INTRODUCTION

The reclamation process consists of four basic steps:

1. Planning
2. Approval
3. Implementation
4. Certification

In order for the system to work efficiently it is necessary that this pathway remains unidirectional, that it gives consistent direction and that everyone involved moves from one step to the other with as little friction as is necessary. Three factors tend to threaten the process:

1. lack of commitment,
2. technical weakness, and
3. complexity.

I will not deal with the management factors; rather I will discuss the technical question.

* Chairman
  Reclamation Research Technical Advisory Council
  Alberta Energy
After observing several reclamation regulatory systems in action it seems that there is often a problem between the planning and approval stages. For example, a company proposes a particular reclamation technique and the government agonizes over whether it will meet their reclamation objectives. Much debate ensues and experts are summoned to hold forth. This process may take on the character of an inquisition unless it is clearly recognized as a technical problem. The lack of sound technical information also exaggerates the reclamation certification process. It is highly desirable to base reclamation approvals on detailed plans and then to base certification on whether the plans have been properly implemented. The key to making this work is an adequate data base which successfully predicts how a given reclamation technique will perform. Technical problems have a certain simple charm: either the required facts are available or they are not. This paper describes one method for making the required facts available.

The Alberta mining industry and the provincial government recognized the value of a strong technical information base and in 1973 took steps to acquire one for making reclamation decisions. Many specific issues were addressed but the fundamental question involved identifying those reclamation techniques which all parties were confident would meet the provincial reclamation objective at minimum cost. The goal is to predict the performance of specific reclamation techniques on specific areas. Reclamation techniques fall into three categories: soil reconstruction, landscaping and revegetation. This discussion focusses on soil reconstruction research within the plains agricultural region. As an example it is simple to present and the experiment has been in place long enough to generate considerable data. The same approach to the soil reconstruction issue, however, is currently underway in the Oil Sands and mountain mining areas.

PROVINCIAL OBJECTIVES

The reclamation objective of coal mine reclamation in Alberta is to build landscapes which will be as useful to man as in the premining state. This involves landscaping, soil reconstruction and revegetation. Following is an outline of a method for evaluating which soil reconstruction strategies will meet Provincial objectives. The Provincial approach to soil reconstruction includes:

1. Identification of premining soil resources
2. Development of a soil salvage and replacement plan
3. Implementation
4. Certification
Soil reconstruction is one of the major items when evaluating reclamation certification. The soil survey and implementation components of soil reconstruction are straight-forward and follow accepted methodologies. The difficult part involves development of the soil reconstruction plan. This is where premining soil conditions are matched to reconstructed soil profiles. If the original soils and overburden could be removed and replaced without disturbance there would be no problem. However, a certain amount of mixing will occur as soil horizons are removed and replaced and even the spoil behaves differently from unmined bedrock. In short, reconstructed topsoils and subsoils will be different from their unmined predecessors. Therefore development of the soil reconstruction plan faces the problem of equating the reconstructed soil with the premining soil. Since the factor to be equated in this case is "usefulness to man" we must ultimately focus on the reconstructed soils capability to grow useful plants. At the planning stage this information would eliminate much of the uncertainty over whether a particular reconstructed soil would meet the reclamation objectives. Predictive power is particularly important in soil reconstruction since:

1. Moving unnecessary volumes or types of soil is expensive and wasteful.

2. It is nearly impossible to adequately upgrade poorly reconstructed soils.

3. Defining the relationship between soil reconstruction technique and crop productivity will allow us to measure the reclaimed area's capability in terms of soil reconstruction technique (e.g. quantities and qualities of salvaged and replaced soil materials).

To summarize, in order for the planning process to be effective relationships must be defined between soil reconstruction strategies and crop productivity. Following is an outline of our methods and progress toward identifying these relationships.

