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RECLAMATION PLANNING AT HAT CREEK, B.C.

Paper Prepared Jointly
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RECLAMATION PLANNING AT HAT CREEK, B.C.

ABSTRACT

B.C. Hydro is presently investigating the possibility of developing the Hat Creek coal deposit in south central British Columbia to produce coal for a thermal electric power plant. As part of the reclamation planning for this project, studies have been undertaken to examine the site specific factors likely to influence the future revegetation of waste piles. The rationale for this test program is described. Test plots have been constructed using a variety of discrete waste materials excavated during a bulk coal sample excavation program undertaken during the summer of 1977. In addition, plots to test revegetation at various slopes have been developed. A wide variety of revegetation species, suitable for establishment of vegetation in the dry climate at Hat Creek were examined and twelve were selected for testing. Three seed mixes of four species each were prepared. Each material was tested for nutrients and appropriate fertilizer was added during seeding. Material test plots were hand seeded with the three different seed mixes while plots to test revegetation at different slopes were hydroseeded using only one seed mix, a mulch and binder. A monitoring program will be undertaken to determine emergence success and productivity of species under each field test condition.

RECLAMATION PLANNING AT HAT CREEK, B.C.

INTRODUCTION

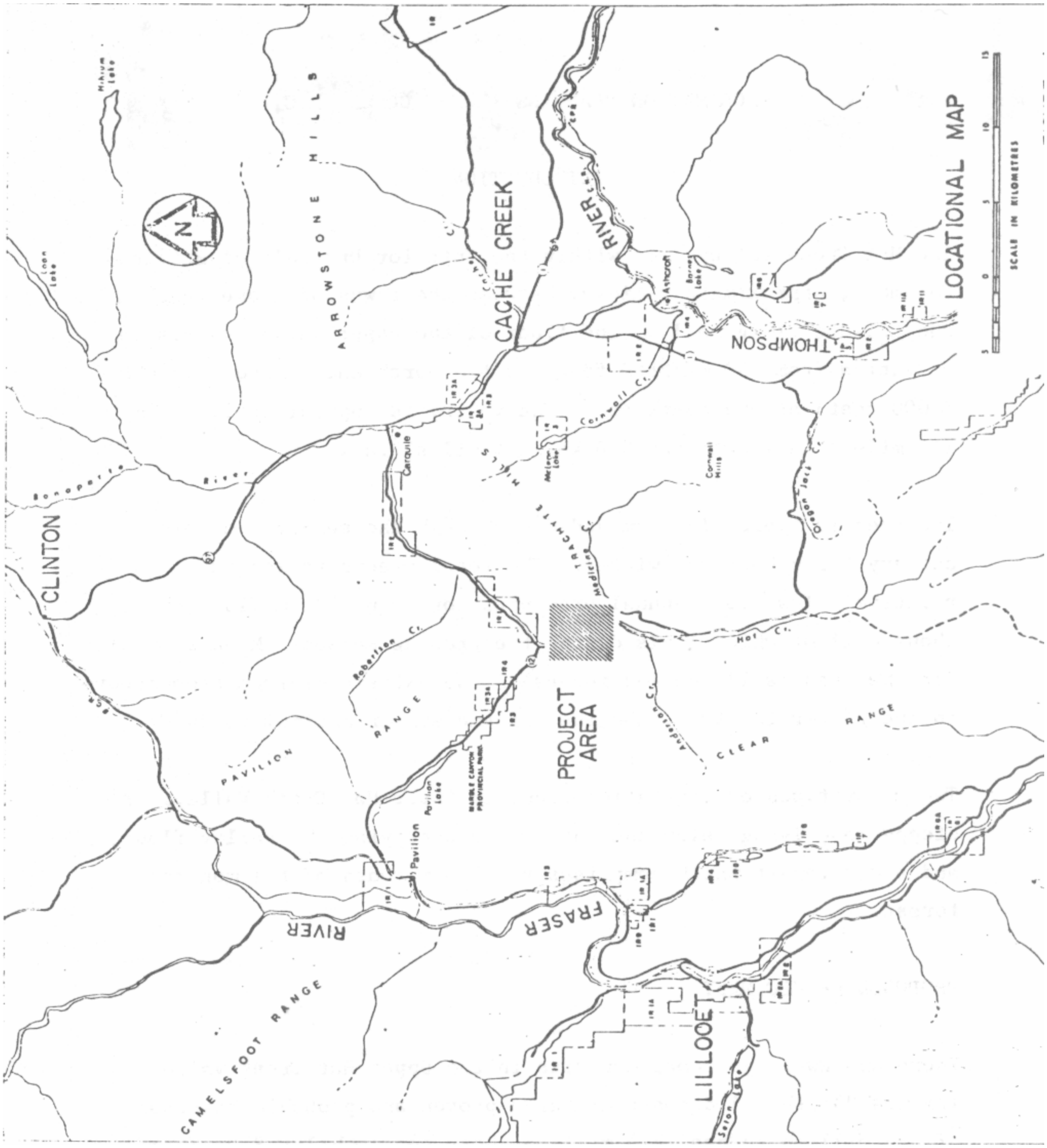
The Hat Creek Valley lies within the Interior Dry Belt of British Columbia, approximately midway between the towns of Cache Creek and Lillooet (Figure 1). The floor of the upper valley ranges in elevation from 850 m (2800 feet) at the north end to about 1220 m (4000 feet) at the south end. The valley is approximately 26 km (16 miles) in length and 3-6 km (2-4 miles) in width.

