Mine Water Management in Environmentally Sensitive Locations

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ABSTRACT

The Coal Corporation of New Zealand Ltd (CoalCorp) is the largest coal producer in New Zealand, with extensive properties in both the North and South Islands.

CoalCorp's North Island operations are centred on Huntly, a town some 80 kilometres to the south of Auckland. Five coal mines, four of which are opencasts, are located in the catchment of Lake Waahi, a lake with significant wildlife, historical and scenic values. The discharges of mine lodgement water in this catchment is the single most important environmental constraint on mining operations.

Throughout New Zealand the use of water is controlled by a statute called the Water and Soil Conservation Act 1967. All industrial water users are required to hold Water Rights, which are in effect licences to take, use, dam, divert or discharge water. Water Rights are obtained through a legally defined process and any potentially affected party has the power to object to their granting. A special tribunal hears the evidence for and against an application, and issues its decision, which is reviewable in a higher court on Appeal. Rights, if granted, are issued subject to conditions and, in the case of mining discharges, limits would be set on flow rate, suspended solids concentrations, turbidity, pH and the concentrations of any potential toxicants.

This paper presents a case study of an integrated, catchment wide water management plan for Lake Waahi, that was prepared by the author, and others while the author was in the employ of CoalCorp, and its predecessor, State Coal Mines. The author is grateful to CoalCorp for their permission to submit this paper.

INTRODUCTION

The Coal Corporation of New Zealand Ltd is New Zealand's largest coal producer, having recently acquired extensive reserves previously managed by State Coal Mines in both the North and South Islands. Operations in the North Island are centred on Huntly (Fig.1), a town in the Waikato region with a population of approximately 7,500 people. The Waikato region is noted for farming, horticulture, coal mining and its lakes and wetlands. The region is dominated by the Waikato River, which flows from Lake Taupo, discharging to the Tasman Sea at Raglan.

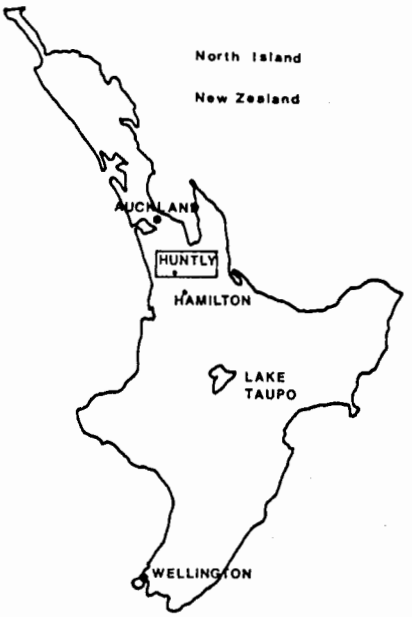

FIGURE 1. LOCALITY PLAN.

CoalCorp owns a total of seven mines at Huntly, and five of these are located in the catchment of Lake Waahi, as shown in Fig. 2. Lake Waahi has a catchment area of 91 square kilometres and is the third largest lake in the region. It is part of a chain of lakes and wetlands supporting a large and diverse water fowl population. In addition to providing habitat, the lake has been a major source of food for wildlife, due to the presence of extensive macrophyte beds. The local Maori people have a long association with the lake, and have used it extensively as a source of freshwater fish including eels, mullet and mussels.

Lake Waahi underwent significant physical changes in the mid-1970's. What was originally a clear lake, of high water quality, had deteriorated to such an extent that the water clarity was visibly worse, many of the aquatic macrophytes in the lake had died, and fish and waterfowl numbers were in decline (1).

