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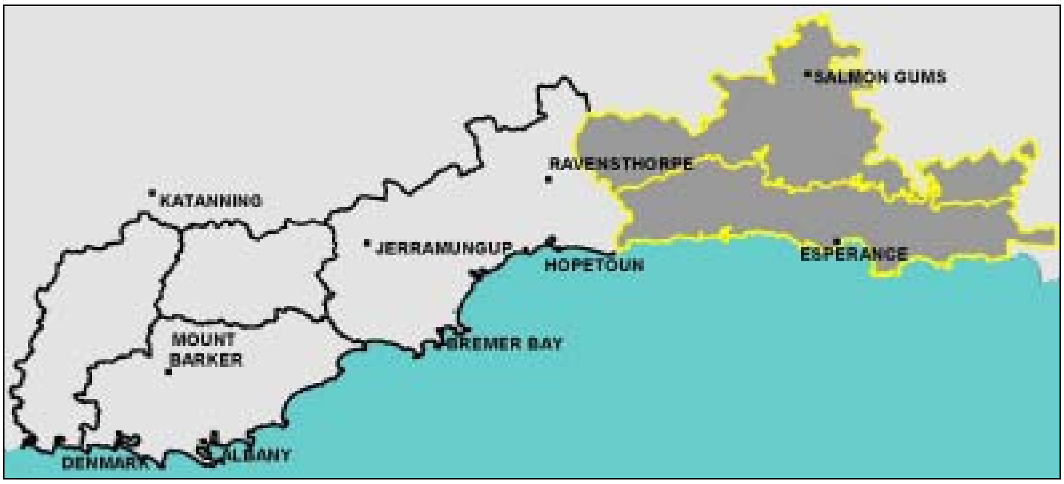

Department of Agriculture
Government of Western Australia

Groundwater trends in the Esperance Sandplain and Mallee sub-regions

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The South Coast Regional Initiative Planning Team (SCRIPT) has divided the South Coast region of Western Australia into six sub-regions. The Esperance Sandplain and Mallee sub-regions encompass the Esperance agricultural district, which contains about 1.5 million hectares of agricultural land. This publication describes the groundwater trends, risk of shallow watertables, and technical feasibility of salinity management in the soil-landscape zones within the Esperance agricultural district.

Soil-landscape zones are spatial units based on geology and geomorphology. Since most groundwater processes in WA are controlled by the geologic and regolith properties, these zones can be used for allocating hydrological attributes such as groundwater characteristics and trends. The hydrological attributes are then used to assess the risk of shallow watertables and technical feasibility of salinity management.

Refer to *Further Information* for descriptions of groundwater flow systems, risk analysis and technical feasibility of salinity management.

History of agricultural development

Agricultural development began in the 1900s in the northern Mallee and in the mid-1950s in the Esperance Sandplain. The development phase finished in the 1970s with new land releases in the eastern and western Mallee.

Prior to clearing the native vegetation, groundwater was generally deeper than 2 m. Since clearing, groundwater recharge has increased causing watertables to rise. Dryland salinity occurs when the groundwater level rises and intersects the land surface. The area of salinity will continue to increase for decades until a new hydrological equilibrium is reached.

Climate

The Esperance agricultural district experiences a temperate climate with cool, wet winters and warm to hot, dry summers. Average annual rainfall declines with distance from the coast and varies throughout each sub-region. The Esperance Sandplain receives 450–600 mm and the Mallee receives 300–450 mm average annual rainfall. A significant proportion of this rainfall occurs outside the May to October growing season; however, it is erratic and unreliable. Annual evaporation ranges from 1,800 mm/yr at Esperance to 2,200 mm/yr at Salmon Gums. While winter evaporation in the Mallee is only slightly higher than that in the Esperance Sandplain, summer evaporation is significantly higher.

Natural drainage systems

The natural drainage systems reflect the geological history of the district. West of Esperance, the landscape has been rejuvenated and is externally drained through a number of well-defined rivers and creeks that flow into wetlands and estuaries located in coastal reserves. East of Esperance and in the north and east of the Mallee where the landscape has not been rejuvenated, drainage systems are poorly defined and drain internally into paperbark (*Melaleuca* spp.) and yate (*Eucalyptus occidentalis*) swamps.