The area is typically warm and dry through the summer and cold and dry throughout the winter. The total precipitation is relatively low, mean annual precipitation being 32 cm (13 inches), about half of which falls during the growing season. Mean snowfall for the area is 133 cm (52 inches). The extreme minimum temperature in the winter is -40° C, and the extreme summer maximum is 34° C.

Two major types of vegetation occur in Upper Hat Creek Valley. A steppe zone lying below the forest and occupying the valley floor, and a dry forest which comprises the lower zones of the montane forest.

PROPOSED DEVELOPMENT

There are two major coal deposits in the Upper Hat Creek Valley (Figure 2), the $1 deposit contains proven and probable reserves of 585 million tonnes (645 million short tons) whilst 8 km (5 miles) to the south the #2 deposit is estimated to contain approximately three times that amount. The coal is low grade but suitable for thermal use in coal fired electric power plants. The present


LOCATIONAL MAP
SCALE IN KILOMETRES
CACHE CREEK
CLINTON
LILLOOET
PROJECT AREA
THOMPSON
RIVER
FRASER
RIVER
ARROWSTONE HILLS
TRACHYTE HILLS
PAVILION RANGE
CLEAR RANGE
CAMELSFOOT RANGE
Pavilion
Pavilion Lake
Carquile
Cornwall Hills
Bonaparte River
Ashcroft
MARBLE CANYON PROVINCIAL PARK

