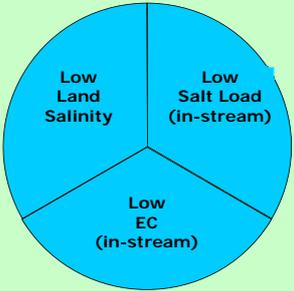


5. Bullen Range Hydrogeological Landscape

LOCALITIES	Bullen Range	
MAP SHEET	Brindabella 1:100 000 Canberra 1:100 000	
CONFIDENCE LEVEL	Moderate	

OVERVIEW

The Bullen Range Hydrogeological Landscape (HGL) extends across the Bullen Range in the western area of the ACT (Figure 1). The HGL covers an area of 30 km² and receives 650 to 950 mm of rain per annum.

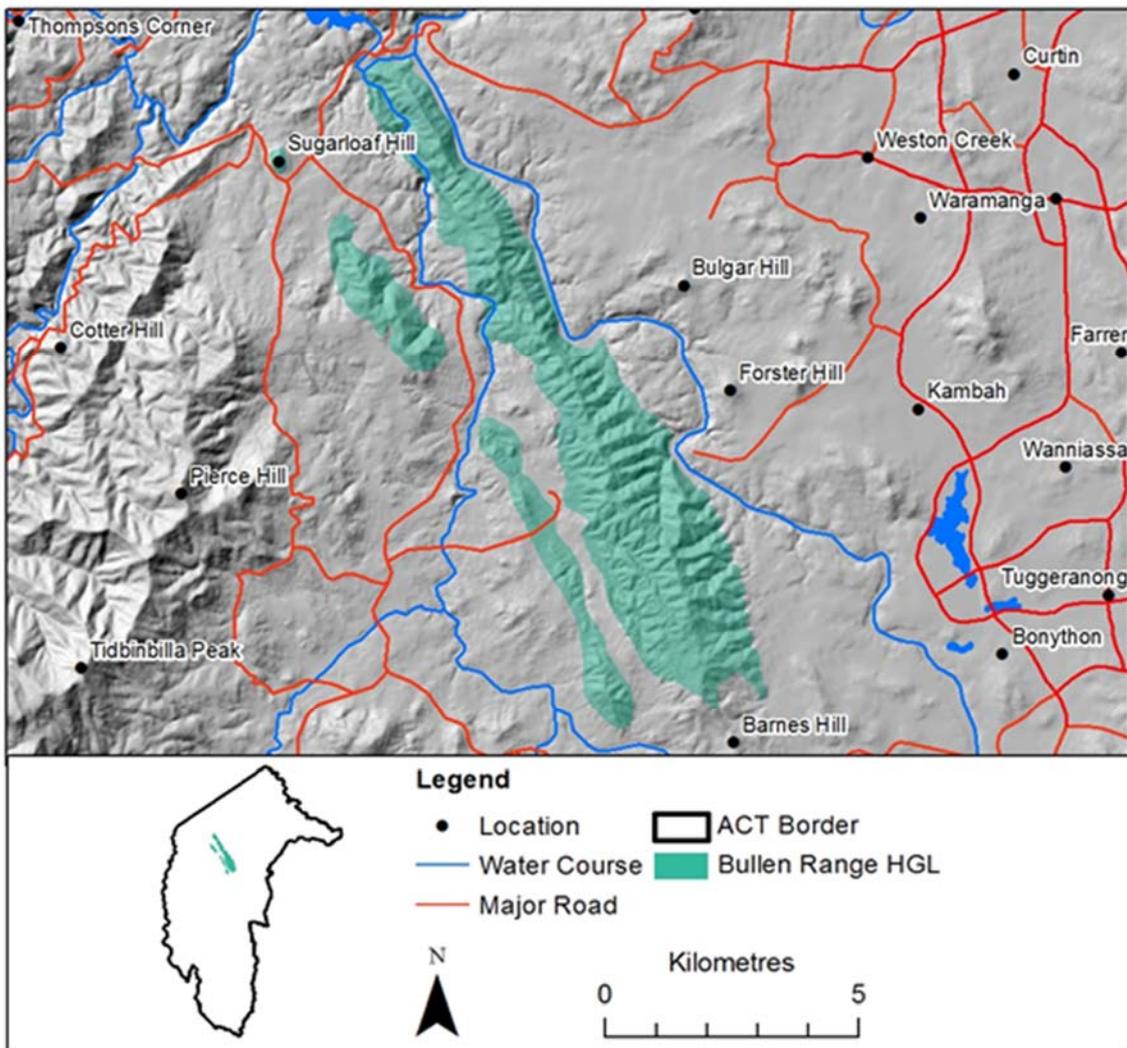


Figure 1: Bullen Range HGL distribution map.