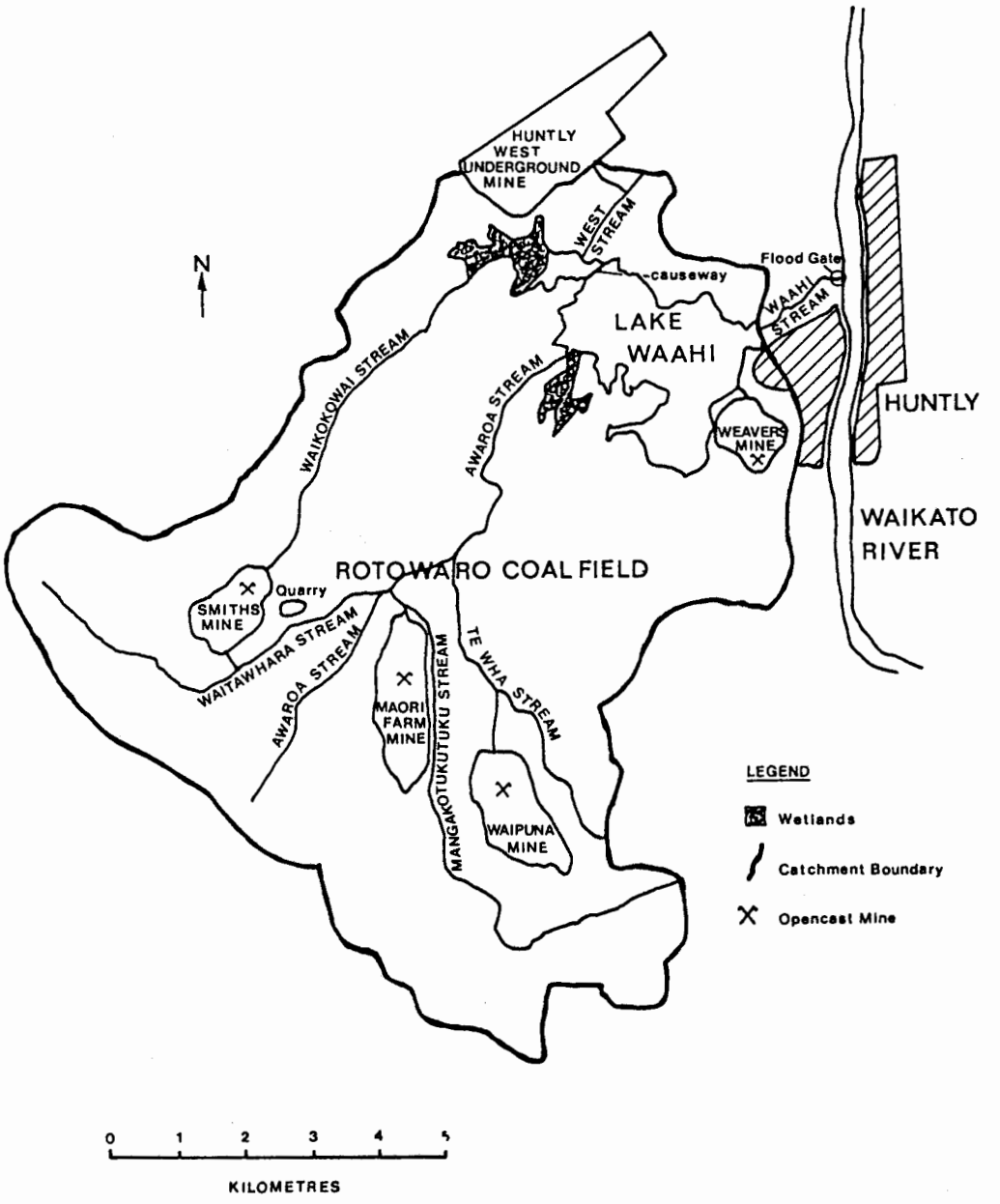

FIGURE 2. Lake Waahi Catchment.

This deterioration in lake water quality coincided with two major events in the catchment. Firstly, opencast coal mining expanded significantly, from what had previously been primarily underground operations. Secondly, the Regional Water Board had installed flood control gates on the stream draining Lake Waahi. Both activities would have contributed to increased sediment loadings on the lake. Opencast mining by State Coal Mines had developed with little runoff and sediment controls, while the flood control gates (which were designed to prevent floods in the Waikato River backing up into the lake, and inundating valuable farm land) prevented regular flushing of the lake.

It was in this environment, in early 1985, that Water Rights for all mines in the Lake Waahi catchment required renewing.

LEGAL FRAMEWORK

All uses of water in New Zealand are regulated via the Water and Soil Conservation Act 1967, an Act designed to promote the multiple uses of water, and generally to preserve water quality. Mining companies are required to obtain Water Rights for any activity that involves the damming, taking, diverting, using or discharging of any water. In particular, for opencast mines Water Rights are typically required to:

a) Take groundwater (either actively, by physical dewatering of strata or passively, by seepage that occurs through pit walls or floor.
b) Dam and divert flows from catchments where out of pit dumping is required.
c) Discharge all mine lodgement waters.

