LAND USE DETERMINATION AND TECHNICAL REPORT FOR THE EAST KIEWA (U2) AREA

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SOIL CONSERVATION AUTHORITY

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SUMMARY

The Land Use Determination (Figure 1) designates three land uses suitable for the East Kiewa U2 area; water production, forestry and recreation. The report describes various biophysical parameters and identifies specific land use hazards.

The East Kiewa U2 area occupies 1800 ha and is situated to the west of Bogon township in the Kiewa valley (Figure 2) in North Eastern Victoria. In the past the area has been used for water production and recreation.

In 1979, the Land Conservation Council (LCC) recommended to the government that the East Kiewa (U2) area be designated as a special form of uncommitted land in which no timber production or construction of access for logging be permitted pending review by the Council in 1986. The recommendations also stated that calibration of the experimental catchments of Springs Creek and Slipper Rock Creek, which commended in 1978, should continue.

In 1980, the government modified the LCC recommendation to review the question of logging in 1986 and indicated that experimental logging of the catchments could take place once the calibration was completed. If the results with regard to stream sedimentation were acceptable to the State Electricity Commission, the Soil Conservation Authority and Forests Commission, Victoria, further logging would be permitted, under prescriptions, in the East Kiewa (U2) area.

The soils of the Upper Kiewa Valley, including the U2 area appear to be sensitive to intensive land use. Past and existing developments clearly illustrate that significant erosion can occur unless soil conservation strategies are adopted from the outset. The high erosion risk is the result of the interaction of several factors: high rainfall combined with temperatures often below freezing, and a large proportion of steep land with highly erodible subsoils.

Logging and associated soil disturbance in the East Kiewa U2 area may result in subtle changes which might be significant in affecting long term resource productivity. That is, there may be a considerable lag phase before the impact of any increased soil loss on land and water resources is recorded. It is therefore important that the hydrologic research project at Springs and Slippery Rock catchments runs its full course before a decision is made to log the remainder of the U2 area outside of the Springs Creek experimental catchment. Furthermore, following the conclusion of the current series of experiments it is essential that forest management prescriptions applying to the U2 experimental area be reviewed to ensure adequate safeguards against short and long term water quality deterioration.

The following report, in conjunction with the Land Use Determination and findings from the experimental catchments, will provide both a basis for future management of the U2 area and useful information on other parts of the East Kiewa catchment.

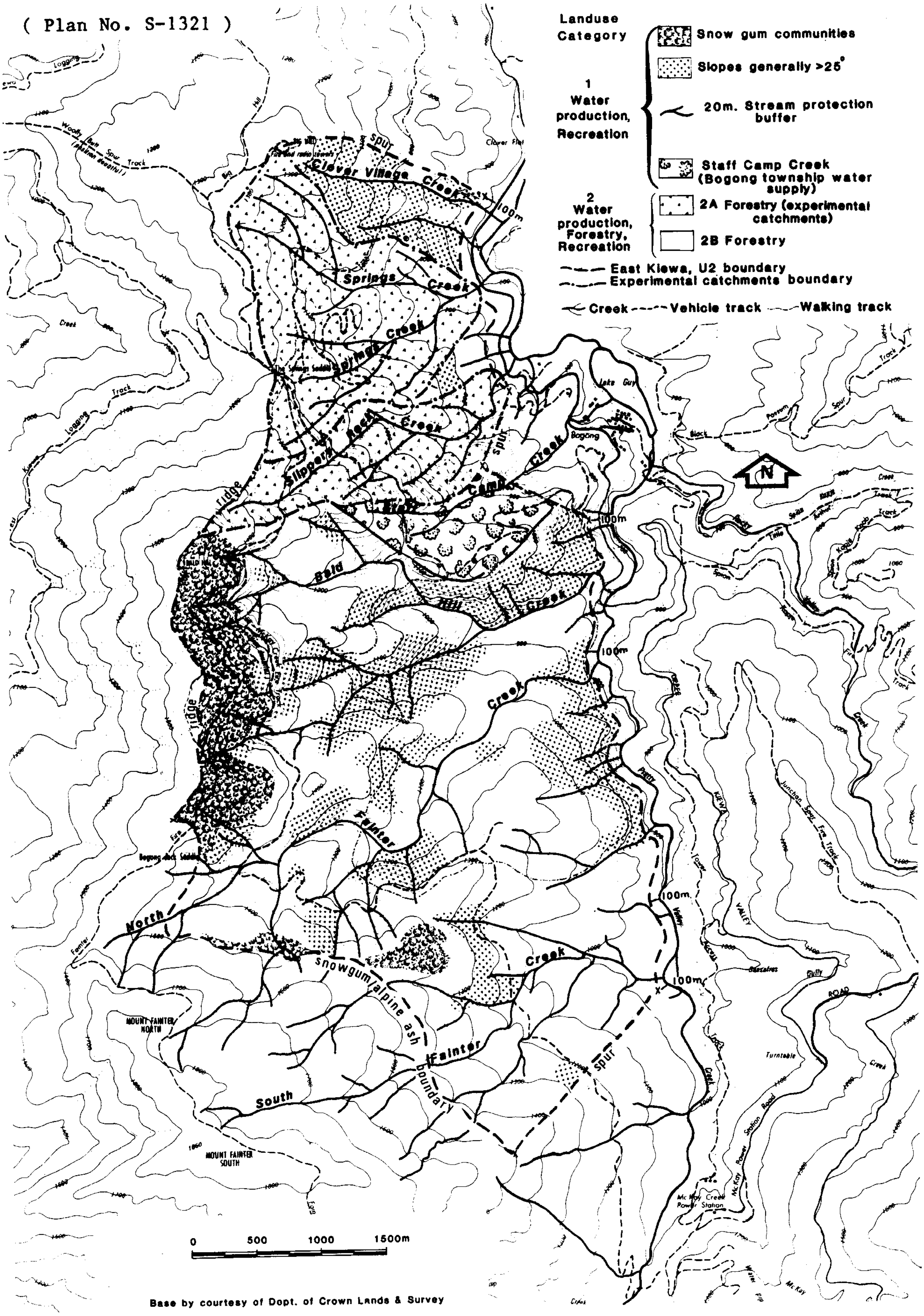
RECOMMENDATIONS

1. The land within the East Kiewa (U2) area be used primarily for water production and that other uses may include forestry and recreation, provided such land uses do not present a significant hazard to land, water quality or water yield.

2. That the various organisations (SCA, SEC, FCV) involved with resource management await the outcome of logging operations in the experimental catchments before deciding on the detailed management prescriptions required to protect the land and water resources of the East Kiewa U2 area.

LAND USE DETERMINATION

Figure 1 - Land Use Determination Plan (Enlargement - Appendix Viii)



LAND USE DETERMINATION

The provisions of individual land use categories are set out below and should be read in conjunction with the Determination Plan.

Table 1. Land Use Determination Categories and Provisions

Category Number		Land Use	Provisions of Category
1		Land to be used for the protection of streams, water courses, reservoirs, domestic water supply. Land affected is: (a) within Staff Camp catchment up-stream of the U2 area boundary, as delineated in LCC Plan No. F19A; (b) slopes generally exceeding 257, as shown on Plan No. S-1321; (c) within 20 metres of any permanent or ephemeral stream as shown on Plan No. S-1321; (d) snow gum communities, as delineated on Plan No. S-1321.	Disturbance of soils and vegetation for stream crossings or any other purpose may be carried out only at locations and in a manner approved by the Soil Conservation Authority. Trees which, during the course of forest operations on adjoining Category 2B land, are inadvertently felled, wholly or partly, into any 20 m protection buffer may only be removed by winching from outside the buffer.
2	2A	Land within Slippery Rock and Springs Creek experimental catchments to be used primarily for water catchment protection, parts of which may also be suitable for forest operations and low intensity recreation.	Forest operations must be in accordance with land use conditions made or approved by the Soil Conservation Authority after consultation with the State Electricity Commission and Forests Commission Victoria. Earthworks for any other purpose may be carried out only after consultation with the Soil Conservation Authority and agreement has been reached on specific management requirements.
	2B	Land to be used primarily for water catchment protection, parts of which may also be suitable for forestry operations and low intensity recreation.	Forest operations must be in accordance with land use conditions made or approved by the Soil Conservation Authority after consultation with the State Electricity Commission Victoria and the Forests Commission Victoria, following evaluation and interpretation of the results of experimental catchment logging trials in the East Kiewa Catchment. Earthworks may be carried out only after consultation with the Soil Conservation Authority and agreement has been reached on specific management requirements.

<u>Other Provisions:</u>

While the categories listed above state the forms of land use which may be permitted with least hazard to the water supply, the Soil Conservation Authority may designate specific requirements or impose conditions under Section 23(4) (a) of the *Soil Conservation and Land Utilization Act* 1958), on land determined as being suitable for forestry, recreation or any other land use. Fainter Fire Tracks may be used as a stock route at times specified by the Soil. Conservation Authority.

<u>Interpretation of Land Use Determination Plan:</u>

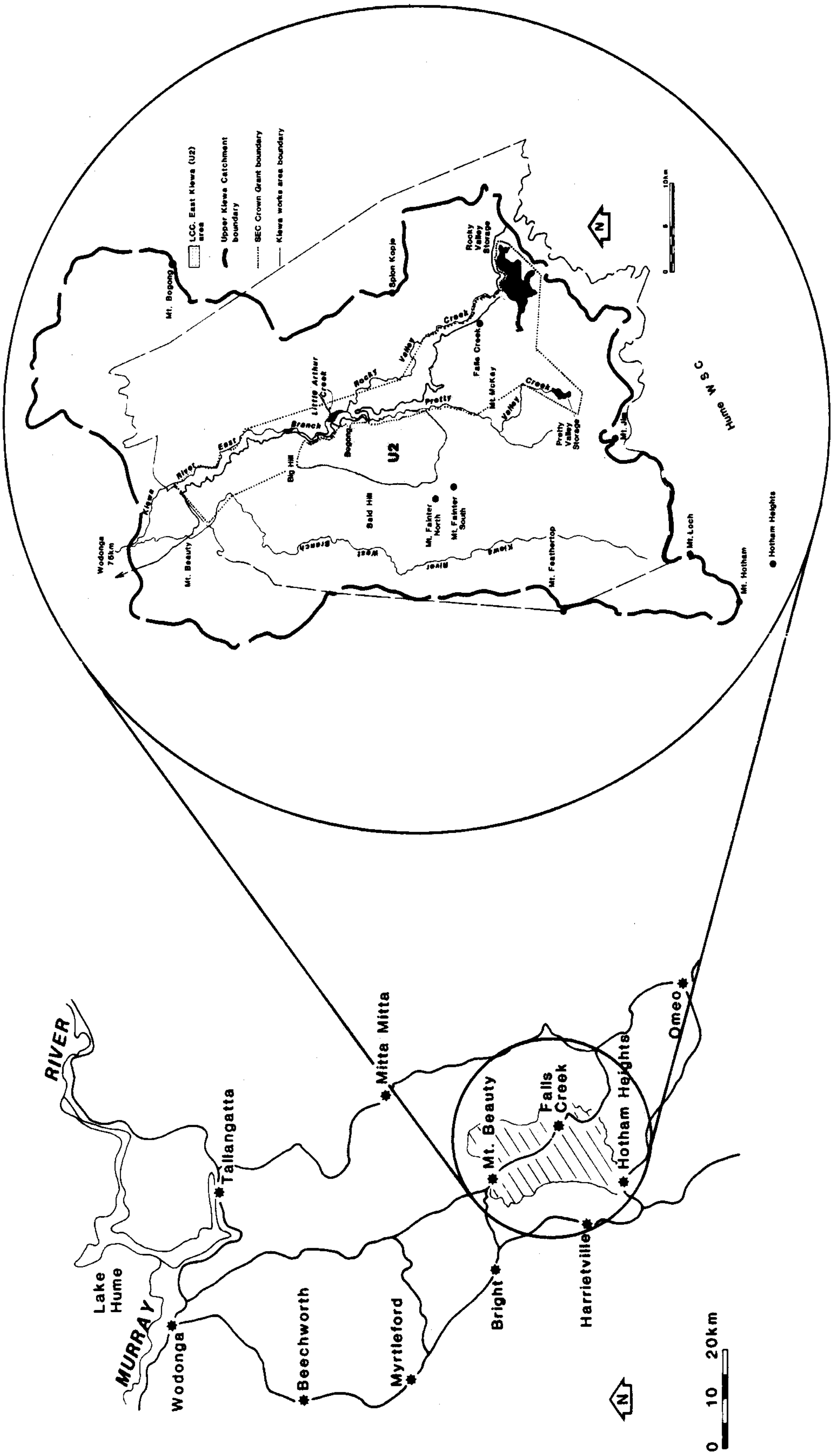
In interpreting the Land Use Determination Plan (Plan No. S-1321), consideration must be given to the limitations of map scale. Detailed field inspection will normally be required to determine the exact location of stream protection buffers and the location, extent and uniformity of land generally exceeding 250 slope.

