PD-NCB Consultants Limited

In association with

Wright Engineers Ltd & Golder Associates

Report No. 8

Reclamation Study
Hat Creek Openpit No.1

to

British Columbia Hydro and Power Authority

London

March 1977

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CHAPTER I

INTRODUCTION

1. The Coal Mines Regulation Act 1969, published by the Department of Mines and Petroleum Resources, British Columbia, lays down that "It is the duty of every owner, agent or manager of a mine to institute and carry out a programme for the protection and reclamation of the surface of the land and water courses affected thereby and, on the discontinuance or abandonment of a mine, to undertake and complete the programme to leave the land and water courses in a condition satisfactory to the minister; and such a programme shall be submitted to and approved by the minister as hereinafter provided."

TERMS OF REFERENCE

2. It was in fulfilment of this requirement that PD-NCB Consultants Limited were asked, as part of the continuation of their services, to produce a further report based on the following Terms of Reference:-

"(i) determine the physical and mechanical properties of the various spoil types,

(ii) determine the safe slopes and stable spoil heap designs,

(iii) determine the drainage requirements,

(iv) ascertain the requirements of the Provincial Government,

(v) consider all environmental aspects in discussion with environmental consultants,

(vi) consider possible sequences of excavation, dumping and backfilling,

(vii) develop procedures and equipment requirements for final contouring,

(viii) determine the cost of reclamation to the required standard,

(ix) examine the effect of the mining project as a whole (including subsequent mines).

Unless specifically requested, the study should be confined to the placement of spoil in the preferred sequence, the construction of safe slopes, grading to final contours, drainage, etc, but not to re-vegetation. "

3. It must be emphasised that this study is confined to site reclamation and the mechanical problems associated with dump placement and drainage. It is not concerned with other forms of pollution as such, since these are being evaluated by other consultants. The various reports will presumably be combined to produce a total environmental impact study.

4. This study was to be carried out concurrently with the up-date study on Openpit No 1 (Report No 9) being carried out by PD-NCB in association with Wright Engineers Limited (WEL) and Golder Associates (GA), since the two are inter-related.

PREVIOUS REPORTS

5. There have been a number of other reports on various aspects of Hat Creek by PD-NCB and associates and by other consultants. Those of the former most relevant to the present study are:-

Report No 2 - Preliminary Report on Hat Creek Openpit No 1, March, 1976.

Report No 3 - Preliminary Report on Hat Creek Openpit No 2, June, 1976.

Report No 6 - Hat Creek Geotechnical Study (by Golder Associates), March, 1977.

Report No 7 - Combined Pit Operation Study for 5,000-MW Power Plant, January, 1977.

Report No 9 - Revised Report on Hat Creek Openpit No 1.

The full list of reports produced by PD-NCB, WEL and GA is given in Appendix "A".

DATA AVAILABLE

6. Appendix "B" of Report No 9 listed all data received from 11th June, 1976, to 5th January, 1977. Appendix "B" of this report covers all subsequent data up to 31st March, 1977.

LOCATION

7. The Upper Hat Creek Valley runs from south to north roughly mid-way between the Fraser River Valley to the west and Thompson River Valley to the east, and is about 120 miles north-east of Vancouver. The location is shown on Plate 1.

8. The nearest railheads are Pavilion on the British Columbia Railway, which is 15 road miles to the north-west, and Ashcroft on the Canadian National Railway, which is 30 road miles to the east. The main access is from the road joining Pavilion to Carquile and from there to the Trans-Canada Highway near Cache Creek.

9. There are two coal deposits within the valley - No 1 to the north with an area of about 1 mile^2, and No 2 to the south with an area of about 4 miles^2. This report is concerned with the No 1 deposit since the previous investigations have shown that the cost of mining this deposit is significantly less than the cost of mining the No 2 deposit. There are a number of reasons for this, of which the shallower depth of overburden and the stability of the strata are the most significant. Although the No 1 deposit is the smaller it still contains sufficient coal to supply a 2,000-MW power station for an operating life of 35 years.

CLIMATE AND TOPOGRAPHY

10. The Hat Creek valley lies in the south-west interior of British Columbia on the western extremity of a dry belt which extends from Lytton to Kamloops. The surface elevation at the No 1 deposit is about 3,000 ft. The recorded mean precipitation is about 12 in per annum, of which 5.5 in falls as snow. Most of this precipitation falls in either the winter or the summer and the spring and autumn are noticeably drier. The winters are cold with mean daily temperatures in January down to -12°C and the summers hot with mean daily temperatures up to 30°C.

11. Most of the valley floor is used for grazing and there are some wooded areas on the side slopes. The high altitude dictates a relatively short growing season and the semi-arid climate means that irrigation is generally necessary for cultivation. Hat Creek is the main source of such water and there are a number of existing water rights that must be respected.

CHAPTER II

GEOLOGICAL AND GEOTECHNICAL CONSTRAINTS

INTRODUCTION

1. The geology and geotechnics have been considered in detail in Reports No 6 and No 9 of this series. This chapter is merely intended to outline those aspects which are of particular relevance to the reclamation of the pit and surrounding areas.

PHYSIOGRAPHY

2. The floor of the upper part of the Hat Creek valley in which the coal is located lies at an approximate elevation of 3,000 ft. The western side of the valley comprises the Clear Range, and the Cornwall and Trachyte Hills are present to the east, land on both sides of the valley rising to over 6,000 ft. The Pavilion Mountains form the high ground to the north of Hat Creek. The proposed pit area lies within the gently sloping valley bottom from the weaker, down-faulted sediments of the Tertiary Coldwater Formation overlain by glacial and colluvial deposits of variable thickness.

3. The regional trend of the drainage in this part of British Columbia is to the north or to the south: Hat Creek runs parallel to the two main water courses, the Thompson and Fraser, but northwards in a contrary direction. It drains most of the hills between the Fraser and Thompson divides and eventually flows north-eastwards into the Bonaparte River and hence south-eastwards into the Thompson River at Ashcroft. The Pavilion Range at the northern end of Upper Hat Creek valley and the Cornwall Hills to the east may have sub-surface drainage, typical of limestone strata.

4. The valley sides and hills are dissected by side valley and tributary creeks draining into Hat Creek (see Plate 2 for detail of local drainage). Erosion surfaces or levels are present reflecting the down-cutting of the Fraser and Thompson Rivers: erosion of the river bed is still in progress partly as a result of glaciation which has produced the deposition of much glacial debris, over-deepening of existing valleys and the formation of meltwater channels, glacial lakes and impeded drainage.

5. Within the mining area, valley sides have rapid changes of relief with side slopes often exceeding gradients of 1:1.5. On the lower ground near the valley bottom the slopes are generally more gentle and more rounded with gradients of less than 1:5 as a result of glacial deposition. Irregular, hummocky topography characteristic of surface instability is apparent in parts of the Upper Hat Creek valley especially on the western side of Openpit No 1 (see Plate 3). Of special significance is a series of mudslides originating from the Finney Lake area. These are shown on Plates 4 and 5. The main active slide area to the west of Hat Creek is particularly important as it enters a critical area of the mine and will require dewatering and partial removal in the early stages of mining.

6. Full details of local topography and water courses are given on Plates 6, 7 and 8 and Plate 9 shows the legend of symbols used.

GEOLOGICAL SETTING

Structure

7. The structure of the No 1 deposit comprises two synclines plunging to the south and separated by an anticlinal area possibly with horst-like faulting on the flanks. The area is apparently terminated by sub-surficial outcrops to the west and north and by faults to the south and east. These structural elements are apparent from the structure contours based on boundaries within the coal deposit after borehole and geophysical log interpretations.

8. The plunge of the main western syncline ranges from 10^0 to 35^0 whilst that of the smaller north-western syncline is probably less than 10^0. The dip of the strata on the flanks of the main syncline lies between 15^0 and more than 60^0 especially on the eastern side against the anticlinal ridge. The north-eastern syncline is probably more gently inclined with dips of 25^0 or less. Other local variations are probable. These structural variations completely preclude strip mining and dictate an openpit form of mine. Very little is known regarding the geological structure outside the coal area. Within a fault block it is reasonable to assume a rough continuity of dip beneath or above the coal zones. Beyond boundary faults no such projection is reasonable. Similarly, other faults outside the coal area are difficult to detect from present drilling or geophysics. It is likely, however, that coal continues at depth, but with substantial overburden, to the south of the proposed mining area. Similarly, some coal may be present to the east of the proposed workings but at high in-situ ratios. No coal is thought to be present beneath any of the proposed embankment locations, but this should be confirmed by drilling.

Materials

9. These have been described in some detail in earlier reports and this section merely summarises those descriptions.

(i) Surficial materials

The west side of the valley, the most unstable with existing mudslides and bentonite boils, comprises glacial till, slide debris and bentonite with breccias, possibly of colluvial origin, and glacial lake deposits. The eastern side of the valley mainly comprises glacio-fluvial materials with some lake deposits. Hence, the west of the valley is most variable and incorporates much weak cohesive soil, while the east is predominantly granular. Although outside the main brief of this report, it is apparent that the more bentonitic areas currently support little or no vegetation and reclamation should include the burial of this material (both from surficial deposits and in-situ strata) if re-vegetation is desired. The natural slope instability is indicative of the consequences if waste disposal did not involve the construction of retaining embankments.

The more granular deposits on the east of the valley will be used for embankment construction and may support re-vegetation better than most other materials in the mine: the surficials on the west will be disposed of behind the embankments. It should be noted that the few soil types recommended for stocking appear to correspond to recent river terraces along or east of Hat Creek.

(ii) Overburden strata

The strata overlying the coal consist mainly of siltstones and clayey siltstones which are weak and frequently bentonitic or carbonaceous. Thin bands of volcanic tuff are present and much of this sequence is sheared or brecciated. Some coarser detrital sediments appear on the east of the deposit but, in general, the overburden should be buried behind the embankments in view of its bentonitic content.

(iii) Coal

This has been broadly subdivided into four zones on quality grounds. Within these zones there may be sub-zones or areas where particular trace elements - eg, copper or chromium - may be concentrated, but as yet details of this are incomplete. There appears to be sufficient low quality coal to consider separate stocking with a view to eventual use. It seems likely that this may, in fact, comprise the largest above-surface coal stockpile and hence leachate studies have included this material; in particular it will be necessary to ensure that low quality coal from the upper zone (A) is cleanly excavated to minimise contamination with swelling clays which could produce future leachate problems.

During the majority of the working life of the mine, coal will be the major rock or soil type exposed in the pit slope and will have a bearing on environmental impact with respect to the character of leachates and the propensity for dust production and for spontaneous combustion. The coal will probably require light blasting but ground vibrations and surface noise (air blast) should be minimal compared with hard rock surface mines. On-bench truck movements should produce less dust from coal surfaces than from dry claystones: the likelihood of burning faces has not been assessed: although sulphur contents are low, such coals do burn spontaneously as evidenced by the ancient burn zones on the outcrop. It is understood that spontaneous combustion tests are planned as part of the current bulk sampling programme.

(iv) Interburden

The materials interbedded with the coal comprise mainly claystones and siltstones, some of which contain swelling clays, and some iron carbonates. The montmorillonitic clays are most abundant in the upper part of the coal (Zone A) and all separately excavated interburden will require burial behind embankments. (The presence of swelling clays is a major reason for preferring to avoid coal washing with its associated slurry lagoons.)

A burn zone including clinker from coal and interburden strata appears to be present over much of the sub-surficial outcrop of lowest coal (Zone D). Its full extent is not known, particularly to the south, but in places it may have an outcrop width of more than 1,000 ft. At present the burn zone is not thought to be active.

Whilst the burn zone materials will not support re-vegetation, they should provide excellent temporary road construction material.

(v) Underburden

Excavation will extend into strata lying beneath the coal. These underlying strata consist of poorly cemented siltstone, sandstones and conglomerates. Some bentonite is present as a cement: stronger cemented bands are calcitic: towards the north the strata beneath the lowest coal appear to be less coarse and more carbonaceous. It cannot be assumed that the sandstones and conglomerates are necessarily stronger than the siltstones or clayey siltstones, owing to bentonitic fines in the matrix. Both the sandstones and siltstones consist of rock fragments and minerals derived from volcanic sources. Breccias with a more granitic aspect have been recorded on the western limits of the area and strong andesite of the Kamloops Group has been detected on the east, but neither rock type should be an important component of the excavation; some of this material will probably be placed in the Medicine Creek dump as its engineering properties are likely to be better than the overburden and interburden strata.

Groundwater

10. Current indications are that groundwater levels follow the topography and that whilst some artesian water may be present on the western flanks of the valley, this may not have a deep-seated origin. Hat Creek valley may, in fact, be a groundwater discharge area and its diversion during mining should reduce pit inflows even though a continuing sub-surface inflow along buried channels within the surficials is likely. There is some evidence that local vegetation differences reflect areas of recharge and high piezometric pressures. Of the main rock types the coal is the most permeable ($k = 10^{-4}$ cm/sec): the claystones ($k = 10^{-8}$ cm/sec) will be difficult to drain and depressurise; local aquifers (coal seams, ironstone bands) and aquitards (claybeds) are expected. Details of groundwater chemistry have been presented in Report No 6.

GEOTECHNICAL CONSIDERATIONS

11. The strongest materials likely to be encountered are the burn zones, calcareous strata underlying Zone D and boulders of glacial erratics. Limestones and in-situ andesite are not likely to constitute significant excavation areas. The coal itself is the next strongest rock and this, as noted above, may require light blasting. In general, however, the materials to be mined are either engineering soils or very weak rocks and hence greatly influence the design of the mine with regard to required working methods, excavated slope angles and the mode of spoil disposal.

Excavated Slopes and
Working Methods

12. An overall slope angle of approximately 16^0 for the excavated pit slopes is currently planned. It may locally be possible to steepen this slope, but elsewhere slope reduction or dewatering will be required. This excavated slope angle (which results from bench widths of 120 ft, with bench slopes of 64^0 and bench heights of 40 ft) may have local bench instability, but is thought to be adequate to prevent large rotational slope failures by shearing through intact materials. An essential part of the pit design is linked to slope stability: to ensure reasonable bench and slope stability, faces must advance continously since long-term slopes cannot be expected to stand to 64^0 on benches. Similarly, it is important that re-entrant angles are avoided where possible, hence the circular or ellipsoidal plan form of the mine. A central ramp provides greater safety in the event of unforeseen slope or multi-bench failures.

13. The location of the access ramp is primarily determined on economic grounds, which are such that minimum excavation is required to start coal production.

14. The preferred location for the access ramp is near to the current Hat Creek stream bed on the northern side of the pit and along a sub-surficial channel. A significant proportion of the slope will lie in gravel (rather than sheared clayey siltstone) and the risk of failure here is reduced. Where the ramp lies at a depth less than two thirds of the thickness of gravel and no excess piezometric head is present, side slopes of 33^0 would seem possible. Where less favourable conditions are present the ramp side slopes will be reduced in the lower sections to about 22^0 and advanced permanent dewatering will be required.

Waste Dump Construction

15. It is considered that only selected sand, gravel and till will be suitable for embankment construction and that the remaining waste will be very weak. The embankment construction materials are located mainly on the east side of the Hat Creek valley: some of the weakest materials from the west side of the valley will require dumping early in the development of the waste dumps. The retaining embankments would have an outside slope of 22^0 and would be constructed in stages at or very near to the locations where acceptable foundations have been proved (Houth Meadows) or inferred (Medicine Creek). The suggested realignment of the access ramp away from the Houth Meadows embankment will further improve stability. Behind the embankment dumped waste should have slopes not exceeding 6^0 (1:10 the gradient of the active mudslide) and when the slope height exceeds 250 ft this should be reduced to less than 3^0 (1:20). Construction of the waste dumps will be on the upstream principle: downstream dumping from the heads of the valley is unacceptable owing to the risk of flowslides in saturated clayey siltstones. Further details of the geotechnics of dump construction are given in Chapter III.

STABILITY AT END OF MINING

16. The rationale for the proposed slopes during mining both in the pit and in the dump is fully explained in Report No 6. In view of the progressive advance of the excavated slopes, short-term to medium-term slope design criteria are appropriate. Long-term stable slopes or shorter term slopes in very weak remoulded materials will require grading to 6^0 or 1:10 (the slope of the waste above the retaining embankment) for complete stability. At the end of mining those on the western side of the pit will be several hundred feet in height and above any potential lake level (see Plate 5). Other slopes will remain around the pit, but should not be so high or not have been excavated in such weak material. As a result of long-term softening due to creep and surface weathering, stable long-term slope angles might be taken as being approximately half the residual or ultimate shear strength, ie 9^0 to 13^0. Hence, there is likely to be instability, as at present, with those final slopes which consist of weak clayey strata, especially if stability during mining was promoted by non-gravitational drainage. In particular, the regraded bench slopes of 26^0 (see Chapter IV) may be expected to further deteriorate and it will be necessary to attempt some measures to improve both bench and overall slopes beyond mere regrading. This matter requires further investigation, but possible steps include attempts to reduce infiltration of surface water by compaction, to aid controlled drainage of surface water (as in Appalachia) and to establish deep-rooted vegetation at the earliest possible time.

CHAPTER III

THE MINING PROJECT - DISTURBANCE

INTRODUCTION

1. This chapter discusses the mining operation and the quantities of spoil material which will be produced. The proposed arrangements for spoil disposal are considered together with dump location and design, and the area of land which will be disturbed by mining and waste dumping.

MINING CONSIDERATIONS

2. The mining method proposed for Hat Creek Openpit No 1 is fully described in Reports No 2 and No 9. Geotechnical considerations have dictated the basic pit design which precludes any possibility of depositing waste within the mine excavation for the following reasons:-

(i) The initial elliptical pit excavation will be developed near to the centre of the coal deposit and will then expand by annular increments to the final pit slope position. Annular expansion will greatly improve the stability of the pit slopes by virtue of the limited period of time that a bench at each elevation must be maintained, but the whole of the pit perimeter must always be accessible during the life of the mine in order to allow expansion and transportation along the benches.

(ii) Extraction of the No 1 deposit to 2,400-ft level (600-ft pit) is thought to be feasible and is proposed for the present study. Inside dumping within the pit excavation would cover some 500 million tons of coal reserves, which could possibly be mined by deepening the pit excavation at a later date if constraints of ground stability permit.

(iii) Any feasible back-filling method would involve mining at one side of the deposit and back-filling on the "footwall" or the waste side as the face advanced into the deposit. This method would involve very adverse stripping ratios until the full depth (corresponding to 2,400-ft elevation) was reached and further extension in depth would be prevented. Also, the "box-cut", ie the void before back-filling could commence, would be almost as big as the pit because of the final slope angles. The even flatter angles of spoil would severely restrict the amount of backfill which could be safely dumped.

3. The cost of replacing spoil in the pit excavation at the end of mining would be enormous and would render the whole mining project uneconomic. Dumping inside the pit excavation could be considered to dispose of spoil from mining the No 2 deposit at a later date however, provided a decision was taken to abandon any remaining coal as an openpit mining prospect.

WASTE PRODUCTION

4. The quantities of surficial and waste material contained in each mining stage are shown in Table IX of Report No 9. Table XIII in the same report shows the required production of these materials by year to keep pace with coal production.

5. As in previous reports, three types of dump material are now considered:-

(i) Surficial glacial deposits of till, sand and gravel which would largely be used for the construction of compacted dump retaining embankments.

(ii) Pit waste comprising very weak rocks ranging from clayey siltstone to conglomerate which break down to engineering soils, and similar weak waste in coal interbeds segregated in the course of selective mining.

(iii) Ash from the power plant conditioned to contain (say) 15% moisture.

6. Table I of this report summarises the loose volume of these materials which will have to be dumped during each mining stage based on swell factors recommended by Golder Associates in Report No 6. A total dumping volume of 1,098 million yd^3 will be required during the life of the mine to accommodate:-

	10^6 loose yd^3
Surficials	377
Pit and segregated waste	624
Conditioned ash	97
Total	1,098

7. Storage space may also be required for 51 million tons of low-grade coal segregated from rom coal by selective mining. However, some of this tonnage may possibly be fed to the power plant by mixing with rom coal.

8. It should be noted that the figure of approximately 1,210 million yd^3 of required storage space quoted in Report No 6 was based upon the production schedule in Report No 2 (now revised downwards by Report No 9).

