Rehabilitation of indigenous forest after mining, West Coast

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Part 2: Giles Creek – Fertiliser response of *Coprosma robusta* and *Nothofagus fusca* seedlings

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Foreword

On 1 April 1987, the Department of Conservation (DoC) was set up to administer some former State Forest Service land and other former Crown Land, and inherited a number of either operational or completed mining licences, as well as receiving ongoing applications for new licences on this land.

In mid-1989, DoC commissioned the former DSIR Division of Land and Soil Sciences (now part of Manaaki Whenua - Landcare Research) to carry out an assessment of land rehabilitation after alluvial gold and coal mining within the DoC estate, West Coast, both as a means of improving future conditions and as a basis for selecting some sites for research trials. This study forms the basis of Part 1 of this publication.

Since then there have been substantial developments in the way that natural resources and the environment are managed. Many of the conditions now imposed on mining operations have been altered by significant changes in both the legislation, notably the Resource Management Act 1991 (RMA), and the organisation, responsibilities, and objectives of central and local government. This legislation, and the associated devolution of government to regional and local authorities, has also affected DoC's mining policy and its administration of environmental and land restoration issues related to mining.

The general mining licence conditions imposed before the RMA specified the legal requirements of miners and, in theory, governed what miners were expected to do in regard to land restoration. Thus, mining licence conditions, and the associated bonds where applicable, were expected to drive the process of land restoration after mining. Primary responsibility for setting mining conditions and for imposing bonds had rested with the former Ministry of Energy (now part of the Ministry of Commerce), operating through the Mines/ Coal Mines Inspectorate, but additional conditions were imposed by the appropriate land-administrating department, e.g. NZ Forest Service or Department of Lands and Survey prior to 1987 or by DoC itself after 1987. Mining conditions, with respect to the sites in this review, were imposed under Section 105(5) of the Mining Act 1971 for the gold mining operations and Section 41 of the Coal Mines Act 1979 for coal mines. For all of the licences there had been a general set of imposed conditions which had common land restoration specifications.

The regulations and administrative matters discussed in Part 1 refer only to the situation in 1989 when the study was produced. However, where operations continue at the sites visited in this study, the conditions pertaining at their start remain to be met. Moreover, conditions of resource consents now imposed by regional authorities under the RMA are not unlike those formerly expected. Clause 5(2)c of the RMA cites the purpose of: "Avoiding, remedying or mitigating any adverse effects of activities on the environment", which is now the legislative backing for land rehabilitation after mining. The general matters raised in the study with regard to rehabilitation of mining sites are still pertinent, and many of the conditions will apply whatever new situation develops. This is one reason for the issue of Part 1 of this publication.

The study in Part 1 suggested means for improving environmental outcomes and mining conditions, which included clearly specifying in the mining licence at its issue the vegetation type required after mining. It was recognised that this requirement was very difficult to do, hence the need for urgent research. The major perceived research need was to investigate the most effective means of ensuring a return to high forest on mined sites in as short a time as possible, and a suggested experimental site was Giles Creek. Parts 2 and 3 of this publication describe projects undertaken towards meeting this need, and a further justification for publishing Part 1 is to give a more comprehensive picture of how DoC policy towards rehabilitation after mining has developed.

Part 1 Past performance on a range of mining sites

Abstract

Twelve sites from a shortlist of 28 gold and coal mining operations in the West Coast Region were selected to be assessed over a 6-day field period in 1989. A specially designed standard comprehensive evaluation form was filled in at each site, with additional information on licence conditions derived from files of both DoC and the former Ministry of Energy. A plethora of confused conditions was evident.

Site conditions prior to mining were assessed as far as practicable from recorded information and from the sites themselves in terms of landforms, soils and former vegetation. Sites ranged from river flats that had at one time been under beech/podocarp or podocarp/hardwood forest with relatively simple recent soils, to high terraces with pakihi vegetation and complex gley podzols, and steepland with podzolised yellow-brown earths, also originally in forest and subsequently modified forest prior to mining. One dune sequence without mining was examined.

Sites were evaluated in terms of whether the standard mining licence conditions for each had been met. For 4 of the 12 sites, the conditions were being, or had been, met to a major degree. At a further 4 sites there had been only minimal compliance; the remainder were gradational between the two extremes. DoC staff had been in contact with the miners at several of the problematical sites. Ten sites were assessed where mining was largely complete on DoC land on the basis of improved, satisfactory or unacceptable environmental outcomes in line with DoC views, requests, and the mining licence conditions. Two sites were ranked as satisfactory, Kapitea Creek and most of Kennedy Creek. The other 8 were considered unacceptable at the time of our visit, although DoC had expectations of improvement in several instances, particularly with regard to revegetation. Reasons for the unacceptable ranking were many and varied, but the most important was that at least one of the specified mining conditions was not met, particularly the stripping, stockpiling and respreading of topsoil (which is of fundamental importance for revegetation), assuming such material was present originally.

Suggested means for DoC to improve environmental outcomes and mining conditions were:

- Formalise policy on desired outcomes after mining.
- Ensure the ecology of potential mining sites is adequately characterised prior to the issue of mining licences.

- Tailor the mining conditions to the desired outcomes. We envisage two possible extremes: total restoration, or a "designer-soil" concept in which a soil is created to meet plant requirements as selected for the site by DoC.
- Clearly specify, in the mining licence at its issue, the vegetation type required after mining.

The major perceived research need was to investigate the most effective means of ensuring a return to high forest on mined sites in as short a time as possible, preferably using indigenous species and excluding grazing animals at early stages. There was also a need to ensure that pakihi soils and vegetation could be re-established following mining. Suggested sites were: Giles Creek (beech/podocarp forest on low, well drained terrace), Kumara (podocarp/hardwood forest on intermediate, poorly-drained terrace), or a new site; for pakihi vegetation, either Addisons Flat, or possibly Gillams Gully. Current trends in semi-natural revegetation could be monitored if exclosure and ordinary plots were established at Kapitea (regenerating podocarp/hardwood forest in presence of gorse).

1. Introduction

A study of a wide range of sites mined for either alluvial gold or coal within the DoC West Coast estate was commissioned by DoC in 1989, primarily to monitor standards of rehabilitation, but also to help in the formulation of future policy on such mining, and to provide data for the selection of future rehabilitation trial sites. There was already some evidence to suggest that standards set by the Ministry of Energy and the former Westland Catchment Board were not being met adequately in all instances. DoC policy on desirable rehabilitation outcomes after mining was still in an early formative stage, and was not related specifically to the range of landforms, soils, underlying materials and ecotypes in which mining was occurring or could occur, although there was a policy to exclude mining from all but modified and low-value ecosystems (see Draft Mining Policy 1988 and Approved Mining Policy 1989, both DoC, unpublished). A further objective of the study was to document this range to some degree and recommend broad guidelines for rehabilitation, and/or research needed to ensure such rehabilitation.

2. Methods

In order to retain as much objectivity as possible, the study team obtained a list of 28 mining operations from DoC, Hokitika, from which they selected 12 for detailed evaluation in the field. The locations of these 12 sites are shown on Fig. 1. More information is given about the sites, including the companies involved and the licence numbers, in the Appendices, Sections 9.1 and 9.2. The information on the mining operations provided by DoC included mining licence number, name of company, mineral mined, size of operation, whether mining was ongoing or complete, whether restoration had been attempted or not, an environmental description, and a locality name. DoC also provided access to files giving information on mining licence conditions and DoC liaison with miners where applicable. Additional file information was obtained from the Ministry of Energy, Greymouth.

The basis for selection was as follows:

- Sites to represent as wide a range of soils, landforms, underlying materials and ecotypes as possible.
- Sites to represent a range from "good" rehabilitation to "bad" rehabilitation as perceived by DoC.
- Sites to show a range in size - both large and small operators to be studied.
- Sites to cover as wide a geographic range as practicable in the limited time available for field visits.

