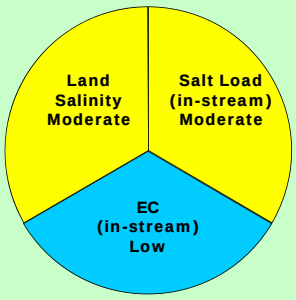
25. Lankeys Hydrogeological Landscape

LOCALITIES	**Lankeys Creek, Chinamans Gap, Yarara, Coppabella, Glenroy, Maginnitys Gap**
MAP SHEET	**Wagga Wagga 1:250 000**
CONFIDENCE LEVEL	**Medium**



OVERVIEW

The Lankeys Hydrogeological Landscape (HGL) extends from the northern boundary of the Murray CMA to the Murray River and from approximately Yarara in the west to Tumbarumba in the east (Figure 1). The HGL covers an area of 888 km^2 and receives 800 to 1100 mm of rain per annum.

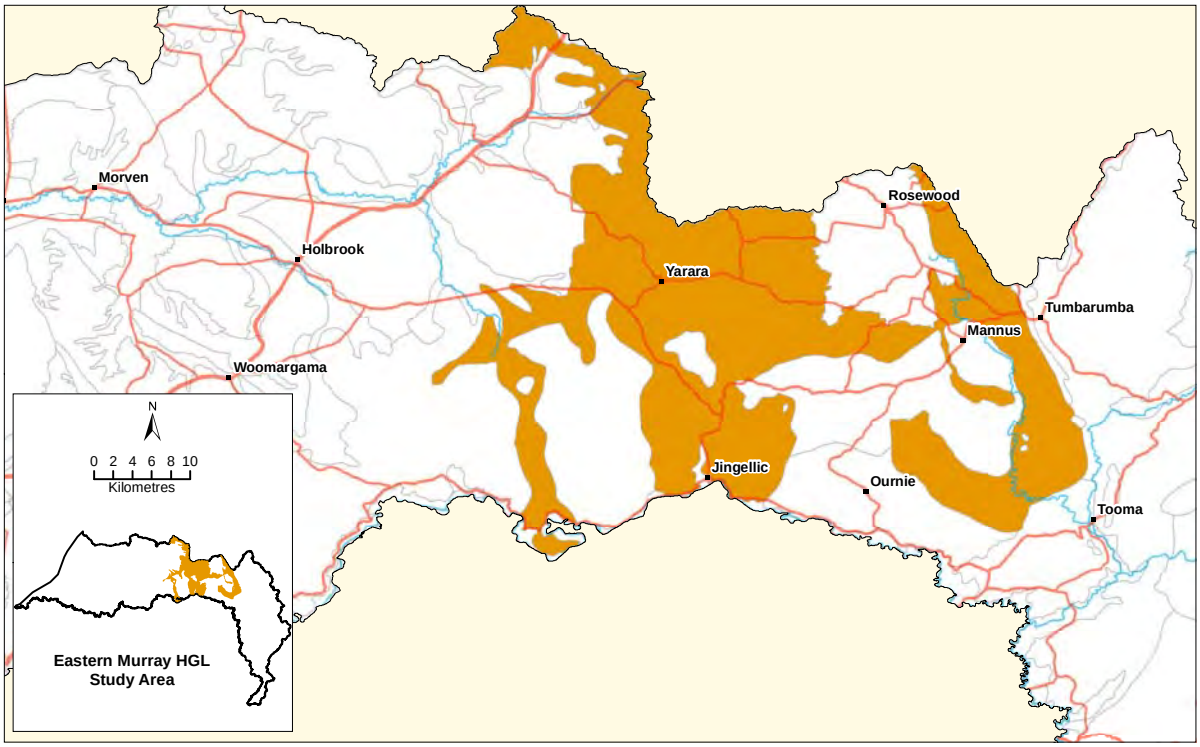


Figure 1: Lankeys HGL distribution map.