Definitions:

Ephemeral stream - drainage line or watercourse carrying surface water during snowmelt, or for short duration following rainfall events of 2 mm per hour or greater intensity.

TECHNICAL REPORT

Figure 2 - Upper Kiewa Catchment, Locality Plan



INTRODUCTION

The Upper Kiewa Catchment was proclaimed in 1965 under the provisions of Section 22(1) of the *Soil Conservation and Land Utilization Act* 1958.

The Kiewa hydro-electric scheme is an important source of electricity for meeting peak demand in both Victoria and New South Wales. Water production for power generation is the primary land use of the area. Above the snowline the high altitude portion of the catchment also provides for summer and winter recreation and cattle grazing. At sub-alpine elevations within the West Kiewa Catchment high quality timber resources are being utilised.

The SEC has expressed concern that logging activities in the East Kiewa valley could increase stream sediment loads, leading to accelerated sedimentation of water storages increased machinery maintenance cost and subsequently, increases in the cost of power production.

In 1978 calibration of the catchments of Springs and Slippery Rock Creeks were commenced with the aim of establishing base rainfall, streamflow and sediment data against which the effects of experimental logging may be assessed.

In June, 1979 the Land Conservation Council published Final Recommendations for land use in the Alpine Area. With respect to the East Kiewa (U2) area the recommendation stated:

U2 That the land (1,800 ha) in the East Kiewa valley indicated on the maps be used to:

(a) maintain the capability of the land to meet future demands

(b) supply water and protect catchments and streams

(c) conserve native flora and fauna

(d) meet the requirements of the State Electricity Commission of Victoria for the protection and operation of the Kiewa hydroelectric scheme

that

(e) calibration of Slippery Rock Creek and Springs Creek catchments, to determine sediment bed-loads and turbidity under undisturbed conditions, continue until adequate data are obtained

(f) the road from Big Hill past McKay Creek power station (with some minor reconstruction near the power station itself) be upgraded to a standard suitable for use by tourist vehicles, subject to the requirements of (e) above

(g) no timber harvesting or construction of access for logging be permitted

and that it be unreserved Crown land withheld from sale, be protected forest under the provisions of the *Forests Act*, 1958, and its use be reviewed by the Council in 1986.

In January 1980 the Government approved the Land Conservation Council recommendation but with the following variations:

"......that, that, subject to stream calibration and experimental logging, demonstrating that logging operations will not cause stream sedimentation at a level unacceptable to the State Electricity commission, the Soil Conservation Authority, and the Forests Commission, Victoria, further logging be permitted in the area listed below under prescriptions determined after the results of experimental logging are known:

(a) that area of land (1800 ha) classified as U2 in the East Kiewa Valley
(b) Little Arthur Creek."

and that

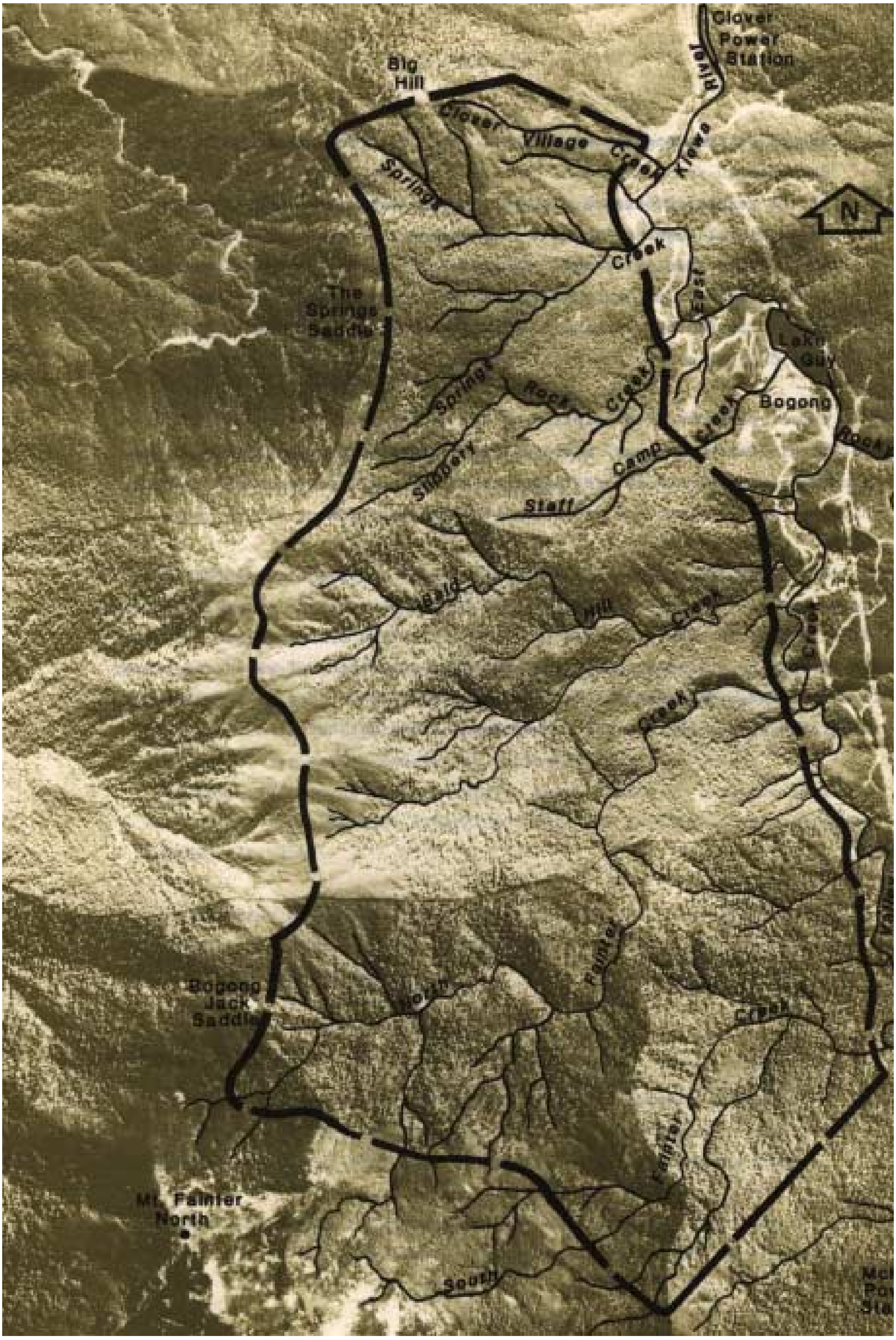
"Plans for stream calibration and experimental logging should be prepared by the Soil Conservation Authority in conjunction with the Forests Commission, Victoria, and the State Electricity Commission.

The Soil Conservation Authority should also prepare a Land Use Determination, and associated logging prescriptions for the East Kiewa Region of the uncommitted area U2, which is a proclaimed Water Supply Catchment. If the results of stream calibration (which may take 5 years) and experimental logging (about 3 years) show that commercial logging can take place, then after the completion of logging the East Kiewa land shall remain as uncommitted and shall continue in this category until reinvestigated by the Land Conservation Council in about 10 years time."

This report presents a description of the biophysical features of the area, including climate, geology, soils and vegetation. The report also discusses existing and future land uses and identifies some of the factors which may lead to land and water quality deterioration.

The purpose of the Land Use Determination is to provide a guide for land management in the public interest. The LUD is designed to ensure that off-site effects resulting from land use activities are minimised and that the capability of the resource for sustained production of water and timber is maintained. The Land Use Determination for the U2 area will be later integrated with a LUD for the entire Upper Kiewa Catchment.

Figure 3 - Photomosaic of the East Kiewa (U2) Area



CHAPTER 1 BIOPHYSICAL DESCRIPTION

1.1 Location

From the Bogong High Plains the East Kiewa River flows north through 15 km of steep mountainous terrain to meet the West Kiewa River on the flood plain, near Mt. Beauty township, approximately 75 km south east of Wodonga (Figure 2).

The 1800 ha area designated as U2 in the LCC Final Recommendations is situated on the west side of the East Kiewa River. The area encompasses the catchment of Clover Village Creek and extends south to the snow gum-alpine ash vegetation boundary near Mt. Fainter Creek in the south. The eastern boundary follows the East Kiewa River and the Falls Creek - Mt. Beauty Road. The ridge from Big Hill to Bogong Jack Saddle marks the western limit of the U2 area (Figures 1 and 3).

1.2 Land description

The land system covering the U2 area has been described by Rowe (1972), as the Darbalang sub-system of the Tawonga land system and comprises the high rainfall, high elevation portion of the steep mountainous sections of the Kiewa River Catchment. The distinguishing features of the Darbalang sub-system are identified and described below (Figure 4).

1.3 Climate

Bogong meteorological station is situated in the East Kiewa valley close to the U2 area. The following information relating to climate is from climatic averages detailed in Appendix I.

1.3.1 Precipitation and runoff

Most precipitation in the area falls as rain, although snowfall on the higher peaks makes a significant contribution to runoff during the spring thaw. Precipitation varies between 1700 and 2200 mm depending on elevation and aspect. Snow usually persists above 1700 m from June to September.

Interception of low cloud and fog also contributes to the moisture regime of the area. Costin (1968) estimated that a 10% increase in water collection from windblown rain, cloud and fog occurred in tree covered areas compared with treeless areas of alpine catchments.

Rainfall shows a marked seasonal variation with most rain falling during the period May to October. Rainfall in the six months from November to April accounts for only one third of the yearly average of 1800 m (Appendix I). Summer rainfall is generally of short duration, high intensity and sporadic distribution. In contrast, winter rainfall is sustained, widespread in distribution and low in intensity.

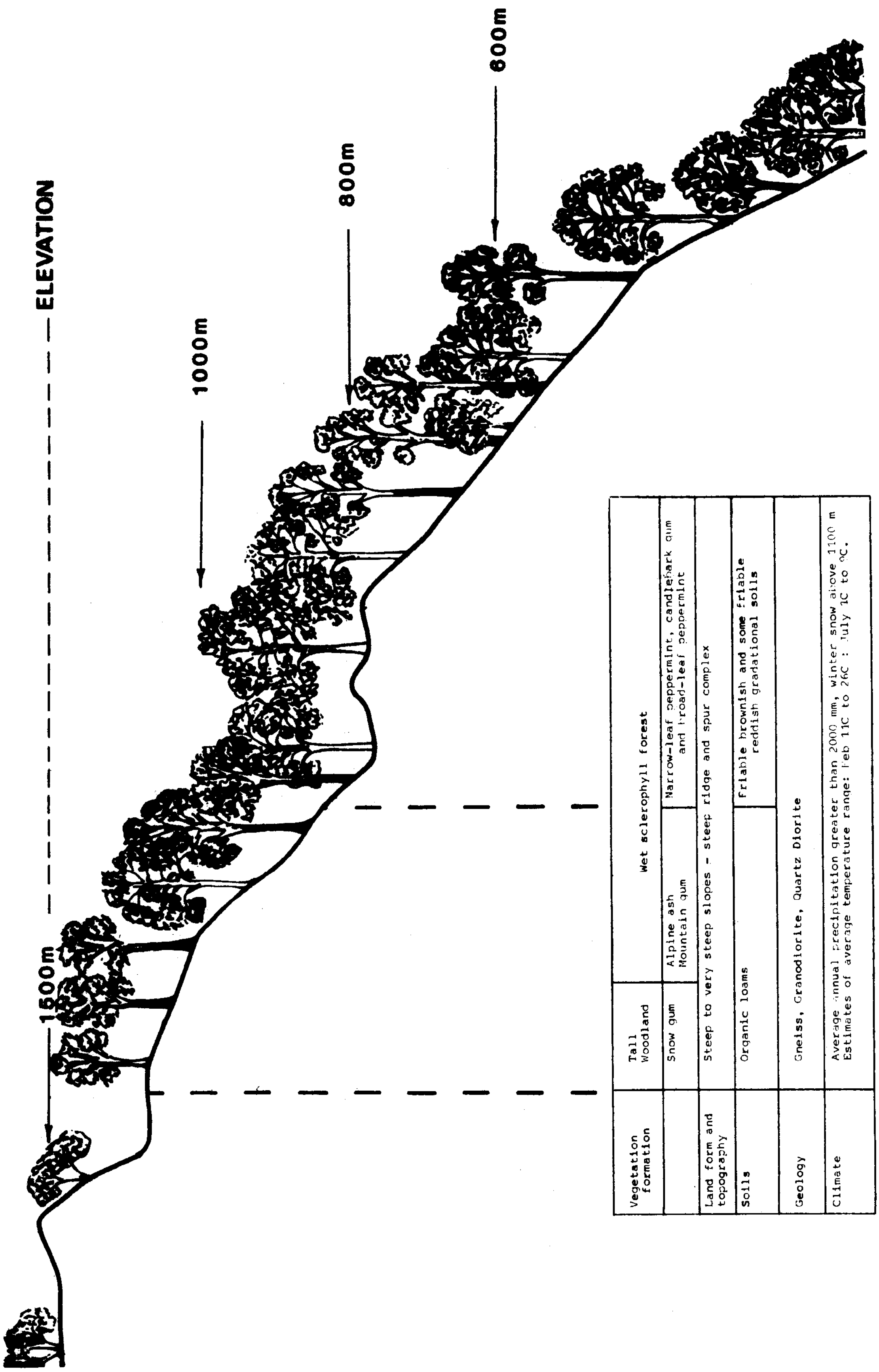
Runoff is reported to be 1140 mm per annum from well developed alpine ash forest typical of the area (McArthur and Cheney, 1965).

