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THE INFLUENCE OF URANIUM MINE TAILINGS ON TREE GROWTH AT ELLIOT LAKE, ONTARIO.

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MINERAL RESEARCH PROGRAM

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REPORT MRP/MRL 77- (OP)

THE INFLUENCE OF URANIUM MINE TAILINGS ON TREE GROWTH AT ELLIOT LAKE, ONTARIO

by

D. R. Murray*

ABSTRACT

A four year study has been carried out to determine the ability of coniferous trees to aid in the reclamation of uranium tailings at Elliot Lake. Five species were planted: white cedar, white spruce, jack pine, scotch pine and red pine. Over 570 bare root, two year old seedlings were planted on bare tailings and in areas of established grasses. A further division was made between areas of coarse and fine tailings.

Overall survival and growth of the trees has been far below expectations from previous experience with several varieties of grasses. The criteria for assessment have been percent survival and yearly growth increases as estimated by plant height. Pine species were superior with survival percentages of 68% for bare coarse tailings, 45% for vegetated coarse tailings, and 34% for vegetated fine tailings. Cedar was the worst with survival percentages of 49%, 14% and 7% respectively. No species survived on bare fine tailings.

The survival and growth of the coniferous trees have been related to the species, environmental conditions and the tailings properties.

Key words: Coniferous Tree Growth, Tailings, Reclamation, Mine Wastes, Uranium, Elliot Lake.

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INTRODUCTION

One objective of uranium tailings reclamation at Elliot Lake is to have the waste area blend in with the surrounding environment. The natural ground cover is a mixed woodland of deciduous and coniferous trees. Coniferous tree seedlings were available in 1974 to initiate the investigation. Surface stabilization would be difficult with tree planting alone. A grass cover was established in 1973 to stabilize a portion of the tailings. Trees were planted in the vegetated tailings and in bare tailings. A comparison was drawn as to the reclamation suitability of the species and the level of effort required for the treatment.

MATERIALS AND METHODS

Two year old tree seedlings were planted in sulphide-containing uranium tailings in the Elliot Lake area in 1974. The tailings material has two distinct textural and chemical areas: coarse and fine. Each area of tailings is representative of a portion of the complete tailings pond. A description of the chemical and physical properties of the two types of tailings are presented in Table 1, and represent the material termed as bare tailings in this report. The vegetated areas have been treated with limestone and fertilizer in sufficient quantity to obtain a grass cover. The method has been described in detail in a previous report (2). Limestone and fertilizer were incorporated into the surface 15 cm to raise the pH to the range of 6.0 to 6.5 at seeding time. Various grass species were band seeded with triple superphosphate fertilizer.

TABLE 1

Characteristics of Uranium Tailings in the Elliot Lake Area (1)

Physical Properties of Uranium Tailings

Physical Properties	Coarse	Fine
Colour	White	Grey - Red or yellow
% - 325 mesh	25	85
Field capacity (%)	1.2 - 7.3	13.0 - 37.4
Wilting coefficient (%)	0.3 - 0.7	3.0 - 13.4
Air entry value (-cm H_2O)	50 - 100	235

Chemical Properties of Uranium Tailings

Chemical Properties		Tailings Coarse	Fine
pH		1.9	2.3
Cation Exchange Capacity (meq /100 g)		0.17	1.75
Toxic Metals			
(NH_4OAc* Soln)	Al	22.2	744.4
(ppm)	Fe	250	500
Available Nutrients			
Nitrogen (NO_3, ppb)		3.04	3.20
Phosphorus			
($NaHCO_3$ Soln, ppm)		0	3.9
Exchangeable Bases			
(NH_4OAc Soln)	K	0.041	0.011
(meq/100g)	Ca	7.61	37.78
	Mg	0.003	0.005
Mineral Content			
(% by weight)	Si	41.3	37.1
	Al	2.0	2.18
	S	1.18	4.25
	Fe	1.15	3.65
	K	1.12	1.14
	Ca	0.28	0.87
	Mg	0.040	0.043
	Mo, Pb	0.05	0.05
Ni, Cu, Zn, Mn, P, Cl		0.01	0.01

* Ammonium Acetate

Maintenance fertilization was carried out each year at 4 - 6 week intervals during the growing season to ensure successful establishment of the grasses.

