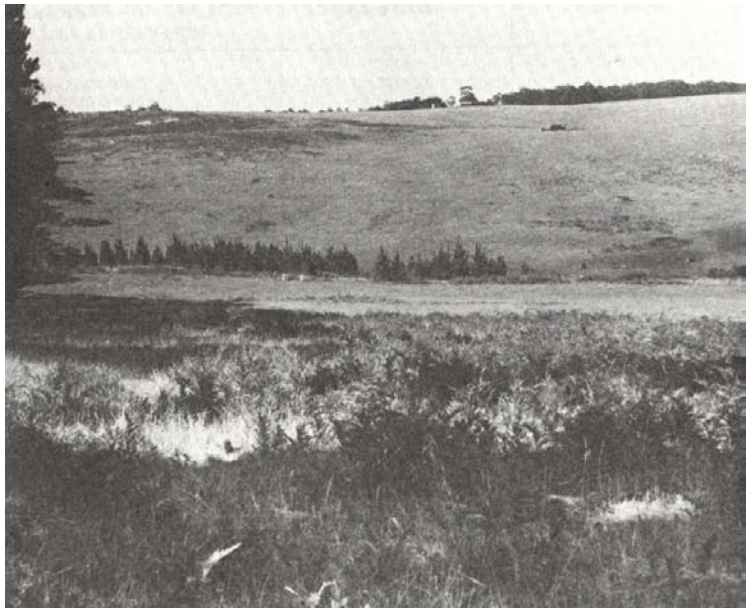
7.43 Yeodene Land System

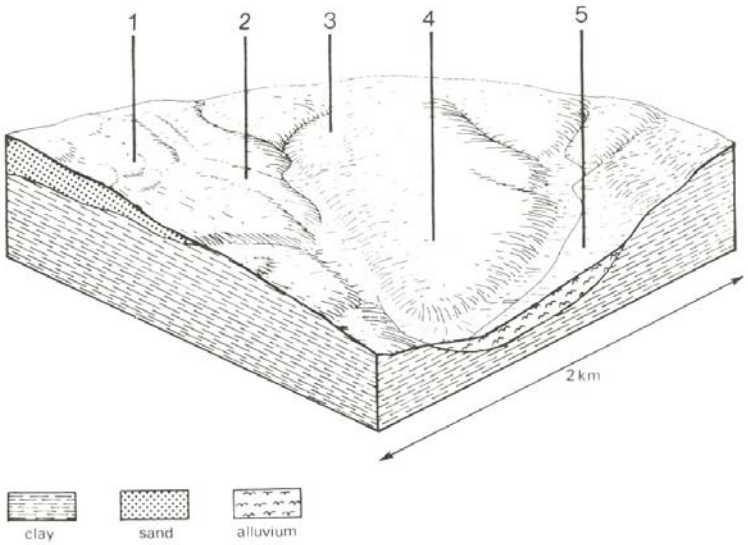
West of Yeodene, a rolling and irregular landscape forms part of a broad ridge extending from the foothills of the Ranges towards Colac. Tertiary sand outcrops on most parts of the landscape, often forming a veneer over exposures of Tertiary silt and clay.

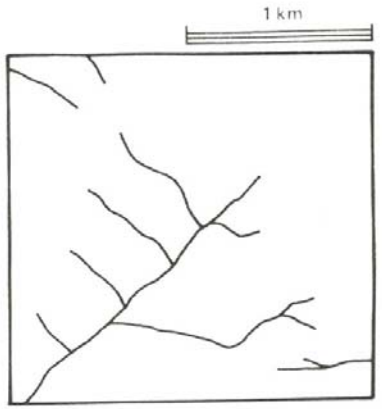
The soils have loamy sand or sandy loam surface textures and are prone to nutrient and moisture deficiencies. Hardpans between the sand veneers and clay horizons may result in perched water tables, although only small areas have such poor site drainage that frequent waterlogging occurs.

Sand and gravel have been extensively mined in some areas, and pine plantations have been established near Yeodene. However, most of the area remains in a fairly natural state and constitutes a significant area of natural vegetation close to Colac. Its potential for recreation is at present not fully utilized. Only minor areas have been cleared for agriculture, but the establishment of improved pastures is difficult.



