Proceedings of the 2nd Annual British Columbia Mine Reclamation Symposium in Vernon, BC, 1978.
The Technical and Research Committee on Reclamation

SPOIL DUMP RESLOPING AT FORDING RIVER OPERATIONS

Paper Presented
by:

J. Popowich
Superintendent, Mine Engineering
Fording Coal Ltd.
Elkford, B.C.

Proceedings of the 2nd Annual British Columbia Mine Reclamation Symposium in Vernon, BC, 1978.
The Technical and Research Committee on Reclamation

SPOIL DUMP RESLOPING AT FORDING RIVER OPERATIONS

ABSTRACT

Much research work has been done on the suitability of materials and the selection of plant species for revegetation purposes. This work is well documented and research is continuing. Limited work, however, has been done on the actual physical preparation of reclamation sites. Fording Coal Limited has undertaken research on optimum resloping techniques. The first phase of this work, completed in 1977, covered the physical resloping of waste dumps from the natural angle of repose (37°) to a range of slope angles from 26° to 34°. Associated costs were closely monitored to determine the effect of resloping requirements on the economics of spoil construction (formed versus free dump spoils).

This paper discusses preliminary results of the resloping test work, specifically equipment limitations, economics of dump construction and planned follow-up work. Also discussed is the integration of these results with mine planning.

Proceedings of the 2nd Annual British Columbia Mine Reclamation Symposium in Vernon, BC, 1978.
The Technical and Research Committee on Reclamation