1.3.2 Temperature, humidity and frost

The mean daily minimum and maximum temperature range is from 11^{o}Cc to 26^{o}C in February and from 1^{o}C to 9^{o}C in July. Aspect is an important factor in determining soil and air temperature and subsequent plant growth. Low temperatures (<10^{o}C) may restrict plant growth for three months from mid May to mid September (Rowe, 1972).

The mean monthly relative humidity ranges from 60 to 70% at 9.00 am falling to about 40% by 3.00 pm. Humidity in winter tends to be somewhat higher with averages around 90% at 9.00 am dropping to 70% by 3.00 pm. Heavy frosts associated with clear, still conditions are common during July.

Figure 4 - Land System Diagram - Darbalang Sib-system



Vegetation formation	Tall Woodland	Wet sclerophyll forest	
	Snow gum	Alpine ash Mountain gum	Narrow-leaf peppermint, candlebark gum and broad-leaf peppermint
Land form and topography	Steep to very steep slopes - steep ridge and spur complex		
Soils	Organic loams		Friable brownish and some friable reddish gradational soils
Geology	Gneiss, Granodiorite, Quartz Diorite		
Climate	Average annual precipitation greater than 2000 mm, winter snow above 1100 m Estimates of average temperature range: Feb 11C to 26C : July 1C to 9C.		

1.3.3 Wind and evaporation

Wind direction is generally from the south or south west in winter, turning north and north westerly in the summer months. Easterly winds are uncommon. Southerly aspects experience lower temperatures and have lower evaporation rates, particularly in summer when southern slopes are sheltered from the hot dry northerly winds. As a consequence, there is generally more moisture available, allowing for longer periods of plant growth on southerly slopes.

Evapotranspiration accounts for approximately one third of the annual rainfall. Potential evaporation measured at Tawonga (elevation 884 m) exceeds precipitation from December to April. At elevations above 900 m plant growth may be limited by a moisture deficit between January and April (Rowe, 1972).

1.4 Geography

1.4.1 Topography, stream development and geology

The mountains of the Kiewa valley form part of the Eastern Highlands of South Eastern Australia. The main axis of the range follows a line north east from Mt. Howitt to Mt. Kosciusko in New South Wales.

Uplift of the mountain range along the Tawonga Fault has taken place at varying rates and subsequent stages in stream rejuvenation are evidenced by the flattened spurs at elevations of 1500, 1200 and 1100 m (Beavis, 1962) (Figure 4).

The erosion capability of the East Kiewa River has been severely weakened by the formation of two main branches - Rocky Valley and Pretty Valley Creeks. The headwaters of these two creeks rise within the high plains where mature alluvial valleys drain to streams with gentle gradients. These meandering watercourses give way to fast flowing mountain streams where the edge of the ancient plateau is reached. Secondary incision has occurred along Pretty Valley and Rocky Valley Creeks forming steep slopes close to the watercourses. Figure 5(i) illustrates this point; the slope running from the East Kiewa River to Big Hill [(F3-Fl, Figure 5(ii)] averages 30%, whereas the slope running from the Pretty Valley Creek to Bald Hill (C4-Cl) averages 30% at the base of the valley but only 15% overall. Stream gradients (Table 2, Figure 6) show a similar trend, Springs Creek has a gradient of 0.29 while South Fainter Creek has a stream gradient of 0.22.

The trellis drainage pattern throughout the U2 area has developed under structural control along the crush zones of faults (Beavis, 1962).

Three geological types may be identified within the U2 area, High plains Gneiss, Kiewa Granodiorites and Big Hill Quartz Diorite. Figure 7 is based on field observation and the earlier works of Beavis (1962) and Laing (1981). High Plains Gneiss forms the base [Figure 8(i)] of a geologically complex area which developed through metamorphic action during the late Ordovician Period.

Table2 - Average stream gradients for the major creeks in the U2 area.

Stream	Springs	Slippery Rock	Staff Camp	Bald Hill	North Painter	South Painter
Maximum elevation (m)	1230	1320	1200	1540	1800	1800
Minimum elevation(m)	590	620	630	715	850	940
Stream length (km)	2.2	2.7	1.8	3.9	5.1	4.0
Gradient	0.29	0.26	0.32	0.22	0.19	0.22

Figure 5 - Schematic cross sections along various spurs in the East Kiewa (U2) area
showing reduction in ridgeline gradients with:

(a) bifurcation of th eEast Kiewa River above Lake Guy

(b) proximity to the Bogon High Plains at the head of Pretty Valley Creek

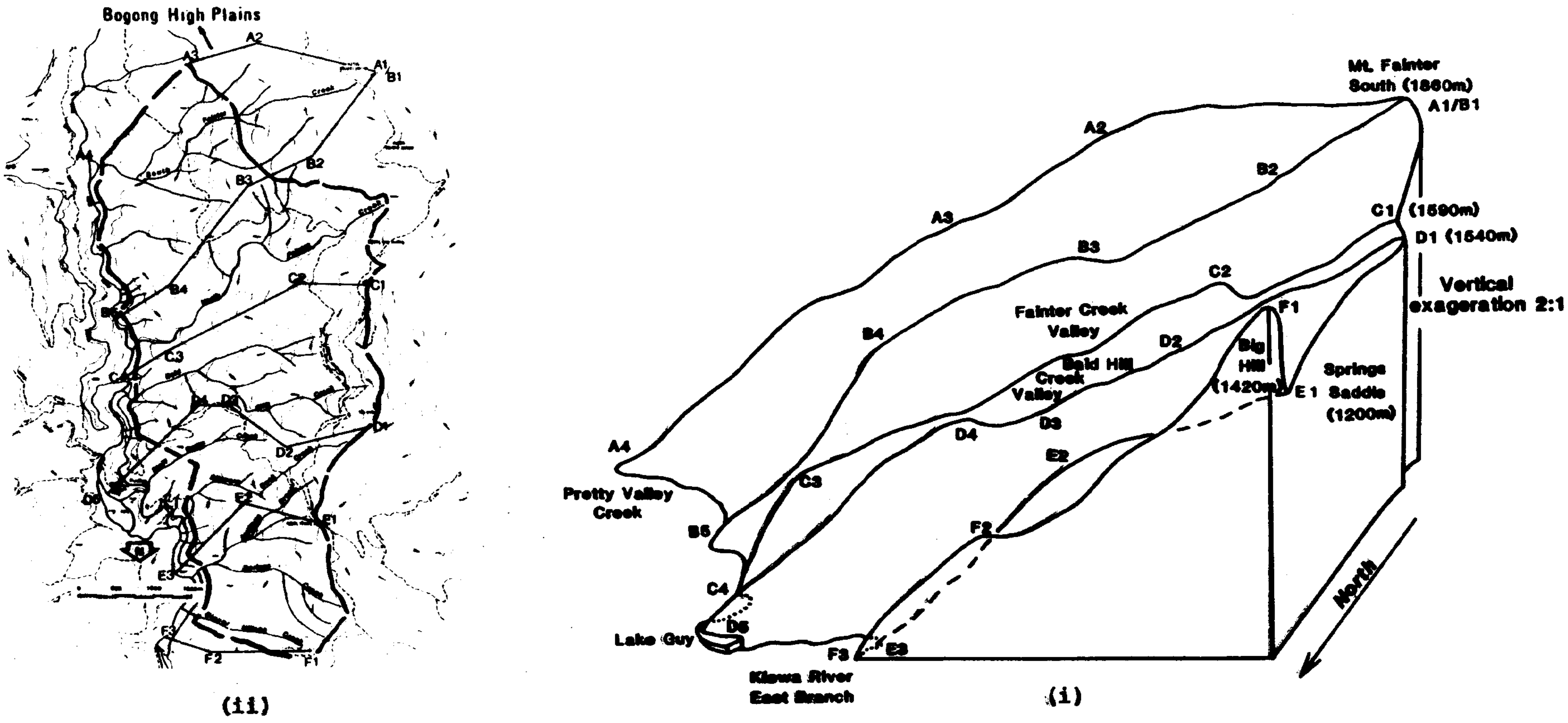
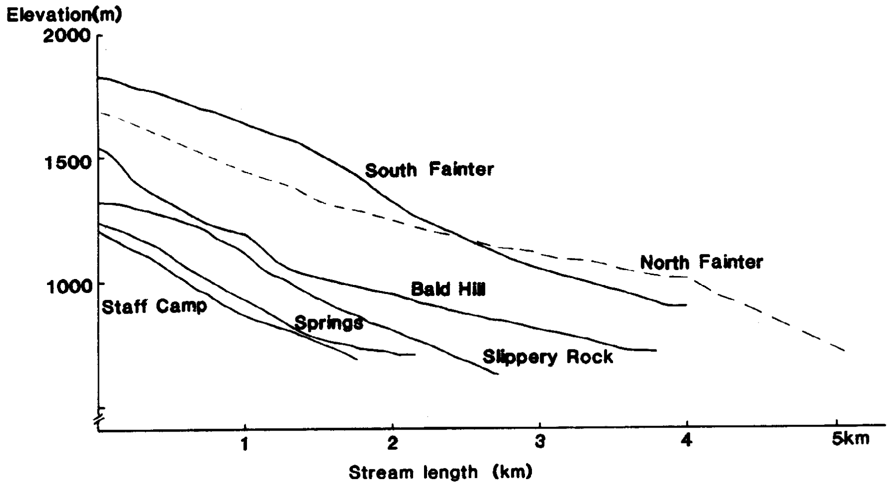


Figure 6 - Cross section along various streams



This belt of material is approximately 15 km wide and runs 60 km in a north-west, south-east direction from the Tawonga Fault near Mt. Beauty to the Great Dividing Range. The younger (Silurian) Kiewa Granodiorite [Figure 8(ii)] has intruded into the gneiss and covers an extensive area (40 sq. km) near Bogong township, with 10 sq. km within the U2 area. The granodiorite material has undergone recystallization which had lead the formation of fresh rock outcrops. Big Hill Quartz Diorite (Figure 8iii) (2.5 sq. km) is intruded into both the gneiss and granodiorite.

1.5 Soils

1.5.1 General description

Mild temperatures in summer and extremely low temperatures in winter have influenced the formation of both uniform and gradational soil types developed on granitoid parent materials in the East Kiewa valley. Appendix II details some physical characteristics of the soil types associated with various landscape components. Soil types follow a sequence from shallow uniform soils on the spurs, to friable gradational soils on steep slopes with uniform deep organic loams close to and within permanent and ephemeral drainage lines.

The surface horizon is generally covered by a litter layer or duff of variable depth which increases with increasing altitude and is of greater depth on southerly than northerly aspects. Pronounced diurnal temperature variations at lower elevations and on northern slopes, result in more rapid mineralisation of organic material. This is reflected in the shallower depth of organic matter in such areas.

'A horizons' are strongly structured, porous and dark coloured. They have low bulk density (0.7 g cm^{-3}) and increase in depth from the spurs to the drainage lines.

'B horizons' occur sporadically, but are particularly well developed at lower elevations (<1100 m). The B horizon structure, although cohesive, is often less well developed than that of the A horizon. Brown colouration, moderate to low dispersion and slaking and low bulk density are common features within B horizons of the area. The depth of the profile to the C horizon is variable, depending on position in the landscape. On spurs, the soil depth to weathering parent material is only a few centimetres. At other places in the landscape, for example gentle slopes, several metres of A and/or B horizon may overlie a deeply weathered C horizon.

