ENVIRONMENTAL CASE STUDIES

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South Pacific Study 5

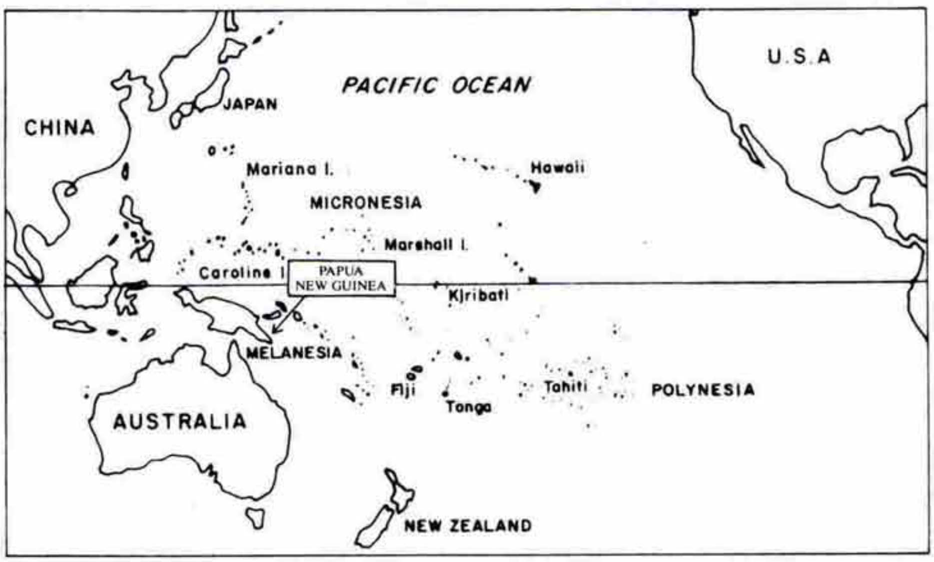
THE EFFECTS OF MINING ON THE ENVIRONMENT OF HIGH ISLANDS: A CASE STUDY OF GOLD MINING ON MISIMA ISLAND, PAPUA NEW GUINEA

BACKGROUND

Papua New Guinea is currently undergoing a minerals exploration boom, especially for gold, and more than 10 potentially economic deposits have already been located. The geological and environmental settings in which these gold deposits have been found are very like those in other Pacific countries, especially the Solomon Islands, Vanuatu and Fiji, and it is certain that these countries will eventually face difficult planning and decision-making situations similar to those currently being experienced in Papua New Guinea.

Like all other mineral development projects, those in Papua New Guinea have associated problems. There has been considerable publicity for instance surrounding environmental management problems such as those of the Ok Tedi and Bougainville mining projects (Chambers 1985), and more recently over a proposed gold mine at Porgera. The even more severe impact of nickel mining on the environment of New Caledonia has been described by Dupon (1986) in the first of the SPREP Environmental Case Studies series. As the pace of mineral development increases so will the degree and extent of environmental impact. The brunt of such impact will continue to be felt most keenly by the local communities whose land will be alienated and whose traditional resources will be destroyed or degraded while the benefits are spread more widely throughout the country.