THE RESEARCH PROGRAM

The Problem

The plains coal seams are usually overlain by bedrocks which contain a high proportion of swelling clays. When exposed to the elements the bedrock shales and sandstones break down into a material that is sticky when wet and very hard when dry. This severely hinders plant growth and agricultural operations. Above the bedrock lie glacial deposits which are usually free of the most adverse properties of the bedrock though they lack the plant nutrients and organic matter characteristic of the overlying topsoil.
Rebuilding a soil profile is one of the major problems in cropland reclamation in Alberta. A soil must be built on levelled overburden which will be as productive as the original soil. Existing evidence indicates that placing topsoil and a buffering material over the spoil is the most efficient method for achieving this goal (Figure 1). However, we do not know how much capping material is needed. Also, where topsoils or subsoils are in short supply other amendments may be useful in soil building.

Mining on Agricultural Land

Cropland is surface mined in two major zones in Alberta. The Ardley Zone running southeast from Mayerthorpe to Red Deer and the Horseshoe Canyon Zone which runs parallel and to the east from Barrhead through Camrose to Drumheller. The Ardley Zone is surface mined near Lake Wabamun to provide coal to the Wabamun and Sundance power plants. Two additional power plants, Keephills and Genessee, are presently under construction and will extend mining southward to the town of Genessee. The Horseshoe Canyon Zone is mined on either side of the Battle River between Forestburg and Halkirk. These mines supply the Battle River Generating Station. Another power plant and mine are being developed to the south at Sheerness (Figure 2).

Approach

Mining in the Ardley and Horseshoe Canyon coal zones involves two different sets of soils, overburden and climate. Also, soil reconstruction and groundwater cannot be studied in isolation. For example, if after mining a saline watertable re-establishes within a foot of the soil surface, the topsoil, regardless of its original quality, will quickly become unsuitable for crops. So in both the Ardley and Horseshoe Canyon zones we are identifying the best methods of reconstructing soils and at the same time we are studying what happens to the groundwater after mining.

RECLAMATION OF COAL MINEDJLAHP

Plains Coal Reclamation Research Program

The Plains Coal Reclamation Research Program (PCRRP) has been designed by the Provincial Government and members of the coal industry to answer questions relating to groundwater and soil reconstruction in both of our plains coal mining zones. Two main projects have been established:
Figure 2

Alberta
ENERGY AND
NATURAL RESOURCES

MAJOR PLAINS COAL ZONES
1982
1) The Plains Soil Reconstruction Project will tell us how to rebuild agricultural soils after mining, and

2) The Plains Hydrology and Reclamation Project will describe what happens to groundwater during mining and after reclamation and how to rebuild the landscape to maximize the agricultural potential.

By combining the results of these experiments we will develop a picture of how mined landscapes work and how they can be designed to ensure the return of their original values.

These projects are installed both at the Highvale and Battle River mining areas. Both are designed for five years of intensive study with the possibility for further monitoring beyond that period.

The program has been jointly designed and managed by Provincial Government and Coal Industry personnel. The projects are also funded by both industry and government. For example, Alberta Power Ltd., Luscar Ltd., Manalta Coal Ltd. and TransAlta Utilities Ltd. constructed the Test Plots at Battle River and Highvale while research and maintenance activities for the Soil Reconstruction and Hydrology Programs are supported by the government from the Heritage Savings Trust Fund.

1. Battle River Soil Reconstruction Project (82-5-LES)
   L. A. Leskiw, Pedology Consultants Ltd.

2. Highvale Soil Reconstruction Project (82-13-SCH)
   L. A. Panek, Montreal Engineering Co. Ltd.

Grain and forage yields are being evaluated on a series of soil reconstruction plots at the Battle River and Highvale Mining areas. Treatments include: depth of subsoil (0 to 3m thicknesses) over sodic spoil, use of bottom ash as an impediment to upward salt migration, use of coal ash and gypsum as soil amendments and reconstruction of solonetzic topsoils using different horizons and mixtures. Lateral salt migration through reconstructed soils over spoil slopes is also being studied. The project began in 1979 at Battle River and construction was completed at Highvale in 1982. (See Figures 3, 4)

Status: Cropping and soil sampling began at Battle River in 1982 and we now have four crop years of data. The first crop was grown at Highvale in 1983. Each site will be studied intensively for at least five years.
FIGURE 3a. LOCATION MAP, BATTLE RIVER SOIL RECONSTRUCTION PROJECT
FIGURE 3b  COMPOUND LAYOUT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT
FIGURE 3c. PLOT LAYOUT - SUBSOIL DEPTH EXPERIMENT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT
FIGURE 3d. PLOT LAYOUT – TORLEA SOIL EXPERIMENT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT
The Technical and Research Committee on Reclamation