As a further aid to objectivity of approach, the DSIR team designed a standard evaluation form, which was filled in for each site examined. The form was divided into 4 parts:

1. *Site information.* Predominantly information concerning site factors prior to mining derived from published and unpublished reports, environmental assessment questionnaires (EAQ), and local knowledge. This part was completed mainly in the office.
2. *Mining history and rehabilitation conditions.* This section outlined the specific conditions attached to the mining licence for rehabilitation, with special reference to those conditions relevant to the DoC estate. The information was derived from the actual mining licences and correspondence on relevant files. Verbal agreements with miners also existed. Conditions relevant to DoC included how the soil, overburden and landscape was to be left after mining, whether ponds were to be created, what sort of vegetation and land use was required, how vegetation was to be handled in the course of mining and whether water courses should be straightened and/or have flood protection work put in place.
3. *Current conditions at site.* Field assessments actually on site were made to determine whether the rehabilitation conditions were being, or had been, met depending on whether mining was ongoing or complete. Where relevant, slope and stability of sidecasts were assessed, thicknesses of respread topsoil and fines were measured, surface stone and silt cover were

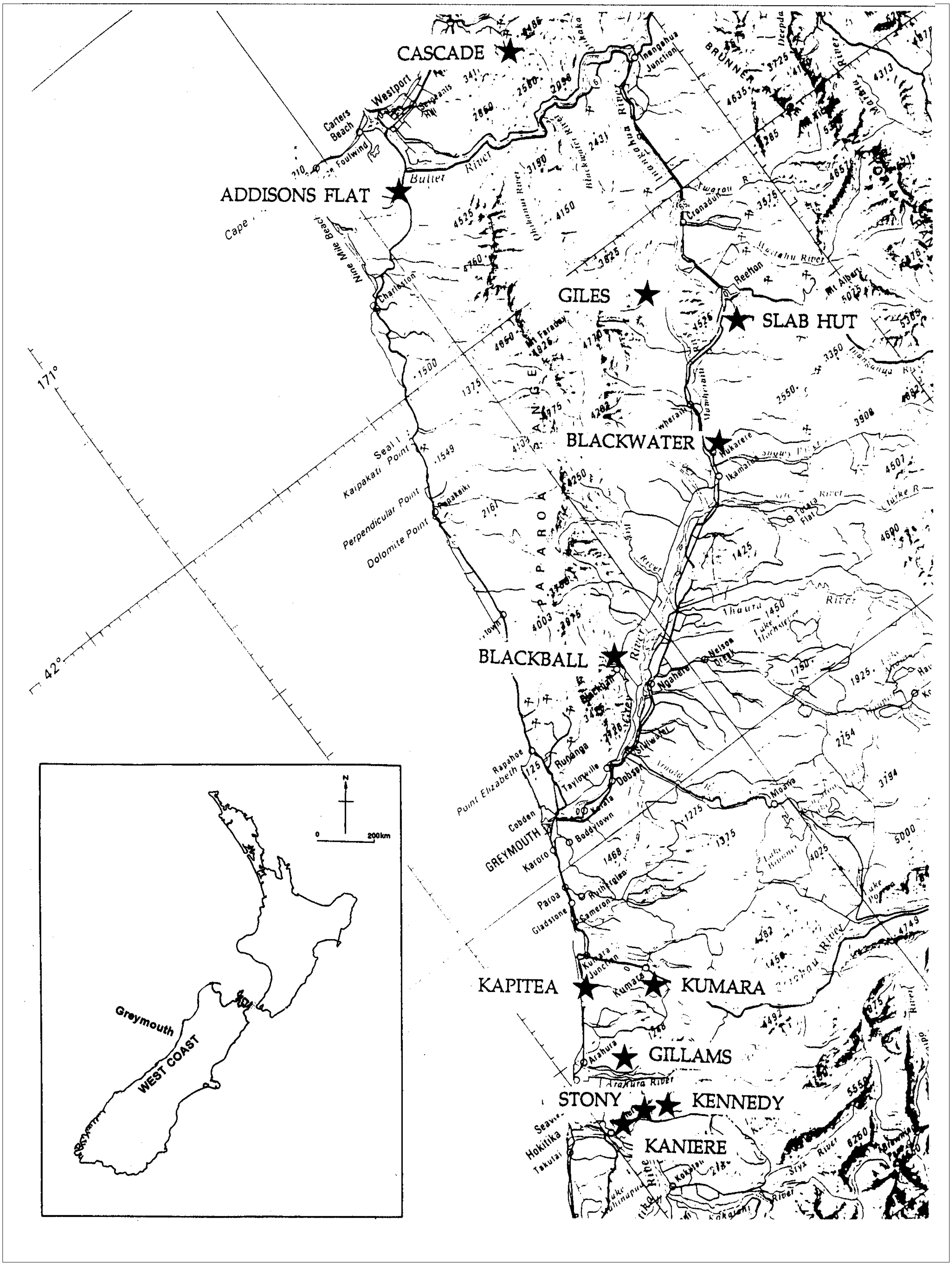

FIGURE 1. MAP SHOWING THE LOCATION OF THE MINING SITES SELECTED FOR DETAILED EVALUATION, WEST COAST REGION.

determined, and vegetation cover and height were described, as were the condition of waterways and ponds. We determined whether animals were present on site and whether there were any measures in place to control them if this was necessary. We also noted whether any wildlife habitats had been specially created.

4. *Adequacy of land rehabilitation to meet DoC policy.* This section was also completed on site while the visual evidence could be assessed. An attempt was made to rank the rehabilitation standard achieved on a 5-point scale; excellent, good, fair, poor, very poor. Rankings were made on the basis of the quantitative evidence of rehabilitation recorded above and a qualitative assessment of environmental outcome: whether the site was improved, satisfactory or unacceptable. The factors ranked were: contouring, soil replacement, topsoil respreading, drainage, erosion control, sediment control, flood protection/waterways, revegetation, post-mining management, wildlife habitat and rehabilitation of temporary mining structures.

After the field assessment and file searching phases, we assembled all the data and compared sites, conditions and environmental outcomes so as to identify strengths and weaknesses to guide future DoC policy formulation on rehabilitation. We discussed current thinking with DoC staff in Hokitika and Wellington prior to production of this report.

3. Conditions prior to mining

3.1 MAIN SITES

Environmental conditions prior to mining at the 12 sites studied (10 gold mining, 2 coal) have been summarised from the evaluation forms in the Appendices, Section 9.1. The information is incomplete and of variable standard because, under current procedures, very few potential mining sites (except potentially very large operations or operations in extremely environmentally-sensitive areas) are surveyed in any scientifically acceptable way before mining. Environmental Assessment Questionnaires (EAQs) are usually inadequate, incomplete or both.

Table 1 is a matrix diagram showing sites in relation to landform and former vegetation cover. Of the 12 sites, slightly more than a third are on river flats and the lowest terraces, mainly reflecting the current alluvial gold mining situation in the region. Of the total number of mining sites supplied to us by DoC, about half were from river flat/lowest terrace situations. Much of the former vegetation cover on such sites had been previously logged-over and was regenerating to varying degrees prior to mining. Second-growth beech/podocarp forest had been present at Slab Hut (Maori Gully), Blackwater, and part of the Blackball site, and second-growth podocarp/hardwood forest with some gorse and scrub at Kapitea and Kennedy Creek.

TABLE 1. MATRIX DIAGRAM SHOWING SITES VISITED IN RELATION TO PHYSIOGRAPHIC POSITION AND BROAD VEGETATION TYPE.

	River flats/ lowest terraces	Fans	Low terraces	Intermediate and high terraces	Steepland
Beech/Podocarp Forest - Primary				Part BLACKBALL (G)	Part CASCADE (C)
Beech/Podocarp Forest - Second Growth	BLACKWATER (G) SLAB HUT (G) Part BLACKBALL (G)			GILES (C)	Part CASCADE (C)
Podocarp/ Hardwood Forest - Second Growth	KAPITEA (G) KENNEDY (G)	STONY (G)	Part KANIERE* (G)	KUMARA (G)	
Pakihi Vegetation				ADDISONS FLAT (G)	
Pakihi Vegetation with regenerating Podocarp patches				GILLAMS GULLY (G)	

(G) gold (C) coal *area of concern to DoC

Soils on the river flats and lowest terraces were comparatively simple prior to mining, being mainly recent soils (topsoils over little-weathered sands, silts and gravels), with some weakly developed yellow-brown earths (as above, but with light yellowish brown subsoils). Natural fertility would have been moderate in comparison with older soils on higher terraces.