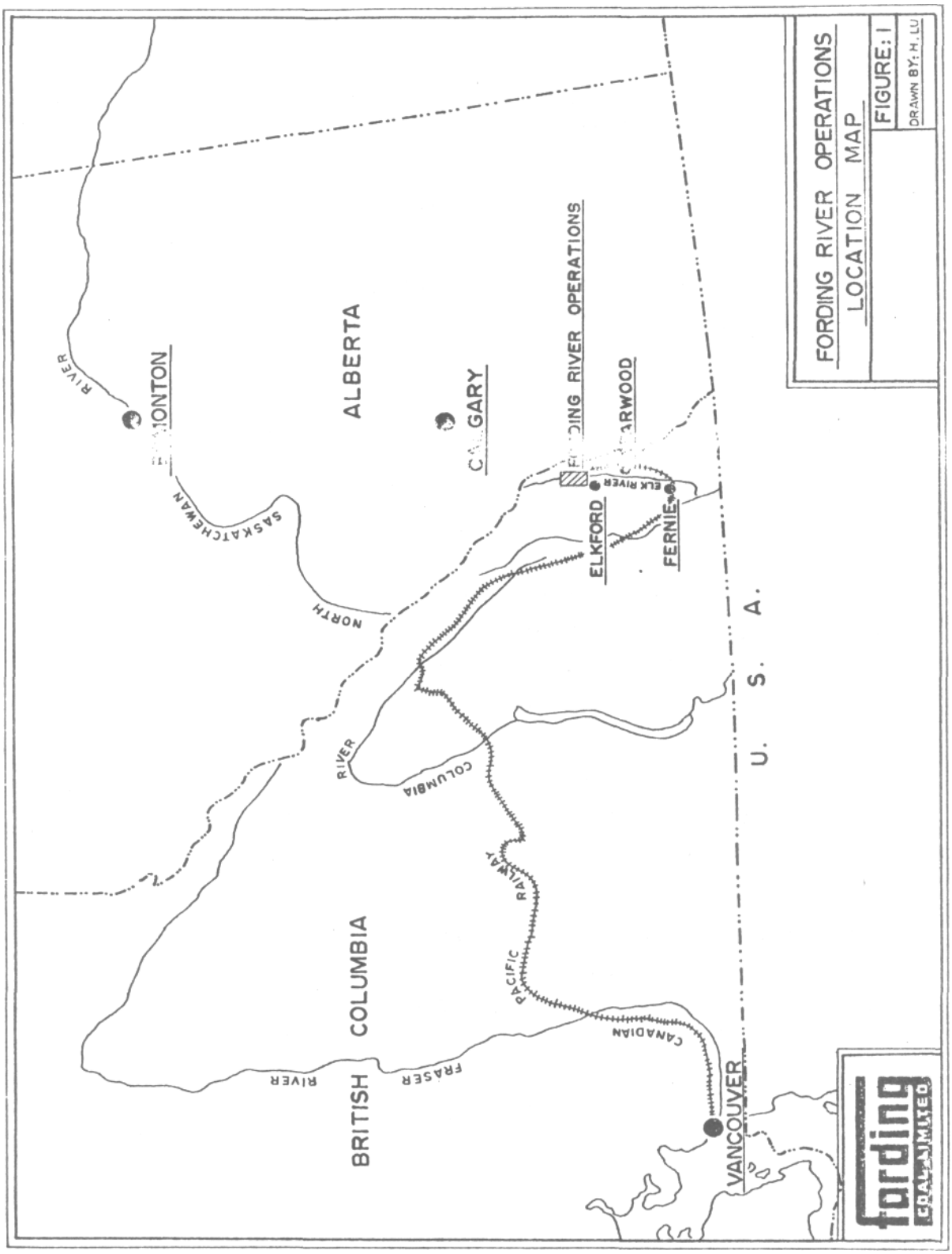
SPOIL DUMP RESLOPING AT FORDING RIVER OPERATIONS

INTRODUCTION

Fording Coal Limited operates the Fording River coal mine located in southeastern British Columbia. The mine site (Figure 1) is within the medial range of the southern Canadian Rocky Mountains, 40 miles north of the Crowsnest Pass and four to seven miles west of the British Columbia-Alberta border.

Fording Coal Limited is owned 60 percent by Canadian Pacific Investments and 40 percent by Cominco Ltd. The operations produce an average of 3 million long tons of cleaned metallurgical coal per annum, primarily for export to Japan. Mining operations commenced in 1972 and are carried out on a three eight-hour shift, seven days per week basis. The operations consist of two types of mining (truck-shovel with 15-yd. shovels and 120-to 170-ton trucks and a 60-yd. dragline). Material moved in 1977 was 25,000,000 bank cubic yards of waste and 4,000,000 long tons of raw coal.

This paper discusses some of the problems and solutions of spoiling in a steep, narrow mountainous valley and the related problems in preparation of spoils for reclamation.


FORDING RIVER OPERATIONS
LOCATION MAP
FIGURE: 1
DRAWN BY: H. LU
ALBERTA
CALGARY
FORDING RIVER OPERATIONS
ELK RIVER
ELKFORD
FERNIE
SASKATCHEWAN
NORTH
RIVER
COLUMBIA
RIVER
U. S. A.
BRITISH COLUMBIA
FRASER
RIVER
CANADIAN
PACIFIC
RAILWAY
VANCOUVER
fording
COAL LIMITED

BIOGEOCLIMATIC ASPECTS

Fording Operations lie within the continental temperate climate zone. Average annual precipitation is 34 inches with temperature extremes of -40° C in winter to 35° in summer.

Mining operations take place from approximately 5000 feet to 7400 feet above sea level.

Vegetation cover on the valley bottom and lower slopes is mainly forest with dominant coniferous species being Engelmann spruce, lodgepole pine and minor amounts of balsam fir and western larch. Grass-shrub communities exist on south and southeast aspects.

The high elevation grassland is classed as moderate winter range for elk and sheep. Elk and moose populations inhabit the valley bottom. Black bear abound in the area and are often seen feeding on reclaimed areas.

Land use in the area is primarily forestry, hunting, fishing and general outdoor activities. Ultimate land use objectives for the mining operations consist of the development of spoils to permit restoration to forest cover as well as open high elevation wildlife grazing areas.

STRUCTURAL GEOLOGY AND MINE LAYOUT

Metallurgical coal seams occur in the lower 2000 feet of the 4000-foot Kootenay formation on both sides of the Fording River valley. Figures *2* and 3 show the existing mine layout and geological sections. The major structural features are two sub-parallel synclines - one on each side of the valley running north-south and a regional (Erickson) fault along the west side of the Fording River.