Esperance Sandplain Zone (245)

The Esperance Sandplain Zone covers 95% of the Esperance Sandplain sub-region and the remainder falls within the Mallee sub-region. It is characterised by a level to undulating sandplain that forms a 40–60 km wide strip along the coast. The sandplain consists of a sheet of fine sand of varying thickness overlying gravel or clay. Grey deep sandy duplex and grey shallow sandy duplex soils are dominant and both of these often contain gravel.

Groundwater flow systems

In areas with well-defined external drainage, groundwater flow systems are local to intermediate, separated by basement highs and ridges. Where drainage is poorly defined the depth to groundwater exceeds 10 m and the groundwater flow systems are intermediate to regional. Local groundwater flow systems occur in areas with shallow basement. Areas with deep sands have localised, perched groundwater flow systems overlying intermediate groundwater flow systems.

Groundwater depth, quality and trends

The depth to groundwater ranges from less than 2 m (Figure 1: bore GS7A) to deeper than 10 m (bore WP1D). The deeper groundwater levels predominantly occur in the east, whereas to the west and north of Esperance, levels are generally shallow.

Groundwater salinity increases with distance from the coast and ranges from 75 mS/m (milliSiemens per metre), which is fresh, in the perched aquifers, to 7,500 mS/m (highly saline) in the intermediate aquifers. Median groundwater salinity is 1,900 mS/m and median pH is 6.5 (neutral). Shallow watertables fluctuate seasonally and the deeper levels are currently rising at rates between 0.05 and 0.30 m/yr.

Risk of shallow watertables

Most of the zone has a moderate risk of shallow watertables, except in the drainage lines where the risk is high (Table 1). However, within 20 to 50 years, 15–20% will have a high risk of shallow watertables. When a new hydrological equilibrium is reached, 25–30% of the zone may be salt-affected.

Technical feasibility of salinity management

In general, the technical feasibility of adapting to salinity is excellent (Figure 1) because the sandy soils are readily leached by rainfall which flushes out the accumulated surface salt. The feasibility of containing salinity is good because there is potential to reduce recharge by growing perennials and to increase discharge with engineered drainage. It is only moderately feasible to attempt to recover salt-affected land because even though undulating landscapes with local groundwater flow systems may be hydrologically responsive, these systems generally overlie intermediate flow systems which require significant recharge reductions over large areas.

Salmon Gums Mallee Zone (246)

The Salmon Gums Mallee Zone covers 94% of the Mallee sub-region and the remainder falls within the Esperance Sandplain sub-region. The zone is characterised by its mallee vegetation and contains a level to gently undulating plain with numerous salt lakes. The dominant soils are alkaline grey sandy duplexes that overlie predominantly marine sediments. The headwaters of the southerly-flowing rivers and creeks are located in the west and south central parts. The northern and eastern areas drain internally into saline playa lakes.

Groundwater flow systems

The groundwater flow systems are predominantly intermediate, with localised systems occurring in areas with shallow basement.

Groundwater depth, quality and trends

The depth to groundwater is typically deeper than 10 m (Figure 1: bores AG21, CA1D and GS1). However, groundwater levels less than 2 m commonly occur in areas with shallow basement, at the headwaters of the rivers and creeks, and in low-lying areas adjacent to the saline playa lakes.

Groundwater salinity in monitoring bores ranges from 1,300 mS/m (saline) to 14,000 mS/m (highly saline), with a median of 5,600 mS/m, which is about as salty as seawater.

Groundwater pH ranges from 2.9 (moderately acid) to 7.0 (neutral), although typically the groundwater has low pH with a median of 3.8 (moderately acid). Groundwater levels are currently rising at rates between 0.05 m/yr (Figure 1: bore MB3D) and 0.25 m/yr (Figure 1: bore CA1D).