It is characterised by steep vegetated landforms decreasing in relief from precipitous, steep hills to rolling hills and steep low hills, and gently inclined foot-slopes of colluvium. The Lankeys HGL is predominantly an erosional environment characterised by steep hills, mountains, hills and rolling hills with narrow crests and ridges, short escarpment, moderately long waxing slopes and narrow drainage lines (Figure 2). The lower landform elements

include gently inclined foot-slopes of colluvium derived from flanking metasediments. This HGL comprises locally metamorphosed consolidated sedimentary rocks from the Ordovician period. Unconsolidated Cenozoic sand plains (sand, gravel and clay) and Quaternary colluvium and alluvium occur on lower slopes and in river valleys. Soils are shallow and stony on crests, ridges and upper slopes; shallow to moderately deep in upper drainage lines; moderately deep and moderately well-drained on lower slopes; and moderately deep in lower drainage lines. Erosion on slopes, including sheet, rill, wind, gully erosion in drainage lines and terracetting (soil creep) on cleared slopes, are common landscape limitations. Lower landforms experience seasonal waterlogging and soil sodicity.

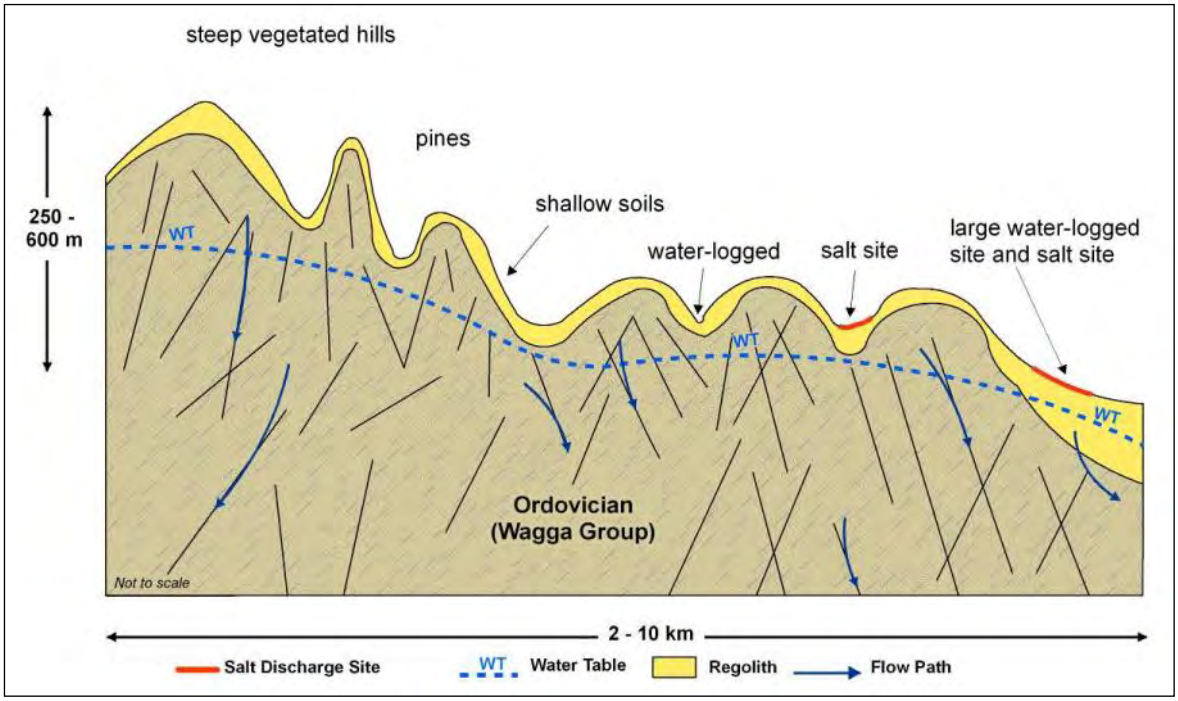


Figure 2: Conceptual cross-section for Lankeys HGL showing the distribution of regolith and landforms, salt sites if present, and flow paths of water infiltrating the system.

Isolated small areas of land salinity have been observed which show mainly waterlogging symptoms and are confined to the lower portion of the landscape. Moderate salt load and low EC levels are present (Table 1).

Table 1: Lankeys HGL salinity expression.

SALINITY EXPRESSION	
Land Salinity (Occurrence)	Moderate – Isolated small areas have been observed which show mainly waterlogging symptoms and are confined to the lower portion of the landscape
Salt Load (Export)	Moderate – No evidence of export but low flow in perennial streams supplies continuous load
EC (Water Quality)	Low water EC was observed

Salt stored within the Lankeys HGL has moderate mobility. There is a low salt store that has high availability (Table 2).

Table 2: Lankeys HGL salt store and availability.