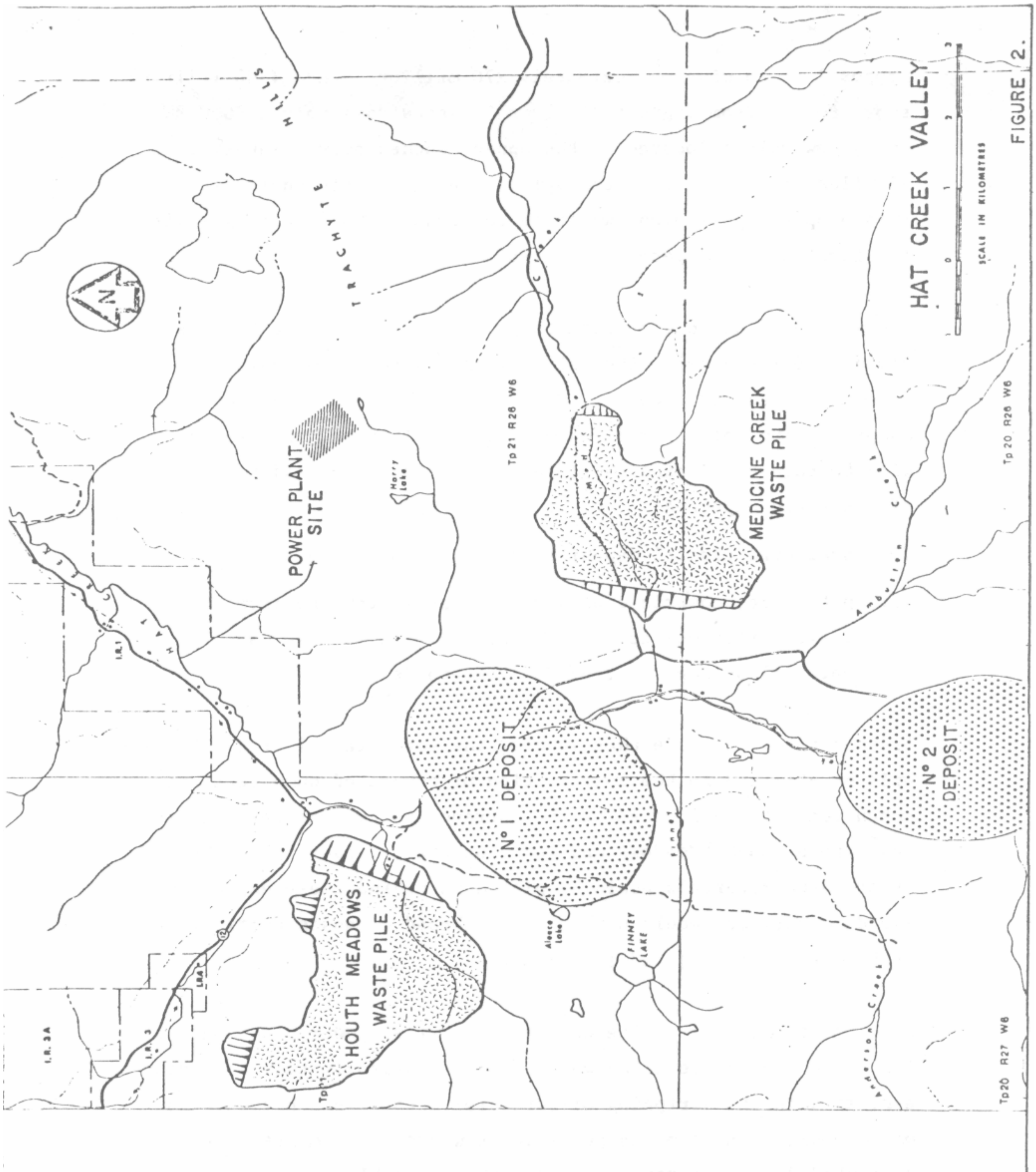

HAT CREEK VALLEY
SCALE IN KILOMETRES
TRACHYTE HILLS
POWER PLANT SITE
MEDICINE CREEK WASTE PILE
N° 1 DEPOSIT
N° 2 DEPOSIT
HOUTH MEADOWS WASTE PILE
FINNEY LAKE
Tp 21 R 26 W6
Tp 20 R 26 W6
Tp20 R27 W6

FIGURE 2.

proposal is to mine approximately 270 million tonnes (300 million) short tons), from deposit #1, over 35 years to supply a 2000 MW (net) powerplant located on the upper benches approximately 5 km (3 miles) to the east of the valley. As presently envisaged this proposed powerplant would be constructed in four stages with the first unit in operation in 1986.

The mine will be an open pit design extending down, in benches, 215 m (700 feet) below the valley floor, with an approximate
diameter at the surface of 3.0 km (9800 feet). A total loose dumping volume of 765 million m (1000 million yd) of wastes will be required during the life of the mine. Two major types of waste are expected:

(i) surficial glacial deposits of till, sand and gravel

(ii) pit waste, comprised of very weak rocks ranging from clayey siltstone to conglomerate as well as weak waste material segregated from coal interbeds.

Present plans indicate that much of the surficial glacial materials
will be utilized in the construction of compacted dump retaining embankments to be located at the entrance to two natural containment areas, Houth Meadows and Medicine Greek (Figure 2). The other waste materials would be placed in behind these enbankments. The dump surfaces would ultimately be broad expanses gently sloped at between 20:1 (3°) and 10:1 (6°).

