SOIL HANDLING CONCEPTS AT THE HIGHVALE MINE

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INTRODUCTION

TransAlta Utilities Corporation's Highvale Mine supplies about 12 million tonnes of coal per year to the Sundance and Keephills thermal power plants, located at Lake Wabamum, 65 km west of Edmonton, Alberta.

Surface coal mining at Highvale began in 1971. To date, coal has been removed from four pits within the Highvale Mine permit area. The pits are located along the south side of Lake Wabamum in a 16 km long, 6560 ha band from east to west (Fig. 1). Mining in each pit commenced near the lake and has proceeded southward over time.

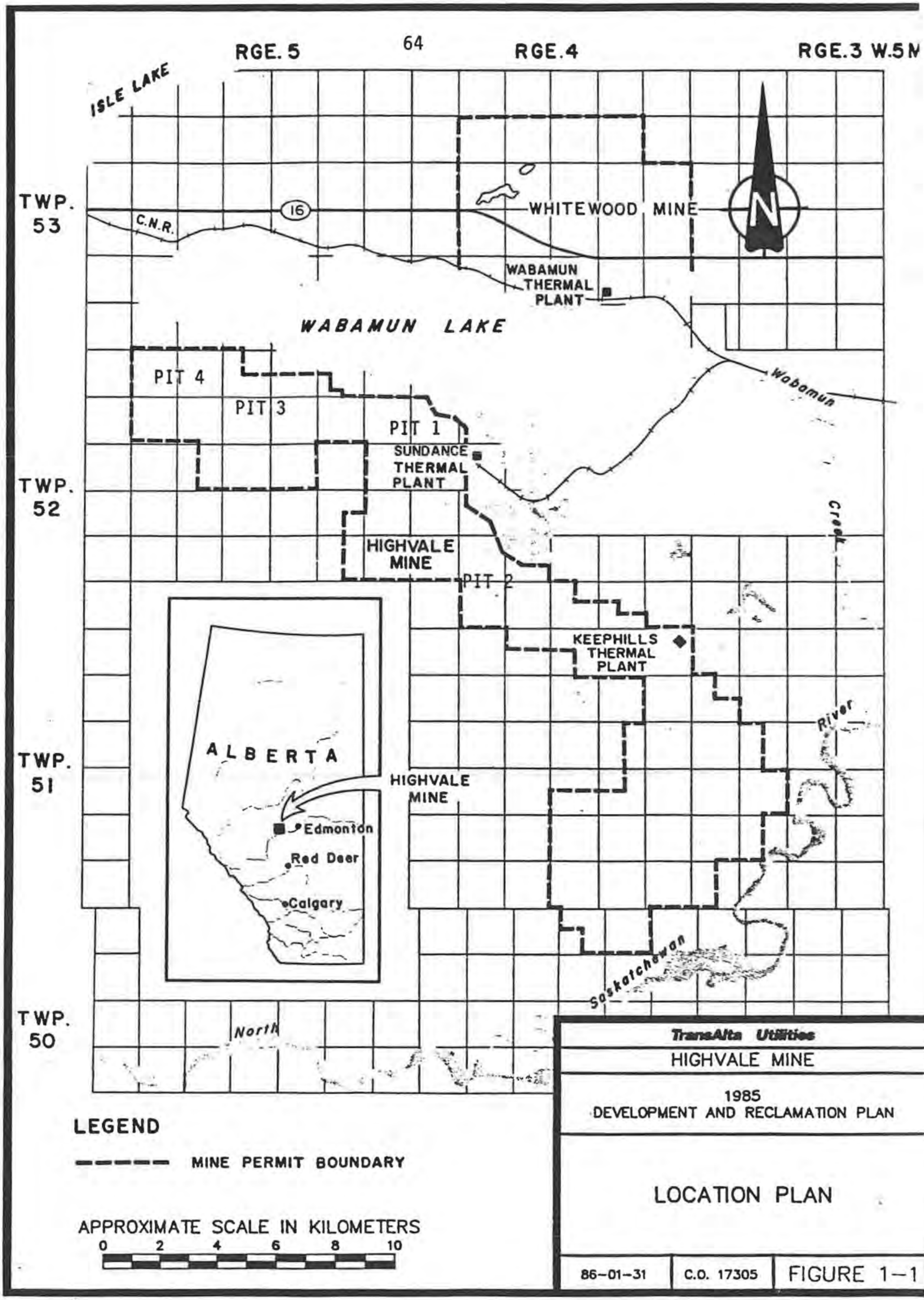
PREMINE SOIL RESOURCES

The soil resources in the area are predominantly thin Black Solodized Solonetzic and Gleysolic soils developed on residual bedrock of the Edmonton Formation. A significant amount of Gray Luvisolic soils, developed on residual sandstone bedrock of the Paskapoo Formation, are also present. The Solonetzic and Gleysolic soils occur on the level to gently undulating terrain near the lake, while the Luvisolic soils are found on the complex topography with moderate to extreme slopes along the south side of the mine area.

The Solonetzic soils are typically high in clay content, sodic and moderately well to imperfectly drained. They have very hard subsoil layers when dry. The Gleysolic soils are also clayey and may be slightly sodic or non-sodic. They are poorly drained and very sticky and plastic when wet.

The Luvisolic soils are generally sandy loam to silt loam textured, and non-sodic to at least 1.5m below the surface. They are well drained, friable soils; however, many of them have never been cultivated because of the steep topography on which they occur.

Small pockets of poorly to very poorly drained Organic soils occur throughout the mine area. The sphagnum peat in these soils is slightly to moderately decomposed.


RGE. 5
RGE.4
RGE.3 W.5M
ISLE LAKE
TWP. 53
TWP. 52
TWP. 51
TWP. 50
16
C.N.R.
WHITEWOOD MINE
WABAMUN THERMAL PLANT
WABAMUN LAKE
