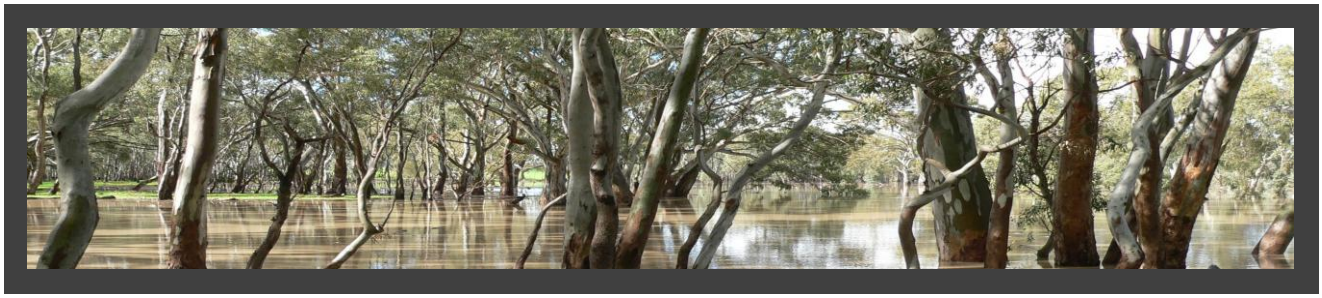

Natural Resources of the Tatiara

A plan for local action

2013 – 2018

Prepared by the Tatiara Local Action Plan Committee

On behalf of the Tatiara District Council

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Purpose of the Plan

The Tatiara District Council has identified the need to develop a local natural resources plan which aims to:

- Describe the natural resource assets of the council area,
- Identify problems in need of remedy or amelioration,
- Promote sustainable land and water management practices,
- Protect and enhance the environment,
- Safeguard and improve upon regional biodiversity,
- Predict and project the consequences of emerging issues,
- Link to the policy agendas of the South East Natural Resources Management Board and the South Australian and Federal governments,

and

- Serve as an investment prospectus for future funding opportunities required to support the implementation of the plan.

In doing so the plan embodies a Vision, a Mission and a set of Goals.

Vision (Where we want to be)

"An informed community managing our natural resources for the future"

Mission (What we have to do to get there)

"Facilitate the continual improvement, understanding and implementation of sustainable environmental and farming practices in the Tatiara"

The plan is a community driven endeavour. It has been prepared by local people who have contributed a wide range of knowledge and experience to the task.

The plan represents a perspective of sustainable agriculture and natural resource management within the Tatiara District Council. However it is not a unique stand-alone document. Natural resource issues cover wide geographic areas and are ever changing in terms of scale and scope. Hence this plan takes into account and considers other plans, both current and previous, that relate to, or border upon, the Tatiara. Some of these are listed as follows.

- South East Natural Resources Management Plan (Revised 2010).
- Limestone Coast Region Plan 2010.
- Water Allocation Plans: Padthaway (2009), Tatiara (2010) and Tintinara – Coonalpyn (2012).
- Lacepede / Tatiara Soil Conservation Board District Plan 2000.
- Tintinara – Coonalpyn Land and Water Management Plan 2006.
- Coorong District Local Action Plan 2012.
- Various Council Development and Strategic Plans.

Appendix 1 shows how the plan integrates with other allied natural resource management bodies and agencies.

Goals

The plan aims to achieve a number of goals concerning the resources associated with agriculture and the natural environment.

- Maintain and improve upon a sustainable agricultural base for the district.
- Increase perennial vegetation and annual surface cover.
- Use groundwater resources within their capacity.
- Limit groundwater rise and salinity effects.
- Improve water use efficiency in both dryland and irrigated enterprises.
- Enhance remnant vegetation and other biodiversity assets.
- Protect soils from erosion.
- Increase soil carbon (fertility) and minimise greenhouse emissions.
- Manage watercourses and wetlands.
- Control pest plants and animals.
- Balance land use with land class capability.
- Encourage ecologically sustainable development.

