



10. Summary and conclusions

The gullies in the upper Hopkins River catchment area are established on soil types that are inherently sensitive to erosion. Clearing, mining and agriculture in the three areas led to increased rates of runoff, accelerated erosion and gullying. The gully network developed rapidly in the first few decades following clearing.

Gullies proceed through an identified cycle of development that commences with initial incision of the valley. Gullies will continue to erode upslope until they approach some point where the area contributing runoff to the gully head does not produce flows that will continue to incise the floor of the gully. The transformation from vertical to inclined gully sidewalls represents a later stage of adjustment and indicates that the gully has approached a stable state. Rehabilitation of gullied areas is most successful when gullies have reached their maximum headward extent and are no longer incising their bed.

Our field investigations show that some gullies are still active in each of the studied physiographic units. The presence of sharp edges to the gully heads, recent undercutting and slumping of gully sidewalls, erosional pipes and nickpoints along the gully network confirm the comments made by landholders that the gullies are still active. Sediment storage in floodouts and in-channel storages was also documented in each of the three areas. However, the proportion of sediments stored along the gully network versus the proportion exported to the Hopkins River varies significantly between the three units. While gullying may still be active, further investigation has shown the sediments eroded from the gully network may not be transported through to the Hopkins River.

Only a small proportion of the sediments eroded from the gully networks in the Ararat Hills unit is stored within the gullies themselves (13%). Similarly, a comparatively small proportion of sediments eroded from the Ararat Hills unit is stored on the floodplain of the Hopkins River (16%). Hence, some 71% of sediment eroded from the Ararat Hills gully network is exported, via the river, from the upper Hopkins River catchment study area.

A number of nickpoints were documented along the Ararat Hills gullies. As these nickpoints continue to migrate up the drainage network, further incision and widening of the gully sidewalls can be expected to occur, releasing more sediment. Grade-control structures present where the road crosses a gully tend to limit the migration of these nickpoints throughout the drainage network. The establishment of Spiny Rush on the gully bed in the lower parts of the network is likely to form an erosion buffer that prevents further incision and widening. These vegetation beds are also important in trapping sediments sourced from eroded areas further up the gully network. The current stability of the lower gully network results in sediments being stored within the gullies, rather than being transported to the Hopkins River. Further investigation of the lower network of Denicull Creek would be required to identify whether there are linkages between sediments eroded along the lower creek and the Hopkins River.

While gullying on the steep slopes of Chalicum Hills has been intense, sediments eroded from these gullies have been stored in large floodouts, and there is no connection with the higher order



streams that connect to the Hopkins River. However, incision and widening along Captains Creek and Jacksons Creek has been an important source of increased sediment supply to the Hopkins River. A proportion of these eroded sediments has been stored along the creek as overbank deposits (15%) and a tributary junction plug/floodout which has formed at the junction of Jacksons Creek with the Hopkins River (11%). Seventy four percent of sediments eroded from Captains and Jacksons Creek have been input into the Hopkins River. The high sediment transport capacity of the Hopkins River downstream of Jacksons Creek has resulted in the export of these sediments from the upper Hopkins Catchment study area. A similar patterning of storage in floodouts, erosion and widening along the higher order stream network is believed to have occurred for Gorrin Creek. However, further investigation of the Hopkins River downstream of Gorrin Creek would be required to determine whether there has been storage in these reaches.

The gullies dissecting the steep slopes of Challicum Hills are still actively eroding. Field surveys and aerial photograph analysis along the higher order streams, where channel incision and widening has occurred would suggest that the major period of adjustment has passed, however in some areas, particularly where there is limited riparian vegetation there is evidence of recent channel instability. Sediments eroded along the higher order streams are unlikely to be transported through to the Hopkins River because of the presence of a large tributary junction plug/floodout at the junction with the Hopkins River. This sediment storage is covered with dense grass and Spiny Rush that are likely to form an effective trap for incoming sediments.

The instability documented at the junction of the Jacksons and Hopkins River has been investigated in detail. Channel incision and widening in the confined reaches downstream of Jacksons Creek, has led to the formation of a nickpoint which is migrating upstream. Continued upstream migration of this nickpoint may lead to a reworking of sediments stored in the floodplain and the creation of a new course for the Hopkins River. Sediments stored in the large tributary junction plug/floodout at the confluence of Jacksons Creek with the Hopkins River may also be reworked. The construction of an artificial levee is unlikely to halt the continued erosion of these nickpoints further upstream.