SALT MOBILITY			
	Low availability	**Moderate** availability	**High** availability
High salt store			
Moderate salt store			
Low salt store			**Lankeys**

The overall salinity hazard in the Lankeys HGL is moderate. This is due to the high likelihood that salinity issues will occur that have potentially limited impacts (Table 3).

Table 3: Likelihood of salinity occurrence, potential impact and overall hazard of salinity for the Lankeys HGL.

OVERALL SALINITY HAZARD			
	Limited potential impact	**Significant** potential impact	**Severe** potential impact
High likelihood of occurrence	**Lankeys**		
Moderate likelihood of occurrence			
Low likelihood of occurrence			

LANDSCAPE FEATURES

The following photographs illustrate landscapes and specific features observed in this HGL. Information used to define the HGL is summarised in Table 4.

Photo 1: The steeper, more elevated elements of the Lankeys HGL generally show some rock outcrop and are mostly vegetated with native forests (Photo: OEH/R Muller).

Photo 2: The rolling hills and low hills within the Lankeys HGL have broad crests with waxing slopes (Photo: OEH/R Muller).

Photo 3: The rolling hills and low hills within the Lankeys HGL near Chinamans Gap have broad crests with waxing slopes that are generally cleared (Photo: OEH/R Muller).

Photo 4:Tree decline and waterlogging are often associated with salinity in the lower parts of the Lankeys HGL (Photo: OEH/R Muller).

Photo 5: The rolling hills and low hills within the Lankeys HGL around Yarara have broad crests with long waxing slopes (Photo: OEH/R Muller).

Photo 6: The lower landform elements of the Lankeys HGL around Yarara are gently inclined and experience seasonal waterlogging and soil sodicity (Photo: OEH/R Muller).

Photo 7: Steep hills and hills with narrow crests and ridges, moderately long waxing slopes and narrow drainage lines occur in the more elevated areas of the Lankeys HGL (Photo: OEH/R Muller).

Photo 8: Vegetated precipitous slopes of Lankeys HGL with short escarpments and colluvium derived from flanking metasediments (Photo: OEH/R Muller).

Photo 9: Establishment of plantation forestry is becoming a significant land use in the Lankeys HGL around Coppabella (Photo: OEH/A Wooldridge).

Photo 10: Moderately long waxing lower slopes of the Lankeys HGL near Yarara (Photo: OEH/A Wooldridge).

Photo 11: Native forest, plantation forestry, grazing and cropping are all practiced within the Lankeys HGL (Photo: OEH/W Cook).

Photo 12: Steep vegetated hills with narrow drainage lines and sheet erosion on lower slopes of the Lankeys HGL (Photo: OEH/W Cook).

Photo 13: Lower elements of the Lankeys HGL experience seasonal waterlogging and soil sodicity, and are susceptible to gully erosion (Photo: OEH/W Cook).

Table 4: Summary of information used to define the Lankeys HGL.

Lithology *(Raymond et al. 2007; Geoscience Australia 2011)*	This HGL comprises locally metamorphosed consolidated sedimentary rocks from the Ordovician period. Unconsolidated Cenozoic sand plains and Quaternary colluvium and alluvium occur on lower slopes and in river valleys. Key lithologies include: • channel and flood plain alluvium – gravel, sand, silt and clay • colluvium and/or residual deposits – boulders, gravel and sand • sand plains – sand dominant, gravel, clay; may include some residual alluvium • Wagga Group – quartzose siltstone, sandstone, quartz-mica schist, mudstone and chert. Minor quartzite, graphitic schist and hornfels.
Annual Rainfall	800–1100 mm
Regolith and Landforms	The Lankeys HGL is slightly to moderately weathered and is characterised by decreasing relief from steep to precipitous mountains (300–600 m relief) and hills (90–300 m relief) with narrow crests and ridges, short scarps, and moderately long colluvial slopes with narrow drainage lines, and rolling low hills (30–90 m) and rises (9–30 m) with gently inclined colluvial slopes, on Ordovician metasedimentary bedrock. Slopes are typically 5–40%, occasionally steeper, local relief is 5–600 m, and this HGL is between 180–900 m elevation. Rock outcrop is rare on low hills, but locally up to 50% on steep hill crests. Regolith materials are dominantly kaolinite-bearing quartzose clayey sands with minor gravels and some sandy clays. On ridge crests and upper slopes there are some angular tabular pebble and cobble-bearing coarse sandy gravels and gravelly sands with variable kaolinitic clay content.
Soil Landscapes *(DECCW 2010)*	This HGL contains a suite of metasedimentary derived soil landscapes. In decreasing relief and slope soil landscapes range from the mountainous Abrahams Bosom through to Veteran, Livingstone, Lloyd and finally the gently inclined Four Mile Creek. Soils include: shallow, stony Leptic Tenosols (Lithosols) and Lithic and Paralithic Leptic Rudosols (Lithosols) on crests, ridges and upper slopes; shallow Red Dermosols and Red Chromosols (structured Red Earths and Red Podzolic Soils); moderately deep (50–100cm) Mesotrophic Black Kandosols (Alluvial Soils, NSG) and Brown Kurosols (Yellow Podzolic Soils) in upper drainage lines; moderately deep (0.5–1.0 m), moderately well-drained Red Chromosols and Kurosols (Red Podzolic Soils) on lower slopes; and moderately deep (0.5–1.0 m) Yellow and Grey Sodosols (Soloths) in lower drainage lines. There are areas of severe salinity at the boundary between the colluvium and alluvium which occurs predominantly in the Four mile Creek soil landscape. In areas of rolling low hills and texture contrast soils (Chromosols and Kurosols), Lloyd soil landscape, localised saline outbreaks are found at breaks of slope.