Bullen Range HGL is characterised by a distinctive shaped ridge line of steeply bedded metasediments of the Adaminaby Group. The Bullen Range Nature Reserve is heavily vegetated, and an area of similar geology to the west forms low hills and rises which are cleared and extensively grazed (Figure 2). The HGL comprises both these distinct areas.

With high rainfall erosion areas in flow lines on upper slopes mobilise sediment into streams. The low hill and rise areas have significant gully erosion on footslopes. There is an opportunity to improve NRM outcomes in this HGL with appropriate grazing management. Sporadic cropping and fodder crop production are also undertaken.

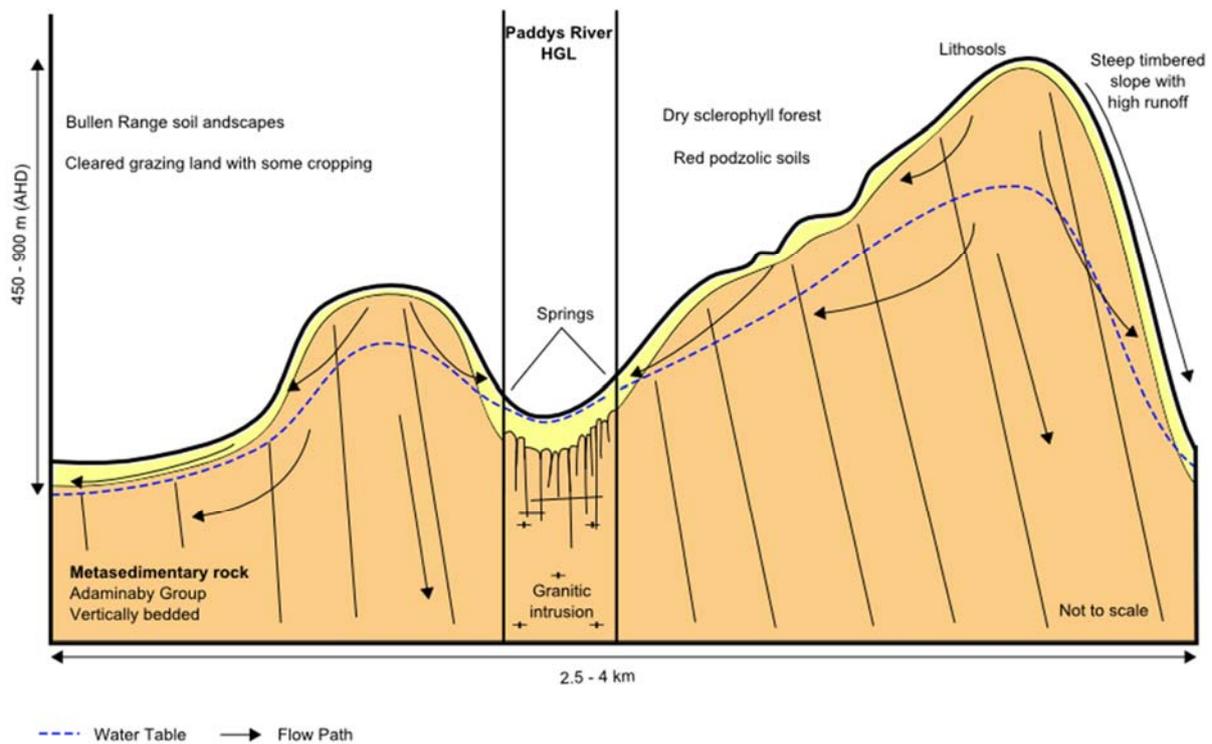


Figure 2: Conceptual cross-section for Bullen Range HGL showing the distribution of regolith and landforms, salt sites if present, and flow paths of water infiltrating the system.