The grasses were established in 1973, one year prior to the planting of the tree seedlings. Coniferous seedlings of jack pine, scotch pine, red pine, white cedar and white spruce were planted in four plots: vegetated coarse tailings, bare coarse tailings, vegetated fine tailings and bare fine tailings. The trees were planted at 2 meter centers. No starter tablets or soil amendments were used to aid the tree establishment. The bare tailings received no amendments. The vegetated tailings received fertilizer only as planned for adequate grass maintenance.

The distribution of the 573 trees planted is reported in Table 2. No distinction is made between the pine species and these were grouped together in the assessment.

The trees were assessed during mid-summer of each year noting the % survival and plant height. The survival for years 1 - 3 was grouped into 3 categories; dead, living and uncertain. In year 4, the survival was assessed as living or dead. The distinction was based on the presence of new growth in the fourth growing season.

Plant height data was collected for all trees classed as living and the mean value is reported for that species and year of assessment.

Several test trees were removed from each test plot to examine root growth and any distinguishing features in the soil profile and by chemical analysis of the soil. New growth tissue from the 1977 growing season was analyzed for excessive accumulation of heavy metals and radionuclides.

TABLE 2

Number of Trees Planted on Uranium Tailings

Tree Species	Vegetated Coarse Tailings	Bare Coarse Tailings	Vegetated Fine Tailings	Bare Fine Tailings
white cedar	66	63	16	16
white spruce	66	30	12	16
jack pine scotch pine red pine	120	96	32	40

Control tissue was taken from new growth of trees grown remote from the tailing area.

RESULTS AND DISCUSSION

Survival of the trees during the four year test period is presented in Fig. 1, 2 and 3. Trees planted on bare fine tailings did not survive beyond year 1, and therefore, are not included in the graphs. During the first two years, there was a rapid decline in all species with a levelling off in year 3 and 4 by pine and spruce species. This was most pronounced on the vegetated tailings. The difficulty in assessing plant health is shown by the vertical lines on the graphs. In many cases, the plant tops would die and new growth would come from the base of the plant or lower branches the following year. As time passed, however, the uncertainty decreased as trees either strengthened or weakened, making subsequent assessment more precise.

