particle's resistance to sliding.

During the field tests it was soon realized that a totally flat surface would produce the most desirable profile (Plates 3, 4). Coverage of the flat portion of the car never presented a serious problem, suggesting that the effects of acceleration and deceleration of the train were negligible compared to the resistance offered by the substrate. The only evidence of failure was the appearance of surface cracks induced by torsional and vibrational stresses to which the cars were subjected during transportation.

5.2 Influence of Loading Method

In practice, the operation of a single loading chute always produced a sloped end at each end of the car (Plates 5, 6). On these slopes, the larger the horizontal component of the opposing force the more stable the system became. At the natural angle of repose where all forces were in balance, any minor disturbance due to acceleration or deceleration of the cars was sufficient to cause failure. To increase crust stability the angle of repose would be decreased at least by the expected maximum acceleration or deceleration of the cars. If this cannot be achieved, then, the strength of the chemical bond within the binder must accommodate the impact of these accelerations plus any torsional or vibrational components.

6. CHEMICAL BINDERS EVALUATED IN PHASE I

A chemical spray is more effective if it shows an affinity for the material on which it is sprayed and if the product (eg. coal) does not slump after the application (Plate 10). Coal readily absorbs oils without any prior surface treatment (lipophilic property) but repels water (hydrophobic property). In the case of emulsions, where water is the continuous phase, wetting of the surface can occur only if the surface has been pretreated with a solution containing a surface-active agent, or if there are sufficient quantities of a fast acting surfactant within the formulation.

Papic and McIntyre[4] tested 83 surfactants to evaluate their ability to improve the wetting of coal by water. Their findings showed that nonionic surfactants of the alkyl-phenylpolyethoxy ether type were the best wetting agents.

During the study the following chemical binding products, with or without the addition of specific surfactants, were tested:

(a) Dowel M167, a latex product by Dowell of Canada.

(b) Alchem 63026, a latex product by Alchem Limited.

(c) Dust Suppressant 100, an asphalt emulsion produced and marketed by Pounder Emulsions Limited.

(d) Dust Suppressant 200, an emulsified petroleum residue produced and marketed by Pounder Emulsions Limited.

(e) Acquatain, a product marketed by Whitlock Construction.

(f) Lignin Derivatives, an experimental product by Cominco.

(g) Coal Spray 100, an oil preparation by Imperial Oil Limited.

(h) Reclamation Oil, a product tested by Cominco.

6.1 Oil and Emulsion Test Results and Comments

Oil sprays and emulsions were the most effective binders (Plates 7, 8, 9). The success of the binders was attributed to the production of a flexible crust, high viscosity and an inherent ability to regenerate their surface. In other words, the stability of the product prevented the formation of a rigid crust by reacting neither with the coal particles nor with the atmosphere. The cohesive forces of the oil phase were enhanced by the lipophilic character of the coal which facilitated spreading of the oil on the coal surface. In this case the oil-coated particles adhered to each other forming a porous and oozy top layer. The same mechanism was operative in regenerating the top layer of the crust whenever a surface crack was produced by vibrational and/or torsional movement of the cars or by settling of the coal. The oils and emulsions were the only products to display this regenerative property.

Some of the disadvantages of using oils included the adverse effects on rubber conveyor belts and the possibility of washing residual oil and/or additives into adjacent water bodies.

Tables 3, 4, 5 and 6 present a summary of the detailed analysis and results of oil and emulsion tests obtained by each participant and previously recorded on Visual Observation Forms - Phase I (See Table 2).

Table 3 shows results for Coal Spray 100; Table 4, Reclamation Oil; Table 5, Dust Suppressant 100; and Table 6, Dust Suppressant 200.

Table 11 is an overall summary based on the best tests from the above tables, and includes the rating and the degree of acceptability of all the products.

6.2 Other Binding Products, Test Results and Comments

The main disadvantage of latex is its brittle crust. Vibrational and torsional movements cracked the surface polymer and patches of polymerized latex were easily removed or displaced by wind (Plate 2). Adherence of the crust to the substrate was minimal, and therefore, the best retention occurred on horizontal surfaces (Plates 10, 11, 12). Because the well polymerized and chemically stable crust of latex products is not water soluble, leaching is unlikely to take place, and therefore, pollution of adjacent water bodies will not occur.

Lignin derivatives, which are strong wetting agents, formed a thick crust which will dissolve readily in water. Following excess rainfall, the lignin derivatives were transported into the bulk of the coal in the cars, and the remaining washed unconsolidated coal behaved as untreated coal in that coal dust became airborne.

Tables 7, 8, 9 and 10 present a summary of the detailed analysis and results of latex and Lignin Derivatives products obtained by each participant and previously recorded on Visual Observation Forms - Phase I (see Table 2). Table 7 shows results for Dowell M167; Table 8, Lignin Derivatives; Table 9, Aquatain; and Table 10, Alchem 63026. Table 11 is a summary based on the best tests from the above tables, and includes the rating and the degree of acceptability of all the products.

7 SPRAYING METHODS

The difficulties of retaining a crust on the surface slopes necessitated an investigation of spraying techniques. Two mechanical techniques were tried: (a) preferential spraying, and (b) a combination of flooding and spraying.

Preferential spraying is the uneven application of chemical binders to different parts of the exposed surface (Plates 13, 14, 15). The slopes were sprayed more than the horizontal surfaces. This technique has been used with moderate success and will continue to be applied when fast and complete wetting can be achieved without binder run-off.

To increase binder retention on slopes, Fording Coal Ltd. devised a penetration-spray system designed to achieve not only maximum penetration and thickness but also an adequate surface coverage (Plates 17, 18). The system employs an oscillating spray bar equipped with nozzles capable of open-orifice discharge and fan spraying. The open-orifice discharges are designed to prevent run-off of the emulsion and the formation of a thick crust by increasing binder penetration. The fan sprays are designed to provide a more uniform and adequate coverage of the surface layer. Using this system, Fording Coal Ltd. demonstrated that undesirable slopes could be stabilized almost entirely (Plates 19, 20).

8 SPRAYING REQUIREMENTS

The major coal companies operating in Western Canada, in direct response to public concern about the coal dust pollution problem and their agreement with the findings of this report, volunteered to apply reasonable measures to control the coal dust emanating from moving trains. As of July 1, 1974, all major mining companies sprayed every train leaving their property.

Unfortunately, not all of the chemical binders offered adequate protection. Industrial and Federal representatives agreed that the single parameter that best describes the effectiveness of the various chemical binders is the residual surface coverage measured at the terminals. Assuming that coal dust originates uniformly from every part of the exposed surface, then effective surface coverage is the only parameter that is directly proportional to the coal dust generated in transit.

The mining companies agreed with the standards presented in Phase I of this report that a minimum of 85% of the surface would be covered immediately and furthermore, that a 90% coverage should be achieved by October 1975.

9 PHASE II FIELD MONITORING

Sections 9 and 10 present a synopsis of the B.H. Levelton and Associates' study. The spraying techniques and methods of crust retention observation and recording were founded on the basis of the Phase I work. In the Levelton study, the range of tests were extended to include complete unit train protection and to assess the coverage resulting from mine optimization of chemical binder required to produce an 85% cover. Table 12 shows the number of trains and cars monitored.

9.1 Coal Shipments

All unit trains originating from western mines consist of open-top rail cars, but the size of cars varies not only between the two major railway companies but also within the same company.

The most common car size used by CP Rail is 48-ft long, 12-ft high and 10-ft wide. Cars from CN Railway are 50-ft long, 10-ft high and 10-ft wide.

Unit trains from Alberta to Vancouver cover a distance of approximately 700 miles at a maximum speed of 45 mph. Coal trains from British Columbia cover approximately the same distance but are allowed to travel at 50 mph.

9.2 Loading Profiles

The total surface profile of the coal cars comprized three distinct sections: a front slope, a central flat area and a rear slope. Typical longitudinal profiles showing slope lengths, slope angles, flat lengths and cross-sectional profiles are shown in Figure 4. The total exposed area, therefore, is comprised of the area along the two slopes plus the flat area.