Wabamun
Creek
PIT 4
PIT 3
PIT 1
SUNDANCE THERMAL PLANT
HIGHVALE MINE
PIT 2
KEEPHILLS THERMAL PLANT
ALBERTA
HIGHVALE MINE
Edmonton
Red Deer
Calgary
River
Saskatchewan
North
LEGEND
MINE PERMIT BOUNDARY
APPROXIMATE SCALE IN KILOMETERS
0 2 4 6 8 10
TransAlta Utilities
HIGHVALE MINE
1985
DEVELOPMENT AND RECLAMATION PLAN
LOCATION PLAN
86-01-31
C.O. 17305
FIGURE 1-1

RECLAMATION TARGET: AGRICULTURAL CAPABILITY

TransAlta Utilities is required, under Alberta Environment's Development and Reclamation Approval for the Highvale Mine, to reclaim the land disturbed by mining so that the land capability of the reclaimed land is equivalent to that which existed prior to disturbance.

Twenty-two percent of the land in the mine area is rated as Agriculture Capability Class 3 prior to mining (Table 1). The Class 3 land is the best in the mine area. Its capability is limited by the poor subsoil qualities associated with the Solonetzic soils. Another 36% of the mine area is rated as Class 4 land. The Class 4 land is also limited by the poor quality subsoil and steeper slopes than the Class 3 land.

About 33% of the mine area is rated Class 5 land. The Class 5 land has very severe limitations to arable agriculture, which may be poor subsoils combined with moderately steep slopes, or wetness or very steep slopes.

The remaining 9% of the mine area is rated as Class 6 land, limited by extreme slopes or is unrated Organic soil and water bodies.

SOIL SALVAGE AND REPLACEMENT HISTORY

Since the mine opened in 1971, the soil salvage and replacement requirements have evolved to more closely meet the land capability targets discussed above.

From 1971 to 1979, TransAlta was required to salvage all topsoil and replace it on levelled minespoil in Pit 01. With growing concern about the potential for salt to move from the minespoil into the topsoil, TransAlta was also required to start replacing a layer of subsoil in 1979. From 1979 to 1981, a 0.3m layer of subsoil and all topsoil was salvaged and replaced on levelled minespoil. This occurred in parts of Pit 01 and Pit 02.