Dump Locations

9. Three main spoil dump locations are proposed and are shown on Plates 3 to 5:-

(i) North Valley Dump

12 million loose yd^3 of surficial material from the initial conveyor incline excavation prior to the start of production will be dumped in the valley immediately to the north of the conveyor incline. The proximity of this dump to the top of the incline provides a useful level area for mine services and part of the coal stockpile, and will also keep down the front-end transportation costs of the initial excavation.

(ii) Medicine Creek Dump

This dump will contain approximately 475 million loose yd^3 of material behind a retaining embankment constructed across the mouth of the valley. It is proposed to store free-draining surficial material and power station ash in this dump, although it will also be necessary to store 123 million loose yd^3 of pit and segregated waste material during the life of the mine. The conveyor interchange station permits in-pit waste to be sent to either dump as required in an emergency.

(iii) Houth Meadows Dump

It is proposed to store 611 million loose yd^3 of waste and surficial materials in the Houth Meadows valley behind a retaining embankment.

10. The volumetric capacity of the proposed dumps is summarised by elevation in Table II and the cumulative volumes are shown graphically for each dump and in total on Plate 10. The proposed distribution of the spoil materials within the dumping volumes is shown in Tables III and IV. Table III shows the distribution of spoil at the approximate mid-point of the mining project (taken as the end of Stage 4), and Table IV shows the spoil distribution when mining is completed.

11. Report No 2 suggests that 180 million loose yd^3 of waste could be disposed of in shallow dumps to the north of the pit. Due to the even slope of the terrain in that area and the absence of natural abutments, large volumes of free-draining surficial material would be required to contain the waste effectively behind retaining embankments. The height of Houth Meadows dump has been raised by 50 ft as an alternative to the formation of this additional dumping area, and has increased the volume of the dump to 611 million loose yd^3 compared with a volume of 550 million loose yd^3 as proposed in Alternative B of Report No 6.

12. Dump locations are also proposed for the retention of stockpiles of blended coal, low-grade coal and topsoil. The locations of these dumps are also shown on Plates 3 to 5.

DUMPING PRINCIPLES

13. The Department of Mines and Petroleum Resources recommends principles to be followed in the location and design of dumps. Those principles are quoted in Appendix "C".

14. The location and construction of dumps are discussed in detail in Report No 6. This present report follows the recommendations of Report No 6 except for the revision to accommodate a larger volume of waste in Houth Meadows as described in paragraph 11 above, and also follows the guidelines as given in Appendix "C".

DUMP LOCATION

15. Within the limitations of the present geological and geotechnical exploration, the foundations for the dumps, and the retaining embankments, appear to be adequate at the sites chosen and shown on Plate 5.

16. The small dump in the valley to the north of the proposed conveyor incline will be adequately contained by the sides of the valley on a thin cover of till. The presence of this dump in the base of the valley may be expected to contribute slightly to the stability of Houth Meadows dump.

17. Houth Meadows dump will be located in gently sloping valley and will be retained by a major embankment (Embankment No 1, Plate 5) located between a northern abutment of outcropping limestone and a southern abutment of Coldwater strata. This embankment will be underlain by glacial till over sand and gravel, and some further investigation is considered advisable to ensure the ultimate stability. The smaller embankments (Embankments No 2 and 3, Plate 5) on the north side of the dump will probably overlie a shallow depth of till over bedrock. The main body of the waste which will be dumped behind the embankments will overlie very soft clayey silts which may have originated as outwash material from the surficial slide to the south-west.

18. The site chosen for the Medicine Creek dump appears to contain glacial till overlying Coldwater rocks in places, but the main embankment (Embankment No 4, Plate 5) will probably overlie Kamloops volcanics.

19. Further investigation by drilling, testing and analysis of the dump locations is recommended before detailed design work can be undertaken. Particular attention will have to be given to abutments, especially at the north end of Embankment No 1, where the natural valley side does not "narrow" to assist in confining the embankment. The availability of suitable embankment construction material also requires investigation. It is essential to check whether mineable coal exists at these locations.

DUMP CONSTRUCTION

General

20. Dumps will be constructed according to the methods commonly used for tailings lagoons in the following sequence:-

(i) form a lagoon at the lower end of the site.

(ii) excavate a permanent drainage ditch around the site perimeter gravitating to the lagoon.

(iii) pump to clear any local ponding within the site.

(iv) remove vegetation and then remove top and sub-soils and other material on site which may be required for reclamation purposes at a subsequent stage.

(v) progressively form blanket or strip "underdrains" of suitably graded gravel and sand at the lower end of the valley in order to provide adequate drainage of the embankment and dumped materials.

(vi) progressively form retaining embankments by compaction in regular lifts using selected surficial materials, and providing an efficient berm drainage system.

(vii) progressive waste dumping in lifts immediately behind and after the formation of the retaining embankment, advancing generally in an uphill direction, and providing a drainage gutter behind the embankment.

(viii) progressively contour and re-soil dumped material as each part of the dump reaches its final level. Some subsequent work may also be required to correct differential settlement which could disrupt or reverse contour drains.

CONSTRUCTION OF RETAINING EMBANKMENTS

21. Retaining embankments will be constructed in stages using suitable materials available at each stage of the pit excavation. Gravel and till are recommended for this purpose, but conditioned power station ash may be used when necessary to supplement supply.

22. The arrangement for delivery of spoil to the dumps is detailed in Chapter VI of Report No 9.

23. Surficial materials used in embankment construction will be delivered to the dump site either by scrapers discharging directly to the embankment, or transported over longer distances by conveyor and discharged on to the embankment by means of a travelling tripper and spreader (see Plate 11).

24. Compaction of this material will be in layers, the height of which will be specified in future geotechnical investigations involving field trials to determine the optimum thickness and the number of passes of compaction equipment (scrapers, dozers, vibrating rollers, etc) required. It will be necessary to raise the embankment by a height equivalent to the spoil stacker lift before a new layer of spoil is spread behind the embankment.

25. Plate 12 illustrates alternative methods of embankment formation.

Alternative A (Downstream Method)

26. Construction is shown commencing with Stage 1 on the upper side of the embankment with a final first stage height of 50 ft, but covering only a part of the final embankment width. Some form of underdrain is essential at this stage.

27. Stage 2 eventually increases the height of the embankment formation by a further 50 ft by layer spreading, and also increases the width on the downhill side. Prior extension of the underdrain will be required.

28. Additional stages will progressively increase the height and width of the embankment ahead of the dumped waste which it will retain until the final formation is achieved. Underdrainage will be extended before each new dumping stage and will drain to the perimeter lagoon downstream of the embankment.

29. This method allows flexibility in the quantity of materials required to complete each lift but does not permit reclamation until such time as the embankment construction is finalised. A large underdrain is required with this method of construction.

Alternative B (Centre Line Method)

30. Dumping in layers is commenced over the anticipated final width of the embankment.

31. Subsequent lifts of about 50 ft vertical interval formed by thinner compacted layers are placed to form the specified finished profile of the embankment. A somewhat smaller underdrain is required than with Alternative A.

32. Large quantities of suitable embankment material will be required in the early stages of construction by this method, particularly where gradients of foundations are relatively steep. It is, however, to be preferred to Alternative A since it will enable some reclamation to proceed at the earliest opportunity and to be completed progressively with the formation of the embankment.

33. Plate 12 also illustrates the slope angles required in embankment construction.

(i) The face of the embankment will be graded to a slope of 1:2 (approximately 26^0) to comply with the requirements for re-vegetation. A toe drain will be provided at each level with a drainage gradient of not less than 1:500. Drainage from the embankment slopes will be transmitted to the bottom of the pit via the toe drains and a column drain or flume.

(ii) A berm 25-ft wide will be left on the lower face for each lift of 50 ft in order to afford a means of access for inspection and reclamation work. An overall slope angle of 1:2.5 (approximately 22^0) will thus be formed on the outer face of the embankment. The berms should have a back slope of not less than 1:100 towards the toe drain.

(iii) Access berms will not be required on the upper side of the embankment since this will be covered by the dumped waste material. A slope of 1:1.3 (approximately 37^0) is recommended in order to ensure an adequate width at the base of the dump.

CONSTRUCTION OF DUMPS

34. As shown in Table IV, some 624 million loose yd^3 of pit and segregated waste material will be disposed of during the life of the mine. Of this volume 501 million loose yd^3 will be dumped behind retaining embankments in Houth Meadows and the remaining 123 million loose yd^3 will be dumped in Medicine Creek. Of the 377 million loose yd^3 of surficial material, 110 million loose yd^3 will be used for embankments and underdrains in the Houth Meadows dump and 54 million loose yd^3 for similar purposes in the Medicine Creek dump. The balance of this material will be deposited in the North Valley dump (12 million loose yd^3) and within the body of the Medicine Creek dump (201 million loose yd^3). The latter dump will also accommodate 97 million loose yd^3 of power station ash.

35. Waste materials will be transported by one or more of the main incline conveyors to the conveyor interchange station where they will then be routed to the required dump. The majority of the waste will be transported by a conveyor running on the north side of Houth Meadows dump up to about 3,000-ft elevation. From this conveyor the spoil will be transferred to a movable conveyor on the embankment of the spoil dump for disposal by travelling tripper and spreader. This arrangement is illustrated on Plate 11. A similar arrangement will be provided to Medicine Creek dump via a main transfer point east of the pit. This arrangement will be able to deliver waste, surficial materials or power station ash to a tripper and spreader on the dump embankment.

36. The waste spreader dumps in successive vertical lifts of about 50 ft, but two lifts may be achieved by dumping both above and below the elevation of the spreader. The conveyor is moved forward as necessary on the established dump by means of a side-boom tractor. The main part of the dump will thus be constructed in horizontal lifts of about 50 ft over the whole of the currently active area of the dump. Exact dumping configuration will, however, require further geotechnical appraisal.

37. Apart from the material used in the construction of compacted retaining embankments, it is expected that the remainder of the waste material will be very weak due to the mineralogy, its remoulded condition after handling and disposal by dumping, and its propensity to soften on exposure. Settlement is not likely to be significant during the life of the mine and the waste is expected to behave as a partially saturated and virtually undrainable material for many years. Its shear strength and bearing capacity are expected to be low. For this reason, a restraint on the gradient of the top surface of a dump relative to the proposed vertical dump height is recommended in Report No 6 in order to control the possible sloughing or flow of dumped waste material over the top of the retaining embankment.

38. The following criteria are recommended by GA (Report No 6) to determine the maximum permitted surface slope of the top of the dumps:-

(i) for slope heights up to 250 ft, slope gradients not to be steeper than 1:10 (approximately 6^0),

(ii) for slope heights greater than 250 ft, slope gradients not to be steeper than 1:20 (approximately 3^0).

39. The upper surface of Houth Meadows dump will rise from the elevation of the top of the proposed retaining embankment at 3,300 ft to approximately 3,800 ft, a vertical height of 500 ft (see Plate 5). To comply with the above criteria the top of this dump is therefore proposed at a gradient of 1:20, with the direction of full dip at right angles to the line of the retaining embankment.

40. Medicine Creek dump, however, will have a vertical height of 250 ft from the top of the embankment at 3,750 ft to a proposed level surface at 4,000 ft elevation. A gradient of 1:10 is therefore proposed in this stronger waste material for the sloping upper surface of this dump.

41. The top surface of the north valley dump will be approximately level but with a gradient of 1:100 to promote drainage and prevent local ponding of water and the dumped material will largely be retained by the side slopes of the valley.

42. Further geotechnical work is required to finalise the details of dump location and construction. Dumping arrangements will therefore be reviewed as this work is completed, and the more detailed methods of building the dumps will be considered, observing the recommendations of the guidelines issued under the Coal Mine Regulations Act (see Appendix "C").

43. The following plans showing the location and extent of the dumping areas are included in this report:-

(i) Plate 3 shows, on a scale of 1 in to 1,000 ft, the mine site area before the commencement of mining activities. The locations of lakes and creeks are shown, together with buildings and habitations, and the southern limit of a reservation which adjoins the proposed site.

(ii) Plate 4 shows the mine site on the same scale at the approximate mid-point of the mine life. The extent and location of the pit excavation, the spoil dumps and transportation systems are shown, as well as the arrangement to divert Hat Creek around the mine excavation, and the drainage control arrangements for each dump.

(iii) Plate 5 shows the same detail as Plate 4 above, but at the conclusion of mining operations. The full extent of the pit excavation and waste dumps is shown.

(iv) All the above plans also show the locations of sections across the mine site, as described in the following paragraph.

44. Plate 13 shows sections through the mine site as follows:-

(i) Section on line A-B which crosses the full width of Houth Meadows dump, the approximate centre of the pit excavation and the dump in the Medicine Creek area. This section illustrates the comparative extent and proximity of the waste dumps and the pit excavation on a line running roughly north-west to south-east, drawn to a "natural" scale of 1 in to 2,000 ft (ie the vertical and horizontal scales are the same).

(ii) Section on line C-D is drawn to a natural scale of 1 in to 1,000 ft through Houth Meadows dump on the full dip of the upper surface slope of the dump. The approximate extent of the dumped material is shown:-

(a) at the end of the first year of production (year 1984/85),

(b) at the mid-point of mining (year 2005/06),

(c) at the conclusion of mining (year 2021/22).

(iii) Section on line E-F is drawn to a natural scale of 1 in to 1,000 ft through Medicine Creek dump on the full dip of the upper surface of the dump. The approximate extent of the dumped material is shown at the same three stages described in paragraph 44 (ii) above.

DISTURBANCE

45. By reference to the plans and sections referred to in paragraphs 43 and 44 the area of land disturbed by the mining operations has been considered under various sub-headings.

46. Table V has been compiled to schedule the area disturbed at the mid-point of mining and at the completion of mining:-

(i) the excavation of the pit, which is expected to reach an area of 1,868 acres.

(ii) the area which will be covered by spoil materials. This is expected to amount in total to 2,848 acres.

(iii) 854 acres have been designated to locate recoverable stockpiles.

(iv) a total of 114 acres will be utilised for drainage control.

(v) transportation and access will occupy 65 acres.

47. A total plan area of 3,749 acres will be utilised by the mid-point of the mining project, and 5,749 acres will be in use at the end of the life of the mine.

48. Measures to reclaim the disturbed areas during and after the conclusion of mining are discussed in Chapter IV.

CHAPTER IV

THE MINING PROJECT - RECLAMATION

INTRODUCTION

1. The statutory requirement as laid down in Section 8 (i) of the Coal Mines Regulation Act, 1969 (Appendix "C") is to "carry out a programme for the protection and reclamation of the surface of the land and watercourses affected thereby, and, on the discontinuance or abandonment of a mine, to undertake and complete the programme to leave the land and watercourses in a condition satisfactory to the Minister; and such a programme shall be submitted for approval to the Minister."

2. The earlier chapters have explained the reasons behind the design of the mining project since this is the starting point of any reclamation programme. To minimise the environmental impact of any mining project the area of disturbance should be kept to a minimum at all times and, ideally, reclamation would follow close behind operations. The particular geological and geotechnical circumstances pertaining at Openpit No 1 have severely restricted the options available for mine design if the coal is to be recovered to the maximum possible extent and the design selected affords minimal opportunity for pit reclamation until the mine is abandoned. In particular, the worked out areas cannot be restored by back-filling, for example, whilst mining is in progress.

PIT VOID

3. Assuming that the project comes to an end when the initial 2,000-MW (net) power plant reaches the end of its 35-year economic life, then about 348 million tons of rom coal will have been removed. The initial swell of the waste material, plus the addition of 97 million yd^3 of power plant ash, is not sufficient to compensate for this loss, especially as consolidation of the spoil will take place and a certain amount of material would be lost in the double handling. It would not, therefore, be possible to regrade the disturbed area to the original contours.

4. The cost of returning this waste would vary according to its character, the length of time it had been in position in the dumps and the transport distances involved. However, the order of cost would be 50¢/yd^3. This would mean that the cost of returning all this material to the pit would be of the order of $500 million and this money would have to be spent after all revenue from the project had ceased (ie it would be a capital item).

5. The removal of the weak claystones from Houth Meadows dump would be particularly difficult but the Medicine Creek dump could theoretically be removed by hydraulicking as the material would flow by gravity into the pit. However, this dump has a final volume of the order of only 475 million yd^3 and the cost of this operation would still be of the order of $200 million. In any case, the upper levels of the pit would still have to be reclaimed by conventional means.

PREFERRED SOLUTION

6. On the assumption that the other coal resources in the valley are not used, the preferred solution is to allow the pit void to fill up and to become a lake and to reclaim the dumps and other areas of disturbance so that they are suitable for either grazing or forestry. This solution has, therefore, been adopted in this report. If, however, a further mine were developed then the Openpit No 1 void should be used for waste disposal, thereby mitigating the disturbance to the remainder of the valley.

7. The proposed reclamation programme, therefore, embodies the following features:-

(i) rehabilitation of Hat Creek,

(ii) making the pit safe and allowing it to become a lake,

(iii) contouring the spoil heaps for long-term stability and establishing suitable gradients for reclamation and water run-off,

(iv) removing all buildings and equipment and restoring the land,

(v) topsoiling when possible or otherwise ensuring that the surface material will encourage plant rehabilitation.

REHABILITATION OF HAT CREEK

8. Some time after the completion of mining it is proposed to decommission the diversion canal and to re-establish the flow of Hat Creek through the pit area, which would then become a lake. This is considered in more detail in the next chapter. For the present, it is sufficient to point out that some flow must be maintained in the lower reaches of the Creek while the pit is being filled and that the diversion canal must remain in operation for this purpose during the transition period. A quantity of 6,000 acre-ft/year (minimum flow recommended by Monenco) has been allowed for this purpose. After allowing for the flow of water round this diversion it has been calculated that it will take about 26 years for the pit to fill to the level of the top of the main incline (2,800-ft elevation). Arrangements will then be made to channel the overflow back into the original course of the creek.

IN-PIT RECLAMATION

9. When mining in Openpit No 1 is completed it will be necessary to recontour the pit slopes with the following objectives:-

(i) to improve stability,

(ii) to provide a final profile which is more visually acceptable while still allowing bench access for maintenance and reclamation purposes,

(iii) to provide a suitable drainage system for surface and percolating water,

(iv) to provide a suitable profile to receive a top dressing and at an inclination suitable for the growth of vegetation,

(v) to cover exposed carbonaceous matter with sterile material in order to prevent spontaneous combustion.

10. Plate 14 shows the proposed mining bench profile with a formation width of 120 ft and a bench height of 40 ft.

11. Minor bench failures are expected to reduce the bench width to an effective 94 ft, and regrading will subsequently be required to produce a maximum slope of 26^0 (or approximately 1:2), giving a final bench width of 58 ft.

12. The total volume per linear yard of bench which must be regraded from the mining profile is 34 yd^3. Slough is expected to average 10 yd^3/yd leaving 24 yd^3/yd to be moved mechanically.

13. It is estimated that the bottom three benches in the pit excavation will be covered by rising water within a period of five years. There seems to be little point in expending effort in recontouring these benches. This leaves a total of 28 benches which will have to be regraded from the 2,560-ft level to about the 3,640-ft level. The total bench length to be regraded will be approximately 143,000 yd and the total volume to be moved will be about 3.44 million bank yd^3 (see Table VI).

14. Lack of sufficient topsoil suitable for reclamation may preclude topsoiling within the pit excavation. If soil is not available a dressing of inert material will be required on areas of exposed coal and carbonaceous material, in addition to the regrading described above, to prevent spontaneous combustion.

15. New drainage channels will be formed as pit benches are recontoured to maintain a controlled flow of water entering the pit.

16. All this work will be carried out as soon as possible after completion of mining. In addition, however, there will be some work connected with the formation of the lake which cannot be completed until the water level approaches its final position.

17. A final level for the water in the pit will be decided upon (as mentioned previously this will be approximately at the level of the top of the pit incline) and before this level is reached beaches will be established for safety reasons and to encourage wild fowl.

18. A sluice gate will be provided at the pit exit so that the lake area can be used for flood control in an emergency. Downstream of this sluice a channel will have to be established through the fill dumped to the north of that point, with a suitable gradient to connect back to the old stream bed. Some protection will be necessary to prevent scour of this fill and the sides of the channel will have to be contoured to acceptable slopes.

19. Trees should be planted on the outer edge of the berms as an aid to slope stability. At 58 ft, the berms are wide enough for this not to impede access for reclamation work.