About a quarter of the 12 sites examined were on intermediate or high terraces, mainly glacial outwash, but one marine. These proportions compared well with the 20% of such sites in these categories in the total list supplied by DoC. Primary beech/podocarp forest is thought to have covered both the terrace scarp and intermediate terrace at Blackball (with more podocarps on the terrace). A terrace of similar height at Kumara formerly carried second-growth podocarp/hardwood forest with patches of gorse and moss on old tailings. Low pakihi vegetation with some gorse occurred at both Addisons Flat and Gillams Gully sites, although there were also patches of regenerating podocarp forest at the latter.

Soils on the generally flat intermediate and high terraces were highly variable prior to mining, particularly in texture, colour and mineralogy. Their common features were poor drainage, very low natural fertility, and broad classification as gley podzols (except for one gley soil). Poor drainage had resulted from silts over gravels, uniform particle size (sands), and very high rainfalls, with iron pans formed in subsurface horizons further impeding drainage after formation in the different soils.

Two sites were examined on low terraces: Giles, where the tall beech/podocarp forest had been selectively logged for rimu; and Kaniere, where the terrace

scarp had formerly carried second-growth podocarp/hardwood forest, with poor pasture, some flax and rushes in the swampy area.

The Giles site formerly had yellow-brown earths (well drained soils with yellowish brown, structured subsoils over gravels and sands) and recent soils on it. At Kaniere, the terrace and swamp are thought to have had stony, poorly drained gley soils beneath their surfaces, with well drained yellow-brown earths on the terrace scarp.

The remaining two sites were single examples of types: Stony Creek, mainly on a sloping fan in second-growth podocarp/hardwood forest; and Cascade, on very steep valley head slopes covered by a mixture of primary and second-growth beech/podocarp forest. The previous soil covers at both sites were difficult to determine because of the complexity of the mining sites and surroundings, but they appear to have been mainly well-drained recent soils from gravels and sands on the fan, and podzolised yellow-brown earths of low natural fertility on the steep slopes. The latter soils appeared to be derived not only from coal measures rocks but also in part from granite gravels in one place and greywacke fossil scree in another.

3.2 SUBSIDIARY SITE - COASTAL SAND COUNTRY

A single coastal sand dune site (Mananui, Mahinapua Scenic Reserve, south of Hokitika) where mining had not been carried out was visited to examine landforms, vegetation cover, soils and stability. The rolling foredune, which had been eroded by the sea and by human traffic, had a cover mainly of gorse, flax, blackberry, whiteywood, some grass and a *Muehlenbeckia* species, probably *complexa*.

Soil development was minimal, comprising 10 cm of very dark grey humic sand topsoil over unweathered blacksand-rich sand. Scattered small wind-shorn totara trees occurred in the inland shelter of this dune, with flax in interdune hollows. Larger totara, together with rimu, miro and hinau overtopped mahoe, pigeonwood, kamahi and supplejack forest on a succession of older dunes with increasingly mature yellow-brown sand soils inland towards the main road. Subsoils of yellow-brown sands are yellowish brown and may have some structure.

3.3 FORMER LAND USES

Three-quarters of the sites examined were mainly former State Forest or Crown Land from which either some tree species or the whole forest had been logged at some stage in the past. On most of these sites, forest regeneration was at varying advanced stages prior to mining. Remaining sites were either used for extensive grazing or were unused awaiting some form of development before they were assigned to DoC.

4. Standard mining licence conditions

The general mining licence conditions imposed before the Resource Management Act 1991 (RMA) specified the legal requirements of miners and, in theory, governed what miners were expected to do in regard to land restoration.

Primary responsibility for setting mining conditions and for imposing bonds was with the Minister of Energy, operating through the Mines/Coal Mines Inspectorate. Mining conditions, with respect to the sites in this review, were imposed under Section 105(5) of the Mining Act 1971 for the gold mining operations and Section 41 of the Coal Mines Act 1979 for coal mines. For the sites visited, Mining Licences were granted over a period of almost a decade (1980-1988) and this spanned a number of somewhat different 'Standard Mining Conditions'. In addition, the restoration requirements for coal mining were different from those for gold mining. However, for all of the licences there had been a general set of imposed conditions which had common land restoration specifications, as presented below.

4.1 FORMER MINISTRY OF ENERGY

Alluvial gold mining

"REHABILITATION OF DISTURBED AREAS

Clause 10. In all mining operations where disturbance of topsoil takes place any topsoil present shall be progressively stripped and stockpiled so as to prevent movement into watercourses. During operations any tailings are to be progressively returned to worked areas and generally levelled off. Any fines (less than 15 mm diameter) screened from the workings and any topsoil previously removed shall be progressively respread over the relevelled areas. On the completion of the operations disturbed areas shall where appropriate be sown out with seed and fertiliser or revegetated to the satisfaction of the Inspector of Mines after consultation with the landowner/occupier.

Clause 11. The maximum surface area to be disturbed by mining and associated works and which has not been fully restored as required by the conditions of this licence to the satisfaction of the Inspector of Mines shall not exceed five/two hectares at any time unless otherwise approved by the Inspector in writing."

Additional conditions

1. Some conditions specified that "...any disturbed area shall be sown out with seed and fertiliser to Ministry of Agriculture and Fisheries recommendations".

2. For several sites lime, fertiliser and seed were specified in detail: e.g. 32-2015 Addisons Flat, Westport:

   "Unless otherwise instructed, regrassing is to be carried out in spring of each year and the following lime, seed and fertiliser to be applied:

   750 kg/ha Westland Pakihi Starter Fertiliser
   3.75 t/ha lime
   Seed mix 18 kg/ha Nui ryegrass, 1 kg/ha Kahu timothy, 3 kg/ha Huia white clover
   All seed to be coated, clover seed to be inoculated also, all weights net before coating.

3. Additional clauses applied to 32-911 Kaniere:

   "Revegetation shall be maintained and if necessary repeated until a standard has been achieved satisfactory to the Inspector of Mines in consultation with the landowner/occupier.

   The disturbed area is to be fenced with sheep proof fence and restored areas are to be progressively returned to the landowner/occupier."

4. Similar clauses to 3. also applied to 32-2356 Stony Creek. In addition, the conditions of this licence specified:

   "Any area of Crown Land within the licence area which is not to become part of Kaniere Farm Settlement, and which adjoins State Forest, is to be fertilised and planted in exotic trees to the satisfaction of New Zealand Forest Service."

5. Where pastoral farming was the post-mining land use, some licences specified that the contours match the surrounding land "...and (be) left so as to be easily negotiable by any normal wheel tractor."

6. More recent licence conditions (e.g. 32-2356 Stony Creek) specified the submission of Annual Work Plans which required considerably more detail on land restoration plans than was covered by the Standard General Mining Conditions.

7. The maximum area of disturbance at any time, where specified, was either five or two hectares.

Coal mining

"RESTORATION

Clause 24. In all mining operations any topsoil shall be progressively stripped and stockpiled so as to prevent movement into watercourses and shall be progressively respread on to backfilled areas and revegetated to the satisfaction of the Inspector of Coal Mines in consultation with the landowner/occupier.

Clause 25. The licensee shall ensure that overburden be replaced and graded so as to conform to existing slopes in the area with a maximum permitted slope of one vertical in five horizontal. If required by the catchment authority, in order to limit runoff velocities across restored slopes, contour drains shall be formed across the slope at the specified intervals.

Clause 26. The licensee shall ensure that, after final grading and before replacement of topsoil, the graded land be scarified or otherwise treated in order to prevent overcompaction, to eliminate slippage surfaces and to aid root penetration.

Clause 27. The licensee shall ensure that restoration of the area is done on a progressive basis and that a revegetation programme be submitted for the approval of the Inspector of Coal Mines in consultation with the Minister of Agriculture and Fisheries and catchment authority and local Conservator of Forests.

Clause 28. The licensee shall ensure that all surface drainage from areas disturbed during mining operations including the overburden dump and stockpiles and rehabilitated land, shall be passed through a sedimentation pond or series of sediment ponds before leaving the licence area.

Clause 29. The licensee shall ensure that sedimentation ponds and other treatment facilities be maintained after mining has ceased until the disturbed areas have been rehabilitated and revegetated to the satisfaction of the Inspector of Coal Mines in consultation with the catchment authority.