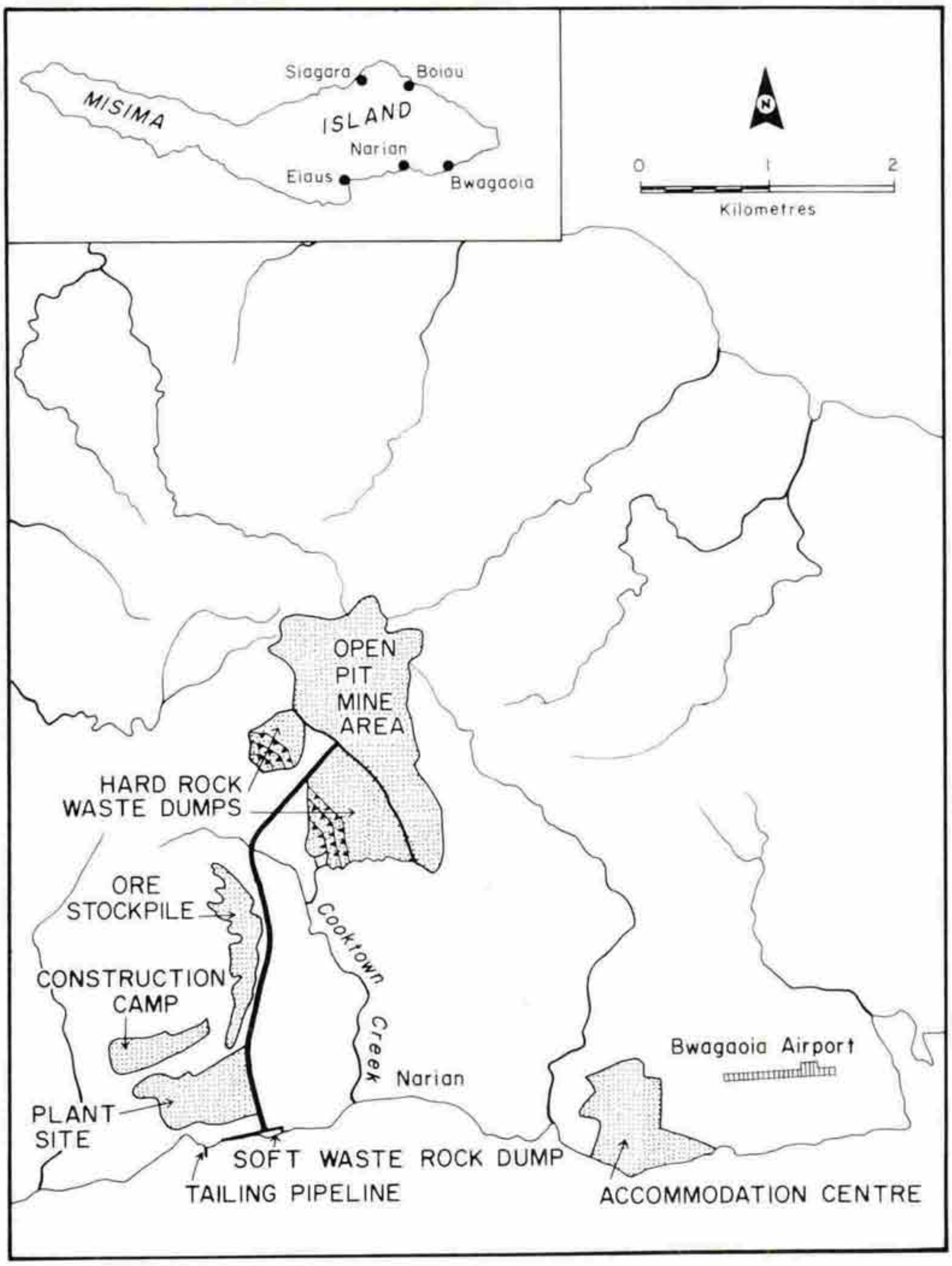
Misima. The site of the open mine pit. The disturbance has been caused by drilling to determine the extent of the ore body.



Papua New Guinea is unique in the Pacific region in that its Constitution has specifically recognised the nation's responsibility to ensure that its environment is protected and its natural resources are wisely used. This responsibility is given legislative effect through the *Environment Planning Act, 1978* which requires that the proponent of a new development project liaises with the Department of Environment and Planning and if necessary prepares an Environment Plan. The Plan, along with the economic and technical feasibility studies, provides the basis on which government approval for the project is judged.

In this case study the environmental planning and management strategy proposed in the Environmental Plan for the Misima Island gold mining project (Natural Systems Research Pty. Ltd. [NSR] 1987) is described and analysed. A major feature of this strategy is that it will be the first in Papua New Guinea to utilise marine disposal of soft rock waste and of tailing (residue) produced by the treatment of the ore. This form of disposal has already been proposed for two other high island gold mines in Papua New Guinea, on Lihir and Fergusson Islands, and is likely to be widely implemented on high islands throughout the Pacific region.

The site of the open mine pit viewed from the west. The ore body lies beneath the prominent hill which has been disturbed by exploration activities. When mining has been completed after 10 years the hill will have been completely removed and replaced by a deep pit.



THE MISIMA GOLD MINING PROJECT

Government approval for Placer (PNG) Pty. Ltd. to proceed with this project was granted in late 1987, construction work began almost immediately afterwards and it is expected that the first gold will be extracted in early 1989.

The objective of the project is to develop and operate an open cut mine and process facilities to recover gold and silver, supported by the necessary infrastructure (NSR 1987). The total ore to be extracted is 56 million tonnes (Mt) at a stripping ratio of 1.3 tonnes of waste to each tonne of ore. This would allow the mine to operate for a little more than 10 years at the planned production rate of 5.475 Mt/annum. Mining will be by conventional open pit techniques and three categories of material will be removed from the pit: ore (56 Mt), hard rock waste (35 Mt) and soft waste (35 Mt).