9.3 Measurements of Surface Coverage

Initially, the areas of both front and rear slopes and the levelled area in the centre were measured in several cars from each of four mining companies. Later, a "trained observer" was exposed repeatedly to measured and observed sections of the cars in order to eliminate unnecessary measurements and costly slow-down procedures at the terminals. Measured and estimated percentages of the front slope, middle surface and rear slope were recorded on a pre-printed "Coal Car Coating Inspection" form (See Figure 5). From these individual area measurements, the extent of crustal cover remaining intact at the Vancouver terminal was calculated as a percentage of the total original coal surface. At the same time, a summary sheet was prepared. This summary included data on:

- Terminal
- Coal origin
- Train number
- Times train left origin and arrived at terminal
- Binder used
- Weather during treatment, during transit and during observation
- Number and location (in train) of cars inspected
- Nature of crust cracks, crust loss and crust character
- Abnormalities in profile
- Special observations
- Percent coverage
- Percent coverage on total coal surface.

In addition, colour photographs were taken of about 220 coal cars. See Plates 21 to 24 for typical photographic recordings.

10 PHASE II MONITORING RESULTS

10.1 Crust Retention Calculations

The number of cars and their respective coverage expressed in percent of total surface area have been tabulated for each mine in Tables 13, 14, 15 and 16. These data have been rearranged below to show the frequency distribution for total cover remaining as a percentage of coal cars inspected.

COVER REMAINING (%)	MINE B (%)	MINE C (%)	MINE A (%)	COVER REMAINING (%)	MINE D (%)
0-50	2.6	6.6	0	0-40	5.0
51-55	0.5	0.9	0	41-45	7.5
56-60	1.0	1.0	1.2	46-50	7.5
61-65	2.1	2.4	0	51-55	22.5
66-70	1.0	9.0	2.5	56-60	25.0
71-75	10.0	14.2	9.9	61-65	25.0
76-80	11.6	18.4	14.8	66-71	7.5
81-85	21.6	16.5	30.9		
86-90	26.3	17.0	21.0		
91-95	17.9	10.4	19.8		
95-100	5.3	3.3	0		

The frequency distribution of total cover remaining is shown graphically in Figure 6. The most frequently occurring coverage within a 5% interval is 86-90% for Mine B, 76-80% for Mine C, 81-85% for Mine A and 61-65% for Mine D.

10.2 Crust Retention on Front and Rear Surface Slopes

The percentage of cover remaining on front and rear slopes for coal shipped from Mines A, B, C and D and is tabulated in Table 17. This frequency distribution has been plotted for 10% intervals in Figures 7, 8, and 9. The most effective coverage observed resulted from levelling the front slope of the cars at the loading site of Mine B. Levelling increased surface crust retention by an average of 40% when compared to Mines A and C.

11 NEW LOADING TECHNIQUES AND CHEMICAL PRODUCTS FOR COAL DUST CONTROL

Since September 1976 all coal mines shipping to British Columbia terminals have adopted a modified method of loading and spraying unit trains.

New and more capable loading (eg. Plate 16) chutes have improved the loading profile, increased dust control and have reduced considerably the total loading time for the unit train. In addition, the operator can more effectively control the total tonnage carried by each car thus fewer variations in the total carrying capacity occur when cars are loaded to the allowable limit. The net result is a substantial saving of time and money.

Encouraged by the potential savings in coal losses and by required environmental controls, many companies in the U.S.A. and Canada are developing new chemical products to equal or better the performance of the products tested in this report.

Coverages approaching 100% can be expected by the end of the 1970's.

12 REFERENCES

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4. M.M. Papic and A.D. McIntyre, "Surface Active Agents in Coal Dust Abatement", p. 85, Coal Age, June 1973.

5. P.L. Schwartz, "Innovations in Railroad Transportation of Mineral Products", Paper presented at the Second International Symposium on Transport and Handling of Minerals, Rotterdam, Netherlands, October 1-6, 1973.

TABLE 1

MOVEMENT OF COAL TO BRITISH COLUMBIA TERMINALS DURING 1973

SHIPPER*	FROM	TO	COAL TRANSPORTED (Short Tons)
CPR	Elkview	Delta	4,847,530
CPR	Fording	Delta	2,464,740
CPR	Coleman	Port Moody	867,497
CPR	Canmore	Port Moody	200,249
CNR	Winniandy	Vancouver	1,658,251
CNR	Luscar	Vancouver	1,265,272

* CPR - Canadian Pacific Railway
CNR - Canadian National Railway

TABLE 2

VISUAL OBSERVATION FORM - PHASE I

Participant ______________________ Spraying date ______________________

Product tested ______________________ Spraying location ______________________

Test No. ______________________ Type of coal ______________________

Train No. ______________________ Test rated by ______________________

Car No.	Parameter	Weather	General Crust Appearance	Crust	Binder Penetration (inches)		Condition of Fines		Remarks
					Top	Sides	Crust	Cracks	
______	origin								
conc. ______	en route								
vol. ______	terminal								
______	origin								
conc. ______	en route								
vol. ______	terminal								
______	origin								
conc. ______	en route								
vol. ______	terminal								
______	origin								
conc. ______	en route								
vol. ______	terminal								
______	origin								
conc. ______	en route								
vol. ______	terminal								

LEGEND:

(H) homogeneous
(C) crushed
(P) patchy
(N) nodulized

(F) friable
(B) brittle
(T) tough

(U) unconsolidated
(C) consolidated

TABLE 3

TEST RESULTS AND SUMMARY: COAL SPRAY 100

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Kaiser	20	100	Good coverage up to 30 gal/car. Excellent coverage above 45 gal/car.
	30	100	
	45	100	
	60	100	
	70	100	
Foraing	40	100	Very homogeneous coverage. Some evidence of blowing. Good results.
	50	100	
	60	100	
	70	100	
	80	100	

Comment

TABLE 4

TEST RESULTS AND SUMMARY: RECLAMATION OIL

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Fording	25	100	Good coverage on slopes.
Fording	50	100	Very good. Minor exposure of ends.
Fording	30	100	Soft crust. Good ends.
Fording	30	100	Good coverage. Minor exposure of ends.

TABLE 5

TEST RESULTS AND SUMMARY: DUST SUPPRESSANT 100

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Ft. Steele	70	30	Good crust. Fair results.
Ft. Steele	75	15	Tough crust. Poor spraying. Good results.
Ft. Steele	45	25	Good crust. Good results.
Ft. Steele	70	10	Brittle to tough crust. Evidence of blowing.
Kaiser	50	5	Homogeneous, brittle to tough. Good coverage.
Kaiser	120	15	Fair to good. Evidence of blowing.
Kaiser	50	25	Good crust. Excellent results.
Fording	50	15	Homogeneous crust. Ends blown. Poor to fair results.
Fording	50	15	Homogeneous crust. Ends blown. Poor to fair results.
Fording	108	10	Homogeneous, poor slopes.
Fording	62	15	Consolidated crust. Slopes partly exposed.

TABLE 6 Dust Sup. 200

TEST RESULTS AND SUMMARY: DUST SUPPRESSANT 200

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Fording	90	15	Homogeneous crust. Exposed ends.
Fording	60	15	Soft crust. Minor exposure of ends.
Fording	50	15	Good coverage on improved profiles.

TABLE 7

TEST RESULTS AND SUMMARY: DOWELL M167

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Ft. Steele	24	9.0	Friable to brittle crust. Fair.
Ft. Steele	60	10.0	End erosion by wind. Fair.
Ft. Steele	25	5.0	Friable crust. Poor penetration.
Ft. Steele	42	5.0	Thicker crust. Fair to good.
Ft. Steele	43	5.0	Patchy. Wind erosion. Poor.
Kaiser	65	7.5	Good coverage. Fair to good results.
Kaiser	40	7.5	Good appearance. Good results.
Kaiser	40	10.0	Brittle to tough crust. Fair.
Fording	40	7.5	Rain had detrimental effect. Poor.
Fording	55	7.5	Brittle crust. Fair results.
Fording	60	5.0	Friable crust. Wind erosion. Poor.

TABLE 8

TEST RESULTS AND SUMMARY: LIGNIN DERIVATIVES

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Fording	50	8	Crust thickness up to 3".
Fording	60	8	Evidence of blowing at both
Fording	70	8	ends. Fair results.
Fording	80	8	
Fording	72	8	Brittle crust. Poor ends.
Fording	80	8	Fair coverage on slopes.
Fording	60	8	Excessive exposure on poor profile.