Land and Soil Capability *(OEH 2012)*	Class 5
Land Use	Mostly native forest (Jingellic and Bogandyera Nature Reserves, Woomargama State Conservation Area and Mundaroo State Forest). Some grazing on volunteer, naturalised, native or sown, improved perennial pasture
Key Land Degradation Issues	• sheet erosion and terracettes (common on cleared slopes) • rill erosion (lower slopes) • wind erosion (crests and ridgelines) • compaction from grazing contributes to hard-setting • high recharge on crests and ridges • gully erosion (drainage lines) • salinity at boundary between colluvium/alluvium • sodicity.
Native Vegetation *(Stelling 1998; Keith 2004)*	Native vegetation in Lankeys HGL is typical of high rainfall and high altitude areas. Species include *Eucalyptus bicostata* (eurabbie) in sheltered, wet areas on fertile soils, *E. pauciflora* (snow gum), *E. mannifera* (brittle gum), *E. rossii* (inland scribbly gum) and *E. goniocalyx* (long-leaf box) on ridges, shallow rocky areas, well drained alluvium or poor shallow soils on rises, typically in high rainfall areas, and *E. viminalis* (ribbon gum), *E. dives* (broad-leaved peppermint), *E. rubida* (candle bark), *E. robertsonii* (Robertson's peppermint) and *E. stellulata* (black sallee) on deeper, more fertile, loam soils. All species tend to have some degree of frost tolerance and are able to withstand periods of snow as well as cold climate. Vegetation on the lower slopes additionally may include *E. bridgesiana* (apple box) where the soils are heavy but well drained; *E. melliodora* (yellow box) on light to heavy, well drained moist soils; and *E. microcarpa* (grey box) on heavy loamy soils. Vegetation communities tend to be grassy woodlands or dry sclerophyll forests, with some wet sclerophyll forests.

HYDROGEOLOGY

Aquifers within this landscape are unconfined to semi-confined with groundwater flow occurring primarily through fractures in bedrock and saprolite. Some flow occurs through sand plains on lower slopes and alluvial sediments in flow lines. Hydraulic conductivity and transmissivity are low. Groundwater recharge rates are estimated to be moderate to high.

Groundwater systems are typically local to intermediate with short to intermediate flow lengths, and are loosely defined by topographic catchments. Water quality within these systems is fresh to marginal. Watertable depths are intermediate to deep.

Medium residence times are typical. These landscapes have a medium to fast response time to changes in land management.

Typical values for the hydrogeological parameters of this HGL are summarised in Table 5.

Table 5: Summary of values for typical hydrogeological parameters of the Lankeys HGL.