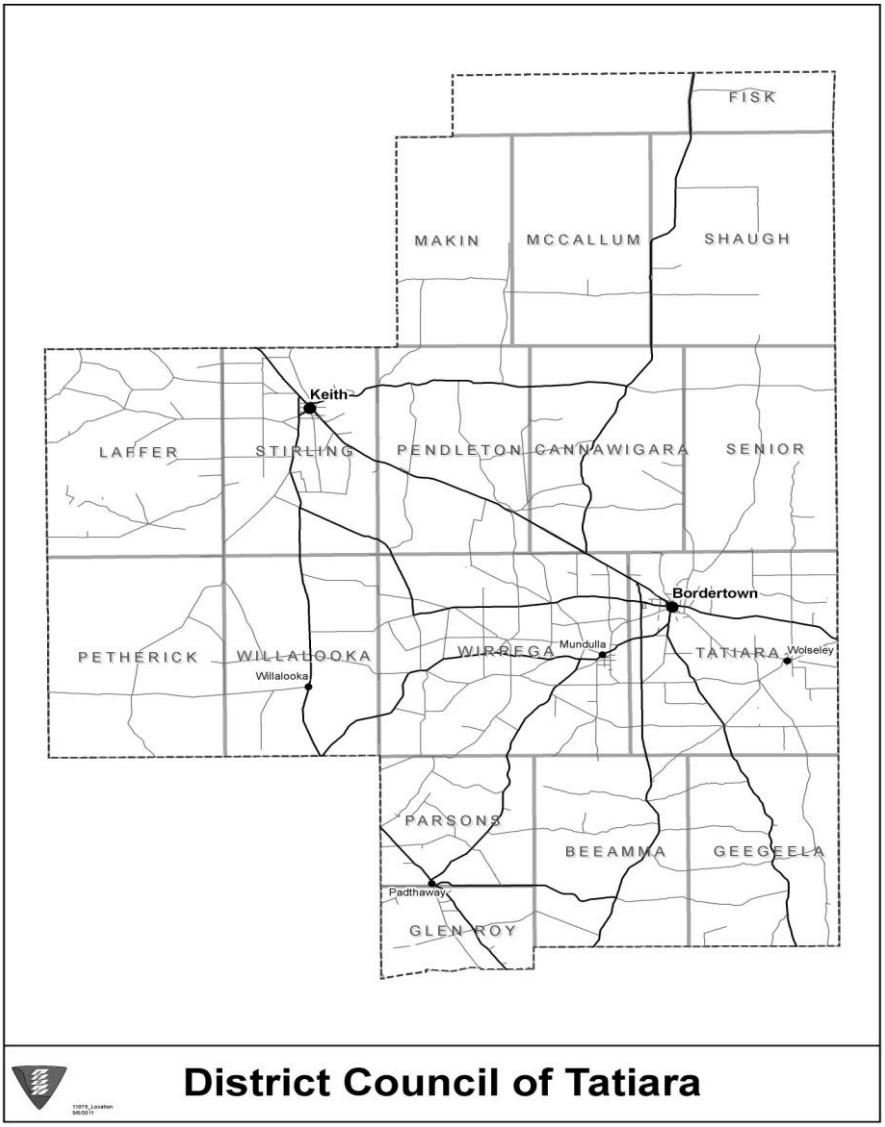

Figure 1: Hundreds within the Tatiara District Council.

Forward

Awareness of the need to improve management of our land and water resources has increased significantly over the last three decades to the point where 'landcare' can now be viewed as an embedded community ethic. The impetus to increase farm productivity and a more diversified agricultural economy has changed land use and soil and aquifer management. New crops are being grown, grazing practices have been modified, irrigation water is used more efficiently and the value of new and remnant native vegetation has gained greater recognition. Biodiversity and the dynamics of sustainable ecological systems now play key roles in our thinking.

The awareness of our natural resources and how to manage them have spread throughout the community. However landcare is not just limited to rural landholders – school children and township residents are active stakeholders as well.

During 2010 the Tatiara District Council appointed a committee to assist it in maintaining and enhancing the progress that has been made over recent years. Borrowing from the example of the Coorong District Council a Local Action Plan group was established. This team has prepared the initial Natural Resources Plan for the Tatiara

The plan describes the key natural resources of the district, identifies a number of issues of concern, suggests remedies or improved practices, discusses the role of biodiversity in the local environment and sets general priorities for action. People and their willingness to be involved as landholders or volunteers are key drivers towards implementation and change.

The plan focuses on the Tatiara but also takes into account matters of regional, state and national importance.

It should be recognised that the issues discussed and the actions identified are not exhaustive and that sustainable natural resource management is an evolving process. Hence the plan will continue to change as information is updated, new issues emerge and technology attempts to keep up, and as community needs and expectations shift.

As an agriculturally based district there are many natural resource challenges to be faced. Factors such as soil structure and fertility, salinity, sodicity, drainage, acidification, wind erosion, both rising and falling water tables, weeds and pest animals all create problems to some degree. Many of these have been around for a long time but they still need attention. The biodiversity of the districts natural resource assets is an indicator of longer term sustainability. Climate variability, water security and atmospheric greenhouse gases are emerging issues that cannot be ignored.

The plan is not a legislative document. It is designed to summarise the issues for the district and through a process of community consultation seek a general understanding and agreement about those of primary importance. In turn, Council is then in a better position to act locally and represent stakeholders at higher levels of government.