TABLE 9

TEST RESULTS AND SUMMARY: AQUATAIN

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Ft. Steele	32	12.5	Weak, friable crust. Slopes exposed.
Ft. Steele	45	14.2	Friable crust. Wind erosion. Poor.
Ft. Steele	18	20.0	Patchy, friable crust. Poor.
Ft. Steele	40	14.3	Patchy crust. Ends eroded.
Ft. Steele	40	33.0	Evidence of blowing. Poor.
Kaiser	32	Not reported	Thin, friable. Poor results.
Kaiser	36		Improved crust. Poor to fair.
Kaiser	23		Friable crust. Poor to fair.
Fording	73	6.6	Homogeneous thin crust. Fair.
Fording	60	6.6	Sides blown. Poor results.
Fording	60	6.6	Thin and friable crust. Ends eroded.

TABLE 10

TEST RESULTS AND SUMMARY: ALCHEM 63026

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Ft. Steele	27	7.2	Friable, inadequate coverage. Poor.
Ft. Steele	27	5.4	Thin crust, excessive wind erosion. Poor.
Ft. Steele	26	3.8	Extremely poor. Little or no crust.
Ft. Steele	27	3.0	Much evidence of blowing. Poor.
Ft. Steele	30	1.6	Poor results on poor profiles.
Kaiser	27	3.8	Thin, friable crust. Much blowing.
Kaiser	27	11.0	Improved crust. Still unacceptable.
Fording	30	4.0	Patchy, friable crust. Poor.
Fording	40	10.0	Slight improvement. Still very patchy.
Fording	26	6.2	Thin and friable. Poor.

TABLE 11

RATING AND ACCEPTABILITY OF CHEMICAL BINDERS
BASED ON COMPARISON TESTS OF BEST PERFORMANCES

(Derived from Tables 3 to 10)

BINDER	VOLUME (Gal.)	CONCENTRATION (%)	GALS/CAR	RATING	ACCEPTABILITY
Coal Spray 100	45	100.0	45.0	1	Best performance on all profiles.
Reclamation Oil	50	100.0	50.0	2	
DS 100	50	25.0	12.5	3	Effective on flat profiles and slopes.
DS 200	50	15.0	7.5	4	
Dowell M167	65	7.5	4.9	5	Effective on flat profiles.
Lignin Derivative	60	8.0	4.8	6	
Acquatain	73	6.6	4.8	7	Unacceptable.
Alchem 63026	40	10.0	4.0	8	

TABLE 12

NUMBER OF TRAINS AND CARS MONITORED DURING PHASE II FIELD WORK

SOURCE	NO. OF TRAINS	TOTAL CARS	CARS/TRAIN (Average)	LOCATION IN TRAIN
Kaiser	12	211	17.6	Front 3 trains Centre 4 Rear 4 All cars 1
Fording	10	215	21.5	Front 6 trains Centre 1 Rear 2 All cars 1
Luscar	4	79	19.7	Front 1 train Centre 1 Rear 2
McIntyre	4	42	20.0 (2 trains) 1.0 (2 trains)	

TABLE 13

MINE B

COVER REMAINING ON COAL ON ARRIVAL AT TERMINAL (PERCENT OF TOTAL SURFACE)

TRAIN	432	434	436	444**	446**	448**	450	457	460	463	468	TOTAL
DATE	Aug 31	SEP 3	4	7	9	10	11	15	17	18	19	
NO CARS	10	18	20	20	13	28	20	20	20	20	2	211
LOCATION	R	C	C	C	R	All	F	C	F	F	R	
WEATHER	Cl	OW	SW	SW	SW	SW	SW	R	SW	SW	SW	
COAL							WET	WET	WET			
PERCENT												
98		5[a]										5
97												
96		5										5
95		5							4			9
94										2		2
93								2	3	1		6
92		1						1		4		6
91		1		1					1	8		11
90			1	3		3	2		5	1		15
89			1	2				1	1			5
88			5	1	1		1	1	1	2		12
87						2		4				6
86			3	2	1		2	2	1	1		12
85			2	4		1	2	3	1		2	15
84			3	1	1		1					6
83					1	2		1				4
82			1		1	3	2	1				8
81			1		2	1	2	2				8
80				1		2			2	1		7
79					2							2
78					1	1	1					3
77						1	2					3
76	1			1	2		3					7
75				1		4	1		1			7
74	1					4	1					
73												
72			2			2						4
71	1					1						2
70					1							1
69												
68				1								1
	(63) 1	(50) 1	(65) 1	(65) 1		(63) 1	(63) 1					
	(59) 1						(60) 1					
	(54) 1											
	(39) 1											
	(38) 1											
	(36) 1											
	(23) 1											

**Binder is "modified" latex.

Footnote: a. The number of cars with percentage cover as shown.

TABLE 14

MINE C

COVER REMAINING ON COAL ON ARRIVAL AT TERMINAL (PERCENT OF TOTAL SURFACE)

TRAIN	821249	821254	821257	821261	821262	821263	821269	821270	821271	821273	Total
DATE	Aug 29	Sept 1	Sept 5	Sept 8	Sept 9	Sept 9	Sep 16	Sep 16	Sep 17	Sep 19	
NO. CARS	44	24	22	20		22	22	24	25	12	
LOCATION	All	F	F	F*	F	F*	F*	R	R	C	
WEATHER	SW	OW	SW	SW	SW	SW	OW	OW	SW	SW	
COAL PERCENT					PART INSPECTED WAS NOT COATED						
97	1										1
96	1		2						2		5
95									1		1
94	6								1		7
93	4								2		6
92	1								2		3
91	3							1	1		5
90	1		1					1	1		4
89	3		1	1					1		6
88	3						1	1	4		9
87	2					2		2	3		9
86	1			1		1		2	2	1	8
85	1		1	1		3	1	1		1	9
84	2						1	2			5
83	1	1	2				1	2	1	1	9
82			1			2		1			4
81			1	2		2	1	1	1		8
80				2		3		1			6
79	2	1	2	1				2		1	9
78	3	2	1	1		2	1			1	11
77	1		1	2			1				5
76	2	1				2				3	8
75						1	2		1	2	6
74	2			1			1	1		1	6
73	2		2	2		1	1				8
72		1		1		1	1	1			5
71			1			1	1	1		1	5
70			1			1	1				3
69		1	1	1			1				4
68		2	1				4				7
67		3					1				4

*Night train SW = Sunny and warm; OW = Overcast and warm; Cl = Cloudy
R = Rain. F = Front; R = Rear; C = Centre.

TABLE 14 (CONTINUED)

MINE C

COVER REMAINING ON COAL ON ARRIVAL AT TERMINAL (PERCENT OF TOTAL SURFACE)

TRAIN	821249	821254	821257	821261	821262	821263	821269	821270	821271	821273	Total
DATE	Aug 29	Sept 1	Sept 5	Sept 8	Sept 9	Sept 9	Sep 16	Sep 16	Sep 17	Sep 19	
NO. CARS	44	24	22	20		22	22	24	25	12	
LOCATION	All	F	F	F*	F	F*	F*	R	R	C	
WEATHER	SW	OW	SW	SW	SW	SW	OW	OW	SW	SW	
COAL											
				(66) 1			(65) 1	(65) 1			
							(64) 1				
								(63) 1			
				(62) 1							
		(60) 1	(60) 1								
	(59) 1										
		(57) 1									
		(55) 1									
		(53) 1									
								(48) 1			
		(43) 1									
		(39) 1									
									(38) 1		
			(36) 1	(36) 1							
				(35) 1							
		(29) 1									
		(23) 1									
								(21) 1			
		(20) 1	(20) 1								
		(0) 2									

*Night Train.

TABLE 15

MINE A

COVER REMAINING ON COAL ON ARRIVAL AT TERMINAL (PERCENT OF TOTAL SURFACE)

TRAIN	L151*	L154	L158	L160	TOTAL
DATE	Aug 28	Sept 3	Sep 14	Sep 16	
NO. CARS	19	20	20	20	
LOCATION		C	R	R	
WEATHER	R	SW	SW	SW	
COAL					
PERCENT					
94				1	1
93	1	1	1	3	6
92				4	4
91			1	3	4
90		1		3	4
89	1			4	5
88					
87	1	1			2
86	2	1	3		6
85	2			1	3
84		4	3	1	8
83		3			3
82	3	1	5		9
81	1	1			2
80			1		1
79	1				1
78	1	2	2		5
77	1		1		2
76		1	2		3
75	1	2			3
74					
73		1			1
72	3	1			4
71					
70					
69					
			1		1

*Night train.