The ore will be delivered by trucks to the processing plant located on the coast. The hard rock waste will be delivered to dumps close to the open pit. The soft waste comprises incompetent oxidised rock which will not store safely in stable dumps; instead it will be hauled to the south coast and dumped directly into the ocean adjacent to the plant site.

The ore treatment plant will be a conventional gold cyanidation plant with gold recovery by the carbon-in-pulp process. The ore will be ground in a ball mill to a diameter of 125-235 micromillimetres. The tailing left after the gold and silver have been extracted will consist of a mixture of water, mud and chemicals such as cyanide used in the extraction process. This tailing will flow to a mixing tank where it will be diluted with sea water to reduce the residual cyanide concentration to a level acceptable for deep ocean discharge down a pipeline.

The mining, processing and waste disposal strategy summarised above was decided on after more than eight years of environmental, economic and technical feasibility studies. The grade of the Misima deposit is extremely low at about 1.3 grams of gold per tonne of ore. This is because in the course of past mining activities most of the high grade ore was extracted by underground mining methods. In adopting this strategy the developer ensured the economic viability of an otherwise marginal project while at the same time reducing to a minimum the area of otherwise productive agricultural land required. On the negative side, the dumping of soft waste will adversely affect the nearshore environment, and the resources available from it, for a distance of up to 9 km along the coast.

The mine is expected to produce about 77.2 and 1,175 tonnes of gold and silver respectively. The total production would amount to export earnings of about US$ 935 million at gold and silver prices of US$ 385 and US$ 6 an ounce respectively.

ENVIRONMENTAL AND SOCIAL SETTING

The Misima gold deposit lies at the eastern end of Misima Island which is 40 km long and 10 km wide at its broadest point. The western end is rugged and rises to a maximum altitude of 1,035 metres above sea level. The eastern end is less rugged and at its highest point, in the vicinity of the mine site, rises to 413 metres. Most of the eastern half of the island consists of low grade metamorphic rocks with porphyritic intrusions. The relatively flat-lying coastal strip is largely formed on raised coral limestone terraces.

Newly prepared yam gardens in forest clearing.

The hilly interior at the eastern end is covered in lowland hill rainforest which shows evidence of having been disturbed within the last 50 years by cyclonic activity, timber-getting for mining and by gardening. The coastal strip and foothills have been cleared in the course of shifting cultivation and the original rainforest has been replaced by woodland, characterised by the prominent, fast growing tree *Kleinhovia hospita.*

Two seasons occur on Misima: the south-east trades from April to November and the north-west monsoon from December to March. Although the annual rainfall is over 3,000 mm and is relatively regular throughout the year, droughts are known to occur, especially during the south-east trades season, and this can cause food shortages or even famines.

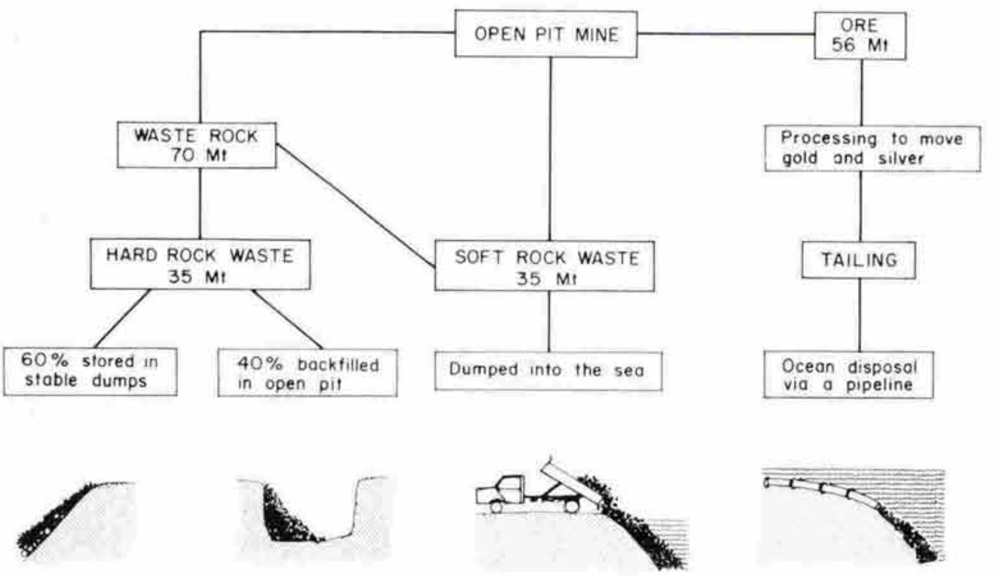
The island currently has adequate land to support its population of about 9,000 people which is concentrated along the coastal strip. It retains ample areas of forest which are rich in a range of raw materials and bush foods, and the surrounding sea is rich in marine resources. Commercial and small-holder copra and cocoa production utilises almost all of the flat coastal land, and subsistence production from shifting cultivation is largely confined to the foothills and mountainous interior.