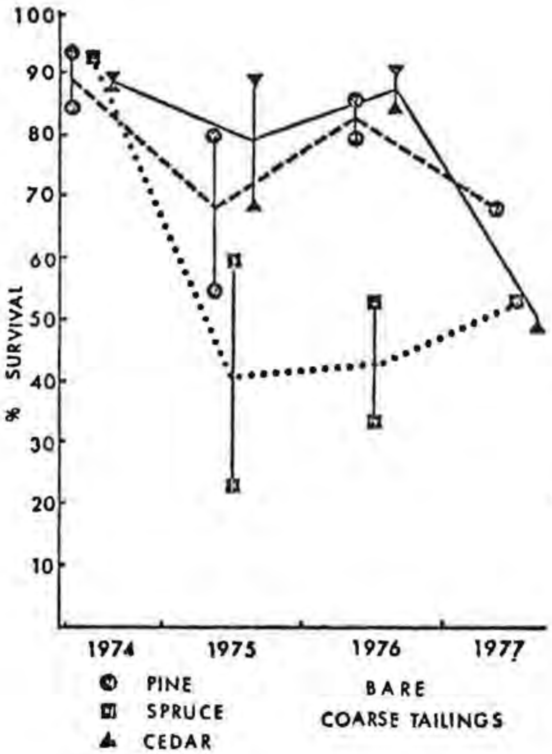

Fig. 1

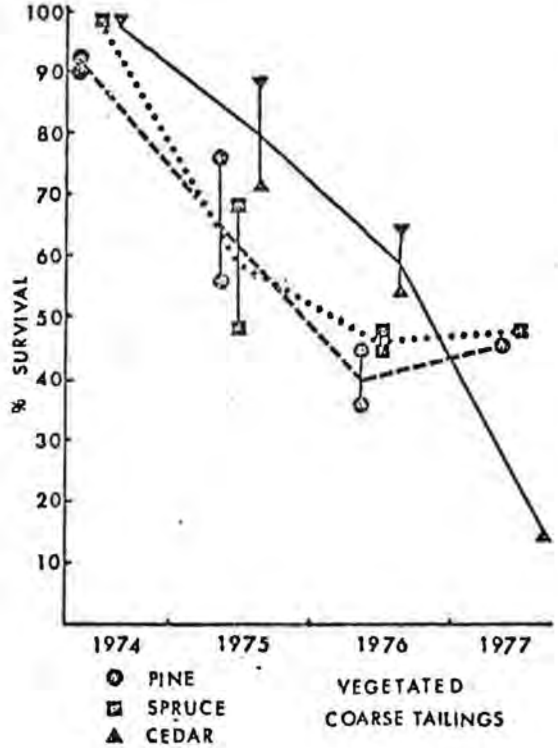

Fig. 2

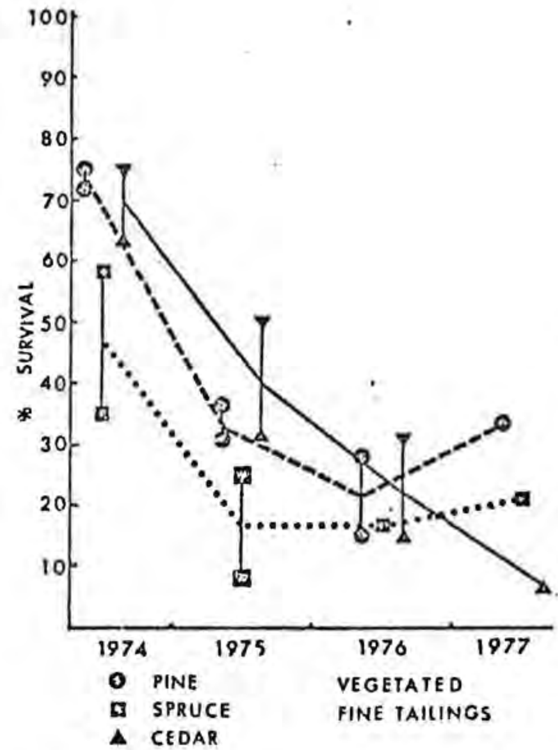

Fig. 3

Survival of Coniferous Trees in Uranium Tailings.

Pine and spruce in contrast to cedar reached a relatively stable level of survival. Survival of the trees in the fourth year is presented in Fig. 4. This data clearly illustrates marked differences between the test plots and the coniferous species. None of the species survived on bare fine tailings. Pine and spruce are consistently superior to cedar, but the tailings material and vegetation cover had a marked influence on tree survival.

Fig. 5, 6 and 7 present the annual mean growth heights of the living trees. Vegetated areas have produced better tree growth than bare tailings areas. The height must be compared with the survival to appreciate the value of various species and surface treatment. The survival and growth of trees is influenced by the tailings chemical properties, moisture conditions, and the vegetative cover present on the tailings. The aggressive uncut grass cover did not permit adequate light exposure for the small seedlings. This contributed to the poor survival rate for the trees in the vegetated areas. When the trees survived, however, and emerged above the grass, the growth of the trees was superior to those planted on bare tailings. This better growth may be attributed to the fertilization program for grass establishment and the protection of the trees by the grass from unstabilized wind-blown tailings.

The trees on bare coarse tailings were exposed to excessive reflected sunlight and heat because of the white colour. The unstable surface has been injurious to the seedlings because the erosion of the surface has exposed roots, has dried the surface, and has provided a source of