TABLE 16

MINE D

COVER REMAINING ON COAL ON ARRIVAL AT TERMINAL (PERCENT OF TOTAL SURFACE)

TRAIN	M380	M381*	M388	M389	TOTAL
DATE	Sep 9	Sep 10	Sep 22	Sep 23	
NO. CARS	18	22	1	1	
LOCATION	F	F-W			
WEATHER	SW	SW			
COAL					
PERCENT					
71	1				1
70		1			1
69		1			1
68					
67					
66					
65					
64	1	1			2
63	3	1			4
62	1				1
61	1	1			2
60				1	1
59	1	2			3
58		2			2
57	2	1			3
56	2				2
55		1			1
54	1				1
53	2	1			3
52	1	1			2
51		2			2
50		1			1
49	1		1		2
48					
47	1				1
46					
45		1			1
44					
43		1			1
42		1			1
30		1			1
0					1

*Night train

TABLE 17

FREQUENCY OF COVERAGE ON

FRONT AND REAR SLOPES

Percent Cover	Kaiser		Luscar		Fording	
	Front	Rear	Front	Rear	Front	Rear
0	1	16	1	13	9	10
5	-	2	-	-	1	-
10	2	14	1	4	19	3
15	-	-	-	1	1	-
20	2	10	1	5	13	6
25	-	5	3	-	3	-
30	-	9	10	4	15	14
35	1	6	1	1	2	-
40	-	18	6	10	23	23
45	-	1	1	1	-	1
50	8	14	16	21	20	32
55	-	1	2	-	-	2
60	5	14	14	14	34	31
65	-	1	2	3	-	3
70	4	11	12	1	27	11
75	1	7	3	2	5	10
80	13	18	4	2	16	18
85	9	9	-	-	2	10
90	42	15	1	1	10	13
95	14	9	-	-	6	15
95+	6	3	-	-	-	9
100	22	8	-	-	-	2

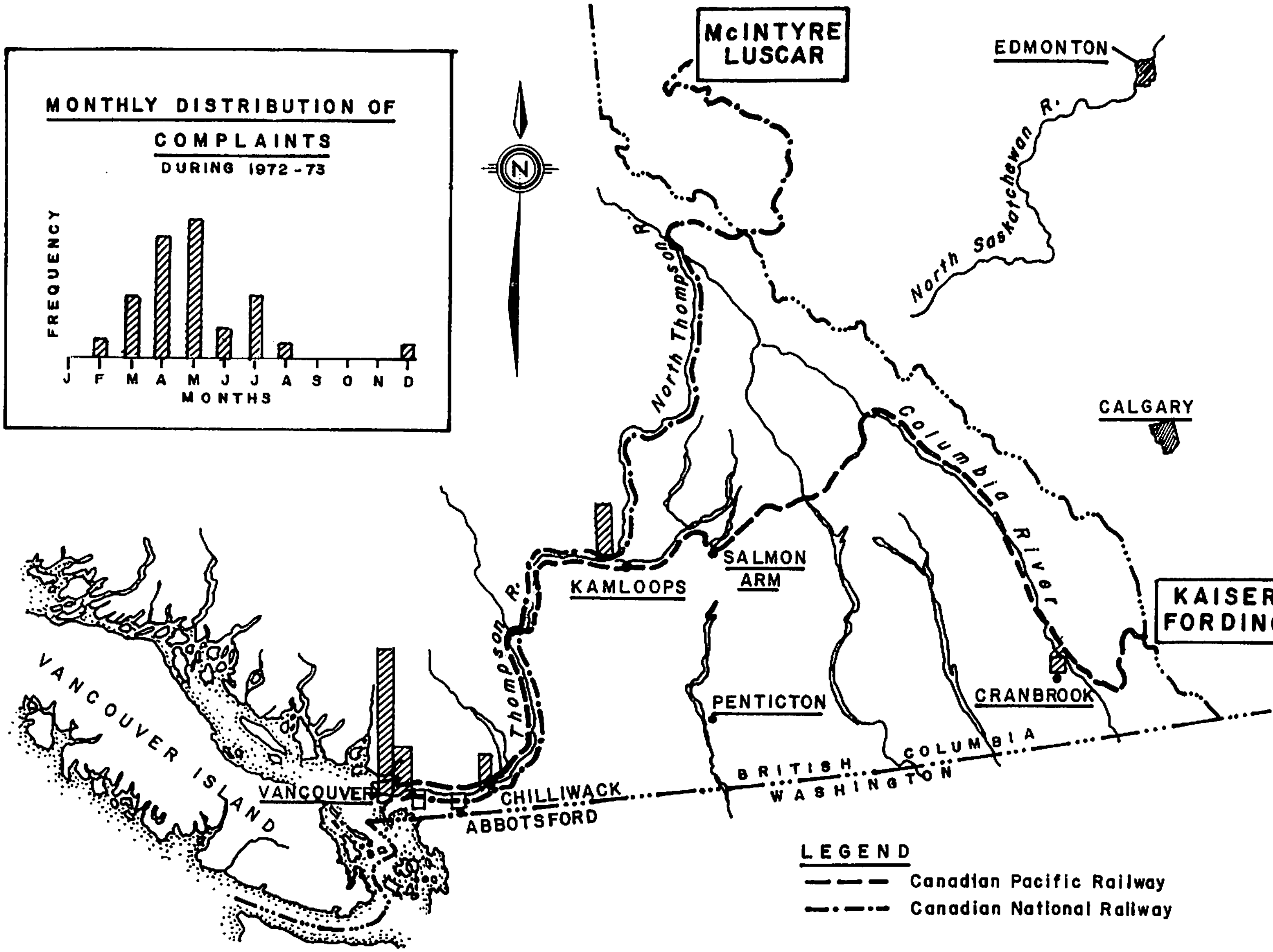


FIGURE I REGIONAL DISTRIBUTION OF COMPLAINTS DURING 1972-1973

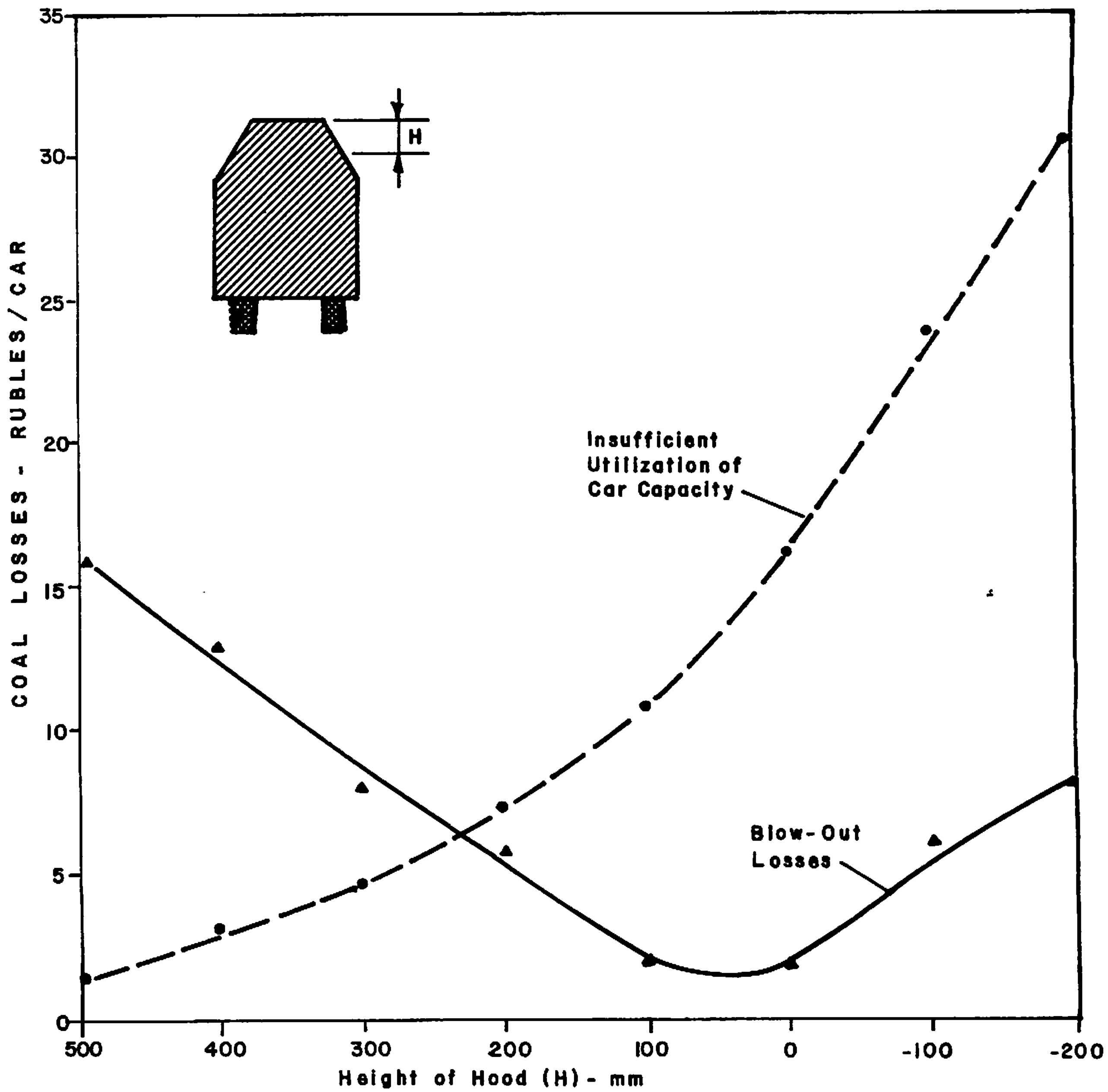


FIGURE 2 COAL LOSSES OF HIGH SPEEDS
(After V.K. Beshketo)