There is little evidence of salinity in this HGL (Table 1).

Table 1: Bullen Range HGL salinity expression.

SALINITY EXPRESSION	
Land Salinity (Occurrence)	Low – no observed salinity
Salt Load (Export)	Low – net dilution landscape
EC (Water Quality)	Low – fresh water

Salt store refers to the amount of salt stored in soil and geology materials. Salt availability refers to how easily this salt can be moved by water. Salt stored within Bullen Range HGL has moderate mobility. The moderate salt store has a moderate availability (Table 2).

Table 2: Bullen Range HGL salt store and availability.

SALT MOBILITY			
	Low availability	Moderate Availability	High availability
High salt store			
Moderate salt store		Bullen Range	
Low salt store			

Overall salinity hazard is based on the likelihood of salinity occurring and how much impact it will have. The overall salinity hazard in Bullen Range HGL is low. This is due to the moderate likelihood that salinity issues will occur and that they could have potentially limited impacts (Table 3).

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

OVERALL SALINITY HAZARD			
	Limited potential impact	Significant potential impact	Severe potential impact
High likelihood of occurrence			
Moderate likelihood of occurrence	Bullen Range		
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: View of Bullen Range in the mid-section of the photograph taken from north (Photo: OEH / W Cook).



Photo 2: Bullen Range indicating steep heavily vegetated slopes (Photo: DPI / A Nicholson).



Photo 3: Bullen Range vegetation and steeply dipping sediments at Kambah Pools (Photo: DPI / A Nicholson).



Photo 4: The western area of the HGL with a rise that has been heavily cleared for grazing (Photo: DPI / A Nicholson).



Photo 5: View from the west looking east across the Deep Space Communications Centre to Bullen Range in the background (Photo: DPI / A Nicholson).



Photo 6: Hill in the western of the two distinct landform areas, indicating minor remnant vegetation and grazing land (Photo: DPI / A Nicholson).



Photo 7: Eastern slope of Bullen Range leading down to Murrumbidgee River (Photo: OEH / W Cook).

Table 4: Summary of information used to define Bullen Range HGL.

<p>Lithology <i>(Raymond et al. 2007; Geoscience Australia 2015)</i></p>	<p>This HGL consists predominantly of Ordovician metasediments. Key lithologies include:</p> <ul style="list-style-type: none"> • Adaminaby Group • Laidlaw Volcanics (minor) • Shannons Flat Granodiorite (minor) • Paddys River Volcanics (minor)
<p>Annual Rainfall</p>	<p>650–950mm</p>
<p>Regolith and Landforms</p>	<p>Soil generally < 1 m with deeper pockets associated with areas of saprolite. While salt store potential is moderate, salt is relatively mobile and moves through the landscape quickly with high rainfall</p> <p>Slopes generally 10–32%; 35–56% in highest areas</p> <p>Elevation range is 450–900 m</p>
<p>Soil Landscapes <i>(Jenkins 1993; Jenkins 2000; Cook & Jenkins in prep)</i></p>	<p>The following soil landscapes are dominant in this HGL:</p> <ul style="list-style-type: none"> • Bullen Range • Bullen Range (variant A) <p>Soils tend to shallow and rapidly drained. Stratic Rudosols (Lithosols) on crests, upper slopes and steeper mid slopes. Red Chromosols (Red Podzolic Soils) from mid to lower slopes</p>

Land and Soil Capability	Class 6
Land Use	<ul style="list-style-type: none"> • native forest • forestry (pines) • grazing
Key Land Degradation Issues	<ul style="list-style-type: none"> • sheet, rill and gully erosion • mass movement • shallow soil
Native Vegetation <i>(Keith 2004; Gellie 2005; Dept of Environment 2012)</i>	<p>This HGL is situated within the IBRA7 South Eastern Highlands (Murrumbateman subregion)</p> <p>The HGL has only partial cleared land with vegetation formations comprising mostly Dry Sclerophyll Forest and small areas of Wet Sclerophyll Forest and Forested Wetlands</p> <p>Local vegetation is described by Gellie (2005)</p>

HYDROGEOLOGY

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

Table 5: Summary of values for typical hydrogeological parameters of Bullen Range HGL.

