

A Preliminary Environmental Investigation of the Logging Operations in the Wawoi Guavi Area, Western Province, Papua New Guinea.

- Immediate impacts & long-term ecological changes -



D. R. Melick

An independent report for Greenpeace Pacific.

August 2003

1. Summary	3
2. Introduction	5
3. Study Area	7
3.1 Topography and climate	9
3.2 Vegetation	10
3.3 Timber resources & logging history	11
3.4 Customary landowners & forest users	13
4. Methods	14
Incidental losses	15
Undersize log measurements	15
Forest structure	15
5. Findings	17
5.1 Roads & bridges	17
5.1.1 Major logging roads	17
5.1.2 Decommissioning forest roads & skid tracks	20
5.2 Logging operations & impacts on the forests	22
5.2.1 Small Gap & Large Gap sites	22
5.2.2 Incidental losses	22
5.2.2.1 Small Gap Sites	23
5.2.2.2 Large Gap Sites	23
5.2.3 Removal of undersized/non-merchantable logs	25
5.2.4 Changes to forest structure	27
5.3 Logging camps & log pools	31
5.3.1 Kesovi	32
5.3.2 Camp 56	34
5.3.3 Kamusi Log Pool	36
5.3.4 Wawoi Guavi Block 1B Log Pool	38
5.4 Destruction of cultural sites	38
5.4.1 Other cultural concerns	41
5.4.1.1 Weylio Village	41
5.4.1.2 Bamu River	42
5.4.1.3 Wawoi River	42
5.4.1.4 Affected gardens and swamps	43
5.5 Water quality	44
6. Discussion	46
The challenges of logging in Wawoi Guavi	46
Potential long-term ecological concerns	47
Rimbunan Hijau's operational methods at Wawoi Guavi	48
7. Conclusions & Recommendations	49
References	51
Appendix 1	54
Appendix 2	55
Appendix 3	56

1. Summary

Extensive areas of the Wawoi Guavi region, Western Province, PNG, have been actively logged for over 20 years. Currently, 732,022ha are logged – a further 811,285ha is expected to be available for logging soon. The biggest logging operator in the region is the Malaysian company, *Rimbunan Hijau*.

This study showed that for the Wawoi Guavi concessions, forestry did not appear to be sustainable in the long-term. In fact, operating practices generally fell below the standards required by PNG Forestry and Environmental laws. Among common breaches were:

- damage to cultural sites;
- watersheds and waterways were deleteriously affected;
- soil erosion was serious and;
- point source pollution of fuel and toxic chemicals was common in log camps.

The effects of logging varied, but timber extraction operations were generally very invasive. Even in the areas of lowest intensity logging, collateral damage to surrounding vegetation was high, with an average of over 11 smaller trees (>10cm dbh) destroyed for each tree extracted. However, these figure paled into insignificance, when compared to the incidental losses recorded in heavily logged areas where virtual clear-felling created gaps of up to several hectares. In these sites, an average of 65 smaller trees were destroyed for each tree removed – this figure ranged up to a staggering 140 trees destroyed per extraction.

Removal of undersized logs was common. An opportunistic, and admittedly small, field survey revealed as many as 38% of logs stacked at landings were undersized. These undersized logs had many potential uses; large numbers are used for building and

maintaining road bridges and camp infrastructure, while some may be milled or veneered for export as processed timber.

Forest structure was clearly modified by logging. Selectively logged forest had a more fragmented canopy over numerous smaller regenerating trees, compared with unlogged forest, which showed a more balanced, uneven-aged structure. The effect of intense large gap logging was even more profound; large gaps became choked with vines, inhibiting forest regeneration. There was no evidence of any widespread proactive regeneration by the logging company and there is a possibility that ongoing logging operations are modifying the structure and composition of large tracts of lowland rainforest. With this in mind the following recommendations are made:

- Regular official inspections of logging operations to ensure the Environmental and Forestry laws are being enforced, and that the rights of workers and landowners are protected.
- Urgent need for detailed ecological investigations to determine possible long-term changes to the affected rainforest.
- Creation of rainforest reserves or refugia, rather than allowing unmitigated high intensity logging.
- Independent monitoring of soil and water quality, both on the logging sites and in downstream communities.
- Realistic assessments of logging extraction rates to enable more accurate modeling of ecosystem changes.

2. Introduction

The lowland rainforests in the Wawoi and Guavi Rivers area constitutes an enormous timber resource that has been exploited by various logging companies for up to 30 years. Starting in the 1970s selective logging operations have been undertaken in a variety of timber concessions. Currently, a total of 732,022ha are being actively logged, this comprises four Timber Rights Permit (TRP) concession areas; Wawoi Guavi Blocks 1, 2 & 3, and Makapa. Logging activities are poised to start on a further 811,285ha in the Kamula Doso Blocks 1, 2 & 3. Clearly natural resource management on this scale must be carefully monitored and controlled, this is plainly mandated in the National Forestry policies of the Government of Papua New Guinea.

The National Government believes responsible logging can provide long-term benefits both to the nation and to the communities who own and live in these areas. Together, the *National Forest Policy* (1991) and the *Forestry Act* (1993; Amendment (2000)) outline the main objectives: exploitation the forest resources to raise revenue, improve services and infrastructure in these areas. However, a key plank of these policies prescribes for protection of the environment and sustained yield management. These policies standardize practices with the intention of ensuring adequate regeneration, minimum harvestable log sizes, minimal disturbance, commissioning of forest management research and environmental monitoring (PNGFA, 1995). In addition, many aspects of forestry are covered under the *Environment Act 2000*, which regulates for the protection of the environment through responsible land-use and protection of ecosystems, waterways, cultural sites and natural areas. Many of these important protection criteria are summarized under the *Papua New Guinea Logging Code of Practice (PNGLCP)* (PNGFA, 1996). This code provides a simple checklist of the minimum compliance standards expected for selective logging operations in PNG.

When applying for Government permission to log the Wawoi Guavi area, the logging companies were clearly conscious of the need to minimize possible environmental damage. The official Environmental Plans prepared by the *Wawoi Guavi Timber Company Pty. Ltd. (WGTC)* for the development of Blocks 2 and 3 (Saulei *et al.*, 1987; PNGFRI, 1990), listed a range of activities, the company agreed to carry out, including; river monitoring for changes in water quality, fish and plant life, monitoring for soil erosion, monitoring of possible fuel and oil discharges, regeneration of logged areas, and establishment of natural regeneration areas. In addition, the Company proposed to undertake an ongoing range of programs to ensure a co-operative and positive relationship with the local people, immigrants and employees.

Given the enormous areas involved in the Wawoi Guavi region, there is a paucity of publicly available data on the impacts of the long-term logging in this area. Neither the *PNG Forest Authority* nor the *Department of Conservation* could provide any details of the Company's outlined monitoring program. The only data available was a brief independent environmental assessment of part of Wawoi Guavi Block 3B that listed a range of breaches of the *PNGLCP* (Erskine, 1999). This lack of environmental and social data is of increasing concern considering the impending expansion of logging activities in this area. Therefore, this study further investigates the evidence of environmental disturbance over a range of logged sites and examines the levels of compliance with the *PNGLCP*. Moreover, preliminary attempts have been made to try and determine the possible ecological implications of large-scale logging in terms of changes to forest structure and dynamics. To this end the regeneration of logged forest sites are studied with a view as to how best to evaluate and monitor these areas in the future.

3. Study Area

The timber areas are situated in the Upper Bamu district of the Western Province near the border of the Gulf and Southern Highlands Provinces, centred approximately 120km northwest of Daru. The area covers 1,543,307ha of predominantly lowland tropical rainforest, which incorporates 7 timber concessions areas; the Wawoi Guavi Blocks 1 –3 on the eastern side of the region and the Kamula Doso Blocks 1-3 on the western side while the Makapa TRP lies in the central southern part of the study area (Fig.1).

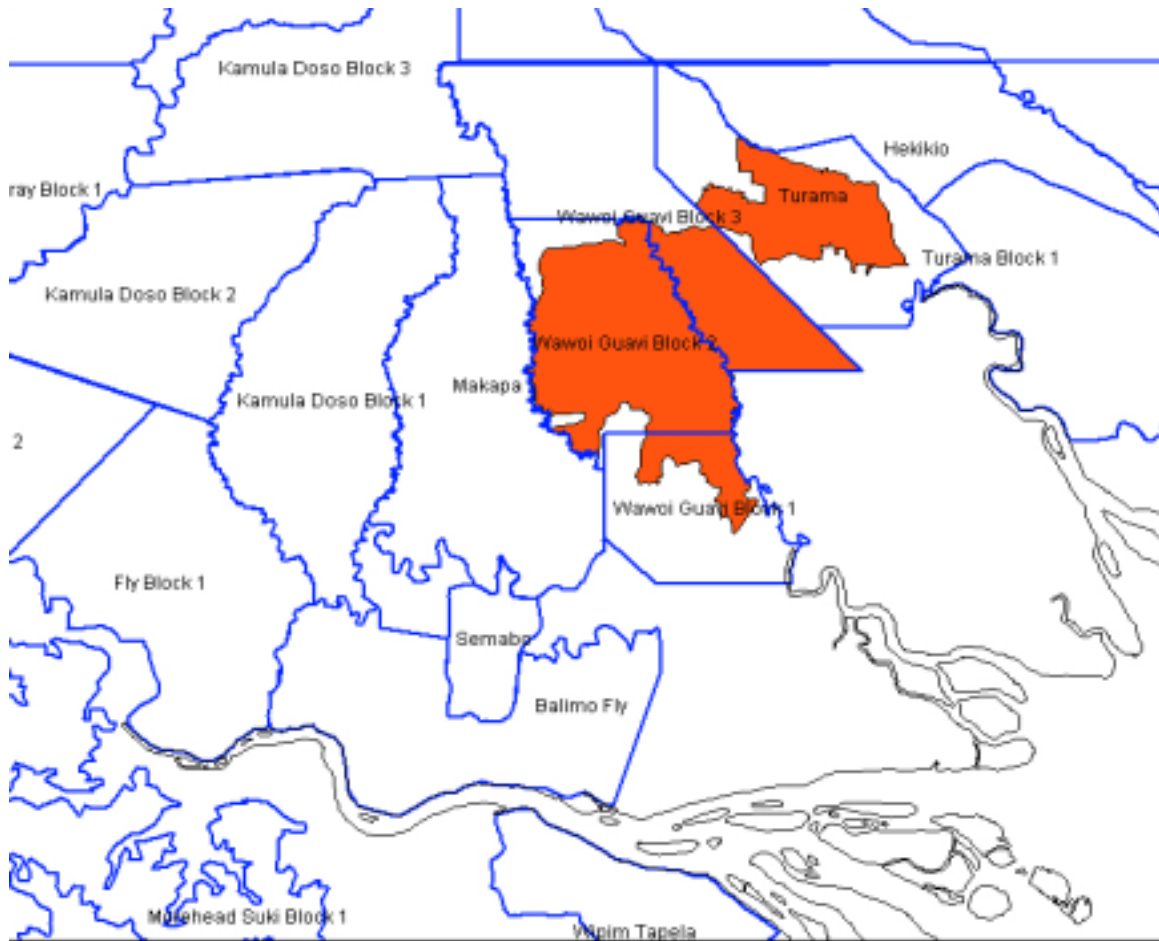


Figure 1. Map showing the general location of the study blocks.