Clause 30. All excavations including trenches, boreholes, pits, shafts or similar surface disturbances made to the surface of the land while mining shall be plugged and filled in to the satisfaction of the Inspector of Coal Mines and local Conservator of Forests immediately after mining operations have been completed but before expiry of the licence.

Clause 31. The licensee shall on completion of operations, and prior to expiry of this licence, remove from the area covered by the licence, all implements and machinery, or associated equipment used in the mining operations unless otherwise directed by the Inspector of Coal Mines in consultation with the landowner and/or occupier."

Additional conditions

For 37-108 Giles Creek Coal Mine there was a requirement to pull and burn, or otherwise dispose of, scattered ragwort in order to prevent its spread.

4.2 CONDITIONS IMPOSED BY OTHER AGENCIES

Associated with the mining conditions administered through the Minister of Energy, other agencies imposed their own conditions regarding land restoration. These were the former Westland Catchment Board, the former New Zealand Forest Service, and the former Department of Lands and Survey.

Restructuring of government departments and associated changes in administrative functions has meant that these historical conditions have now become the responsibility of DoC - in some instances for only specified areas within the mining licences now under DOC stewardship, and for others the entire licence area.

New Zealand Forest Service

NZFS Standard Conditions generally specified the following:

"Clause 8. LAND RESTORATION

The licensee shall, as directed by the Conservator, remove or level all waste, or level all tailings and other material arising from the licensee's operations and shall where required replace topsoil so as to make the land suitable for afforestation or other forest management. Detailed requirements for restoration and revegetation are included as special conditions of this consent."

On some of the licences, Special Conditions were imposed:

"SPECIAL CONDITIONS

Clause 12. A bond in the name of the licensee is required as security against non-compliance with the terms and conditions of this consent and to guarantee compensation to the Minister of Forests for damage to land and forest values caused by, or resulting from, the licensee's activities. The amount which will be required will be determined by the Conservator on consideration of the work plan required under Condition 1 of this consent and may be varied by the Conservator if variations to this work plan are approved.

The amount of bond required to cover forest and land values on the entire licence area during the term of the licence is estimated to be up to $x.

Clause 13. The licensee shall not cause damage to stream banks and the protective vegetation thereon during his operations under this consent.

Clause 14. The licensee shall protect from damage any site defined by the Conservator and identified to the licensee as being of historic value or of particular ecological value.

Clause 15. The licensee shall, after consultation with the Conservator, and as directed by the Conservator work the licence area in a sequence that causes minimum disturbance to afforestation and other forest management activities.

Clause 16. Where required by the Conservator, the licensee is to strip and stockpile topsoil (i.e., A and 0 soil horizons) ahead of mining or prospecting operations.

Clause 17. The licensee shall ensure that fines are mixed with coarse tailings either before or during levelling and such levelling creates slopes of not more than 12 degrees.

Clause 18. The licensee shall, if the Conservator so requires, respread topsoil evenly over the levelled tailings and leave it in a smooth but not excessively compacted condition.

Clause 19. Following restorative measures, revegetation to the specifications of the Conservator is to be implemented by the licensee at his own expense. If required, the Conservator will provide the licensee with a written prescription indicating the revegetation required which may include the establishment of a suitable nurse crop to encourage the regeneration of native species.

Clause 21. The licensee shall use settling ponds to ensure that there is no downgrading of the existing water supply.

Clause 22. The licensee's machinery and method of operation must meet the Conservator's requirements before operations commence and during operations, in order that the maximum recovery and best distribution of fines is achieved."

For some mining sites (e.g. 32-1588 Slab Hut) documentation of specific revegetation requirements from the Mines Inspection Group of the Ministry of Energy and/or DoC to the miner recorded species lists and planting techniques to be used. These specifications were imposed under Clause 19 of the NZFS Special Conditions and Clause 10 of the Standard Alluvial Mining Conditions.

Personal communications between DoC staff and miners on revegetation measures had occurred at some sites where the original revegetation specifications later became inappropriate. Some verbal agreements had been reached, but it was considered undesirable by the study team to record such agreements as they had no legal standing.

Department of Lands and Survey

Department of Lands and Survey Conditions generally required the miners to return the land to pastoral farming. Therefore, the requirements for recontouring, topsoil respreading, fertiliser and lime application rates, and seed mixtures/seeding rates, etc., were specified either generally (e.g. "grassed with a seed mix recommended by the Department of Lands and Survey") or in detail (e.g. "with a fertiliser input of 2.5 tonne/ha lime and 750 kg/ha superphosphate") with pasture as the specified vegetation.

Catchment Board

Catchment Board Conditions were not seen for any of the mining sites examined in this study except one. The following conditions were imposed on licence 32-2004 Blackwater River:

(a) Topsoil was required to be stripped and stockpiled ahead of mining. Tailings were to be progressively returned to worked areas and generally levelled off. Any fines (<15 mm) and topsoil previously removed "shall be progressively respread over the re-levelled areas".

On completion of mining operations, disturbed areas "shall, where appropriate, be sown out with seed and fertiliser to MAF recommendations or to the satisfaction of the Inspector of Mines".

(b) On completion of mining operations, any fine spoil "shall be spread over disturbed areas which shall be levelled off, oversown and topdressed to MAF recommendations".

(c) All access tracks and batters "shall be maintained in a stable condition and oversown and topdressed if required".

(d) Adequate drainage "shall be provided on all access tracks and benches to prevent erosion of any adjacent land".

These conditions tended to be similar to, but not necessarily the same as, those imposed by the other agencies.

4.3 SUMMARY STATEMENT

This review has highlighted a confusion of imposed mining licence conditions. This confusion was partly caused by the array of different agencies involved and partly by the administrative changes which occurred over the duration of the licences. In some cases the conditions had given the miners reasonably consistent land rehabilitation specifications, but in others there had been a considerable degree of inconsistency.

Current regulating authorities for land use consents for mining, which specify land rehabilitation requirements under the Resource Management Act 1991, are centralised in the regional and district councils. DoC, as custodian of the government's conservation estate, has an input into imposing conditions on mining operations.

5. Site assessment after mining

We considered both compliance with specified, written conditions attached to the mining licence, and an assessed environmental outcome based on what was seen as a desirable end point by DoC staff.

Because of the complex situation which developed as a result of an organisation (DoC) with different objectives from the former state owner (New Zealand Forest Service or Department of Lands and Survey) taking over land in the course of mining, however, it is difficult to give a definitive answer to the question of whether the mining conditions were adhered to in many instances.

5.1 WERE THE MINING CONDITIONS MET?

At sites where mining was ongoing (Cascade, Giles, Kennedy, Kaniere, Stony) it was only possible to note whether the miners were going through early stages of meeting mining conditions, such as separately stockpiling topsoil, settling sediment from water, etc., although at Giles, Kaniere and Kennedy there were completed or partially completed areas.

At 4 of the 12 sites we visited the specified mining conditions were being or had been met to a major degree (Appendices, Section 9.2). At a further 4 sites there had been only minimal compliance with the conditions and, usually, a long file history of attempts by various agencies to enforce compliance. The remaining sites were gradational between the two extremes, and in all 4 instances local DoC staff were in contact with the miners.

The sites where conditions were largely met were Kapitea, Kennedy, Stony and, to a lesser extent, Giles. Sites with minimal compliance were the major part of Blackball, Blackwater, Kumara, and Gillams Gully. Of the other 4 sites, the Cascade opencast coal mine was at an early stage, but there had been no soil stockpiling; at Addisons Flat the miner had undertaken to further level and

respread materials which were left after mining; at Kaniere the company had recently made attempts to comply with DoC requests; at Slab Hut correspondence indicated that the miners were assisting with revegetation, as their bond had not been released.

It appeared that the 2 or 5 hectares maximum area of disturbance by mining (Clause 11 of the Standard Mining Conditions) had not been adhered to at a number of the sites visited. However, it was not known whether the Inspector of Mines gave written approval for these departures.

For most of the sites we examined the original mining conditions specified a final site that was to be sown down to pasture (exceptions were: Cascade, no vegetation type given; Giles, part Slab Hut, and part Blackwater, back to "original condition"). With the transfer of land to DoC, that organisation has approached miners to seek their assistance to produce environmental outcomes more in keeping with the surrounding environment, except for Kennedy, which will revert to a grazing licence area.