Figure 7 - Geology

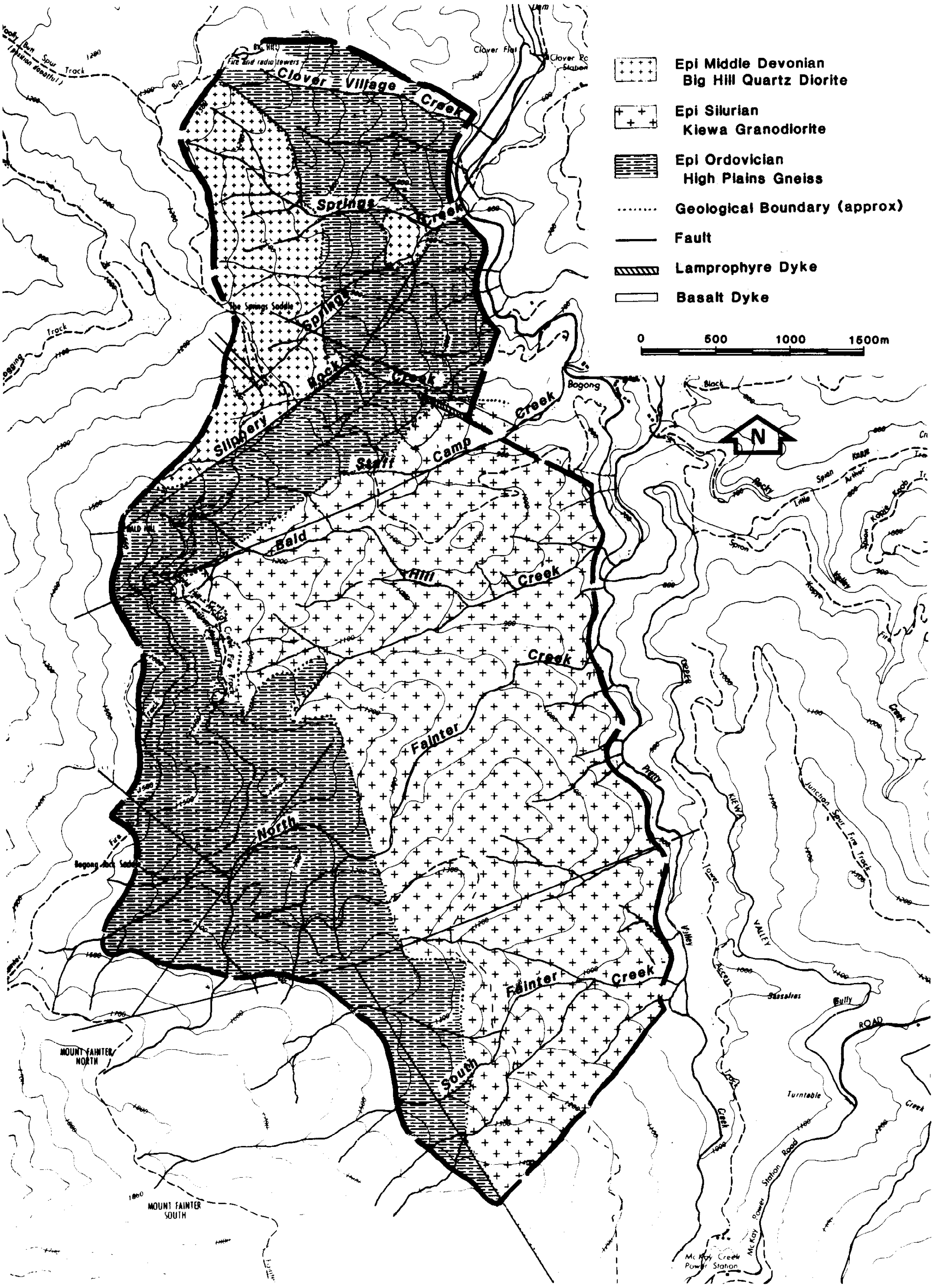
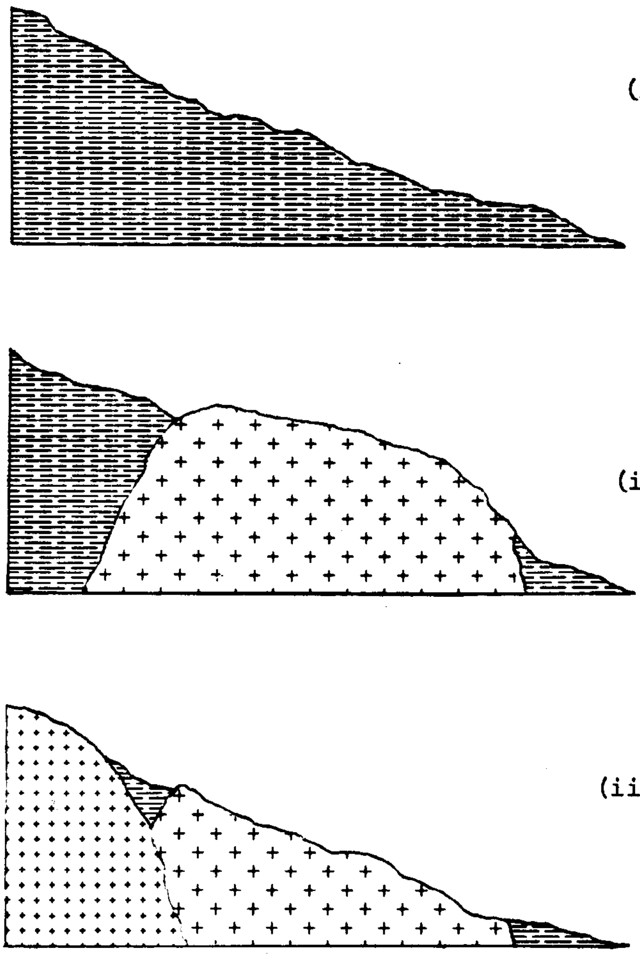


Figure 8 - Schematic geological development of the East Kiewa U2 area



(i) Ordovician Period
High Plains Gneissic
sediments
(430-350 Million years ago)

(ii) Intrusion of Silurian Period
Kiewa Granodiorite
(350-315 Million years ago)

(iii) Intrusion of Middle
Devonian Period
Quartz Diorite
(280-290 Million years ago)

'C horizons' found throughout the U2 area are yellow or brownish yellow, have a high bulk density (>1.0 g cm^{-3}) and are highly erodible. Their coarse texture and resultant low cohesion allows rapid slaking. The clay fraction is moderately dispersive when exposed to erosive forces. Mechanical analysis of C horizon samples revealed that the weathered parent material consists of approximately 35% coarse sand, 35% fine sand, 15% silt and 15% clay size particles. Of course variations in particle size distribution will occur, however the differences between soils on the different geologies is not sufficient to warrant the implementation of different management practices for each geology.

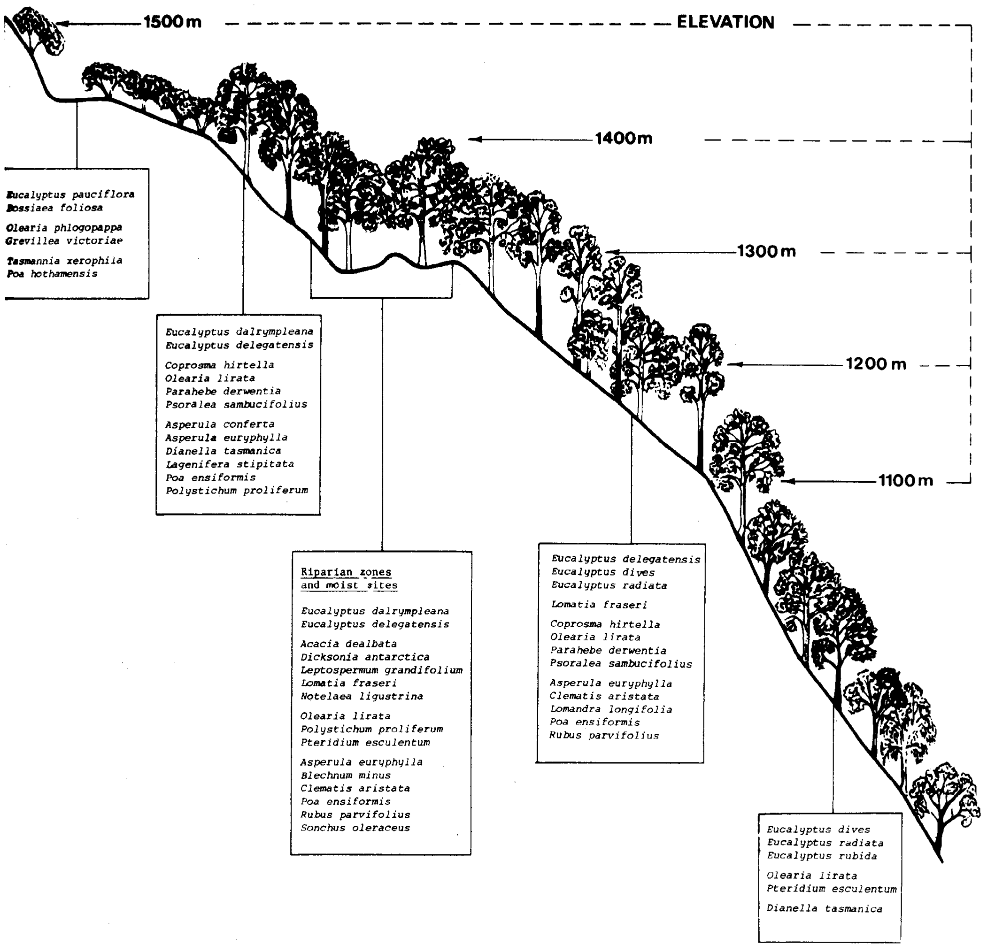
1.5.2 Hydraulic conductivity

In the friable topsoils on gentle slopes, the hydraulic conductivity of the A horizon was approximately 0.12 m day^{-1}, while hydraulic conductivity in the lower C horizon was considerably lower, 0.05 m day^{-1}. During spring snowmelt and intense summer storms, this difference in hydraulic conductivity between the two horizons may induce a perched water table. The resultant seepage flow may generate surface soil wash on steeper slopes.

1.5.3 Nutrient status

Leaching of soil nutrients is common from highly permeable, coarse textured soils especially in areas of high rainfall. Previous studies by Rowe (1972) indicate that soil fertility levels are low in these mountain soils developed on granitic parent material. Of the soils discussed by Rowe (1972), organic loams and friable brownish gradational soils of the region exhibit the lowest ratio of metal cations to cation exchange capacity. Soil and plant nutrients released through accelerated weathering processes, or following regeneration burning, are thus subject to leaching from the soil profile, or loss through erosion. Consequently soil fertility is reduced.

Figure 9 - Vegetation transect



1.5.4 Vegetation

Vegetation within the U2 area (Figure 8) is separated into two broad forest types-wet sclerophyll forest and tall woodland forest.

Wet sclerophyll forest with narrow-leaf peppermint (*Eucalyptus radiata*), candlebark gum (*E. rubida*) and broad-leaf peppermint (*E. dives*) persists to elevations of 850-1100 m. The dominant eucalypt species at elevations above the mixed species forest are alpine ash (*E. delegatensis*) and mountain gum (*E. dalrympleana*). The better quality and more extensive stands of alpine ash dominate the cooler, wetter sites. Age of the stands varies, but most of the existing ash resource has regenerated from the bushfires of 1919 and 1939. Tall woodland forest consisting mainly of snow gum (*E. pauciflora*) is common above 1400 m. Understorey vegetation and ground cover species likely to be encountered in the area are also listed in Figure 8. Mountain tea-tree (*Leptospermum grandifolium*) occurs at elevations above 1100 m and is a notable example of a species closely associated with hydrologically sensitive areas.

CHAPTER 2 LAND USE

Water production as a land use will be dealt with under a separate heading in Chapter 3.

2.1 Existing land tenure, access and use

The U2 area is completely forested and is classified as unreserved Crown Land which abuts the SEC Crown Grant boundary, both the U2 and the SEC Crown Grant areas are within the Kiewa Works Protection Area (KWPA) (Figure 2).

The KWPA has been recognised by the Land Conservation Council as an "area of importance for the operation and protection of the Kiewa hydro-electric scheme". The SEC Crown Grant boundary has recently been altered to allow planning for the proposed utilisation of existing timber resources in this portion (U2) of the Upper Kiewa Catchment.

The Big Hill firetrack connects to the Bogong High Plains road near Bogong Township and becomes the Fainter firetrack at Springs Saddle. Fainter firetrack is still used as a stock access route to the Bogong High Plains. Other management access tracks include the Bald Hill-Mt. McKay Creek firetrack, of recent construction for fire suppression purposes, and the Springs Saddle to Balloon Site 3 firetrack. This latter track was originally constructed to provide access to a suitable terminal point for aircraft observation during aerial spraying of insecticide for suppression of stick insects (Didymuria violescent).

In addition to the 21 km of vehicle access tracks, three walking tracks totalling 12 km traverse the area: the Big Hill track from Springs Saddle; the Fainter Creek track from the Bogong High Plains near Pretty Valley bridge; and the Upper Fainter Creek track which connects the two already mentioned.

All tracks were constructed by the SEC and strict control over access is maintained through a system of locked gates. Apart from seasonal movement of some cattle en route to the Bogong High Plains and use by small numbers of bushwalkers, all tracks exist principally for catchment management purposes.