3.1 Topography and climate

The upper part of the study area encompasses southern outliers of the mountain ranges of the Southern Highlands and elevations rise to about 500m a.s.l. with watercourses cutting through some steep, deep valleys. However, the majority of the sites affected by logging activities are lower (rarely rising in excess of 50m a.s.l.), generally comprised of undulating country merging into swampy areas near the rivers. Geologically, this region is part of an extensive area of relict alluvial plains, dissected in varying degrees by

meandering rivers and channels (Loffler, 1977). Soils are heavily leached laterites, predominately red clays overlying white clay, with some small occurrences of richer brown volcanic soils in the northernmost parts of the site. This area is an important watershed for the Wawoi, Guavi and Aramia Rivers, which feed into the Bamu River, while the western Kamula Doso blocks are also catchments for the Aiema and other rivers that are tributaries of Strickland River.

This lowland part of the Western Province is subject to a tropical humid climate. The area has a mean annual rainfall of 3.2m (McAlpine *et al.*, 1983). Although rain may fall throughout the year, a wetter season occurs between February and June, while August and September constitute a dry period. Temperatures are reasonably steady all year with mean maxima ranging from 28 - 32°C and mean minima varying from 20 - 25°C. Relative humidity is high all year round ranging from 75 – 85% and 80 – 90% during the dry and wet seasons respectively (McAlpine *et al.*, 1983).

3.2 Vegetation

The predominant vegetation in the Wawoi Guavi - Kamula Doso area is broadly classified as lowland tropical rainforest, more specifically described as small crowned forest (Whitmore 1984; Richards 1996). The major canopy tree species include, *Anisoptera thurifera* (Mersawa), *Calophyllum* spp., *Canarium* spp., *Hopea* sp., *Pometia pinnata* (Taun), *Terminalia* sp., *Mastixiodenderon* sp., *Endospermum* sp., *Palaquium* sp., *Pterocymbium* sp., *Dysoxylum* sp., *Ficus* sp., *Myristica* sp., *Octomeles sumatrana*, *Eleocarpus* sp, *Planchonella* sp. and *Pterocarpus indicus* (Rosewood). The ground cover is generally sparse though lianes, palms and pandana are well-developed.

Being such a large area, the vegetation ranges over a variety of habitats from swamp through riparian, lowland rainforest, up to fringing montane forest. Although the forest is generally tall (30-35m high) and structurally complex, the forest structure can be uneven, with canopy height, closure and crown size variable depending upon site conditions.

According to Paijmans (1976;cited in Saulei *et al.*, (1987)), the vegetation may be classified as Open Lowland Plain Rainforest; this forest is characterized by somewhat smaller crowns, lower stature with a greater number of larger gaps; the emergents are widely crowned but are lower and more widely spaced. In frequently flooded alluvial plains the canopy is higher with large emergents reaching 40m in height, while on undulating plains and low ridges the forest stature may be lower with more even crown sizes (PNGFRI, 1990).

In flood-prone sites on the lower sections of the Guavi River stands of *Sonneratia lanceolata* were reported. This occurrence of *Sonneratia* was noted with interest since this important coastal mangrove genus had not been previously reported in PNG (PNGFRI, 1990). Similarly, the same study also noted the occurrence of seedlings of several montane species (*Galbulimima belgraveana*, *Lithocarpus* sp. and *Dacrydium* sp.) in the lowland rainforests of Wawoi Guavi Block 3, even though the altitude was only 35m a.s.l. This presumably reflects the proximity of the neighbouring montane zones to the north.

3.3 Timber resources & logging history

Large-scale timber harvesting has occurred in this region for about 30 years. Wawoi Guavi Block 1 was logged from the 1970s, initially by a company from Singapore. Following this, a second rotation of logging was managed in Block 1 in the early 1980s by a collective of Asian companies; *Straits Marine* and *Pacific Wood Contractors* (*PWC*), a subsidiary of *Rimbunan Hijau* (*RH*). A third logging rotation of this Block was finished in 2000 – this was managed by *Wawoi Guavi Timber Co*, (*WGTC*), also a subsidiary of *RH*. Wawoi Guavi Block 2 was logged by *WGTC* from about 1987 through to 1992, after which some second rotation logging commenced. Logging of Block 3A by *WGTC* commenced in about 1991.

Currently most of Block 3A has been logged and some second rotation logging may be occurring. The only significant unlogged areas in the Wawoi Guavi concessions are in the upper part of Block 3B – it is estimated that these areas will be logged over the next few years. Logging activities in Wawoi Guavi are performed by *PWC* and *WGTC* – both these companies are subsidiaries of *RH*. For brevity and clarity, *RH* will be referred to as the operating company in this report. A separate Malaysian company, *Innovision*, commenced logging operations in Makapa TRP from about 1998.

Surveys conducted by the Government and *RH* of the Wawoi Guavi Timber areas revealed estimated harvestable wood volumes of 18.75m³/ha for Block 2, and 18.2m³/ha for Block 3 (Saulei *et al.*, 1987; PNGFRI, 1990). Although these yields are relatively low, the forest was considered viable for logging for several reasons. Firstly, surveys show that the Wawoi Guavi Blocks are dominated by economic timber species, particularly *Anisoptera* sp. (Mersawa). Other common commercial species included *Calophyllum* spp, *Canarium* spp. and *Pometia pinnata* (Taun) (for a more comprehensive list see Appendix 1). Secondly, the logging operations were envisaged as long-term ventures and the areas involved are potentially huge – a total of 1,287,714ha for the Concessions held (and potentially held) by *RH*. These concessions are listed in Table 1

All these concessions can be exploited with the same infrastructure, namely, the *RH* processing mills at Panakowa and Kamusi, the constructed road network, the river transport system and the loading facilities already established at Umuda Island. In addition the Makapa TRP (255,593ha) is operated by a second company *Innovision Pty Ltd* (*Vanimo Jaya*). They operate a large log pool on the Wawoi River and also transport logs down the Bamu to load on ships at Umuda Island. Makapa TRP brings the total area affected by current or impending logging up to 1,543,307ha.

Table 1. Details of the forestry concession areas in the Wawoi Guavi region.

Concession Area	Size (ha)	Operating Company
Wawoi Guavi Block 1 TRP	88, 872	<i>Wawoi Guavi Timber Co. (Rimbunan Hijau)</i>
Wawoi Guavi Block 2 TRP	180,354	As above
Wawoi Guavi Block 3 TRP	207,203	As above
Makapa TRP	255,593	<i>Innovision (Vanimo Jaya)</i>
Kamula Doso Block FMA	288,414	TBA; potentially <i>Rimbunan Hijau</i>
Kamula Doso Block 2 FMA	265,265	As above
Kamula Doso Block 3 FMA	257,606	As above
TOTAL	1,543,307	

3.4 Customary landowners & forest users

The Upper Bamu area is relatively lightly populated, and accurate data remains elusive due to the semi-nomadic existence of some of the forest peoples. This region is the traditional land of many tribes and clans. In the area covered by this study (Block 3A and to a lesser extent 3B) the biggest landowners are the Kosuo Tribe. This Tribe comprises numerous Clans. Within Block 3A these clans are; Nedane, Kapolasi (*syn.* Haya), Ubei and Hebira. Within Block 3B clans from Kosuo Tribe include; Batamo, Demeta and Kamala. From the Musula region of Block 3B, the following clans are major landowners; Kamalasivise, Kamalaolebisa, Hetaka, Tepela, Tikiri, Heseke, Subara, Kasoro and Hi. In the northern part of Block 3A and into the Kamula Doso region the Kamola Tribe is a major landowner. For the local people the forest contains a large number of sacred and culturally significant sites. Moreover, these people depend heavily upon forest resources; it contains a many hunting lodges, building materials, medicines and gardens (predominant crops include sago palm, banana, sweet potato, pumpkin, sugar cane and cassava), and supports a rich fauna and several important food species for local hunters including cassowary, wallabies, tree kangaroos and wild pigs. People also fish extensively in the rivers and waterways.

The total population of the region surrounding the Wawoi Guavi Block 2 development was estimated at 1956, seemingly based upon figures from 1980 (Saulei *et al.*, 1987). The population was found to have increased in several villages several years later (PNGFRI, 1990), however, this study gives no details of total affected population and does not appear to include figures for Wawoi Falls (estimated population about 700). Therefore with the expansion of the logging project, the numbers of affected people is likely to increase significantly. Moreover, the figures cited do not include the villages downstream on the Bamu, which sometimes claim to have been impacted by logging activities upstream.

In their Environmental Plan for the *Wawoi Guavi Timber Co.*, Saulei *et al.* (1987) concluded that a significant influx of immigrants (following work with the logging projects) had occurred by 1987 and this population flow was likely to increase. These authors warned of the likelihood for conflict between immigrant groups and traditional landowners.

4. Methods

This study was undertaken during the start of the dry season from 7 - 17 August 2003. As great an area was covered as was logistically possible, although pressure and travel restrictions from *RH* ensured that most detailed work was undertaken in Block 3A. Unless noted otherwise, all sites were visited, inspected and recorded. Digital images were made where necessary and locations were measured using a *Garmin XTrak* GPS, which is considered accurate to within 9m. Other measurements of ground distances and log measurements were made with tape measures. Where no empirical data was available, attempts were made to interview people directly involved; where information is anecdotal the fact is acknowledged in the text.

Incidental losses

Incidental tree losses were measured at numerous sites where active logging was occurring. Due to large differences in logging practices, these data were collected and categorized in several ways. At sites where selective logging was relatively low impact (i.e. with skid tracks leading to individual felling sites), the affected area was defined as the obvious gap created around the tree stump at the end of a skid trail – these sites are referred to as “Small Gap” sites. Any stem >10cm diameter breast height (dbh) that had been knocked over, cut down, flattened or uprooted was defined as having been killed. At other sites where logging intensity was high, and multiple trees had been extracted from large gaps, much debris was unidentifiable, so radiating transects were run into similar adjacent forest and nearest-neighbour measurements determined the density of smaller trees (Cottam & Curtis, 1956). These data were then used to calculate incidental loss rates – these sites are referred to as “Large Gap” sites.