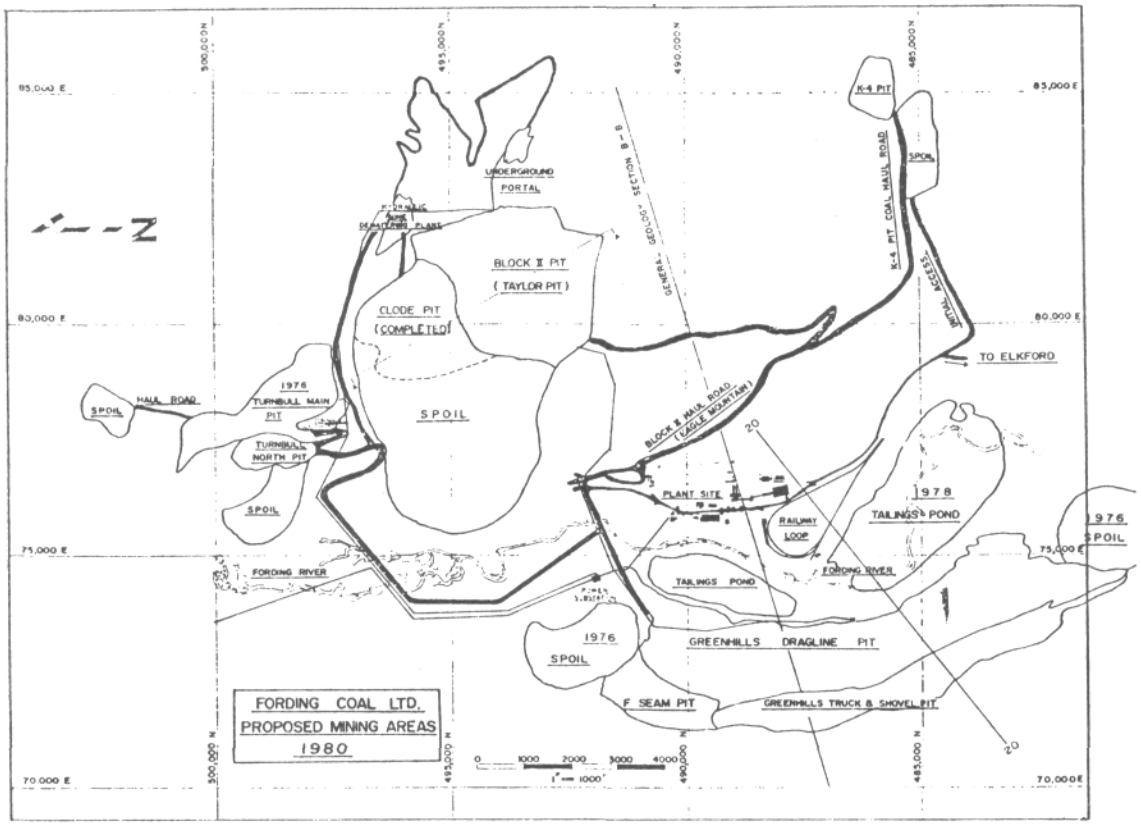


FIGURE 2 — Fording Coal Surface Plan.