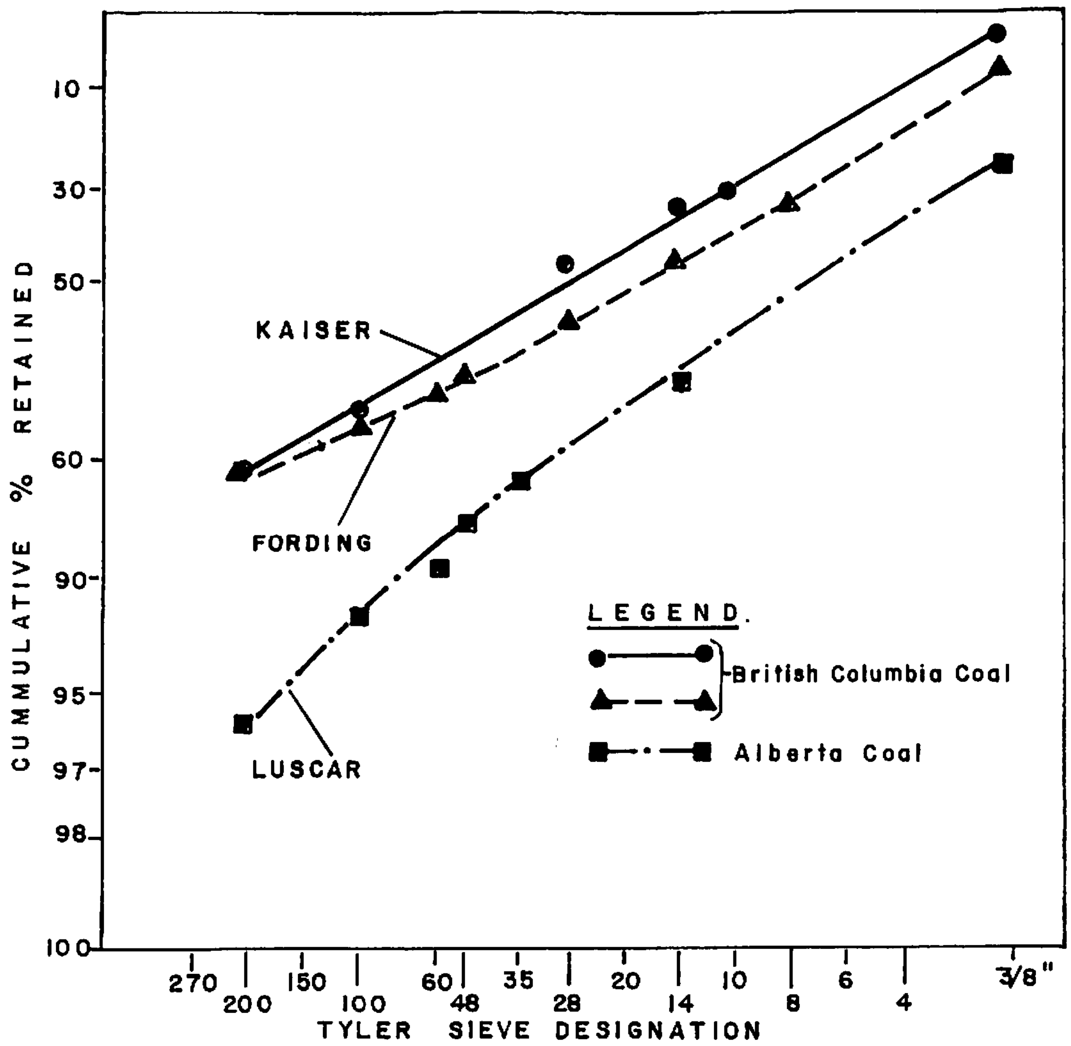


FIGURE 3 COMPARATIVE SCREEN ANALYSIS OF BRITISH COLUMBIA AND ALBERTA COALS

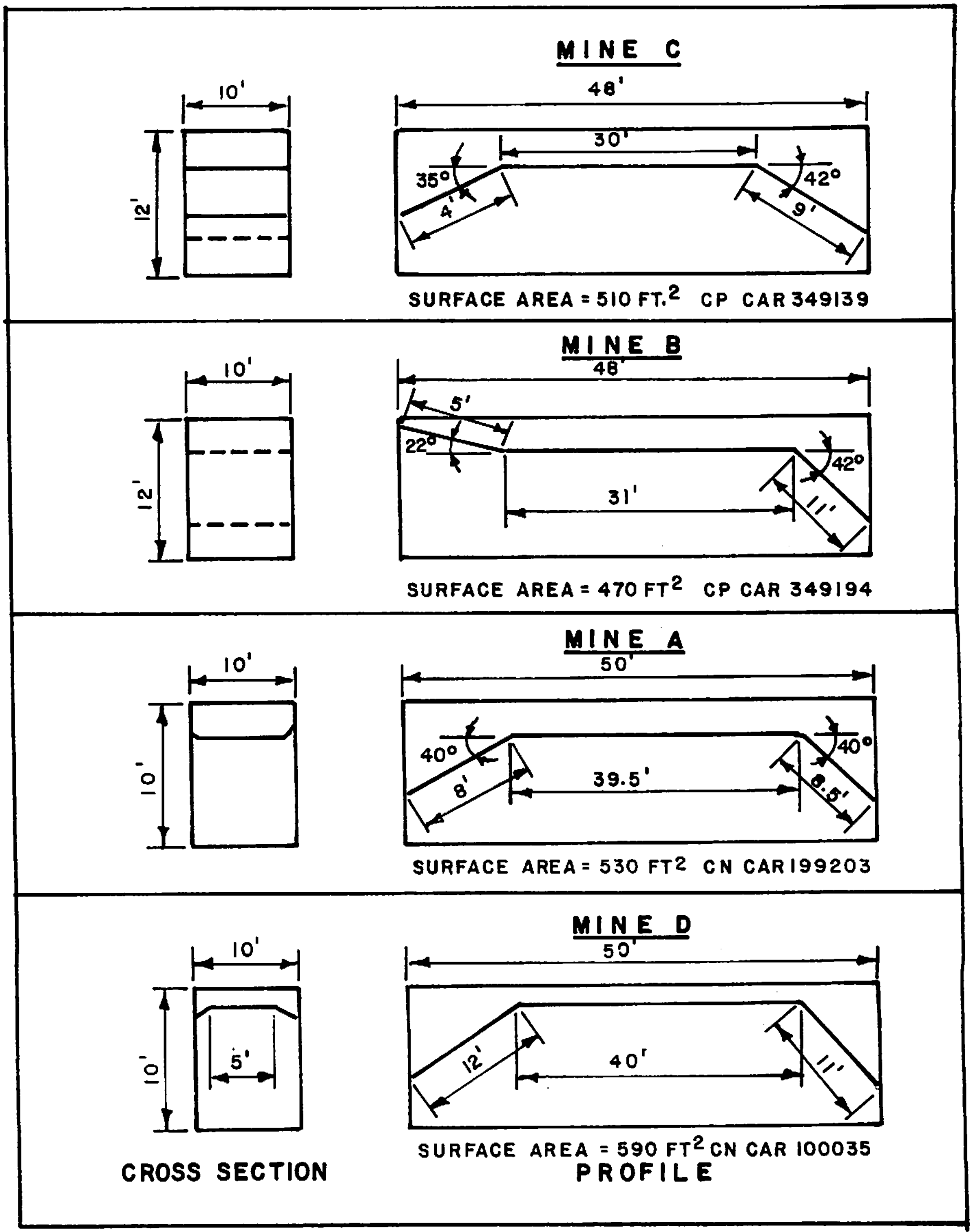


FIGURE 4 TYPICAL COAL CAR SURFACE DIMENSIONS
(From Levelton & Associates Ltd.)