Aquifer Type	Unconfined to semi-confined in fractured rock and saprolite Lateral flow through unconsolidated colluvial sediments on lower slopes
Hydraulic Conductivity	Moderate Range: 10 ⁻² –10 m/day
Aquifer Transmissivity	Low Range: <2 m ² /day
Specific Yield	Low Range: <5%
Hydraulic Gradient	Steep Range: >30%
Groundwater Salinity	Fresh Range: <800 µS/cm
Depth to Watertable	Deep Range: >8 m
Typical Sub-Catchment Size	Small (<100 ha)
Scale (Flow Length)	Small Flow length: <5 km (short)
Recharge Estimate	Moderate

Residence Time	Short to medium (months to 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 should be considered when deciding on appropriate management actions. Short and long-term climate cycles also should be considered as they have a bearing on salinity processes, particularly salt load and land salinity.

Landscape Functions – Bullen Range 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**.

Landscape Management Strategies – Bullen Range HGL

Appropriate strategies pertinent to this landscape:

- **Maintain or maximise runoff (10)**
- **Maintain current hydrology (11)**

Key Management Focus – Bullen Range HGL

Bullen Range is extensively vegetated and the current nature reserve is the most appropriate land use. The grazing areas to the west have good potential for improved NRM outcomes through appropriate grazing management.

There are significant soil erosion issues in this HGL.

Specific Land Management Opportunities

Specific opportunities for this HGL:

- a portion of this landscape is grazing of perennial pasture – there is significant opportunity to improve onsite and offsite outcomes with changes to grazing management

- timbered landscape components present, provide re-vegetation options for NRM outcomes as well as shade and shelter for stock
- there is a good base of perennial native pastures in grazing areas.

Specific Land Management Constraints

Constraints on land management in this HGL include:

- In timbered areas the fire regime will have a large impact on the landscape hydrology
- In timbered areas access and topography limit land management options
- In grazing areas management should consider the characteristics of soils, particularly acid soils. Soil erosion, particularly gully erosion, is a limitation on water quality, soil health and sediment yield
- Grazing management and perennial grasslands have a reduced impact on salinity processes in high rainfall areas
- The tenure of grazing land is a constraint to long-term planning and land management for catchment and landscape outcomes.

Specific Targeted Actions

Management areas for this HGL are illustrated in Figures 3 and 4. The specific management actions for these areas are described in Table 6.