Undersize log measurements

In terms of size, merchantable trees are defined as those greater than 50cm diameter at breast height (dbh), or above fluting (PNGFA, 1996). Therefore, all the log measurements in this study were made on the lower end of logs, where the initial cut had been made – this was determined by evidence of remains of fluting or obvious flaring. When the base of log could not be ascertained, the log was considered to be legally sized (i.e. it was regarded that it may be the top section cut from a legal sized tree) – therefore the measures are conservative.

Forest structure

Forest structure and density measurements were determined using a total of sixteen 100m² quadrats in variously affected sites in Wawoi Guavi Block 3A. The forests were typical lowland rainforest of 25-30 height growing on similar clay soils at altitude of about 100-80m. The unlogged forest (6°57.042'S 142°45.747'E) occurred in a forest reserve that had been protected from logging. The logged forests (7°03.638'S:

142°49.410'E) had been selectively logged over the last 5 years up until about 1 year ago. The diameters of all tree stems within quadrats were measured at breast height (dbh) enabling the calculation of size-class characteristics and tree densities.

5. Findings

5.1 Roads & bridges

5.1.1 Major logging roads

The Wawoi Guavi timber concessions contain a multitude of logging roads, ranging from major transport roads for log jinkers and supply trucks, through to small access roads and skid trails. Only a relatively small number of these roads could be directly recorded, however, the major roads from Kesovi to Camp 56 and from Wawoi Falls to Kilometer 66 were surveyed, together with numerous secondary roads and skid trails. The major roads were generally restricted to the ridge tops, particularly in the upper reaches of Block 3 where the terrain topography is quite steep. Due to the scale of operations and the highly erosive nature of the predominant red clay soils, the area of most concern was the high input of clay sediment into the headwaters of the waterways. Swales and small valleys were often filled with large banks of clay soil that washed down watercourses.

These problems were exacerbated by consistently poor bridge design, leading to collapsed logs in streams and unstable banks that resulted in the constriction of watercourses with sediment and debris. Without exception, bridges did not appear to incorporate the required geotextile anti-rotting layer; rather soil was piled directly on logs and wood planks. Consequently, most bridges are likely to require constant repair or replacement. This poor construction not only degrades waterways, but generates a steady demand for replacement logs and timber. Moreover, poor bridge and road engineering means the road system is unlikely to be useful to local road users once active logging operations have ceased.

Drainage is also a problem with large-scale erosion common and no evidence of the implementation of erosion control measures such as scour protection or installation of upstream debris deflectors. The road surface is generally red clay without any gravel or metal surfacing – this makes the road virtually impassable in wet conditions. Secondary roads on steep terrain are subject to acute undercutting, washout, instability and collapse of culverts and bridges. In addition, water seepage often creates bog holes, rutting and corrugations. Also of concern is the generally invasive nature of road construction. Canopy removal was generally in excess of the 40m maximum width permitted (*PNGGLCP* Key Standard 9) and road construction commonly involved felling and pushing of soil and trees directly into the surrounding forest or down adjacent gullies.

Some specific problems observed on the main roads included:

- ✘ Road width >40m — ***PNGGLCP* Key Standard 9 (38 breaches).**
- ✘ Pushing of excess soil into the forest — ***PNGGLCP* Key Standard 6 (33 breaches).**
- ✘ Trees felled and pushed into surrounding forest — ***PNGGLCP* Key Standard 15 (29 breaches).**
- ✘ Incorrect use of soil on directly on logs without appropriate use of a layer of anti rotting geotextile material — ***PNGGLCP* Key Standard 12 (23 breaches).**
- ✘ Road drainage into water crossings — ***PNGGLCP* Key Standard 14 (22 breaches).**
- ✘ Soil pushed into streams — ***PNGGLCP* Key Standard 10 (22 breaches).**
- ✘ Substandard road drainage including blocked culverts, scoured turnouts and discharge of drains directly into watercourses without appropriate vegetation buffers — ***PNGGLCP* Key Standard 11 (20 breaches).**

Examples of these infractions and problems are given in Figs. 2 - 7 and a full list of *PNGGLCP* Key Standard contraventions observed in the project are detailed in Appendix 3.



Figure 2.
Bridges were not built to last.



Figure 6.
Poor drainage and deep ruts are a major problem on forest roads.



Figure 4.
Road widths were often excessive.



Figure

3.
A new, unstable bridge over the Aworra River.



Figure 7.
Soil and debris was often pushed into the forest.



Figur

e 5.
Erosion was a common problem on the exposed clay soils.

5.1.2 Decommissioning forest roads & skid tracks

Numerous secondary forest access roads and skid trails were examined during this study. No forest roads appeared to have been decommissioned, bridges were often left in place, albeit in poor condition and edge berms were left intact. On skid tracks no water bars were apparent on steep gradients; furthermore, river crossings (including solid earth dams) had not been decommissioned (Figs. 8 & 9). Specific breaches were seen on virtually every water crossing encountered. In no cases did it appear that the correct procedure of using logs as temporary crossing had been followed. The rationale behind this is unclear, it maybe laziness or possibly *RH* are envisaging a second logging rotation, however, in the interim the erosion of banks and sedimentation of waterways is a major concern. The following breaches of *PNG LCP* were common;

- ✘ Soil in streams from skid tracks – ***PNG LCP* Key Standard 10.**
- ✘ Failure to remove temporary log bridges and use of soil directly in streams – ***PNG LCP* Key Standard 18.**
- ✘ Failure to decommission forest roads – ***PNG LCP* Key Standard 19.**
- ✘ Failure to construct water bars on steep gradients – ***PNG LCP* Key Standard 21.**





Figure 8.
No water bars across steep skid tracks often led to severe erosion.

Figure 9.
Skid tracks were commonly bulldozed right across streams.

5.2 Logging operations & impacts on the forests

5.2.1 Small Gap & Large Gap sites

The extent and variance of the logging operations at Wawoi Guavi was striking. Networks of logging roads spread throughout the region and logging effects varied, depending upon the topography and intensity of tree extraction. For these reasons, it was difficult to uniformly describe the effects of logging. In some set-ups, timber extraction appeared to be relatively light, with single tree extractions and skidding tracks minimized. These areas are referred to as “Small Gap” sites. Most of these sites were on Nedane Clan lands, over which logging operations had been monitored as closely as possible by the landowners (Sakas Aonomo, landowner; Pers. Comm). However, in many other areas, logging operations were far more indiscriminate. Numerous sites were examined in which large disturbances were created by multiple tree extractions; gaps up to several hectares were observed (particularly in the setups just south of Wawoi Falls) and gaps of about a hectare were not uncommon. These high impact areas are referred to as “Large Gap” sites. Some specific observations of the logging effects in these areas are described below.

5.2.2 Incidental losses

As a comparison to earlier studies of rainforests logging in other regions, an investigation was made into the incidental losses incurred by surrounding trees during timber extraction .

5.2.2.1 Small Gap Sites

Examination of 12 freshly logged sites off skid trails in Nedane Clan lands in Block 3A (centred 7°03.638'S: 142°49.410'E) found number of smaller trees destroyed (>10cm) for a single log extraction ranged from 7 – 22 trees, with an average of 11.83 (\pm 1.47 s.e.m.). This figure was quite high but significantly lower than that reported by Erskine (1999) for Wawoi Guavi Block 3B (see Table 2).

5.2.2.2 Large Gap Sites

Eleven freshly logged sites were studied by following skid trails off the main road near Wawoi Falls in the northern section of Block 3A (centred 6°55.320'S: 142°39.196'E). In this region logging was very intensive and large gaps up to several hectares had been created (Figs. 10 & 11). The rates of incidental losses were found to be staggeringly high, with the number of trees (>10cm dbh) destroyed for each tree removed ranging from 45 – 140, with an average of 65.32 (\pm 9.25 s.e.m.). These results are far higher than anything previously recorded for selective logging and are more analogous to a clear-felling operation.

It was noted by Erskine (1999), that direct comparison of incidental losses from different studies is difficult, given the variation in methodologies and definitions used. However, it is abundantly clear that for the large gap sites at Wawoi Guavi, the damage to surrounding vegetation is extraordinarily severe - it is difficult to reconcile the results with any definition of selective logging.

Table 2. Average numbers of small trees (>10cm dbh) lost during selective logging at various locations

Location of study	Ave incidental losses per tree extracted	Reference
Queensland, Australia	2.7	Chrome <i>et al.</i> (1992)
Amazonia, Brazil	4.9	Uhl & Vieira (1989)
Kalimantan, Indonesia	5.7	Abdulhadi <i>et al.</i> (1981)
Wawoi Guavi, PNG (Small Gap)	11.8	This study
Sabah, Malaysia	15.6	Nicholson (1958)
Wawoi Guavi, PNG	16.7	Erskine (1999)
Kiunga-Aiambak, PNG	17.1	Melick (2003)
Wawoi Guavi, PNG (Large Gap)	65.3	This study



Figure 10.
Large gaps were created by intensive logging near Wawoi Falls



Figure 11.
A gap of more than 1.5ha, created by intensive logging in Block 3A.

5.2.3 Removal of undersized/non-merchantable logs

The identification of undersized (<50cm dbh) logs in stockpiles was not uncommon. Often discarded piles of undersized logs were left in old log landings, some undersized logs were also observed in stockpiles at Camp 56 and Kamusi. However, determining the numbers of undersized logs removed from the forest is problematical since these small logs may be milled or veneered, used for construction or destroyed if rejected. In an attempt to record the incidence of undersize log removal, a random sampling was made on 11 August 2003 by recording all logs seen in the small landings through the active logging zone along the Wawoi Falls road from 6°53.235'S: 142°40.546'E to 6°55.117'S: 142°39.116'E. A total of 91 logs were recorded of which 35 (38.5%) were found to be undersized. However, 22 of these were marked "P" or "POST", suggesting they were destined for construction activities (Fig. 12). When these construction logs were discounted, 18.9% of the logs marked for timber use were still undersized.

The above data, though merely an opportunistic spot sampling, suggests that removal of small trees from the forest is widespread. This suspicion was further supported by an

inspection of sites in Block 3B in which active logging is yet to commence.

Observations in the forest at 6°58.606'S: 142°50.675'E, near the Kana (or Aworra) River, revealed large gaps and extensive log removal, presumably to construct the nearby bridge and culverts (Figs. 13 & 14). Thus, it is clear that rates of un-merchantable tree removal are significant and need to be considered in ecological modeling of logging impacts.

any timber is cut for export many trees are removed for culverts and bridge building.



Figure 13.
An “unlogged” area in Block 3B. Even before



Figure 12.
Undersize logs in a stockpile – they appear to be destined for construction purposes.



Figure 14.
Large amounts of timber are extracted to build and maintain infrastructure for logging.