5.2 ENVIRONMENTAL OUTCOMES

We attempted to assess environmental outcomes only for sites where mining had been completed and in terms of DoC philosophy as to what was a "desirable outcome" for particular sites. Discussions with DoC staff in Hokitika and Wellington showed that there was a wide range of views within the organisation as to what was the most desirable environmental outcome, in a general sense, after mining. The range was from the ultimate restoration of tall forest, where that was the forest cover that previously existed, on landscapes and soils closely similar to those prior to mining, to establishing a vegetation cover and landscape that fitted into the regional context, but in which the species were not necessarily those that formerly occupied the site. The concept of "trading" sites (now equivalent to "mitigation" in the RMA context) was also discussed, where a current grazing licence area might be exchanged for a mined site rehabilitated to pasture, and the old grazing area planted in, for example, kahikatea. Some of the common results of alluvial gold mining, and to a lesser extent, coal mining, such as ponds, could be viewed as desirable in that they diversified the habitat, or undesirable in that they altered a formerly natural balance.

The importance of maintaining genetic variability also needs to be considered. This can only be done if rehabilitation is achieved using indigenous species from the immediate area (Ecological District) of the site. Although nursery-grown stock from other regions may grow more vigorously than local seedlings, their introduction causes genetic dilution and should be avoided. Exotic species which could be used as cover crops or which are adventitious must be carefully evaluated in terms of their potential for suppressing or competing with indigenous species, as against their ability to control erosion rapidly by limiting topsoil loss or loss of other fines.

In our opinion, for the majority of the 10 sites that we visited where mining was complete or partially completed, the environmental outcome at the time of the visit was unacceptable, although there was at least limited compliance with the specified mining conditions at all but 4 sites. We emphasise "at the time of the

visit" because personal communication from DoC regional staff implied at least verbal agreements with miners to improve final environmental outcomes, even though machinery was no longer on site in several instances.

The only completed site where the environmental outcome was considered satisfactory was Kapitea, although Kennedy, which was incomplete but in an advanced stage of rehabilitation should be satisfactory eventually.

Reasons why so many sites were rated unacceptable were varied and complex, but could usually be attributed to failure to comply with at least one of the specified conditions for rehabilitation. Sites formerly flat were left steeply sloping, tailings and spoil heaps were unstabilised and/or bouldery, drainage conditions were altered, unsuitable seedlings had died, a pond was polluted by oil.

One of the most common reasons for a poor rating was failure to separately strip, stockpile and respread topsoil.

At Blackball, Gillams Gully and Kumara, all the above applied except the oil pollution, no seedlings were planted, and there had been some flattening of tailings at each site to make an access road. At Giles, Slab Hut and Blackwater, the tailings had been satisfactorily levelled for the most part, but either no soil had been spread, leaving stony and/or bouldery surfaces, or small amounts of soil material had been mixed with stones and overburden, thus limiting revegetation potential, at least in the short term. At the part of Kaniere of concern to DoC, the slope of the tailings bank had been reduced and seed planted to stabilise it, but the lack of soil both on the bank and the flat area at the foot would not aid regeneration of vegetation. Attempts at revegetation had been made at Giles on materials in which some soil had been mixed in some places. Exposure, unusually dry conditions, and the use of relatively old, bare-rooted stock were probable contributory factors to the high death rates of the beech seedlings there: 100% on coal measures overburden alone, 80% on bare mixtures of overburden, gravels and some soil, and 35% on similar mixtures covered by pasture (based on 20 tree counts, each area). At Addisons Flat the environment had been somewhat enhanced by the creation of several ponds, but there has been only limited flattening and respreading of materials, some of which were unstable. The miner had undertaken to carry out further work.

In assessing the 10 sites where mining was either complete and/or some serious attempts had been made towards achieving a satisfactory or improved environmental outcome, we incorporated the range of views expressed by DoC at the start of this section as well as our own assessments. Thus we considered Addisons Flat in terms of a return to pakihi vegetation with poor drainage, not to the podocarp forest which probably occupied the site prior to gold mining in the last century. Also we considered the Blackwater clearing in beech forest in terms of a return to similar forest in as short a time as practicable. Other options could be available, but are not discussed here.

6. Suggestions for improvement

6.1 ESTABLISH DESIRED MINING OUTCOMES

A necessary precursor to improving the requirements and enforcement procedures within mining conditions as they apply to land under DoC stewardship is for DoC to define the outcome or range of outcomes it requires after mining in the future. There has been considerable confusion because changes in land allocation have resulted in changes in desired end uses of land. Much of the alluvial mining of the 5 years prior to 1989 in what is now the DoC estate had been on or close to river flats and terraces where older mining was formerly carried out. Thus many of the soils, landforms and forest types had been previously disturbed. Despite this, it has been shown that some operators have been capable of relatively successful rehabilitation (Kapitea, for example) by adhering closely to mining conditions and additional advice.

The field of indigenous ecosystem rehabilitation is still relatively new in New Zealand. As a result of education and inspection to ensure mining conditions are met, considerable success is now being achieved with pasture and exotic forest re-establishment after alluvial mining on the West Coast. Only limited and largely uncontrolled trial work had been carried out prior to 1989 to re-establish indigenous vegetation after mining; new work is proposed in Section 7. An essential prerogative of such work is a knowledge of the site conditions prior to mining.

6.2 ENSURE THAT PROSPECTIVE MINING SITES ARE ADEQUATELY CHARACTERISED

While the stripping of topsoil can be a relatively simple matter in an established farming situation, and procedures for producing adequate pasture are well known, indigenous ecosystems are much more complex and may be fragile. At the simplest extremes of description, both topsoils and subsoils vary in natural nutrient status, drainage characteristics, and the type of organisms they can support. Hence it is essential to characterise natural ecosystem sites prior to mining if there is to be any real chance of re-establishing anything like similar conditions after mining is complete.

We found difficulty in trying to reconstruct what prior conditions had been at several sites, particularly where mining was complete in narrow valley-bottom situations, and where no topsoil had been re-spread. The EAQs filled in by the prospective miners or their agents were found to be inadequate for establishing essential baseline information. Future conditions should specify standards for EAQs.

6.3 TAILOR THE MINING CONDITIONS TO THE DESIRED OUTCOMES

If mining conditions are to be adhered to, and if necessary enforced, it is important that there are clear guidelines for the miner from the start of the operation. Also the miner must understand the reasons why certain courses of action are required (further education of miners will be necessary).

We envisage two possible extreme pathways to outcomes:

1. *Restore as closely as possible to original condition as a long-term objective.*

   This would involve, at the least, separately stripping, stockpiling and re-spreading one or several layers of soil, depending on the age and complexity of the site, under carefully controlled conditions, and re-establishing the topography of the site as closely as possible. Re-vegetation will be discussed below. A change to the mining conditions would be necessary to: (a) ensure that a survey was carried out by qualified personnel to determine the soil and landscape pattern at a scale suitable for restoration planning prior to DoC approval to mine the land, and (b), to widen the existing mining conditions from manipulation of topsoil alone to include subsoil and possibly substrate layers.

2. *Produce a "designer-soil' to suit plant requirements as specified for particular sites by DoC.*

   This could be a short-term objective, as soil changes with time would be more rapid than if the original soil was largely returned. It should be possible to ensure subsequent good or poor drainage by manipulation of re-contoured underlying materials. We know this can be done to produce good drainage; research is required to check that poor drainage can be successfully induced. We recommend that the mining licence conditions should retain the requirement to separately strip, stockpile and re-spread topsoil; the underlying mix will depend on the drainage and plant requirements. Advantages of this approach are that it would probably be simpler for the miner and would allow DoC flexibility in deciding options prior to mining. Disadvantages are that, while simple soils (recent soils from river flats, sand dunes, etc.) could be relatively easily copied by "designer soils", the new system could require large inputs of fertilisers, lime, acidifiers and biotic components, as well as machinery time, in order to simulate more complex soil/plant systems.