2.2 Hardwood production

The U2 area is now seen to have value as a hardwood resource area. It lies partly within Block 23 (Pretty Valley) and Block 16 (Clover) as defined by the Bright Forest District. No previous logging is recorded for either block, although several mature alpine ash trees in the Springs Creek catchment have been felled in the past 10 to 20 years, presumably for experimental purposes. The future of logging operations in the U2 area is to be determined following assessment of the results from the East Kiewa experimental catchment logging operations. A detailed assessment of the extent and quality of the timber resource within the U2 area outside the experimental catchments has not yet been undertaken.

Harvesting of timber within 30% (70 ha) of the 244 ha experimental area (Springs Creek catchment) has required the construction of an additional 5 km (approx.) of access roading. Prescriptions (Forests Comm., 1982; Appendix III) applied to the location, design and construction of such roading. It is probable that some sections of roading will be retained for catchment management once the area has been logged.

Fire occurrence has been low, with recorded outbreaks in recent times in the mixed species stands only. There is no record of burning in the alpine ash since the fires of 1939. Minor fuel reduction burns were carried out in 1978 in an area adjacent to the Big Hill firetrack above Bogong township.

2.3 Domestic water supply

The Staff Camp Creek subcatchment (74 ha) supplies untreated water for domestic use in Bogong Village. During vacation periods, the existing supply must meet the demands of over 200 people plus many day visitors.

The extent of land use within Staff Camp Creek Catchment must be limited for a number of reasons. Low flow in summer sometimes limits water availability in Bogong township. If forest harvesting were permitted in this catchment then there may be a deleterious long term effect on water yield. In addition, detention time both in stream and in the reticulation system is short. With a direct offtake, any increase in the intensity of land use will be rapidly detected by increases in turbidity and sediment within the system.

CHAPTER 3 WATER PRODUCTION AND USE

3.1 Water supply and use

Streams in the U2 area enter into Pretty Valley Creek, which becomes the East Kiewa River after the junction with Rocky Valley Creek above Bogong village.

As mentioned in the previous chapter, water for Bogong township is obtained from Staff Camp Creek Catchment (74 ha), within the U2 area water is conveyed via a small pipeline from the offtake to a concrete fire service reservoir (estimated capacity 0.3 ML) adjacent to the Big Hill fire track above Bogong village, and then to a break pressure tank adjacent to Bogong High Plains road. Both storages provide limited detention and allow only a little of the suspended sediment to settle out. Water from the reservoir enters the reticulation system without further treatment.

Water from most of the U2 area (experimental catchments excluded) flows into Lake Guy (1480 ML) which is used principally as a water storage for Clover Power Station, Lake Guy also acts as a sediment trap and provides for recreation in the summer months. Clover Dam (255 ML) downstream from Lake Guy was constructed to store water for power generation. Water may be diverted from Clover Power Station into the headrace tunnel leading to the West Kiewa Power Station or released back into the East Kiewa River. Mt. Beauty Waterworks Trust manages a water supply offtake on the West Kiewa River, 1 km upstream of Mt. Beauty township. Thus it is possible for water from the East Kiewa Valley, including the U2 area, to enter the domestic water supply for Mt. Beauty. There is a need therefore, to protect and maintain water quality at its current high standard.

3.2 Water quality

Long term water quality data have been recorded by the State Rivers and Water Supply Commission below the junction of the East and West Kiewa Rivers at Mongans Bridge (Appendix IV). The U2 area, with its current low intensity of land use, would be expected to generate water of better quality than that derived from other parts of the Upper Kiewa catchment in which there has been forestry, road and ski resort development or grazing activities. However, even in virtually undisturbed areas, for example Staff Camp Creek (74 ha), there have been reports of high turbidity following high intensity storms.

Water temperature fluctuates from 15°C to 24°C in summer and 4°C to 7°C in winter (Appendix IV). Snowmelt maintains low stream temperatures in winter, while a shallow river bed and low flow allows considerable warming of the water in summer. Stream temperatures and streamflows have a direct effect on the dissolved oxygen content of the water. In the Kiewa River dissolved oxygen ranges from 8-13 mg 1^{-1}.

Electrical conductivity (E.C.[*]), a measure of the total amount of dissolved salts, is low, with values ranging from 30 to 50 $ms.cm^{-1}$. The levels of dissolved salts in the Kiewa River are well within published standards for drinking water (Department of Health *et al*., 1980).

pH varies between 6.3 and 8.0 (whereas 6.5 to 9.2 is acceptable: Department of Health, *et al*,1980). Under normal flow, pH averages 7.4.

There are many natural detention sites (such as those created by fallen trees) and some man made ones (such as storages) along the length of the various stream systems where sediment may settle. As a consequence, turbidity measurements taken at normal stream flow levels may fall to provide an accurate representation of the total amount of clay sized material being moved out of the steeper parts of the catchment in the medium to long term. To estimate this amount more accurately, turbidity measurements would need to be made during both the rising and falling stages of the hydrograph thereby including the infrequent but significant pulses of colloidal material which moves downstream.

Turbidity figures at base flow range from 0.3 to 4.5 NTU, and rise to 22 NTU during peak flow. Turbidity measurements of samples taken from various tributaries of Pretty Valley Creek during April 1981 indicated that turbidity was extremely low (0.25 - 0.50 NTU). The fundamental water quality problem is not turbidity but the coarser sediment or bedload which is conveyed by the stream system.

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[*] EC. is measured in microsiemens per centimetre ($ms.cm^{-1}$).
#NTU - Nephelometric Turbidity Units.

Sediment samples from Springs Creek were composed of 70% coarse sand (0.2 - 2.00 mm) and 17% fine sand (0.02 - 0.2 mm), the remainder being 7% silt (0.02 - 0.002 mm) and 6% clay size particles (<0.002 mm). Sedimentation reduces the efficiency of hydroelectric operations and necessitates the cleaning of detention dams, pipelines and water storages. Moreover, the costs of such maintenance and replacement of pumps and turbines may be passed directly to the consumer in the form of increased electricity tariffs.

The rate of 'natural' sediment generation in the experimental catchments of Slippery Rock and Springs Creek has been measured (C. Leitch Pers. Comm.) and is found to range from 0.071-0.229 t hay^{-1} y^{-1}, varying according to annual rainfall amount and intensity. This yield is relatively high compared with other experimental areas. The Corranderrk catchments of Picaninny and Blue Jacket yielded 0.040 t ha^{-1} y^{-1} and 0.022 t ha^{-1} y^{-1} respectively prior to treatment (Langford and O'Shaughnessy, 1980). Catchment characteristics such as ground cover, slope, infiltration rate, stream gradient and geology are among the important factors determining soil loss.

While soil loss from forested land is a non-point source of sediment input to streams, various point sources of sediment production can be identified throughout the region, notably, culverts draining road cut and fill batters, aqueducts and the resort area of Falls Creek. Remedial soil conservation measures have been undertaken by most land management bodies in the East Kiewa valley, including the Country Roads Board, State Electricity Commission and Falls Creek Committee of Management. Without proper management, increases in the intensity of land use will compound existing problems of soil erosion and water quality in the East Kiewa valley.

3.3 Flow and yield characteristics

On a seasonal basis, consistently low flow is experienced in summer, with flow being variable in autumn (Appendix III). Creek levels rise from the onset of winter, reaching their peak during the spring (late September) snowmelt.

The steep gradient of various creeks (Table 2, Figure 6) within the U2 area results in a rapid rise in water level in response to rainfall events. However, the rate of decline in such a hydrograph tends to be gradual due to storage in the flank and springhead areas of sub-catchments (Bren and Turner 1980).

The U2 area occupies 10% of the East Kiewa Catchment, but because it is situated at a low elevation in relation to the rest of the East Kiewa Catchment, it is estimated that it contributes a lower proportion (6-7%) of the total catchment water yield. Lower runoff yield from sub-alpine sections of the catchment may also be, attributed to vegetation differences, resulting in greater losses of water through evapotranspiration than is observed in high plains vegetation communities.

Fire within sub-alpine catchments has been found to dramatically affect streamflow, as is indicated by an extract from the following paper by McArthur and Cheney (1965).

> "During the 1939 fires in Victoria, one catchment of 1700 acres (690 ha) was burnt and an adjoining catchment of 1800 acres (730 ha) remained unburnt in the Bogong High Plains of Victoria. Both catchments carried comparable sub-alpine vegetation. Immediately following the fire the streamflow increased by 60 percent from 9 to 16 cusecs (22 to 39ML.day^{-1}) in the absence of rain. After 170 points (43 mm) of rain fell five days after the fire, streamflow on the burnt catchment was increased by over 90 percent for several days."

CHAPTER 4 HAZARDS TO THE WATER SUPPLY

4.1 Soil disturbance

Soil disturbance takes many forms and, as mentioned previously, soil movement may be the result of either natural or accelerated erosion. Disturbance of subsoils and subsequent erosion is the major concern of water users and managers in the East Kiewa valley. The main areas involved are steep slopes (>20º, >36%), hydrologically sensitive areas, for example seepage depressions, and the stream environs.

4.1.1 Forest operations

Sediment generated by 'natural' erosion and sediment derived from other sources such as aqueducts and road batters both contribute to the total sediment load reaching Lake Guy. It is therefore important to clarify whether or not additional roading and subsequent forest harvesting operations in the East Kiewa area are likely to increase significantly the total load of sediment reaching Lake Guy. Of particular concern is the impact which the development of any ill conceived and poorly constructed roads may have upon Lake Guy.

Clearly it is impossible to determine with certainty the extent to which levels of sediment generation from the U2 area will be increased by forest operations. However, it is possible, using the current estimated base level of sediment generation from Springs Creek and Slippery Rock catchments, to estimate the range within which this increase in sediment production is likely to fall. The lower and upper limits of this range are derived by employing an assumed maximum and an assumed minimum amount by which forest operations will increase the base rate. These assumptions, together with the base rate estimate, are then input to a deterministic model (described in Appendix V) which predicts the total additional sediment generated during the period of logging operations in the catchment.

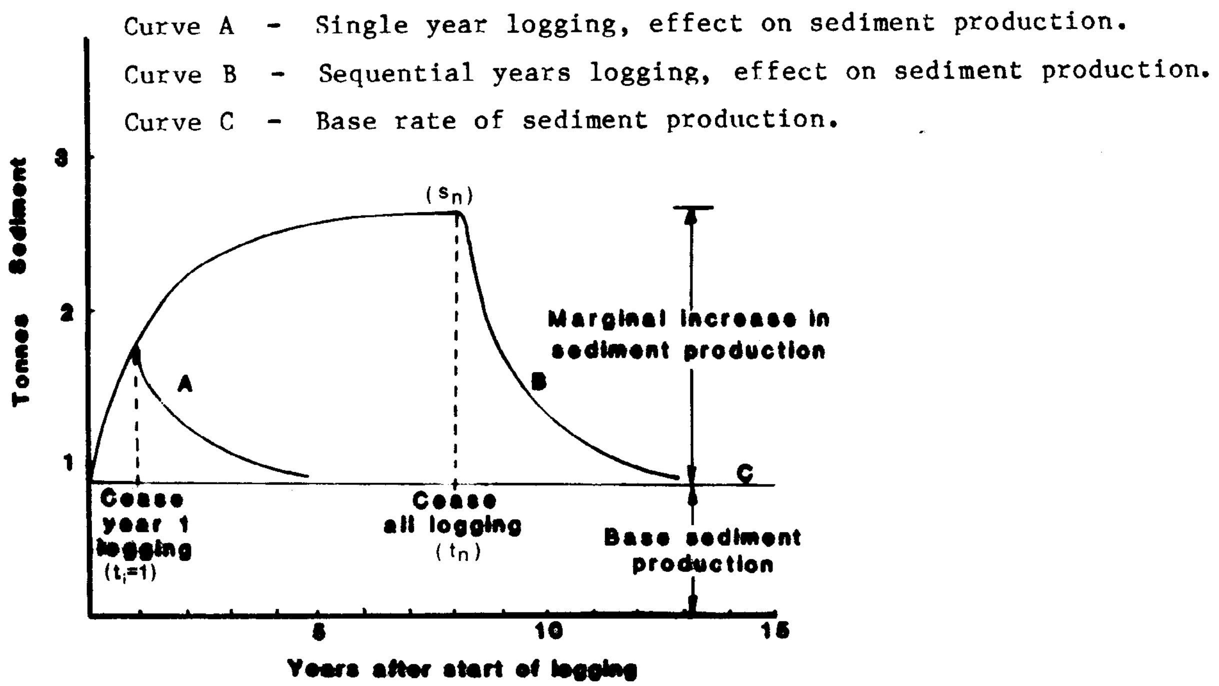
The results derived from the model reflect the pattern of change in sediment yield which has been established in many areas following forest harvesting and regeneration. Specifically, in the period immediately following harvesting, sediment yields increase markedly of most surface protective cover. Sediment yield then stabilises in response to the increasing surface protection afforded by vegetative regrowth. Finally, after a period of years, the sediment yield approaches the previous base level.