Neither Council or individual landholders and ratepayers are in a position to comprehensively fund all the actions that arise from this plan. Therefore it is expected that the document will act as an investment prospectus in support of future applications for financial support from state and federal governments when opportunities arise.

Adrian Barber
Chair, Tatiara Local Action Plan Committee.

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Role of the Coorong Tatiara Local Action Plan Project

The Coorong Tatiara Local Action Plan Project brings together the objectives and activities of both the Coorong and Tatiara Local Action Plans to promote and enhance natural resource management and sustainable agriculture across a broad area of the Upper South East.

The role of the Project involves:

- Seeking funds from a range of Local, State and Commonwealth Government sources, along with industry organisations, to address issues identified in the Local Action Plans.
- Engaging with stakeholders to implement on-ground works programs that provide benefits to the natural environment and sustainable agriculture.
- Conducting education programs with landholders, students and the public.
- Partnering with other agencies to deliver natural resource management and sustainable agriculture outcomes within the region.
- Encouraging community participation in the Project's activities.

The Project aims to fulfil its role by:

- Distributing funds to landholders for approved on-ground works activities and monitoring, reporting and promoting the success of these undertakings.
- Conducting or jointly sponsoring a range of field days, seminars and other educational events.
- Supporting school and youth involvement in environmental projects.
- Providing representation, knowledge and experience to other groups involved in natural resource management.
- Maintaining an ongoing communication strategy including newsletters, fact sheets, the media and a web presence.
- Providing support and resources that enable community groups and individuals to further develop their understanding and skills in environmental management.
- Enhancing partnerships between the community, government, industry, indigenous groups, individual landholders and volunteers.
- Receiving governance and guidance from the two respective Local Action Plan Committees of the Coorong and Tatiara District Councils.
- Undertaking activities across both Council areas, or separately, depending on identified issues and available funding.
- Reviewing achievements and refreshing targets on an ongoing basis.

The Tatiara Local Action Plan Committee recognises that the management of natural resources starts with individuals. Each community member has the responsibility and ability to improve their land management practices, while influencing management of lands surrounding their own. They also need to sustain a profitable income for themselves and contribute to a viable community.

Despite this, some issues are too large or complex for individuals to tackle without support. A key feature of this plan is to assist individuals and neighbourhood groups with on-farm and community activities that address these larger issues in an effective and timely manner.

Executive summary

The Natural Resources Plan for the Tatiara (also referred to as the Local Action Plan) covers an area of 6,515 square kilometres in the Upper South East of South Australia.

This inaugural plan has been prepared by the Tatiara Local Action Plan Committee at the request of the Tatiara District Council. The plan is a community driven document. It has been developed by local people who have brought a wide range of knowledge and experience to the task.

The plan provides brief descriptions of the natural and community resources of the Council area. These are aspects such as soil types, aquifers and water use, farm practices, the extent and condition of native vegetation and social and economic infrastructure.

The Committee has identified a number of topics considered to be of importance to natural resource management and sustainable agriculture in the district and these are grouped into six themes.

Land and soils

Dryland salinity
Irrigation salinity
Wind erosion
Soil pH (acidity and alkalinity)
Non-wetting sands
Sodic soils and waterlogging
Water erosion
Soil structure, biota and fertility
Matching land use with land capability

Water and aquifers

Runaway holes and drainage bores
Water security
Aquifer extraction, recharge and salinity status
Watercourses and wetlands

Vegetation and biodiversity

Native vegetation, biodiversity and loss of habitat
Remnant vegetation preservation

Agricultural and environmental protection

Pest plants
Pest animals

Climate challenges

Greenhouse gas emissions
Climate change and variability

Social and economic

Social infrastructure
Economic impacts
Indigenous heritage
Community engagement, education and awareness

Each of the topics is discussed and management actions are identified that can improve the condition of the resource or ameliorate any problems.

The plan describes the current program of works being undertaken by the Coorong Tatiara Local Action Plan Project and identifies further activities that could or should be undertaken in the future.

The plan recognises that local financial resources are inadequate to address current and emerging natural resource management issues and seeks to attract external funding from State or Commonwealth Governments. This may be via direct project grants or through partnership arrangements with other agencies.

In doing so, the plan links with the priorities of the South East Natural Resources Management Board and through to the South Australian Natural Resource Management framework.

Sustainability needs to take into account the triple bottom line of economic, social and environmental interactions. All must be adequately nurtured and integrated for the whole to work as a viable system.

The Natural Resources Plan for the Tatiara seeks a balanced program of works and projects that support a sustainable approach to landscape management involving both the agricultural industry and concerned citizens in partnership for the future.