Acid sands in this comparatively dry area will not support vigorous pastures and the control of weeds such as* Pteridium esculentum *and* Rubus *spp. is difficult.





YEODENE Area: 58 km^2	Component and its proportion of land system				
	1 35%	2 25%	3 5%	4 30%	5 5%
CLIMATE Rainfall, mm Temperature, 0^{o}C Seasonal growth limitations	**Annual**: 750 – 850, lowest January (40), highest August (100) **Annual**: 13, lowest July (8), highest February (9) **Temperature**: less than 10^{o}C (av.) June – August **Precipitation**: less than potential evapotranspiration late October – early April				
GEOLOGY Age, lithology		Paleocene unconsolidated sand, silt and clay Recent sand veneer			
TOPOGRAPHY Landscape Elevation, m Local relief, m Drainage pattern Drainage density, km/km^2 Land form Land form element Slope (and range), % Slope shape	Rolling plain in the western parts of the Barwon catchment and northern parts of the Gellibrand catchment 120 – 260 40 Dendritic 1.5 Plain Crest, slope 9 (1-15) Convex	Slope 15 (5-20) Irregular	Broad slightly depressed area 2 (0-5_ Concave	Crest, slope 8 (1-15) Linear	Drainage line 3 (1-5) Concave
NATIVE VEGETATION Structure Dominant species	Woodland *E. viminalis, E. obliqua, E. radiata*	Woodland *E. radiata, E. ovata, E. viminalis*, occasionally *E. obliqua*	Low woodland *E. nitida, E. radiata*, occasionally *E. viminalis*	Open forest *E. obliqua, E. radiata*	Low woodland *E. ovata, Acacia melanoxylon, Leptospermum juniperinum, Melaleuca squarrosa*
SOIL Parent material Description Surface texture Permeability Depth, m	Quartz sand Grey sand soils, uniform texture Loamy sand Very high >2	Silt and clay with sand veneer Grey sand soils, weakly structured clay underlay Loamy sand Low >2	Silt and clay with sand veneer Grey sand soils, weakly structured clay underlay Loamy sand Low 0.6	Clay, silt and sand Yellow gradational soils, weak structure Sandy loam High >2	Colluvial and alluvial sand, silt and clay, plant remains Black sand soils, uniform texture Silty loam Moderate >2
LAND USE	**Uncleared areas:** Hardwood forestry for posts, poles and fuel; sand and gravel extraction; forest grazing; water supply; passive and active recreation; softwood forestry. **Minor cleared areas:** Sheep and beef cattle grazing; dairy farming				
SOIL DETERIORATION HAZARD Critical land features, processes, forms	Very low inherent fertility and high permeability lead to nutrient decline.	Low inherent fertility and leaching of permeable surfaces lead to nutrient decline. Weakly structured surfaces and low permeabilities lead to sheet erosion on steeper slopes.	Low permeability and poor site drainage lead to seasonal waterlogging and soil compaction.	Weakly structured surfaces on steeper slopes are prone to sheet erosion.	High water tables lead to waterlogging and soil compaction. Run-off from adjacent hills leads to siltation and flooding.

8. SOIL CONSERVATION

In their natural condition, soil and vegetation are stable except on some exposed coastal situations. Upon disturbance, however, a major change in one causes changes in the others. If the vegetation is damaged, the soil erodes. If the soil deteriorates, then the vegetation degenerates. In both cases the quality and regulation of the waters will decline. The sensitivity of the land varies between land systems.

Soils deterioration occurs in various forms. Sheet, rill, gully and wind erosion result in the loss of soil material, as does mass movement, although to a more limited extent. Soil salting, loss of nutrients and decline in structure result in lower plant growth and water usage. Deterioration of streams frequently results, and accelerated stream flow may lead to flooding, streambank erosion and excessive sedimentation of land and utilities. Access and trafficability become more difficult and aesthetic appeal is lost.

Exposure of tree roots and elevation of grass tussocks on small pedestals indicates that sheet erosion losses have been quite extensive on these steep northerly facing slopes abutting Moggs Creek.

All forms of deterioration involve the community in losses, either directly or indirectly, and these losses are part of the less obvious costs associated with a particular activity or form of production.