Risk of shallow watertables

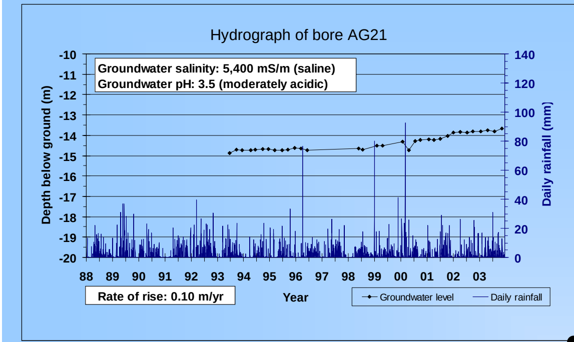
Currently, most of the zone has a moderate risk of shallow watertables and the risk should remain moderate over the next 20 to 50 years (Table 1). Nevertheless, in the next century when potential salinity develops fully and a new hydrological equilibrium is reached, up to 25% may be salt-affected; therefore, it is considered to have a long-term, high salinity risk.

Technical feasibility of salinity management

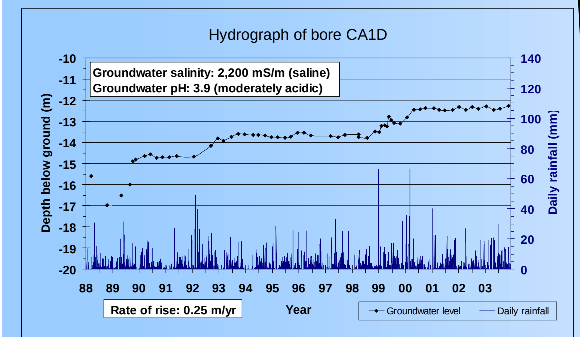
Viable salinity management options are limited for this zone because the low to medium annual rainfall reduces the opportunity and profitability of growing perennials.

Additionally, the predominantly internal drainage system restricts the volume of surface water that can exit, and the very low (<0.1%) groundwater gradients limit the hydrologic responsiveness. Consequently, recovery of salt-affected land has low technical feasibility and containing or adapting to salinity has a moderate technical feasibility (Figure 1).

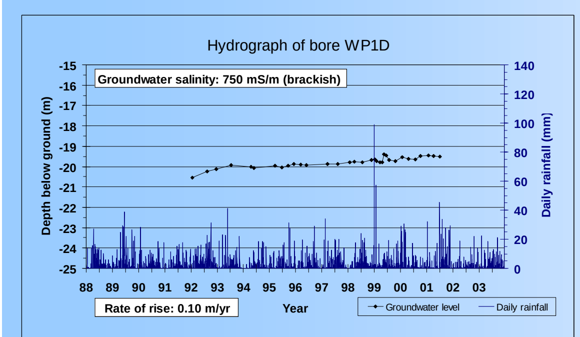
SCRIPT sub-region	Soil-landscape zone	Proportion of sub-region's agricultural land (%)	Time until potential salinity fully develops[SIF]	Salinity management technical feasibility[SIF]		
				Recovery	Containment	Adaptation
Esperance Sandplain	Esperance Sandplain (245)	95	Medium-term (30–75 yrs)	Moderate	Good	Excellent
Mallee	Salmon Gums Mallee (246)	94	Long-term (>75 yrs)	Low	Moderate	Moderate



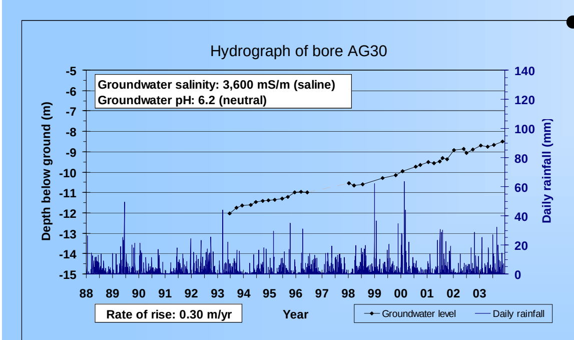
Location: North of Esperance; Grass Patch West area
Soil-landscape system: Scaddan (246Sc)
Soil: Alkaline grey shallow sandy duplex
Land use: Cropping / pasture
Landform: Lower slope
Average annual rainfall: 375 mm