With an assumed in-service date for the first power plant unit of 1986, the mining operation would commence approximately four years earlier with the stripping of surficial materials. Revegetation would commence as soon as possible on waste embankments, areas disturbed during construction and other possible retaining structures associated with the development as a whole.

OBJECTIVES OF RECLAMATION

In devising this aspect of the reclamation program B.C. Hydro has considered both long and short term objectives.

The rapid establishment of vegetation on the disturbed area is the primary short term goal. This is required to improve surface stability, by preventing wind or water-borne erosion and to enhance the aesthetics of the waste piles. In the long term, vegetation should be self sustaining and not require continued additions of fertilizer or water (irrigation).

An essential aspect of reclamation planning is the determination of the ultimate land use of the disturbed areas following reclamation. In general terms, the potential land use should not be less than that prior to disturbance.

The present land use in the Hat Creek Valley is primarily directed towards cattle ranching. There are 13 independent ranching operations in the valley of which six would be directly affected. In total, approximately 3300 hectares (8300 acres) would be disturbed by the mine and associated waste dumps of which the vast majority is presently unimproved range land. Long term use or exploitation of the revegetated waste dumps has been examined. Several alter natives have been considered; for example, wildlife habitat, recreation, agriculture (ranching) and forestry. At present B.C. Hydro favours a mixed agriculture (ranching) and wildlife habitat alternative since these activities constitute the primary land use in the area of development.

RECLAMATION FOR THE HAT CREEK PROJECT

In June 1976, B.C. Hydro retained Acres Consulting Services Ltd. to examine the waste materials to be generated from deposit number one and to study the characteristics of these materials and their potential for revegetation.

At that early stage only laboratory scale studies were undertaken. However, during the summer of 1977, a bulk sample of coal was mined in order to examine its combustion characteristics, in an existing large scale power plant. Three trenches were excavated, two to extract coal and a third to test slope stabilities in weak (clay) material. In total 27,000 cubic meters of waste materials were generated. This program afforded an ideal opportunity for examining in greater detail the different waste materials likely to be encountered in the full-scale operation.

PLANNING

A number of years are required before definite trends in revegetation success can be evaluated, especially in an environment such as that found at Hat Creek. For this reason field revegetation tests have been undertaken at this early stage in conjunction with the Bulk Sample Program. These early investigations will form the basis of future reclamation planning and will be used in the development of the optimum site specific methods thereby reducing the future costs, both economic and environmental, of reclamation.

Two specific test programs have been undertaken at Hat Creek. One is designed to test the revegetation potential of slopes of different steepness. The second study is intended to examine the many waste materials likely to be generated and to determine their characteristics as growth media.

From drilling data there are known to be a wide variety of waste materials which would be exposed during the life of this mine.