Types of Deterioration

Sheet erosion

Sheet erosion is the removal of surface layers of soil by water. The impact of raindrops disturbs soil particles, which may then be suspended in turbulent surface run-off water and carried downslope. The susceptibility depends on the structure, permeability and dispersibility of the soil, the length and gradient of the slope, the intensity of the rain-storm and the degree of protection that the soil receives from the cover of vegetation and litter. Often only small amounts of material are removed at any one time. The exposure of tree roots, elevation of grass tussocks on small pedestals of topsoil and accumulation of soil material on the uphill side of fences and other obstructions often provide evidence of sheet erosion.

The most sensitive areas are found on the drier slopes of the Otway Range in the Lorne, Forrest, Moggs Creek and Yahoo Creek land systems. Long steep slopes, weakly structured and often dispersible topsoils and low infiltration rates are critical factors. The steep hills of the Mount Mackenzie and Bunker Hill land systems are less susceptible, as infiltration rates are high. Other sensitive areas occur in most land systems, except for the lateritic plateaux, basalt plains and alluvial deposits.

Gully erosion

When water is concentrated into small rivulets or drainage lines, its eroding action can result in the development of shallow channels, known as rills, or deep and extensive gullies. In the most severe cases, gullies can undermine bridges and roads as well as create problems of access and management.

Wormbete Creek, a tributary of the Barwon River, causes particular problems through actively eroding gullies. Headward extension of this gully has caused loss of productive land, damaged fences, decreased trafficability and access and reduced aesthetic appeal.

The mechanisms by which gullies have been initiated and continue to extend both laterally and headward take many different forms. All forms stem from an imbalance in the hydrological regime, usually brought about by the replacement of the native vegetation with pasture species or crops.

The coarsely structured, dispersible soils of the Deepdene land system and the Heytesbury settlement area are prone to sapping, leading to extensive gully and tunnel erosion. Many of the drainage lines in the Paraparap and Anglesea land systems are also susceptible. In the higher-rainfall areas, scouring is a more important mechanism than sapping and this is responsible for much of the damage in the Pennyroyal and Barwon River land systems.

Mass movement

The migration of material downslope under the action of gravity can range from rockslides and avalanches through to earth glows and soil creep. The gradient of the natural or artificial slope is the critical factor in determining the susceptibility to mass movement. When saturated with water, the soil loses much of its cohesive strength and, combined with the added weight of soil water, the force of gravity may take the soil beyond the threshold of stability. Under natural conditions the binding effect of tree roots increases this threshold value. Vibrations such as earthquakes or even the passing of traffic aggravate the instability by bringing about slight compaction of the solids. This forces out pore water, which cannot escape and so acts as a lubricant to the soil mass.

In the Lorne and Aire land systems, the soil material liberated may slide down the hillside, particularly if bedding or joint plains are parallel to the slope of the land (Joyce and Evans 1976). More commonly, however, slumps (as distinct from landslides) occur. The shearing plane takes a curved form, with the soil moving vertically downwards at the toe. The soils on slopes close to the coast are highly dispersible and are very prone to both landslides and landslips.

Apart from the Otway Range, the Heytesbury settlement area contains highly susceptible areas. Springs emerging from below the base of the lateritic capping in the Tomahawk Creek land system have probably increased in incidence and total flow since clearing. Prolonged saturation often results in slumps at these points in the landscape.

The Deepdene, Pennyroyal and Anglesea land systems also possess sensitive areas. In weakly structured dispersible soils, these slumps may trigger off earth flows, where the original slumped mass moves downhill each successive season, pushing more soil in front of it in a slow turbulent flow. Notable earth flows are found in the Lorne and Anglesea land systems.

Earth flows are a common feature of the steep hills: This one near Upper Gellibrand threatens the road that crosses it.

Salting

Wherever landscapes contain significant levels of soluble salts, these salts tend to accumulate in groundwater and run-off. Land use changes involving replacement of the native vegetation often lead to a rise in the regional water tables, upsetting the natural hydrological regime. The soluble salts in the groundwater are concentrated near the surface as the water evaporates. Salts frequently reach toxic levels, restricting plant growth.