For underground operations Water Rights are typically required to:
a) Take groundwater that is the natural mine water make.
b) Discharge all underground water make,
c) Discharge runoff from surface facilities,
d) Dam and/or divert any flow paths altered as a result of surface subsidence.

The process of obtaining Water Rights in New Zealand is essentially one of public participation, where any potentially affected party has the ability to object to Rights being granted. Because of this, there is considerable onus on the mine operator to prove, in a court setting, that his activities will not adversely effect the water use of other parties. For example, a farmer living adjacent to an opencast would require that his farm bore supply is not compromised. Also an environmental group may object to suspended solids levels in a discharge on the grounds that public recreational activities such as swimming were hampered, or that zinc concentrations posed threats to aquatic ecology.

The legal process starts with the mining company making application(s) for Water Rights to the Regional Water Board. On receipt of the applications, a Public Notice is placed in local newspapers outlining details of any rights sought and inviting the public to object. Any potential objector then has 28 days to examine the application, and any accompanying technical information, and to formally lodge an objection. Once the objection period has expired, the Regional Water Board sets a date on which the case will be heard. The Hearing is presided over by a Tribunal that has the powers of a Commission of Enquiry, and any party has the right to engage legal counsel to put its case. The Tribunal considers all the evidence and issues its ruling. Any party has the right to appeal this decision to the Planning Tribunal.

The Water and Soil Conservation Act prescribes standards for certain waters by way of a classification process. The rivers, lakes and streams of the Waikato River are "classified", meaning that the standards prescribed in the Act must be met by all discharges. These are shown in Table 1.

The natural water temperature shall not be changed by more than 3 degrees celcius.

The pH shall be within the range of 6 to 9, except where due to natural causes.

The waters shall not be tainted so as to make them unpalatable, nor contain toxic substances to the extent they are unsafe for consumption by farm animals, nor shall they emit objectionable odours.

There shall be no destruction of natural aquatic life by reason of a concentration of toxic substances.

The natural colour and clarity of the water shall not be changed to a conspicuous extent.

The oxygen content in solution in the waters shall not be reduced below 5 milligrams per litre.

Table 1 : Water Classification Standards

CATCHMENT CHARACTERISTICS

The Lake Waahi catchment is dominated by farming, coal mining and the lake itself. Mining commenced in about 1845, when early farmers robbed outcrop coal for domestic heating, and by the 1920's a number of large underground pits were in operation, in the Rotowaro Coalfield (Fig.2). Small scale opencasts were developed from 1944 onwards, and reached their current size in the late 1970's.

The catchment consists of approximately 91 square kilometres (9,100 hectares), and is depicted in Fig.2. Approximately half the catchment consists of flat land and this is contained in the northern half of the catchment. The southern half of the catchment is undulating to steep hill country.

Annual rainfall at Huntly, in the north of the catchment is 1265 mm (50 inches), with rainfall being well spread throughout the year, as shown in Table 2. Annual evaporation is assessed at approximately 750 mm, giving a net annual excess.

MONTH	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RAINFALL (mm)	71	83	90	106	118	138	132	119	101	110	94	103

Table 2: Mean Monthly Rainfall at Huntly (2)

Rainfall will increase with altitude, and at the head of the catchment rainfall increases to about 1600 mm per annum.

The New Zealand Meterological Service operates a full climate station at Huntly and storm rainfalls for selected return periods are shown in Table 3.

RETURN PERIOD	STORM DURATION		
	24 hours	48 hours	72 hours
2 years	79	101	105
5 years	107	136	137
10 years	126	158	158

Table 3 : Storm Rainfalls at Huntly for Various Return Periods (3,4)

Surface runoff in the catchment is dominated by two streams, namely the Awaroa, and Waitawhara, as shown in Fig.2, while the lake discharges to the Waikato River via a single waterway, the Waahi Stream.

WATER MANAGEMENT OBJECTIVES

The primary aims of water management at the various mines is to obtain the necessary water rights, for the longest term possible, and in the most cost-effective manner. It should be stressed that the cheapest solution is not necessarily the most cost-effective. Water Rights in New Zealand are not granted for indefinite periods, but rather for fixed periods of time and the term of the Right is determined by the Tribunal at the time it brings down its decision. Because Water Rights are transferrable from one owner to another, they are an asset with a tradeable value. Furthermore, it is illegal to operate without Water Rights. For these reasons, and because the costs associated with the Hearing process (which are normally borne by the Applicant) are large, there are significant advantages in obtaining long term rights. The trade off however, is that water management plans, and commitment to activities such as water treatment need to be more expansive. It must also be remembered that whatever the term of a right is, the Tribunal is bound to ensure that the requirements of the law, as outlined in Table 1, are satisfied.