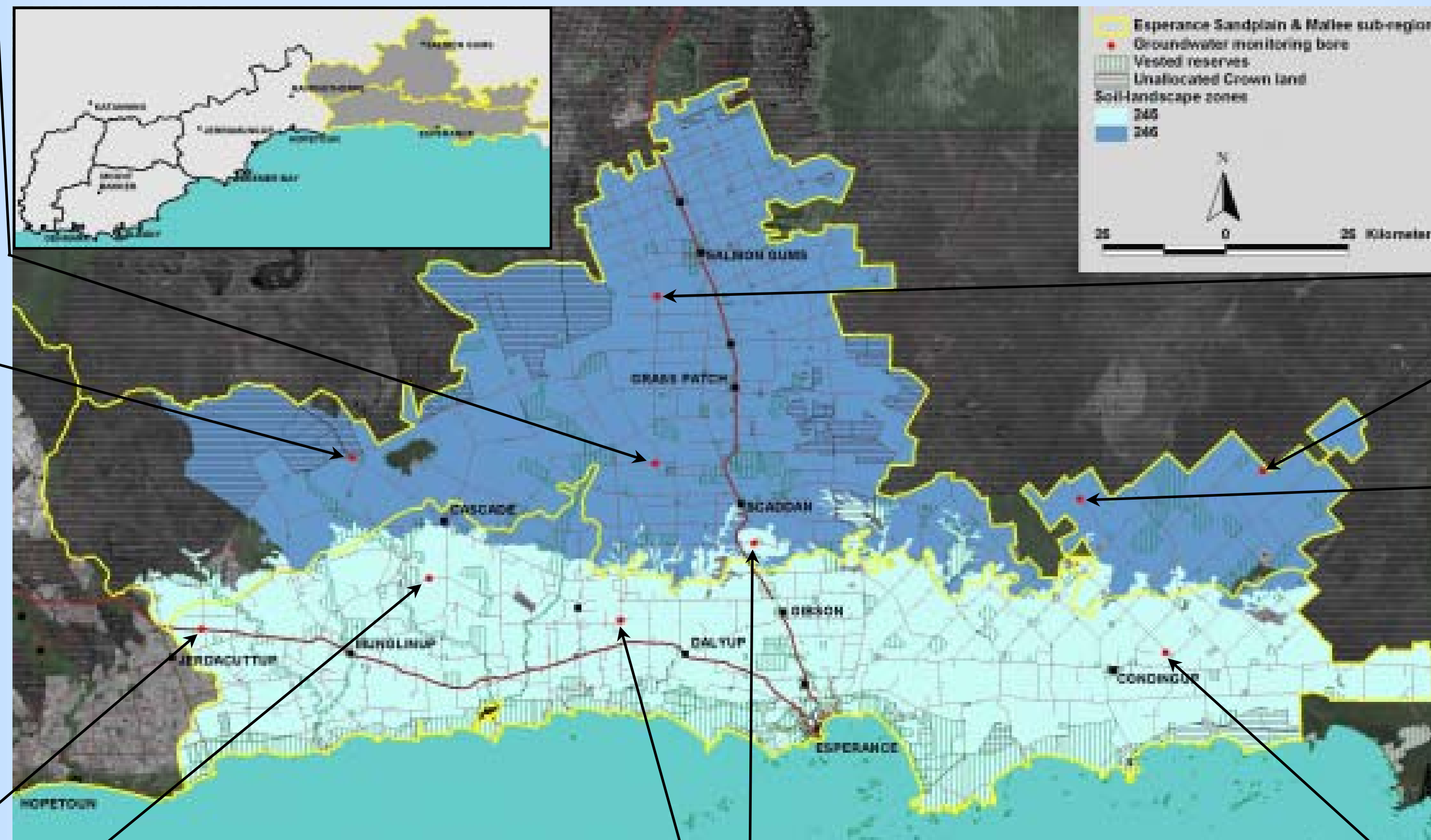
Location: North-west of Esperance; Young River catchment
Soil-landscape system: Scaddan (246Sc)
Soil: Alkaline grey shallow sandy duplex
Land use: Cropping / pasture
Landform: Upper slope
Average annual rainfall: 350 mm