From 1982 to 1983, TransAlta salvaged and replaced 1.0m of subsoil as well as all the topsoil in parts of Pit 02. During this time, a more rigorous evaluation of soil suitability for use in reclamation was conducted at Highvale, using soil chemical criteria provided in Alberta Agriculture (1981). The result was that, over 80% of the mine area, subsoil was suitable and salvaged for replacement in a 1.5m layer above levelled minespoil. In the remaining 20% of the mine area, only a thin layer of suitable subsoil was available and salvaged for replacement in a 0.5m layer above minespoil. Soil salvage and replacement continued in this manner from 1983 to 1986.

A detailed review of TransAlta's reclamation program and experience in 1985 revealed the need to revaluate the criteria used to determine what was suitable subsoil for use in reclamation. As a result of the revaluation,

TABLE 1. RECLAMATION TARGET:

LAND CAPABILITY BEFORE MINING

AGRICULTURE CAPABILITY CLASS	LIMITATION	PERCENT OF MINE AREA
2	CLIMATE	0
3	CLAY,HARD,SODIC	22
4	CLAY,HARD,SODIC,SLOPE	36
5	CLAY,HARD,SODIC,SLOPE WETNESS	33
6	SLOPE	5
0	ORGANIC,WATER	4

TransAlta is now replacing 1.5m of suitable subsoil over 21% of the area mined since 1986 and 0.35m of suitable soil over the remaining areas disturbed by mining. The following section describes how TransAlta's current soil salvage and replacement concepts were developed.

DEVELOPMENT OF CURRENT SOIL HANDLING CONCEPTS

In 1985, TransAlta reviewed the entire reclamation program at Highvale, in preparation for the submission of a new Five Year Development and Reclamation Plan in 1986 (TransAlta Utilities, 1986).

The experience that TransAlta had gained, in managing the fields with soil which had been replaced up to 1985, pointed to a number of practical problems. Most of the replaced subsoils were high in clay content and moderately sodic. They were well compacted by the heavy equipment during replacement. As a result, water entering the soil could not easily penetrate beyond the topsoil. After snowmelt, or a heavy rain, the saturated topsoil layer would take weeks to dry sufficiently to allow normal field operations to proceed. Depending on the timing of such events, a two or three week delay in seeding, weed control or harvest can lead to significant losses in the quantity and quality of the crop.

The topsoil replaced in most fields has been clay loam textured and may also be slightly sodic. It generally is low in organic matter and nutrients. It behaves much like the Solonetzic topsoils from which it originated; puddling and dispersing when wet and crusting when dry. The poor tilth of these topsoils has resulted in slow and uneven crop emergence and growth. As a result, weeds can often successfully compete, lowering the quantity and quality of the crop.

FACTORS TO IMPROVE RECLAIMED SOIL QUALITY

Three areas were identified where improvements could be made which would result in better quality soils and less of the management problems described above. They were:

A) improve the quality of the subsoil salvaged and replaced in the future;

B) minimize the loss of quality during topsoil and subsoil handling in the future; and

C) implement subsoil ripping and other soil conservation methods after soil replacement.

A) Improve the Quality of Subsoil Handled for Reclamation

Soil Information

The first activity that was completed in 1985, to allow more rigorous selection of subsoil for use in reclamation, was to consolidate and upgrade the available soils information in the areas to be mined in the twenty-five year period 1986-2011. The soil survey information and maps were based on a soil profile inspection intensity of one per hectare. Samples of topsoil and subsoil were taken from about 200 of the inspection sites. In addition, 37 soil profiles were described and sampled in detail. Laboratory results on key chemical and physical characteristics were compiled for each type of soil in the mine area.

Additionally, overburden was drilled, logged and sampled at 200m intervals in the mine area. Results for the same key chemical and physical characteristics were compiled by stratigraphy and soil type.

Subsoil Suitability Rating

The second activity was to re-examine the criteria used to determine whether subsoil was suitable for salvage and replacement, and then apply the results to the soil and overburden data base.

As mentioned above, prior to 1986 several chemical criteria were used to determine subsoil suitability. They included pH, SAR, EC, ESP and Calcium Carbonate. The only quantitative physical criterium that was used was Saturation Percentage.