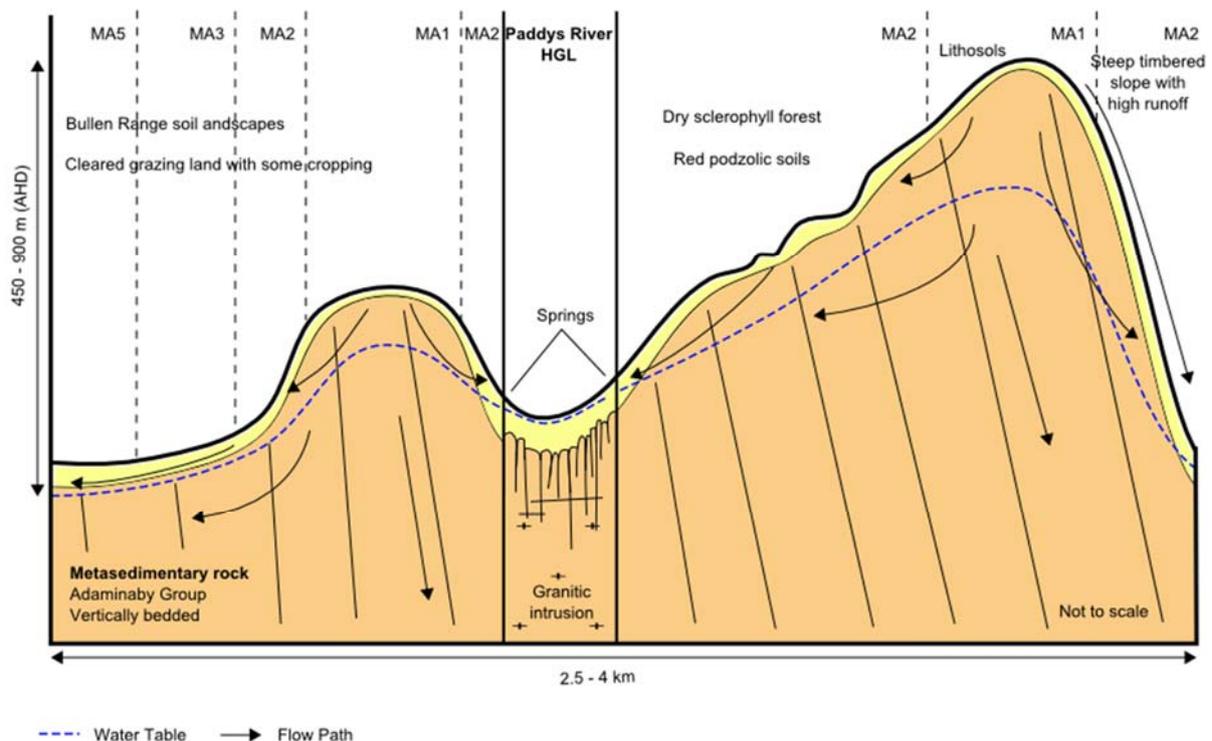


Figure 3: Management cross-section for Bullen Range HGL showing defined management areas.