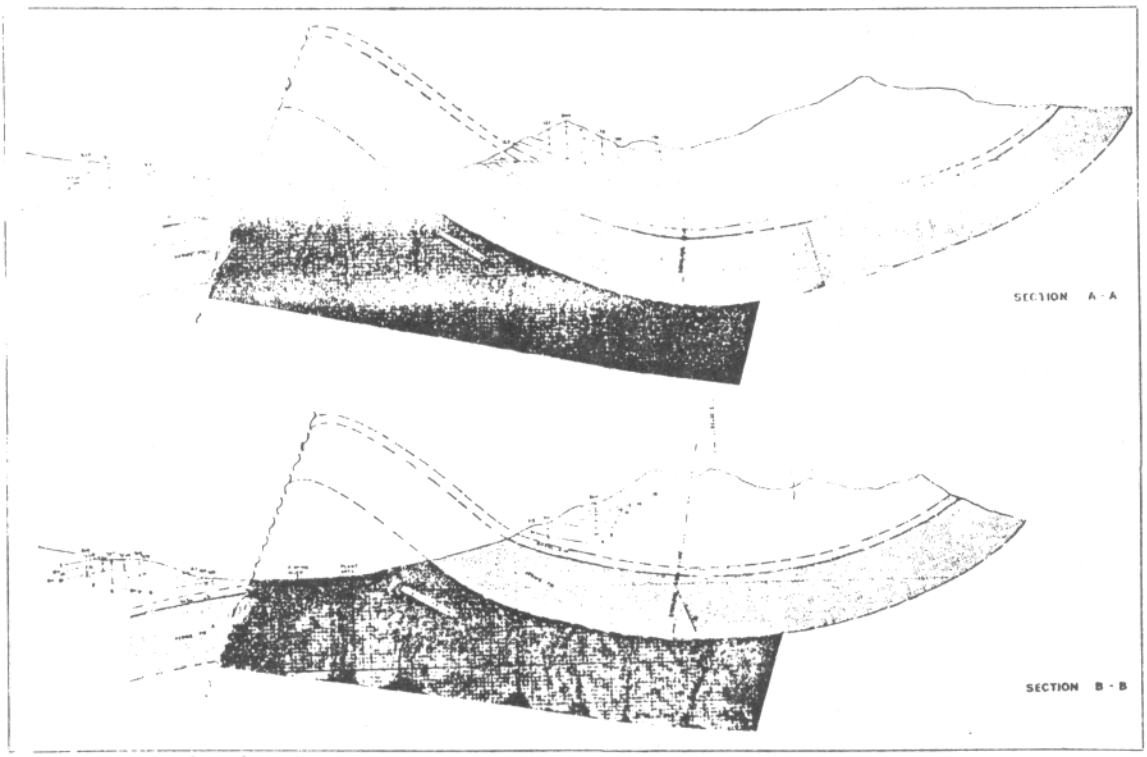


FIGURE 3 — General Geological Section.

Truck-shovel operations exist on the eastern side of the valley in Clode and Turnbull pits. Dragline mining with truck-shovel prestrip exists on the western side of the valley. Both operations create massive quantities of waste which will require extensive site preparation for reclamation purposes.