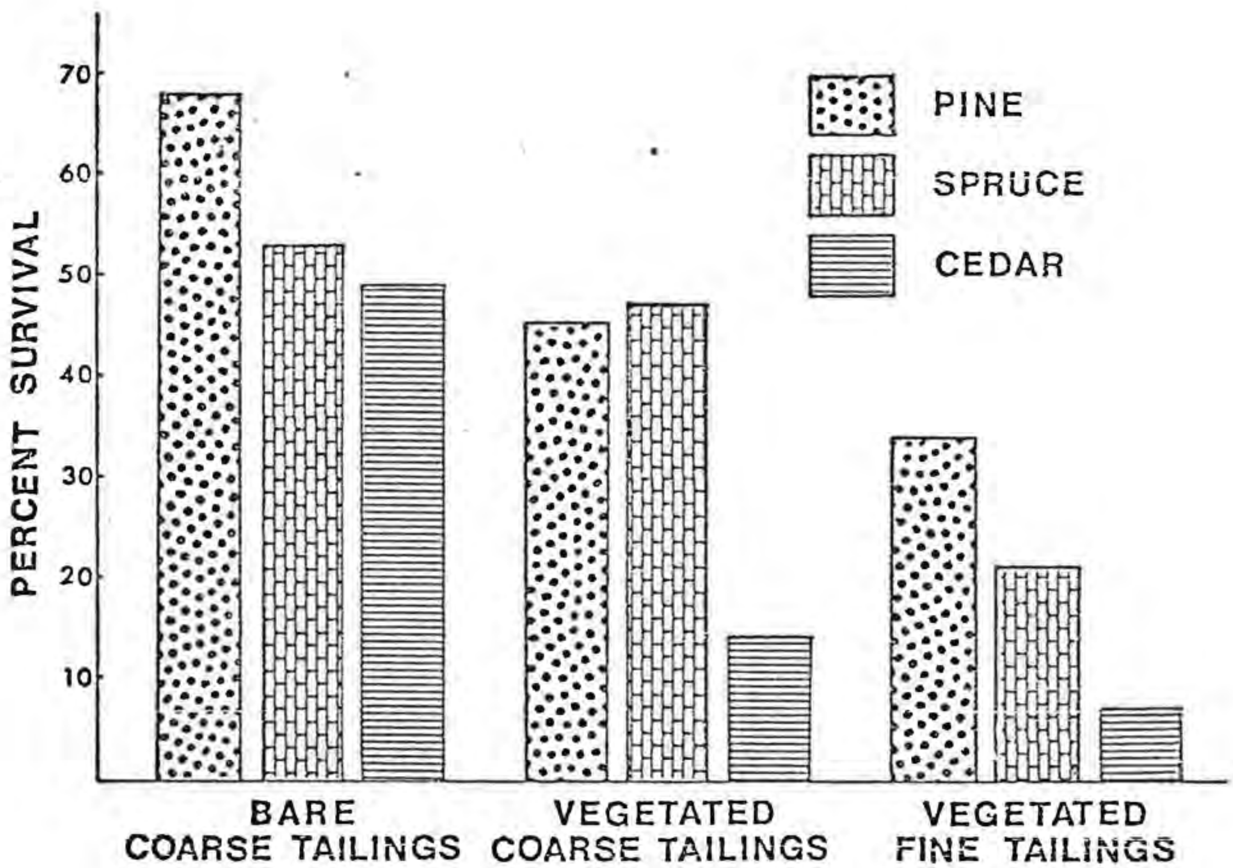

Fig. 4: Survival of Coniferous Trees during the fourth year of growth on Tailings.