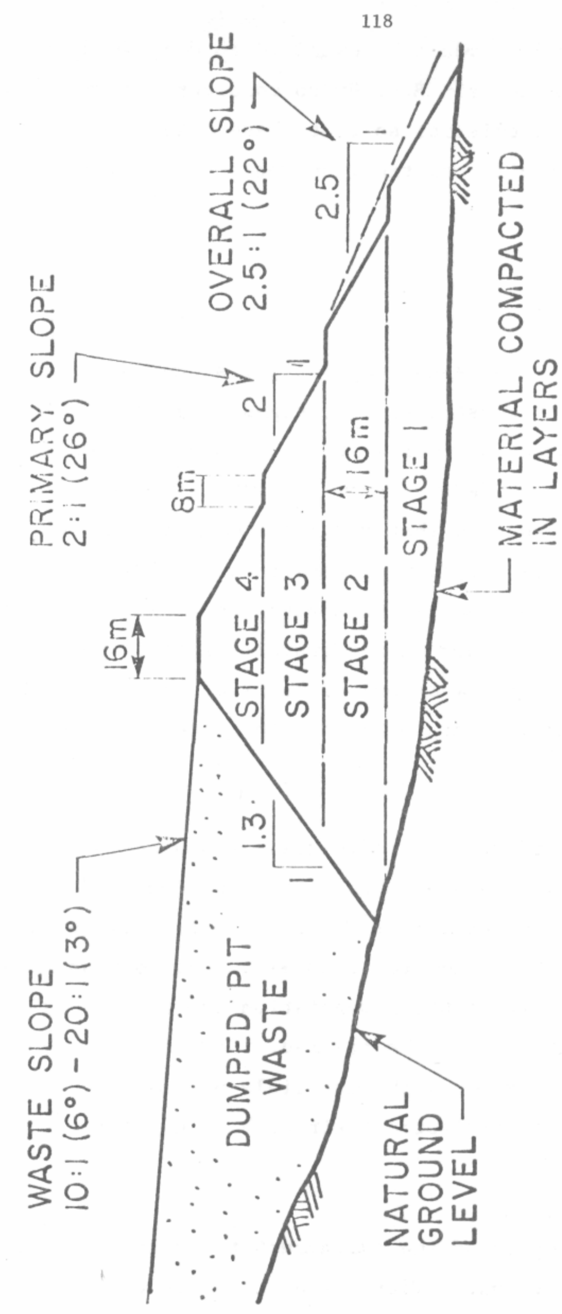
Each of these materials would be expected to display different characteristics as growth media. B.C. Hydro considers it important to examine these characteristics so that these data may be used in designing the waste pile construction sequence and mine excavation plans.

Embankment Plots

The bulk of the waste at each dump will be stored behind a competent retaining embankment constructed in stages (Figure 3). The preliminary design indicates a vertical rise of 16 m (50 feet) and a bench width of 8 m (25 feet) common to each lift. With such an arrangement it is expected that reclamation of the embankment faces may be carried out as the dump is constructed. The types of materials selected for these embankments have been identified as glacial till at Medicine Creek, and recent gravels at Houth Meadows. These material selections were made on the basis of their availability, geotechnical properties and location with respect to the mine and waste dumps.

Preliminary embankment design indicates a slope between benches of 2:1(26°) for each lift stage, this being the recommended guideline from the B.C. Department of Mines and Petroleum Resources. This slope, based on reclamation studies in the Kootenay Coal fields, is recommended as that at which vegetation can readily establish and at which slope stability may be assured. Geotechnical consultants for B.C. Hydro have examined the materials proposed for embankment construction and have indicated their stable angle of repose to be approximately 35°.

The design slope angles of the embankment faces are under consideration for two practical reasons. First, the economics of this plan indicate that by using a steeper slope between lifts, less overall



SCHEMATIC OF A SECTION
THROUGH A RETAINING EMBANKMENT

FIGURE 3.

material and time would be required and therefore the cost of the embankment would be less. Second, if less construction material were required, a greater flexibility would be provided to the mining operation; separate excavations for suitable embankment material may thus be reduced or avoided entirely.

B.C. Hydro has therefore undertaken the construction of test plots to examine the potential for revegetation embankment materials at slopes of 22°, 26°, and 30° under Hat Creek climatic conditions.

Locations for these test areas have been carefully selected to simulate as closely as possible, conditions to be encountered by the embankments proper, e.g. aspect, elevation.

Waste Material Plots

It is apparent that there will be a number of different waste materials generated at this mine. It is as yet uncertain which materials will be present, or desirable, on the waste dump surfaces at the completion of the project.

The Bulk Sample Program provided the opportunity to obtain suitable quantities of waste sufficient for field plots. The field plots were designed to test the potential of the various media to support plant growth and to determine optimum vegetation species/waste material combinations. The results of this work would be used in the selection of materials for surfacing the waste dumps.

PROGRAM

Waste Materials

Preliminary Evaluation

Prior to the commencement of excavation for the Bulk Sample Program a preliminary soil survey was undertaken with the assistance of

Mr. A. Dawson and Mr. R. Kline of the B.C. Ministry of Agriculture. Soil parent materials likely to be encountered during the trenching program were examined. Tests on selected samples were carried out at the Ministry of Agriculture's Soil Testing Laboratory in Kelowna.