5.2.4 Changes to forest structure

Forest structure tends to become simplified after logging. Removal of larger trees produces regrowth, resulting in a more uniform stand structure with a large number of smaller regenerating trees. This trend was clear in the preliminary studies performed in the selectively logged forests at Wawoi Guavi. Size-frequency histograms from recently logged and unlogged forest shows a clear demarcation, with recently logged forest demonstrating a classic young regrowth structure, while the unlogged forest has an

uneven-aged structure that reflects the occurrence of more old-growth trees (Fig.15). Even within a mature rainforest, there are a large number of shade tolerant saplings, this too is evident in the results obtained in this study. As expected, overstorey canopy cover was reduced by the gaps created in logged forest. Similarly, the basal areas of trees was reduced in logged forest, while the density of stems increased – once again this reflects a classic regrowth response to a disturbed forest system, i.e. a reduction in the numbers of large trees and an increased number of saplings (Table 3).

Table 3. Characteristics of unlogged and selectively logged (Small Gap) rainforest in Wawoi Guavi Block 3A.

	Basal area (m ² ha ⁻¹)	Density (stems ha ⁻¹)	Canopy cover (overstorey)
Unlogged	85.7	3600	85-95%
Logged (over the last 5 years)	52.2	5375	50-60%

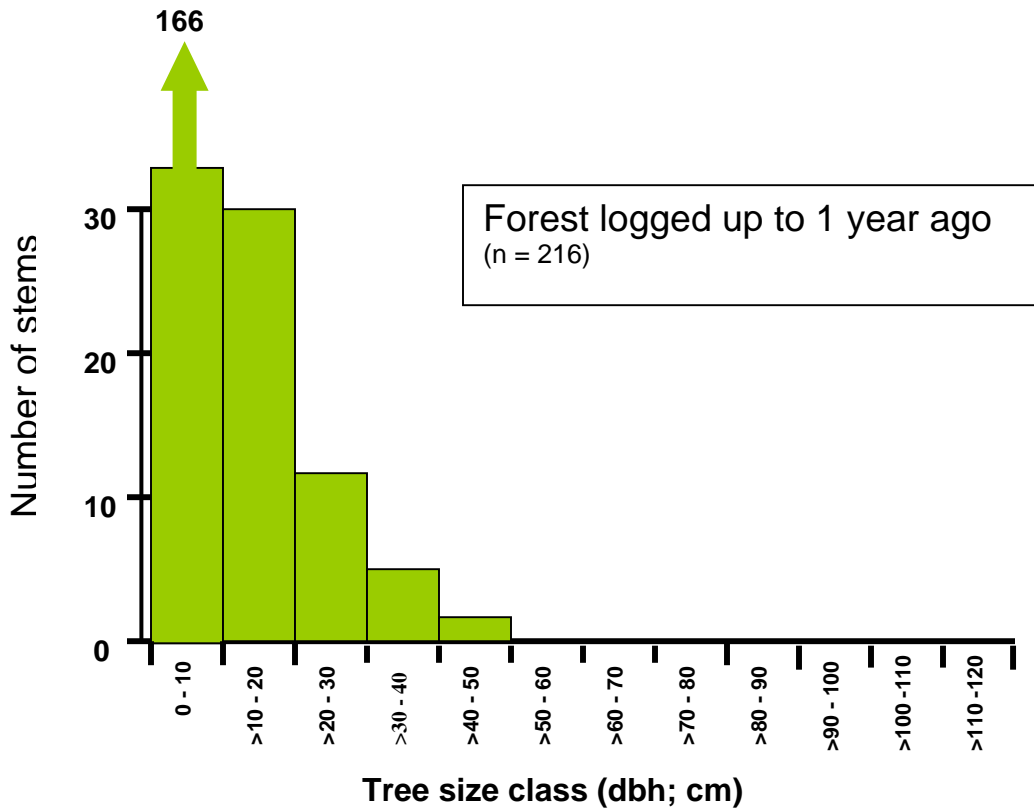
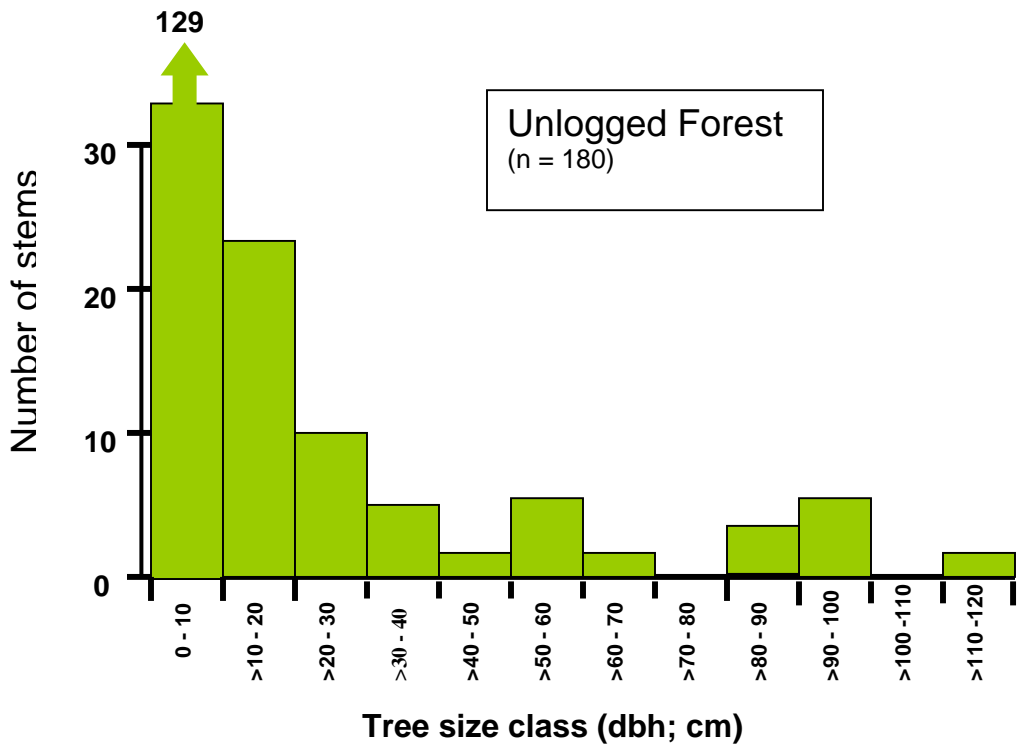


Figure 15. Tree diameter (dbh) - frequency histograms of forest in Wawoi Guavi Block 3A show that logged forest comprises numerous smaller trees compared with unlogged forest that has a more uneven-aged structure.

In the areas where log extraction was very high – the Large Gap sites – there was no point in performing structural analyses since there were no stems to measure. These sites will probably become vine-dominated and, consequently, secondary succession of tree species will be greatly retarded compared with that expected in forests where gaps are small. Vines were often observed invading large gaps; this was graphically illustrated by the dominance of vines such as *Merremia peltata* in the niches created by abandoned logging roads, both across the roads themselves and festooned over gap edge vegetation (Figs. 16 & 17).



Figure 16.
Vines invade large gaps in the rainforest
and retard tree regeneration.



Figure 17.
Vines will dominate decommissioned roads for
a considerable time.

5.3 Logging camps & log pools

5.3.1 Kesovi

The Kesovi log camp (7°13.285'S: 142°44.536'E) was established near the Wawoi River in 1996/97 and is being decommissioned with the building of a new camp on the Guavi River. Kesovi Camp has several ongoing environmental problems; debris is scattered around the site and fuel and oil contaminate the surrounding environment. Moreover, the sanitation is poor, with inappropriate disposal of rubbish and waste water. The following specific examples were recorded:

Fuel storage and leakage: Diesel fuel is permanently stored in a large (approx. 40,000litre) tank with no bunding or other leak protection situated approximately 80m from a tributary of the Wawoi River. Fuel leakage through the soil and down slope into the creek was evident.

✘ This is a contravention of PNGLCP Section D. Waste Management. 3. Toxic Materials 3.1.5 & Section E. Workshop, Fuel Storage & Field Servicing 2. 1 inclusive & the PNG Environment Act 2000.

Oil contamination: Pooled oil and leaking barrels were observed behind several workshop areas. This oil has polluted the adjacent swampy garden areas and waterways (Figs. 18 & 19).

✘ This is a contravention of PNGLCP Section D. Workshop, Fuel Storage & Field Servicing 1. 1.1 Waste Management. 3. Toxic Materials 3.1 inclusive & the PNG Environment Act 2000.



Figure 18.
Oil spills are common at Kesovi.



Figure 19.
Oil and fuel leaks into the swamp at Kesovi.

Waste Disposal: Waste water is piped through the outlying houses into an adjacent swamp and creek. Rubbish has been dumped into the creek.

✘ This is a contravention of PNGLCP Section F. Camp Hygiene 1.4; 2.3 & the PNG Environment Act 2000.

Waste Disposal: Discarded plant equipment, old tyres and batteries are scattered over the site.

✘ This is a contravention of PNGLCP Key Standard 23.

5.3.2 Camp 56

This operating log camp and workshop (7°07.689'S: 142°49.907'E) was established in 2000. There were serious breaches of environmental laws, which are detailed below;

Fuel storage and leakage: Diesel fuel is permanently stored in a several tanks around the complex. None of these tanks were bunded or otherwise leak protected. Fuel leakage through the soil and in the adjacent waterways was evident (Figs. 20 & 21.).

✘ This is a contravention of *PNGLCP* Section D. Waste Management. 3. Toxic Materials 3.1.5 & Section E. Workshop, Fuel Storage & Field Servicing 2. 1 inclusive & the PNG Environment Act 2000.

Oil contamination: A large waste oil sump was dug directly into the soil behind the workshop (Fig. 22). This oil pool was often inundated by heavy rain, washing oil into the adjacent drains down into the nearby creek a tributary of the Pabobi River. Oil contamination of surrounding soil and rivers was evident (Fig. 23).

✘ This is a contravention of *PNGLCP* Section D. Waste Management. 3. Toxic Materials 3.1 inclusive & the PNG Environment Act 2000.

Waste Disposal: Waste water is piped through the outlying houses into an adjacent swamp and creek. Rubbish has been dumped into the creek.

✘ This is a contravention of *PNGLCP* Section F. Camp Hygiene 1.4; 2.3 & the PNG Environment Act 2000.

Waste Disposal: Old tyres and lead-acid batteries are scattered over the site.

✘ This is a contravention of *PNGLCP* Key Standard 23.



Figure 20.
Diesel leaks are common at log camps.
There was never any bunding or leak
protection installed.



Figure 22.
Waste oil is dumped in a pit behind Camp
56. This site becomes flooded in heavy
rain.