The Tatiara at a glance

The Tatiara district is located in the Upper South East of South Australia approximately 200 kilometres southeast of Adelaide and adjoins the Victorian state border. It covers an area of 6,515 km^2. The population is approximately 7,000 people with about half living in townships. Land uses include mixed dryland cropping and grazing, irrigated broad acre crops, viticulture, horticulture, hay and pasture seed production and pastures for grazing. Livestock enterprises are principally wool sheep, prime lambs and beef cattle. Other primary industries include beekeeping, floriculture and olives.

Approximately 20 percent of the area is covered with remnant native vegetation. Protected areas include part of Ngarkat, along with Moot-Yang-Gunya, Poocher, Wolseley Common, Mount Monster, Aberdour, Padthaway, Desert Camp, Gum Lagoon, Harding Springs, Mount Shaugh, Mount Rescue, Custon, Pine Hill Soak and Bangham conservation parks and a number of smaller conservation reserves.

Major natural resource issues include salinity in land and water resources, watertable rise (and decline), sustainable groundwater use, soil structure and fertility, pest animal and weed control, wind and water erosion, remnant vegetation management, threats to biodiversity and various dieback conditions in mature trees.

Rainfall averages 400 mm in the north to 525 mm in the south.

Irrigation allocations from the unconfined aquifer amount to approximately 280 GL per annum with an estimated average usage factor of around 60%. This water is applied to approximately 5% of the district's agricultural land.

Two seasonal watercourses, the Tatiara and Nalang Creeks flow from the east and terminate in swamps and runaway holes in and around Mundulla and the Cannawigara Road areas.

The number of farm businesses is approximately 800.

The district straddles the Adelaide – Melbourne transport route with other major roads leading to the Lower South East and Riverland regions.

The main towns are Bordertown and Keith with smaller settlements at Wolseley, Mundulla and Padthaway.

Figure 2: Irrigated enterprises are a key component of the local economy.

1. Resource descriptions

1.1 Topography

The Tatiara district is divided by topography into two distinct landforms, the low-lying undulating remnant coastal plain to the southwest and the sand dune and clay soil highlands to the northeast. The two landforms are separated by a scarp running diagonally through the district which is formed by the Marmon-Jabuk and Kanawinka faults. The scarp marks the landward edge of the sea from almost one million years ago.

The natural resources of each landform are quite different. They are referred to as the Coastal Plain and the Mallee Highlands with loess (unstratified, geologically recent sedimentary deposits of silty or loamy material) soil intrusions in the eastern and central region.

On a broad scale the topography forms a series of elevations stepping up from sea level at the coast with ridges and interdunal flats aligned in a southeast to northwest direction. Slope and surface drainage on the flats is to the west and northwest.

The low undulating areas of the coastal plain were once seafloor. These historically inundated soils are generally nutrient poor and carry high subsurface salt loads, similar to areas directly adjacent to the coast and the Coorong.

The Tatiara overlies the junctions between the Murray Basin, Padthaway Ridge and Otway Basin. The Padthaway Ridge is a low ridge of marine origin shale. In some areas granite extrudes through faults in the shale. Examples include Mount Monster, Christmas Rocks and Kongal Rocks.

The Padthaway Ridge separates the Murray Basin from the Southern Ocean. It intercepts considerable portions of the regional groundwater flow, directing it towards the Murray mouth or seawards around Kingston.

1.2 Landscapes and soils

For the purpose of this plan the soils of the district are described by general categories associated with major landscape features. Where particular individual soil types present management problems they are discussed in the Issues section. A landscape can be considered as a tract of land with a repeating pattern of geology, topography, soil types and vegetation.

Detailed information on soil types and their profiles and distribution can be referenced from a DVD-ROM *Regional Land Resource Information for Southern South Australia 2007* prepared by the former Department of Water, Land and Biodiversity Conservation. See Appendix 2 for a separate map of the major soil types represented in the Tatiara.

The soils of the Tatiara vary in composition, but are mainly sediments of marine origin. There are some areas of riverine and glacial sediment deep within the soil profile and other areas that were formed on basement rock.

Although there are significant areas of highly productive land within the Tatiara, there are many areas where agriculture is only possible as a result of technological advancements in the use of fertilisers and trace elements and developments in soil enhancement practices.

A number of threats to the landscape features have been identified and these may impact on more than one soil category.

- Soil acidification
- Dryland salinity
- Wind erosion

- Soil fertility decline
- Water repellence
- Soil structure and physical condition
- Soil sodicity and waterlogging
- Effects of irrigation
- Soil borne diseases and contaminants

1.2.1 Dune rises and flats

The dunes generally vary in height from a few metres to tens of metres and are interspersed with areas of flats (swales) of various size. The dunes may lie in longitudinal or jumbled formations. Longitudinal dunes tend to have a southeast-northwest orientation. The dunes are geologically ancient seacoast windblown deposits. The swales may contain swampy depressions depending on the nature of the underlying subsurface and the height of the unconfined aquifer. The proportion of dunes in the landscape can vary from 30% to 100%.