To better reflect the physical behaviour of the replaced soils, clay percentage, consistence and exchangeable sodium percentage were added to the list of key criteria for Highvale (Table 2). Levels were identified for each criterium beyond which the subsoil being rated would be unsuitable for use in reclamation. A range of levels was also identified within which a subsoil would be rated "poor" (Table 2). The levels for each criterium were taken from Alberta Agriculture (1981).

Soil and overburden data were then compared, site by site and horizon by horizon, with the criteria levels in Table 2. If the soil level for any one criteria exceeded the suitable limits in the table, the soil was considered unsuitable for use in reclamation. Also, if the soil levels for two of the criteria in the following combinations were in the "poor" range, the soil was rated unsuitable:

Clay and Consistence
or Clay and SAR
or Clay and ESP
or Consistence and SAR
or Consistence and ESP

TABLE 2. SOIL CRITERIA USED FOR RECLAMATION SUITABILITY RATING

CRITERIUM	UNSUITABLE IF:	POOR IF:
pH	<4.5 or >8.5	8.0–8.5
SAR	>12	8–12
ESP	>15	10–15
EC (mS/cm)	>10	5–10
SAT'N %	>120	80–120
CLAY %	>60	40–60
CONSISTENCE	EXTR.HARD or VERY FIRM or VERY STICKY and VERY PLASTIC	VERY HARD or FIRM or STICKY & PLASTIC

Categories of Suitable Subsoil

The results of rating all the soil types in the mine area are summarized in Table 3. The mineral soil types can be grouped into three categories, based on the amount and suitability of the subsoil. The first group, Solonetzic and Gleysolic soils, have no suitable subsoil for reclamation. The key factors in the rating of this group of soils are high clay content, hard consistence and sodicity. The second group consists of clayey Luvisolic soils. They have a thin layer of suitable subsoil. The parent material of these soils is rated unsuitable due to its high clay content and hard consistence. The third group is composed of coarse loamy Luvisolic soils which have a thick layer of suitable subsoil. Using the overburden data correlated to the soil types, the thickness of suitable subsoil in the "deep Luvisol" group can exceed 6.0m in some locations. The Organic soils were not formally rated using the above system. They are, however, considered suitable as a soil amendment if such an amendment is needed to improve topsoil quality.

Subsoil Salvage and Replacement

The total area and location of each soil suitability grouping was then determined for the 25 year period 1986-2011, (Table 4). The subsoil replacement depths were determined from the thickness of the "B" horizons in the Solonetzic/Gleysolic and clayey Luvisolic groups. The average subsoil replacement depth over 72% of the mined areas is 0.35m. In another 23% of the mined area, suitable subsoil will be replaced to 1.5m thickness, which is the maximum required. The proportion of mined area receiving 1.5m of subsoil is similar to the proportion of Deep Luvisolic soils existing prior to mining. Five percent of the area disturbed by mining will be comprised of end cuts. The end cuts are likely to become water bodies in the reclaimed landscape and will therefore not require soil replacement.

Soil replacement is also guided by the postmine topography left after the spoil materials are contoured. Sixty-six percent of the postmine landscape will have level to gently sloping land (<3 degrees). The replacement of 1.5m of subsoil and 0.2m of topsoil will take place on this type of landscape to maximize the agricultural capability of the reclaimed land. The remaining steeper landscapes will have 0.35m of subsoil and 0.2m of topsoil replaced. Figure 2 illustrates the soil replacement concepts.

The amount of each agricultural capability class projected for the post-mining landscape is compared with the premining capability targets in Table 5. There are minor differences in the proportions of each capability class, with the biggest shift being a 14% decrease in Class 5 land, balanced mostly by increases in Class 4 and Class 6 land. It is important to note the differences in the limitations to agriculture between the premine and postmine landscapes. Generally, the limitations for Classes 3, 4 and 5 postmining land will be more manageable than the hard, sodic, clay soils over most of the premine land.