Figure 21.
Diesel slicks visible through a broken bridge behind Camp 56.



Figure 23.
Oil contamination in the River at Camp 56.

5.3.3 Kamusi Log Pool

Kamusi is a large log pool and workers township located on the banks of the Guavi River (7°25.808'S: 143°07.506'E). Several environmental concerns are detailed below;

Fuel storage and leakage: An enormous volume of diesel fuel is permanently stored in a numerous tanks adjacent to the wharf on the Guavi River. None of these tanks were bunded or otherwise leak protected. Fuel leakage through the soil and into the Guavi River, which is within 50 metres was evident (Fig. 24).

✘ This is a contravention of PNGLCP Section D. Waste Management. 3. Toxic Materials 3.1.5 & Section E. Workshop, Fuel Storage & Field Servicing 2. 1 inclusive & the PNG Environment Act 2000.

Toxic chemicals: Potential contamination of water table with toxic chemicals. Logs were dunked insecticide/anti fungal chemical (sample taken for analysis). Leaching of this chemical was apparent into the soil and also into the Guavi River. On occasions when log rafts are used, this chemical can leach directly into the river.

✘ This is a contravention of PNGLCP Section D. Waste Management. 3. Toxic Materials 3.1.5 & the PNG Environment Act 2000.

Toxic chemical safety: Workers were stoking bark and log fires through thick smoke with no protective clothing or masks – some of this debris had reportedly been chemically treated with chemicals (Fig. 25).

✘ This is a contravention of PNGLCP Section G. Safety: Protective Clothing and Safety Equipment 1. 1.1.5.

Figure 24.
Millions of litres of fuel are stored on the banks of the Guavi River at Kamusi. There is no bunding and leaks to the river are common.





Figure 25.
A worker stokes the log and bark fires at Kamusi without protective mask or clothing.

5.3.4 Wawoi Guavi Block 1B Log Pool

This log pool (7°40.578'S: 142°59.346'E) was decommissioned in 1999/2000. Much debris still remained in the area including old housing material, oil and fuel drums, machine parts, storage tanks, cables and sundry debris. There was evidence of oil spillage that had contaminated the soil at an old workshop site together with old lead-acid batteries, oil and fuel filters. Several piles of discarded logs were observed, some of these appeared to be undersized (<50cm diameter). A large holed log barge was also present, apparently used as a wharf.

✘ This is a contravention of PNGLCP Key Standard 24 and Section D: Waste Management, Subsections 2 & 3. & the PNG Environment Act 2000.

There did not appear to have been any concerted attempt made to rehabilitate this site, the clay soil showed no evidence of ripping, sheet erosion was common, while channel erosion was also apparent underneath the vine regrowth which was starting to dominate the vegetation.

✘ This is a contravention of PNGLCP Key Standard 22.

5.4 Destruction of cultural sites

To the tribal people who live in the Wawoi Guavi area, the forest holds immense spiritual and cultural significance. During the course of this study one of the most common and passionate complaints against logging operations was the disregard of the logging contractors to cultural sensitivities and the destruction of many important and sacred sites. Numerous accounts were related to the author regarding the destruction of sacred places, however, the only those sites personally inspected are listed below.

Batamo Burial Grounds (centred approx 6°58.500'S; 142°52.000'E). The ancient burial grounds on Yokoname Mountain are very significant to the Batamo Clan. The bones of their ancestors rest on shelves scattered around the mountain and the site forms a spiritual home for the Clan. Recently a survey road was pegged directly through the site in preparation for construction of a logging road to extend activities in Block 3B. Locals have removed survey tags and protested to the logging company – so far to no avail. (Hokowe Pamowe, Headman, Batamo Clan, Pers. Comm.).

✘ This is a contravention of PINGLCP Key Standards 2a; 3.

Bula (Spy Camp) (7°01.642'S; 142°50.121'E): This place is significant to members of the Haya (*syn.* Kapolasi) Clan, who used the site for generations. Road construction passed very close to the site and the old native nut trees (*Canarium indica*) were logged.

✘ This is a contravention of PINGLCP Key Standards 2a; 3.

Sacred Gully (6°56.006'S; E142°45.048'E): This site was known to members of the Haya (*syn.* Kapolasi) Clan as “Kesayamona” – “Place of the Giant Earthworm” – this spot revered as a place of separation and purity. Construction of the logging road through to Weylio destroyed this site.

✘ This is a contravention of PINGLCP Key Standards 2a; 3.

Sacred Pass (6°55.788'S: 142°38.917'E): This site was sacred to the nursing mothers of the Kamola Tribe and involved an important ritual whenever the pass was crossed. Construction of the logging road through to Wawoi Falls destroyed this site despite the requests of local tribespeople (Fig. 26).

✘ This is a contravention of PINGLCP Key Standards 2a; 3.



Figure 26.

Once a sacred place to the Kamola Tribe, this pass has been destroyed by the logging road.

Sacred Place (6°52.600'S: 142°45.750'E): Construction of the airstrip and road at Weylio destroyed this site that was sacred for new mothers of the Haya (*syn.* Kapolasi) who performed a ritual here to ensure healthy children. (Kuwene Nakeye, Elder, Kapolasi Clan, Pers. Comm.).

✘ This is a contravention of PINGLCP Key Standards 2a; 3.

Health Creek (7°03.652'S: 142°49.75'E). This creek was significant to the Nedane Clan

as its waters were considered to confer health and cleansing. Road building and bridge construction contrary to landowner requests have sullied and choked the creek. Clan members now say the properties of the stream have been lost. (S. Aonomo, Nedane Clan Elder; Pers. Comm.).

✘ This is a contravention of PNGLCP Key Standards 2a; 3.

Bura River (7°00.595'S: 142°49.229'E). This river is considered a sacred nature reserve, no fish or crocodiles may be caught or eaten from it. Kosuo Tribal legends describe the river as the ancient trail of a giant crocodile. Road building and bridge construction contrary to landowner requests have polluted the river, moreover, toxic sap from unscaled Taun logs (*Pometia* sp) used in bridge construction are claimed to have poisoned the river water (S. Aonomo, Kosuo Tribal Elder; Pers. Comm.).

✘ This is a contravention of PNGLCP Key Standards 2a; 3.

5.4.1 Other cultural concerns

5.4.1.1 Weylio Village

At Weylio (6°52.512'S: 142°45.052'E), the major logging road has been pushed directly through the middle of the village. Local villagers expressed anger, claiming that large trucks and Company vehicles are a constant source of danger and disruption during logging activities (A. Ubiya, Weylio Landowner; Pers. Comm.) (Fig. 27).



Figure 27.
The logging road passes directly through the middle of Weylio Village.

✘ The expansion of the logging road into the village would seem to be a breach of *PNG LCP* Key Standard 2b, which allows for a 500m buffer zone around the village.

5.4.1.2 *Bamu River*

A log barge sunk in the Bamu River off the village of Emeti (7°53.027'S; 143°15.524'E) in about 1987. A large mud bar has developed behind the barge and villagers claim the dynamics of the river have changed resulting in increased erosion and loss of land from their village; approximately 100m of river frontage has eroded over the last 15 years (J. Urukoi, Emeti Landowner, Pers. Comm.). Moreover, the villagers refuse to touch the barge believing it has “bad or evil magic”. The logging company promised to remove the barge, but salvage or removal would now look most unlikely. Regardless of whether the barge has exacerbated the bank erosion at Emeti, failure to remove the barge from the waterway demonstrates a lack of cultural sensitivity and **constitutes a breach of the *Environment Act* (2000) and *PNG LCP* Key Standard 24.**

5.4.1.3 *Wawoi River*

The river is used extensively as a conduit for log transport and consequently tug and barge traffic may be high when conditions are suitable. Villagers at Sogae complained

that oil slicks were common on the river during logging operations. Although these claims were anecdotal several environmental impacts were observed during this study. Firstly, oils slicks were evident on numerous occasions – these varied from relatively small (probably resulting from spillages of a few litres) through to quite extensive. One slick sighted 8 August 2003 ran for over 8 kilometers (first sighted 7°37.683'S: 142°57.136'E and extending to 7°38.213'S: 142°54.008'E) – particularly heavy film and strong odour was observed at (7°37.386'S: 142°55.029'E). Also barge damage to the riparian vegetation was quite common, especially on the outer edges of river curves. This damage varied from streamside debarking and scaring of trees, to gouging of the banks and destruction of one or more trees. This damage was clearly discernable from natural flood disturbances due to the tell-tale gouge marks and the height above flood level. Tree damage was personally observed on 7/8/03 –8/8/03 as the towed barges impacted riparian trees at 7°36.451'S: 142°57.850'E.

✘ These impacts are a contravention of the *Environment Act (2000)*.

5.4.1.4 *Affected gardens and swamps*

Road building and logging activities have encroached upon numerous village gardens and more importantly affected sago swamps, which are particularly valued by the local people. Some of these sites were directly affected by road construction or pollution, such as the gardens at Kesovi and sago swamps adjacent to the road at Weylio Village and along the major logging road at 7°01.610'S: 142°50.125'E and 6°57.028'S: 142°45.791'E respectively. In addition, numerous other sites were described to the author, with claims that pollutants and altered water flow since road construction and logging activities had destroyed swamps and gardens – few of these sites were examined in detail.

5.5 Water quality

The question of water quality and potential pollution problems was of central concern to all villages visited on the Bamu, Wawoi and Aramia Rivers. Landowners and villagers dependent upon these rivers consistently claimed that water quality has decreased both in terms of chemical contaminants and increased silting. There was great suspicion from many people that chemical contaminants in the water such as insecticides, fuel oil and other toxins had deleteriously affected human health, fish health and fish stocking rates. On several occasions, villagers approached the author to show sick and deformed fish, claiming that these were related to upstream logging activities. Although fuel and oil slicks were often sighted in the rivers and point source pollution into waterways and swamps was common at the log camps (see Section 5.3), there is no empirical evidence to directly link this with health problems in people or animals. However, the persistent nature of such claims, certainly highlights the need for a consistent and transparent monitoring of water quality in affected rivers. *Rimbunan Hijau* promised this sort of program in their initial environmental planning (Saulei *et al.*, 1987; PNGFRI, 1990) – no data has been made available to the knowledge of this author.

There is no doubt that the extensive road building, forest clearance and soil movement associated with the Wawoi Guavi timber projects have created extensive localized erosion and sediment run-off. While some silting and clay deposition into streams would be naturally occurring in the red clay soils following heavy rains and flood damage, clear streams were observed running through deep clays in unlogged sites. By contrast, it was apparent deforestation and road-building significantly decrease water quality – runoff from access roads and erosion around stream crossings are a significant contributor to increased water turbidity and silting of the rivers (Fig.28). Moreover, the nature of the terrain and the positioning of the major roads along ridgelines – with some earth filling of gullies – has often modified the headwater catchments and altered the down slope hydrology in these regions.