The dunes consist of siliceous sands which originated from erosion and re-deposition of the sandy sediments of the Murray basin and the coastal plain during relatively recent climatic periods.

The flats commonly consist of sand over clay soil types. The sediments underlying the flats are highly variable and may consist of sandy clays, heavy clays, marls or limestone.

Cleared dune rises act as preferential groundwater recharge areas in the absence of deep rooted pasture (lucerne) or other perennial vegetation.

Productive potential and land use

Dune rises and flats have a low productive potential in their natural state and may suffer from water repellence. They are also susceptible to acidification and wind erosion. Clay spreading and clay delving have greatly improved the resource capability and large areas of these soils are likely to be altered using these processes. Lucerne has historically been the preferred pasture species on the dunes with some use of Veldt grass and Evening primrose. The landscape is predominantly used for dryland grazing, however in recent years claying has made crop production far more profitable.

This landscape has retained a relatively high level of remnant vegetation, providing significant social and environmental value.

1.2.2 Deep sands

Deep sands may be interspersed within the Dune rise landscape. Predominantly characterised by tall and steep dune formations, this landscape is of inherently low fertility and prone to wind erosion. The soil is of deep bleached siliceous sands.

Productive potential and land use

This landscape is considered of low economic value for agriculture and often retains a high proportion of remnant native vegetation (often Stringybark and Yakka associations).

The sandy soils are particularly poor at retaining nutrients with a large proportion being lost beyond the root zone of most pasture and crop species due to leaching.

1.2.3 Sand over clay

Almost three quarters of this landscape consists of grey sandy surfaced soils, the majority of which have clay subsoils overlying soft or rubbly lime at depth. A characteristic feature of virtually all the sandy soils is the presence of a strongly bleached subsurface layer. Clay subsoils are usually yellow-brown mottled in colour. The bleaching and mottling indicate seasonal waterlogging and the clay subsoil is commonly dispersive (sodic). Non-sandy soils include sandy loam over clay types, cracking clays, and a variety of soils prone to waterlogging.

The topography is of flat to gently undulating plains that are commonly interrupted by low stony rises and ridges. Small swamps are common in places, especially where underground water tables are close to the surface or perched water tables overly impermeable clays. Jumbled sand dunes can also be present.

Productive potential and land use

The sandy soils have low natural fertility and are prone to acidification, water repellence and wind erosion if left exposed. A significant problem can be waterlogging, caused by water perching on the dense dispersive subsoil clay. Use of deep ripping, delving and gypsum incorporation to break up the clay has met with variable success. In the west of the Tatiara there is some risk of salinisation.

Originally these soils were sown down to annual pastures for grazing but now crop rotations are common. Irrigation using both flood and centre pivot systems may be used for the production of hay crops and pasture seeds.

1.2.4 Red Gum country

This landscape is typically flat to gently undulating with minor sandy and stony rises. Seasonal swamps and runaway holes provide recharge to the groundwater table.

The main soils are shallow red and black sandy loam to loam over limestone, and sandy loam over red, grey or brown clay with soft to rubbly lime at depth.

Productive potential and land use

The soils are moderately fertile and generally well drained, although salt can build up after prolonged irrigation. This landclass is some of the most productive in the Tatiara.

A wide range of dryland crops and pastures are grown and irrigation is used for the production of hay, pasture seeds and winegrapes.

1.2.5 Wimmera country

As the name implies, this landscape is the westward extension of the Victorian Wimmera. It is a very gently undulating slightly elevated plain which the Tatiara and Nalang Creeks pass through. Localised micro-depressions (crabholes or gilgai) occur in places as a result differential shrinking and swelling of clayey substrate materials.

The characteristic soils are deep cracking clays. These tend to be black to dark grey or brown. They are usually alkaline throughout. Associated soils are hard sandy loams over red or brown clays, with soft lime at depth.

To the north of the Dukes Highway and surrounding the Tatiara creek mixed soils form a transition zone. Here the soil types can change markedly within small distances and may consist of red sandy clays with free ironstone, red hard setting clays, black or grey clay loams and sandy rises.

Remnant vegetation associations can be quite variable with stands of River box, Redgum, Bluegum, Peppermint box, Bulloak, Mallee, Stringybark and Native pine all present.

Productive potential and land use

The clays are naturally fertile although commonly deficient in phosphorus. Surface soils are often hard setting, a condition usually corrected by gypsum application. They readily accept water, but become very sticky and difficult to work when wet. Due to the low permeability of the red and brown clays, waterlogging can occasionally be a problem.