RECLAMATION OF DUMPS

20. The requirement to build the dumps in layers, starting at the lowest point, has already been explained in Chapter III. This means that the potential for dump reclamation is very small during the early years of the project. The external faces of the embankments can be reclaimed as they are constructed but these represent a very small percentage of the total area. Only grass should be allowed on these faces during the mining project as trees could hinder routine inspection of the stability and surface of the embankments. Trees may, however, be planted on completion of dumping.

21. Unlike the bench faces in the pit excavation, the exposed embankments will be formed at the required maximum slope. Regrading will not, therefore, be necessary before top dressing proceeds. The formation benches at 50-ft intervals will be maintained for access, and drainage ditches will be formed to control run-off and percolating water.

22. Plates 5 and 13 show the proposed final dump profiles. The upper surface of Houth Meadows dump is formed at a slope of 1:20, which will promote efficient drainage from the dump. In the case of Medicine Creek dump, however, the top surface of the dump has been assumed to be flat for the purpose of volume calculation but, in practice, a carefully graded slope of not less than 1:200 will be required to prevent local ponding.

23. Plate 13 shows that by the mid-point of mining Houth Meadows dump will have reached the top of its main embankment and it will be possible to start reclaiming the top surface of the dump. This work will then carry on steadily for the rest of the production phase.

24. Medicine Creek dump does not reach the elevation of the top of its embankment until a few years later, but as soon as this does occur it will be possible to start reclaiming the surface of this dump also.

25. During the spring there will be considerable snow melt and precipitation run-off from the surface of the dumps. Unless something is done to control this it will flow towards the embankments and then down their exposed faces causing erosion.

26. It is therefore proposed to cover the final surface with a "herring-bone" system of ditches which will channel the flow to the perimeter drainage ditch. The size, orientation and spacing of these ditches will be finalised when more is known about the quantity and duration of the run-off.

RECLAMATION OF COAL STOCKPILES

27. Under the simplest scenario of one mine supplying one power plant it is unlikely that it will be possible to exactly match the power plant requirements with the stocks; therefore, some coal will remain in the stockpiles.

28. If this cannot be disposed of or sold for some other purpose then it will have to be covered over. In any case, a layer of spoil should be placed over the area and covered with topsoil.

29. Similar treatment will be necessary for the separate area reserved for stocking low-grade coal, although it is to be hoped that most of this coal can be used by the power station during its last years life when it will necessarily be operating at a comparatively low load factor.

REMOVAL OF BUILDINGS AND EQUIPMENT

30. It has been assumed that all the mine buildings will be demolished and their sites cleared. In practice, however, it is possible that certain of them, such as the vehicle workshop and the stores, could be usefully retained for some ranching related purpose. Ideally, all floors and paved areas should be removed. In practice, it may be acceptable if they are broken into suitably sized pieces and then covered with not less than 3 ft of spoil and topsoiled over.

31. The fixed equipment includes all the conveyors and other coal and spoil handling equipment, the electrical supply system and all the service pipework. The heavy structural steelwork and the electrical copper will have a substantial scrap value, which will more than cover the cost of removal. After the structures have been dismantled or demolished, the concrete foundations should be broken up and either removed or covered with not less than 3 ft of spoil.

32. The fixed plant within the pit should be treated in a similar manner except that any foundations which will shortly be submerged can be left unbroken. Other foundations should be removed and the material dumped in the bottom of the pit.

33. Any roads which no longer serve a useful purpose should be broken up and the material dumped in the bottom of the pit. It is likely, however, that most of them will be useful for through traffic, for access to the dump areas or for ranching operations. If so, they should be left, provided some competent body is prepared to take over responsibility for their upkeep.

AVAILABILITY OF TOPSOIL

34. The preliminary environmental impact study of the proposed Hat Creek development produced by BCR and DCA in August, 1975, estimated that an average thickness of 1 ft of topsoil suitable for reclamation existed on the proposed mine site. However, a more recent work entitled "Report on Hat Creek Field Work in Regards to Soils Suitable for Reclamation", dated 21st October, 1976, and prepared for Acres Consulting Services by J.T. Forster of Canadian Bio Resources Consultants Limited, considered that much smaller volumes of soil material within the area of the pit were suitable for re-use.

35. Plate 15 shows the areas of soil which Forster considered to be suitable and Table VII summarises the volumes of the soil based on thicknesses quoted in his report. It must be emphasised that only areas within the final pit outline have been included, and there may be more suitable topsoil under the dump areas.

36. A total of about 500,000 bank yd^3 of soil appears to be available within the pit excavation but little is presently known about availability of soil throughout the rest of the site. Detailed arrangements for handling and storage of sub-soil and topsoil will therefore be considered when further information is available.

37. It has been assumed that in the absence of sufficient suitable soils any suitable soil-forming materials found during the course of mining will be saved and stored to make up the required quantities. Areas of land have been set aside to store these materials as shown on Plate 5.

38. It would be possible, in theory, to truck in additional material from outside the valley, but the quantities involved would be enormous. An additional inch of cover would require of the order of 1 million tons of material and the cost, to say nothing of the wear and tear on the local roads, would not justify this.

SCHEDULE OF RECLAMATION

39. Having laid down the reclamation work which must be carried out, it is now possible to consider the timetable in more specific terms. Section 8 of the Coal Mines Regulation Act requires plans showing the areas proposed for reclamation at the mid-point of mining, at the end of mining and ten years after mining is completed. These have been provided as listed below. In addition, Table VIII shows the acreages disturbed by functions at each of these three dates.

Plate 6 - Mid-Point of Mining (Year 2005/06)

40. By the time the mid-point of mining is reached, reclamation procedures should be completed on the face of Embankments No 1, 2 and 4. The construction of Embankments No 3 and 5 will be about to commence, with reclamation proceeding with embankment construction.

41. The remainder of the dumps and the surface of the excavated pit will still be active and will not, therefore, permit reclamation work. This will also apply to other utilised areas until mining is completed.

Plate 7 - Completion of Mining
(Year 2021/22)

42. Reclamation work will proceed as the final formation profile of the top of each dump is completed. By the year 2021/22 when coal production is scheduled to end, it is expected that both Houth Meadows and Medicine Creek dumps will be fully reclaimed.

43. Unlike the dumps, however, where pre-stripping will enable the reclamation work to be completed by the time mining is completed, work to reclaim the remaining areas under utilisation will not be possible until all mining activity has ceased.

Plate 8 - Ten Years After Mining
(Year 2031/32)

44. By the year 2031/32 all reclamation work is expected to be completed. The waste dump areas, including the North Valley dump, should be fully reclaimed and put to the proposed final use.

45. Rising water in the pit excavation will probably reach an elevation of 2,600 ft. This will cover an estimated 115 acres which will already have been reclaimed in 2022/23 to 2026/27.

46. Lagoons and ditches will not be reclaimed as they will continue to drain the area after dump reclamation has been completed.

47. The diverted access road will be required permanently and will be left in a satisfactory condition. Clear-water reservoirs will also be left to assist irrigation in the valley.

48. The extent to which low-grade coal will be fed into rom coal is not yet known and, consequently, the size of the remaining stockpile when the generating plant is decommissioned is unknown. If a use is not found for the low-grade coal it will have to be compacted and covered with inert material to prevent spontaneous combustion. This work is scheduled to be done after mining is completed but, in practice, it may be necessary to compact and cover the stockpile progressively while dumping.

49. Any unused blended coal stock remaining after power generation has ceased which cannot be supplied to a suitable market will have to be treated in a similar manner to the low-grade coal. A top dressing will be required on the site, however, even if virtually the whole of the stock is consumed.

50. Workshops, conveyors and other fixed installations will be cleared from the site at the conclusion of their useful life.

WESTFIELD OPENPIT,
SCOTLAND

51. An existing coal openpit operation, at Westfield in Scotland, is described in Appendix "D" and comparisons are made with the mining and reclamation work proposed for Hat Creek.

52. Although this has many similarities, there is one major difference in that, at Westfield, it is possible to dump at least some of the spoil within the pit. This is due to a number of reasons, not least of which is the fact that the better ground conditions allow steeper pit slopes.

CHAPTER V

DISTURBANCE TO WATER REGIME

INTRODUCTION

1. The development of the pit will modify the water regime in the valley in several ways. It will require the diversion of Hat Creek round the pit area and this will necessarily change the flow patterns in the lower reaches of the Creek. The changing contours produced by the dumps will locally alter the stream flow and the water run-off. Finally, there is bound to be a certain amount of leachate both from the dumps and the pit and the quantity and quality of this must be controlled so that it does not exceed the permissible standards for mine effluent.

DIVERSION OF HAT CREEK

2. The present course of Hat Creek is through the centre of the proposed pit area. It is necessary, therefore, to provide an alternative route for the water at present handled by the Creek. This change must be made before mining commences and must remain operational throughout the working life of the mine and possibly for some time thereafter.

3. It is proposed to provide this alternative route by constructing a canal around the east side of the pit at about the 3,200-ft contour. The reasoning behind this choice and the design philosophy were explained in the report "Hat Creek Diversion Study", produced by Monenco in November, 1976.

4. In addition to Hat Creek itself there are other creeks which enter the pit area at elevations below 3,200 ft. It is proposed to collect these in a reservoir near the pit rim and to pump the water up into the diversion canal. This proposal is also described in detail in the Monenco Report. Plate 2 shows the relationship of the pit and the various water courses in the valley.

REHABILITATION OF HAT CREEK

5. Although out of time sequence, it is convenient at this point to consider the implications of rehabilitating Hat Creek on the termination of mining. There are two possibilities, either to leave the Creek diversion in operation or to return it to its original course. The first possibility implies the maintenance of the canal and its associated dam in perpetuity. Whatever is done with the Creek, the pit will, if left unattended, gradually fill up due to precipitation and the ingress of ground water. There is no way of preventing this short of continuing to pump out the pit, and this, too, in perpetuity. Under these conditions there is every advantage in directing the Creek back into the pit and letting it fill up until it overflows at the lowest point of the rim. This is at the top of the access ramp which is close to the present course of the Creek.

6. There is only limited information available as to the likely seepage rate, but the indications are that it will take over 100 years for the pit to fill due to seepage and precipitation alone, and this neglects the effect of surface evaporation. It is not possible to divert all the flow of Hat Creek back into the pit as a minimum flow must be maintained in the lower reaches of the Creek. However, by diverting most of the flow it is possible to fill the pit in about 26 years. The actual period depends on the magnitude of the annual floods but the 95% confidence limits are between 22 and 33 years. This means that the diversion canal must be maintained for this period, so its total life will be of the order of 60 years.

CHANGES IN LOWER REACHES OF CREEK

7. Any alteration to the course of Hat Creek is bound to change the conditions in the lower reaches of the Creek to a greater or lesser degree. The most significant change will be after completion of mining when a major portion of the flow will be diverted to fill the pit void. During this period it will be necessary to maintain a certain minimum flow for environmental and ecological reasons. There are also legal requirements in the form of existing water licences.

EXISTING WATER LICENCES

8. There are about 100 existing licences to remove water from Hat Creek or its tributaries, plus about another 30 on that section of the Bonaparte River below its junction with Hat Creek. Fortunately, most of the Hat Creek licences are located upstream of the proposed Openpit No 1, and are therefore not affected by it. There are, however, eleven licences for locations within or near the pit and dump areas. These requirements, amounting to 793 acre-ft/year are for irrigation purposes and would be eliminated or at least modified by the development of the pit.

9. There are also six licences located on Hat Creek, downstream of the pit. These amount to 182 acre-ft/year and their rights would have to be taken into account when considering any diversion proposals for Hat Creek.

10. Both groups of licences are listed in Table IX.

11. Any change of flow in the lower reaches of Hat Creek could also affect the water licences in the lower reaches of the Bonaparte River. However, Hat Creek only contributes 18% to the flow (as measured at Cache Creek). This can be sub-divided into 15% from the upper reaches and 3% from the section below the proposed pit site. Thus, the implications on Bonaparte Creek can be neglected, at least at this preliminary stage. During the operating years of the pit there will be no reduction of flow; in fact, there will be a marginal increase due to the effect of ground dewatering. There will, however, be a major reduction during the reclamation period if some of the flow is used to fill the pit. It is at this point that care will have to be taken to ensure that the water rights are respected.

STREAMS IN DUMP AREAS

12. One of the dumps will overlay a section of Medicine Creek, the water from which must be diverted round the dump area. Flow from the east will be stopped by retaining embankment No 5 and a small sump will be necessary to prevent flow under the dump. The water collecting here will be pumped into the main lagoon (No 4) from whence it will be discharged, under controlled conditions, into the diversion canal. Several other seasonal streams join Medicine Creek in or near the dump area, but it is intended that most of the water from these should be impounded by the diversion ditches cut round the periphery of the dump.

13. In spite of all these precautions there will still be percolation into the dump. This will be collected by means of an underdrain formed of sand, gravel, cobbles and boulders.

14. The water flows in the area of the other dump in Houth Meadows are fewer and consist only of seasonal creeks with a far more limited catchment area. The methods of control used will be generally similar to those proposed for Medicine Creek.

CONTROL OF SURFACE WATER

15. Pollution regulations require that run-off from the dump areas and from the pit should be retained in a settling lagoon, and that the water should only be discharged into a water-course if it complies with the relevant effluent standards. These standards and their implications are considered in more detail below.

16. The lagoons would, of course, serve as sedimentation basins and the retention time would permit some aeration which would assist the precipitation of excess iron. Even if the resulting clarified water does not meet the standards for discharge to water courses, much of it would be used for industrial purposes, ie dust suppression, washing down equipment, etc.

17. Such run-off is bound to contain trace elements leached from the pit and dump materials. One obvious way of reducing the degree of leaching is to reduce the quantities of water passing over or through the respective areas.

Lagoons and Their Location

18. Practical considerations dictate that the number of lagoons be kept to the minimum. There are also advantages in combining the effluent from different areas as this mixing can help to meet the required standards. This occurs partly due to the averaging caused by blending and partly to chemical neutralisation between components from the different sources.

19. The collection of the water from the Medicine Creek dump into lagoon No 4 has already been mentioned. The run-off from the adjacent low-grade coal stocking area will be collected in its own lagoon, No 5, from which it will be discharged under controlled conditions to lagoon No 4. The leachate from the coal area is likely to be acidic but this should be neutralised to a considerable extent by the dump run-off which is expected to be mildly alkaline. This system will therefore handle all flow from the area to the east of the pit.

20. The water from the pit itself and all the other dump and stocking areas will eventually collect in a single lagoon (No 6) located on the northern edge of the disturbed area. However, it will reach this by a variety of routes. The main flow from the Houth Meadows dump will be collected in lagoon No 1 between the main dump embankment and the pit incline. This same lagoon will also receive the water pumped out from the pit. The water collected at the toes of the two auxiliary embankments will be collected in auxiliary lagoons No 2 and 3. The contents of all three lagoons will then be discharged into lagoon No 6. Run-off from the North Valley dump and from the coal blending and stocking area will go direct to lagoon No 6. The dams for all these lagoons, although relatively small, will need to be properly designed when the material to be used is known.

Flow of Water into the Pit

21. Water will enter the pit from three main sources:-

(i) natural precipitation falling over the pit area,

(ii) surface drainage from surrounding areas (due to natural precipitation over these areas),

(iii) seepage from surrounding strata.

22. Mining considerations require that these quantities be kept to the minimum, since water in the pit is a nuisance and costs money to remove. There is no way of reducing the amount of natural precipitation over the pit, which amounts to about 1,200 acre-ft/year at the mid-point of the project and 1,900 acre-ft/year at the end.

23. The drainage from surrounding areas can largely be prevented from entering the pit by constructing a system of drainage trenches at or near the pit rim. The Hat Creek diversion channel will serve this purpose for part of the east side of the pit.

24. This surface water will be relatively uncontaminated, so that collected from the south and east of the pit will go to the pit rim dam for transfer to the diversion canal. That collected from the west side of the pit will go to the Houth Meadows lagoon. This is proposed to reduce the number of collection points although there are disadvantages in mixing this water with the pit leachate. The system of ditches is shown on Plate 5.

25. Precipitation falling between the drainage ditch and the pit rim is likely to find its way into the pit. This, together with the precipitation falling into the pit, will leach out some trace elements on its way to the pit bottom.

26. However, the main source of contamination will be from the water seeping into the pit. The rate of seepage can be controlled to a limited extent by lowering the water table using borehole dewatering pumps. It is proposed to install these, at least to a limited extent, as an aid to slope stability. GA's estimate is that the dewatering pumps will handle between 100 and 250 gpm and that a similar amount of water will seep through the walls of the pit. It must be emphasised, however, that these figures are based on very limited data. Changing the units, this means that a total of 2,400 to 6,000 acre-ft/year of water will be coming out of the strata round the pit. As this material will have percolated through a considerable distance of strata (mainly coal since its permeability is much higher than that of the other rocks), it will have leached out a variety of trace elements from the ground. This may cause problems if the impurities exceed the levels permitted for mine effluent. This will be considered in more detail later after the problems of run-off from the dumps have been outlined.

Houth Meadows Dump

27. As mentioned previously, Houth Meadows dump will contain the claystones and other slow-draining materials. The fact that these materials are slow draining increases the importance of minimising the intake of extra water, particularly by the provision of peripheral drains. Since slow-draining material like clay is also slow to absorb water, provided the top surface is levelled, most of the snow-melt and the early summer rain will just run off, but precautions must be taken to see that spoil is not dumped during the winter on to ground covered by deep snow as this will introduce a considerable amount of water into the pile which will take a long time to disperse.

28. It is likely that it will be necessary to place a layer of gravel or other free-draining material on top of each layer of fill to prevent ponding and to allow disposal and reclamation machines to operate. This will have the ancillary advantage of allowing any subsequently trapped snow-melt to migrate sideways towards the edge of the dump. Pore water within the dump is, of course, a major reason for low strength and the reduction of pore water pressure is a normal way of improving stability. However, even the encouragement of drainage from the dump will not yield much flow because of the low permeability.

29. After cataloguing all the problems of clay in dumps, it is worth mentioning one beneficial property. Clay in general, and bentonite in particular, has the property of absorbing free cations. This will mean that trace metals such as copper and iron will tend to be absorbed by the clay rather than be leached out and it is these elements which are otherwise most likely to cause toxicity in the mine effluent.

Medicine Creek Dump

30. Medicine Creek dump will, in general, contain the more free-draining material. This means that its potential for leachate production is greater. Peripheral ditches will limit the ingress from the surrounding area but some thought should be given to sealing the top surface of each layer using clay or other impermeable material. This is not required for year-round protection but to minimise the impact of the snow melt and the early summer rains.

REQUIRED EFFLUENT STANDARDS

31. The relevant standards for mine effluent are given in the publication "Pollution Control Objectives for the Mine, Mine-Milling and Smelting Industries of British Columbia", produced by the Department of Lands, Forests and Water Resources, 1973. This specifies three emission yardsticks. It is recommended that all new or proposed discharges meet the strictest standard (described as level A). It is expected that nearly all existing waste discharges now meet the lowest proposed standard (level C) and it is recommended that these should be up-graded to at least the interim standard (level B). It should be pointed out, however, that these standards are very stringent. For instance, in respect of certain elements level A is stricter than the World Health Organisation "maximum permissible" standard for drinking water. A comparison of some of the requirements of these standards is shown in Table X.

PIT AND DUMP LEACHATE

32. There is only very limited information available as to the quality and quantity of leachate which can be expected from the pit and the dumps. Acres Consulting Services Limited are at present investigating leachate quality as part of their environmental terms of reference, but their report is not due until later in the year. They have, however, produced preliminary analysis information from which it is possible to deduce some of the eventual problems which might be encountered.

33. Acres carried out two basic tests, each on a range of seven samples. These were for total leachable salts and for rate of release of soluble salts. The latter tests involved passing water through the samples for not less than five days and collecting and analysing each day's "make" separately. The seven samples were three grades of coal, a low-grade waste, a non-carbonaceous waste and two examples of overburden material.

34. The concentrations of the various salts and trace metals obtained in the total leachable tests were, on average, an order of magnitude greater than the initial recorded rate of release. The rate of release recorded in the first day's test was also greater than that recorded on subsequent days. This raises the problem as to which result most nearly corresponds to what would happen under field conditions.

35. If it is assumed that the rate of release figures for days two to five represent the likely steady leaching rate then the pH and the suspended solids are well within the level A effluent standard, as are most of the salts and trace metals. The only metals which equal or exceed this standard are chromium, copper and iron. It must, however, be stressed that, while this does appear to be the most logical assumption, it does give more optimistic results than would be obtained from a hypothesis based on the initial release rates.