6.4 SPECIFY THE TYPE OF VEGETATION REQUIRED AFTER MINING

This is extremely difficult to do at present because of the number of aspects requiring policy decisions and research, and the relatively long time requirement for growth of native forest to maturity. We also know that gorse infestation is a feature of many current mining sites; while it may act as a nurse

crop for many native species, it is not part of the natural succession, and may compete with more desirable species. The gorse mite, *Tetranychus lintearius*, recently introduced on a trial basis in several parts of the country, may offer a solution.

Some of the options for revegetation are:

1. *Allow natural regeneration from nearby seed sources.*

   Despite the work of Fitzgerald and Franklin (separate 1987 unpublished report for former Ministry of Energy), it is not known for sure that this will ultimately result in similar forest on site. They did not recognise the potential effects of large numbers of wild browsing animals in the latter part of this century or of major soil changes resulting from no soil restoration measures after early mining. However, early mining was not necessarily as disruptive to underlying materials as can be achieved by modern methods. The gorse competition factor needs investigation. Sites could be enhanced by soil replacement, weed suppression measures, and animal control.

2. *Plant sites with either nursery-grown stock or wildings.*

   Our observations suggest that this technique has been only partially successful to date, for various reasons, many speculative, but commonly because mining conditions of topsoil replacement after mining were not met. The negative effects of browsing animals on planted native trees were graphically shown in the Kennedy Creek area when stock got in to a fenced exclosure. Open bare sites present particularly difficult microclimatic conditions for the establishment and survival of some species of native seedlings planted in a similar manner to exotic trees. The Giles Creek plantings illustrate this point.

   There is an urgent need for research on establishing indigenous species on restored soils in attempts to speed up natural succession if ultimate high forest closely similar to that on or near the site is the desired objective. While much is known about planting and growing a variety of indigenous trees and shrubs, the re-creation of whole ecosystems is not well understood.

   Although we did not visit the South Westland beach and foredune sand mining sites, we did examine a soil and vegetation sequence at Mananui. Foredunes with recent soils (topsoils over unweathered sands) at such sites can be relatively easily restored provided that the sand can be stabilised quickly. A major DoC decision must be made on the desired vegetation after mining, as exotic weeds are present in most of the foredune sequences that we have observed (and contribute to their stability). Use of exotic plants such as marram grass and lupins to effect sand stabilisation, for example, has to be balanced against native plants (such as pingao, sand fescue, silvery sand grass) which may be more difficult to establish. The technology of using artificial protective matting materials to help initial stabilisation of exposed sand is a management option worth considering. Older dunes with more complex soils and vegetation would require revegetation research.

7. Research needs

Certain immediate research needs are apparent in view of the current variable success with attempts at replanting with indigenous species on both coal and alluvial gold mined sites, the possible requirements to return sites to close to original ecological condition before mining, and the largely unknown pathways if self-seeding from adjacent forest or re-spread organic horizons occurs.

7.1 NEED FOR A FOREST RESEARCH SITE

In our opinion, the most crucial situation to research is where there is a need to return a high forest site to that condition (i.e. ecology closely similar to original) as fast as possible after mining. Our reasons for this are:

1. New mining within the DoC West Coast estate is likely to occur in areas where either disturbance was less in the past, faster (or older) forest regeneration has occurred, or there has been no previous disturbance.
2. Previous Forest Service research on recreating indigenous forest was aimed at promoting specific tree species, either beech or podocarps, on a limited range of sites, and after relatively minor disturbance to underlying soils and materials.
3. There is little available information, other than hearsay, on the medium-term effects of competing exotic plant species and browsing animals on regenerating and planted indigenous species in the major West Coast ecological situations. Effects can be observed, but only in uncontrolled situations where original conditions are unrecorded or unknown.

The two high forest situations probably most likely to be potentially subject to mining are, in the broadest ecological sense, beech/podocarp forest and podocarp-dominated forest, with the former more likely than the latter.

Of the sites we examined, the Giles Creek coal-mining site appeared to offer some possibilities for future research. Although it is coal rather than gold mining, it is a well drained low terrace situation and the mine is moving into tall (but cutover) red and silver beech forest on yellow-brown earths in which we consider the subsoil as well as the topsoil as an important resource. Terrace gravels overlie the coal measures. There would be a need to carry out a semi-detailed soil and general ecological survey of the area as a basis for any new research trial.

The other possible site, but which has lower potential, was alongside the current Cook's gold mining operation on the poorly-drained intermediate terrace near Greenstone Road, Kumara. Although we did not examine this operation as part of the study, it is ongoing and appeared to be about to move into second- growth podocarp forest with mixed hardwoods. Soils are mapped as Maimai gley soils, but would need verification and close examination if part of this area were to be selected for a research trial. Similarly the vegetation and

general ecology should be adequately categorised. We do not know at this stage what vegetation is required after mining on this site.

7.2 NEED FOR A PAKIHI VEGETATION RESEARCH SITE

In previous research proposals to DoC (1988, 1989), we identified a need to research the revegetation of pakihi soil sites after mining, including the re-establishment of wet, very low fertility soils. Our study shows that this need is still evident, as at both the sites formerly with partial pakihi vegetation present, current site conditions are unlikely to result in such vegetation re-establishing itself naturally. With suitable earthmoving machinery, it might be possible to set up a restoration trial at the abandoned Gillams Gully site, or, a possibly better alternative would be to characterise a site in advance of the ongoing Addisons Flat gold mining operation near Westport.

7.3 NEED FOR MONITORING CURRENTLY REVEGETATING SITES

Although base data are patchy or lacking, there would be some advantages in monitoring natural regeneration in the presence of exotic weeds, both with and without animal control measures, as a basis for comparison with the other trial(s). The site we visited that was best suited to this purpose was Kapitea (seaward site). A genuinely stock-proof exclosure would need to be erected and a marked, comparable site established nearby. Podocarp/hardwood forest, in competition with (or assisted by?) gorse is the likely future vegetation type on this site. A similar experiment might be set up in the forest clearing at Blackwater (red/silver beech), although there is no topsoil or litter on the latter site, and gorse is already partially established.

7.4 POSSIBILITY OF COMPLETELY NEW RESEARCH SITES

All of the above-mentioned sites have the advantages and disadvantages discussed. The most obvious disadvantage is that mining is progressing and time for forward survey, base-line studies or site evaluation is short. Hence completely new sites should not be discounted. Scientifically rigorous environmental studies (soils, vegetation, wildlife, hydrology) before mining would provide a sound basis for evaluating the effects of mining and land restoration treatments on the ecosystem. This is particularly pertinent given the generally inadequate data on the EAQs submitted by the miners. Large-scale and progressive sites are to be preferred. The Mikonui gold dredging operation should be kept in mind as a possibility for the replacement of dune and swamp soils and vegetation after mining.

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9. Appendices

9.1 SUMMARIES OF ENVIRONMENTAL CONDITIONS

[C] Mining completed. [O] Mining ongoing.

ML number, Mineral	Name of miner or company, Location	Former vegetation cover	Landform
37-096 Coal [O]	Cascade Mining Ltd., Cascade Creek	Beech/podocarp forest, mature and pole stands up to 10 m high; latter include kamahi, quintinia.	Very steep slopes into valley head.
32-2015 Blacksand mining-gold [O]	Aotea Minerals Ltd., Addisons Flat	Pakihi vegetation with some gorse, flax, rushes etc.	Marine bench/old intermediate terrace.
37-108 Coal [O]	Dunollie Coal Mines Ltd, Giles Creek	Beech/podocarp forest - some previously logged.	Low alluvial terraces and creek bed. Toe slopes of adjacent hill country.
32-1588 Gold [C]	Prodigal, Slab Hut (Maori Creek)	Logged over beech/podocarp forest with patches of gorse and bracken.	Narrow valley bottom - formerly 2 low terraces separated by 3 m scarp.
32-582 Gold [C] 32-1934 21-2004*	Owen. Andrews *McLennan,McLennan &Baynes (area mined by G. Piner), Blackwater River	Pasture *Red and silver beech/ podocarp forest.	Terraces, *small valleys and toe slopes of hill country; part of low terrace.
* Includes forested area of concern to DoC			
32-1651 Gold [C]	Huston, German Gully, Blackball Creek	Scrub and gorse on river flats, beech/podocarp forest on steep slopes and old terrace.	River flats, terrace scarp and old, high terrace remnant.
32-1108 Gold [C]	R.E. Russ, Kumara	Scrub consisting of kanuka, kamahi, tree ferns, with possibly some gorse, mossy areas.	Former terrace and lower slopes of moraine ridge. Some areas of rolling tailings.
32-2746 Gold [C]	Smith and McDonnell, Kapitea Creek	Regenerating podocarp/hardwood forest, scrub and gorse.	River flats and low terraces.