Due to their inherent fertility the soils are able to sustain a program of continuous cropping incorporating rotations of cereals, pulse crops and oilseeds with ley pasture break years. However in times of drought this landscape can perform less favourably when compared to the surrounding Red Gum country and Sand over clays due to its lesser ability to respond to light spring rainfall events.

1.2.6 Range country

These are landscapes of rises and hills, more or less parallel to the coast line. They are the ancient coastal dunes, stranded as the sea level progressively receded over the last million years or so. The ranges are composed of shell and silica and calcareous sands which have hardened at the surface to sheet or rubbly rock called calcarenite (a special type of limestone). Sand from the original dunes has been reworked by wind action into sand spreads and new dunes that now over lie most of the calcarenite. The distribution of this sand is highly variable, but tends to be deeper and more widespread on the eastern or leeward sides of the ranges.

The ranges have heights varying from less than 10 m up to 60 m, and slopes up to 12%.

Productive potential and land use

The sandy soils have low inherent fertility and are prone to water repellence, acidification and wind erosion. The shallower soils over calcarenite can be difficult to work (cultivate) due to surface stone and sheet rock. There is some scope for improved pasture productivity to increase water use efficiency and carrying capacity. Lucerne establishment and persistence is a key issue.

This landscape is considered to be good winter country and a place of refuge for livestock in wet years where adjacent low lying areas may be inundated.

The Range country of the Tatiara represents a key store of remnant native vegetation and biodiversity protection.

1.2.7 Sand over limestone

This landscape is generally located to the southwest of the Range country at the divide between the mallee highlands and the coastal plains. The flat plains are the floors of the ancient lagoons which separated the coastal dunes (just as the modern Coorong does today). On the flats there are shallow loamy sands over limestone, often with a clayey subsoil, sand over clay soils, grey clays and variable swamp soils where the watertable is near or at the surface.

Surface stone and occasional sheet rock are common. Granite outcrops occur where molten rock from deep in the earth's crust has solidified and been exposed to erosion at the surface (eg Mount Monster). These rocks pre-date any of the other geological materials of the Tatiara by hundreds of millions of years. Other outcrops appear along an ancient fault line with granite intrusions at regular intervals.

Throughout this landscape the unconfined aquifer is relatively close to the surface. However the available water tends to be in the upper range of salinity for most agricultural crops.

Productive potential and land use

The soils are generally well drained and with the shallow water resource large areas have been developed for irrigation. Irrigated crops are predominantly hay and pasture seed production, mainly lucerne seed. Irrigation application is mainly via flood systems.

A wide range of dryland crops are grown along with grazing of livestock. This landscape is generally suitable for diversified mixed farming enterprises.

1.2.8 Salty flats

The key feature of this landscape is a saline watertable at shallow depth. The flats are corridor plains (old lagoons) extending inland from the coast between ancient coastal dunes. These corridors have an imperceptible fall to the north. Swamps occur where the natural flow of water is interrupted. The corridors also have a slight fall to the west, causing water to pool against the adjacent range. Chains of swamps on this alignment are common and may be permanent seasonal wetlands. Low sandy and stony hummocks can be found scattered across the corridors. The more northerly and eastern saline flats are not clearly bounded by linear ranges, and consist of a mosaic of flats, swamps, sandy and stony rises.

Throughout the landscape the severity of surface salinity is determined by the salinity of the shallow underground water table, usually at 1 to 2 metres. The degree of surface inundation varies depending on seasonal rainfall and interdunal flows.

The main soils on the flats are sand over clay, shallow sandy loam over limestone, and calcareous loam over pipe clay or black clay.

Productive potential and land use

A large proportion of the landscape consists of highly saline soils which are defined as being too salty for any field crops and conventional pasture species. Inherent soil fertility is poor and particularly phosphate deficient.

In the last 15 years the Upper South East Dryland Salinity and Flood Management Scheme has been implemented to construct a network of man-made drains to remove saline waters from the landscape. This program of work has also involved the introduction of salt tolerant pastures, retention and rehabilitation of areas of native vegetation and re-establishment of deep rooted perennials (lucerne and revegetation) on the adjacent dune rises. The scheme also redirects seasonal floodwaters into wetland areas where appropriate.

Grazing of livestock is the main enterprise but is dependent on the provision of fresh stock water and the supplementation of several trace elements (copper, cobalt and selenium). The rapidly rising cost of pipeline delivered water from the Murray is a threat to the longer term profitability of grazing in this and adjacent land classes.

The salt and waterlogging tolerant pasture species, puccinellia and tall wheat grass, are both perennial grasses and research continues on a suitable range of salt tolerant legumes that can be added to the pasture mix.