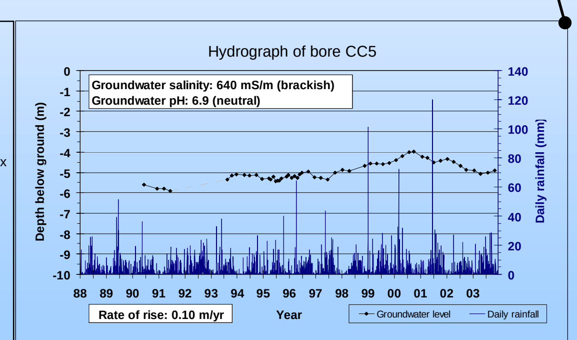
Location: West of Esperance; Oldfield River catchment
Soil-landscape system: Munglinup (245Mu)
Soil: Grey deep sandy duplex (gravelly)
Land use: Cropping / pasture
Landform: Flat
Average annual rainfall: 500 mm

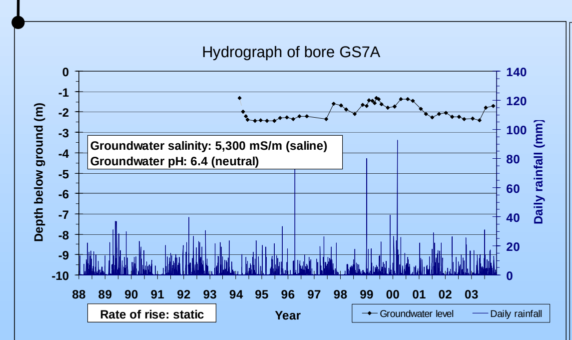


Location: North-west of Esperance; Young River catchment
Soil-landscape system: Munglinup (245Mu)
Soil: Grey deep sandy duplex (gravelly)
Land use: Cropping / pasture
Landform: Flat
Average annual rainfall: 450 mm

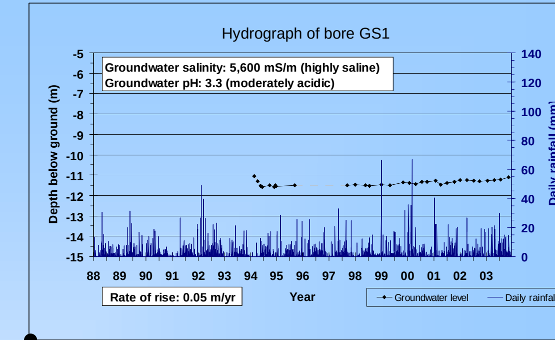


Location: North-west of Esperance; Coobidge Creek catchment
Soil-landscape system: Esperance (245Es)
Soil: Grey deep sandy duplex
Land use: Cropping / pasture
Landform: Flat
Average annual rainfall: 525 mm

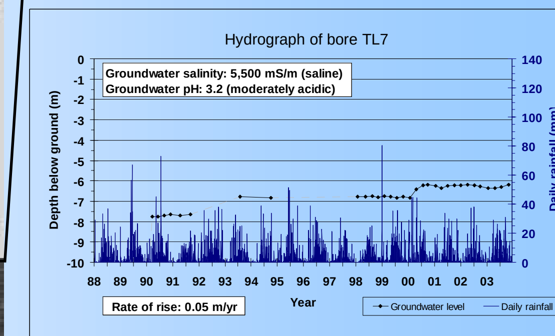




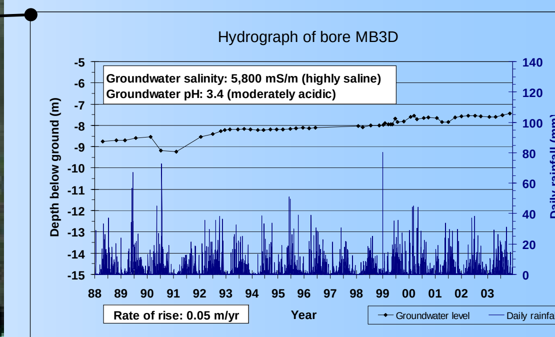
Location: North of Esperance; Dalyup Catchment
Soil-landscape system: Esperance (245Es)
Soil: Pale deep sand
Land use: Roadside
Landform: Simple slope
Average annual rainfall: 450 mm