Misima islanders practise a form of shifting cultivation characterised by mixed gardens usually dominated by a single staple, in this case yams (*Dioscorea* spp.).

THE HISTORY OF MINING

Alluvial gold was discovered on Misima Island in 1888 and about 100,000 ounces was produced from alluvial workings before the source of the gold was traced to the headwaters of Cooktown Creek in 1904. Mining of the underground lode (vein) gold began in 1915 and continued at the rate of around 100 tons a day until early 1942 when the approaching Japanese forces caused the evacuation of the island. Attempts after the war to re-commence mining were unsuccessful, largely because of extensive collapse in the underground workings.

The total output from alluvial and



Rapid recovery of the coral reef is expected once mining stops, as was the case along the coast adjacent to Cooktown Creek after mining ceased in 1942. Recovery, or restoration, of reefs is brought about naturally by recolonisation and regeneration.

Tailing disposal

The location of the treatment plant on the coast, the avaibility of deep water a short distance from the shore and the absence of any deep water subsistence or commercial fisheries resources use, provided an opportunity for the disposal of tailing deep in the ocean. The proposed submarine tailing disposal system consists of a pipeline transporting tailing from the plant, a mixing tank, an outfall discharge pipe, a seawater intake pipe and flow regulating devices (NSR 1987: 27-30). The tailing will be mixed with seawater in the mixing tank and the resulting slurry will be discharged through the outfall pipe to the ocean at a depth of between 75 and 100 metres. The slurry will be denser than the surrounding ocean water at the discharge point and it will flow down the steep submarine slope as a density current and will not mix with, or pollute, the surface seawater.

The tailings will accumulate on the deep sea floor and smother marine habitats there, either forcing away or killing those animals which cannot adjust to the new conditions. The Misima people do not fish at such great depths and there is little potential for commercial deep water fishing.

ENVIRONMENTAL MONITORING AND MANAGEMENT

These assessments of the likely impacts of the project on the environment are predictions, not established facts. It is therefore important that the actual impacts are carefully and regularly monitored by the government, the company and the Misima community to ensure that they do not exceed the levels predicted in the Environmental Plan, and that those impacts which do occur are managed appropriately so as to minimise their adverse effects.

A detailed environmental management and monitoring programme was proposed in the Environmental Plan (NSR 1987, section 10) and this has been agreed to, with modifications, by the Department of Environment and Conservation and Placer (PNG) Pty. Ltd.

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Derelict stamp battery used to crush the gold-bearing ore during the underground phase of mining.

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underground workings since 1888 is estimated to have been approximately 250,000 ounces. The early mining activity supported its own infrastructure and a considerable number of expatriates and local people were employed by the mining companies.

The environment legacy of intermittent gold mining over the past 100 years is evident today in the form of old tunnels, roadworks, derelict buildings and equipment and the degraded vegetation surrounding the old workings. In Cooktown Creek and its tributaries there was a considerable build-up of waste rock and mercury amalgamation and cyanide tailing which were dumped into the stream system without any pre-treatment. Most of this has since been transported out to sea but some of it has accumulated in the lower Cooktown Creek valley.

This long-term but relatively small-scale phase of mining must have had a considerable impact on the terrestrial, riverine and nearshore marine environments. The hills surrounding the mine site are well vegetated but the original forest cover has only partially returned more than 40 years after mining ceased. The Cooktown Creek system has fully recovered and sago stands have long since been re-established in its lower reaches. The coral reefs near the mouth of Cooktown Creek must have suffered considerable damage from the continuous discharge of mine wastes from Cooktown Creek but they have now fully recovered.