FIGURE 3b. PLOT LAYOUT - BOTTOM ASH EXPERIMENT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT
FIGURE 3f. PLOT LAYOUT - SLOPE DRAINAGE EXPERIMENT 1, BATTLE RIVER SOIL RECONSTRUCTION PROJECT
A. ALFALFA (RAMBLER) AND BROMEGRASS (CHARLTON)
B. BARLEY (KLONDIKE)
0.0 NO SUBSOIL
0.25 0.25m SUBSOIL
0.50 0.50m SUBSOIL
1.00 1.00m SUBSOIL
1.50 1.50m SUBSOIL
3.00 3.00m SUBSOIL

FIGURE 4b.
HIGHVALE SOIL RECONSTRUCTION PROJECT
SUBSOIL EXPERIMENT LAYOUT
RESULTS

The following histograms indicate 1983 yield data from the Battle River and Highvale soil reconstruction plots. Three of the experiments from Battle River are presented: Subsoil Depth, Bottom Ash and Torlea. The two former experiments have both small grain and forage treatments while the latter is planted to forage only. 1983 was the first crop year at Highvale so only grain yields are shown. The treatment yields are compared with 5 year average yields within the same County (1975-1979). Yields within Canadian land inventory classes are indicated on each histogram with standard deviations of the mean and sample size (A).

At Battle River grain yields were consistently far below County averages and showed no treatment effects, in either the subsoil depth or the bottom ash experiments. 1983 was a drought year in eastern Alberta and this may have overcome the treatment effects. Many local farmers in 1983 had better grain yields nonetheless. Forage yields in the Subsoil Depth, Bottom Ash and Torlea experiments were nearly double those of local solonetzic soils even at the lowest treatment levels and equal to the best local soils with mid-range treatment levels. Bottom Ash incorporation in the reconstructed soil had a very strong positive effect on yields. This was only the second crop year at Battle River and at least five years of results are required before reliable conclusions can be drawn (Figures 5, 6, 7).

The Highvale plots were first planted and harvested in 1983. Therefore only grain yields were taken. The results indicate a trend toward increased yields up to 1.0m of subsoil. Yields exceeding or matching local Class 1 land were achieved with subsoil depths of 1.0 or more while yields equivalent to Class 3 and 5 land were achieved at 0.5m of subsoil depth (Figure 8).

CONCLUSION

Early results of the Battle River and Highvale Soil Reconstruction Projects indicate that, in all but one case, crop yields are a function of soil reconstruction method. The specific nature of the functions cannot be reliably extended into future performance until at least five years of results are compiled.
The Technical and Research Committee on Reclamation
Fig. 7  BATTLE RIVER TORLEA SOIL EXPERIMENT
1983 FORAGE YIELDS

A, B, and C respectively signify surface amendments of 15 cm of Ash, 20 T/ha gypsum and a control.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Soil Reconstruction</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Spoll</td>
</tr>
<tr>
<td>2</td>
<td>10 cm topsoll/spoll</td>
</tr>
<tr>
<td>3</td>
<td>10 cm topsoll/20 cm B and upper C horizons/spoll</td>
</tr>
<tr>
<td>4</td>
<td>10 cm topsoll/45 cm B and upper C horizons/spoll</td>
</tr>
<tr>
<td>5</td>
<td>10 cm topsoll/75 cm C horizon/spoll</td>
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<tr>
<td>6</td>
<td>10 cm topsoll/100 cm C horizon/spoll</td>
</tr>
<tr>
<td>7</td>
<td>10 cm topsoll/45 cm C horizon/20 cm Ash/spoll</td>
</tr>
</tbody>
</table>
Fig. 8

HIGHVALE SOIL RECONSTRUCTION PROJECT
SUBSOIL DEPTH EXPERIMENT
1983 BARLEY YIELDS
Of immediate significance is the fact that the soil reconstruction plots are providing the means of achieving specific post mining agricultural productivity goals by identifying the appropriate soil reconstruction methods. The early results indicate that manipulation of material selection and quantities in soil reconstruction will allow mine planners and regulatory staff to reestablish a wide range of agricultural capabilities in the post mining landscape. The treatments presently under study in the field plots, so far at least, achieve yields which generally bracket the range of local crop yields. The one exception is grain yield at Battle River which is well below local averages and has not yet responded to different soil reconstruction treatments.