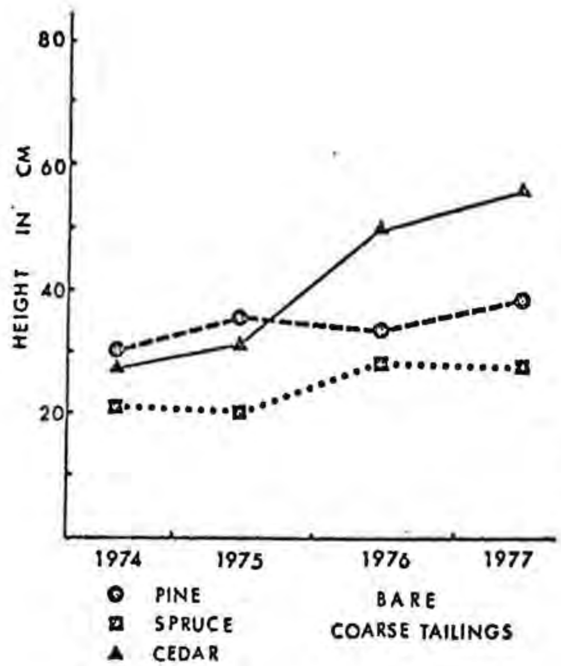

Fig. 1

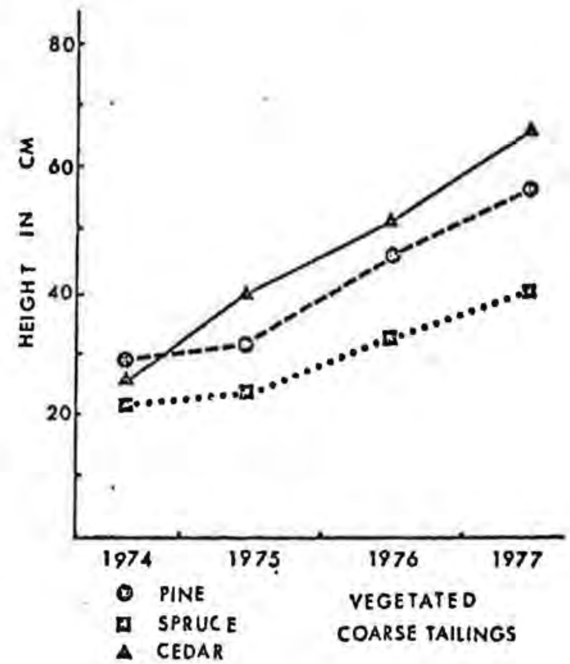

Fig. 2

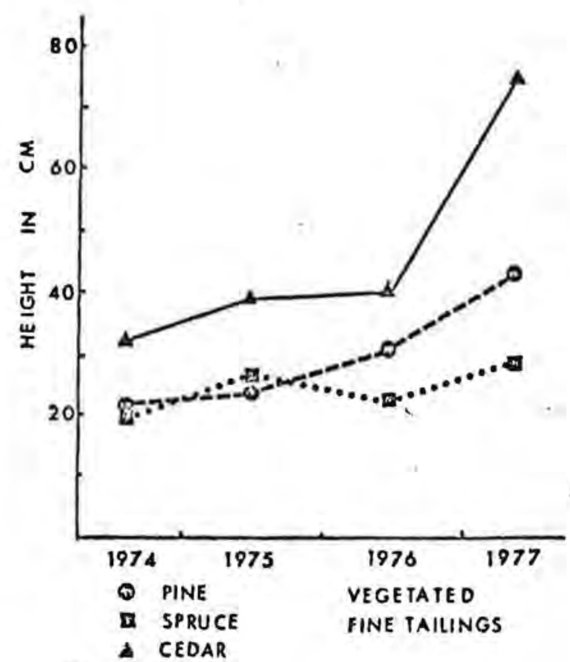

Fig. 3

Coniferous Tree Growth on Uranium Tailings.

wind-blown particles.

The tailings moisture level was critical for establishing grasses and similarly should affect tree growth. On coarse tailings, drought conditions tended to occur rapidly, whereas on fine tailings, flooding was common. The death of all plants on bare fine tailings was partly attributed to the 5 weeks of flooding which occured each spring and the subsequent soil moisture levels (30% - 40%) for the remainder of the year. This caused poor aeration of the root zone, and the death of the tree species planted. In contrast, tree survival was better on the coarse tailings due to a more suitable moisture balance than that present in the fine tailings. Water available for tree growth has been considered equal for the bare coarse and vegetated coarse tailings plots. Rapid drying occurred on the bare tailings while competition for moisture occurred on vegetated tailings.

The chemical properties of the tailings are noxious to grasses and amendments were necessary to establish grasses. No natural encroachment had occurred over the 6 year period prior to this study. Heavy metal content and low pH are closely related and would account for the lack of natural recolonization by grasses or trees. This also explains the lack of success of any vegetation on bare fine tailings. The coarse tailings has shown some acceptance of tree seedlings. This unexpected result without soil treatment could be accounted for by the coarse texture of the material and the effect of leaching of heavy metals from the surface profile creating a more favourable micro-environment. Due to the downward movement of water and chemicals the pH has increased from pH 1.9 to between pH 3.5

and pH 4.0. In the vegetated areas the soil has remained at ≥ pH 5 and the grasses have been supplied periodically with nutrients. The depth of root penetration in coarse tailings has been 15 - 20 cm while in the fine tailings the root penetration has been 5 - 10 cm. In fine tailings this shallow depth was definitely marked with a change in pH from the surface at pH 5.5 to pH 3.0 at a depth of 15 cm. With coarse tailings the change of pH with depth was small, less than 1 pH unit.

Of the species studied, the pine is the preferred species after 4 years of growth. Cedar was thought to be better for the first 3 years, but survival continued to decrease with time; survival of cedar was the poorest at the completion of this study. Spruce appeared poorest at first, but have been more persistent if they survive the first year.