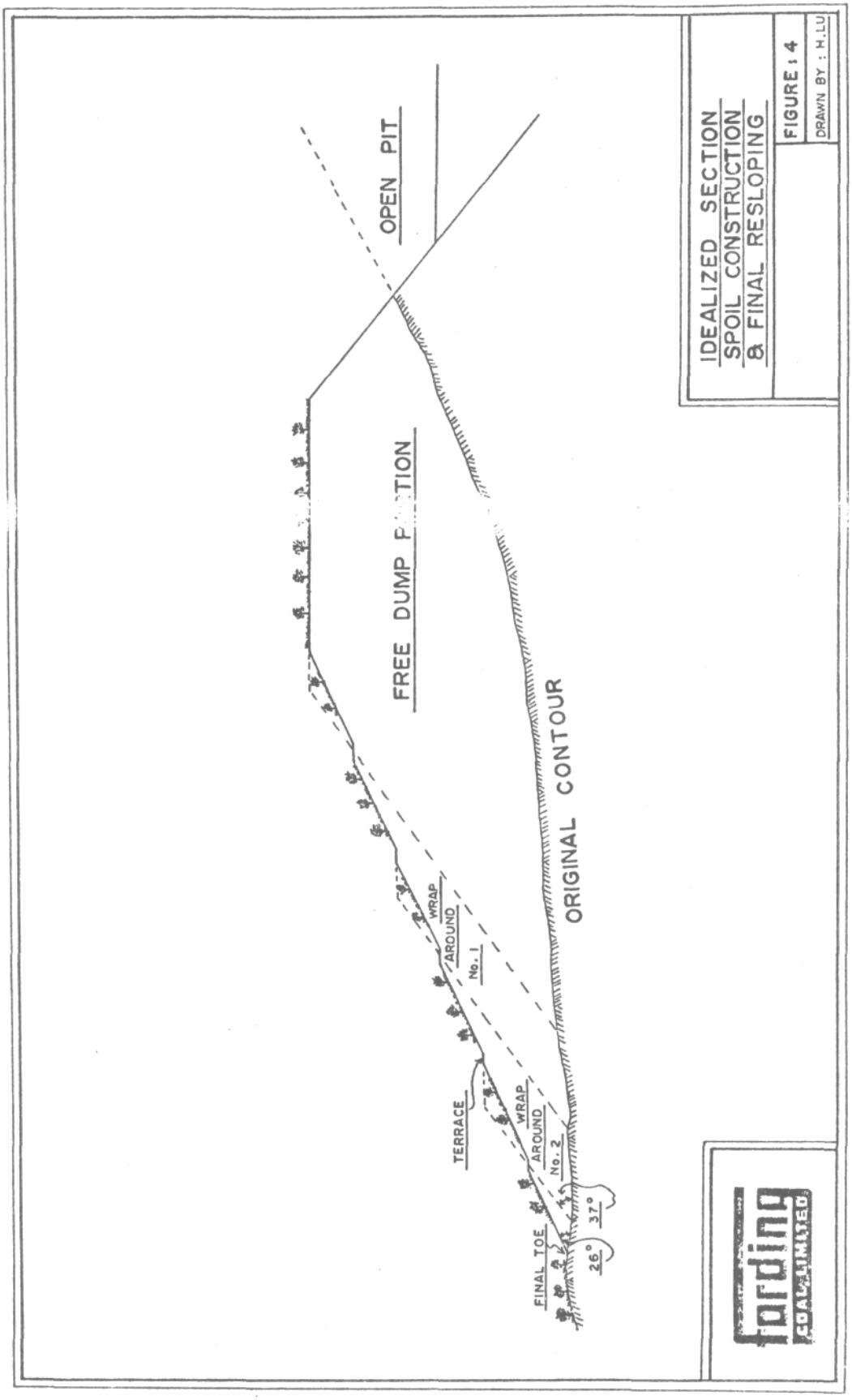
SPOIL CONSTRUCTION

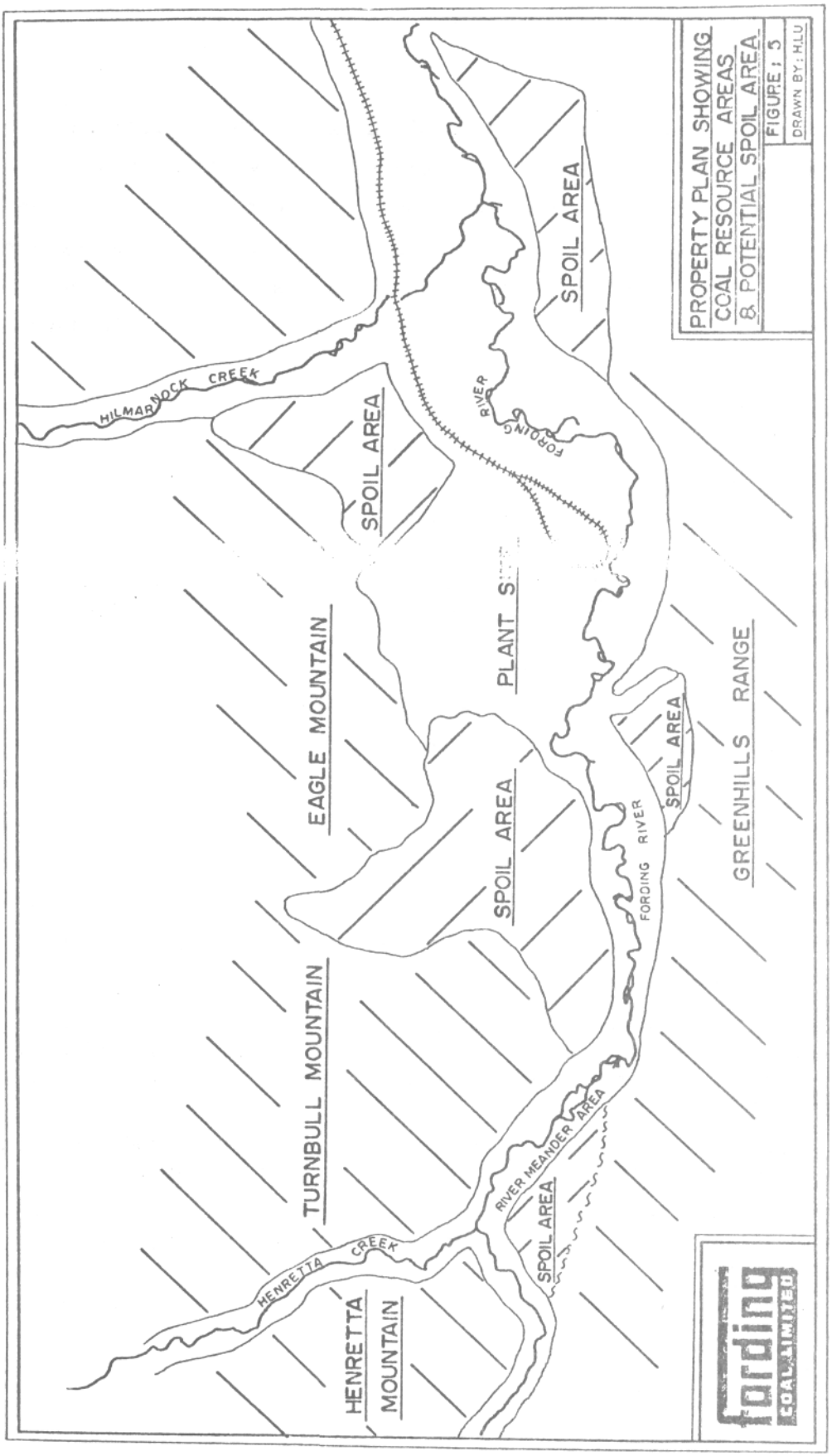
Normal spoil construction can be of two types: free dump or formed spoils. Free dump construction can be defined as dumping waste from any elevation. Formed spoils consist of layering waste materials in lifts (i.e. 100 to 200 feet). Economics of mining normally show free dump construction to be more beneficial, however, dumps greater than two hundred feet pose a problem for reclamation. Figure 4 shows normal dump construction at Fording River operations. Free dumping is maximized followed by wrap-around dumping to provide for spoil stability and for reclamation purposes.