This general pattern is shown in Figure 10. Two curves are shown in the graph: one showing the general pattern of increase and declining yield from a single season's harvesting; the other showing the accumulated effects of logging over a number of seasons where the progressive decline in sediment yield from a previously cut area is off-set by the increase in yield from more recently cut areas. That is, until there is a final cessation of logging in the total area under consideration sediment production will not return to normal levels.

Increases in sediment production from forest operations have been reported to range from two to one hundred and fifty times the base rate of sediment production (Langford and O'Shaughnessy, 1980; Rice et al., 1979; Frediksen, 1970). Clearly many environmental factors determine the sensitivity of a catchment to the impact of forestry operations and in particular the magnitude of the increase in sediment production which will follow such operations.

On the basis of an assessment of the above mentioned studies (and taking into account both the principal physical characteristics of the U2 area and the climatic regime which it experiences) it has been assumed (perhaps conservatively) that forestry operations will increase the rate of sediment generation by between two and four times the base rate. Using these assumed maximum and minimum figures, together with the estimated base sediment generation rate of 0.175 t ha^{-1} y^{-1} (C.Leitch. Pers. Comm.), the model has been employed to produce high and low estimates of the annual and cumulative amounts of sediment which would be generated from all the 50 ha coupes in a 400 ha area during an eight year logging period and during the following seven year period by the end of which sediment production would have returned to near base levels.

Figure 10 - Trends following a doubling of sediment production during and after logging of eight – 50 ha areas at a rate of 50 ha per year.



While the detailed results obtained from the model are listed in able V-I in Appendix V, the sediment results are summarised below.

* The additional sediment yield from forest harvesting operations covering 50 ha would amount to between 8.75 and 26.25 tonnes above the base rate of sediment generation (0.175 t ha^{-1} y^{-1}) in the first year of operations.

* The additional sediment yield over the eight year logging period (50 ha y^{-1}) would amount to between 982 and 2943 tonnes (8.1 to 24.2) percent addition to estimated total of catchment sediment yield.

* If the seven years following the cessation of logging is assessed (a total fifteen year period) the additional sediment yield would amount to between 1121 and 3358 tonnes or greater (4.9 to 14.7 percent additional sediment to the estimated production from the steeper areas (= 87500 ha) of the catchment.

* The volume of additional sediment would amount to between 3203 and 9594 m^3 or 0.22 to 0.65 percent of the volume of Lake Guy, over the fifteen year period. Natural sediment additions would amount to approximately 65251 m^3 or 4.4 percent of dam capacity over the same period.

4.1.2 Slope

Excluding Staff Camp Creek (71 ha) and the experimental catchments (383 ha), 7% (125 ha) of the area is between 250 and 300, while 16% (290 ha) of the area is greater than 300 slope.

Slope limitations for forest operations are an important management factor in reducing sediment production from harvesting areas. Studies by Langford and O'Shaughnessy (1980) indicate that on stable gradational soils 250 (47%) should be the upper limit for economic forest harvesting. It would therefore appear reasonable to apply a 200 slope limit to forest operations on sites where soils are of a skeletal nature or geological instability is apparent. A 250 maximum limit should apply to all other forest operations in the U2 area, outside the experimental catchments.

4.1.3 Roads
Road construction, use and maintenance inevitably result in sediment production and water quality deterioration (Boughton, 1970). Stream turbidity levels are increased during runoff events and the problem can be compounded if forest operations continue during wet periods.

The construction of roadside drains which discharge directly into watercourses has led to serious deterioration of water quality in many of our water supply catchments.

If the problems of turbidity and sediment accession to streams are to be overcome, then it is essential that road drainage be diverted, as far as is possible, away from streams and into a stable disposal area or buffer zone.

Environmental considerations for roading and forest harvesting, under Australian conditions, are illustrated and detailed by Cameron and Henderson (1979).

4.1.4 Batter failure
The collapse of both cut and fill batters is the result of alteration of the structural and hydraulic characteristics of the Slope. Road batters unless stabilised are a continual source of sediment, a large proportion of which eventually finds its way into streams and water storages. Appendix VII is a summary of a report by Beavis (1968), on factors contributing to batter failure in the Kiewa Catchment.

4.1.5 Soil compaction
Soil compaction produced by machinery and vehicles poses both a hydrological and soil erosion hazard. The subject of compaction effects on forest soils has been reviewed by Greacen and Sands (1980).

Compaction of soil results in a decrease in total porosity which is largely attributable to a decrease in macroporosity. Infiltration and saturated hydraulic conductivity are also reduced, while bulk density is increased. These changes in soil physical properties increase runoff and thus the rate of soil erosion from compacted sites. Anaerobic conditions in compacted areas (log landings) may also contribute to a reduction in the rate of forest regrowth. Greacen and Sands (1980) reported in their review that soil compaction effects are most persistent in coarser textured soils, particularly sands where compaction effects may persist for more than 50 years. Most of the soils in the U2 area are dominated by sand and would thus be subject to severe compaction effects if it were not for the high organic matter content of the “A” horizon which alleviates compaction to some extent. Snig tracks, log landings and other sites where traffic is concentrated will suffer the more permanent effects of compaction.

4.2 Streambank erosion
Streambank erosion is part of a natural process, the rate of which is determined by several factors. The capacity of the stream to remove soil and organic debris depends upon its discharge volume, depth, velocity and nature of the material it is removing.

The streambanks of the tributaries of Pretty Valley Creek are composed of coarse grained (Section 3.2), loose soil mixed with organic debris derived from forest litter. As such, these soils are extremely susceptible to erosion during storm events. Streambank erosion is likely to increase if, as a result of reduced evapotranspiration and increased overland flow after forest harvesting, there is an increase in runoff.

4.3 Fire
Forest fire represents a significant factor in the alteration of some Australian soils, the final effect depends on the temperature and duration of the burn, amount and type of fuel, wind speed, soil type and other variables. Some of the effects of fire on the Australian environment have been described by Gill et al. (1981).

Following fire there is a reduction in protective surface cover and numbers of surface obstacles which would normally cause detention of surface flows. In respect of water quality the main impact of postlogging fire will be an increase in the amount of sediment entering the stream system. The degree to which sediment production increases depends upon numerous factors for example, the condition of buffer strip areas, the intensity of the regeneration burn, topography and post-burn rainfall intensities.

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APPENDICES

APPENDIX I - CLIMATIC AVERAGES - BOGONG (COMMONWEALTH BUREAU OF METEOROLOGY)

Number 083004 Latitude 36 Deg 48 Min S Longitude 147 Deg 14 Min E Elevation 731.5 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 am Mean Temperatures (C) and Mean Relative Humidity (%)													
Dry Bulb	19.3	18.9	16.2	11.6	7.2	4.4	3.2	5.0	8.0	12.6	15.2	17.5	11.6
Wet Bulb	14.8	14.6	13.1	9.6	6.1	3.9	2.7	4.2	6.5	9.5	11.1	13.1	9.1
Dew Point	11	11	11	8	5	3	2	3	5	6	7	10	7
Humidity	60	61	69	77	85	92	92	88	80	66	59	60	74
3 pm Mean Temperatures (C) and Mean Relative Humidity (%)													
Dry Bulb	24.6	25.1	22.3	17.5	11.7	9.5	8.1	9.1	11.8	15.9	18.8	21.6	16.3
Wet Bulb	16.6	16.6	15.3	12.5	8.8	7.3	5.8	6.6	8.3	11.1	12.6	14.9	11.4
Dew Point	11	10	10	8	6	5	3	4	4	6	7	10	7
Humidity	42	39	45	54	67	72	70	68	60	53	46	46	55
Daily Maximum Temperature (C)													
Mean	25.8	26.1	23.5	18.5	12.8	10.4	9.0	10.4	13.1	7.3	20.2	22.8	17.5
86 Percentile	30.0	30.6	27.2	22.8	17.2	13.3	12.2	14.0	17.2	22.0	25.0	27.8	
14 Percentile	21.1	21.1	19.4	12.8	7.8	7.2	5.6	6.7	8.9	12.2	15.0	17.2	
Daily Minimum Temperature (C)													
Mean	10.9	11.4	9.5	6.6	3.7	2.0	0.8	2.0	3.1	5.6	7.0	9.3	6.0
86 Percentile	15.0	15.6	13.3	10.0	7.2	5.6	3.9	4.4	6.1	9.4	10.6	13.3	
14 Percentile	6.1	7.8	5.6	3.3	0.0	-1.1	-1.7	-1.1	0.0	1.7	2.8	5.0	
Rainfall (mm)													
Mean	77	83	91	140	182	202	239	239	169	172	125	93	1812
Median	56	61	68	106	137	177	236	232	162	151	105	91	1777
Raindays (No)													
Mean	7	7	8	10	13	15	16	17	14	15	12	10	144

APPENDIX II - SOILS ASSOCIATED WITH VARIOUS LANDSCAPE COMPONENTS

Landscape component	Description	Classification Factual key, (and other profile forms)	Horizon design-ation	Average horizon depth (cm)	Colour (Munsell)	Texture	Pedality	Average organic carbon (%)	Average bulk density ($g.cm^{-3}$)	Slaking	Dis-persion
Spurs	Shallow organic loams	Um 7.11 Uniform medium textured (Uc 5.22, Gn 2.01, Gn 2.41)	O	2	-	D	NP	-	-	-	-
			A	5	dark grey/ brown	CL-SCL	HP	7	0.9	L	L
			C	75	brownish yellow	SC	NP	<1	1.3	H	M
Ephemeral stream zones	Deep organic loams	Um 7.11 Uniform medium textured (Gn 2.01)	O	20	-	D	NP	-	-	-	-
			A	75	black	OL-SCL	HP-WP	10	0.7	L	L
			C	125	brown	SCL	NP	<1	1.3	L-M	L-M
Steep slopes >11° (20%)	Organic loams	Um 7.11 Uniform medium textured	O	10	-	D	NP	-	-	-	-
			A	15	dark grey/ brown	CL-SCL	HP			L	L
	Friable brown and some friable reddish soils (<1100 m elevation)	Gn 2.41, 2.01 Gradational	B (Gn soils only)	100	brown, reddish brown	SCL	WP	1-2	0.9	M	L
			C	200	brownish yellow, yellow	SC	NP	< 1	1.5	H	M
Gentle slopes >11° (20%)	Organic loams	Um 7.11 Uniform medium textured	O	7	-	D	NP	-	-	-	-
			A	20-35	black, dark yellowish brown, grey	OL-CL	HP	9	0.7	L	L
	Friable brown and some friable reddish soils (<1100 m elevation)	Gn 2.41 Gradational	B (Gn soils only)	300	brown, strong brown	SCL	WP	2	1.3	L	L
			C	200-400	-	-	NP	< 1	-	-	-

Key: Texture

- D - Duff, litter
- OL - Organic loam
- SCL - Sandy clay loam
- SC - Sandy clay
- CL - Clay loam

Pedality

- NP - Non-pedal
- WP - Weakly pedal
- HP - Highly pedal

Slaking/Dispersion

- L - Low
- M - Moderate
- H - High

APPENDIX III

FORESTS COMMISSION, VICTORIA; EXPERIMENTAL CATCHMENT PRESCRIPTIONS

A. PREAMBLE

These prescriptions apply to the catchment of Springs Creek where experimental logging will be carried out to determine the effect of alpine ash logging on downstream sediment levels. They are essentially the same as those that apply elsewhere in the Kiewa catchment and are applicable to operational scale logging.

B. PERMANENT ACCESS ROADS

The permanent access roads include the link road between the West Kiewa Logging Road and Springs Creek and the Big Hill Fire Tracks. All timber is be transported via the West Kiewa Logging Road. No timber traffic is permitted via Bogong Village.

1. Requirements for road realignment, widening or additional drainage will be determined by the Forests Commission after consultation and joint inspection with Soil Conservation Authority and State Electricity Commission.

2. All culverts must be constructed of concrete, steel or similar material, and be of an effective internal diameter not less than 375 mm. A durable bar must be placed below the outlet of each culvert to spread emitted water. Emitted water must not flow over the spoil batter. Attention is to be given to spreading and filtering of runoff water from culverts through vegetation, and direct discharge into streams will be avoided.

3. Crossings over major streams should be bridges or culverts whose diameter shall be adequate to take peak flows.

4. Sections of roads that are continually wet despite adequate drainage shall be surfaced by the licensee.

5. Maintenance of the surfaces, table drains and culverts of the roads within the area and the West Kiewa Logging Road/Springs Saddle link road is to be the responsibility of the licensee during the period of the experimental logging and is to be carried out under the supervision of the Forests Commission, Victoria.

6. If the logging operations cease for a period greater than one allocation year then the FCV will consult with the SEC regarding the responsibility for the maintenance of the road,

C. TEMPORARY ACCESS ROADS

<u>Definition</u>

Temporary access roads may be regarded as all formed roads or tracks other than the permanent access roads.

1. Temporary access roads are to be constructed on a grade line approved by the Forests Commission. As far as is practicable cross slopes of greater than 30^{o} will be avoided and grades are generally not to exceed 1 in 8 except for short sections.