TABLE 3. SOIL SUITABILITY FOR USE IN RECLAMATION AT HIGHVALE.				
SOIL	**HORIZON**	**THICKNESS**	**RATING**	**LIMITATIONS**
SOLONETZIC	A	0.19	S	
& GLEYSOLIC	B	0.30	U	CLAY,SODIC,HARD
	C	1.2	U	CLAY,SODIC,HARD
CLAYEY	A	0.19	S	
LUVISOLIC	B	0.38	S	
	C	1.18	U	CLAY,HARD
DEEP	A	0.19	S	
LUVISOLIC	B	0.47	S	
	C	1.03	S	
ORGANIC	UNCLASSIFIED – Generally Suitable as Soil Ammendment if Needed			

TABLE 4. SUITABLE SOIL : HOW MUCH AND WHERE?

SOIL	AREA (ha)	PERCENT OF MINE AREA	SUITABILITY
SOLONETZIC & GLEYSOLIC	1448	54	TOPSOIL ONLY
CLAYEY LUVISOLIC	532	20	TOPSOIL & "B" HORIZON SUBSOIL
DEEP LUVISOLIC	592	22	TOPSOIL & 1.5 to 6.0m. SUBSOIL
ORGANIC	92	4	AS SOIL AMMEND-MENT

FIGURE 2. SOIL REPLACEMENT CONCEPTS

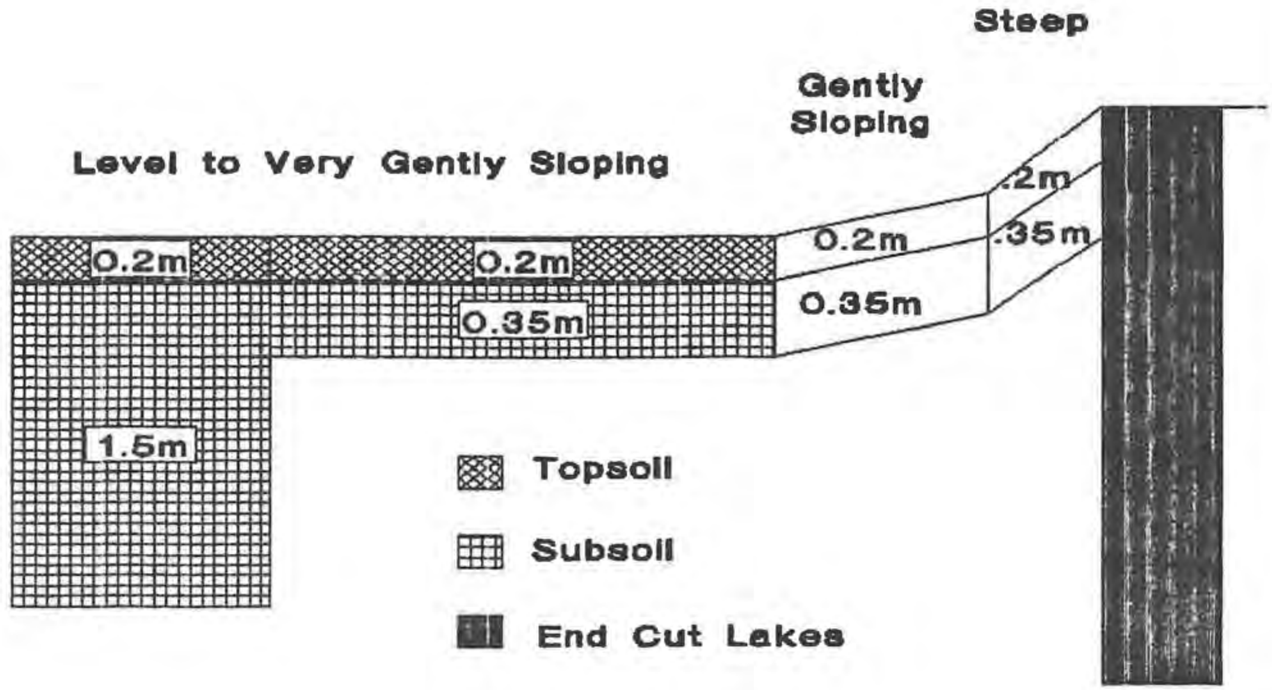


TABLE 5. LAND CAPABILITY BEFORE AND AFTER MINING

PREMINING			POSTMINING	
AGRICULTURE CAPABILITY CLASS	LIMITATION	PERCENT OF MINE AREA	PERCENT OF MINE AREA	LIMITATION
2	CLIMATE	0	0	CLIMATE
3	CLAY,HARD,SODIC	22	23	FERTILITY,TEXTURE
4	CLAY,HARD,SODIC,SLOPE	36	43	FERTILITY,TEXTURE,SODIC
5	CLAY,HARD,SODIC SLOPE,WETNESS	33	19	SLOPE,SODIC
6	SLOPE	5	10	SLOPE
0	ORGANIC,WATER	4	10	END CUT LAKES

B) Minimize the Loss of Soil Quality During Handling

Soil salvage and replacement at Highvale is conducted with scrapers, assisted by a D9 bulldozer. As the subsoil salvage has become much more selective, it is important to clearly guide the mine operator during salvage and replacement so that topsoil is not diluted with subsoil and that only suitable subsoil is salvaged and replaced. TransAlta has achieved this by placing a pedologist full time in the field at Highvale. The Pedologist's activities are summarized in Table 6. They include providing the mine operator with the necessary soil information for budgeting and scheduling, supervising the salvage and replacement of topsoil and subsoil, sampling and documenting the amount and quality of soil replaced, updating maps and records of soil handled and evaluating changes in soil quality and crop growth over time.

C) Implement Subsoil Ripping and Other Soil Conservation Methods

Deep ripping of the replaced subsoil to overcome compaction was first tried in Pit 02 in 1986. It proved most effective in drying the field after heavy rainfall. The farm tractor was able to travel on the field within three days of a rainfall as opposed to two to three weeks. In 1987, all the reclaimed fields at Highvale were deep ripped. Deep ripping is now one of the first activities our farm staff complete on new reclaimed fields.