PRIOR TO MINING

Former soils	Underlying materials	Former land use(s)
Millerton steepland soils (podzolised yellow-brown earths); some yellow-brown earths from granite gravels.	Brunner coal measures; sandstones, carbonaceous shale, coal. Also fossil scree deposits and some granite gravels.	State Forest partially logged over for pit props 30-40 years ago, now regenerating.
Charleston and Addison gley podzols.	Terrace gravels over marine gravels and sands (Terangi Interglacial).	Old mining area with workings, ponds, gravel heaps. Mostly derelict pakihi land in between.
Ikamatua yellow-brown earths - smaller areas of Hokitika (recent soils) and Ahaura (YBE). [Miner plans to move into Ahaura soils.]	Taranaki Series (Tertiary) Coal Measures overlain by post-glacial alluvial gravels and sandy alluvium.	State Forest
Thought to have been Ikamatua yellow-brown earths.	Post-glacial alluvium and some colluvium from Old Man Gravels; greywacke, some granite and schist.	Unused State Forest which had been logged for podocarps.
Okarito (gley podzols) and Ikamatua (YBE) on terraces *Blackball hill soils and Mahoney steepland soils in hill country, both yellow-brown earths.	Terrace - Waimean glacial outwash gravels (mostly greywacke with minor component of schist and granite). *Hills-Old Man Gravels with a fine sandy matrix.	Pastoral farming. *State forest - formerly cut-over. Some old gold workings.
Hokitika (recent soils), Ikamatua (yellow-brown earths) on river flats, Mawhera, Okarito (gley podzols) on terrace, Deadman hill soils (yellow-brown earths) on scarp.	Post-glacial alluvium; greywacke with some granite, below river flats, and Loopline Formation glacial outwash gravels below loess on terrace and scarp.	Unused State Forest and Crown Land on slopes and terrace; river flats cleared and reverting; rough grazing?
Thought to have been Maimai gley soils on terrace, Hochestetter hill soils (yellow-brown earths) on lower slopes.	Loopline glacial outwash gravels; mainly greywacke with some granite. Moraine of similar age on adjacent ridge.	Unused Crown Land. Part had been formerly mined for gold in the 1870s.
Harihari gleyed recent soils on river flats. Maimai gley soils and Kumara gley podzols on terraces.	Alluvial gravels (Holocene) beneath river flats. Loopline outwash gravels beneath low terraces.	Rough grazing and derelict (State Forest).

ML number, Mineral	Name of miner or company, Location	Former vegetation cover	Landform
32-1202 Gold [C]	M.H. & R.A. Ferguson, Gillams Gully Road	Regenerating podocarp forest (rimu, kahikatea, kamahi) with patches of gorse, manuka and low pakihi vegetation.	High level terrace and possibly some fan.
32-911 Gold [0] 32-2547	Platinum Metals, Tucker Minerals, Kaniere	Pasture and rushes; patches of regenerating podocarp/hardwood forest; flax and swamp vegetation; some *Pinus radiata.*	Two terrace levels separated by scarp. Moraine ridge to east.
32-2356 Gold [0]	Johnson & Godfrey, Stony Creek	15% pasture, 25% gorse, 50% cutover podocarp/hardwood regenerating forest, 10% pakihi vegetation.	60% fan, 20% terrace, 15% river flats, 5% toe slopes of adjacent hill country (moraine).
32-2544 Gold [0]	L & M, Kennedy Creek	75% scrub (mostly gorse) and regenerating podocarp/hardwood forest, 15% cutover podocarp/hardwood forest, 5% rough pasture, 5% swamp.	River flats (creek in valley) and adjacent low river terraces.

Former soils	Underlying materials	Former land use(s)
Okarito and Mawhera gley podzols; possibly some Kamaka gley soils.	Loopline Formation glacial outwash gravels and varved silts; rock types in gravels are greywacke, granite and some schist. Partial loess cover over gravels.	Unused or extensive grazing. Partial native forest regeneration and wildlife habitat.
Maimai gley soils on terraces, possibly with some Rotokohu organic soils. Flagstaff (gley soils) and Hochstetter (yellow-brown earths) on moraine. Deadman (YBE) on scarp.	Moana Formation glacial outwash gravels; greywacke and schist, some granite. Moraine of similar age and rock types. Patches where schist very common.	Pastoral farming, wildlife conservation habitat, exotic forestry.
Turiwhate recent soils on fan. Maimai gley soils and Kumara gley podzols on terrace. Moana podzols on moraine.	Cockeye Formation glacial outwash gravels and moraine (Waimaungan) - mainly greywacke with minor granite and schist.	Part (10%) pastoral farming (sheep and beef) - Landcorp. Most (85%) unused; pakihi land (possibly used for sphagnum collection) and some unused cutover indigenous forest.
Hokitika recent soils on river flats; Kumara gley podzols on terraces.	Holocene river gravels. Loopline Formation glacial outwash gravels on terraces, with some loess. Mainly greywacke with some granite and schist.	Rough grazing (sheep & beef), mostly in lower reaches of the valley. Regenerating cut-over podocarp-hardwood forest.

9.2 ASSESSMENTS OF LAND REHABILITATION

[C] Mining completed [O] Mining ongoing

ML number, Location	Revegetation, Wildlife habitat	Contouring	Soil replacement, Drainage
37-096 Cascade [O]	Very poor to date. Bare overburden dumps which will be moved to back-fill excavations	None to date	Very poor; no separate stockpiling of soils or surrogate materinls
32-2105 Addisons Flat [O]	Reveg. - Very poor. None done to date Wildlife - Fair. Ponds created but few perimeter plantings (e.g. flax) Pakihi vegetation not re-established	Good. Mainly rolling and in keeping with the previous landscape of the site.	Soil replacement - Poor. Very little soil replaced - most appears to have been used to construct pond embankments. Drainage - Poor. The formerly poorly drained site is now well to excessively drained (better for agricultural development but not for pakihi re-establishment)
37-108 Giles Crcek [O]	Reveg. - Poor. High percentage of silver beech seedlings (winter 1988 planting - 3–4 year old bare-rooted stock from Totara Flat nursery) have died on exposed sites. Only approx. one-third of the area of rehabilitated ground has a reasonable vegetative cover - grass and weeds from an unspecified seeding with ryegrass (no fertiliser). Wildlife - Very poor. Predominantly bare, open ground.	Good. Short slopes, not too steep	Soil replacement - Fair to poor. Insufficient soil materials available from early mine workings. Recovering soil now. Too much mixing of materials (topsoil, subsoil, overburden gravels and sands). 'Topsoil' has been respread on the surface in placcs but high stone and boulder content. Drainage - Good. Drains established and appear to be effective.
32-1588 Slab Hut [C]	Very poor to date. Some native plantings near creek. Some rush colonisation. Most of DoC land bare ground.	Good. Flat to hummocky ground surface probably similar to original.	Poor. Topsoils and subsoils mixed with wood and stones; many surface stones. Compaction will impede drainage along old road line.
32-582 32-1934 32-2004* Blackwater River [C] *Includes forested area of concern to DoC	*Reveg - Very poor. No efforts to date Pasture - Fair; about 12% of rehabilitated area has been sown in pasture - high weed content. Wildlife - Very poor. Bare, open ground.	*Good. Site is gently sloping away from steep faces. Pasture site - Very good. Smooth, easy rolling microtopography sloping back to the mined cliff face.	*Soil replacement - Very poor. No soil stripping or replacement. Pasture site - Fair. Approx. 25% recontoured ground has topsoil respread, further stockpiles of topsoil to be respread. *Drainage - Good. Sloping ground is well drained. Pasture site - Good. Well to excessively drained - better than original high terrace.