In Victoria this process tends to be most marked in areas with rainfalls between 600 and 700 mm (Gibbons 1971). The Paraparap, Deepdene, Birregurra, Winchelsea and Anglesea land systems are among the most susceptible.

Rising salt concentrations in the topsoil both stunt and kills the pasture in lower parts of the landscape. Stock often camp on these areas, trampling the vegetation, and this may lead to sheet and gully erosion.

Lateritic landscapes have been associated with high salt content of associated soils and groundwaters (Dimmock *et al*. 1974). Although no soil salting has been observed in the wetter climates of the Heytesbury settlement area, rises in the salinity of streams have been recorded since the widespread clearing of the dissected lateritic plateaux.

Soil nutrient decline

The cycle of soil nutrients from root absorption through biomass, litter fall, leaching and root absorption again is sensitive to change. Removal or replacement of deep-rooted native vegetation may result in marked increases in run-off (Blake 1975) and a lower ability of the shallow-rooted introduced species to intercept nutrients being leached downwards. Litter fall may be reduced, leading to fewer organic colloids and adsorbed plant nutrients in the surface soil. Soil temperatures may rise, leading to more rapid oxidation of the existing organic matter.

Highly permeable soils of low initial fertility are the most susceptible. These include the sands of the Bald Hills, Chapple Vale, Redwater Creek, Bunker Hill, Yeodene and Porcupine Creek land systems. To a lesser extent, the Beech Forest, Mount Sabine, Mount Mackenzie and Hordern Vale land systems are also susceptible.

Phosphorus fixation is another hazard relating to soil fertility. Although not directly a deterioration of the land in itself, it can severely limit the growth of introduced crops and pastures, thus aggravating leaching of nutrients. Susceptible areas are the lateritic landscapes of the Simpson, Gherang Gherang and Wonga land systems, and to a lesser extent the Deepdene, Paraparap, Barongarook and Anglesea land systems.

Land use in the upper parts of the Barwon River catchment effects land downstream. Unwise use can result in increased flooding, sedimentation and prolonged waterlogging.

Soil structure decline

Soil structure may deteriorate due to loss of organic matter or disturbance. Organic colloids are the main binding force of the structural units of the surface soil. Removal or humification without replacement results in loss of surface structure. Disturbance, particularly when the soil is wet and cohesive forces are low, may mechanically shatter the structural units. Soils with initially weak surface structure are the most susceptible. Such soils tend to have a low infiltration capacity, low available water capacity, dispersion problems and a tendency to set hard in summer.

The majority of soils in the study area are susceptible to structure decline. Particularly susceptible areas are found in the poorly drained parts of the Tomahawk Creek, Kennedys Creek and Waarre land systems.

Wind erosion

Sandy soils are poorly structured and have a low water-holding capacity. In the Cape Otway and Point Roadknight land systems, strong onshore winds and poor protection from the indigenous vegetation, especially when trampled by frequent pedestrian traffic or cattle, result in the dunes becoming unstable. Roads and utilities are affected by shifting dunes in these areas.

Deterioration of streams

The above forms of deterioration are essentially on-site effects. However, they also result in off-site effects, the most important of which is the deterioration of streams.

The loss of soil material, soil structure, soil fertility and associated plant vigour leads to increased surface run-off, with less water percolating through the soil. The height and incidence of flooding increase, and the perennial nature of streams diminishes. Turbidity rises while erosion is taking place. Increased salinity of streams from cleared catchments containing significant quantities of soluble salts limits their use for domestic and irrigation purposes.

Soil Conservation and Land Use

Grazing

The management of land for grazing usually involves replacement of the native trees and shrubs with shallow-rooted grasses and forbs. The accompanying change to the natural hydrological regime leads to the previously mentioned forms of deterioration.

Gully erosion has occurred in many areas and has been particularly prevalent in the steep drainage lines of the Deepdene land system to the west of the Barwon River. Headward eroding gullies are also common in some of the eastern tributaries of the Barwon River, such as Wormbete Creek.

Soil salting has occurred in many of the drainage lines of the plains to the north and east of the Otway Range. Pastures on saline areas become yellow, and less vigorous. Stock accumulate on these areas and trample the vegetation, which may lead to other forms of deterioration such as gully erosion.