The focus of the management of the reclaimed lands is to develop and maintain a level of topsoil tilth which will allow those lands to sustain farming, using techniques typical of the Highvale area. In most reclaimed fields, this means a program of organic matter development in the topsoil during the first few years after soil replacement. A number of techniques have been considered and tested in the past. Currently, the operational focus is to increase and maintain organic matter through the use of manure and high root-to-shoot ratio forages. These and other methods are being tested for their long term effectiveness at Highvale. The details of this work will be described in the following paper by Chanasyk et al.

SUMMARY AND CONCLUSIONS

After ten years of experimenting and gaining operational experience in reclamation at the Highvale Mine, TransAlta found a number of difficulties in managing the reclaimed land. The difficulties related to the poor quality of subsoil replaced, compaction of the replaced subsoil, and poor quality topsoil with low levels of organic matter. As a result of these findings:

TABLE 6. FIELD PEDOLOGIST : ANNUAL ACTIVITIES

1. CONFIRM SOIL TYPES AND BOUNDARIES

   -done year prior to salvage

2. PROVIDE SALVAGE LOCATION AND DEPTH MAPS

   -by June of year prior to salvage

3. SUPERVISE CONTRACTORS' SALVAGE OPERATIONS

4. MONITOR REPLACEMENT DEPTHS & SAMPLE FOR SOIL QUALITY DETERMINATION. TAKE CORRECTIVE ACTION AS REQUIRED

5. PREPARE REGULAR REPORTS ON ACTUAL AREAS, DEPTHS VOLUMES AND QUALITY OF SOILS HANDLED

6. MEASURE AND EVALUATE SOIL QUALITY CHANGES AND CROP GROWTH (YIELD) IN RECLAIMED FIELDS OVER TIME

* TransAlta has become more selective in soil salvage and replacement - only the non-sodic, coarse loamy subsoils are handled.

* TransAlta has placed full time qualified personnel in the field to assist the mine operator in maintaining the quality of topsoil and subsoil salvaged and replaced.

* A focus in the form of soil quality standards has been set for the reclaimed fields so that normal farm practices may be sustained in the long term.

* Deep ripping, manuring and other soil management methods have been inplemented to achieve and maintain the soil quality standards.

* A research program has been put in place to determine the long term effectiveness of the reclaimed land management techniques now being used.

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