B. H. LEVELTON & ASSOCIATES LTD. 1755 WEST 4TH., VANCOUVER, B.C. V6J 1M2 PHONE 736-6516

COAL CAR COATING INSPECTION

Terminal ________ Date Treated ________ Origin ________

Photo No. ________ CP/CN Train No. ________

Inspector ________ Date Examined ________ Car No. ________

Time ________ Binder ________

Weather - During Treatment ________ During Trip ________ On Arrival ________

	FRONT	FLAT	REAR	TOTAL
% Coverage				
Condition				
Du-t Escapement Evidence				
Crust Flexibility				
Crust Thickness				
Crust Failure Nature and Prevalence				
Incomplete Coverage				

Terminal ________ Date Treated ________ Origin ________

Photo No. ________ CP/CN Train No. ________

Inspector ________ Date Examined ________ Car No. ________

Time ________ Binder ________

Weather - During Treatment ________ During Trip ________ On Arrival ________

	FRONT	FLAT	REAR	TOTAL
% Coverage				
Condition				
Dust Escapement Evidence				
Crust Flexibility				
Crust Thickness				
Crust Failure Nature and Prevalence				
Incomplete Coverage				

FIGURE 5

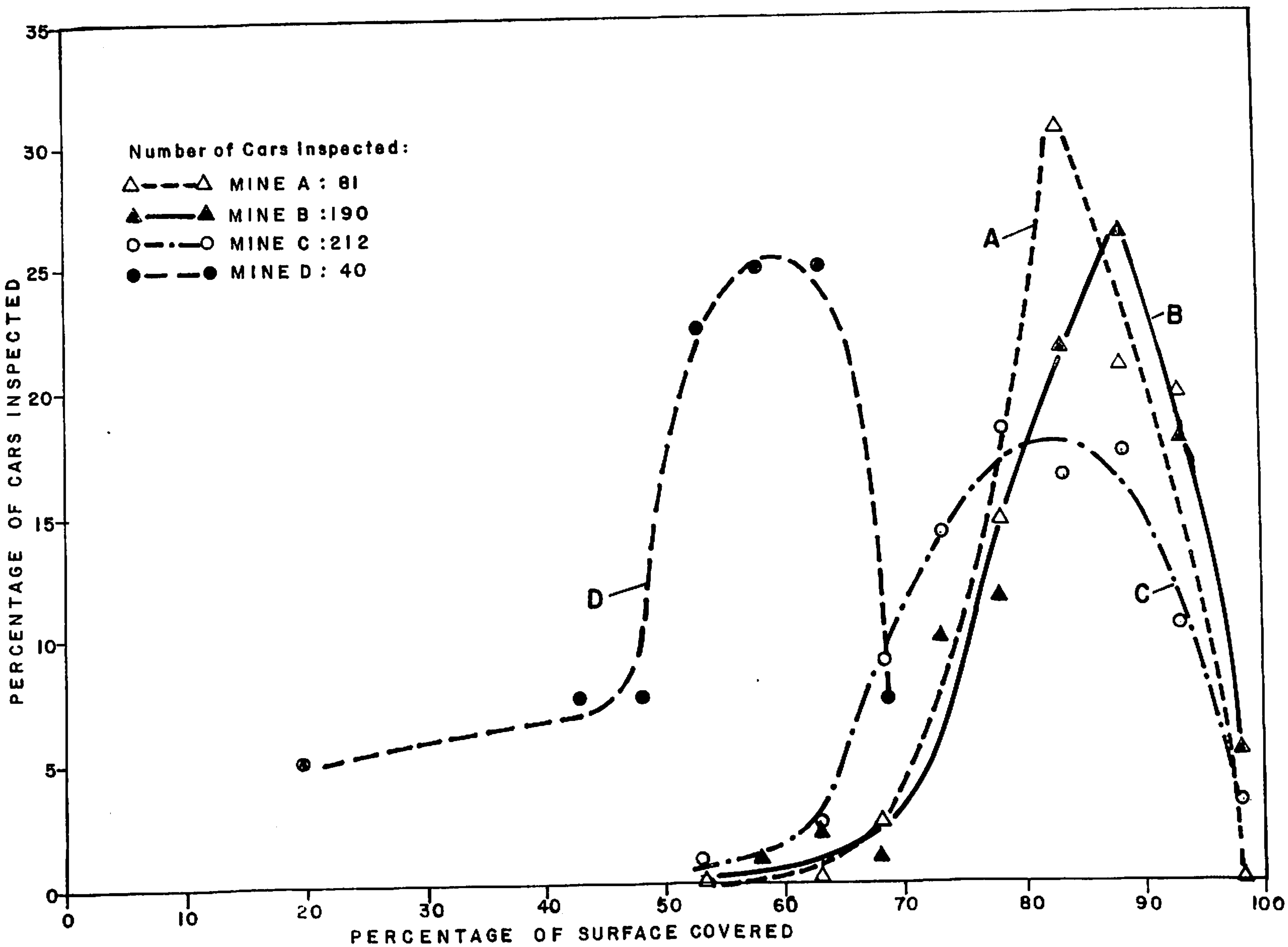


FIGURE 6 DISTRIBUTION OF COVER REMAINING ON TOTAL SURFACE OF COAL CARS

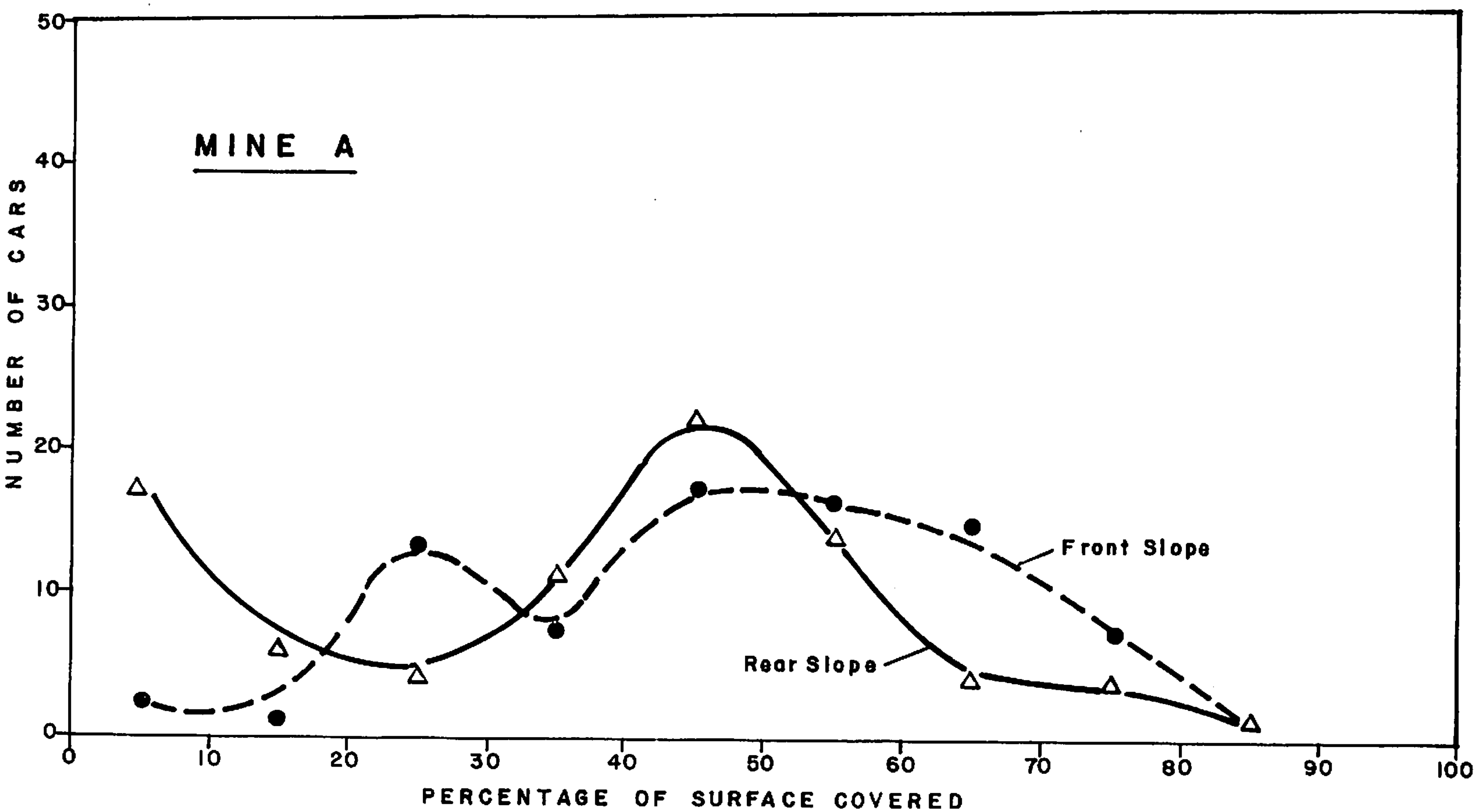


FIGURE 7 DISTRIBUTION OF COVER REMAINING ON FRONT AND REAR SLOPES

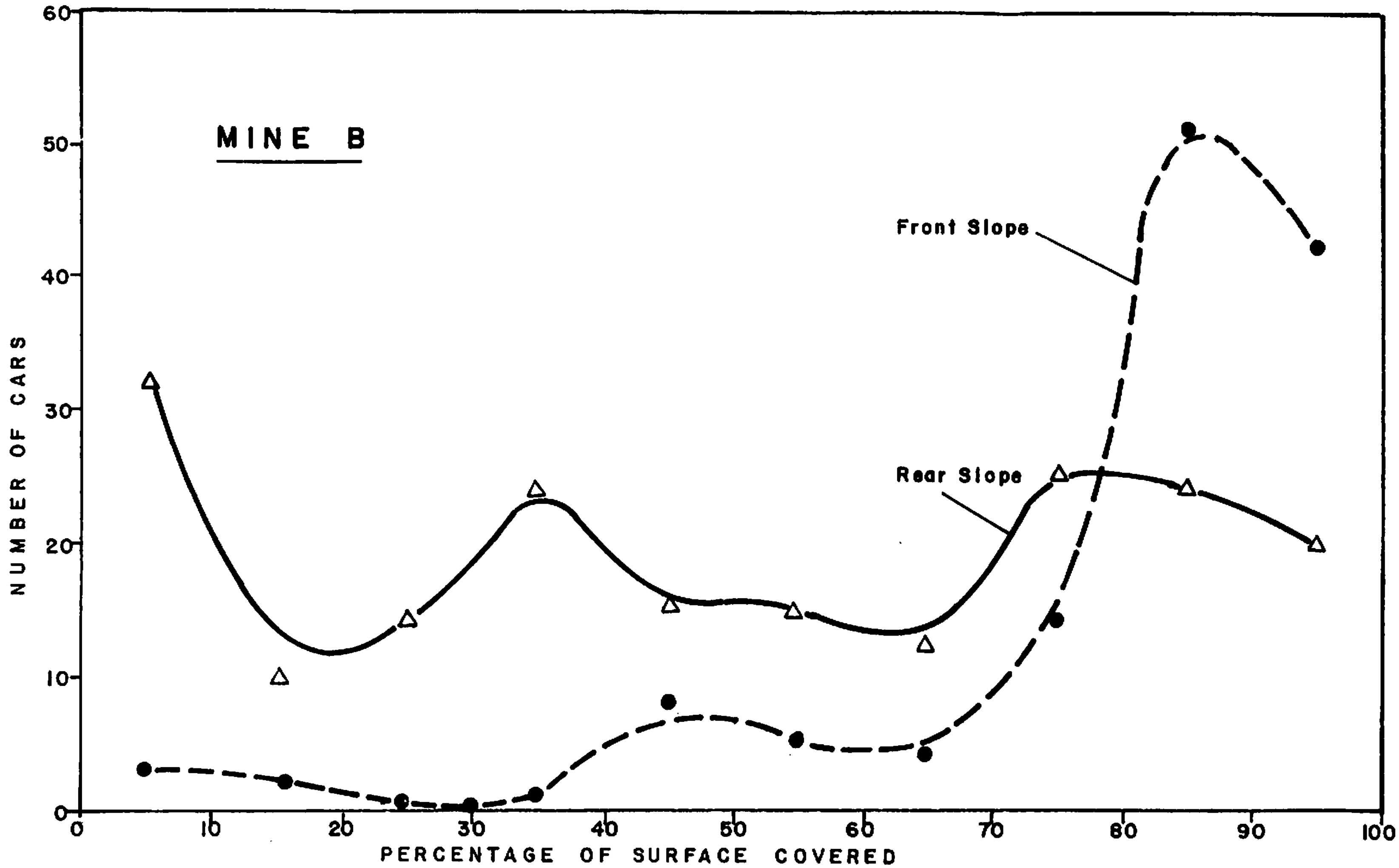


FIGURE 8 DISTRIBUTION OF COVER REMAINING ON FRONT AND REAR SLOPES

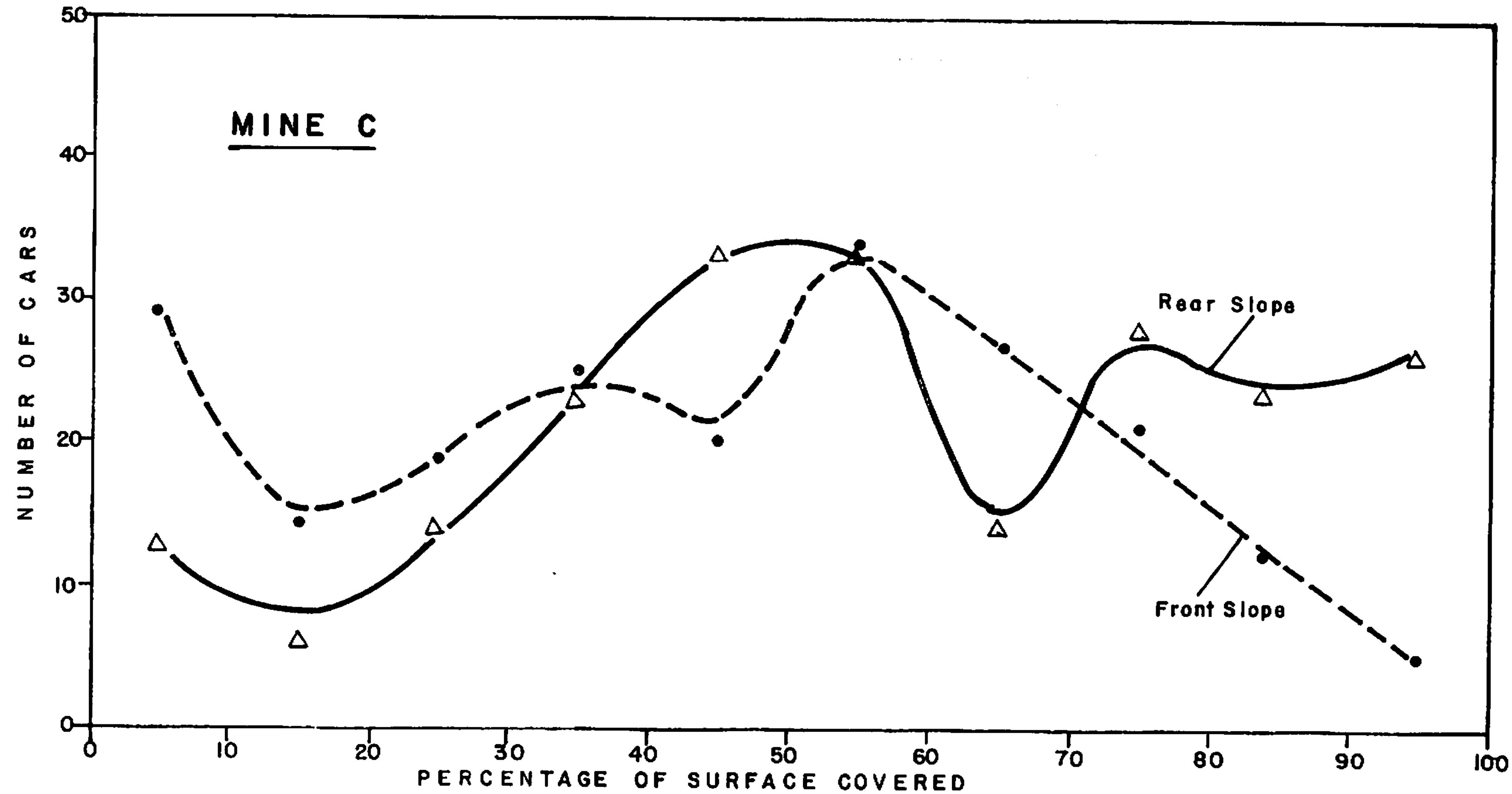


FIGURE 9 DISTRIBUTION OF COVER REMAINING ON FRONT AND REAR SLOPES

PLATE NO. 1: COAL LOSSES IN TRANSIT

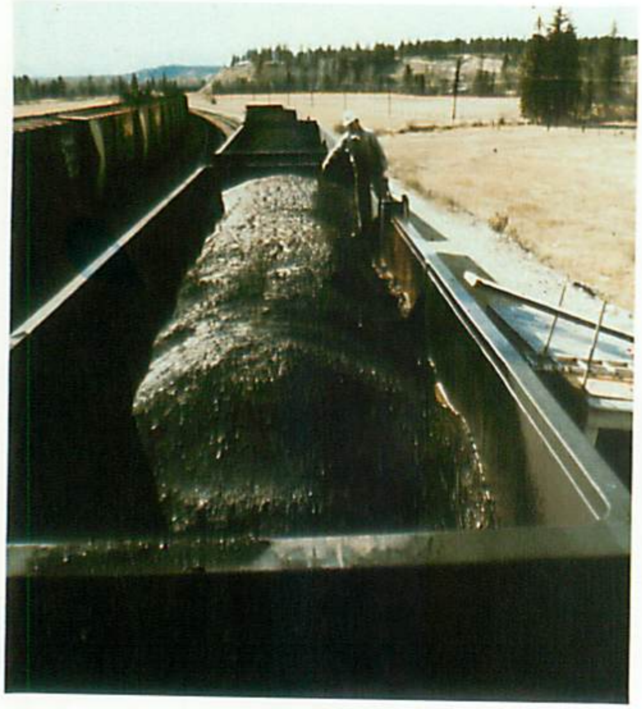
PLATE NO. 2: INCOMPLETE COVERAGE OF SLOPES

❮ PLATE NO.3: UNTREATED CAR SHOWING POOLS OF WATER AND COARSE COAL

PLATE NO.4: PREFERENTIAL WIND EROSION OF UNTREATED CAR ❯

PLATE NO.5: ORIGINAL LOADING METHOD

PLATE NO.6: FORMATION OF UNDESIRABLE SLOPES



❮ PLATE NO.7: HAND APPLICATION OF ASPHALT EMULSION

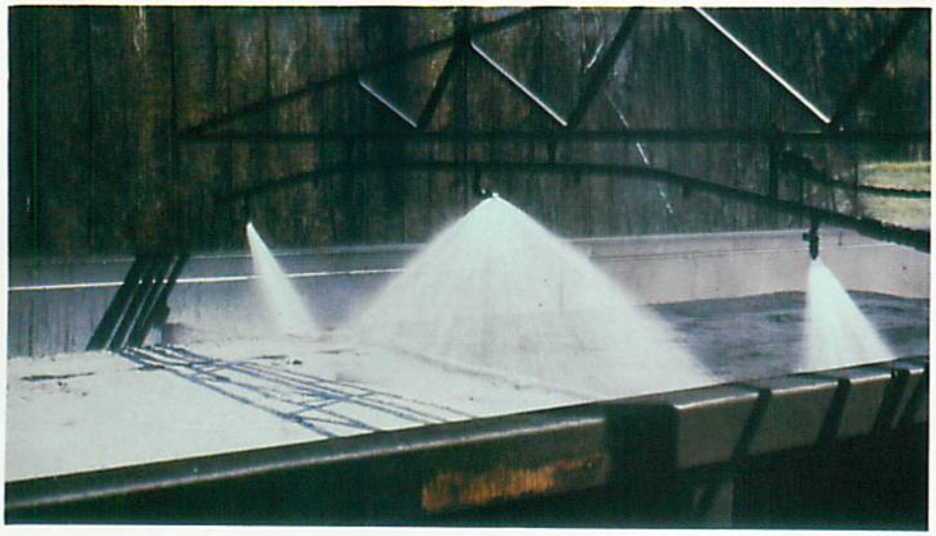
PLATE NO.8: CAR IN PLATE 7 AT KAMLOOPS ❯