The root growth of the trees has been restricted in all cases to a shallow depth of tailings. Cedar produced a large number of fine roots with no definite main root and the depth was limited to 20 cm with the healthiest plants. Spruce produced numerous lateral roots just below the surface which were often up to 1 meter in length. On the bare tailings these roots had become exposed because of erosion of the loose tailings. There were not many fibrous roots and if present they were short and stubby. Pine roots formed major branch roots, but showed definite bending of the root from vertical penetration to horizontal growth. In fine tailings this was 5 - 10 cm, while in coarse tailings it was 15 - 20 cm. Very few fibrous roots were present and the root hairs were short.

In all cases the roots were black in colour. This could be an indication of poor compatibility of the plants with the micro-environment within the tailings. The balance between survival and death may be a very narrow range which is dependent on the extent of injury to the root tissue. The lack of fibrous roots and stubby root hairs may be an adaptation of the tree to this environment.

Spruce and cedar normally have shallow root systems. Cedar prefer a non-acid soil with adequate moisture, thus the acid in dry conditions of the tailings may contribute to the lack of tree success. Spruce will tolerate slightly acid soils, but prefer a calcareous based soil for best growth. Pine prefer slightly acid soils and poor quality sand textured soils. Normally pine have moderately deep roots. The tailings texture and acidity are more suitable to pine trees, but excess acidity would hamper good growth.

Thus it is not surprising that pine is the preferred species for tailings reclamation. Growth of trees on bare coarse tailings indicates that the material is not completely adverse to tree growth. Growth is not exceptional, but the effort expended on establishment is minimal.

CONCLUSIONS

The use of coniferous trees for reclamation of uranium tailings does not appear to be a rapid solution. The survival and growth rate are not sufficiently encouraging to depend entirely on trees. Surface stabilization of bare tailings was not obtained with trees as it was with a grass cover. The use of fertilizer tablets may increase tree survival and growth during future test work.

Although tree survival was optimal on bare coarse tailings, the best growth rate occurred in the vegetated plots and is attributed to the following factors:

1) Retention of nutrients by the organic layer.

2) Protection from abrasion and erosion by the grass cover.

Of the species tested, pines are the most suitable conifer species for growth on uranium tailings.

ACKNOWLEDGEMENT

The author wishes to acknowledge the fruitful discussion and assistance of Dr. D. W. Moffett.

REFERENCES

1. G. Zahary, D. Murray and B. Joare, Reclamation - A challenge to open-pit mining operations in Canada; World Mining Congress, Lima, Peru; November 1974.

2. D. Murray, D. Moffett, Vegetating the Elliot Lake uranium mine tailings; MRP/MRL 76-114 (J); Journal of Soil and Water Conservation, July August, 1977, pp 29-30.

PROCEEDINGS

OF

THE SECOND ANNUAL GENERAL MEETING

OF THE

CANADIAN LAND RECLAMATION ASSOCIATION

August 17, 18, 19 & 20 — 1977 Edmonton, Alberta

(Sponsored by the Faculty of Extension, University of Alberta)

P R O G R A M

Canadian Land Reclamation Association

Second Annual General Meeting

August 17, 18, 19, 20, 1977

Edmonton, Alberta

Wednesday, August 17 (Optional Field Trips)

Field Trip No. 1 (Athabasca Tar Sands)

Leader: Philip Lulman (Syncrude Canada Ltd.)

Fee: $100.00 (covers bus and air transportation, lunch, and field trip information pamphlets)

Schedule: 7:30 am.- delegates board bus at Parking Lot T, located immediately south of the Lister Hall Student Residence complex. Air transportation from Edmonton Industrial Airport to Fort McMurray and return. Guided bus tour of surface mining and reclamation operations on Syncrude Canada Ltd. and Great Canadian Oil Sands Ltd. leases. 6:30 p.m.- delegates arrive back at Parking Lot T, University of Alberta campus.

Field Trip No. 2 (Aspen Parkland; Forestburg Coal Mine Reclamation)

Leader: George Robbins (Luscar Ltd.)