The results indicated that these soils were generally alkaline with the presence of free carbonates at 20 cm or deeper and that nitrogen and phosphorus were the common limiting micronutrients. Extreme variability was noted both vertically and spatially between the soil profiles sampled. In addition the topsoil thickness for stripping purposes was identified.

The soil survey in combination with the information obtained from the drill core and drill core logs was used in selecting, for stockpiling, individual waste materials from the trenches during excavation.

Detailed Material Selection

Seven different materials were selected from the excavation of the three bulk sample trenches, and approximately 300 cubic metres of each type were separated and stockpiled for further testing.

Material selection was based on such gross soil characteristics as colour, preliminary textural data, pH, electrical conductivity and carbonate presence. This information was generated on site at a small field laboratory.

The following seven waste materials were selected: bentonitic clay, baked clay, colluvium, carbonaceous shale, coal waste, (reject), glacial gravels and a gritstone/siltstone mix. In addition to these wastes, a large sample of fly ash produced from coal combustion tests was returned to the valley and included in the waste material test program.

Materials to be utilized in the construction of waste embankments were located and characterized in a similar manner as above.

All these materials were subsequently analyzed in greater detail at the Ministry of the Environment and the Ministry of Agriculture laboratories in Kelowna. Table 1 indicates some of the properties of these materials and the recommended fertilizer application rates.

TABLE 1

ANALYSIS OF SUBSURFACE SOIL MATERIALS

DESCRIPTION	ORGANIC MATTER %	pH (H_2O)	SALTS mmho/cm	AVAILABLE PLANT NUTRIENTS kg/ha N	P	K	Ca	Mg	ppm S	NUTRIENTS TO BE APPLIED FOR A GRASS-LEGUME CROP — NUTRIENT RECOMMENDED kg/ha N	P	K
Aleece Lake												
Colluvium	0.6	8.7	6.00	35	8	242	11127	1120+	30+	22-34	135	67
Carbonaceous shale	30.4	4.5	3.00	108	18	263	6686	1120+	30+	22-34	112	56
Bentonitic clay	0.9	7.9	8.60	6	11	1100	10154	1120+	30+	22-34	135	0
Baked clay	0.8	7.8	3.30	2	36	898	10503	1120+	30+	22-34	67	0
Glacial gravels	1.7	8.0	0.48	6	12	423	10005	1120+	30+	22-34	135	0-45
Coal Waste	30+	5.0	3.20	18	19	662	4968	1120+	30+	22-34	112	0
Gritstone	0.5	8.4	3.00	1	25	608	4027	1120+	30+	22-34	90	0
Fly Ash	2.8	7.7	2.95	62	63	185	3690	253	N.A.	22-34	78	90
Topsoil	7.0	7.4	0.60	17	45	1053	11200+	1120+	30+	22-34	45	0
Houth Meadows												
Recent gravels	0.9	8.1	0.24	4	19	219	5990	734	10.6	22-34	112	78
Topsoil	3.9	7.7	0.40	40	33	553	10979	1120+	13.4	22-34	78	0
Medicine Creek												
Till	1.2	8.2	0.32	2	11	388	9215	1120+	19.4	22-34	135	0-45

N.A. - not analyzed

Material Characterization

A list of the parameters chosen to assist in characterizing the waste materials is presented in Table 2.

TABLE 2

SELECTED SOIL PARAMETERS FOR WASTE CHARACTERIZATION

- pH	- cation exchange capacity
- electrical conductivity	- exchangable cations
- macronutrients	- selected trace element
- boron	- analysis (available)
- organic matter	- soluble salts
- texture	- carbonate presence
- colour	

Generally the waste materials exhibit alkaline soil reaction; coal waste and carbonaceous shale are exceptions and are acidic. The favoured pH for soil supporting most types of vegetative cover is near neutral. Values ranging between 6.0 and 8.0 have been reported as the range preferred by most grass species.

The electrical conductivity of the majority of the waste materials is moderate to high. Soil conductivity is a measure of the concentration of soluble salts in the soil solution. High salt contents cause adverse soil conditions and result in poor establishment of vegetation. The limiting value for suitable soil conductivity, depending on the vegetative species grown, is from 2 mmhos/cm to *iv* 8 mmhos/cm.