36. The effluent standards specifically exclude the dilution effect where the effluent meets the main water course. If, however, the run-off water and the leachate are collected together in a settling pond the former will have a diluent effect and it would seem permissible to take advantage of this.

37. If problems are encountered in meeting the required effluent standards then it is likely that chromium, copper and iron will be the critical elements. The occurrence of high concentrations of copper has already been remarked upon by Fletcher in his report "Analyses of Hat Creek Coal", dated 2nd April, 1976, although the scale of its occurrence is unknown at present. The key to its control lies, to some extent, in determining its geological location.

CHAPTER VI

EQUIPMENT AND ECONOMICS

METHOD OF APPROACH

1. Whatever the theory, the reclamation will not, and indeed should not, be carried out in isolation from the main mining operation. Machines will be moved from one duty to another to meet day-to-day requirements, and maintenance and supervision will be carried out on a common basis.

2. Costs have been allocated to the reclamation account in accordance with the man and machine hours required to carry out this work. These costs have been obtained by multiplying the machine hours by the hourly operating and ownership costs. It has not been considered necessary to do this on a yearly basis but by considering the project as being divided into three basic stages.

Early Years of Mine Production

3. As has already been explained, only a minimal amount of reclamation work is possible during the early years of mine production. The stripping of the top soil from the pit and dump areas, and the forming of the drainage ditches and lagoons have all been allowed for in the mining project. Thus, the only time spent on reclamation work is for the grading and topsoiling of the exposed faces of the dump retaining walls. This is a very small operation and it has been assumed that it will be carried out by the men and machines allocated for constructing the dumps, so no additional reclamation cost has been included.

Later Years of Mine Production

4. Shortly before the mid-point of mining production, the level of Houth Meadows dump will reach the top of its main retaining embankment. Medicine Creek dump will reach the same condition a few years later. This will enable a start to be made on reclaiming the top surface of the dumps. This reclamation will then continue progressively as increasing areas of the dumps reach their final heights.

5. Since the coal requirement will decrease sharply during the last four years of the power station's operation, there is also a reduced waste production during this period. This means that the backlog of unreclaimed dump area can be reduced to the minimum at this stage, and indeed primary dump reclamation should be complete within months of termination of coal production.

6. To cover all this work a dozer (Cat D9 or similar) fitted with a wide-angled blade and a grader (Cat 16G or similar) have each been allowed for 50,000 working hours during this period. This is equivalent to one of each machine working a single shift (2,500 hr/year) for 20 years. This estimate is felt to be marginally higher than that actually required but it will compensate for the lack of any provision in the early years.

Period After Completion of Mining

7. After cessation of coal production it will be possible to complete any work on the dumps, to start breaking down and reclaiming the pit benches, and to reclaim the other disturbed surface areas.

8. Environmental requirements are that this work should be completed as soon as possible. This course also makes economic sense as the longer the job continues, the more costly it tends to become. Accordingly, the following schedule of plant has been allowed for a total period of four years. To expedite the work and to obtain the best machine availability it has been assumed that two shifts will be worked (ie 5,000 hours/year/machine).

2 dozers (D9 or similar) with wide blades

1 grader (16G or similar)

1 scraper (641B or similar)

2 35-ton off-highway trucks

1 7-yd^3 wheel loader (988 or similar)

9. It must be emphasised that this is only one possible selection of machines capable of carrying out the work. The introduction of new and improved machines which will occur during the life of the project may mean that the final selection will be markedly different. However, any new machine will, by its nature, have a greater rather than a smaller capability. So the numbers required and, hopefully, the costs involved could be less.

10. At this stage, the main pit workshop will have been closed, or will at least be running down, so separate provision will have to be made for maintenance and for service back-up. The reclamation labour force will also have grown to a size that will require separate supervision, but these matters are discussed below under the heading Labour Requirements.

Removal of Plant and Buildings

11. On completion of mining it is possible to start demolition of the fixed plant and buildings. As stated in Chapter V, it has been assumed that the scrap or reclamation values will cover the costs of demolition. It is also most likely that this work will be carried out by a specialist contractor.

Re-diversion of Hat Creek

12. As soon as mining is complete, most of the waters of Hat Creek will be diverted back into the pit with the intention of filling this. Diversion work will therefore be required at the inlet to the pit. Some time before the pit is full, provision will have to be made for an outlet near to the head of the pit incline, but this will be at least 20 years after completion of mining. When the pit is full and overflowing it will be possible to "decommission" the diversion canal.

13. A lump sum of $400,000 has been allowed for diverting the canal into the pit. This includes costs for provision of the necessary weirs and sluices to control the proportions flowing into the pit and along the canal, the latter being necessary to maintain a minimum flow in the lower reaches of the Creek. A further lump sum of $1.1 million has also been allowed for providing the overflow outlet channel and the associated control sluice near the head of the pit incline and for the eventual "decommissioning" of the canal, athough this will not be possible until many years after the rest of the work.

LABOUR REQUIREMENTS

14. Based on the above reasoning, the labour requirements for the various stages of the project are as follows.

Early Production Years

15. No special provision allowed.

Later Production Years

16. Two machine operators have been allowed.

Post Production Period

17. The seven machines allowed, working two shifts, require 14 operators plus provision for absentees and holidays. In addition, provision must be made for maintenance, support services and supervision. This gives a total requirement of:-

Machine operators	14
Spare operator	1
Maintenance and service labour	6
Operations foreman	1
Maintenance foreman	1
General superintendent	1
Total	24

18. All this labour will be required for a period of four years. This total excludes the labour required for the demolition work which it has been assumed will be carried out by contractors. However, it is estimated that this would require 20 men for a maximum of two years.

19. It is also assumed that the eventual "decommissioning" of the canal and the reclamation of its course will be carried out by a contractor so no specific labour requirement has been made for this.

ECONOMICS

20. The costs of reclamation can be built up in a similar method to the labour requirements.

Early Production Years

21. No special provision allowed.

Later Production Years

22. The following machines for 50,000 hours:-

	10^3 \$
1 dozer @ \$71/hr	3,550
1 grader @ \$56/hr	2,800
Total	6,350

Post Production Period

23. The following machines for 5,000 hr/year for four years:-

	10^3\$
2 dozers @ \$71/hr	2,840
1 grader @ \$56/hr	1,120
1 scraper @ \$80/hr	1,600
2 35-ton trucks @ \$40/hr	1,600
1 front end loader @ \$50/hr	1,000
Plus 20% for service vehicles, supervision, etc.	1,640
	9,800
Removal of surface buildings and plant - no net cost	nil
Diversion at Hat Creek into pit (lump sum)	400
Final decommissioning of canal (lump sum)	1,100
Total	11,300

24. This gives a total reclamation cost of \$17,650,000 which when divided by the total rom coal production of 348 million tons is equivalent to about 5¢/ton of coal produced. The fact that most of this expenditure is towards the end of the project means that the discounted cost per ton is much less than this. At 10% discount rate it is less than 1¢/ton and at 15% discount rate it is less than 0.5¢/ton.

CHAPTER VII

SUMMARY AND RECOMMENDATIONS

GENERAL

1. As stated in Chapter I, this report has been carried out concurrently with the update study on Openpit No 1 (Report No 9). Consequently, any conclusions reached here can only be as good as the basic input to the update report. This means that as further and more detailed work is carried out on the development of Openpit No 1, the reclamation plan will have to be altered or at least modified to accord with the new information.

TIMING OF RECLAMATION

2. The location and configuration of the deposit requires that it be worked as an openpit, and there is no economic alternative method of extraction. This mode of operation has disadvantages in that it limits the amount of reclamation work which can be carried out during the early years of production but, again, there is no economic alternative method. However, after completion of mining it will be possible to restore the shape and surface of the valley to something which, while different, will be aesthetically and economically at least equal to that existing at present.

3. It is beyond the terms of this study to assess whether the short-term disruption of the valley is too high a price to pay for the benefits of extracting the fuel beneath it, or to assess the environmental impact of alternative methods of obtaining equivalent amounts of energy.

GEOLOGICAL AND GEOTECHNICAL CONSTRAINTS

4. There are, at present, considerable gaps in the geological and geotechnical information. Although more information will become available prior to the actual start of mining, the detailed mining plan will depend on how the various materials handle in practice. These changes can affect the method and mode of reclamation. Also, greater knowledge of the material properties may alter the design of the proposed dumps. Their location is also dependent on further investigation showing that they would not sterilise any mineable reserves of coal. It is therefore necessary to maintain a flexible reclamation plan to accommodate these changes and, indeed, where possible to turn them to advantage.

CHANGED SHAPE OF VALLEY

5. It has already been explained in Chapter IV that, economics apart, it is not possible to put the valley back to the condition appertaining prior to mining. This is simply because some 300 million tons of material will effectively have disappeared.

6. There are two basic uses to which the pit void can be put. It could be used to accommodate spoil from a second mining venture or, alternatively, it could be allowed, and indeed be encouraged, to form a lake. The latter could have major local recreational and irrigational functions. In addition, its surge volume would moderate the effect of the annual floods on the lower reaches of the Creek.

7. One major potential problem is the lack of recoverable topsoil from within the areas to be disturbed. This is why the emphasis has been on restoring the valley to something approaching its original fertility rather than promising to transform it into high-grade arable land. The tonnages and areas involved preclude the economic importation of topsoil.

POLLUTION POTENTIAL

8. Current practice is to divide pollution into solids, liquids, gases and noise. While these will all have some local effect, the only one likely, in this instance, to have impact beyond the mine fence is liquid.

9. The operation of mining will expose large amounts of material previously buried at great depth. Some of this material will contain trace elements which would have been better left undisturbed. The effect of rain and groundwater will be to leach out some of these elements and some of the resultant effluent will find its way into the various controlled and confined water courses. It is planned, therefore, to isolate and collect the run-off from the pit and dump areas and to analyse and, if necessary, treat these before discharge. There are strict regulations controlling the standards of mine effluent which may be discharged and arrangements will be made to comply with these.

COST OF RECLAMATION

10. As already explained in Chapter VI, the reclamation work proposed will cost nearly $18 million (mostly near the end of mining operations), and in fact this is only a fraction of the total since the cost of much of the work associated with reclamation (eg the formation and shaping of the dumps, control of leachate, etc) has already been included in the main mining operation. This is a good example of the philosophy that reclamation work should be designed into the project from the outset and carried out to the maximum extent possible concurrent with mining operations. This sum also excludes the costs of fertiliser, seeding and re-forestation which are beyond the scope of this report.

11. This expenditure is necessary if the environment is to be protected. It is, however, easier to see it in perspective if it is re-expressed as being equivalent to 5¢ per ton of coal extracted.

APPENDIX "A"

LIST OF REPORTS PREPARED BY PD-NCB CONSULTANTS IN ASSOCIATION WITH WRIGHT ENGINEERS AND GOLDER ASSOCIATES

No	
1	Interim Report on Geological and Geotechnical Exploration at Hat Creek - November 1975
2	Preliminary Report on Hat Creek Openpit No 1 - March 1976 (incorporates Report No 1)
3	Preliminary Report on Hat Creek Openpit No 2 - March 1976
4	Hat Creek Geotechnical Study Interim Conclusions - October 1976
5	BC Hydro Hat Creek Project. Coal Resources Optimisation and Production Scheduling (Crops) System Phase II - General Methods of Approach (Interim) - December 1976
6	Hat Creek Geotechnical Study (Final) - March 1977
7	Hat Creek Power Project. Combined Pit Operation Study for 5,000-MW Power Plant - January 1977
8	Reclamation Study Related to Mining of Hat Creek Openpit No 1 (this report)
9	Revision of Feasibility Report on Hat Creek Openpit No 1
10	Description of Computer System (five volumes)

APPENDIX "B"

LIST OF DOCUMENTS AND DRAWINGS RECEIVED BY PD-NCB FROM 6TH JANUARY, 1977, TO 31ST MARCH, 1977

RECORD OF COMPLETED DRILL HOLES

Record sheets with measured co-ordinates of holes:-

DDH 75-105 to DDH 76-208

P76-1 to P76-30

BAH 76-1 to BAH 76-15

DDH 76-801 to DDH 76-821

RH 74-1 to RH 76-21

GEOPHYSCIAL LOGS OF BOREHOLES

Gamma ray logs of holes DDH 76-814 and DDH 76-817.

GRAPHICAL GEOLOGICAL LOGS SCALE 1 INCH TO 40 FEET

76-161, 76-162, 76-164, 76-166, 76-168, 76-169, 76-171, 76-172, 76-174, 76-175, 76-179, 76-181, 76-183, 76-187, 76-188, 76-191, 76-192, 76-193, 76-196 to 76-208.

MISCELLANEOUS CORRESPONDENCE

Letter dated 31st December, 1976, to C. Guelke from L.T. Jory referring to a DCA revised work schedule.

COAL ANALYTICAL DATA

Boreholes 76-124, 76-138, 76-160, 76-161, 76-164, 76-166, 76-168, 76-169, 76-171, 76-172, 76-174, 76-175, 76-179, 76-180, 76-181, 76-183, 76-186, 76-187, 76-188, 76-190, 76-191, 76-192, 76-193, 76-194, 76-196, 76-197, 76-198, 76-199, 76-200, 76-201, 76-202, 76-203, 76-204, 76-205, 76-206, 76-207, 76-208, 76-817.

APPENDIX "C"

COMPLIANCE WITH SECTION 8 OF THE COAL MINES REGULATION ACT

The statutory requirements for land reclamation in connection with the operation of a coal mine are contained in Section 8 of the Coal Mines Regulation Act. Sub-sections 1, 2 and 3 are reproduced below for reference.

EXTRACT FROM THE COAL MINES REGULATION ACT

"8. (1) It is the duty of every owner, agent, or manager of a mine to institute and carry out a programme for the protection and reclamation of the surface of the land and watercourses affected thereby, and, on the discontinuance or abandonment of a mine, to undertake and complete the programme to leave the land and watercourses in a condition satisfactory to the minister; and such a programme shall be submitted to and approved by the minister as hereinafter provided.

(2) The owner, agent, or manager shall file with the minister a report in such form and containing such information as the minister may prescribe before commencing

- (a) exploratory work at a mine where the employment of mechanical equipment is likely to disturb the surface of the land in clearing, stripping, trenching, and such other operations as the minister may consider likely to cause significant disturbance of the surface of the land; or

- (b) preparatory work for production from a mine.

(3) The report shall include the following:-

- (a) A map showing the location and extent of the mine, and the location of any lakes, streams, and inhabited places in the vicinity:

- (b) Particulars of the nature of the mine and the extent of the area to be occupied during the probable duration of the mining operation:

- (c) Particulars of the nature and present uses of the land to be used:

- (d) A programme for reclamation and conservation of the land during, and on the discontinuance or abandonment of, the mining operation, with particular reference to

  - (i) the location of the land;

  - (ii) the effect of the programme on livestock or wildlife, watercourses, farms, inhabited places in the vicinity of the mine, and the appearance of the site of the mine; and

  - (iii) the potential use of the land, having regard to its best and fullest use, and its importance for existing and future timber, grazing, water, recreation, wildlife, or mineral use."

The following details of a programme of protection and reclamation were provided by the British Columbia Department of Mines and Petroleum Resources. These details are required to be submitted to that department in pursuance of Section 8 of the Coal Mines Regulation Act:-

"1) <u>Layout Plan of Minesite</u>

Include plan of minesite area (topographic, with watercourses marked on) approximately 1:10,000 showing best appreciation of site at start, mid-point in the mining program, and at completion including: plant complex, lagoons, clearwater reservoir, haul roads, coarse tailings, overburden dump, waste rock dump, soil stockpile, revegetation facilities.

2) <u>Schedule of Disturbance</u>

Schedule of land area disturbed, estimated for mid-point and completion. Include subtotals for Pits, Roads, Overburden, Waste, Plant, Lagoon, Stockpile, Other, Total.

3) <u>Schedule of Reclamation</u>

Schedule of land area proposed for reclamation mid-point, completion and completion + 10 years, according to previous subheadings.

4) <u>Overburden Dump Stability and Erosion Control</u>

A. Principles to follow in location and design of dumps:

1. Site chosen should maximize volume of spoil with minimum surface area, eg valley floor mountainside juncture.

2. Retain precipitation on terraces to prevent run-off from dump.

3. Surface slope no greater than (2:1, 26^0) to provide stable surface for revegetation.

4. Construct dump in lifts as opposed to dumping.

5. Exclude excess snow from dump during winter work.

6. Retain runoff from dump area in a settling pond.

7. Revegetate dump current with expansion - possible only if constructed in lifts, with toe first.

B. Details to be provided:

1. Section through dump at end of first year, mid-point, completion.

<u>Reclamation Program</u>

A. Description of manpower, equipment, plant, methods; to be used for site preparation, culture (seed collection, nursery, greenhouse, planting), seeding, fertilizing; at start, mid-point and completion.

B. An estimate of the location and volume of surface soils proposed to be used for revegetation, and schedule for stockpiling.[1] A forecast of the productivity of reclaimed areas in comparison with present[2] with respect to forestry, range and wildlife.[3]

Drainage Control and Water Quality

Provide a plan showing best appreciation of drainage control at the end of year 1, at mid-point and at completion indicating:

1) How surface run-off is to be routed around disturbed areas (location of perimeter ditch center lines).

2) How watercourses and drainage paths are to be treated within areas proposed for disturbance (location of new watercourse center lines). It is recognized that a water licence is required in this regard from Water Rights Branch, and that referral to Fish and Wildlife Branch is made.[4] The following parameters should not be changed in such a manner that overall productivity of fish habitat is impaired: gradient; hydraulic radius, horizontal curvature; substrata; and cover.

3) Potential for emergency containment of run-off in the event of unforeseen sediment problems from roadways; plant site; waste and overburden dumps.

4) Provision for monitoring sediment or turbidity characteristics of run-off from disturbed areas: roadways; plant site; waste dumps to alert the need for use of emergency containment.

5) Sediment control proposed for individual drainages from plant site complex.

6) Description of measures to be taken to minimize siltation from roads.

7) A copy of pollution control measures required by Pollution Control Branch.[5]

Notes

[1] Secretariat inventory to provide soil map with classification as to capability for revegetation. Final map of soil availability for reclamation, and volume, by consultant.

[2] Vegetation mapping from both Secretariat and consultant. Forecast of productivity from consultant.

[3] Mapping of land capability for ungulates, special features (links or other) from Secretariat, Fish and Wildlife, consultant. Summary by consultant. Mitigation proposed by consultant to satisfy Fish and Wildlife Branch.

[4] Mitigation for habitat change by consultant, Fish and Wildlife Branch. Assistance in species distribution from Secretariat inventory.

[5] Control of point discharge of industrial process wastes by Pollution Control Branch (Tailings Lagoon)."

APPENDIX "D"

EXAMPLE OF AN EXISTING COAL OPENPIT - WESTFIELD, SCOTLAND

1. The method of operation proposed for Hat Creek is unusual for coal mining although it is common for metalliferous mining. It is, therefore, worthwhile considering briefly an existing coal openpit to illustrate the scale of such an operation and the steps which can be taken to ameliorate the effects on the local environment.

2. A coal deposit having certain geological and geometric similarities with Hat Creek is that at Westfield, Scotland. This is now being worked as an openpit mine to a maximum depth of 450 ft within a shape similar to that proposed for Hat Creek. The principal differences are that the Westfield coal is bituminous, with correspondingly stronger waste rocks; the output is only 1 million to 2 million tpa, and the climate and relief are less extreme.

3. An aerial view of the pit and its surrounds is shown on the photograph, together with an overlay naming the salient features. These are briefly described below.

THE PIT

4. Geologically, the deposit has close parallels with that at Hat Creek. There is a thick coal bed (about 200 ft) in the basin centre, which thins markedly on the flanks (to less than 20 ft). A central, slightly-faulted, anticlinal ridge was present in earlier workings and slumped and disturbed coal with intercalated dipping coals is apparent.

5. The prominent features of mining are the benches and the inclined haul roads. Unlike the proposals for Hat Creek, all the material is brought to the surface by large off-highway trucks. It will be noted that the slopes are considerably steeper (30^0 to 42^0) than those proposed for Hat Creek. Instability in the excavated slopes has chiefly been located along existing discontinuities rather than due to failure through intact strata. High groundwater pressures are present but no serious attempts at dewatering have been made, although some rock anchoring has been attempted.