Erosion control, Sediment control	Flood protection	Environmental outcome	Mining conditions
Very poor, overburden heaps unstabilised; fines being lost by erosion	N/A	Not assessed, as mining at early stage; will need careful monitoring to ensure miner meets obligations	Some conditions not being currently met; no separate removal of topsoil. Sediment control is being carried out.
Erosion - Very poor. No revegetation or stabilisation of pond/ waterway embankments Sediment control - Fair. Ponds may trap sediment run off	Poor. No stabilisution of channel banks	Unacceptable. No revegetation. Pakihi re-establishment is unlikely. If left, the rehabilitated areas are most likely to become infested with gorse. Long-term regeneration of native podocarp - hardwood forest (as per old mining sites) may follow if fire can be prevented.	Not met. Specified conversion to pasture, but DoC has intervened as pasture now inappropriate. Work on the site is continuing.
Erosion control - Good. Only minor rilling of rehabilitated ground. Sediment control - Good. Most sediment being channelled into the mine hole.	Fair. Attempts made to stabilise re-aligned Giles Creek - with rock-filled railway wagons and rip-rap boulders. Erosion of side-casts into Giles Creek near the sandstone outcrop observed.	Unacceptable. Some revegetation attempts - small area seeded, larger area planted with silver beech seedlings but survival rate generally is low (open microsites, no slash, animals present). Soil stripping initially poor but is better under current mining operations. Mostly bare, open, exposed ground - relatively early stage in the mine development.	Miner making efforts. Specified revegetation to initial conditions (general clause).
Good. Site left mainly flat except for small areas of sidecasts with 25° slopes	Very poor. Minimal attempts to confine creek to channel line	Considered unacceptable, although company has agreed to pay for further native species plantings.	Only partially met; long correspondence on file in attempts to force miners to revegetate; some recent success.
*Erosion - Poor. No contour channels - potential for rill and gully erosion. Pasture site - Mostly good. Low erosion potential except for bare 35° sidecast down to Blackwater R. Sediment control - not applicable, mining completed.	Not applicable. May be minor flooding from uncontrolled side creeks out of hill country.	*Unacceptable - No soil replacement, no revegetation, bare, open site (likely to revert to gorse if left in present condition). Pasture area - unacceptable. Rehabilitation efforts incomplete - work is continuing and is on the right track.	Not met on DoC site - Topsoil not stripped and respread, no revegetation to date. Mines Inspectorate has made several requests for topsoil to be respread, the forested area to be fenced off, and this site to be sown with Maku lotus and beech seedlings (which may be taken from the adjacent forest) to be clump planted.

ML number, Location	Revegetation, Wildlife habitat	Contouring	Soil replacement, Drainage
32-1651 Blackball [C?]	Fair to very poor. Lower river flats and some tailings revegetated; main steep slopes left bare. Ponds are a new wildlife habitat.	Good to poor. Lower river flats well contoured; main tailings left as tipped.	Soil replacement - Poor to very poor. All materials mixed on river flats. No soil stripped or replaced on slopes. Drainage good on flats; nothing like original on slopes.
32-1108 Kumara [C]	Very poor. No attempt at revegetation made.	Poor. Only partial recontouring along roadway.	Very poor: no topsoil stockpiled or respread; however, the areas of former tailings would not have had much topsoil.
32-2746 Kapitea Creek [C]	Reveg. - Good. Ground cover of lotus, rushes, clover and many weed species (especially rushes and gorse seedlings). Forest slash respread and evidence of native species regeneration (pungas, wineberry etc). Should return to similar vegetation to that before mining, given time. Wildlife - Good Ponds have smoothed edges. Punga clumps (2) replanted. Reasonable ground cover which will improve with time.	Good. Gentle side-slopes. Undulating microtopography	Soil replacement - Good. Reasonable thickness of soil (mostly topsoil but some subsoil mixed in) respread over tailings. Drainage - Good. Appears to be similar to the pre-mining condition.
32-1202 Gillams Gully Road [C]	Very poor. No attempt at revegetation. Pond had oil on surface	Very poor - only tailings flattened to make central roadway.	Very poor - no separate stockpiling of topsoil and no soil respread
32-911 32-2547 Kaniere [O]	Poor; only lotus sown to help stabilise slope above swamp; some natural colonisation by rushes and Carex comans. Shallow ponds provide new wildlife habitat.	Fair; attempts made to level tailings and stabilise some slopes except for very steep eroding slopes around Tucker Minerals deep hole.	Poor, no topsoil stripped or stockpiled in past. Platinum now doing so but not Tucker. Drainage within DoC area likely to be similar to pre-mining condition.
32-2356 Stony Creek [O]	Reveg. - not applicable. Mining continuing - none done at this site as yet. Wildlife - as above.	Flat-topped tailings dump over terrace (swamp). None done on this site.	Not applicable - soil stockpiles surrounding current mining operations.

Erosion control, Sediment control	Flood protection	Environmental outcome	Mining conditions
Excellent on river flats, lower slopes, very poor on main slopes; no attempts at contol. Sediment mainly trapped in ponds	Fair - channel created and banked; no large rip-rap to confine stream.	Considered unacceptable for major slopes and tailings heaps, Satisfactory for river flats in that conditions met and site probably similar to pre-mining condition.	Largely met on lower river flats; not met on steep slopes or terrace; long history of non-compliance recorded on files.
Fair; site partially flattened; sediment ponds had been used.	N/A	Definitely unacceptable. Very little attempt has been made to comply with rehabilitation standards.	Most conditions not met or only superficially complied with. Virtually no rehabilitation.
Erosion - Good. Well controlled by microrelief and revegetation measures. Sediment control - not applicable	Poor. No rip-rap along Kapitea Creek but equates to pre-mining condition probably.	Satisfactory. Soil replacement good and forest slash returned on surface. Revegetation of site is rapid - a reasonably good ground cover has established. Gorse is probably going to dominate initially but the native seedlings observed will eventually suppress the gorse if fire can be excluded. Browsing animals may be a problem; some observed on site.	Probably achieved. Soil snd slash replaced; contoured according to specification; ground cover of Maku lotus established; two clumps of pungas replanted.
Very poor - stripped materials are eroding as they are at maximum angle of repose; pond may have been used for sediment control.	N/A	Definitely unacceptable. Almost no attempt has been made to comply with rehabilitation standards.	Not met except for pond for sediment control. No rehabilitation carried out.
Poor to very poor. Scarp above swamp stabilised, but other slopes show major erosion, particularly Tucker area. Sediment allowed into swamp, and waterways discoloured.	N/A	Considered unacceptable for much of area, although attempts made on scarp above swamp and ponds. Sediment is still being discharged.	Some conditions complied with (such as contouring), but sediment control and soil respreading not adhered to. DoC in contact with miners.
Erosion - not applicable. Sediment control - Good. Series of settling ponds established downstream before discharge into Kaniere River.	Not applicable	Not applicable - mining continuing.	At least partially being met - some soil stripping, and sediment control is good.

ML number, Location	Revegetation, Wildlife habitat	Contouring	Soil replacement, Drainage
32-2544 Kennedy Creek [O]	Reveg. - Poor. Only the MoE trial site (50 m^2) and small restored areas have been sown or planted to date (with Hebe seedlings). Work is proceeding - the intention is to sow pasture. Wildlife - Poor. Several small, open mining ponds remain - wetland habitat. Most of the mined area of the valley is bare, open ground with little or no vegetation cover. However, revegetation is planned.	Good. Slopes mainly flat or very gently sloping congruous with the original valley floor.	Soil replacement - Fair. Incomplete - soil stockpiles remain to be respread. Areas where soil has been respread are reasonably good. Drainage - Good. Channels are open, little or no surface ponding, mostly well to excessively drained.

Erosion control, Sediment control	Flood protection	Environmental outcome	Mining conditions
Erosion - Poor. Rip-rap along Kennedy Creek channel is widely spaced - potential for streambank erosion. Sediment control - Good. Little sediment being discharged into Kennedy Creek (out of the settling pond system).	Poor, rip-rap too widely spaced along creek channel.	Satisfactory but incomplete. Recontouring is good; soil is being respread over the contoured tailings; although little revegetation has commenced to date, plans are to sow pasture in autumn 1990.	Partially met - contouring and soil replacement being done; little revegetation to date but an autumn sowing is planned (DoC grazing licence area).

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