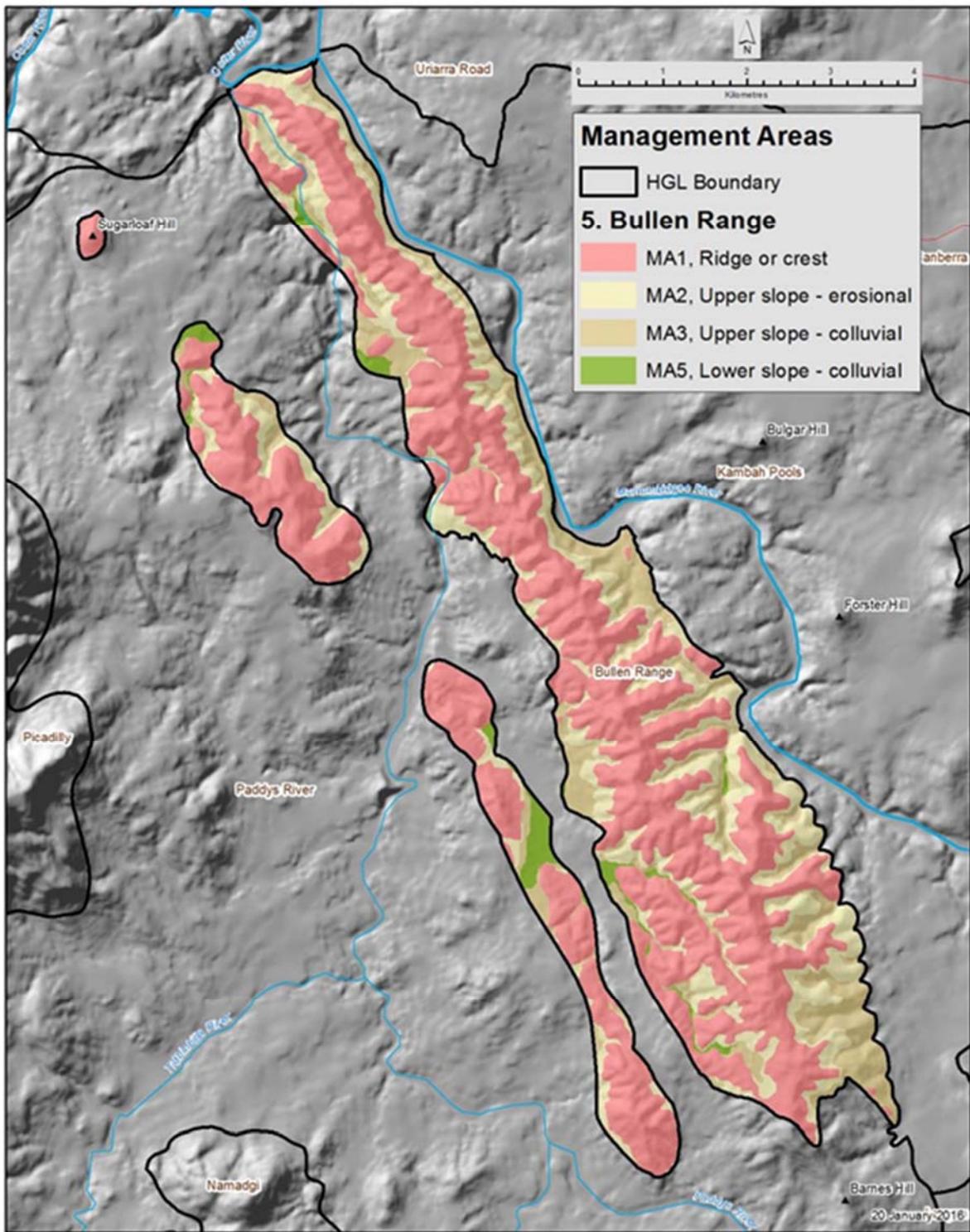


Figure 4: Spatial distribution of management areas for Bullen Range HGL.

Table 6: Specific management actions for management areas within Bullen Range HGL.

Management Area (MA)	Action
<p>MA 1 (RIDGES)</p>	<p>Vegetation for ecosystem function Maintain and improve existing native woody vegetation to reduce discharge (VE3) Maintain and improve existing native vegetation to protect current landscape hydrology (VE8)</p>
<p>MA 2 (UPPER SLOPE – EROSIONAL)</p>	<p>Vegetation for ecosystem function Maintain and improve existing native woody vegetation to reduce discharge (VE3) Maintain and improve existing native vegetation to protect current landscape hydrology (VE8) Vegetation for production Improve grazing management of existing perennial pastures to manage recharge (VP1) Establish and manage perennial pastures to manage recharge (VP2) Improve grazing management to improve or maintain native pastures to manage recharge (VP5)</p>
<p>MA 3 (UPPER SLOPE – COLLUVIAL)</p>	<p>Vegetation for ecosystem function Interception planting of native woody species to target shallow groundwater (VE2) Establish and manage trees that are integrated into farming logistics to reduce recharge (VE 5) Maintain and improve existing native vegetation to protect current landscape hydrology (VE8) Vegetation for production Improve grazing management of existing perennial pastures to manage recharge (VP1) Establish and manage perennial pastures to manage recharge (VP2) Establish and manage perennial pastures to intercept shallow lateral groundwater flow (VP3) Improve grazing management to improve or maintain native pastures to manage recharge (VP5)</p>

Management Area (MA)	Action
MA 5	<p>Vegetation for ecosystem function</p> <p>Maintain and improve existing native woody vegetation to reduce discharge (VE3)</p> <p>Maintain and improve existing native vegetation to protect current landscape hydrology (VE8)</p> <p>Establish and manage trees to integrate into existing farming infrastructure and logistics and for multiple outcomes including reduced recharge (VE5)</p> <p>Interception planting of native woody species to target shallow groundwater (VE2)</p> <p>Vegetation for production</p> <p>Improve grazing management of existing perennial pastures to manage recharge (VP1)</p> <p>Establish and manage perennial pastures to manage recharge (VP2)</p> <p>Improve grazing management to improve or maintain native pastures to manage recharge (VP5)</p> <p>Farming Systems</p> <p>Pasture cropping with annual cereals into perennial pastures to manage recharge (FS1)</p> <p>Phase farming with perennial component-crop rotations to manage recharge (FS3)</p>

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 Bullen Range HGL.

At Risk Management Areas	Action
MA 1,2 & 3	<p>Poor management of grazing pastures (DLU2)</p> <p>Clearing and poor management of native vegetation (DLU4)</p>
MA 3 & 5	<p>Annual cropping with annual plants (DLU3)</p> <p>Locating infrastructure on discharge areas (DLU7)</p> <p>Poor soil management loss of surface soil layers (DLU10)</p>

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