Overgrazing of sloping land and trampling of the vegetation and soil have led to sheet erosion in many places, particularly the foothills of the Range and parts of the Heytesbury settlement area. Much of the damage occurs during the summer months, when the highest-intensity rainstorms coincide with a period of low growth potential, as shown in Figure 5. If grazing has been heavy, the soil has little or no protective vegetative cover when these summer thunderstorms occur, and losses can be severe.

Landslips are common the steep slopes of the Otway Range and are increasing in occurrence following clearing in the Heytesbury settlement area. Cleared hillsides of the Lorne, Forrest, Yahoo Creek, Pennyroyal and Aire land systems are covered by terracettes, often referred to as ‘sheep tracks’. They are in fact the surface expression of numerous small slumps and are usually found where unweathered rock is close to the surface. Where they adjoin previous slipped areas, they have a stabilizing influence, preventing larger rotational slumps from occurring (Joyce and Evans 1976).

Soil nutrient losses are prevalent on the freely drained soils of the high-rainfall areas, but regular topdressing has often maintained or increased soil fertility of the more productive land. Topdressing is not economic on many of the sand and phosphate-fixing soils, and the low levels of nutrients initially present tend to be lost under grazing.

Deterioration of soil structure in the Beech Forest and Mount Sabine land systems after prolonged periods of pasture growth is presumably associated with lower levels of organic matter. Loss of surface structure by pugging is a problem in most wet areas, particularly where cattle are grazed during winter.

Overgrazing and trampling by cattle have led to wind erosion of sand dunes near the mouth of the Aire River. The native grasses are susceptible to trampling and establishing of improved pastures is difficult. The dunes east of Torquay also show evidence of past grazing damage.

With the exception of wind erosion, prevention of these forms of deterioration primarily rests with maintaining a hydrological balance similar to that of the original system under native vegetation. Deep-rooted perennial pasture species, such as *Phalaris tuberosa*, and trees can tap moisture and nutrients from well below the soil surface, thus reducing total run-off and recycling nutrients. Continues use of fertilizers is necessary to maintain vigorous plant growth and actively using soil water. Dense root and shoot growth also lend physical stability to the soil, limiting mass movement, sheet and gully erosion.

Treatment of existing problems may be expensive. Actively eroding gullies can be stabilized by diverting run-off or replacing the head of the gully with a concrete structure or a grassed chute. The appropriate method depends on the mechanisms involved.

Salt-affected areas can be revegetated by sowing salt-tolerant grasses such as *Agropyron* spp. and *Puccinella* spp. Soil amelioration with gypsum is often used to improve drainage.

Overgrazing should be avoided on areas prone to sheet erosion. Where slopes are too steep for drilling of seed and fertilizer, aerial seeding of improved pasture species may be practicable.

Landslips can sometimes be halted by fencing out the slumped area and planting trees. Run-off water from roads, dairies and buildings should not be discharged onto susceptible slopes, particularly in the Heytesbury settlement area. In the Waarre land system, slopes of more than about 18% are susceptible, while the Tomahawk Creek and Kennedys Creek land systems have a steeper critical angle.

Under grazing it is particularly difficult to control wind erosion on the coastal dunes. Although some light grazing can be supported, overgrazing damages the vegetation and the shifting dunes will not usually revegetate naturally. Expensive reclamation work, such as hand-planting *Ammophila arenaria*, will be required.

Cropping

Sheet erosion has occurred on much of the sloping land used for cropping in the Beech Forest, Hordern Vale and Bellbrae land systems. Intense spring and summer rains often occur after ploughing or sowing, and the surface run-off remove the more fertile topsoil.

Contour cultivation, retention of trash and strip cropping can reduce these losses. Problems are encountered, however, in handling machinery along the contour on sloping land.

Overcropping causes serious damage to soil structure. Mechanical disturbance shatters the structural units, often weakened from depletion of organic matter. Fields that have been cropped for several generations in the Beech Forest land system show marked decline in surface soil structure.

Rotations incorporating those with nitrogen-fixing legumes, will increase organic matter. Continued use of fertilizers is necessary to maintain vigorous growth and to return organic matter to the soil.