Fee: $25.00 (covers bus transportation, lunch, and field trip information pamphlets)

Schedule: 8:00 a.m. - delegates board bus at Parking Lot T, located immediately south of the Lister Hall student residence complex. Guided bus tour southeast of Edmonton, stopping at various points of interest (oil spill reclamation field plots; Black Nugget Park [abandoned minesite]; trench plots on Dodds-Roundhill Coal Field; solonetzic soil deep ploughing site) on the way to the Luscar Ltd. Coal Mine at Forestburg. 6:30 p.m. - delegates arrive back at Parking Lot T, University of Alberta campus.

Thursday, August 18

Events:	Opening of Formal Meeting; Presentation of Papers
Location:	Multi-Media Room, located on second floor of Education Building, University of Alberta.
8:00 a.m.	Authors of papers being presented on August 18 meet with paper presentation chairmen and audio-visual co-ordinator (Douglas Patching)
9:00 a.m.	Meeting Opened by Dr. Jack Winch (President of the C.L.R.A.; Head of the Department of Crop Science, University of Guelph). Comments by Dr. Winch.
9:15 a.m.	Welcome to delegates on behalf of the Government of Alberta by the Hon. Mr. Dallas Schmidt, (Associate Minister Responsible for Lands, Alberta Department of Energy and Natural Resources)
9:25 a.m.	Commencement of Paper Presentations. Morning session chaired by Mr. Henry Thiessen (Chairman of the Land Surface Conservation and Reclamation Council and Assistant Deputy Minister, Alberta Department of Environment).
9:30 a.m.	Paper 1. Combined Overburden Revegetation and Wastewater Disposal in the Southern Alberta Foothills by H.F. Thimm, G.J. Clark and G. Baker (presented by Harald Thimm of Chemex Reclamation and Sump Disposal Services Ltd., Calgary, Alberta).
10:00 a.m.	Paper 2. Brine Spillage in the Oil Industry; The Natural Recovery of an Area Affected by a Salt Water Spill near Swan Hills, Alberta by M.J. Rowell and J.M. Crepin (presented by Michael Rowell of Norwest Soils Research Ltd., Edmonton, Alberta)
10:30 a.m.	Coffee Recess
11:00 a.m.	Paper 3. The Interaction of Groundwater and Surface Materials in Mine Reclamation by Philip L. Hall of Groundwater Consultants Group Ltd., Edmonton, Alberta.
11:30 a.m.	Paper 4. Subsurface Water Chemistry in Mined Land Reclamation; Key to Development of a Productive Post-Mining Landscape by S.R. Moran and J.A. Cherry (presented by Stephen Moran of the Research Council of Alberta, Edmonton, Alberta).
12:00 noon	Lunch Recess

1:25 p.m. Continuation of Paper Presentations. Afternoon session chaired by Mr. Philip Lulman (member of C.L.R.A. executive; reclamation research ecologist with Syncrude Canada Ltd.).

1:30 p.m. Paper 5. Coal Mine Spoils and Their Revegetation Patterns in Central Alberta by A.E.A. Schumacher, R. Hermesh and A.L. Bedwany (presented by Alex Schumacher of Montreal Engineering Company Ltd., Calgary, Alberta).

2:00 p.m. Paper 6. Surface Reclamation Situations and Practices on Coal Exploration and Surface Mine Sites at Sparwood, B.C. by R.J. Berdusco and A.W. Milligan (presented by Roger Berdusco of Kaiser Resources Ltd., Sparwood, B.C.).

2:30 p.m. Paper 7. Agronomic Properties and Reclamation Possibilities for Surface Materials on Syncrude Lease #17 by H.M. Etter and G.L. Lesko (presented by Harold Etter of Thurber Consultants Ltd., Victoria, B.C.).

3:00 p.m. Paper 8. The Use of Peat, Fertilizers and Mine Overburden to Stabilize Steep Tailings Sand Slopes by Michael J. Rowell of Norwest Soils Research Ltd., Edmonton, Alberta.

3:30 p.m. Coffee Recess

4:00 p.m. Paper 9. Oil Sands Tailings; Integrated Planning to Provide Long-Term Stabilization by David W. Devenny of E.B.A. Engineering Consultants Ltd., Edmonton, Alberta.

4:30 p.m. Paper 10. Bioengineering. The Use of Plant Biomass to Stabilize and Reclaim Highly Disturbed Sites by H. Schiechtel and K. (Nick) Horstmann (presented by Margit Kuttler).