Aquifer Type	Unconfined to semi-confined in fractured rock and saprolite Lateral flow through unconsolidated colluvial and alluvial sediments on lower slopes and in flow lines
Hydraulic Conductivity	Low Range: $<10^{-2}$ m/day
Aquifer Transmissivity	Low Range: <2 m^2/day
Specific Yield	Low to moderate Range: <5–15%
Hydraulic Gradient	Moderate to steep Range: 10–>30%
Groundwater Salinity	Fresh to marginal Range: <800–1600 µS/cm
Depth to Watertable	Intermediate to deep Range: 2–>8 m
Typical Sub-Catchment Size	Small (<100 ha)
Scale (Flow Length)	Local to intermediate Flow length: <15 km (short to intermediate)
Recharge Estimate	Moderate to high
Residence Time	Medium (years)
Responsiveness to Change	Fast to medium (months to years)

MANAGEMENT OPTIONS

Overarching salinity management strategies have specific biophysical outcomes. These are achieved by implementing a series of targeted land management actions that take into account the opportunities and constraints of the particular HGL. The actions recognise the need for diffuse and specific activities within the landscape to impact on salinity. Further explanation of land management functions, strategies and actions can be found in Wooldridge *et al.* (2015).

Salinity is driven by interactions between water-use capacity of vegetation, physical soil properties and hydrogeological processes within the HGL.

Actions that influence the way water is used by vegetation or stored in the soil profile will have impacts on recharge. The influence of both continual and episodic recharge and the

impacts of extreme weather events need to be considered when deciding on appropriate management actions. Short and long-term climate cycles also need to be considered as they have a bearing on salinity processes, particularly salt load and land salinity.

Landscape Salinity Functions – Lankeys HGL

Functions this landscape provides within a catchment scale salinity context:

- **A.** The landscape provides fresh water runoff as an important water source
- **B.** The landscape provides fresh water runoff as an important dilution flow source
- **C.** The landscape provides important base flows to local streams
- **D.** The landscape generates salt loads which enter the streams and are redistributed in the catchment
- **G.** The landscape contains important land assets (including infrastructure and high value agricultural land) on which salinity processes impact.

Management Strategy Objectives – Lankeys HGL

Appropriate strategies pertinent to this landscape:

- **Maintain or maximise runoff (10):** This HGL contributes significant fresh water as a resource and dilution flow to the system. The fresh runoff mitigates the salt load, stream salinity and EC concentration of local streams and the greater catchment.
- **Discharge rehabilitation and management (4):** The salt sites are small in size and isolated in the lower portion of the landscape, often associated with large waterlogged areas Discharge management will improve on-site and off-site salinity outcomes when vegetation is matched to salt sites.
- **Buffer the salt store – keep it dry and immobile (1):** There are minor stores of salt in the lower landform areas, which are highly available, and which vegetation can buffer, limiting the salinity impact. They are generally in the lower colluvial elements of the landscape associated with areas of waterlogging.

Key Management Focus – Lankeys HGL

Grazing management is the key focus for this unit. This includes management of pasture systems based on perennial plants on both waterlogged areas and the wider recharging landscape. Grazing management and infrastructure should consider wet areas as sensitive to grazing.

This landscape is a net dilution salinity landscape in a catchment context. Actions should aim to minimise salinity impacts but maintain runoff from this landscape. This landscape is important as it provides fresh water within the catchment. This means careful consideration and planning need to be given to land uses which reduce runoff. Large scale revegetation with trees is not recommended on this unit.

Specific Land Management Opportunities

Specific opportunities for this HGL:

- Waterlogged and seasonally wet areas exist in parts of this HGL. These areas offer potential for pastures/grazing systems based on pastures which have waterlogging tolerance.

Specific Land Management Constraints

Constraints for land management in this HGL include:

- Seasonal waterlogging occurs during low growth periods of the year.

Specific Targeted Actions

Management areas for this HGL are illustrated in Figure 3. The specific management actions for these areas are described in Table 6.