6. These steeper slopes have allowed the pit to progress laterally rather than outwards, although earlier workings in the 1950s were in the shape of an expanding cone. Spoil is also stronger than at Hat Creek and is placed at an overall slope of 26^0. Following the development of the mine to full depth in 1969 dumping was possible inside the void as slides of waste rock were not expected. Some coal has been covered at the base of the synclines since its removal would have required substantial and uneconomic underdigging.

7. A large void will remain at the end of mining. Current plans for reclamation include re-diverting the initial drainage into the void to form an artificial lake and regrading some, but not all, the benches above the final water level. It is recognised that some continuing water treatment programme may be necessary until re-vegetation is fully established in view of the presence of acid-forming materials in the strata.

8. The vehicles on the benches and in the foreground of the photograph give an indication of scale.

WASTE AND SOIL DUMPS

9. Obviously, the initial spoil had to be dumped outside the pit, and the partially reclaimed dump of this material is shown in the background of the photograph. During the opening-up phase material was crushed in the mine and transported to this dump by conveyor, the route of which is still just visible. The dump was formed using a spreader working along the long axis. A retaining embankment was used to hold back the spoil which included wet fines from the washery. This embankment was not adequately located on a suitably deep foundation and a large slide occurred in 1971 during dump construction.

10. In spite of its rather unimaginative shape (designed in 1955), it can be seen that the dump is already blending into the countryside and serves to screen the pit and the ancillary works from the south.

11. Two dumps holding topsoil and sub-soil are shown in the foreground. All available surficial soils suitable for use in restoration are selectively stripped and stacked in small (15 ft to 25 ft), trapezoidal mounds for subsequent spreading.

12. The photograph shows several dark grey areas to the right which are temporary slurry ponds. These ponds are frequently excavated and the duff may be blended with rom coal for electricity generation, whilst non-coaly discards are carefully disposed of within the pit spoil. At the end of mining all the lagoons will be dug out and the area reclaimed.

MINE WORKSHOP

13. The mine workshop is shown near the slurry pond. Since all the material is trucked out of the pit and the conveyor system is no longer operational there is little fixed plant so most of the maintenance work is on the pit vehicles.

EXPLOSIVES FACTORY

14. The pit has always experienced problems with groundwater. This has meant that it was necessary to change from ANFO explosives to a special product sensitised with nitroglycerine. As up to 200 tons of this explosive are required each month, a small mixing and packaging factory was set up.

COAL PREPARATION PLANT

15. The coal preparation plant can be seen on the edge of the photograph. The washed product goes to several customers of whom the most important is the 2,400-MW South of Scotland Electricity Board power station at Longannet. The slurry by-product is transported to the 60-MW power plant at Methil which was specifically designed to burn this low-grade fuel. The coal stocking areas and the rail loading points are shown adjacent to the coal preparation plant.

LURGI COAL GASIFICATION PLANT

16. Just beyond the coal preparation plant is the Lurgi coal gasification plant (not shown on photograph). While not strictly relevant to Hat Creek, it is interesting enough to be worth a passing mention. The plant was originally built by the Gas Council to produce "towns gas" (ie 550 Btu/scf) by the total gasification of coal under pressure in the presence of oxygen. The plant was only operational for a few years before it was made uneconomic by the production of towns gas from

what was then low-price oil, and subsequently by natural gas imported from Algeria and later from the North Sea. The plant was then modified to include a methanation step so as to produce SNG. It operated like this commercially for a while but has subsequently been used as a "test bed" for sponsored experimental research on various coals. Over 25,000 tons have been shipped from the USA for testing in this way.


AERIAL VIEW LOOKING SOUTH OF WESTFIELD OPENCAST COAL SITE
PEAT & SMALL TREES
RECLAIMED WASTE FROM INITIAL VOID
DIRECTION OF DEPOSITION
REGRADED, TOP & SUBSOILING COMPLETED
PEAT & WASTE
RETAINING BUND
FORMER CONVEYOR ROUTE
FOR SPOIL FROM FIRST VOID
AVEL TO BE
IP & SUB SOIL
RAIL ROAD
MAKE UP WATER RESERVOIR
REGRADED FOR RECLAMATION
CONVEYOR TO
RAIL ROAD
SPOIL HEAP
PREP PLANT
BACKFILL
COAL HAUL ROAD
WASHERY
SPOIL DISPOSAL ROAD
MINE DRAINAGE
LAGOON
FLOOR OF BASAL
COAL INSITU
COAL
STOCKING GROUND
MINE
WORKSHOP
STANDBY LAGOONS
SLURRY STORAGE
EXPLOSIVES
FACTORY
DIRECTION OF PIT ADVANCE
WASTE DUMP
AREA STRIPPED OF
TOP AND SUBSOIL
DUMP
TOP AND SUBSOIL DUMP
DRAINAGE DIVERSION DITCH
TOP AND SUBSOIL DUMP

TABLE I

VOLUMES OF SPOIL SENT TO WASTE DUMPS BY MINING STAGES

Mining Stage	Surficials				Pit and Segregated Waste				Conditioned Ash		Total to Dumps	
	10^6 bank yd^3		10^6 loose yd^3		10^6 bank yd^3		10^6 loose yd^3		10^6 loose yd^3		10^6 loose yd^3	
	zero swell	15% swell	stage	cum	pit waste	seg waste	stage total	cum	stage	cum	stage	cum
1	6	12	20	20	4	0	5	5	0	0	25	25
2	12	0	12	32	6	2	11	16	5	5	28	53
3	32	7	40	72	36	6	56	72	17	22	113	166
4	72	29	105	177	112	14	168	240	38	60	311	477
5	8	66	84	261	90	7	129	369	20	80	233	710
6	0	65	75	336	109	4	150	519	11	91	236	946
7 (part)	0	36	41	377	77	2	105	624	6	97	152	1,098
Total	130	215	377	-	434	35	624	-	97	-	1,098	-

Notes:

1. Bank volumes from Table XIII, Report No 9.
2. 130 x 10^6 bank yd^3 of surficial material used in embankment construction with zero swell (see Report No 6). Remaining surficials at 15% swell.
3. Pit and segregated waste at 33% swell (see Report No 6).
4. Dry ash 28% of rom coal by weight (on average).
5. Ash conditioned to 15% moisture.
6. Loose density of conditioned ash 1.2 tons/yd^3.

TABLE II

SUMMARY OF SPOIL SPACE BY ELEVATION

(10^6 yd^3)

Elevation	North Valley		Houth Meadows		Medicine Creek		Total	
	Interval	Cum	Interval	Cum	Interval	Cum	Interval	Cum
2,700	1	1	-	-	-	-	1	1
2,800	8	9	-	-	-	-	8	9
2,900	3	12	8	8	-	-	11	20
3,000	-	12	35	43	-	-	35	55
3,100	-	12	59	102	-	-	59	114
3,200	-	12	79	181	-	-	79	193
3,300	-	12	104	285	1	1	105	298
3,400	-	12	113	398	9	10	122	420
3,500	-	12	95	493	26	36	121	541
3,600	-	12	67	560	51	87	118	659
3,700	-	12	39	599	81	168	120	779
3,800	-	12	12	611	103	271	115	894
3,900	-	12	-	611	105	376	105	999
4,000	-	12	-	611	99	475	99	1,098

TABLE III

PROPOSED DISTRIBUTION OF WASTE VOLUMES AT MID-POINT OF MINING (STAGE 4)

(10^6 loose yd^3)

Location	Surficials	Pit and Segregated Waste	Conditioned Ash	Totals
Production				
Openpit No 1 to Stage 4	177	240	60	477
Disposal				
North Valley Dump	12	-	-	12
Houth Meadows				
Embankment No 1	59	-	-	-
Embankment No 2	13	-	-	-
Embankment No 3	-	-	-	-
Underdrain	15	-	-	-
General	-	240	-	-
Sub-total	87	240	-	327
Medicine Creek				
Embankment No 4	36	-	-	-
Embankment No 5	-	-	-	-
Underdrain	12	-	-	-
General	30	-	60	-
Sub-total	78	-	60	138
Totals	177	240	60	477

TABLE IV

PROPOSED FINAL DISTRIBUTION OF WASTE VOLUMES

(10^6 loose yd^3)

Location	Surficials	Pit and Segregated Waste	Conditioned Ash	Totals
Production				
Openpit No 1 to year 2021/22	377	624	97	1,098
Disposal				
North Valley Dump	12	-	-	12
Houth Meadows				
Embankment No 1	59	-	-	-
Embankment No 2	13	-	-	-
Embankment No 3	20	-	-	-
Underdrain	18	-	-	-
General	-	501	-	-
Sub-total	110	501	-	611
Medicine Creek				
Embankment No 4	36	-	-	-
Embankment No 5	2	-	-	-
Underdrain	16	-	-	-
General	201	123	97	-
Sub-total	255	123	97	475
Totals	377	624	97	1,098

TABLE V

SCHEDULE OF LAND AREA DISTURBED AT MID-POINT AND COMPLETION OF MINING

(acres)

Description of Disturbed Area	Area at Mid-Point of Mining	Area at Completion of Mining
Excavation of pit	1,165	1,868
Surficials and ash dumps:		
Medicine Creek	580	1,204
North Valley	124	124
Waste dump at Houth Meadows	1,006	1,520
Diverted access road	11	11
Conveyors and maintenance roads	51	51
Workshops and maintenance area	3	3
Lagoons:		
Lagoon 1	3	3
Lagoon 2	1	1
Lagoon 3	1	1
Lagoon 4	2	2
Clearwater reservoirs:		
Upper reservoir	19	19
Lower reservoir	30	30
Drainage ditches	20	20
Hat Creek diversion	38	38
Stockpiles:		
Low-grade coal	158	317
Blending stockpile	87	87
Sub and topsoils (approximate)	450	450
Total area of land in use	3,749	5,749
Intervening and adjacent areas	4,615	2,615
Total area of disturbance	8,364	8,364

TABLE VI

VOLUME TO BE REGRADED ON PIT BENCHES

Bench Level ft	Length yd	Volume 10^3 bank yd^3*	Cumulative Volume 10^3 bank yd^3
2,560			
2,600	6,667	160	160
2,640	7,167	172	332
2,680	7,667	184	516
2,720	8,167	196	712
2,760	9,000	216	928
2,800	9,167	220	1,148
2,840	8,333	200	1,348
2,880	8,167	196	1,544
2,920	8,000	192	1,736
2,960	7,833	188	1,924
3,000	7,800	187	2,111
3,040	7,167	172	2,283
3,080	6,667	160	2,443
3,120	6,333	152	2,595
3,160	5,833	140	2,735
3,200	5,333	128	2,863
3,240	5,000	120	2,983
3,280	4,000	96	3,079
3,320	3,333	80	3,159
3,360	2,500	60	3,219
3,400	2,267	54	3,273
3,440	2,167	52	3,325
3,480	2,000	48	3,373
3,520	1,167	28	3,401
3,560	1,000	24	3,425
3,600	433	11	3,436
3,640	333	8	3,444
Total	143,501	3,444	–

*At 24 bank yd^3/yd linear

TABLE VII

SUMMARY OF TOP SOIL VOLUME SUITABLE FOR RECLAMATION PURPOSES

Soil Type	Area 10^6 ft^2	Soil Thickness ft	Volume 10^3 yd^3
1B	1.12	3.75	155
2A	2.64	2.33	228
3B	1.24	2.50	115
Total	-	-	498

Notes:
1. Based on "Report on Hat Creek Field Work in Regards to Soils Suitable for Reclamation" by J.T. Forster, dated 21st October, 1976.
2. Soils areas are shown on Plate 15.

TABLE VIII

SCHEDULE OF RECLAMATION

(acres)

Description of Reclaimed Area	Reclaimed Area at Mid-Point of Mining	Reclaimed Area at Completion of Mining	Reclaimed Area at Completion of Mining Plus 10 Years		
			As Land	As Water	Total
Excavation of pit	-	-	1,311(1)	557	1,868
Surficials and ash dumps:					
Medicine Creek	110	1,204	1,204	-	1,204
North Valley	-	-	124	-	124
Waste dump at Houth Meadows	312	1,520	1,520	-	1,520
Diverted access road	-	-	11(2)	-	11
Conveyors and maintenance roads	-	-	51	-	51
Workshops and maintenance area	-	-	3	-	3
Lagoons:					
Lagoon 1	-	-	-	3	3
Lagoon 2	-	-	-	1	1
Lagoon 3	-	-	-	1	1
Lagoon 4	-	-	-	2	2
Clearwater reservoirs:					
Upper reservoir	-	-	-	19	19
Lower reservoir	-	-	-	30	30
Drainage ditches	-	-	-	20	20
Hat Creek diversion	-	-	-	38	38
Stockpiles:					
Low grade coal	-	-	317	-	317
Blending stockpile	-	-	87	-	87
Sub and topsoils (approximate)	-	-	450	-	450
Total used area reclaimed	422	2,724	5,078	671	5,749
Intervening area reclaimed	-	-	2,615	-	2,615
Total reclaimed area	422	2,724	7,693	671	8,364

(1) Plus 115 acres reclaimed but flooded 2026/27 to 2031/32

(2) Remains as permanent highway

TABLE IX

WATER RIGHTS ON HAT CREEK WHICH COULD BE AFFECTED BY OPENPIT NO 1

(i) Water rights located in or near pit area

Water Source	Date	Volume (acre-ft/yr)	Remarks
Lloyd Creek	4 May 1911	86	in Houth Meadows
Lloyd Creek	4 May 1911	16	in Houth Meadows
Finney Creek	26 Jan 1918	95	within pit
Medicine Creek	18 Jun 1938	50	in dump area
Medicine Creek	10 May 1945	50	in dump area
Finney Creek	22 Aug 1958	200	near pit rim
Hat Creek	1 Aug 1961	86	within pit
Hat Creek	1 Aug 1961	30	within pit
Hat Creek	1 Aug 1961	50	within pit
Ambusten Creek	1 Aug 1961	30	near pit rim
Finney Creek	1 Aug 1961	100	near pit rim
Total	-	793	-

(ii) Water rights on lower reaches of Hat Creek (ie between pit and confluence with Bonaparte River)

Water Source	Date	Volume (acre-ft/yr)	Remarks
Hat Creek	Sep 1888	2	) volumes were expressed
Hat Creek	Mar 1894	1	) in gpd and have been
Hat Creek	Sep 1888	2	) converted and rounded
Hat Creek	Jan 1871	2	) off for consistency
Hat Creek	16 Feb 1897	171	
Hat Creek	30 Oct 1951	4	
Total	-	182	-

TABLE X

RELEVANT WATER STANDARDS

Characteristics (ppm unless otherwise indicated)	BC Mine Effluent Standards			WHO Drinking Water	
	Level A	Level B	Level C	Highest Desirable	Maximum Permissible
Total suspended solids	50	150	-	500	1,500
Total dissolved solids	<2,500	<3,500	<5,000		
pH (pH units)	6.5-8.5	6.5-9.5	6.0-10	7.0-8.5	6.5-9.2
Aluminium	0.50	1.00	10.00		
Ammonia	0.50	1.00	10.00		
Antimony	0.05	0.25	1.00		
Arsenic	0.05	0.25	1.00		(0.05)
Cadmium	0.005	0.01	0.02		(0.01)
Chromium	0.05	0.30	0.50		
Cobalt	0.10	0.50	1.00		
Copper	0.05	0.30	1.00	0.05	1.5
Cyanide*	0.10	0.50	2.00		(0.05)
Fluoride	2.50	5.00	15.00		
Iron	0.30	1.00	5.00	0.1	1.0
Lead	0.05	0.10	0.50		(0.1)
Manganese	0.05	0.50	1.50	0.05	0.5
Magnesium	150	300	500	150	150
Mercury*	0.001	0.003	0.01		(0.001)
Molybdenum	0.50	1.00	10.00		
Nickel	0.30	0.50	1.00		
Nitrates/Nitrites (as N)	10.00	25.00	50.00		

/continued

TABLE X
(continued)

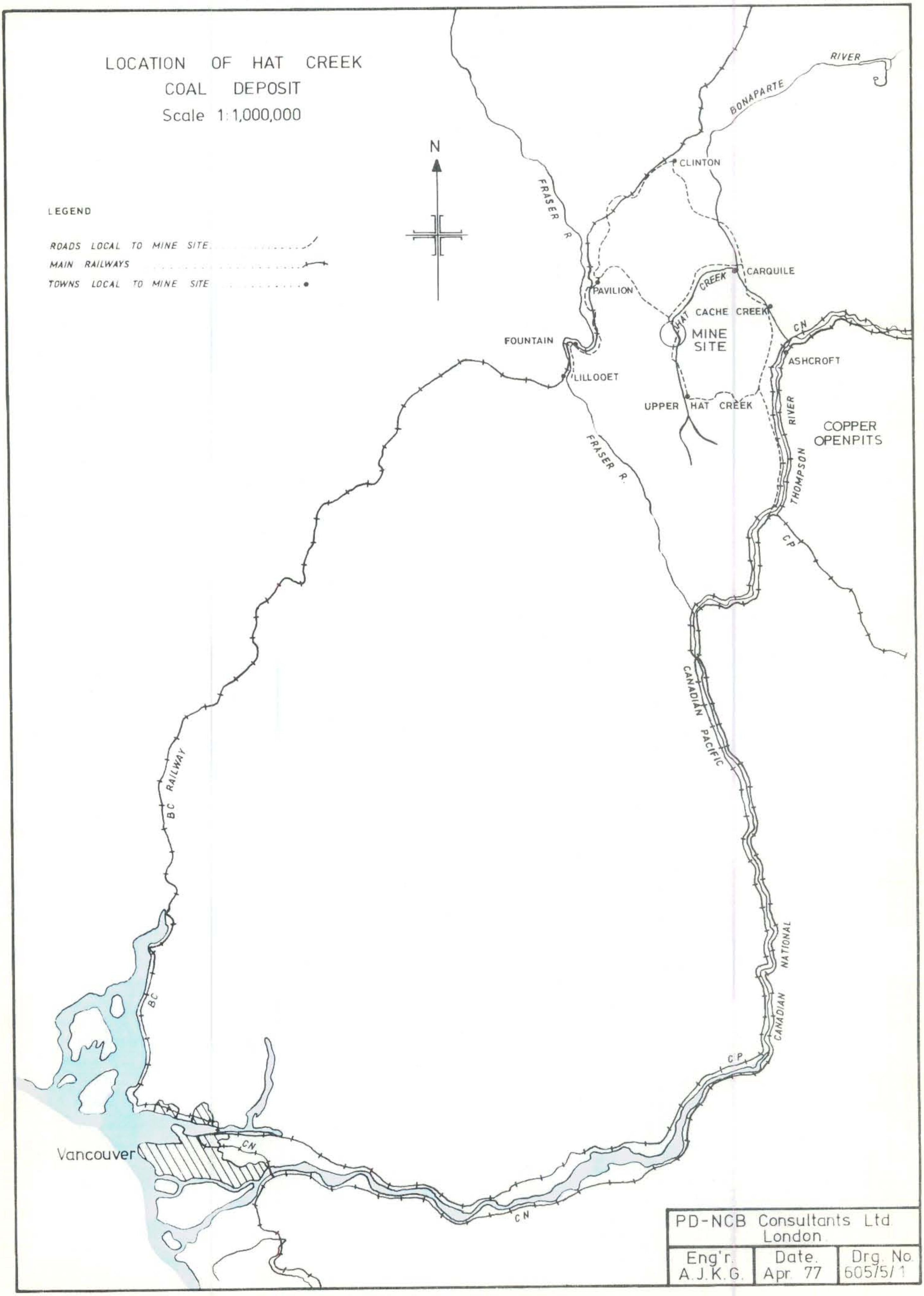
Characteristics (ppm unless otherwise indicated)	BC Mine Effluent Standards			WHO Drinking Water	
	Level A	Level B	Level C	Highest Desirable	Maximum Permissible
Phosphate (as P)*	2.00	5.00	10.00		
Selenium	0.05	0.10	1.00		(0.01)
Silver	0.10	0.50	1.00		
Sulphate	50	250	1,000	200	400
Uranyl	2.00	5.00	10.00		
Zinc	0.50	5.00	10.00	5	15
Oil and grease	15.00	15.00	15.00	0.01	0.30

Notes: 1. Elements are materials passing through 0.45 micron filter except those marked * which are total. A figure in brackets indicates that it is tentative.