Forestry

Both establishment and harvesting of hardwood and softwood forests cause serious changes to the natural hydrological balance. Pine establishment on disused agricultural land and previously forested land has led to widespread deterioration. The steep north- and west-facing slopes of the Lorne, Forrest, Moggs Creek, Aire, Mount Mackenzie, Bunker Hill and Yahoo Creek land systems are the most severely affected.

Steep slopes in and around drainage lines are more stable under hardwood than softwood forestry, because of longer growth period and more selective logging practices.

Sheet erosion losses can be minimised by working in coupes along the contour, and by maintaining an adequate vegetative cover with litter layers over the soil surface.

The incidence of landslips increases following harvesting, when the binding effect of tree roots is removed and the soil is subject to saturation for longer periods. The study area share the current trend to reduce the total area of productive forest land and manage this smaller area for higher yields. As with agriculture, nutrients removed in forest produce need to be replaced through the use of fertilizers. The fertilizer requirements of soils designated for long-term hardwood and softwood production require investigation.

Fuel-reduction burns are an established part of forestry practice and most of the native hardwood stands are burnt every few years by low-intensity fire, mainly in spring or autumn. When the litter and humus are burnt, the nutrients in the ash become more soluble. Although this increases the rate of removal by leaching. The long-term effect that fuel-reduction burning may have on soil fertility requires further investigation.

Residential use

One of the results of residential development is an increase in the area of surfaces, such as roads, paths and roofs, impermeable to rainfall. Diversion of this water into drainage lines has increased the incidence of landslips, gully erosion and siltation.

Development of the coastal belt from Torquay to Apollo Bay has resulted in many problems. Careful planning is needed to confine development to gentler areas and dispose of run-off water in properly constructed drains.

Recreation

The sand dunes at Cape Otway, Point Impossible, Point Roadknight, Anglesea, Apollo Bay and other localities along the coast have been trampled by pedestrian traffic. Drifting sand has encroached onto roads, building and other services.

Sand dunes afford inland areas the best protection from the erosive power of the sea. The native species that colonize these dunes are very susceptible to trampling pressure and the introduced grass *Ammophila arenaria* is widely used to restabilize drifting dunes. Fending the dunes off from pedestrian access and siting of access tracks away from wind hollow have also been found necessary to ensure successful rehabilitation.

Coastal dunes are in a constant state of seasonal flux. This photo was taken in early spring, after heavy winter seas had removed much of the sand from the beach and formed a small cliff.

Over-use of pedestrian access tracks in the Anglesea and Rivernook land systems, where the soils are highly dispersible, has lead to deep rilling and gullying along coastal cliffs. These tracks need to be sited along gentle slopes without long straight steep sections and with adequate provision for the disposal of surface run-off.

Off-road vehicle activity causes sheet and rill erosion on steep sloping land close to tourist centres along the coast. The passage of trail bikes, dune buggies and four-wheel-drive vehicles destroys the vegetative cover and disturbs the soil surface. Areas need to be provided and managed for these activities on less sensitive sites, such as disused sand and gravel extraction pits.

Trail bikes can cause major problems in sensitive areas. Here, vegetation has been destroyed and rapid surface run-off has removed topsoil and cut rills into the subsoil.

Roads and tracks

Scouring of forest roads and tracks is particularly severe in the high-rainfall areas. Where drainage is inadequate, water becomes concentrated in wheel ruts. Care is needed in road design, with domes surfaces and adequate table drains and culverts to dispose of water on safe vegetated areas. Long straight steep sections are to be avoided, but cross ripping gives long slopes some protection from scouring. Closure of some forest roads in winter will limit the creation of deep wheel ruts.

The diversion of run-off water from roads and tracks may lead to landslips. Fill batters on mountain roads are particularly susceptible. As far as possible, water in table drains should be diverted onto gentle slopes.

Rilling and slumping are problems on the over-steep slopes of road batters. Some of the larger road batters in the Mount Mackenzie land system are particularly susceptible to rilling. Rockslides and slumps along the Great Ocean Road are a hazard to motorists, and expensive clean-up operations are undertaken each wet period. Many of the road batters in the Heytesbury settlement area exhibit severe slumping.