The majority of sediments eroded from the gullies that have incised the steeper slopes of Skeleton Hills are stored as large floodouts (96%). Sediments stored in these floodouts may be reworked through reincision by advancing gully heads. Incision and widening of the higher order channels downstream from these floodouts have contributed the majority of sediments to the Hopkins River. This phase of incision and widening appears to have passed. Colonisation of the bed by Spiny Rush and the deposition of sediments as lower inset terraces within the incised channel, indicates that there is no longer active transport of sediments to the Hopkins River.

The lack of sediment storage along the Hopkins River downstream of the Skeleton Hills drainage area indicates that these sediments have been transported further downstream. The river in this section of the upper Hopkins River catchment has an incised channel morphology. The river has eroded its bed down to bedrock, limiting further incision. The establishment of Spiny Rush along the channel margins indicates that the channel is no longer widening and has reached a relatively



stable state. Study of aerial photographs indicates that this incised channel form continues over a distance of 9.2 km and represents a sediment loss of some 139,470 m³.

It is important to recognise that sediment budgets provide us with an account of past erosion, transport and storage of sediments in a drainage network. However, this may not necessarily elucidate the current, or future, patterns of sediment movement through the system. For instance, our interpretation of the Ararat Hills sediment budget and the contemporary gully network is that the sediment eroded in the past have been efficiently transported through the system to the Hopkins River and exported from the study area. Now, with an increasing density of vegetation on the gully beds, sediment tends to be trapped within in-gully storages and floodouts. A similar interpretation can be made for both the Challicum and Skeleton Hills physiographic units. Across the study area, the direct coupling of source areas with the Hopkins River via the gully network is now, largely, no longer apparent.

Recognising different coupling relationships, how they changed over time and their current status formed the basis for considering management actions in the three physiographic units. Recent investigations of gully control works in the Eppalock catchment provided an insight into those control works that are likely to be effective in rehabilitating the gullies in the upper Hopkins River catchment. The sodic and dispersive nature of the soils which make these areas susceptible to seepage and tunnel erosion, are difficult to stabilise using structural control works. A combination of structural and non-structural works is recommended in areas where seepage erosion and tunnelling are still active.

Battering of gullies may be undertaken in the Ararat and Skeleton Hills area. Diversion banks will be required to divert flow from gullies that are actively incising their bed and eroding their sidewalls. Revegetation of these battered areas and stabilisation of these waterways will have a higher probability of success if these areas are fenced off and stock are excluded. The gullies that have formed on the steep slopes of Challicum Hills are active. We recommend a combination of structural and non-structural works in this area. Construction of diversion banks and deep drainage will be required to divert surface and subsurface flow away from gully heads. Erosional pipes can be ripped up followed by battering and recompaction of soils. Planting of deep rooted trees in the contributory area of the gully network will serve to lower groundwater levels.

Efforts are required to maintain and improve the condition of vegetation cover on floodouts, particularly where gully heads are threatening to reincise the floodout. The process of erosion and channel instability in the area downstream of Jacksons Creek on the Hopkins River if allowed to continue will result in major adjustments of channel form. To arrest this erosion, we recommend extensive planting of deep-rooted trees across the floodplain. Investigations in the Eppalock Catchment, and elsewhere show that vegetation can also be used effectively to stabilise gully sidewalls and streambanks.

Further monitoring of gully dimensions is recommended in each of the three areas based on a series of monumented cross-sections positioned along the length of the gully network. The position of nickpoints and their height should also be monitored along Kurrajong Creek. Groundwater levels



may be monitored by establishing a network of piezometers in the upslope contributing areas of gullies in the Challicum Hills. Knowledge of groundwater levels and the extent of the tunnel network will be useful for designing the structural and non-structural works required to stabilise and rehabilitate the active gullies in Challicum Hills.

Knowledge gaps and future work

We have identified three additional areas that require work to complete the study for the entire catchment area. The areas are the Mount Langi Ghiran area, Green Hill Lake drainage area and tributaries east and south of Ararat. These areas are about as large (and diverse) as the areas that we have already analysed. Widening the study to include these additional areas will provide the information required to complete the sediment budget for the entire upper Hopkins River.

This study has not investigated the ecological condition of the upper Hopkins River catchment. Increased sediment loads from the gullied areas has resulted in sedimentation. The ISC 1999 data indicates that there is little in-stream habitat in this section of the river. An additional study that investigates the ecological condition of the river, and the potential for habitat improvement work is recommended.