5:00 p.m. End of August 18 Sessions.

Friday, August 19

Events:	Presentation of Papers; C.L.R.A. Annual General Business Meeting; C.L.R.A. Annual Dinner.
Locations:	Paper presentations and C.L.R.A. Annual General Business Meeting in Multi-Media Room, located on second floor of Education Building, University of Alberta. - Annual Dinner held in Banquet Room located on second floor of Lister Hall.
8:00 a.m.	Authors of Papers being presented on August 19 meet with paper presentation chairmen and audio-visual co-ordinator (Douglas Patching).
8:30 a.m.	Showing of Film Rye on the Rocks. This film depicts reclamation situations at Copper Cliff, Ontario and is being shown for the purpose of introducing delegates to the site of the 1978 C.L.R.A. meeting (Sudbury, Ontario).
8:55 a.m.	Continuation of Paper Presentations. Morning session chaired by Dr. J.V. Thirgood (Vice-President of C.L.R.A.; member of Forestry Faculty, University of British Columbia).
9:00 a.m.	Paper 11. Reclamation of Coal Refuse Material on an Abandoned Mine Site at Staunton, Illinois by M.L. Wilkey and S.D. Zellmer (presented by Michael Wilkey of the Argonne National Laboratory, Argonne, Illinois).
9:30 a.m.	Paper 12. A Case Study of Materials and Techniques Used in the Rehabilitation of a Pit and a Quarry in Southern Ontario by Sherry E. Yundt of the Ontario Ministry of Natural Resources, Toronto, Ontario).
10:00 a.m.	Coffee Recess.
10:30 a.m.	Paper 13. Amelioration and Revegetation of Smelter-Contaminated Soils in the Coeur D'Alene Mining District of Northern Idaho by D.B. Carter, H. Loewenstein and F.H. Pitkin (presented by Daniel Carter of Technicolor Graphic Services Inc., Sioux Falls, South Dakota).
11:00 a.m.	Paper 14. The Influence of Uranium Mine Tailings on Tree Growth at Elliot Lake, Ontario by David R. Murray of the Elliot Lake Laboratory, Elliot Lake, Ontario.

11:30 a.m. Paper 15. Weathering Coal Mine Waste. Assessing Potential Side Effects at Luscar, Alberta by D.W. Devenny and D.E. Ryder (presented by David Devenny of E.B.A. Engineering Consultants Ltd., Edmonton, Alberta).

12:00 noon Lunch Recess.

1:25 p.m. Continuation of Paper Presentations. Afternoon session chaired by Dr. John Railton, (Manager, Environmental Planning, Calgary Power Ltd., Calgary, Alberta).

1:30 p.m. Paper 16. The Distribution of Nutrients and Organic Matter in Native Mountain Grasslands and Reclaimed Coalmined Areas in Southeastern B.C. by Paul F. Ziemkiewicz of the Faculty of Forestry, University of B.C., Vancouver, British Columbia.

2:00 p.m. Paper 17. Systems Inventory of Surficial Disturbance, Peace River Coal Block, B.C. by D.M. (Murray) Galbraith of the British Columbia Ministry of Mines and Petroleum Resources, Victoria, British Columbia.

2:30 p.m. Paper 18. The Selection and Utilization of Native Grasses for Reclamation in the Rocky Mountains of Alberta by D. Walker, R.S. Sadasivaiah and J. Weijer (presented by David Walker of the Department of Genetics, University of Alberta, Edmonton, Alberta).

3:00 p.m. Coffee Recess; Distribution of Proceedings.

3:30 p.m. Commencement of 1977 General Business Meeting of the Canadian Land Reclamation Association. Meeting chaired by Dr. J.V. Winch, C.L.R.A. President.

7:30 p.m. Commencement of C.L.R.A. Annual Dinner in Banquet Room, second floor of Lister Hall.

Guest Speaker: William T. Plass, Principal Plant Ecologist, U.S.D.A. Forest Service, Northeastern Forest Experiment Station, Princeton, West Virginia.

Topic of Speech: Challenges in Co-operative Reclamation Research.

Note: Following the Annual Dinner and Mr. Plass's speech, delegates may retire to the adjacent Gold Room. A bartender will be on service until midnight.