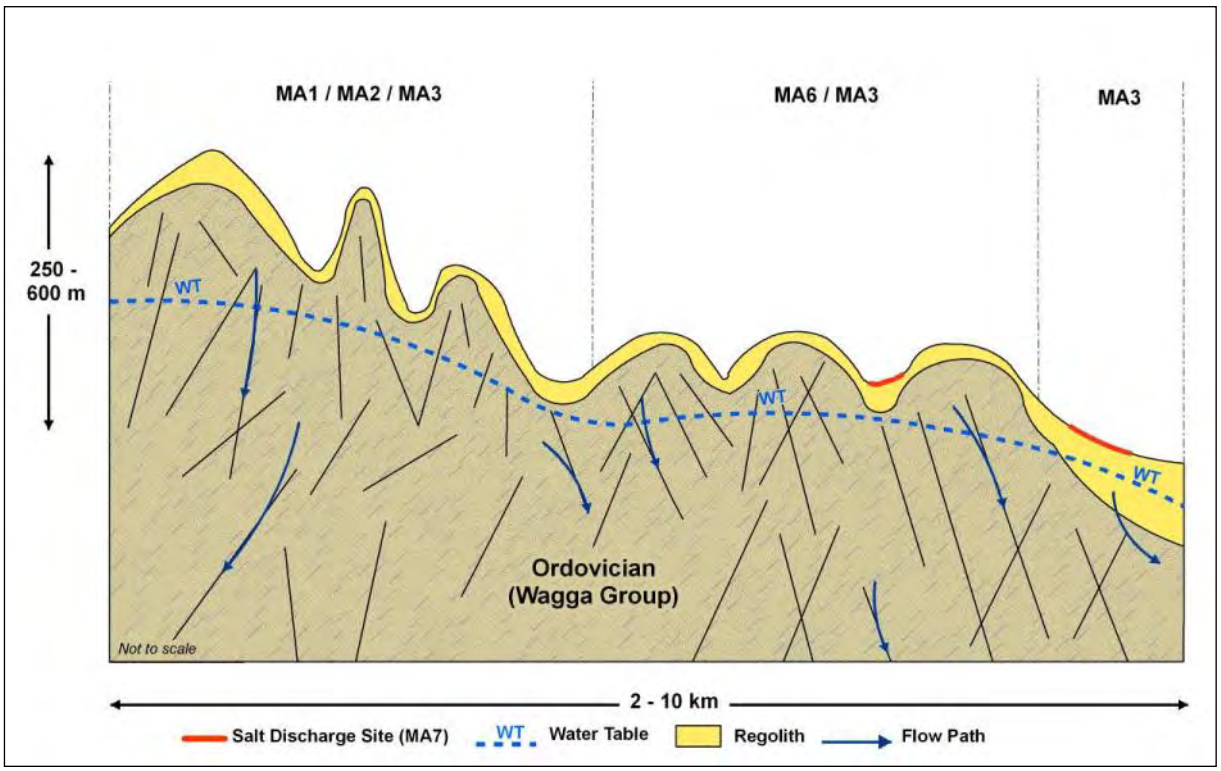


Figure 3: Management cross-section for Lankeys HGL showing defined management areas.

Table 6: Specific management actions for management areas within the Lankeys HGL.

Management Area (MA)	Action
MA1/2/3 (RIDGES & UPPER SLOPES – EROSIONAL & COLLUVIAL)	**Vegetation for ecosystem function** Maintain and improve existing native woody vegetation to reduce discharge **(VE3).** Revegetate non-agricultural land with native species to manage recharge **(VE6).**
MA6/3 (RISES & UPPER SLOPES – COLLUVIAL)	**Vegetation for ecosystem function** Maintain and improve native woody vegetation **(VE3).** Revegetate non-agricultural land with native species to manage recharge **(VE6).** **Vegetation for production** Improve grazing management of existing perennial pastures to manage recharge **(VP1).** Improve grazing management to improve or maintain native pastures to manage recharge **(VP5).**
MA3 (UPPER SLOPES – COLLUVIAL)	**Vegetation for ecosystem function** Maintain and improve existing native woody vegetation to reduce discharge **(VE3).** **Vegetation for production** Improve grazing management of existing perennial pastures to manage recharge **(VP1).** Improve grazing management to improve or maintain native pastures to manage recharge **(VP5).**
MA7 (SALINE SITES)	**Salt land rehabilitation** Fence and isolate salt land and discharge areas to promote revegetation **(SR1).** Undertake rehabilitation to ameliorate land salinity processes and reduce land degradation **(SR4).** Reduce animal impact on scalds by providing mineral supplements to stock **(SR7).**

High Hazard Land Use

There are some management actions that should be discouraged in this HGL as they will have negative impacts on salinity (Table 7).

Table 7: Management actions having negative salinity impacts in the Lankeys HGL.

At Risk Management Areas	Action
MA1/2/3 (RIDGES & UPPER SLOPES – EROSIONAL & COLLUVIAL)	Establish commercial forestry to manage recharge **(VP7).** Reducing runoff from fresh surface water catchments **(DLU6).**
MA6/3 (RISES & UPPER SLOPES – COLLUVIAL)	Establish commercial forestry to manage recharge **(VP7).** Reducing runoff from fresh surface water catchments **(DLU6).**

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