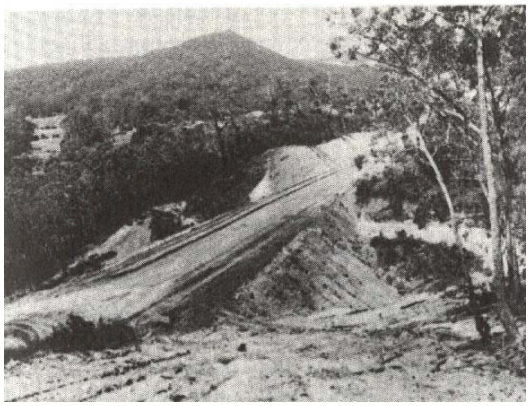
Correct design of road batters minimizes these problems. In exposed rock or other compacted material, near-vertical-cut batters can be successfully made, but generally a slop of 200% is recommended for stable soils while some soils will still be a source of sediment at slopes less than 50%. A catch drain constructed near the top of the batter will divert water. In large batters, further catch drains should be installed at intervals down the slope. Subsoil drainage may need to be provided

in areas prone to slumping. Protection of the soil can be achieved by spraying with bitumen mulch or chemical stabilizers. Plant cover is established by 'keying in' topsoil and applying seed and fertilizer mixtures (Gavin, Knight and Richmond 1979).

Extractive industries

Disused sand and gravel extraction pits provide a poor medium for plant germination. Compacted sand on sloping pits are prone to sheet and rill erosion, and abandoned sites in Chapple Vale, Bald Hills, Gherang Gherang, Porcupine Creek and Ferguson Hill land systems remain as scars on the landscape. The impermeable silicified hardpans in the Rivernook land system have led to extensive deep rilling. Similar damage has occurred on silicified hardpans in the Junction Track land system.

Reclamation procedures for these extraction sites involve the initial retention of the topsoil overburden and its subsequent redistribution over the surface to a depth of at least 20 cm. Regeneration of native species can be encouraged by hand planting or spreading seed, but usually the topsoil contains sufficient seed. Steeply sloping land is not suitable for extraction pits, and surface run-off water needs to be diverted onto gentle spurs.



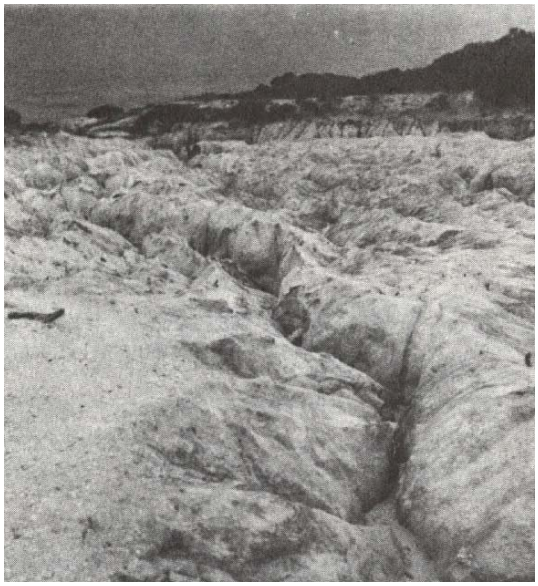
Large road batters and other bare surfaces can deteriorate rapidly. This road re-alignment near Mount Mackenzie is a source of copious sediment in the Gellibrand water supply catchment.

Water supply protection

All domestic water supply catchment within the study area are used for other purposes as well as the supply of water. The maintenance of water quality mainly depends on successful soil conservation practices in these other land uses.

Poorly sited and maintained roads and tracks, streambank and gully erosion and poorly managed forestry operations appear to be the main sources of sediment in streams. High colour can also result from excessive forest trash in drainage lines, from diversion of dairy effluent into water-courses and from stock gaining free access to streams.

Land use also influences water quantity. Higher yields of water are obtained from agricultural land, but compaction of the soil surface and reduced interception storage result in increased surface runoff. Larger flows thus occur during and immediately after storms, with less water being stored for slow release to streams. The perennial nature of streams declines. Water supply systems without large storage dams are the most affected, as the lowest summer flow limits the total supply potential. Storage dams also allow some of the coarser sediment time to settle before reticulation to residential centres, and this results in a less sensitive system than river offtakes provide.



Silicified hardpans near Rotter Point are prone to deep and extensive rilling in old unreclaimed extraction pits.