THE PREDICTED ENVIRONMENTAL IMPACTS OF THE OPEN CUT MINE

The major issues raised in the Environmental Plan by the development of this open cut gold mine and its infrastructure were as follows (NSR 1987:48):

(a) the capacity of the island to physically accommodate the project and continue to provide sufficient gardening land for a growing population;

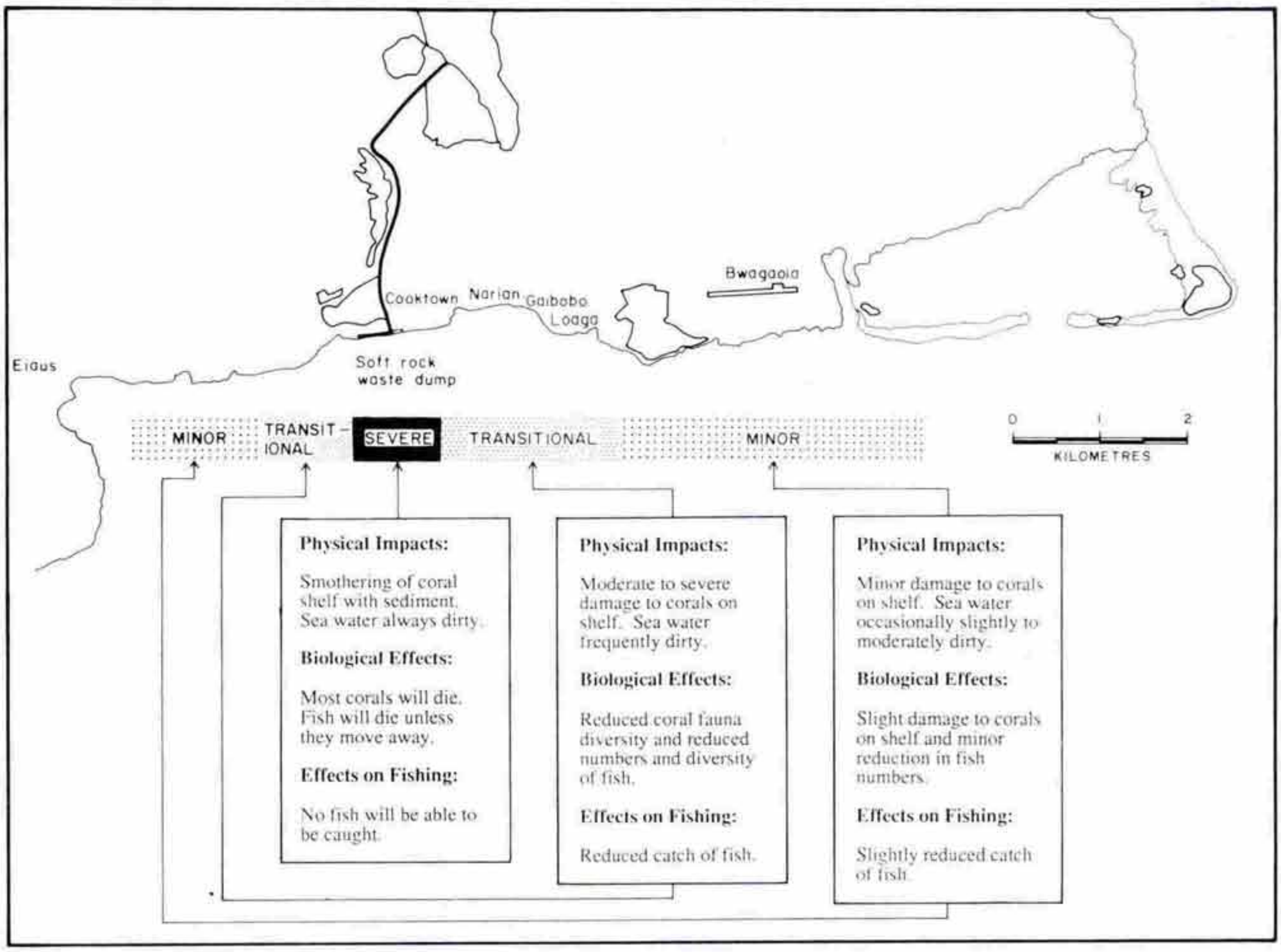
(b) the capacity of the streams and surrounding ocean to assimilate wastes from the project;

(c) the effects of the project's land requirements and discharges on natural ecological values, and the subsistence and commercial resources utilised by local people.