2. Batters will not be sloped except where it is determined, after consultation with the relevant SCA officers, that sloping would reduce batter slumping during winter conditions. Batters should be sloped off at the time the road is formed up.

3. Where outslope drainage is not possible and where minor earth-on-log cross drains would not be stable, culverts shall be used for cross draining. All culverts must be constructed of concrete, steel or similar material and be of an effective internal diameter not less than 375 mm. A durable bar must be placed below the outlet of each culvert to spread emitted water. Water emitted from culverts must not flow over the spoil batter. Attention is to be given to spreading and filtering of runoff water from culverts through vegetation.

4. Crossings over major streams should be bridges, culverts or hard fords. The diameter of culverts shall be adequate to take peak flows.

5. Sections of roads that are continually wet despite adequate drainage shall be surfaced by the licensee.

6. Maintenance of the road surfaces, table drains and culverts, is to be the responsibility of the logging licensee, and is to be carried out under the supervision of the PCV.

7. In the case where tracks have no further apparent use to the FCV and SEC following completion of logging operations, they should be breached and barred and allowed to revegetate, and open cross drains shall be cut across the tracks 30 metres from stream crossings such that road runoff is discharged into vegetation.

D HARVESTING AND REGENERATION OPERATIONS

1. Timber harvesting operations are prohibited during the period 1 July to 30 September except for the cartage of logs from approved dumps.

2. From 1 July to 30 September carting of logs from dumps will be prohibited during heavy rain and for 24 hours thereafter.

3. Carting of logs may be restricted by the SEC after consultation with the District Forester if the condition of the roads is such that continued use by log trucks would prevent the use of the road by 2 - wheel drive vehicles.

4. Wherever practicable no felling, snigging or similar operations are to be located within 20 m on either side of permanent streams. In situations where numerous small watercourses occur in the headwaters of a catchment, and the frequency of such watercourses and the nature of the topography make the reservation of streamside strips impracticable, tree felling, log removal and burning is permissible, provided that movement of logging equipment within 20 m of the watercourse is excluded except for the crossing of water-courses by way of properly constructed crossings.

   Crossings must be removed at the completion of logging where directed by the Forests Commission.

5. No snigging is to take place whilst heavy rain is falling.

6. On shifting an operation from a particular landing, and also at the end of each season, all snig tracks should be breached and barred to prevent soil movement, and the landing drained under the supervision of the Forests Commission.

7. When a landing is no longer required, the disturbed area shall be levelled to conform to the natural contour and drained so that runoff is directed into the surrounding vegetation.

8. As far as practicable, running streams will be kept clear of tree heads.

9. No regeneration burning shall be carried out without the approval of the District forester of the FCV after he has consulted with the SEC Works Forestry Officer. After burning is completed control lines will be breached and barred by the Forests Commission as necessary to prevent scouring.

10. Diesel fuel, petrol and oil must be stored in an area cleared for at least 10 m in all directions and at least 60 m away from running streams, and empty drums and containers must be stacked and removed prior to cessation of work for the season. Servicing of vehicles and logging equipment must not be carried out within 100 m of running stream. All matters in this clause will be supervised by PCV officers.

E SPECIFIC REGULATIONS APPLICABLE TO THE KIEWA WORKS PROTECTION AREA

The logging area lies within the boundaries of the Kiewa Works Protection Area controlled by regulations administered by the SEC.

1. It will be the licensee's responsibility to obtain a permit from the SEC to use explosives; and the conditions under which a permit is issued must be observed.

2. Log trucks must be driven in a cautious manner and loads must be securely placed on the trucks.

3. The licensee and his logging staff will be allowed access to the area but the Principal Hydro Engineer may restrict entry if deemed necessary following consultation with the District Forester.

4. No cartage of logs below the Big Hill log stack area will be allowed on Sundays, Public Holidays or after dark.

5. Notice must be given on a SEC working day of intention to cart on Sundays or Public Holidays to the Big Hill log stack from the logging area, and the Big Hill gate must be closed on these days every time log trucks pass through either way.

6. On every day that carting to the Big Hill log stack area takes place, a sign, to be supplied by the SEC, must be placed at the turn-off into the log stack area.

7. Camping by logging crews is not permitted in the KWPA.

F FIRE PROTECTION

1. The Forest Industries Fire Protection Regulations of 1978 and subsequent amendments are to be enforced by the Forests Commission.

2. The Sections of the *Forests Act* of 1958 and subsequent amendments and the Kiewa works Protection Regulations dealing with the prevention and protection from fire shall be enforced.

3. The sawmiller's staff are required to attend fires in the KWPA in accordance with sawlog licences condition if so directed.

4. The SEC will not be held responsible for any cost incurred by the licensee's staff fighting fires in the KWPA.

5. Prior to each summer season, the SEC Kiewa Branch will advise the licensee and contractors of the SEC fire fighting organisation.

APPENDIX IV - WATER QUALITY DATA - MONGANS BRIDGE

(Source: State Rivers and Water Supply Commission)

Date	Time	Gauge height (m)	Discharge (Ml.day^{-1})	Stream temp. C°	E.C.‡ @ 25°C ms.cm^{-1}	Turbidity (J.T.U.*)	pH	Dissolved oxygen (mg.l^{-1})
15/10/75	14:20	2.16	5422.1	11.0	22	-----	7.1	11.0
12/11/75	13:45	1.58	2496.0	15.0	31	-----	7.2	10.4
11/02/76	12:25	0.73	369.2	19.0	39	-----	7.5	9.4
09/03/76	10:00	0.66	294.0	16.0	47	-----	7.3	08.4
01/06/76	12:15	0.58	206.2	8.5	41	-----	7.3	11.6
01/07/76	10:20	1.05	948.3	5.5	27	-----	7.0	10.2
28/07/76	10:00	0.94	710.	4.0	28	-----	7.4	9.8
25/08/76	13:10	0.87	618.6	6.5	32	-----	7.6	12.8
22/09/76	11:30	1.63	2634.0	8.0	22	-----	7.4	11.5
18/10/76	15:00	1.66	2844.	10.0	21	-----	7.2	----
16/11/76	10:40	1.18	1275.	12.5	24	-----	6.5	11.3
14/12/76	09:40	0.79	497.	14.5	35	-----	7.3	9.9
11/01/77	09:50	0.65	282.	20.0	35	-----	7.2	9.4
10/02/77	10:20	0.55	154.0	21.0	39	-----	7.4	10.4
08/03/77	13:50	0.68	317.	20.0	38	-----	7.9	12.2
06/04/77	10:40	1.22	1419.0	13.0	23	1.4	7.8	10.4
28/04/77	12:15	0.54	171.0	11.0	50	0.9	7.7	11.7
31/05/77	13:15	0.96	750.0	6.0	31	3.0	5.8	12.8
29/06/77	15:00	1.79	3355.0	7.5	28	22.0	6.8	11.4
27/07/77	13:30	1.17	1271.0	5.0	35	9.3	6.9	11.2
25/08/77	11:30	1.15	1203.0	6.5	28	0.8	6.8	12.2
20/09/77	11:30	0.98	795.6	8.5	31	0.6	6.4	11.5
19/10/77	12:00	1.08	1025.2	10.0	19	0.6	7.3	12.8
14/11/77	11:00	0.64	267.0	15.0	29	0.8	7.4	10.5
13/12/77	13:20	0.53	151.8	24.0	27	0.5	7.3	10.7
17/01/78	13:15	0.65	243.0	23.5	35	0.5	7.4	10.7
14/02/78	13:00	0.59	175.0	21.5	40	0.3	7.7	10.6
15/03/78	12:00	0.54	101.0	24.5	184	0.9	7.5	----
08/05/78	13:45	0.90	660.0	13.0	30	0.8	7.1	----
07/06/78	13:20	1.40	1999.6	8.0	20	1.3	8.0	----
03/07/78	14:20	1.33	1704.8	6.3	22	1.4	7.1	----
01/08/78	14:30	1.42	1977.4	5.8	24	1.2	7.0	----
29/08/78	12:00	1.32	1679.6	7.0	29	0.8	6.3	13.4
26/09/78	10:40	1.46	2066.8	8.8	38	0.8	6.8	12.4
23/10/78	10:25	1.20	1259.2	14.8	41	0.9	6.9	9.9
21/11/78	14:05	1.34	1742.0	14.6	24	1.9	6.3	11.0
20/12/78	09:10	1.44	1914.0	12.0	19	1.1	6.8	11.8
17/01/79	13:00	1.07	1047.9	19.6	36	1.1	6.8	8.1
14/02/79	10:00	0.60	207.0	19.7	40	1.0	6.8	9.4
13/03/79	15:20	0.51	84.0	22.8	37	1.0	7.5	9.6
09/04/79	10:30	0.66	249.9	13.5	42	1.5	7.2	10.2
23/04/79	09:50	0.67	260.0	12.5	----	1.6	7.4	11.6
10/05/79	09:30	0.69	303.0	9.2	40	1.0	6.6	12.0
04/06/79	15:00	0.73	338.2	7.9	60	1.1	7.5	12.8
02/07/79	14:15	1.04	906.7	7.5	42	4.5	7.4	----
23/07/79	10:05	1.24	1355.0	5.7	----	3.3	----	----
31/07/79	11:10	1.23	1285.5	4.9	----	1.2	7.7	----
24/09/79	13:10	1.60	2620.	9.6	45	1.1	6.3	12.3
23/10/79	09:30	1.93	3692.0	10.6	25	2.7	6.4	----
20/11/79	10:20	1.06	1055.	14.6	27	1.6	7.0	9.5
19/12/79	12:00	.78	782.0	15.0	16	0.5	----	----
15/01/80	10:15	0.66	284.0	19.4	40	0.7	----	----
21/01/80	11:00	.70	315.0	19.0	44	0.5	8.0	9.8
12/02/80	09:50	.53	105.	21.0	49	0.5	7.4	10.2
11/03/80	12:10	0.62	152.	17.5	53	0.6	8.0	9.8
09/04/80	11:05	.60	138.	13.5	44	0.8	7.8	9.6
23/04/80	11:20	.66	271.	16.0	55	2.4	7.7	9.2
08/05/80	14:00	.59	174.	13.8	45	10.0	8.2	10.8
03/06/80	12:20	0.85	553.	7.4	33	0.9	7.7	11.5
01/07/80	12:40	1.00	839.	6.8	34	2.0	7.3	11.5
21/07/80	11:00	1.15	1139.	6.2	35	3.6	8.2	12.0
29/07/80	14:50	2.00	4112.	8.0	24	4.0	7.6	11.4
26/08/80	12:00	1.57	2447.	7.0	22	1.1	8.2	12.3
23/09/80	13:45	1.99	3691.	9.0	22	2.4	7.8	11.5
21/10/80	14:20	1.59	2568.	13.5	22	1.2	8.2	9.9
23/10/80	10:00	1.59	2396.	12.0	24	1.5	8.3	10.6
13/11/80	11:05	1.43	1884.0	14.2	24	1.6	8.0	9.7
19/01/81	11:25	0.57	202.	24.2	40	0.5	----	7.7
02/02/81	09:30	0.55	128.	22.2	41	1.2	6.7	8.5
19/02/81	14:10	0.61	205.0	23.0	42	-----	7.9	9.6
18/03/81	13:00	0.56	166.0	18.2	43	-----	8.1	9.4
14/04/81	10:30	0.62	223.0	15.1	46	-----	8.0	9.2
29/04/81	10:20	0.51	84.0	10.2	52	-----	7.6	10.4
12/05/81	10:45	0.73	362.0	10.5	34	-----	7.7	10.6
10/06/81	13:56	0.49	836.0	7.8	37	-----	7.9	11.3

‡ E.C. - Electrical conductivity

* J.T.U. - Jackson turbidity unit, similar to N.T.U., nephlometive turbidity unit.

APPENDIX V

Sediment generation model

This model determines the total amount of sediment which might be generated from a forest harvesting area during and following operations in that area. Using the predictions from the model, the total impact on catchment values of the proposed operations can then be estimated.

Several assumptions are made in the model:

- Logging and roading operations are implemented concurrently in the area (not necessarily for the same coupes).
- The rate of sediment reduction follows a half-life decay function. In reality, climatic factors would cause variation in the rate of vegetation regrowth and sediment reduction.
- For the U2 area the total area to be logged will be about 400 ha over a period of eight years. That is, 50 ha y^{-1}.
- 1.0m^3 of silt weighs approximately 0.350 t (Langford and O'Shaughnessy, 1980; M. Papworth, Pers. Comm.; C. Leitch, Pers. Comm.).
- A base sediment production rate of 0.175 t ha^{-1} y^{-1} (C. Leitch, Pers. Comm.) excluding most bedload.
- Sediment yield is increased between two and four times during logging (Langford and O'Shaughnessy, 1980; Rice et al.,1979; Fredericksen, 1970).
- Sediment is generated only from the area downstream of Rocky Valley and Pretty Valley reservoirs. 3700 ha).
- Sediment delivery ratio (SDR) equal to one.