Sources: 1. Pollution Control Objectives for the Mine, Mine-Milling and Smelting Industries of British Columbia - Department of Lands, Forests and Water Resources, 1973.

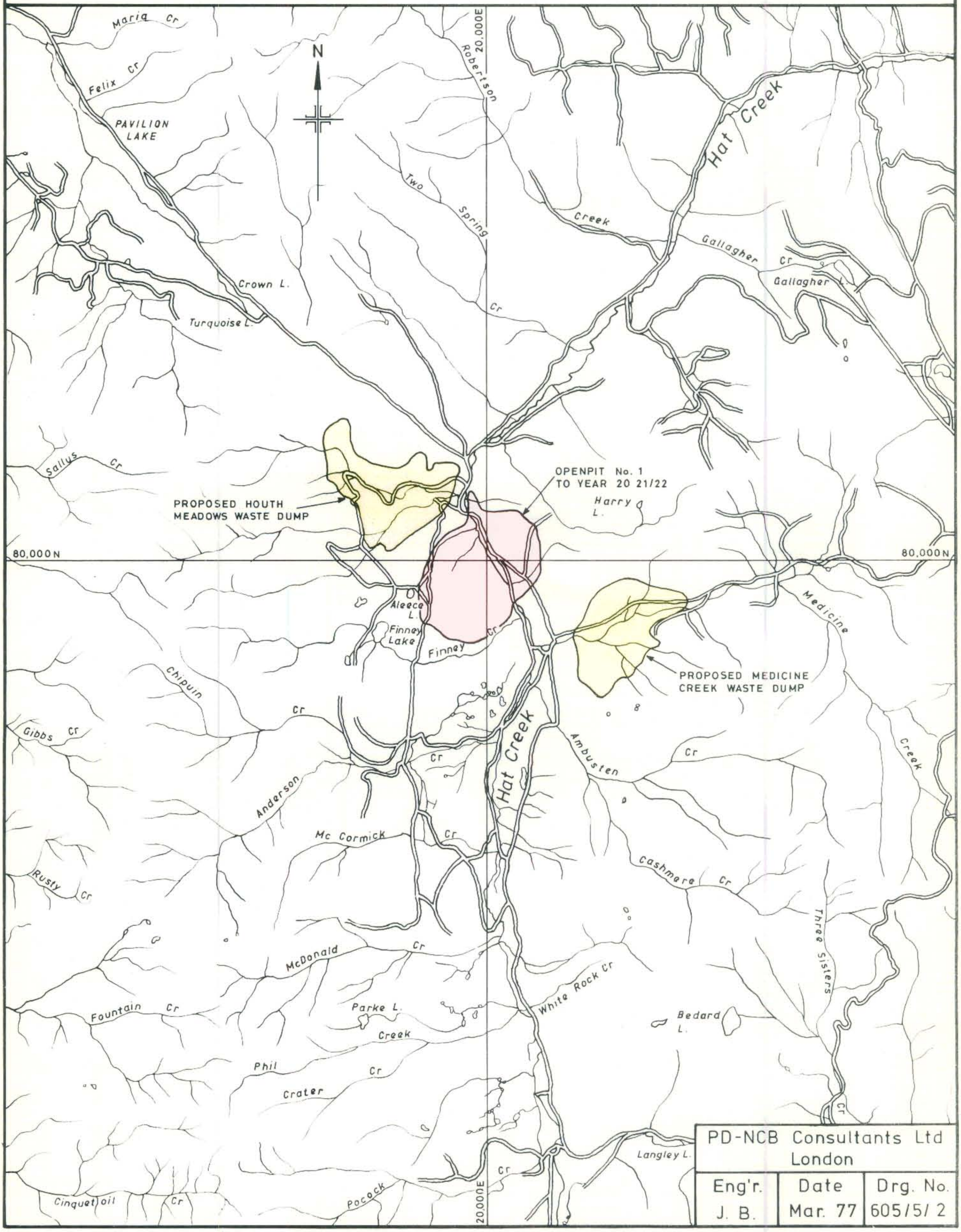
2. International Standards for Drinking Water - Third Edition - World Health Organisation, Geneva, 1971

PLATE 1


LOCATION OF HAT CREEK
COAL DEPOSIT
Scale 1:1,000,000
LEGEND
ROADS LOCAL TO MINE SITE
MAIN RAILWAYS
TOWNS LOCAL TO MINE SITE
N
RIVER
BONAPARTE
CLINTON
FRASER R
CARQUILE
HAT CREEK
PAVILION
CACHE CREEK
CN
MINE SITE
FOUNTAIN
ASHCROFT
LILLOOET
UPPER HAT CREEK
RIVER
COPPER OPENPITS
FRASER R.
THOMPSON
CP
CANADIAN PACIFIC
BC RAILWAY
NATIONAL
CANADIAN
BC
CP
Vancouver
CN
CN
PD-NCB Consultants Ltd
London
Eng'r.
A.J.K.G.
Date.
Apr. 77
Drg. No.
605/5/1

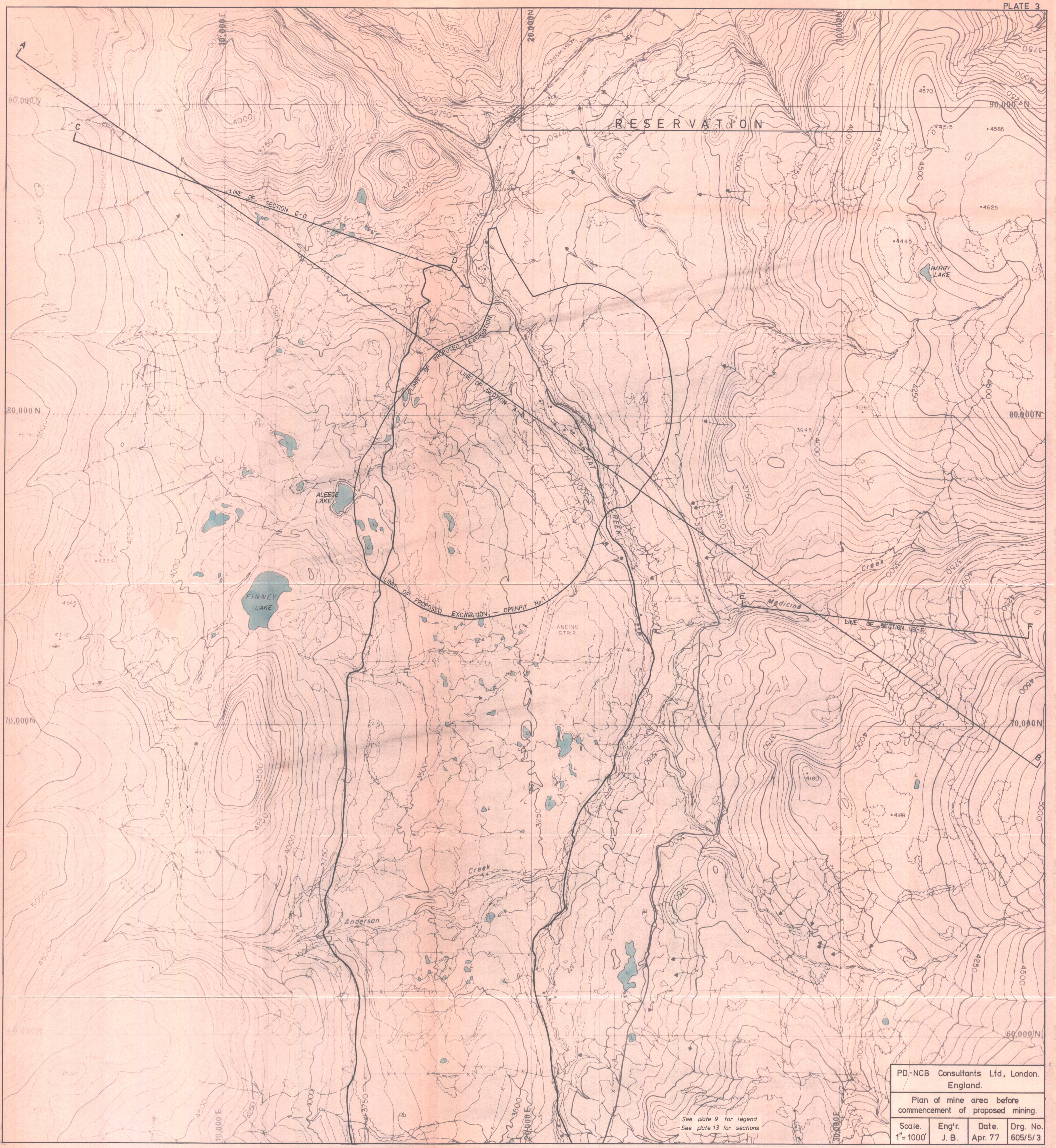
DETAIL MAP OF UPPER HAT CREEK VALLEY

Scale = 1:125,000



PD-NCB Consultants Ltd London		
Eng'r.	Date	Drg. No.
J. B.	Mar. 77	605/5/2

PLATE 3


RESERVATION
TRANSMISSION LINE
LINE OF SECTION C-D
LINE OF SECTION A-B
LINE OF SECTION E-F
LIMIT OF PROPOSED EXCAVATION
LIMIT OF PROPOSED EXCAVATION - OPENPIT No.1
HARRY LAKE
ALEGGE LAKE
FINNEY LAKE
Medicine Creek
Anderson Creek
PIPE
LANDING STRIP
90,000 N
80,000 N
70,000 N
60,000 N
10,000 E
20,000 E
30,000 E
See plate 9 for legend.
See plate 13 for sections.
PD-NCB Consultants Ltd, London.
England.
Plan of mine area before
commencement of proposed mining.
Scale. 1" = 1000'
Eng'r. J. B.
Date. Apr. 77
Drg. No. 605/5/3

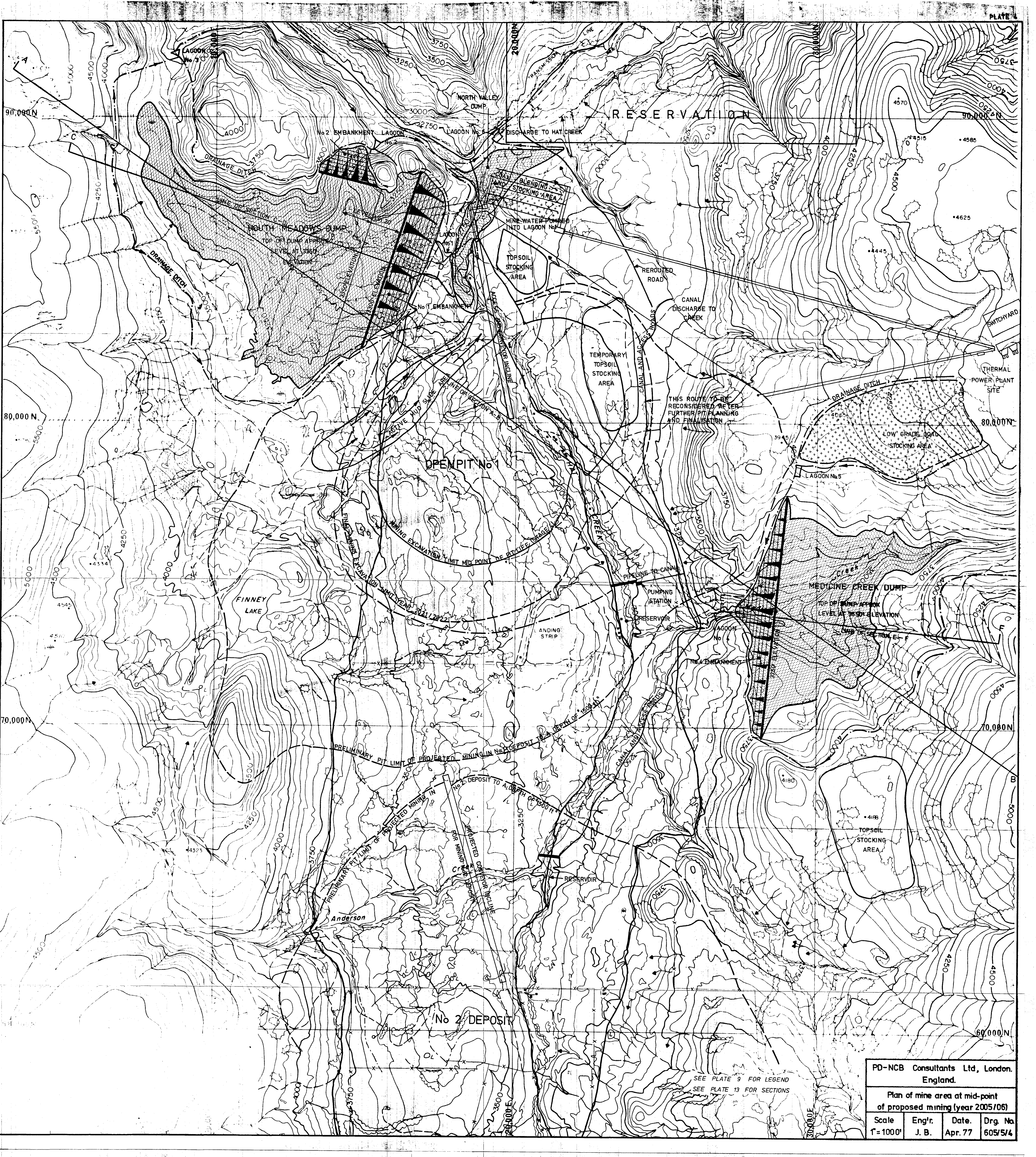
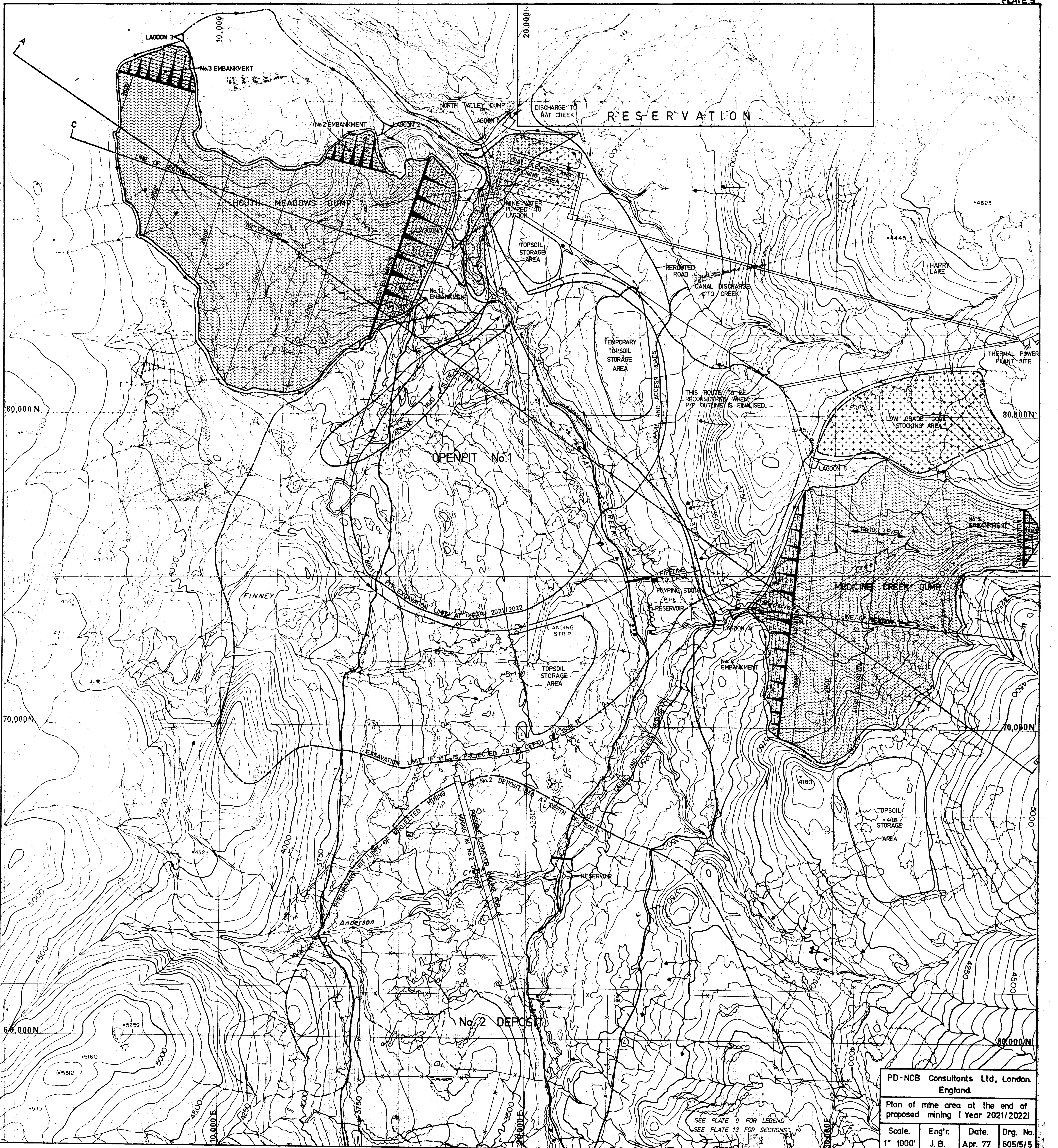


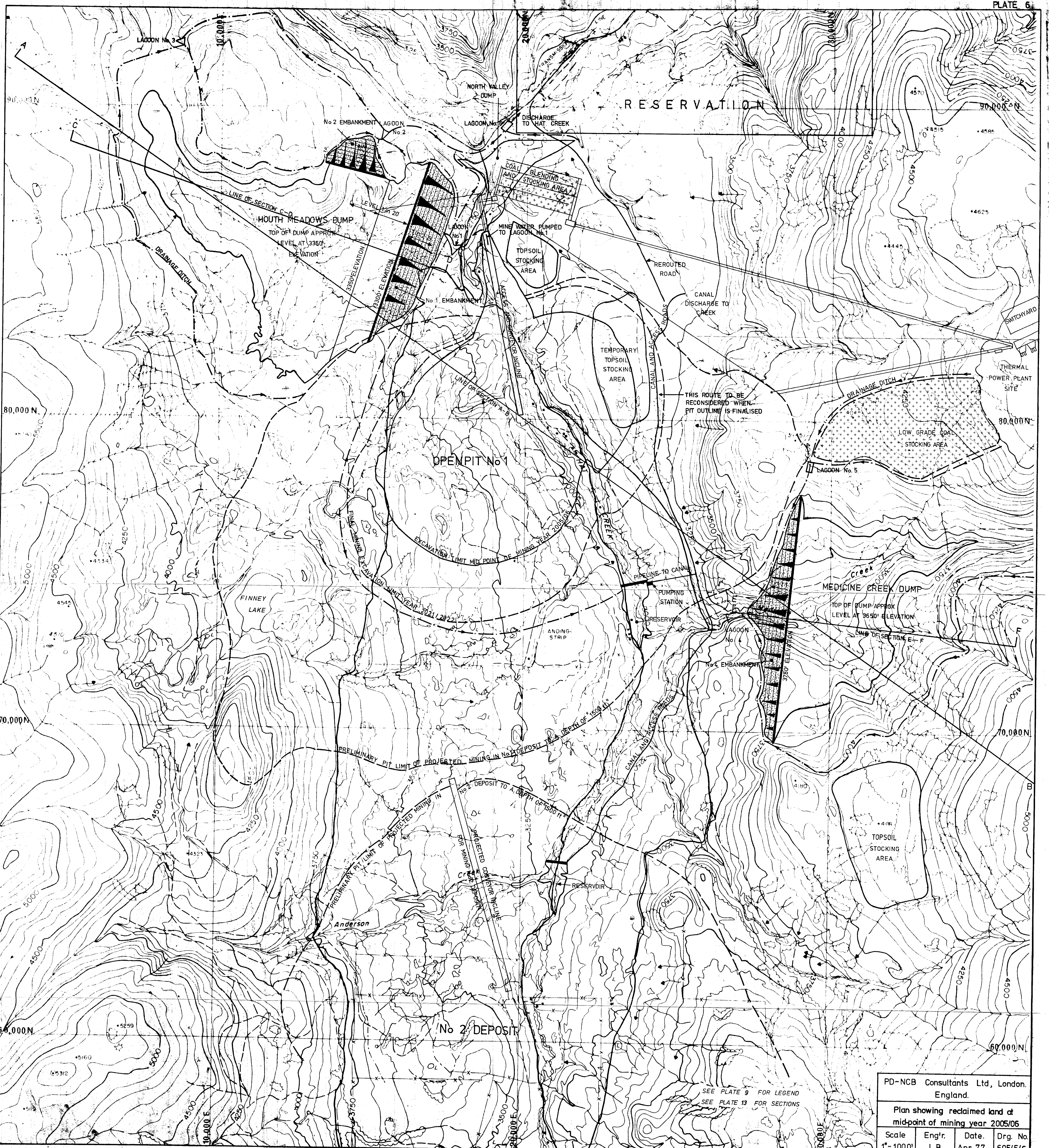
PLATE 4
RESERVATION
LAGOON No 3
NORTH VALLEY DUMP
No 2 EMBANKMENT
LAGOON No 2
LAGOON No 6
DISCHARGE TO HAT CREEK
TRANSMISSION LINE
DRAINAGE DITCH
BLENDING AND STOCKING AREA
LINE OF SECTION C-D
HOUTH MEADOWS DUMP
TOP OF DUMP APPROX LEVEL AT 3350 ELEVATION
MINE WATER PUMPED INTO LAGOON No 1
LAGOON No 1
TOPSOIL STOCKING AREA
REROUTED ROAD
No 1 EMBANKMENT
ACCESS AND CONVEYOR INCLINE
CANAL DISCHARGE TO CREEK
SWITCHYARD
TEMPORARY TOPSOIL STOCKING AREA
CANAL AND ACCESS ROADS
THIS ROUTE TO BE RECONSIDERED AFTER FURTHER PIT PLANNING AND FINALISATION
THERMAL POWER PLANT SITE
LOW GRADE COAL STOCKING AREA
LAGOON No 5
ACTIVE MUD SLIDE AREA
LINE OF SECTION A-B
OPENPIT No 1
MINING EXCAVATION LIMIT MID POINT OF PIT LIFE (STAGE 1)
FINAL MINING EXCAVATION LIMIT (YEAR 2021/2022)
PIPELINE TO CANAL
PUMPING STATION
RESERVOIR
MEDICINE CREEK DUMP
TOP OF DUMP APPROX LEVEL AT 3550 ELEVATION
LINE OF SECTION E-F
No 4 EMBANKMENT
FINNEY LAKE
LANDING STRIP
PRELIMINARY PIT LIMIT OF PROJECTED MINING IN No 2 DEPOSIT TO A DEPTH OF 1500 ft
PROJECTED CONVEYOR INCLINE FOR MINING No 2 DEPOSIT
TOPSOIL STOCKING AREA
Anderson
No 2 DEPOSIT
90,000 N
80,000 N
70,000 N
60,000 N
20,000 E
30,000 E
SEE PLATE 9 FOR LEGEND
SEE PLATE 13 FOR SECTIONS
PD-NCB Consultants Ltd, London. England.
Plan of mine area at mid-point of proposed mining (year 2005/06)
Scale 1" = 1000'
Eng'r. J. B.
Date. Apr. 77
Drg. No. 605/5/4