SPOILING CONSIDERATIONS

The narrow steep valley and the extensive lateral coal deposits result in problems of fitting spoil volumes into available areas. It is necessary that all economic surface mining reserves are recovered before being buried under millions of yards of waste material. Figure 5 shows the surface area available for spoiling. In addition to basic space considerations, other factors involved are the Fording River meander belt, regional drainage patterns (creeks etc.), wildlife corridors, haulroad and powerline right-of-ways, plant site location, tailings ponds — in other words minimization of the total land disturbance.

It is therefore essential that spoil volumes in any given area be maximized. This is best achieved by optimizing the slopes at which spoils may be reworked while allowing for adequate reclamation.


IDEALIZED SECTION
SPOIL CONSTRUCTION
& FINAL RESLOPING
FIGURE : 4
DRAWN BY : H.LU
OPEN PIT
FREE DUMP P TION
ORIGINAL CONTOUR
WRAP AROUND No. 1
TERRACE
WRAP AROUND No. 2
FINAL TOE
26°
37°
fording
COAL LIMITED


PROPERTY PLAN SHOWING
COAL RESOURCE AREAS
& POTENTIAL SPOIL AREA
FIGURE : 5
DRAWN BY: H.L.U
HILMARNOCK CREEK
SPOIL AREA
FORDING RIVER
SPOIL AREA
EAGLE MOUNTAIN
PLANT S
SPOIL AREA
FORDING RIVER
SPOIL AREA
GREENHILLS RANGE
TURNBULL MOUNTAIN
RIVER MEANDER AREA
SPOIL AREA
HENRETTA CREEK
HENRETTA MOUNTAIN
fording
COAL LIMITED

Current guidelines require that a slope of 26° (biological angle of repose) be utilized. Some doubt remains as to whether this is the most suitable, economic slope angle when natural areas in the Fording valley support vegetation growth on slopes in *excess* of 30 degrees. There are obvious benefits if it can be demonstrated that adequate reclamation can be achieved in slope angles in *excess* of 26 degrees. These include:

- a reduction in land area disturbance.
- a reduction in material movement required during the resloping stage of reclamation,
- a reduction in mining costs as haul distances are reduced by increasing spoil capacity of a given area,
- a reduction in revegetation materials as the net reclaimed surface area is decreased through increases in the reclaimed slope angle.