Figure 28.
Sediment input from unsurfaced roads and logging activities are negatively affecting water quality in the Wawoi Guavi area.

6. Discussion

The challenges of logging in Wawoi Guavi

There was never any doubt that logging operations on the scale that are occurring in the Wawoi Guavi area were destined to have a very significant impact on the ecology and social structure of the region. Even when using best practices, it would be very difficult for timber operations not to cause considerable disturbances. The topography of the Wawoi Guavi area (particularly in the steeper upper sections) together with the highly erosive deep clay soils, make for an unforgiving road-building and operational environment. These problems are exacerbated by the lack of any adequate surfacing material for the roads – the absence of gravel or a suitable alternative was always recognized by *Rimbunan Hijau (RH)* as a potential problem for the stability and longevity of the road systems in this project (Saulei *et al.*, 1987).

What is disturbing, however, is that even given the vulnerable nature of the environment, *RH* operational methods generally appear to be far from best practice. As detailed in this report, road building, bridge construction, logging practices and waste disposal were consistently below the requirements of *PNG Logging Code of Practice (PNGLCP)* (1996). It is apparent that *RH* considers expenditure on reducing environmental impacts to be a fairly low priority. Stark examples included the storage of millions of litres of diesel on the banks of the Guavi River, with no bunding or leak protection and the consistently poor bridge engineering – only one properly constructed bridge was observed (the steel bridge over the Kesovi River) and this was, reportedly, only built after the previous timber bridges consistently collapsed. Virtually all stream and river crossing studied in this project were sub-standard.

In terms of logging practices, the impacts ranged from high, to extraordinarily severe for a selective logging project. Even in lower impact “small gap” sites, the construction of skid trails was cavalier and scant regard was paid to the correct methods to minimize

stream-crossing disturbance. The preservation of buffer zones around creeks often seemed to be an abstract concept to the logging operators. Of even greater concern, were the very high impact “large gap” sites, which, as described in the report, were virtually mini clear-felling operations, resulting in a Swiss cheese of large gaps within the forest. These big gaps together with the large disturbances created by road building have severely fragmented sections of the rainforest. The extent of this damage needs further investigation both on the ground and from aerial photo interpretation.

Potential long-term ecological concerns

The immediate environmental impacts of logging in the Wawoi Guavi Area are quite obvious. Extensive sections of forest have been disturbed, road building is widespread and pollution of waterways is all too common. However, what may be of even greater long-term concern is the question as to whether the forest ecosystem in this region is being altered for the long-term. Regeneration of forest species is directly affected by the size and frequency of gaps, this in turn determines the overall landscape ecology (see for example Pickett & White, (1985); White & Harrod, (1987)). The preliminary results presented here, clearly show that forest structures and dynamics at Wawoi Guavi are being changed by logging – what is not clear is the extent to which these areas will recover, and whether the floristics (i.e. species composition) of large tracts of forest are being altered irrevocably. It seems likely that thick vine infestation of large gaps will impede forest regeneration, in much the same way that large vine thickets persist in cyclone-disturbed rainforest (Webb 1958). Environment plans supplied by *RH*, predicted optimistically that major hardwood species would be regenerated in forest gaps (Saulei *et al.*, 1987), however, there was little evidence of hardwood regeneration in many highly disturbed sites.

The reason, this question of regeneration and maintenance of species diversity is so vital here, is that the scale of logging operations in this region of Western Province is vast – and, logging is set to expand further. Moreover, the rate of timber extraction is very rapid, so the need for detailed monitoring of ecological changes is very pressing.

It is also clear from the seminal data presented in this report, that very high numbers of logs are being removed that are never sold (and therefore not recorded). The stated rates of timber extraction are obviously the tip of the iceberg in terms of overall forest ecology. Logging Companies are highly unlikely to supply accurate figures contrary to self-interest, so more realistic modeling should be used. These data would also be of interest to



Whether a log is sold as timber or not, it still holds ecological value.

landowners who may feel royalty payments should be based upon total timber extracted (i.e. the impact on the environment) rather than a percentage of logs actually sold.

Rimbunan Hijau's operational methods at Wawoi Guavi

In their Environmental Plans submitted to the PNG Government, *Rimbunan Hijau* clearly appreciated the political importance of appearing to be concerned about ecological sustainability and minimizing environmental and social impacts in the Wawoi Guavi project (see Saulei *et al.*, 1987; PNGFRI, 1990). Having examined some of the logging operations, it is now difficult to view the responsible environmental position espoused in these Plans on behalf of *RH* with anything other than cynicism. There was no apparent program to regenerate the forest in the Block 3 area – and since

responsibility to maintain Permanent Sample Plots (PSP) and Timber Stand Improvement (TSI) experiments, was shifted from the logging operators to the PNG Forest Authority (PNGFA, 1995), there is little onus on the Company to do so. The only active regeneration seen in the project was the planting of Rosewood (*Pterocarpus indicus*) seedlings along the roadside north of Kamusi – this was reportedly the initiative of the international *Société Général de Surveillance* (SGS) organization.

A final comment must be passed on the attitude of *RH* to external, independent examination. If this study is anything to go by, then *RH* has no interest in independent scrutiny of their practices. This report was written with no input from *RH* – requests for information regarding operational procedures were ignored and there was no response to queries about the results of the ongoing environmental monitoring programs the Company is supposed to be conducting. On the contrary, *RH* was obstructive. Armed Taskforce National Police (using *RH* supplied transport from Kamusi) attempted to intimidate and stop visits to the study site and surrounding villages, despite landowner invitations. Once on site, roads were chained to try and limit travel around the timber concessions. While these actions were disconcerting, they did demonstrate the rigid control *RH* exerts over all aspects of life in their timber concessions and reinforced allegations made by numerous Wawoi Guavi landowners and *RH* workers regarding human rights abuses and insensitivity to cultural issues.

7. Conclusions & Recommendations

The logging practices in the Wawoi Guavi Timber concessions often fell below the standards required by PNG law and there is little evidence that sustainable forestry practices are being widely employed. The logging company *RH* seems to be generally

indifferent to local cultural sensitivities, rather an onus is placed on removing as much timber as cheaply as possible. Of potentially great importance are the long-term changes to the forest ecosystem. The scale, speed and intensity of logging is so great, that there is a real possibility that the structure and floristics of vast tracts of lowland rainforest are being altered – just the sort of effect that selective logging is supposed to avoid. Alteration of the floristics is not only a potential concern in terms of loss of biodiversity, but is also important to local landowners who are keen to see a replenishment of the hardwood resource for future generations. It would seem prudent for land use managers in PNG to seriously consider the landscape ecology issues raised by such large logging ventures – the concern is the rapid rate of logging and the lack of any significant ecological data.

Unfortunately, recent history suggests that forest policy is unlikely to shift radically. Numerous concerns expressed about the over-logging of Papua New Guinea's forest resources (i.e. Nadarajah, 1996; Wood, 1996) have produced no real management changes. However, if forest managers are serious about their responsibilities under PNG law, the following recommendations must be urgently considered:

- More regular and thorough inspections to ensure the Forestry and Environmental laws of PNG are being met by logging contractors, and that the rights of workers and landowners are being protected.
- Ideally, large tracts of representative forest should be reserved, and serious ecological studies undertaken to more fully understand the regeneration dynamics of the logged forests. If research reveals that forests are regenerating adequately, reserve areas can always be exploited at a later time.
- Independent baseline monitoring studies of soil and water quality are essential. If there is a link between logging activities and downstream health concerns, these data are vital.
- Realistic figures need to be obtained for the overall numbers of trees removed – merchantable, illegal, for building use, repairs or otherwise. These figures would enable more accurate estimates of ecological damage.

- National land-use managers must seriously consider the wisdom of allowing large-scale logging on environmentally sensitive sites (with high rainfall and erosive soils), where even companies more responsible than *RH* would struggle to minimize environmental damage. At the very least, stakeholders must be presented with realistic assessments of potential environmental impacts rather than untenable and optimistic industry planning documents.

References

Abdulhadi R, Kartawinata K & Sukardjo S (1981). Effects of mechanised logging in the lowland dipterocarp forest at Lempake, East Kalimantan Indonesia. *Malaysian Forestry* **44**: 407-18.

Chrome HJ, Moore LA & Richards GC (1992). A study of logging damage in upland rainforest in north Queensland. *Forest Ecology & Management* **49**: 1-29.

Cottam G & Curtis JT (1956). The use of distance measures in phytosociological sampling. *Ecology* **37**: 451-60.

Erskine PD (1999). *An Environmental Assessment of Logging Operations in Wawoi Guavi Block 3*. Report for Community Rights Advocacy Forum Inc. (ICRAF) and Greenpeace Pacific.

Loffler E (1977). *Geomorphology of Papua New Guinea*. Australian National University Press, Canberra.

McAlpine JR, Keig G & Falls R (1983). *Climate of Papua New Guinea*. Australian National University Press, Canberra.

Melick DR (2003). *An Environmental Audit of the Kiunga-Aiambak Road and logging*

project, Western Province, Papua New Guinea. Report for the LMROA and Greenpeace Pacific.

Nadarajah T (1996). Is PNG's Forest Resource Overcommitted? In: *From Rio to Rai. Volume 3 A Quarter of Next to Nothing. Papers from the 20th Waigani Seminar Seminar* (D Gladman, D Mowbray & J Duguman eds.): 79-108. University of PNG, Press, Port Moresby.

Nicholson DI (1958). An analysis of logging damage in tropical rainforest Northern Borneo. *Malaysian Forestry* **21**: 235-45.

Papua New Guinea Dept. of Environment & Conservation (2000). *Papua New Guinea Environment Act 2000.*

Papua New Guinea Forest Authority (PNGFA) (1995). *Planning Monitoring and Control Procedures for Natural Forest Logging Operations under Timber Permit. November 1995.*

Papua New Guinea Forest Authority (PNGFA) (1996). *Papua New Guinea Logging Code of Practice. First edition April 1996; 70pp.*

Papua New Guinea Forest Research Institute (PNGFRI) (1990). *An Environmental Plan for The Six Month Interim Logging Operations in the Wawoi Guavi Block III Timber Rights Purchased Area. February 1990.* Prepared for the Wawoi Guavi Timber Company Pty. Ltd.: 32pp.

Papua New Guinea Ministry of Forests (1991). *National Forest Policy.*

Pickett STA. & White PS (1985). *The Ecology of Natural Disturbance and Patch Dynamics.* Academic Press, New York.

Richards PW (1996). *The Tropical Rain Forest*. 2nd Edition. Cambridge University Press.