PD-NCB Consultants Ltd, London. England.			
Plan of mine area at the end of proposed mining (Year 2021/2022)			
Scale. 1" 1000'	Eng'r. J. B.	Date. Apr. 77	Drg. No. 605/5/5

SEE PLATE 9 FOR LEGEND
SEE PLATE 13 FOR SECTIONS

PLATE 6



PD-NCB Consultants Ltd, London. England.			
Plan showing reclaimed land at mid-point of mining year 2005/06			
Scale	Eng'r.	Date.	Drg. No.
1" = 1000'	J. B.	Apr. 77	605/5/6

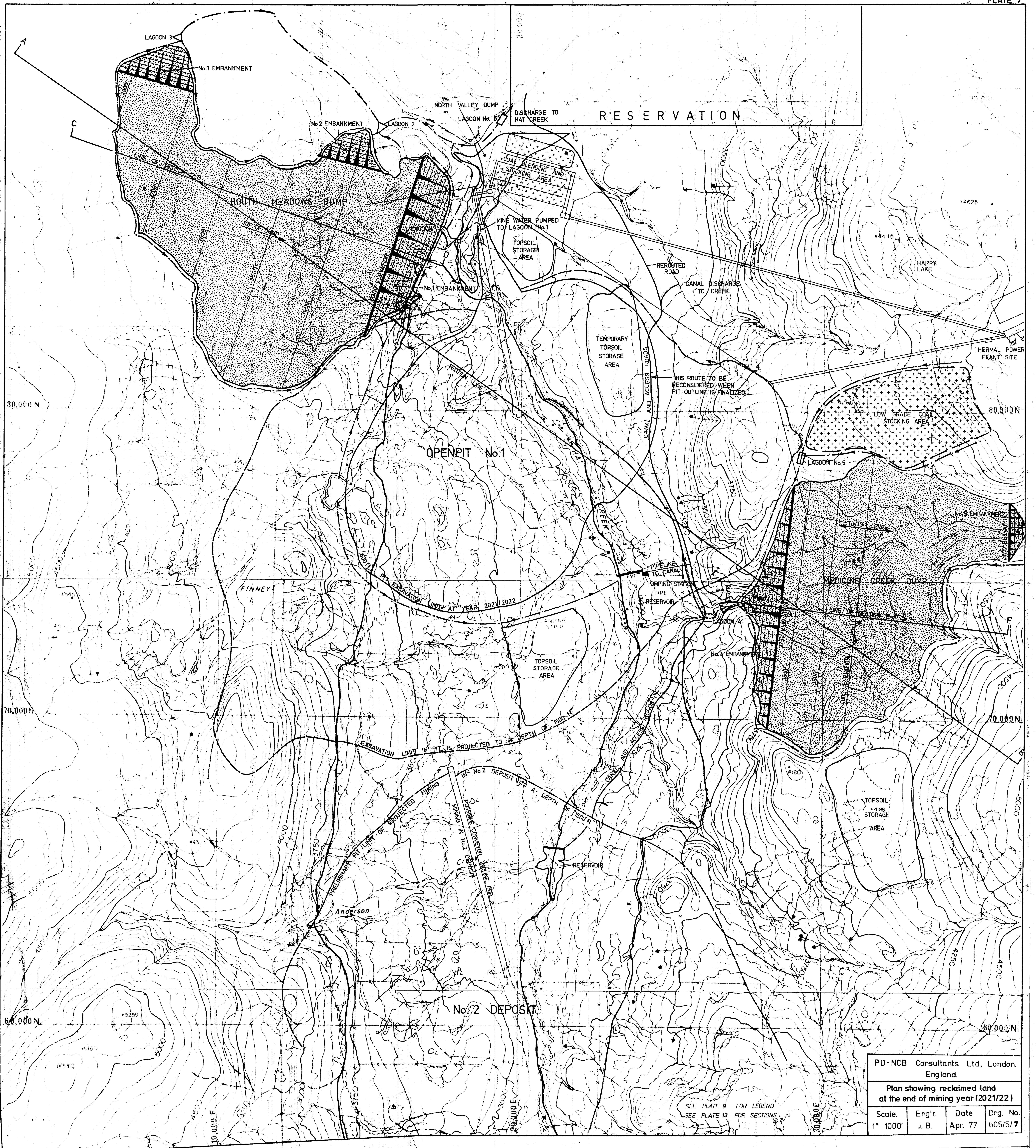

RESERVATION
LAGOON 3
No.3 EMBANKMENT
No.2 EMBANKMENT
LAGOON 2
NORTH VALLEY DUMP
LAGOON No. 6
DISCHARGE TO HAT CREEK
COAL BLENDING AND STOCKING AREA
HOUTH MEADOWS DUMP
MINE WATER PUMPED TO LAGOON No.1
TOPSOIL STORAGE AREA
No.1 EMBANKMENT
REROUTED ROAD
CANAL DISCHARGE TO CREEK
HARRY LAKE
THERMAL POWER PLANT SITE
TEMPORARY TOPSOIL STORAGE AREA
CANAL AND ACCESS ROADS
THIS ROUTE TO BE RECONSIDERED WHEN PIT OUTLINE IS FINALIZED
SECTION LINE B
LOW GRADE COAL STOCKING AREA
LAGOON No.5
OPENPIT No.1
HAT CREEK
No.5 EMBANKMENT
PIPELINE TO CANAL
PUMPING STATION
PIPE
RESERVOIR
MEDICINE CREEK DUMP
LINE OF SECTION
No.4 EMBANKMENT
FINNEY L
PIT EXCAVATION LIMIT AT YEAR 2021/2022
TOPSOIL STORAGE AREA
EXCAVATION LIMIT IF PIT IS PROJECTED TO A DEPTH OF 1500 ft
CANAL AND ACCESS ROADS
PRELIMINARY PIT LIMIT OF PROJECTED MINING IN No.2 DEPOSIT TO A DEPTH OF 1500 ft
POSSIBLE CONVEYOR INCLINE FOR MINING IN No.2 DEPOSIT
TOPSOIL STORAGE AREA
RESERVOIR
Anderson
No. 2 DEPOSIT
80,000 N
70,000 N
60,000 N
10,000 E
20,000 E
30,000 E
SEE PLATE 9 FOR LEGEND
SEE PLATE 13 FOR SECTIONS
PD-NCB Consultants Ltd, London England.
Plan showing reclaimed land at the end of mining year (2021/22)
Scale. 1" 1000'
Eng'r. J. B.
Date. Apr. 77
Drg. No 605/5/7

PLATE 8

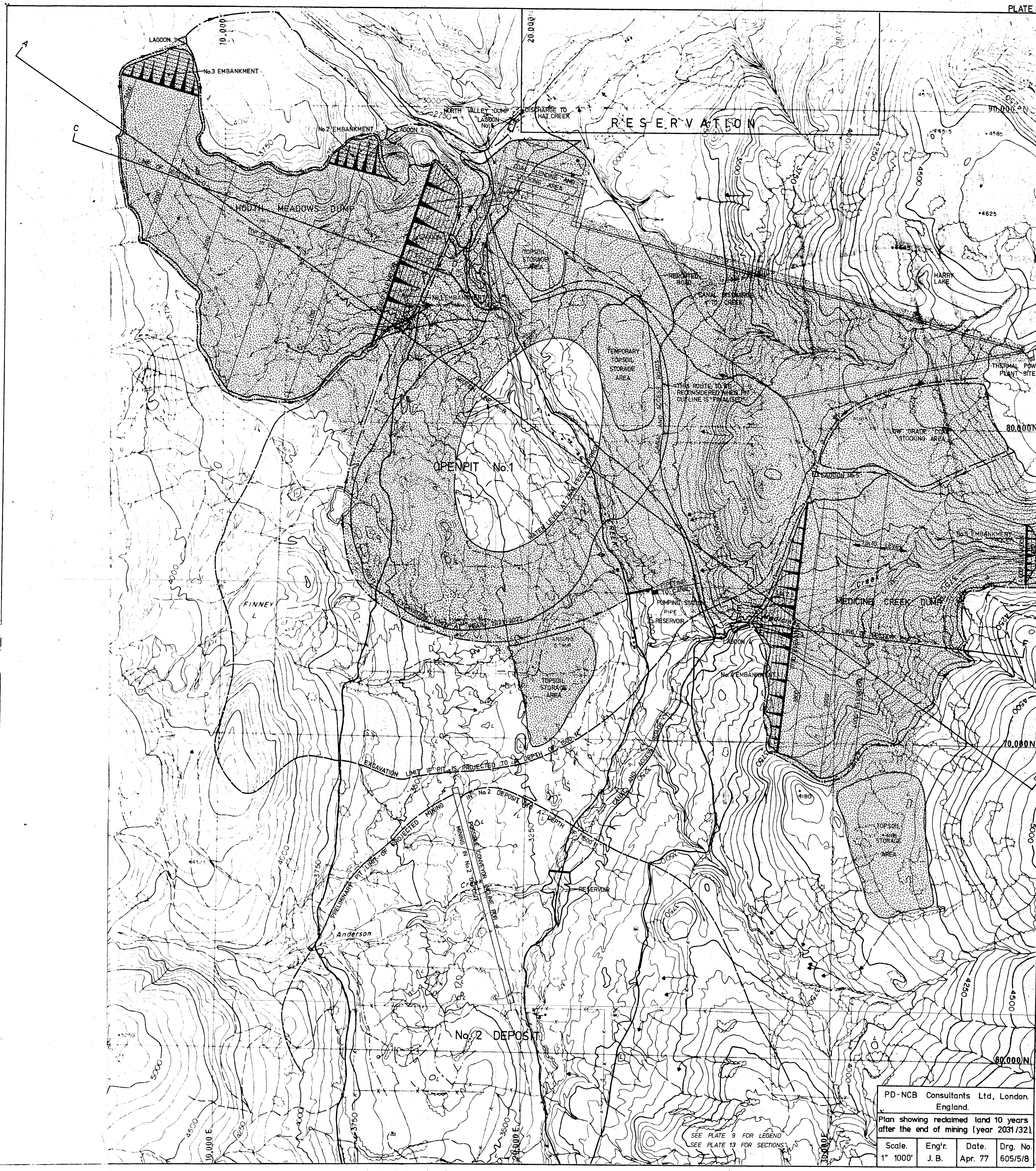

LAGOON 3
No.3 EMBANKMENT
No.2 EMBANKMENT
LAGOON 2
NORTH VALLEY DUMP
LAGOON No.1
DISCHARGE TO HAT CREEK
RESERVATION
COAL BLENDING AND STOCKING AREA
HOUTH MEADOWS DUMP
LAGOON
No.1 EMBANKMENT
TOPSOIL STORAGE AREA
REROUTED ROAD
CANAL DISCHARGE INTO CREEK
HARRY LAKE
TEMPORARY TOPSOIL STORAGE AREA
THIS ROUTE TO BE RECONSIDERED WHEN PIT OUTLINE IS FINALISED
THERMAL POWER PLANT SITE
LOW GRADE COAL STOCKING AREA
OPENPIT No.1
WATER LEVEL AT 2450 FEET
LAGOON
No.5 EMBANKMENT
MEDICINE CREEK DUMP
PIPELINE TO CANAL
PUMPING STATION
PIPE
RESERVOIR
LAGOON
No.4 EMBANKMENT
LINE OF SECTION
FINNEY L
TOPSOIL STORAGE AREA
EXCAVATION LIMIT IF PIT IS PROJECTED TO A DEPTH OF 1500 ft
PRELIMINARY PIT LIMIT OF PROJECTED MINING IN No.2 DEPOSIT TO A DEPTH OF 1500 ft
POSSIBLE CONVEYOR INCLINE FOR MINING IN No.2 DEPOSIT
CANAL AND ACCESS ROADS
RESERVOIR
TOPSOIL STORAGE AREA
Anderson
No. 2 DEPOSIT
90,000 N
80,000 N
70,000 N
60,000 N
10,000 E
20,000 E
30,000 E
SEE PLATE 9 FOR LEGEND
SEE PLATE 13 FOR SECTIONS
PD-NCB Consultants Ltd, London. England.
Plan showing reclaimed land 10 years after the end of mining (year 2031/32).
Scale. 1" 1000'
Eng'r. J. B.
Date. Apr. 77
Drg. No. 605/5/8

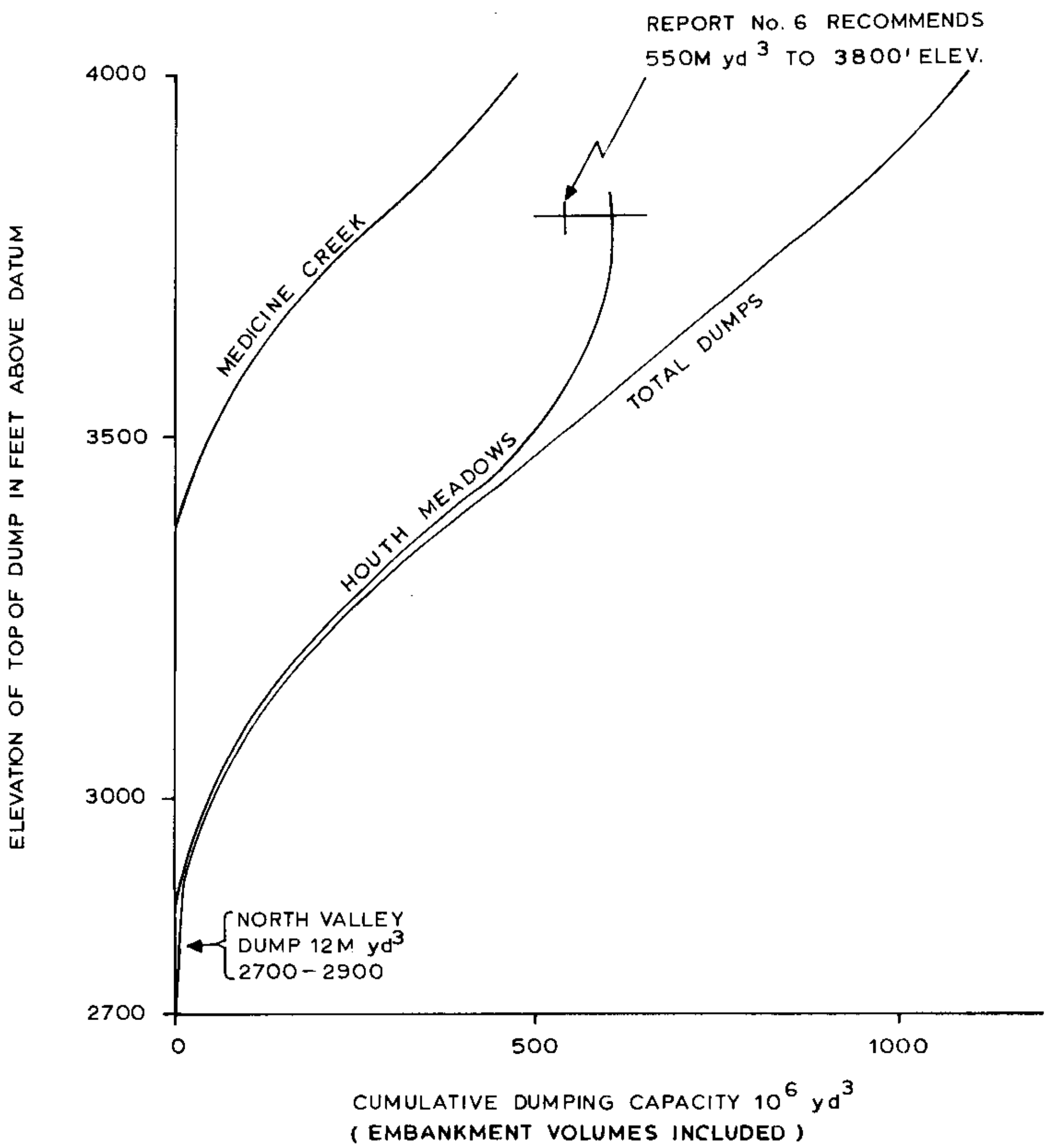
PLATE 9

LEGEND OF SYMBOLS USED ON TOPOGRAPHICAL MAPS

Roads	
Building or Habitation	
Fence	X
Power transmission line	
Lake	L
Creek	
Swamp	
Ditch	
Contours — Index	3250
Intermediate	
Depression	
Spot elevation	• 3945
Tree line	
Stocking area	
Mine dumps	
Mine dumps reclaimed	

PD–NCB Consultants Ltd., London		
Eng'r J. B.	Date April 77	Drg. No. 605/5/9

CUMULATIVE CAPACITY OF WASTE DUMPS



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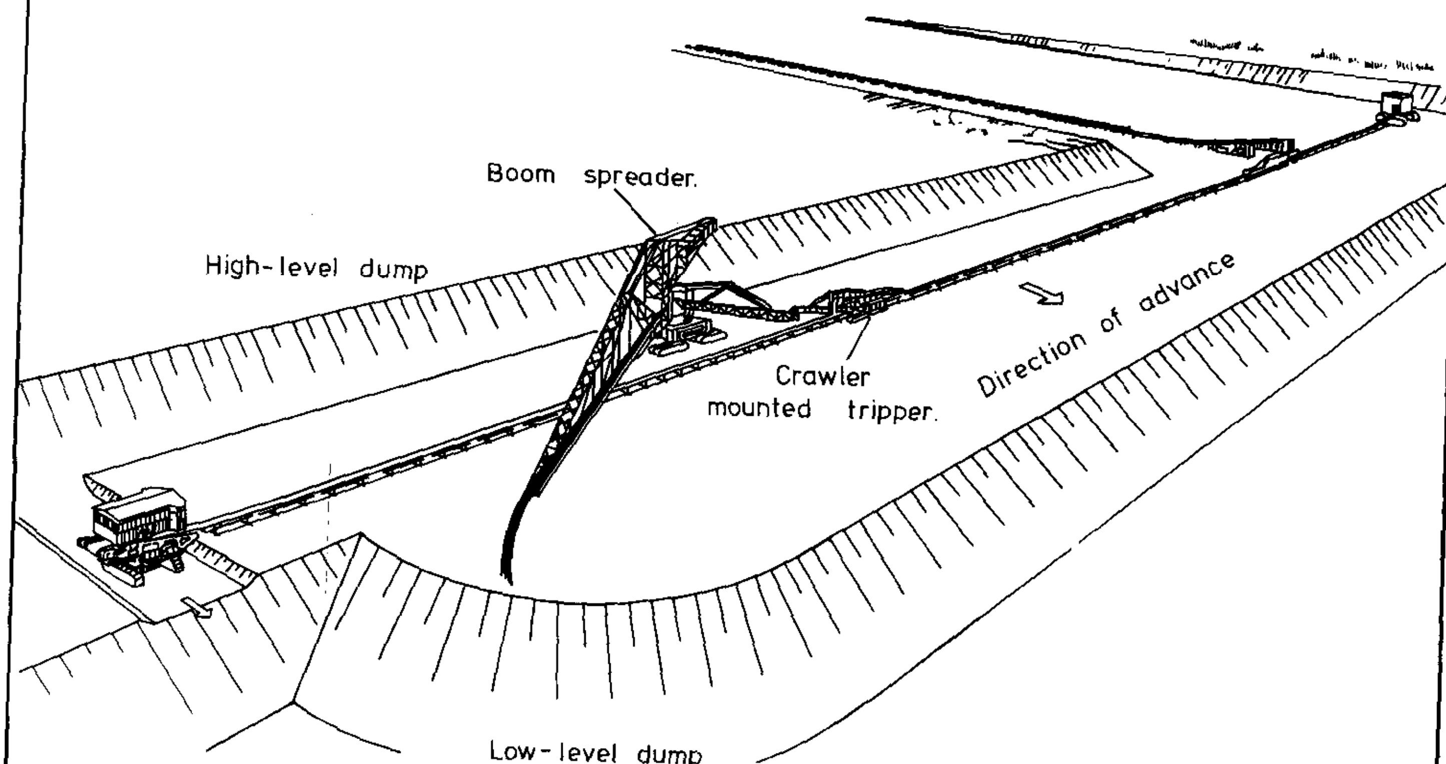
Eng'r	Date	Drg. No.
J. B.	Mar 77	605/5/10

TYPICAL DUMP FORMATION USING BOOM SPREADER.