**IMPLICATIONS FOR THE BEOGIOATORY PROCESS**

Once company and government staff have reason to believe that a given reclamation technique will work then a detailed description of the technique constitutes the reclamation condition within the approval. For example, for soil reconstruction a map would be presented showing the distribution, amounts and quantities of replaced soils; for revegetation a map showing the distribution of forage, commercial forestry plantings and shrubland would be presented along with species composition lists. Similarly, the landscaping condition would consist of resloping criteria and a map showing the general resloped topography.

The officers responsible for certifying the reclaimed land then ensure that the various techniques have been applied per the approval. This significantly shortens the certification period and adds objectivity to the certification process.
SCHEDULE "A"

THIS IS SCHEDULE "A" TO ANNEX 1 ATTACHED TO AND FORMING PART OF THE AGREEMENT DATED AS OF THE EFFECTIVE DATE, AND ENTERED INTO BETWEEN THE MINISTER OF ENERGY AND NATURAL RESOURCES AND THE ALBERTA RESEARCH COUNCIL

PROCESS IMPROVEMENT

(2835-SP-85/15)

PROJECT OBJECTIVES:

To find and assess methods which can be used to convert Alberta Coals to liquid products.

SUMMARY

Using the assumption that a significant future market for coal-derived products will be liquid transportation fuels, the Office asked ARC to propose a research program in coprocessing of coal and Alberta heavy oils and bitumen. ARC has responded with the present program of research.

The program consists of four interrelated component projects:

a) New Process Development (2835-SP-85/5)
b) Process Improvements (2835-SP-85/15)
c) Process Evaluation (2835-SP-85/16)
d) Liquid Characterization (2835-SP-85/17)

The central or core project is Process Improvements. AOCRT directed ARC to find out how the Pyrosol process could be made more cost-effective as the point of departure for the core project. Events have overtaken this request, consequently a completely different concept is proposed. An invention disclosure has been filed on this new concept to protect any possible patent rights for the Crown. The new process will consist of two stages, solubilization followed by flash hydropyrolysis. The solubilization step will require an innovative approach, and this will be the goal of the New Process Development Project. Specific economic goals will be set for each step in the new process through the Process Evaluation Project, as benchmarked against the Pyrosol process, which represents the present state of the art. A principal outcome from this project will be a "Figure of Merit" calculation which could be used for comparing competing processes.

Most published coal liquefaction process evaluations do not satisfactorily describe product quality. Nor do they explain the chemical changes that occur in process fluids at each step in processing. The Liquid Characterization Project is intended to fill this need. An analysis tree has been developed and specific tests for important compounds in bitumen are under study. A parallel testing will be carried out for solubilized coal. These tests will be
reaction pathways, the results of which will be used in the Process Improvements Project. In its later phases, the liquid characterization protocols will be used to monitor the quality of process fluids at each step.

Phase 1 of the program will be exploratory experimentation, which is scheduled to continue until September of 1986 for all projects. Phase 2 will end in January of 1987, allowing two months for evaluation of results from all projects and preparation of detailed workplans for phase 3 bench scale experimentation on the steps selected from options examined in phases 1 and 2. Phase 3 will begin April 1, 1987.
SCHEDULE "B"

THIS IS SCHEDULE "B" TO ANNEX 2 ATTACHED TO AND FORMING PART OF THE AGREEMENT DATED AS OF THE EFFECTIVE DATE, AND ENTERED INTO BETWEEN THE MINISTER OF ENERGY AND NATURAL RESOURCES AND THE ALBERTA RESEARCH COUNCIL.

PROCESS IMPROVEMENTS

(2835-SP-85/15)

Statement of Work and Time Schedule

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Process Improvements
(2835-SP-85/15)

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