With opencast pits, the principal water management requirements are to collect all mine contaminated runoff (including that from unrehabilitated overburden) and to remove suspended solids to acceptable levels prior to discharge. It is also necessary, in cases where acidic runoff occurs, to correct pH so that pH is in the range 6-9. Because of the high annual rainfalls and the intensity of storm events in the catchment, the containment and treatment of runoff is not a simple manner.

A peculiarity of the Lake Waahi mines is that all opencasts are adjacent to previously abandoned underground workings, most of which are flooded. This has three implications for water management. Firstly, the quantity and quality of water encountered when the workings are breached needs to be calculated, and their impact on receiving waters assessed. Secondly, any implications flooded workings pose to highwall stability need to be assessed. Thirdly, the implications on other water users of any dewatering associated with these workings needs to be assessed.

With underground mines, the issues are quite different, and fall into two categories. The first category relates to the discharge of water collected underground, and its quality. The second category relates to the implications of subsidence on surface and groundwater resources. At first glance the subsidence related issues may appear to be superficial and, in a technical sense they generally are. However, the New Zealand mining legislation does not require mine operators to own the surface of the land under which they are mining. Instead any mining induced damage is the subject of compensation. Because of this, land owners use the Water Rights process as a means of ensuring their interests are not compromised.

The issues relating to each of the mines in the catchment are discussed in the following sections.

SITE SPECIFIC ISSUES

Weavers Opencast Mine

Renewal of Water Rights for the Weavers Opencast Mine were required at a time when attention was just beginning to focus on the health of Lake Waahi, and what could and should be attempted by way of lake rehabilitation. Clearly, these debates were external to the mining industry, and ones over which it had little control. The attitude of regulatory agencies and environmental groups was that the situation required extensive research and that the interests of the environment were best served by granting short term rights, so that by the time

the research was done, the results could be incorporated into longer term Water Rights. Although scientifically sound, this was not a particularly acceptable solution from the mine operator's perspective, as it did not provide security of tenure on the property.

The core issue associated with the Weavers Mine, was its proximity to Lake Waahi (see Fig.2). Being only about two hundred metres from the lake and with no streams available in which to dilute wastewater prior to its reaching the lake, meant that if long term Water Rights were to be obtained then there were only two alternatives. The first of these was to discharge directly to the Waikato River, where adequate dilution was available, while the second was to treat mine water to levels that would not compromise the future restoration plans for the lake. Preliminary cost estimates showed that reticulating water to the River was prohibitively expensive and that discharge to the lake was the only viable option. The key issues, were what was an appropriate discharge standard and how could it be achieved in practice.

In deriving appropriate discharge standards the water quality implications for the lake had to be considered, as did the feasibility and cost of achieving these standards. Accordingly, specialist water quality and water treatment consultants were retained (5,6).

Prior to its collapse in the 1970's Lake Waahi was typically very clear, with a suspended solids concentration of approximately 5 g/m^3 and a turbidity of 5 NTU, and 5NTU.It supported an extensive colony of aquatic macrophytes over much of its bed. By mid-1985 typical values had risen to approximately 50 g/m^3 and 50 NTU, respectively, and much of the macrophyte community had disappeared. The weight of expert opinion was that the build up of suspended sediments had reduced light penetration in the lake water column to such an extent that the photosynthetic activity of the macrophytes was too low to enable their survival. The fact that macrophytes only remained in shallow water further reinforced this hypothesis.

The rationale for the discharge standards finally selected will not be discussed here, but is discussed in detail in Reference 6. However, experts generally agreed that if average suspended solids concentrations of 10 g/m^3 were maintained, with peaks not to exceed 20 g/m^3 (with numerically equivalent turbidities) then the rehabilitation of the lake would not be compromised.

Water treatment at the site was difficult due to the presence of a predominance of sub-micron sized particles in the effluent. Accordingly, a radial flow clarifier was required to achieve the required standard, and this has now been commissioned.

A key feature of the water management system is the ability to regulate flow through the clarifier. The design of adequate in-pit sumpage, with a capacity to store a 10 year return period 24 hour duration storm-event, means that flood peaks can be attenuated, and an even throughput to the clarifier maintained.