However, the final slope angles must provide for:-

- the safety of operations (during resloping),
- efficient revegetation techniques,
- adequate drainage control,
- land surfaces consistent with final land use objectives.

Reclamation is generally considered to be site specific. Accordingly, Fording Coal initiated research in 1977 on spoil resloping. Specific objectives of this research were:

- to establish resloped areas with varying slope angles, climatic exposure and base material composition to allow field reclamation research to determine vegetation growth on slope angles with varying conditions,
- to evaluate equipment performance, safety, planning and operating guidelines when resloping waste dumps at various angles,
- to establish field reclamation research areas in locations rep resentative of the two principal mining methods — dragline and truck-shovel,
- to initiate full-scale reclamation work in areas of final spoiling.

FIELD WORK - 1977

Two spoil areas for research were chosen: Greenhills south (dragline) and Turnbull (truck-shovel). The Greenhills area was at the final spoil limits, and the Turnbull area is not planned for additional spoiling for several years allowing for long-term research.

Local contractors were hired for the initial resloping as mine operations did not have sufficient equipment required for this work. Details of the project were discussed with equipment operators so they could contribute effectively to the project. This approach was very successful in obtaining operational data on equipment limitations and operator safety.

Project parameters were as follows:

- development of panels with slope angles of 26° to 34° (use of crawler dozers only),
- development of a 20-foot wide terrace at approximately mid-point on the spoils *face.* This terrace would have a 2° cross-sectional slope for drainage purposes,

  use of the terrace for access for top-soiling and revegetation purposes (hydroseeder and light vehicle access). It is important to note that spoils at Fording can exceed 1000 feet in vertical height,
- use of the terraces for research into drainage considerations primarily to determine the effects of runoff on seed and fertilizer retention on the spoil face,
- provision of slopes having varying facing aspects (all directions),
- variation of surface materials (glacial till, peatmoss or natural mudstones and shales),
- detailed cost collection,
- use of various equipment sizes (D-6, D-8 and D-9's).

SPOIL COMPOSITION

Waste materials consist basically of sandstone, carbonaceous mudstone, siltstone and some glacial till. Normal dump construction results in the more competent sandstone rolling to the bottom of the spoil area; while the less competent materials (shales and mudstones), remain at the crest (or top) portion of the dump. The coarse sandstone provides for good drainage at the base of the spoil. Resloping pushes the finer crest materials (which degrade quickly - less than two years) over the face of the spoil giving an excellent surface for revegetation.

REVEGETATION PRACTICES

It is Fording's intention to use natural materials as much as possible. Research work has been extensive with numerous test plots being studied both for vegetation species related to material types and altitude as well as maintenance (fertilization) requirements.

Vegetation materials were based on previous test results with an application of the seed mixture at 40 lb. per acre and complete fertilizer, 13-16-10, at 300 lbs. per acre.

The seed mix applied by hydroseeder consisted of:

10% Alsike Clover	5% Red Top
35% Rambler Alfalfa	10% Canada Blue Grass
25% Creeping Red Fescue	15% Climax Timothy

RESLOPING RESULTS

Most of the resloping was conducted during ideal weather conditions. Work was held up during short periods of moist conditions for reasons of operator safety.

Equipment Limitations

It was found that dozers worked most effectively on slopes up to 28° to 30°. High productivity was obtained. The equipment had a natural tendency to cut the slopes at 28°. Slopes from 30° to 34° resulted in cross pushing (low productivity) and deep grouser or crawler track markings.

At angles above 28° it was found that the dozers would climb efficiently in a forward position only. Reverse climb was possible but resulted in a low productivity.

Clinometers mounted on the dozers are required to maintain grade control.

No mechanical difficulties were encountered.

Spoil Stability

Minor crescent-shaped failures occurred on slopes of 32° to 34°. Failures were of the surface material only (less than a foot deep) and were related to fine wet material. In general, these were not a problem and are not expected to pose future problems.