Land and Resource Use Impacts

Land alienation and the associated depletion of traditional resources was one major issue. Most of the population of about 9,000 people lives along the coast of the eastern end of the island, and although there is currently no shortage of gardening land the population is increasing rapidly and there was concern that alienation of land for the mining project might lead to land shortages.

Population-land use studies demonstrated that even if the mine did not proceed, by about the year 2010 land shortages would begin to seriously affect the local people. Thus it was realised from an early stage in project planning that it was highly desirable that wherever possible, project infrastructure should be placed on land of low productivity for use as gardening land and for exploitation of bushland resources. The mine site and hard rock waste dumps will be in hilly terrain on largely non-productive land away from populated and gardened land. The processing plant and accommodation facilities will be located on freehold land presently used as coconut plantations. Only the haul road and the low grade ore stockpile will be situated on productive village-owned land. Money reaching the local community from mining will allow increased purchases of food from stores and this may offset some of the effects of pressure on subsistence land.



Sediment washing out from Cooktown Creek as a result of mining exploration activities. The dumping of soft wastes into the sea will create a permanent, and even larger, plume of turbid (dirty) water than this.

Stream Impacts

During the construction phase, which will last about 15 months, about 200,000 cubic metres of sediment (mostly soil) will find its way into Cooktown Creek. A further 170,000 cubic metres will reach the Creek during the 10 year life of the mine. Much smaller amounts will reach other streams surrounding the project area but the impact on these streams will be negligible compared with that on Cooktown Creek. Although most of this sediment will eventually be washed out to sea, there will be localised accumulations of sediment in the valleys which, in the case of Cooktown Creek, will affect a locally important sago swamp. In addition the stream waters will be continuously muddy because of their high sediment load.

The loss of sago resources is expected to be small and compensation will be paid for these losses. The company has already installed piped water supply systems for all villages adjacent to the project area. None of these water sources will be affected by project construction or operation.

Waste Disposal

Waste disposal was the other main issue. Two alternative tailing disposal techniques were considered; land disposal and ocean disposal (NSR 1987: 26-30). Land disposal would have required the construction of a dam capable of permanently storing the tailing and soft waste rock and withstanding extreme rainfall and run-off during cyclones. As all the flat coastal land is currently in productive use, the tailing dam would need to be sited in the mountainous interior of the island. Preliminary investigations indicated that several dams would be needed and that there was a definite risk that dams in such terrain might fail due to seismic or climatic events.

Hard rock waste disposal

About 60% of the 35 Mt of hard rock waste will be stored in stable dumps in the hilly interior on land which is largely unproductive. The remaining 40% of hard rock waste will be used to back-fill one end of the open pit. Because the rocks are non-acid producing the leachate from these dumps is not expected to be acidic or to contain high concentrations of dissolved metals or other contaminants (NSR 1987:31).

Soft waste rock disposal

Three alternatives for disposing of the 35 Mt of soft waste were considered: containment by a dam located about 1 km upstream from the Cooktown Creek mouth; milling the soft waste and disposing it, along with the tailing, down the submarine pipeline; and hauling the soft waste to the ocean for surface discharge (NSR 1987: 32-33). The ocean surface disposal method was chosen because it was considerably cheaper than the other options. A soft waste dump site will be constructed along the shoreline below the plant site. When soft waste is dumped from 109 tonne rear-dump trucks over the dump face the material will cascade down the steep slope as a density current like that produced by the submarine tailings disposal system. The submarine slope would become covered by a veneer of soft waste sediment and a localised increase in turbidity would occur at and surrounding the dump site. Soft waste production will peak at 7.3 Mt a year, and this corresponds to about 20,000 tonnes a day or 183 truck loads a day.

It was this aspect of the overall waste disposal strategy that caused the greatest concern and considerable effort was given to predicting its physical and biological effects (NSR 1987: 107-126). In a zone 0.5 km either side of the dump site the effects were predicted to be severe with sedimentation damage to the fringing coral reef and with the water in the nearshore zone being frequently turbid. This would lead to a marked reduction in coral fauna diversity and reduced numbers and diversity of fish. There would be a significant reduction in the numbers of fish that could be caught by local villagers.

The effects would be progressively less severe either side of this central zone and would cease about 3 km to the west and 6 km to the east of the dump site. Compensation will be paid by the company to the villagers for losses of marine resources and amenity as a direct result of discolouration of nearshore waters from soft waste disposal.