Another important aspect is to minimise the size of mining affected catchment and this has been achieved by ensuring that rehabilitation is an ongoing activity. By rehabilitating overburden progressively the quantities of waste water requiring treatment are minimised thereby also minimising the size of the treatment facility, and the cost of operating it.

Huntly West Underground Mine

One particularly vital aspect of water management at the Huntly West Mine was the impact that longwall mining would have on surface hydrology. Studies (7) showed that up to 130 hectares of privately owned farm land in low lying areas could be innundated. A variety of options were available, including a pumped drainage system that maintained full pasture production, infilling areas of subsided land to restore pre-subsidence land forms, deepening of drains and allowing partial drainage by gravity, and the "do nothing" option.

The selection of one of the above options is simply one of economics, and is a matter of optimising the cost of land purchase and capital expenditure on drainage measures. For example, is it cheaper to install a pumped drainage system and purchase no land, or to carry out engineering works to improve drainage and purchase less land? For the case in question, the cheapest option was to deepen drains and conduct minor works, thereby reducing the 130 hectares of flooded land to approximately 25 hectares.

From a water quality perspective the issue of suspended solids in the discharge could be dealt with by conventional coagulation/flocculation technology using settling ponds, given the amount of dilution available. However, the concentrations of boron in the discharge are higher than recommended by the literature (8) meaning that, at face value, the requirements of Table 1 cannot be met. Several disposal options were investigated including: deep-well reinjection of waste, piping the discharge to the Waikato River (where greater dilution exists), spray irrigation of the waste, and chemical treatment. However, all were technically difficult and prohibitively expensive.

In parallel with the evaluation of disposal options CoalCorp also evaluated the toxicity of the mine effluent to organisms present in the receiving waters (9). In this way, the applicability of overseas water quality criteria was ascertained, and site specific toxicity criteria determined. This information has resulted in CoalCorp seeking Water Rights to continue discharging mine water to Lake Waahi.

Pending the resolution of the treatment and toxicity questions, short term water rights were granted in mid-1986, for a period of two years. These issues have now been resolved, and applications for long-term Water Rights are being prepared currently.

Rotowaro Coalfield Mines

The Rotowaro Coalfield, at the south of the Lake Waahi catchment (Fig.2), consists of three opencast mines (Smiths, Waipuna and Maori Farm), a hardrock quarry, and several coal handling areas and stockpiles.

A similar approach to that adopted for the Weavers Mine (10) was used in the Rotowaro Coalfield. Because of the dilutions available in receiving streams adjacent to the individual operations, water treatment facilities that were less sophisticated than those at Weavers were appropriate. The major issue was in determining the cumulative impact of all these operations on Lake Waahi and ensuring that long term lake restoration objectives were not compromised. This was readily achieved containing stormwater in-pit and discharging over an extended period at an average suspended solids concentration of 30 g/m^3. Given that discharges from the mines occurred over extended periods following rainfall the impact of the discharges had to be assessed under a range of stream flow conditions.

Specific aspects of water management at the individual mine sites are discussed below.

a) Waipuna Mine

In the early stages of mine development considerable out of pit overburden dumping had occurred, with most runoff not being reticulated to the mine sump. The mine occupied 175 hectares, with overburden being placed in four separate valleys, which do not drain naturally to the pit. A major engineering undertaking was the design and construction of water reticulation measures, to contain this runoff and these were implemented in 1986/87.

A second issue to be addressed was the acidic nature of runoff from certain portions of the mine,(11) which produced a discharge from the sump with an average pH of 5.5, and which had been as low as pH 3.9. An associated issue was the concentration of various trace metals under these acidic conditions.

A major constraint on the future development of the Waipuna Mine will be the presence of approximately three square kilometres of abandoned, flooded underground workings, sited behind the current highwall. A detailed piezometer network through these, and other workings in the coalfield, coupled with a pumping test programme was designed by the author (12). The results of these tests will enable final dewatering design to be completed. It should also be realised that the assessment of impact that water from these workings would have on water quality from the overall mine was an integral aspect of the water management plan for this mine.