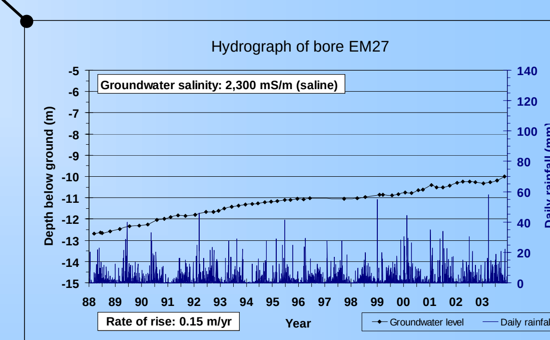
Location: North of Esperance; Salmon Gums area
Soil-landscape system: Salmon Gums (246Sg)
Soil: Alkaline grey deep sandy duplex
Land use: Cropping / pasture
Landform: Flat
Average annual rainfall: 350 mm



Location: North-east of Esperance; Beaumont area
Soil-landscape system: Buraminya (246Bu)
Soil: Calcareous loamy earth
Land use: Cropping / pasture
Landform: Flat
Average annual rainfall: 375 mm



Location: North-east of Esperance; Kau area
Soil-landscape system: Halbert (246Ha)
Soil: Alkaline grey shallow sandy duplex
Land use: Cropping / pasture
Landform: Flat
Average annual rainfall: 425 mm



Location: East of Esperance; Mungliginup Creek catchment
Soil-landscape system: Esperance (245Es)
Soil: Alkaline grey deep sandy duplex
Land use: Cropping / pasture
Landform: Lower slope
Average annual rainfall: 525 mm

Figure 1: Groundwater trends in the Esperance Sandplain and Mallee sub-regions

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Table 1: Risk of shallow watertables for systems in the Esperance Sandplain and Mallee sub-regions

SCRIPT sub-region	Soil-landscape zone	Soil-landscape system	% of sub-region's agricultural land in system	Risk of shallow watertables[NLWRA]			Proportion of system with low-lying areas (0–0.5 m)[LMP]
				2000	2020	2050	
Esperance Sandplain	Esperance Sandplain (245)	Esperance (245Es)	51	M	M	H	25
		Munglinup (245Mu)	19	M	H	H	15
		Young (245Yo)	9	H	H	H	10
		Condingup (245Co)	4	M	M	M	20
		Ney (245Ne)	2	M	M	H	10
		Other	10	NA	NA	NA	-
	Salmon Gums Mallee (246)	Scaddan (246Sc)	4	M	M	M	25
		Halbert (246Ha)	1	M	M	M	45
Mallee	Salmon Gums Mallee (246)	Scaddan (246Sc)	45	M	M	M	25
		Halbert (246Ha)	26	M	M	M	20
		Salmon Gums (246Sg)	18	L	L	L	25
		Buraminya (246Bu)	4	M	H	H	30
		Wittenoom (246Wm)	1	NA	NA	NA	10
	Esperance Sandplain (245)	Esperance (245Es)	3	M	M	H	35
		Munglinup (245Mu)	1	M	H	H	15
		Ney (245Ne)	1	M	M	H	10
		Young (245Yo)	1	H	H	H	10

Source: Short and McConnell (2001)

NLWRA and LMP: Refer to *Further Information* for definitions and risk categories

Further information

Soil-landscape zones and systems

Soil-landscape mapping in south-western Australia is based on a hierarchical system that enables correlation between surveys at different scales and maintains a consistent approach for dealing with areas of varying complexity in both landscape and soil patterns.

The first two levels of the hierarchy, *regions* and *provinces,* are based on the descriptions and framework introduced by the CSIRO Division of Soils in 1983 for the whole of Australia. The remaining four levels of the hierarchy - *zones, systems, subsystems* and *phases* are based on mapping conducted by the Department of Agriculture, Western Australia. At higher levels in the hierarchy the mapping units are based on regional geomorphological differences and at lower levels the individual soil and landscape components become more important.