Swamps and wetter flats provide valuable wetland habitats and large areas are retained as conservation parks or privately-owned reserves much of which is under Heritage Agreements.

1.2.9 Terra Rossa

The Tatiara includes one small strip of Terra Rossa soils near Padthaway. This landscape is characterised by level to gently undulating plains and low linear ridges and may show calcrete and limestone outcrops in places. Sandy loam to loam soils are predominantly spread over a limestone or gravel base.

Productive potential and land use

The soils are mainly of moderate to high fertility, although most have limited water holding capacity. These features have made this landscape highly desirable to the viticulture industry but it is also suitable for a wide range of agricultural and irrigated horticultural enterprises.

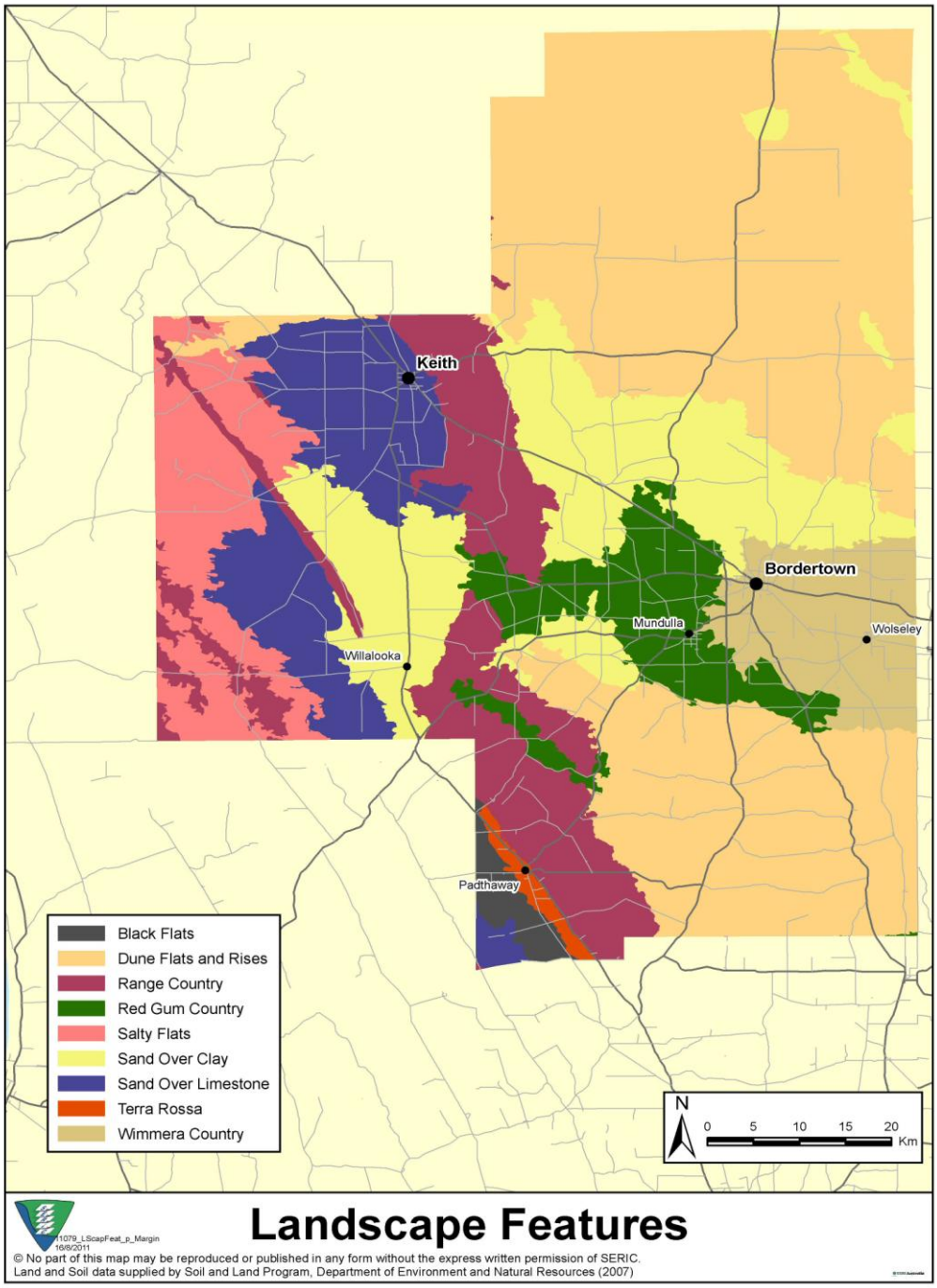


Figure 3: Soil associations within the Tatiara based on landscape classes.