Accordingly, acid neutralisation was an integral part of the recently installed water treatment plant. (13)

b) Maori Farm Opencast Mine

The Maori Farm Mine is located immediately adjacent to a variety of coal handling facilities, that have a total area of 15.5 hectares. Given the abundance of coal fines at these ancilliary facilities, they pose significant threats to water quality. Furthermore, these areas are busy areas, with minimal sumpage space available. Given these space constraints it was not possible to contain entire storm events on site. The solution adopted was to provide sumpage to cope with the relatively short duration high intensity storms, and to install pumps in the sumps capable of reticulating higher flows to a holding sump at the main treatment plant.

Problems with flooded underground workings were anticipated at this mine also (13), and a further complicating factor was an adjacent aquifer that was being tapped by local farmers for their farm water supplies. This issue was successfully addressed by a groundwater assessment made by the author.

c) Smith's Opencast Mine

Whereas all other opencast mines in the catchment are large below-ground excavations, with ample stormwater retention potential, the Smith's Mine is sited on top of a ridge. Accordingly, runoff control is difficult, with drainage entering two distinct catchments at the north and southeast of the prospect respectively (Fig.2). Acid drainage from portions of the mine was also a problem to be addressed.

In order to minimise capital expenditure on water treatment works, treatment at only one site was desirable. Fortunately, the vast majority of runoff could be reticulated to the north, while the remnant catchment in the south east was rehabilitated, as a priority matter.

Even though runoff was reticulated to a single point in the mine, the terrain did not permit large volumes of water to be retained in pit. Two alternatives were available. The first was to design a treatment system that was capable of handling peak storm flows (14), while the second was to create extra storage by the construction of large earth dams, and install a small treatment plant (13). Option 2 was finally selected.

A feature of the water management plan at the Smith's Mine has been the construction of two earth dams in a valley to the north of the active mine. The total retention capacity of these structures is approximately 86,000 cubic metres, necessitating dams with crest heights in the order of 15 metres. The presence of farming communities downstream made the integrity of these structures a priority matter.

CONCLUSIONS

Although long term Water Rights for the Huntly West underground mine are still to be obtained, the development of a catchment wide approach to water management has been a success, with Water Rights granted for all opencast operations.
By considering the impact on Lake Waahi, and its tributary streams, of all

CoalCorp activities, regulatory agencies have been convinced that their long term objectives of lake restoration have not been compromised, and in fact, that the measures described in this paper are the first step in this process.

To date, the approach adopted has received support from interested groups and has shown that coal mining can be undertaken in environmentally sensitive locations, given that due attention is paid to the environment.

REFERENCES

(1) Kingett and Associates, Lake Waahi - An Environmental History, Prepared for Ministry of Energy, 1984.

(2) New Zealand Meteorological Service, Summaries of Climatological Observations to 1980, NZMS Miscellaneous Publication 117, 1983.

(3) New Zealand Meteorological Service, The Frequency of High Intensity Rainfalls in New Zealand, Part II, NZMS Miscellaneous Publication 162, 1980.

(4) New Zealand Meteorological Service, Depth - Duration - Frequency Tables Based on Daily Rainfalls. Supplement to: The Frequency of High Intensity Rainfalls in New Zealand, 1980.

(5) Morrison Cooper and Partners, Interim Report on Waste Water Treatment and Costs, Prepared for State Coal Mines, 1985.

(6) P. H. Mitchell, P. D. Kingett, S. D. Wong, Statements of Expert Evidence Before Waikato Valley Authority, State Coal Mines, 1985.

(7) Tonkin and Taylor Ltd, Huntly West Mine Surface Water Hydrology Study, Prepared for Coal Corporation of New Zealand Ltd, 1987.

(8) Kingett and Associates, The Huntly West Underground Coal Mine : Water Quality, Prepared for State Coal Mines, 1986.

(9) Water Quality Centre, Huntly West Mine Effluent Ecotoxicity Studies, Unpublished Draft Report prepared for Coal Corporation of NZ Ltd, 1987.

(10) State Coal Mines, Rotowaro Opencast Coal Mines, Water Right Application, 1986.

(11) Kingett and Associates, Rotowaro Water Right Investigations - Water Resource Investigations, Prepared for State Coal Mines, 1986.

(12) P. H. Mitchell, Rotowaro Water Right Application - Groundwater Hydrology, State Coal Mines, 1986.

(13) Morrison Cooper and Partners, Proposed Rotowaro Opencast Coal Mines Wastewater Treatment, Prepared for State Coal Mines, 1986.

(14) P. H. Mitchell, Rotowaro Water Right Application - Stormwater Flow Estimates, State Coal Mines, 1986.