The level of mapping unit is implicit in its label and as the scale of mapping increases, the label (in brackets) becomes more detailed. For example, the South Coast region falls into the hierarchy's Western Region (<u>2</u>) and predominantly within the Stirling Province (2<u>4</u>) with some overlap into the Avon Province (2<u>5</u>). Zones within these provinces are defined using geomorphological and geological criteria, and areas in these zones with recurring patterns of landforms, soils and vegetation, are grouped into systems. For example, the Esperance Sandplain sub-region contains predominantly the Esperance Sandplain Zone (24<u>5</u>), which contains a number of systems, including the Munglinup System (245<u>Mu</u>) and the Esperance System (245<u>Es</u>). The information in this publication pertains to soil-landscape zone and system level.

Groundwater flow systems

Groundwater processes causing salinity can be categorised according to their flow systems because the scale (local, intermediate or regional) of the system reflects the ease with which salinisation can be managed.

Local groundwater flow systems are those where recharge and discharge of groundwater are in close proximity — usually within 1–3 km. These systems are very responsive to land use changes.

Intermediate groundwater flow systems have a horizontal extent of 5–10 km and generally occur across several properties.

Regional groundwater flow systems have groundwater recharge and discharge areas separated by distances of 50 km or more and consequently these systems are very slow to respond to land use changes. Regional groundwater flow systems can be overlain by local and intermediate groundwater flow systems.

National Land and Water Resources Audit (NLWRA)

The NLWRA was established in 1997 under the *Natural Heritage Trust Act*, to collect and collate primary data and information related to natural resource management. The extent and impacts of dryland salinity were identified as part of the NLWRA.

Risk of shallow watertables

Risk of shallow watertables was assessed using groundwater level trend data from the Department of Agriculture's AgBores database. Risk of shallow watertables (Table 2) was applied to entire soil-landscape system units based on an assessment of the most frequently occurring groundwater depth and trend data for each unit.

Table 2: Definition of risk categories

Risk	Groundwater level and trend
High (H)	<2 m 2–5 m and rising
Moderate (M)	<2 m and falling 2–5 m and static or falling 5–10 m and rising >10 m and rising
Low (L)	5–10 m and static or falling >10 m and static
No risk	>10 m and falling
Not assessed (NA)	Insufficient groundwater data to make an assessment

Land Monitor Project (LMP)

The LMP was a satellite and terrain-based assessment combined with mapping of salinity, topography, and vegetation extent and change.

Low-lying areas

A Digital Elevation Model was used to determine 'height above flowpath' in order to map low-lying areas. Height above flowpath measures the vertical elevation from flowpaths, which are areas where water flow accumulation is high (not just creeklines). Once the flowpath is defined, the low-lying areas within a discrete (0.0–0.5 m) height class above the flowpath can be identified. Low-lying areas may be at risk of flooding, inundation and waterlogging, and where groundwater levels are rising, indicate areas with potential to develop shallow watertables.

Salinity Investment Framework (SIF)

The SIF was undertaken to guide public investment in salinity management initiatives. As part of the process, an assessment of the range of salinity management options was undertaken for each soil-landscape zone. The options assessed included existing engineering and plant-based practices or systems that will deliver the maximum impact on the extent and severity of salinity.

Timing of salinity

Hydrological equilibrium occurs when the groundwater in an area of risk ceases to rise and the area of groundwater discharge ceases to expand. The average time required for a soil zone to reach hydrological equilibrium (Table 3) was assessed on the basis of available groundwater level trend data and analyses prepared for the National Land and Water Resources Audit.

Table 3: Timing scales of salinity

Term	Time until potential salinity develops fully
Imminent	<10 years
Short-term	10–20 years
Short-medium term	20–30 years
Medium-term	30–75 years
Long-term	>75 years

Technical feasibility of salinity management

Technical feasibility is a measure of the availability and capacity of salinity management options to recover, contain or adapt to salt-affected land. The technical feasibility factors are largely qualitative and were based on published data and assessments by hydrologists from the Department of Agriculture. The technical feasibility is based on the average hydrological responsiveness of the entire soil-landscape zone.

Definitions of technical feasibility are:

- recovery – reverse the salinisation process and recover degraded land and water resources
- containment – manage salinity so that further impacts are minimised
- adaptation – live with and adapt to the consequences of salinity and minimise the losses.

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