Saulei SM, Genolagani JM, Tenakanai CD & Kiapranis R (1987). Detailed Environmental Plan for the Wawoi Guavi Block 2 Timber Rights Purchased Area, Upper Bamu, Western Province, Papua New Guinea. July 1997. Prepared for the Wawoi Guavi Timber Company Pty. Ltd.: 54pp.

Webb LJ (1958). Cyclones as an ecological factor in tropical lowland rain forests, North Queensland. *Aust J. Bot.* **6**, 220-8..

White PS & Harrod J (1997). Disturbance and diversity in a landscape context. In: *Wildlife and landscapes* (Bissonette, J., ed.) p 128-59. New York: Springer-Verlag.

Whitmore TC (1984). *Tropical Rainforests of the Far East*. Clarendon Press.

Wood M (1996). From Rio to Reciprocity? Perspectives on 'Sustainable' Logging in the Western Province. In: *From Rio to Rai. Volume 3 A Quarter of Next to Nothing. Papers from the 20th Waigani Seminar* (D Gladman, D Mowbray & J Duguman eds.): 217-44. University of PNG, Press, Port Moresby

Uhl C & Vieira ICG (1989). Ecological impacts of selective logging in the Brazilian Amazon, a case study from the Paragominas region of the State of Para. *Biotropica* **21**: 98-106.

Appendix 1

Survey results showing the percentage volume of economic timber tree species in the Wawoi Guavi Blocks 1 & 2 Timber Areas, Upper Bamu, Western Province (from Saulei *et al.*, 1987).

Species	Volume (m³)	Percentage
<i>Anisoptera</i>	592	26.5
<i>Calophyllum</i>	456	20.4
<i>Buchanania</i>	212	10.0
<i>Canarium</i>	89	4.0
<i>Mastixiodendron</i>	81	3.6
<i>Terminalia</i>	71	3.2
<i>Dracontomelum</i>	66	3.0
<i>Endospermum</i>	63	2.8
<i>Cryptocarya</i>	57	2.5
<i>Palaquium</i>	46	2.1
<i>Pterygota</i>	42	1.9
<i>Euginia</i>	37	1.7
<i>Elmerrillia</i>	37	1.7
<i>Pometia</i>	34	1.5
<i>Dillenia</i>	31	1.4
<i>Flindersia</i>	31	1.4
<i>Pterocymbium</i>	30	1.3
<i>Ganophyllum</i>	21	0.9
<i>Planchonella</i>	21	0.9
<i>Hopea</i>	18	0.8
<i>Myristica</i>	17	0.7
<i>Alstonia</i>	16	0.7
<i>Artocarpus</i>	14	0.6
<i>Xanthophyllum</i>	14	0.6
<i>Camptosperma</i>	13	0.6
<i>Sloanea</i>	13	0.6
<i>Anthocephalus</i>	10	0.5
Others	101	6.1
TOTAL	1,532.5	100.0

Appendix 2

Estimates of the percentage composition of main timber tree species in the Wawoi Guavi Block 3 Timber Area, Upper Bamu, Western Province (from PNGFRI, 1990).

Species Composition %

<i>Anisoptera</i>	12.0
<i>Buchanania</i>	11.4
<i>Celtis</i>	8.8
<i>Palaquium</i>	7.5
<i>Octomeles sumatrana</i>	6.5
<i>Dracontomelum</i>	5.2
<i>Canarium</i>	4.6
<i>Calophyllum</i>	4.2
<i>Pometia</i>	3.2
Others	36.6
TOTAL	100.0

Appendix 3

Specific contraventions of the PNG Logging Code of Practice (*PNGLCP*) observed in the Wawoi Guavi timber concessions during August 2003.

Position	PNGLCP Key St. No	Brief description
S6 56.006 E142 45.048	2	Logging encroachment into buffer zone
S6 59.030 E142 49.259	2	Logging encroachment into buffer zone
S7 01.642 E142 50.121	2	Logging encroachment into buffer zone
S6 55.788 E142 38.917	2	Logging encroachment into buffer zone
S7 07.846 E142 50.076	2	Logging encroachment into buffer zone
S6 52.512 E142 45.052	3	Encroachment of road through cultural site.
S6 52.512 E142 45.052	3	Encroachment of road through cultural site.
S7 01.642 E142 50.121	3	Encroachment of road through cultural site.
S7 00.595 E142 49.229	3	Encroachment of road through cultural site.
S6 55.788 E142 38.917	3	Encroachment of road through cultural site.
S6 54.108 E142 39.486	4	Excessively large log landing
S6 55.532 E142 39.193	4	Excessively large log landing
S6 58.541 E142 49.694	4	Excessively large log landing
S6 59.044 E142 49.206	4	Excessively large log landing
S6 55.998 E142 38.455	4	Excessively large log landing
S7 07.455 E142 47.267	4	Excessively large log landing
S7 02.784 E142 49.242	6	Soil pushed into forest
S7 00.567 E142 49.506	6	Soil pushed into forest
S6 57.610 E142 46.383	6	Soil pushed into forest
S6 57.137 E142 45.878	6	Soil pushed into forest
S6 56.973 E142 45.679	6	Soil pushed into forest
S6 56.923 E142 43.290	6	Soil pushed into forest
S6 55.509 E142 42.733	6	Soil pushed into forest
S6 54.955 E142 42.251	6	Soil pushed into forest
S6 54.692 E142 42.183	6	Soil pushed into forest
S6 53.293 E142 41.694	6	Soil pushed into forest
S6 53.123 E142 41.642	6	Soil pushed into forest
S6 53.284 E142 41.166	6	Soil pushed into forest
S6 53.630 E142 40.004	6	Soil pushed into forest
S6 53.687 E142 39.897	6	Soil pushed into forest
S6 53.824 E142 39.773	6	Soil pushed into forest
S6 54.386 E142 39.415	6	Soil pushed into forest
S6 54.721 E142 39.249	6	Soil pushed into forest
S6 55.320 E142 39.196	6	Soil pushed into forest
S6 55.532 E142 39.193	6	Soil pushed into forest
S6 55.842 E142 38.668	6	Soil pushed into forest
S6 56.089 E142 38.517	6	Soil pushed into forest

S6 55.139 E142 44.972	6	Soil pushed into forest
S6 59.030 E142 49.259	6	Soil pushed into forest
S6 58.260 E142 50.139	6	Soil pushed into forest
S6 58.324 E142 49.895	6	Soil pushed into forest
S6 58.586 E142 49.680	6	Soil pushed into forest
S6 59.181 E142 49.191	6	Soil pushed into forest
S7 00.057 E142 49.332	6	Soil pushed into forest
S7 05.368 E142 49.686	6	Soil pushed into forest
S7 05.694 E142 45.785	6	Soil pushed into forest
S7 10.375 E142 45.800	6	Soil pushed into forest
S7 11.075 E142 45.940	6	Soil pushed into forest
S7 11.683 E142 45.981	6	Soil pushed into forest
S7 00.103 E142 48.433	9	Road width exceeding 40m
S6 59.708 E142 48.020	9	Road width exceeding 40m
S6 59.149 E142 47.543	9	Road width exceeding 40m
S6 57.892 E142 46.731	9	Road width exceeding 40m
S6 57.610 E142 46.383	9	Road width exceeding 40m
S6 57.137 E142 45.878	9	Road width exceeding 40m
S6 56.973 E142 45.679	9	Road width exceeding 40m
S6 56.331 E142 45.398	9	Road width exceeding 40m
S6 56.400 E142 44.980	9	Road width exceeding 40m
S6 57.195 E142 43.913	9	Road width exceeding 40m
S6 55.654 E142 42.784	9	Road width exceeding 40m
S6 53.981 E142 41.823	9	Road width exceeding 40m
S6 53.293 E142 41.694	9	Road width exceeding 40m
S6 53.412 E142 40.551	9	Road width exceeding 40m
S6 54.108 E142 39.486	9	Road width exceeding 40m
S6 58.873 E142 49.382	9	Road width exceeding 40m
S6 59.770 E142 49.225	9	Road width exceeding 40m
S6 59.911 E142 49.242	9	Road width exceeding 40m
S7 00.423 E142 49.392	9	Road width exceeding 40m
S7 04.563 E142 49.862	9	Road width exceeding 40m
S7 07.169 E142 50.129	9	Road width exceeding 40m
S7 07.649 E142 48.840	9	Road width exceeding 40m
S7 07.655 E142 48.430	9	Road width exceeding 40m
S7 07.473 E142 47.383	9	Road width exceeding 40m
S7 06.032 E142 45.912	9	Road width exceeding 40m
S7 05.772 E142 45.515	9	Road width exceeding 40m
S7 06.409 E142 45.293	9	Road width exceeding 40m
S7 06.977 E142 45.355	9	Road width exceeding 40m
S7 07.497 E142 45.404	9	Road width exceeding 40m
S7 08.075 E142 45.530	9	Road width exceeding 40m
S7 08.486 E142 45.889	9	Road width exceeding 40m
S7 10.040 E142 45.636	9	Road width exceeding 40m
S7 10.421 E142 45.895	9	Road width exceeding 40m
S7 11.117 E142 45.918	9	Road width exceeding 40m
S7 11.898 E142 46.032	9	Road width exceeding 40m
S7 12.150 E142 45.947	9	Road width exceeding 40m
S7 12.348 E142 45.890	9	Road width exceeding 40m
S7 12.463 E142 45.834	9	Road width exceeding 40m