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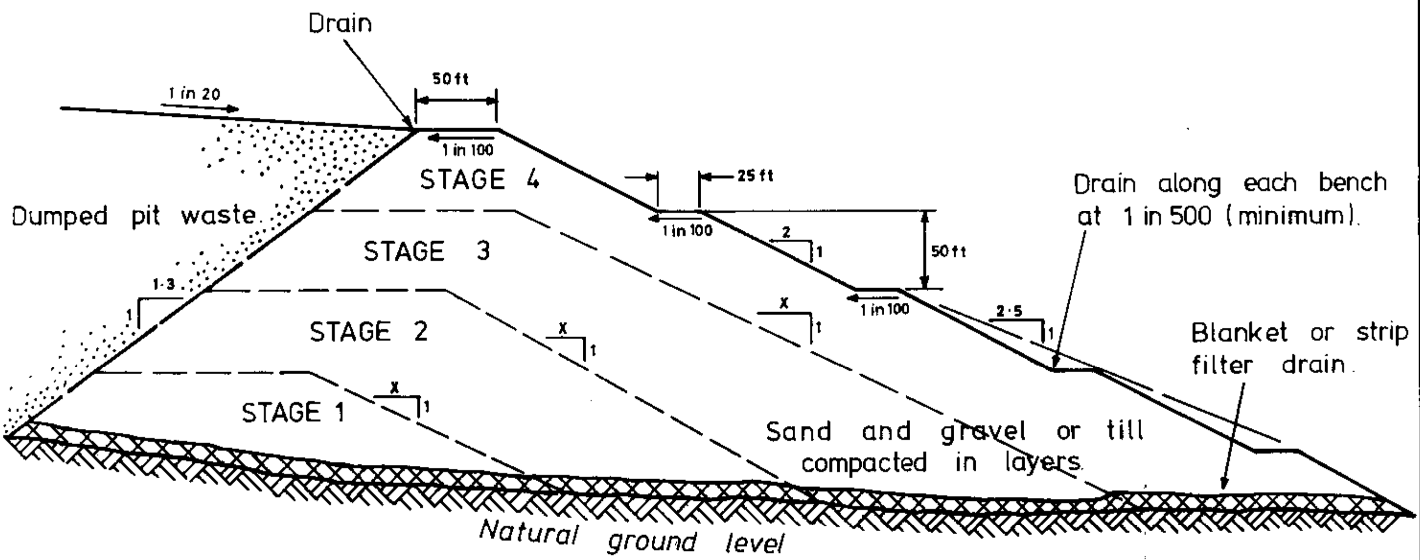
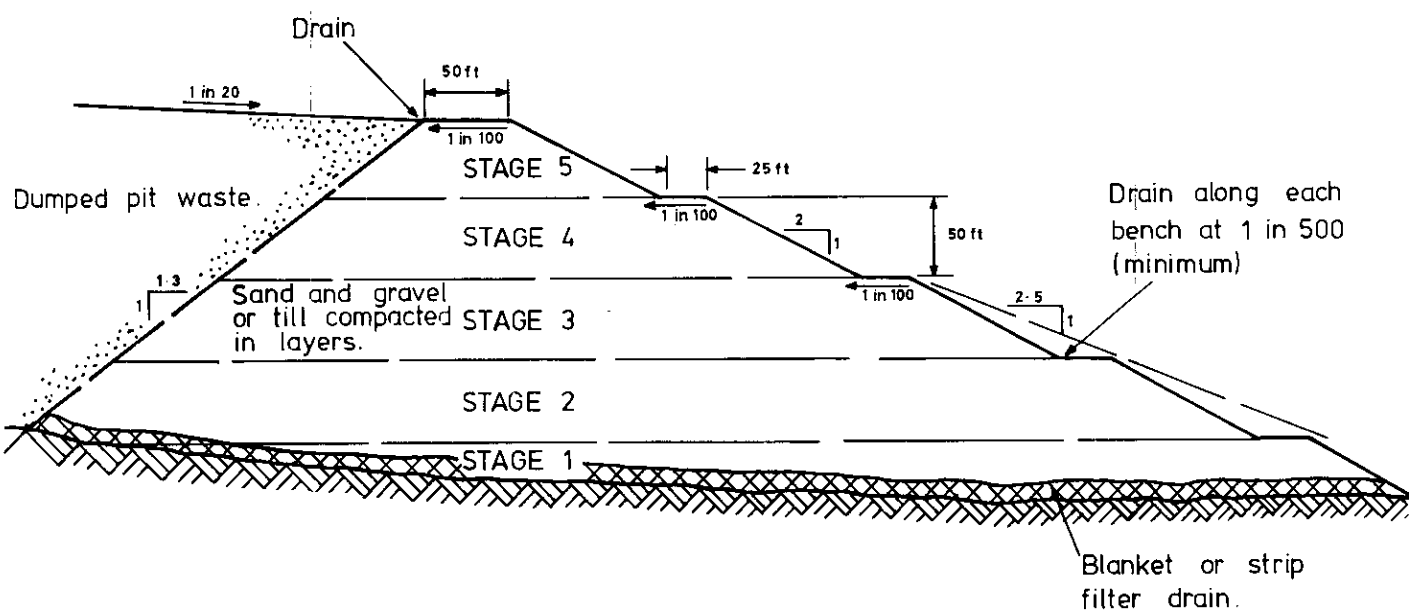
Eng'r. A.J. K.G.	Date. Apr. 77	Drg. No. 605/5/11

ALTERNATIVE METHODS OF RETAINING EMBANKMENT CONSTRUCTION.



Slope x of initial stages would vary to suit stability needs, and availability of construction materials from pit excavation.

ALTERNATIVE A
(Downstream Construction.)



ALTERNATIVE B
(Centreline Construction.)

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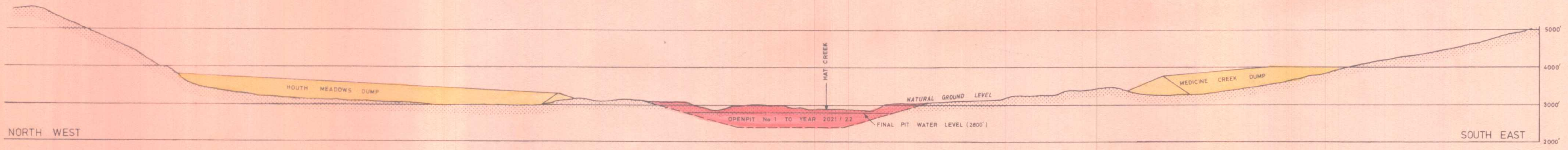
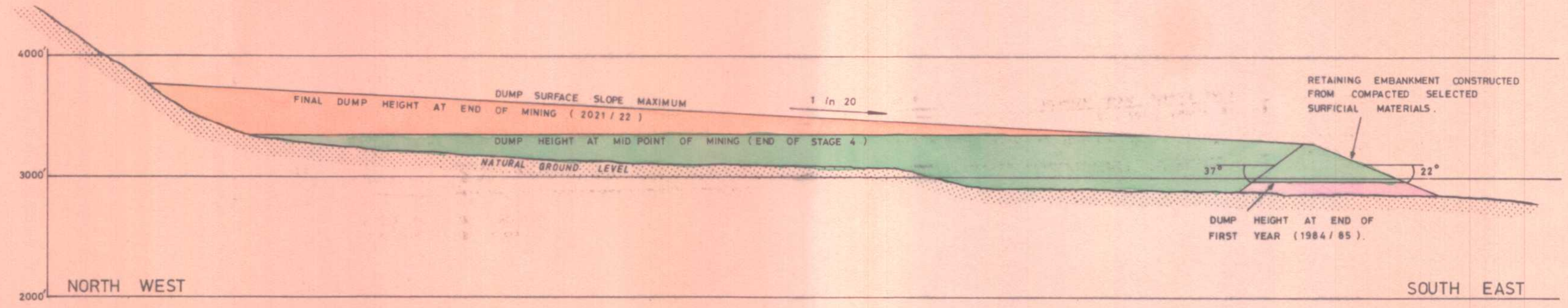
Eng'r. J. B.	Date. Apr. 77.	Drg. No. 605/5/12

SECTION THROUGH PROPOSED WASTE DUMPS



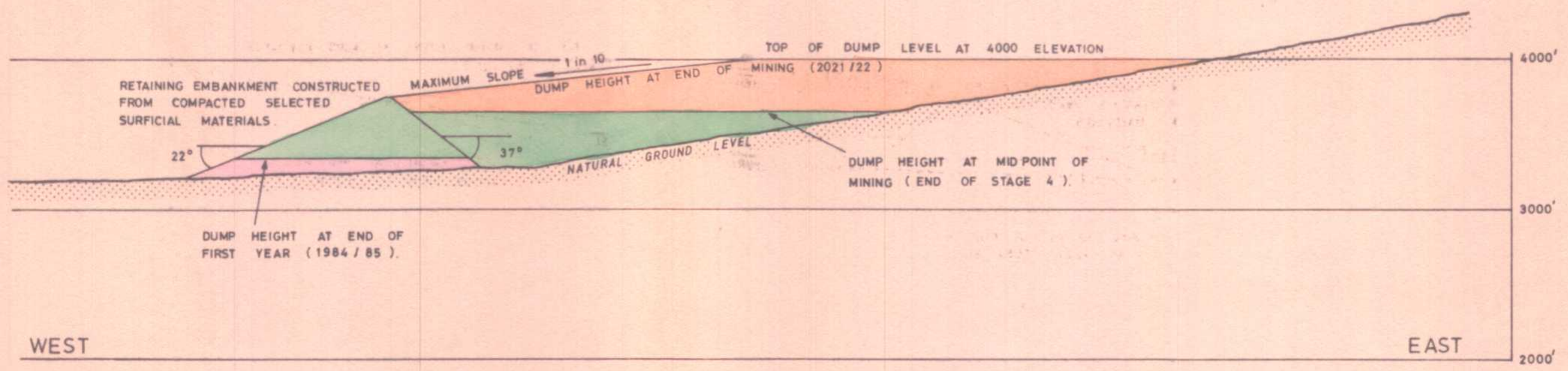
SECTION A-B THROUGH OPENPIT No 1 AND WASTE DUMPS

Natural Scale : 1" = 2000'



SECTION C-D THROUGH HOUTH MEADOWS DUMP

Natural Scale : 1" = 1000'



SECTION E-F THROUGH MEDICINE CREEK DUMP

Natural Scale : 1" = 1000'

NOTES : 1 Dumped materials summarized in Tables III & IV

2 Lines of section shown on Plates 4 & 5

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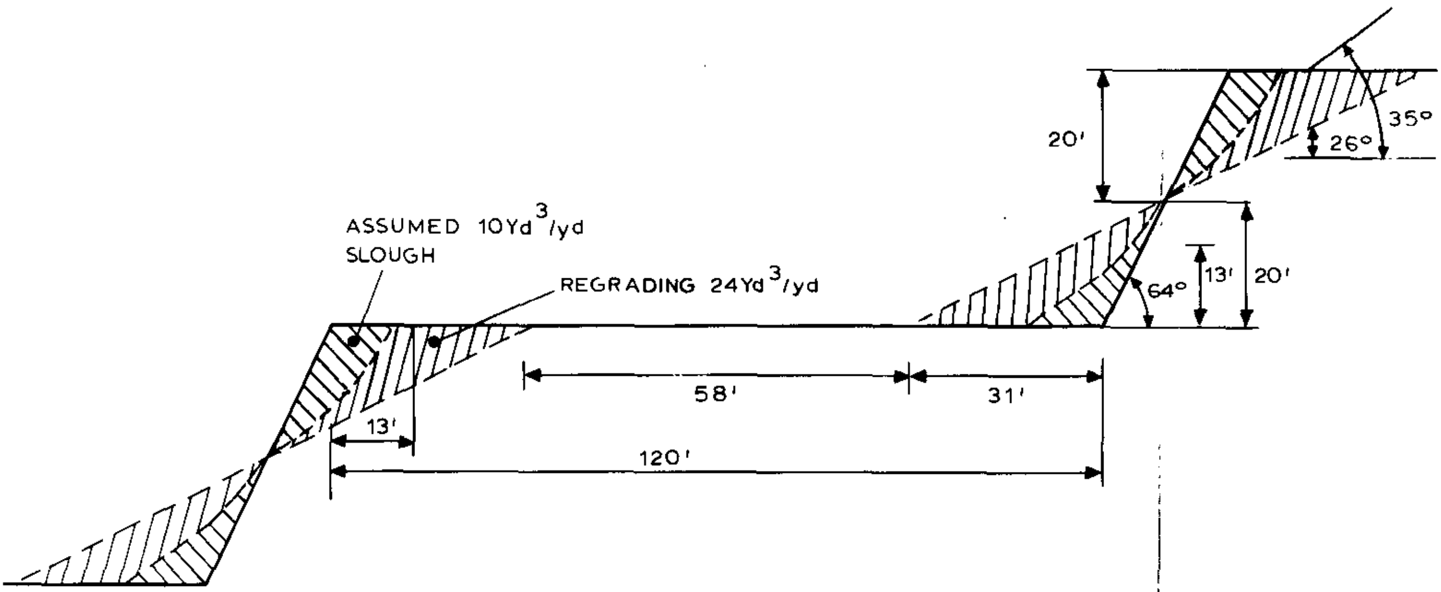
Eng'r. J. B.	Date. Apr. 77	Drg. No. 605/5/13

ASSUMED SLOUGH AND REQUIRED RE-GRADING OF EXCAVATED PIT BENCHES



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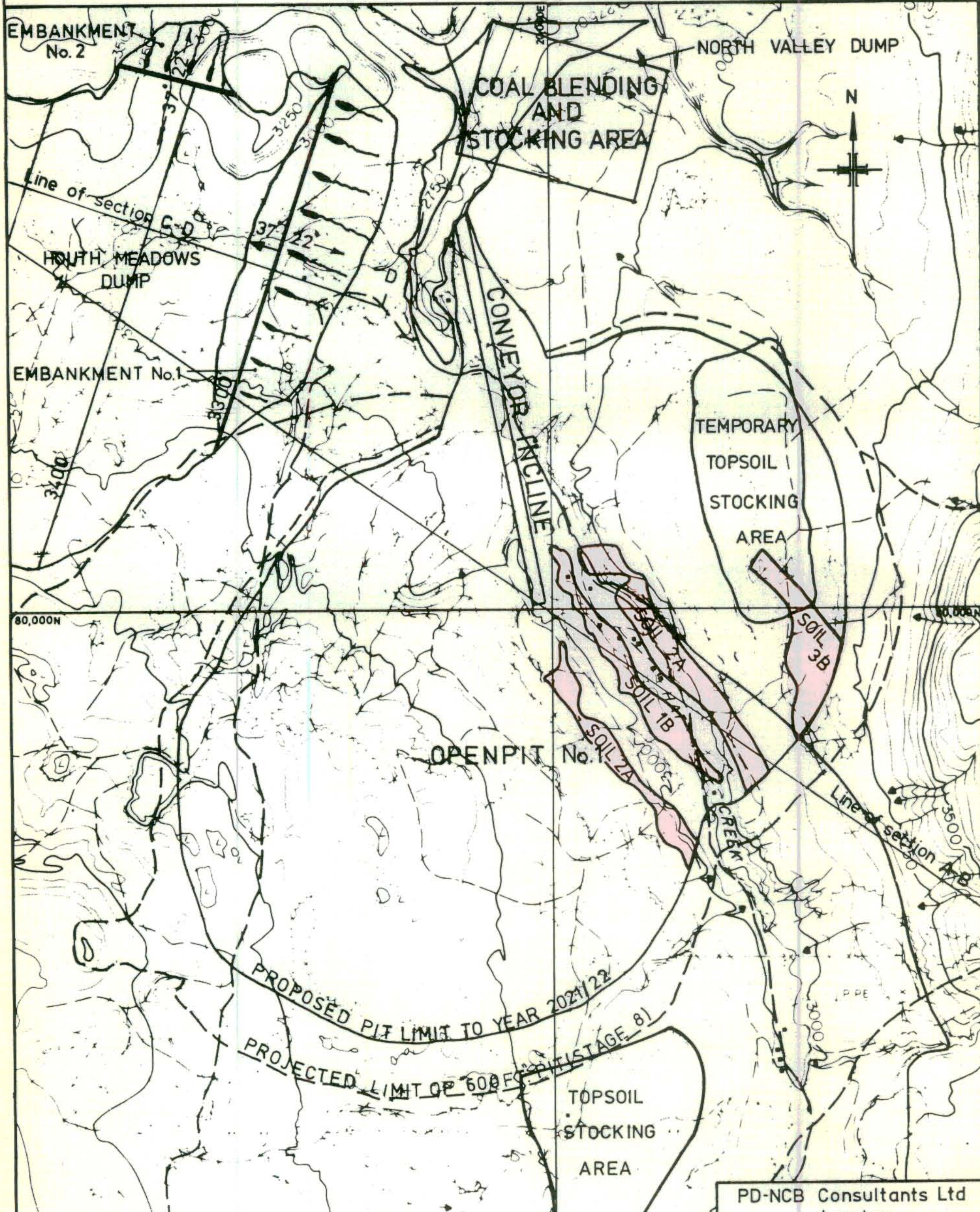
J. B.	April 77	605/5/14

LOCATION OF TOPSOIL SUITABLE FOR RECLAMATION

SCALE = 1": 2000'



NOTE : ESTIMATED SOIL QUANTITIES ARE SHOWN IN TABLE VII

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J. B	May 77	605/5/15