Deficiencies in soil nitrogren and phosphorous are common to all the waste materials tested. Applications of potassium are required for optimum plant growth on a number of the materials. Other macro-nutrients, calcium, magnesium and sulphur are available in adequate amounts.

The organic matter content of the coal waste material and the carbonaceous shale is very high, approximately 30%. The majority of the waste materials, however, contain very little organic matter, in the order of 1% or less. Organic matter has a high cation exchange capacity and therefore has the ability to hold plant nutrients in the soil. It is also composed of potential nutrients required for plant growth. Depending on the degree of decomposition, it can act to provide some surface protection and stabilization of the soil structure.

The wide range of colours exhibited by the waste materials at Hat Creek is striking. The colour of the waste materials directly affects the heat absorption of the material. Under hot, dry con ditions the waste materials exhibiting very dark colours (low colour values) may be limiting in the establishment of vegetation due to excessive temperature stress.

A diversity of soil textures is common to the waste materials tested. The texture of the soil material plays a major role in the storage of available water as well as being a major parameter in determining the erosion characteristic of a material.

Vegetation

In preparation for seed selection for the revegetation test plots, a survey of existing vegetation in the Hat Creek Valley was undertaken with the assistance of Messrs. A. Bawtree and J. Ryder of the B.C. Ministry of Agriculture in Kamloops. A wide variety of herbs, forbs and shrubs typical for this area's climate and soils were identified. Follow up discussions were held and proved invaluable in the evaluation and selection of candidate species for revegetation tests.

The selection of vegetation species was based on the following considerations: Species had to be suitable for the long cold winters and hot dry summers prevalent in the Hat Creek Valley. Species under consideration were reviewed taking into account the properties of the waste materials to be encountered. In addition, seed had to be available in sufficient quantities and in a viable state; agronomic species were therefore chosen rather than native species.

Seed was applied in mixes of four species each. Whilst a diversity of rooting systems would aid in the stabilizing of a surface, care was exercised when making up seed mixes, to ensure that the various species were compatible in terms of rooting competition.

Each seed mix contained at least one perennial legume and one grass species which made up approximately 25% and 40% of the mix, by number of seeds, respectively. The remaining 35% of the mix was made up with species that may establish quickly or be suitable under a variety of soil conditions. It was reasoned that the annual species would die out after the first year by which time the perennials would be sufficiently established to take their place. Legumes were included with grasses in the seed mix since they have the ability to fix atmospheric nitrogen and would be most useful in the nitrogen deficient soils, typical of Hat Creek. The seed mixes utilized at Hat Creek are presented in Table 3.

The total seed application rate of approximately 2,150 seeds per square metre (200 seeds per square foot) was arbitrarily established. Assuming an 80% germination rate the number of seedlings per square metre would be 1,720 (160 seedlings per square foot). This rate should be adequate to supply sufficient ground cover and yet avoid excessive competition between plants for the limited available moisture and nutrients. The suitability of this application rate will be further evaluated when results from field trials are obtained.

TABLE 3

EXPERIMENTAL SEED MIXES

GRASS OR LEGUME (VARIETY)	BY NUMBER OF SEED	
SEED MIX I		
CRESTED WHEATGRASS (NORDAN)	41	
CANADA BLUEGRASS	29	
ALFALFA (DRYLANDER) FALL	26	
RYE	4	
	APPLICATION RATE	57 KG/HA
SEED MIX II		
RUSSIAN WILD RYE GRASS	3	
SLENDER WHEATGRASS	9	
SAINFOIN (MELROSE)	18	
SWEET CLOVER	25	
	APPLICATION RATE	108 KG/HA
SEED MIX III		
SMOOTH BROMEGRASS (MANCHAR)	19	
STREAMBRANK WHEATGRASS	39	
CANADA BLUEGRASS (RUBENS)	14	
DOUBLE CUT RED CLOVER	28	
	APPLICATION RATE	48 KG/HA

The test plots were all seeded in the fall in order that maximum use could be made of moisture accumulated over the winter months, for early growth in the spring.