❮ PLATE NO.9: CAR IN PLATE 7 AT WESTSHORE TERMINALS

❮ PLATE NO.10: UNIFORM SURFACE COVER

PLATE NO.11: CLOSE-UP SHOWING PENETRATION OF BINDER ❯

❮ PLATE NO.12: WELL PROTECTED FRONT-END SURFACE



❮ PLATE NO.13: PREFERENTIAL SPRAYING PATTERN OF A WELL PREPARED SURFACE

PLATE NO.14: END SPRAYING ❯

❮ PLATE NO.15: ADDITIONAL WATER SPRAYS TO INCREASE PENETRATION OF BINDER

❮ PLATE NO. 16:
MODIFIED LOADING
METHOD

PLATE NO. 17:
COMBINATION OF
FLOODING AND
SPRAYING ❯

❮ PLATE NO. 18:
PROPERLY LOADED AND
SPRAYED SURFACE

⟨ PLATE NO. 19:
EFFECTIVE SPRAYING
ON AN UNEVEN PROFILE

PLATE NO. 20: LIMITED CRUST FAILURE OF SLOPED AREA
IN CAR IN PLATE 19

PLATE 21: SLIDE 434-2
MINE B
CAR 349498
DATE SEPT. 3, 1975
COVERAGE 95%

PLATE 22: SLIDE 254-1
MINE C
CAR 351620
DATE Sept. 2, 1975
COVERAGE 70%

< PLATE 23:
SLIDE L154-1
MINE A
CAR 199013
DATE SEPT. 3, 1975
COVERAGE 95%

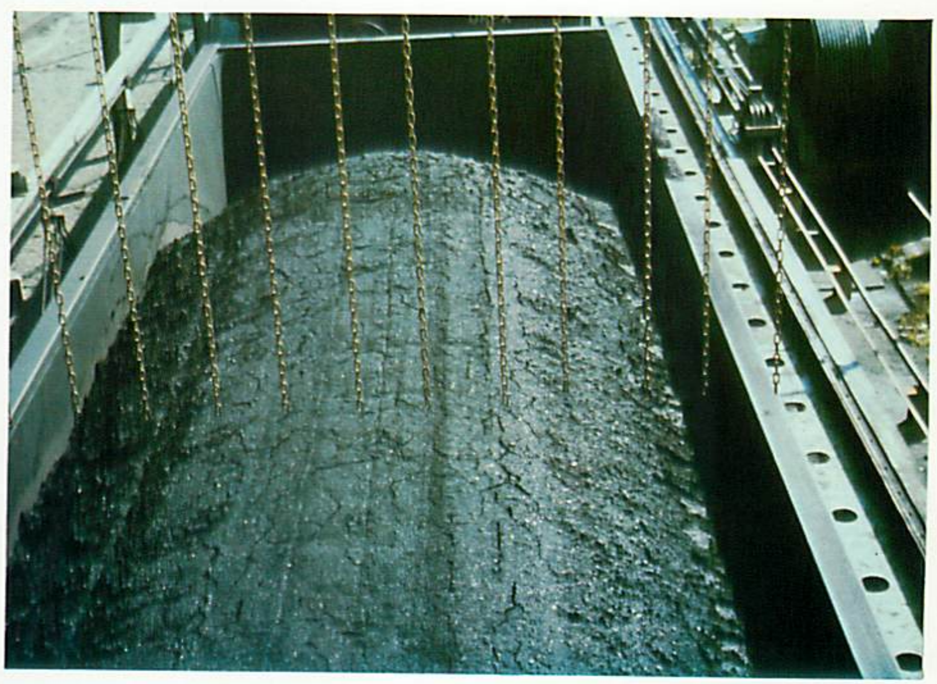


PLATE 24:
SLIDE M280-10
MINE D
CAR 100945
DATE SEPT. 9,1975
COVEERAGE 80% >