Analysis of the slope material showed good subsurface drainage.

Terrace Development

Spoils at the Fording River mine can be up to 1000 feet high. Experience has shown development of spoils of this height to be safe provided material placement procedures and spoil stability monitoring are followed. However, resloping of such spoil introduces other factors such as operator safety, cost of dozing (rehandle), and lack

of access for reclamation work.

Spoil heights resloped during the 1977 program varied from 100 to 200 feet high. Terraces of 20-feet width were created at approximately the mid point of the spoil face (50 to 100-foot intervals). Development of these terraces proved effective both from the operation point of view, drainage control, and access for re-vegetation. The hydroseeder was able to distrlbute vegetation materials over all of the faces encountered.

Development of spoils in less than 200-foot layers would result in additional spoiling costs during operations (maintenance of spoil faces, berms, etc.) More work is required on terrace interval.

Terraces will also provide for wildlife migration.

Drainage Considerations

Limited information has been obtained to date. Pure dozer work results in a major down dip drainage pattern as a result of the final slope surfacing. Minor cross-dip patterns are created by grouser marks.

Spoils with terraces at 75 to 100-foot intervals provide for devel-opment of major cross-face drainage patterns. Two dozers, operating in parallel on the terraces, can move harrows across the face. This would also facilitate the mixing of revegetation materials into the subsurface.

Terrace construction should allow for drainage away from the spoils to prevent gullying or down dip erosion. Cross-dams on the terraces

can be constructed to prevent major erosion along the terrace. However, drainage must be adequate to prevent failure of the crest of the terrace.

Cost Results

Costs for resloping varied with the push distance involved (between $1,000 and $5,000 per plan acre). Costs for dozing varied from $0.30 to $0.40 per loose cubic yard. Comparison with haulage costs indicate that vertical lifts for spoil development should be in the order of 200 feet. However, more work is required due to site-specific conditions such as relation of pit area to spoil location, use of larger equipment for resloping, balance of the correct materials for revegetation, and availability of resurfacing materials if correct on-site materials are not available.

CONCLUSIONS

Preliminary results indicate that spoil resloped angles can be increased to at least 28° with a posslbility of 30°. Operator safety appears to be adequate. Drainage and revegetation consid-erations are satisfied. Surface stability of the spoils appears adequate.

The 1978 follow-up work will include monitoring of surface drainage patterns and vegetation growth with respect to plant species and aspect. Major spoil stability is being analysed utilizing internal angles of friction to determine the factor of safety for the spoil heights and spoil composition encountered at Fording Coal.

Current spoiling plans at Fording utilize 26° reslope angles. Planning revisions are underway to determine the effect of 28° and 30° reslope faces on spoil volumes available. The 1977 field work has indicated that it is essential that reclamation planning be integrated with all stages of mine planning and mine development.

DISCUSSIONS RELATED TO J. POPOWICH'S PAPER

Dave Headdon - University of Calgary. What about internal stress deformation and hydrologically caused problems of slumping?

ANS. I can't answer that in detail. We have consultants who are looking into those problems at this time. I assume they are using all factors involved.

Lionel Jackson - Institute of Sedimentary and Petroleum Geology. Have you any estimates of what the related costs would be if the intervals of wrap-around terraces were changed?

ANS. No. If we construct our dumps with 200-foot intervals then the costs would be consistent with the numbers I've indicated today. If we decide to reslope from 300-foot intervals then the costs would change. The cost differential would increase quite quickly.

Allen Lamb - Interior Reforestation. Could the slope angle be changed from 26° to 30° by the use .of rip rap at the toe of the slope and, if so, would the cost of moving the rip rap into place be justified?

ANS. That, in fact, is happening right now, because in our spoiling operations we get a definite segregation of the materials. The more competent sandstone blocks, some of which are 8-10 feet across, end up at the bottom of the spoil at the toe. To answer your question, I think that it would require some engineering analysis to determine whether that particular type of toe stability would help the overall dump stability. We are not really concerned with the toe. Our concern is where you may get failures three-quarters the way up a slope, especially on a dump 1200 feet in height.