S6 58.768 E142 49.413	10	Soil in stream from road
S7 07.662 E142 49.524	10	Soil in stream from road
S7 25.808 E143 07.506	10	Soil in stream from road
S7 03.652 E142 49.751	10	Soil in stream from road
S7 03.052 E142 49.283	10	Soil in stream from road
S7 00.584 E142 49.224	10	Soil in stream from road
S6 57.080 E142 45.819	10	Soil in stream from road
S6 57.028 E142 45.791	10	Soil in stream from road
S6 57.904 E142 43.866	10	Soil in stream from road
S6 53.446 E142 40.868	10	Soil in stream from road
S6 53.351 E142 40.320	10	Soil in stream from road
S6 52.541 E142 44.942	10	Soil in stream from road
S6 53.152 E142 44.646	10	Soil in stream from road
S6 58.706 E142 50.604	10	Soil in stream from road
S6 58.458 E142 50.340	10	Soil in stream from road
S7 07.765 E142 49.878	10	Soil in stream from road
S7 07.662 E142 49.524	10	Soil in stream from road
S7 07.554 E142 49.377	10	Soil in stream from road
S7 07.603 E142 49.161	10	Soil in stream from road
S7 07.681 E142 48.686	10	Soil in stream from road
S7 06.695 E142 46.861	10	Soil in stream from road
S7 07.705 E142 48.517	10	Soil in stream from road
S7 03.571 E142 49.695	11	Road drainage problems
S7 00.606 E142 49.368	11	Road drainage problems
S6 57.577 E142 46.337	11	Road drainage problems
S6 57.456 E142 46.259	11	Road drainage problems
S6 56.973 E142 45.679	11	Road drainage problems
S6 56.169 E142 43.117	11	Road drainage problems
S6 54.853 E142 42.164	11	Road drainage problems
S6 55.129 E142 39.210	11	Road drainage problems
S6 55.772 E142 39.065	11	Road drainage problems
S6 58.610 E142 49.556	11	Road drainage problems
S7 07.393 E142 47.898	11	Road drainage problems
S7 08.692 E142 45.814	11	Road drainage problems
S7 03.652 E142 49.751	12	Soil on log bridges/poor construction
S7 03.052 E142 49.283	12	Soil on log bridges/poor construction
S7 00.584 E142 49.224	12	Soil on log bridges/poor construction
S6 57.080 E142 45.819	12	Soil on log bridges/poor construction
S6 57.028 E142 45.791	12	Soil on log bridges/poor construction
S6 57.904 E142 43.866	12	Soil on log bridges/poor construction
S6 53.446 E142 40.868	12	Soil on log bridges/poor construction
S6 53.351 E142 40.320	12	Soil on log bridges/poor construction
S6 52.541 E142 44.942	12	Soil on log bridges/poor construction
S6 53.152 E142 44.646	12	Soil on log bridges/poor construction
S6 58.706 E142 50.604	12	Soil on log bridges/poor construction
S6 58.458 E142 50.340	12	Soil on log bridges/poor construction
S7 07.765 E142 49.878	12	Soil on log bridges/poor construction
S7 07.662 E142 49.524	12	Soil on log bridges/poor construction
S7 07.554 E142 49.377	12	Soil on log bridges/poor construction
S7 07.603 E142 49.161	12	Soil on log bridges/poor construction

S7 07.681 E142 48.686	12	Soil on log bridges/poor construction
S7 07.705 E142 48.517	12	Soil on log bridges/poor construction
S7 06.695 E142 46.861	12	Soil on log bridges/poor construction
S7 13.294 E142 44.931	12	Soil on log bridges/poor construction
S7 25.808 E143 07.506	12	Soil on log bridges/poor construction
S7 13.285 E142 44.536	12	Soil on log bridges/poor construction
S7 07.725 E142 50.032	12	Soil on log bridges/poor construction
S6 54.721 E142 39.249	13	Log cluster
S6 56.471 E142 39.047	13	Log cluster
S6 56.876 E142 39.262	13	Log cluster
S6 56.970 E142 39.298	13	Log cluster
S6 58.768 E142 49.413	13	Log cluster
S7 13.057 E142 45.729	13	Log cluster
S7 13.321 E142 44.794	13	Log cluster
S7 13.354 E142 44.724	13	Log cluster
S6 57.080 E142 45.819	14	Road drainage at water crossing
S6 58.768 E142 49.413	14	Road drainage at water crossing
S7 03.652 E142 49.751	14	Road drainage at water crossing
S7 03.052 E142 49.283	14	Road drainage at water crossing
S7 00.584 E142 49.224	14	Road drainage at water crossing
S6 57.080 E142 45.819	14	Road drainage at water crossing
S6 57.028 E142 45.791	14	Road drainage at water crossing
S6 57.904 E142 43.866	14	Road drainage at water crossing
S6 53.446 E142 40.868	14	Road drainage at water crossing
S6 53.351 E142 40.320	14	Road drainage at water crossing
S6 52.541 E142 44.942	14	Road drainage at water crossing
S6 53.152 E142 44.646	14	Road drainage at water crossing
S6 58.706 E142 50.604	14	Road drainage at water crossing
S6 58.458 E142 50.340	14	Road drainage at water crossing
S7 07.765 E142 49.878	14	Road drainage at water crossing
S7 07.662 E142 49.524	14	Road drainage at water crossing
S7 07.554 E142 49.377	14	Road drainage at water crossing
S7 07.603 E142 49.161	14	Road drainage at water crossing
S7 07.681 E142 48.686	14	Road drainage at water crossing
S7 07.705 E142 48.517	14	Road drainage at water crossing
S7 06.695 E142 46.861	14	Road drainage at water crossing
S7 13.294 E142 44.931	14	Road drainage at water crossing
S6 58.227 E142 50.013	15	Trees felled into forest
S6 53.687 E142 39.897	15	Trees felled into forest
S6 53.824 E142 39.773	15	Trees felled into forest
S6 54.386 E142 39.415	15	Trees felled into forest
S6 54.721 E142 39.249	15	Trees felled into forest
S6 55.320 E142 39.196	15	Trees felled into forest
S6 55.532 E142 39.193	15	Trees felled into forest
S6 55.842 E142 38.668	15	Trees felled into forest
S6 56.089 E142 38.517	15	Trees felled into forest
S6 55.139 E142 44.972	15	Trees felled into forest
S6 59.030 E142 49.259	15	Trees felled into forest
S6 58.260 E142 50.139	15	Trees felled into forest
S6 58.324 E142 49.895	15	Trees felled into forest

S6 58.586 E142 49.680	15	Trees felled into forest
S6 59.181 E142 49.191	15	Trees felled into forest
S7 00.057 E142 49.332	15	Trees felled into forest
S7 05.368 E142 49.686	15	Trees felled into forest
S7 05.694 E142 45.785	15	Trees felled into forest
S7 10.375 E142 45.800	15	Trees felled into forest
S7 11.075 E142 45.940	15	Trees felled into forest
S7 11.683 E142 45.981	15	Trees felled into forest
S7 07.655 E142 48.430	15	Trees felled into forest
S7 07.473 E142 47.383	15	Trees felled into forest
S7 06.032 E142 45.912	15	Trees felled into forest
S7 05.772 E142 45.515	15	Trees felled into forest
S7 06.409 E142 45.293	15	Trees felled into forest
S7 06.977 E142 45.355	15	Trees felled into forest
S7 07.497 E142 45.404	15	Trees felled into forest
S7 08.075 E142 45.530	15	Trees felled into forest
S7 03.385 E142 52.129	17	Felling and skidding into buffer zones
S7 03.520 E142 51.812	17	Felling and skidding into buffer zones
S6 56.006 E142 45.048	17	Felling and skidding into buffer zones
S6 59.030 E142 49.259	17	Felling and skidding into buffer zones
S7 01.642 E142 50.121	17	Felling and skidding into buffer zones
S6 55.788 E142 38.917	17	Felling and skidding into buffer zones
S6 54.753 E142 39.239	17	Felling and skidding into buffer zones
S6 54.902 E142 39.174	17	Felling and skidding into buffer zones
S6 55.030 E142 39.184	17	Felling and skidding into buffer zones
S6 58.606 E142 50.675	17	Felling and skidding into buffer zones
S6 58.343 E142 49.894	17	Felling and skidding into buffer zones
S7 03.385 E142 52.129	18	Damming of waterways
S7 03.520 E142 51.812	18	Damming of waterways
S6 58.343 E142 49.894	18	Damming of waterways
S7 03.385 E142 52.129	19	Incorrect decommissioning
S7 03.385 E142 52.129	19	Incorrect decommissioning
S6 54.753 E142 39.239	19	Incorrect decommissioning
S6 54.902 E142 39.174	19	Incorrect decommissioning
S6 55.030 E142 39.184	19	Incorrect decommissioning
S6 58.606 E142 50.675	19	Incorrect decommissioning
S6 58.343 E142 49.894	19	Incorrect decommissioning
S7 03.052 E142 49.283	20	Debris in stream
S7 03.385 E142 52.129	20	Debris in stream
S7 03.385 E142 52.129	20	Debris in stream
S6 57.028 E142 45.791	20	Debris in stream
S6 53.351 E142 40.320	20	Debris in stream
S6 59.030 E142 49.259	21	No water bars
S7 03.385 E142 52.129	21	No water bars
S7 03.385 E142 52.129	21	No water bars
S7 40.578 E142 59.346	22	Failure to rehabilitate log pool
S7 00.556 E142 49.621	23	Failure to clean rubbish/debris
S7 00.103 E142 48.433	23	Failure to clean rubbish/debris
S6 59.478 E142 47.689	23	Failure to clean rubbish/debris
S6 56.157 E142 45.029	23	Failure to clean rubbish/debris

S6 52.987 E142 41.581	23	Failure to clean rubbish/debris
S6 53.452 E142 41.106	23	Failure to clean rubbish/debris
S6 53.687 E142 39.897	23	Failure to clean rubbish/debris
S7 06.080 E142 45.593	23	Failure to clean rubbish/debris
S7 08.961 E142 45.749	23	Failure to clean rubbish/debris
S7 03.214 E142 50.574	23	Failure to clean rubbish/debris
S7 36.451 E142 57.850	23	Failure to clean rubbish/debris
S6 59.501 E142 49.202	23	Failure to clean rubbish/debris
S6 59.552 E142 49.177	23	Failure to clean rubbish/debris
S6 58.317 E142 47.416	23	Failure to clean rubbish/debris
S6 53.235 E142 40.546	23	Failure to clean rubbish/debris
S6 53.235 E142 40.443	23	Failure to clean rubbish/debris
S6 53.248 E142 40.438	23	Failure to clean rubbish/debris
S6 53.346 E142 40.241	23	Failure to clean rubbish/debris
S6 53.340 E142 40.172	23	Failure to clean rubbish/debris
S6 53.406 E142 40.129	23	Failure to clean rubbish/debris
S6 54.630 E142 39.303	23	Failure to clean rubbish/debris
S7 07.473 E142 47.383	23	Failure to clean rubbish/debris
S7 06.695 E142 46.861	23	Failure to clean rubbish/debris
S7 13.354 E142 44.724	24	Waste management incorrect
S7 53.027 E143 15.524	24	Waste management incorrect
S7 40.578 E142 59.346	24	Waste management incorrect
S7 07.725 E142 50.032	D	Camp 56 - waste oil storage/disposal
S7 07.790 E142 50.044	E	Camp 56 - Fuel storage
S7 07.725 E142 50.032	E	Camp 56 - Solid waste disposal
S6 58.409 E142 49.843	E	Fuel storage
S6 55.801 E142 38.936	E	Fuel storage
S7 25.808 E143 07.506	E	Kamusi - Fuel storage
S7 13.285 E142 44.536	E	Kesovi - Fuel storage
S7 07.689 E142 49.907	F	Camp 56 - Greywater and rubbish into stream
S7 13.285 E142 44.536	F	Kesovi - Hygiene
S7 25.808 E143 07.506	F	Kamusi - Waste disposal
S7 25.808 E143 07.506	G	Kamusi - Burning off with no masks