The model does not take account of:

- Soil loss from landslips which may have been initiated by interference with sensitive hydrogeological features;
- extreme climatic events;
- Effect of increased and decreased water yield and subsequent sediment production from logged subcatchments.

The. graph (Figure V-1), developed from Table V-I, relates to the amount of sediment generated over a fifteen year period for a 400 ha area logged over eight years. The rising part of the annual sediment production curve (equation 1) refers to the active logging and forest regeneration part of the cycle, while the. falling part (equation 2) describes for any one year the marginal amount of sediment generated following logging of the last area.

$S_i = A\{MB[1-\exp(-0.693\{t_i\})]\}$……………………………………(1)

$S_p = S_n \exp(-0.693[t_i - t_n])$ ………………………………………..(2)

Where:

S_i	Marginal sediment produced in i^{th} year of logging,
S_p	Marginal sediment produced in i^{th} year of post logging phase,
S	Marginal sediment produced in final year of logging ($S_n = S_i$),
B	Base rate of sediment production (kg),
M	Multiplier of base rate sediment production,
A	Area logged per year (ha),
t_n	Year in which logging ceases,
t_i	Year within study period.

Curve A	Single Year logging, effect on sediment production.
Curve B	Sequential years logging, effect on sediment production.
Curve C	Base rate of sediment production.

***Figure V-I	Trends following a doubling of sediment production during and after logging of eight - 50 ha areas at a rate of 50 ha per year.***

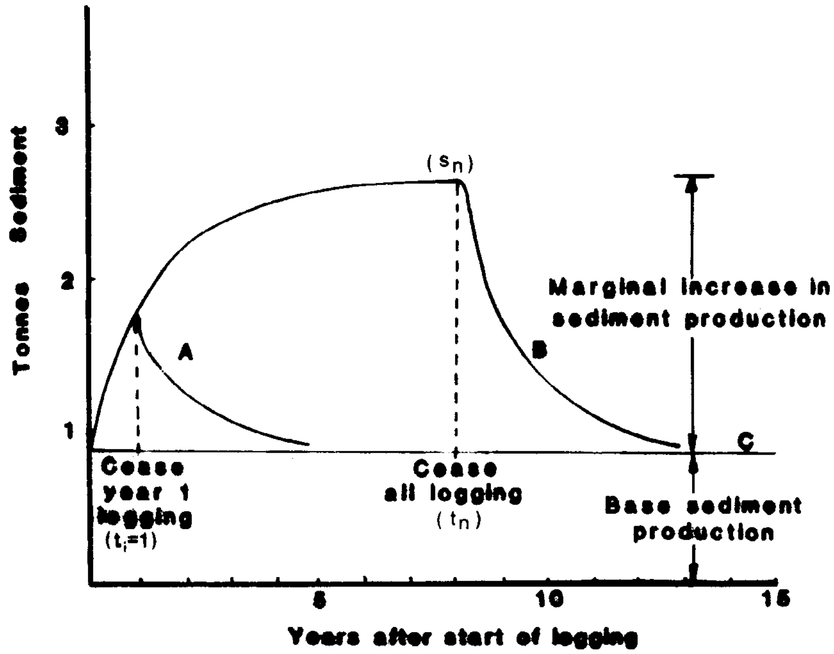


Table V-I - Increased sediment production for one hectare in different areas over 15 years
Base sediment rate (BR) = 175 kg ha^{-1}
Low sediment rate (LR = BR x 2) = 350 kg ha^{-1}
High sediment rate (HR = BR x 4) = 700 kg ha^{-1}

Area Number	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	H R (kg)	263	131	65.6	33	16.4	8.2	4.1	2.0	1.0						
	L R (kg)	87.5	44	22	11	5.5	2.8	1.4	0.7	0.4	0.2					
2	H R (kg)		525	263	131	65.5	33	16.4	8.2	4.1	2.0	1.0				
	L R (kg)		175	87.5	44	22	11	5.5	2.8	1.4	0.7	0.4	0.2			
3	H R (kg)			525	263	131	65.5	33	16.4	8.2	4.1	2.0	1.0			
	L R (kg)			175	87.5	44	22	11	5.5	2.8	1.4	0.7	0.4	0.2		
4	H R (kg)				525	263	131	65.5	33	16.4	8.2	4.1	2.0	1.0		
	L R (kg)				175	87.5	44	22	11	5.5	2.8	1.4	0.7	0.4	0.2	
5	H R (kg)					525	263	131	65.5	33	16.4	8.2	4.1	2.0	1.0	
	L R (kg)					175	87.5	44	22	11	5.5	2.8	1.4	0.7	0.4	0.2
6	H R (kg)						525	263	131	65.5	33	16.4	8.2	4.1	2.0	1.0
	L R (kg)						175	87.5	44	22	11	5.5	2.8	1.4	0.7	0.4
7	H R (kg)							525	263	131	65.5	33	16.4	8.2	4.1	2.0
	L R (kg)							175	87.5	44	22	11	5.5	2.8	1.4	0.7
8	H R (kg)								525	263	131	65.5	33	16.4	8.2	4.1
	L R (kg)								175	87.5	44	22	11	5.5	2.8	1.4
Yearly Total	H R (kg)	525	788	919	985	1018	1034	1042	1046	523	262	131	65	33	16	8
	L R (kg)	175	263	307	329	340	345	348	349	175	87	44	22	11	5.5	2.7
Accum-ulated total	H R (kg)	525	1313	2232	3217	4235	5269	6311	7357	7880	8142	8273	8338	8371	8387	8395
	L R (kg)	175	438	745	1074	1414	1759	2170	2456	2631	2718	2762	2784	2195	2801	2803

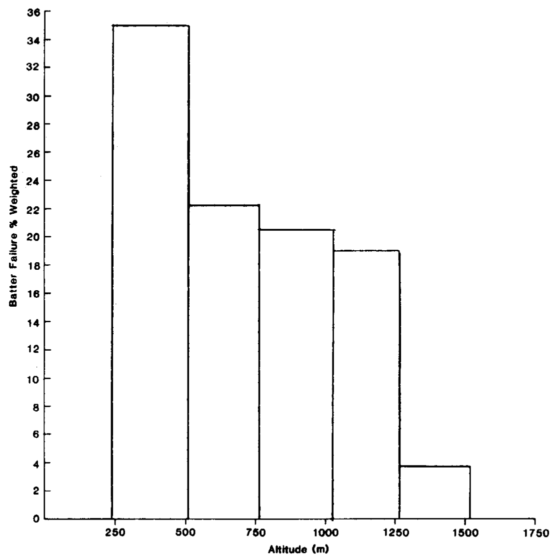
APPENDIX VI

SUMMARY OF FACTORS CONTRIBUTING TO BATTER FAILURE IN THE KIEWA AREA (Beavis 1968)

The report by Beavis (1968) indicated that slopes below 30º (57%) and above 40º (84%) were least prone to failure. (On existing roads within the U2 area the slope angle above which batter failure occurs appears to be 30º - 35º. Aspect may have some bearing on this apparent difference in critical slope angle.) Slope failure was more likely to occur near spurs (54%) than in gullies, (46%).

Batter failure tended to decrease with increase in altitude, this relationship is illustrated in Figure VII-I. Slope failure occurred most commonly on south-east and north-west aspects, largely because north-west slopes receive the heaviest precipitation while south-east slopes are slow drying. Approximately 5% of total road batter length was found to slump or slip.

Figure VI-I - Relationship between better failure and altitude



It is also reported that 85% to 90% of batter failure occurs in the first year following road construction. Batter height and slope do not appear be important factors influencing failure, slip circle failure accounted fol 63% of all failures recorded.

Below is a table relating rock type to the total percentage and weighted percentage of total failures on each rock type.

Table 1 - Percentage weighted batter failure in differing rock types (Beavis, 1968).

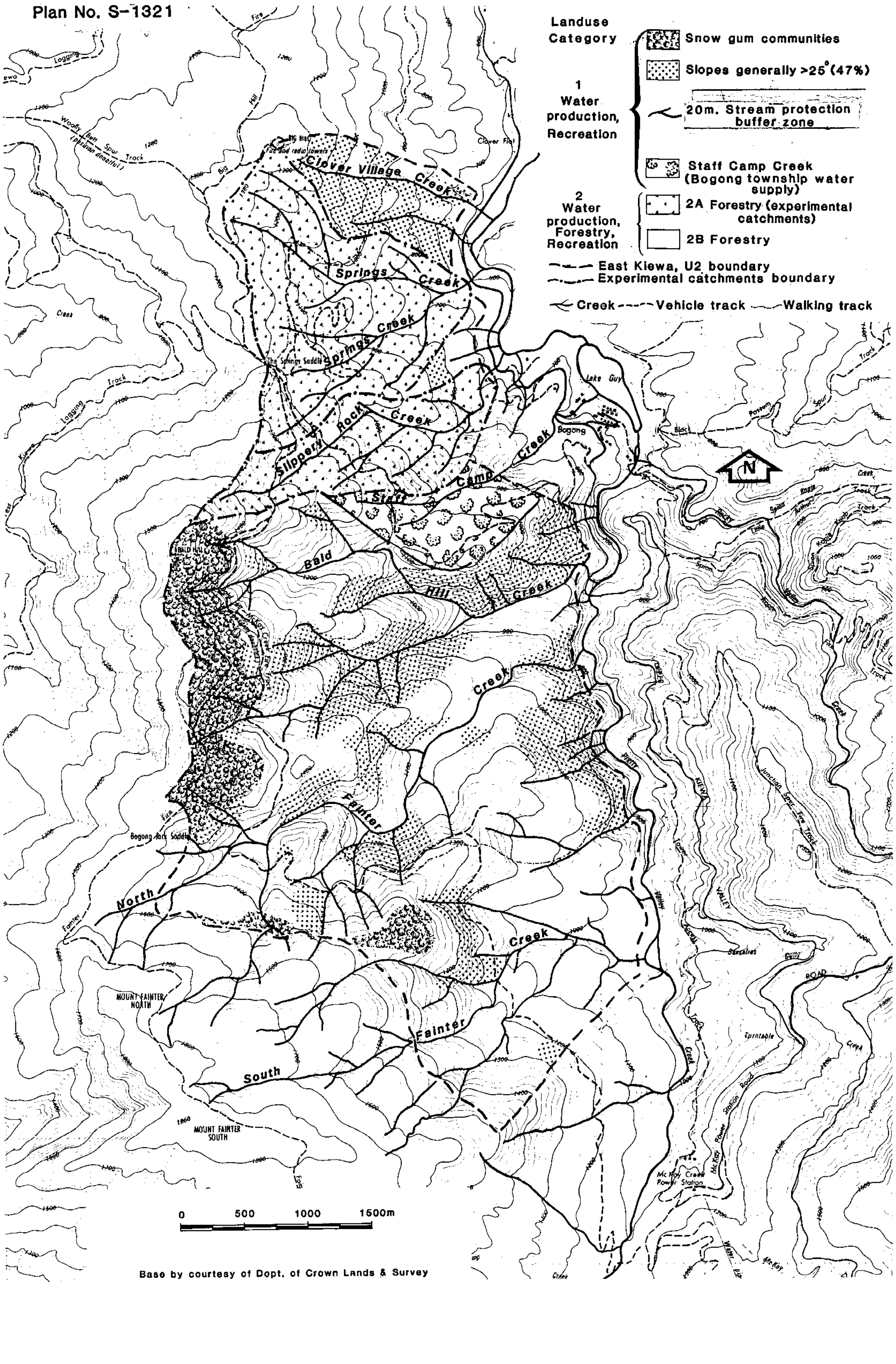
Rock Type	% Total Failures	% weighted Failure
Alluvium	2.1	30.0
Hillwash	10.2	16.1
Slip Debris	5.1	25.2
Gneiss	28.5	10.6
Granodiorite	54.1	18.1

Batter failure was also found to be more prevalent in slightly decomposed, rock than in sound or completely decomposed rock. Frost action was responsible for the displacement of impervious surface layers, large masses of earth and the margins of slips.

APPENDIX VII

LAND USE DETERMINATION PLAN

ENLARGEMENT



Plan No. S-1321
Landuse Category
1 Water production, Recreation
Snow gum communities
Slopes generally >25°(47%)
20m. Stream protection buffer zone
Staff Camp Creek (Bogong township water supply)
2 Water production, Forestry, Recreation
2A Forestry (experimental catchments)
2B Forestry
East Kiewa, U2 boundary
Experimental catchments boundary
Creek
Vehicle track
Walking track
N
Clover Village Creek
Springs Creek
Springs Creek
Slippery Rock Creek
Staff Camp Creek
Bald Hill Creek
Creek
Fainter
North
Creek
Fainter
South
Lake Guy
Bogong
MOUNT FAINTER NORTH
MOUNT FAINTER SOUTH
0 500 1000 1500m
Base by courtesy of Dept. of Crown Lands & Survey