Test Plot Design and Construction

Slope Test Plots

General Considerations The test plots were designed to simulate, as closely as possible, an expanse of waste embankment. As previously mentioned preliminary design of these structures calls for construction of 16 m (50 feet) lifts. Therefore the test plots have common 16 m vertical rises with the slope lengths differing depending on gradient.

Three different slopes, 22°, 26° and 30° were selected to provide a wide range. The 22° slope was included in order to avoid a bias toward steeper slope. Plot widths were restricted to 16 m (50 feet) per slope. This was chosen arbitrarily as a sufficient width to prevent any edge effects from distorting the results. Slope lengths were as follows:

Slope	Slope Length(m)	(ft)
22°	40.5	133
26°	34.7	114
30°	30.5	100

All sloped areas were hydroseeded. One seed mix was used on all plots to avoid excessively complicating the experiment. Seed mix I, mulch (2242 kg/ha Silva Fibre), chemical binder (Dowell J197 13.5 kg/ha) and fertilizer (Table 1) were "hydro" spread in one application.

Test plots were fenced to ensure that grazing livestock did not interfere with the experiments.

Houth Meadows The plots are located immediately to the north of the proposed embankment location, elevation, 900 m, and aspect, ESE, are therefore duplicated. These areas were prepared by clearing and recontouring an expanse of hillside and trucking in sufficient gravel from Trench B, to provide approximately aim deep layer. Each 16 m wide plot was divided into two halves, one half being treated with a thin layer (5 cm) of topsoil.

Most of the lower "bench" area was also hydroseeded. Again seed, fertilizer and mulch were spread in one application, however, the mulch rate was reduced to 1350 kg/ha (1200 lb/acre) and the binder was omitted.

Medicine Creek The Medicine Creek Valley is located on the east side of Hat Creek Valley. The proposed embankment would therefore face almost due west. It was considered that an embankment with such an aspect would be warmer and therefore drier. Consequently it may be more difficult for vegetation to establish. An area of similar elevation, 1035 m, and aspect close to the location of „., the proposed waste embankment was selected. The surficial material in this location is glacial till, and since this would be the material of which the embankment would be constructed, there was no need to import material for the test plots. The vegetated area was already quite steep, 22°-26°. Topsoil was stripped from the area and, following ripping to a depth of about 0.7 m (2 feet), the slope was recontoured to the required dimensions. As a result of the difficulty in delivering topsoil, this treatment was omitted from the Medicine Creek test plots.

The entire area was hydroseeded as before. Again the lower "bench" areas received a smaller mulch application and no binder.

Waste Material Test Plots

Growth tests of vegetation on a wide variety of waste materials is being conducted at a site near Aleece Lake. This location was selected for the following reasons:

(a) it. has an elevation approximately equal to that of the final stages of the waste piles.

(b) it is located in a relatively flat and open area to expose it more reasonably to the prevailing elements.

(c) it is a location unlikely to be disturbed by the proposed mining operation for several years.

The Aleece Lake site is to the west of the proposed mine. The area has an elevation of 1067 m (3500 feet) and is presently located on the ultimate boundary of the open pit. The area around the plots was fenced to prevent damage by cattle.

The plots were designed to have dimensions of approximately 16 m x 16 m x 1 m. Topsoil was spread over half the surface area to a depth of 5 cm. In order to test each seed mix independently the plots were further divided into three subplots. Thus each seed mix was applied to an area of 16 m x 5 m, half of which was dressed with topsoil. Plots were seeded and fertilized using a hand held cyclone seeder. To prevent cross contamination, adjoining test strips on each plot were overlain with plastic sheets.

Monitoring and Evaluation

A program is being established to monitor vegetation progress at the various test areas. This program will be designed to obtain information on the success of seedling emergence, by late spring, and to estimate the productivity of these soil materials by determining the aerial biomass production at the end of the growing season.

Studies to determine vegetation quality are being devised. Analysis of the major constituent and selected trace elements in plant tissue are being considered in order to evaluate the uptake of elements by vegetation from the waste materials.

DISCUSSION RELATED TO F.G. MATHORN AND D.K. McQUEEN'S PAPER

There was no discussion about this paper.