NOTES ON USE OF MAPS SHOWN IN THE TATIARA NATURAL RESOURCES PLAN:

1. The data is derived from limited field inspection, and is subject to change without notice.
2. Boundaries between mapping units should be treated as transition zones.
3. The maps are intended to provide a regional overview and should not be used to draw conclusions about conditions at specific locations.
4. Under no circumstances must the scale of the map be enlarged beyond its scale of mapping.
5. Advice from DEWNR Soil and Land Program should be sought prior to using this information for commercial decision making.
6. Under no circumstances may the data or information associated with the maps or any accompanying report be altered in any way without the express permission of DEWNR Soil and Land Program.

Land and Soil data supplied by Soil and Land Program, Department of Environment and Natural Resources (2007).

1.3 Surface waters

Two watercourses flow into the Tatiara district from the western Wimmera region of Victoria. These are the Tatiara and Nalang Creeks. Both creeks have their headwater catchments in the near-border zone and seasonal flows are dependent on local rainfall.

The Tatiara Creek flows from Victoria via Pine Hill through Bordertown to Poocher Swamp and continues through Cannawigara Swamp and several smaller ephemeral wetlands. Some of these wetlands have runaway holes within them and others exist in isolation, the most notable being Scown's runaway hole. Considerable work since 1981 has facilitated the access of floodwaters in wet years to other runaway holes along the Cannawigara Road. Some property owners on the low-lying country have also constructed drainage bores to alleviate flooding. Both the runaway holes and drainage bores play a key role in directing excess water as recharge back into the underground aquifer.

The Nalang Creek flows south and west from Choopawhip Swamp to terminate in the Moot-Yang-Gunya Swamp at Mundulla. Choopawhip Swamp is also fed by a surface drain from the Victorian border zone. An overflow path from Moot-Yang-Gunya Swamp joins with the Tatiara Creek near Scown's runaway hole.

The creeks provide valuable recharge to the unconfined aquifer and both the Poocher and Mundulla Swamps are on the list of Nationally Important Wetlands.

A floodplain continues westward along the Cannawigara Road and reaches the Riddoch Highway south of Keith, where it is diverted both north and south by the Black Range. The last time floodwater reached this point was in 1981. The 1998 flood was successfully recharged to the aquifer through the runaway holes and drainage bores and did not cause damage of the scale of the 1981 event or reach the Riddoch Highway despite the flow volume being approximately equal.

One of the design objectives for the Upper South East Dryland Salinity and Flood Management Scheme drainage network is to collect and channel any future major floodwaters north via Mount

Charles and south around the end of the Black Range to eventually empty into the Coorong at Salt Creek. Provision is also made to redirect floodwaters into wetlands along the flow paths.

The watercourses and swamps provide wetland habitats for the flora and fauna of the district and are a valuable resource for biodiversity conservation.

1.4 Unconfined aquifer

Parts of the Tatiara are subject to changing water table levels and increased groundwater salinities. This is generally due to human induced changes to the groundwater system, including clearance of native vegetation and groundwater extraction.

Throughout the western part and some of the mallee highlands clearing of native vegetation, along with deterioration of historic lucerne stands has caused greater recharge of the unconfined aquifer than naturally occurred. This increased recharge dissolves and mobilises salt from the soil profile, flushing it into the groundwater.

The unconfined aquifer underlying the Tatiara is a complex system of numerous interconnected hydrogeological units consisting of calcareous sandstone and limestone formations. The lateral underground water flow is influenced by watertable elevations (contours) and is generally east to west across the region. However this flow is slow moving, estimated at approximately 50 – 100 metres per year.

The unconfined aquifer is the primary source for stock, domestic and irrigation requirements in the Tatiara. SA Water has a borefield west of Bordertown where a localised unconfined aquifer of good quality water adjacent to the Poocher Swamp is extracted for use as mains water in the township, whereas Keith is supplied via a pipeline from the River Murray pumped from Tailem Bend.

The use, control and management of the underground water resource are governed by the:

- Water allocation plan for the Tatiara Prescribed Wells area (2010).
- Water allocation plan for the Padthaway Prescribed Wells area (2009).
- Tintinara - Coonalpyn Water Allocation Plan (2012).
- Border Groundwaters Agreement 1985. (20 km either side of the South Australian – Victorian border).

These legislative documents set the licensing conditions whereby end users may extract water from both the unconfined and confined aquifers. The Water Allocation Plans divide the landscape into separate Management Areas and the annual total volume that can be extracted in each area will vary. The Plans aim to ensure that water resources are managed sustainably for current and future requirements and that the needs of water-dependent ecosystems are met.

Figure 4: Flood irrigation of lucerne.

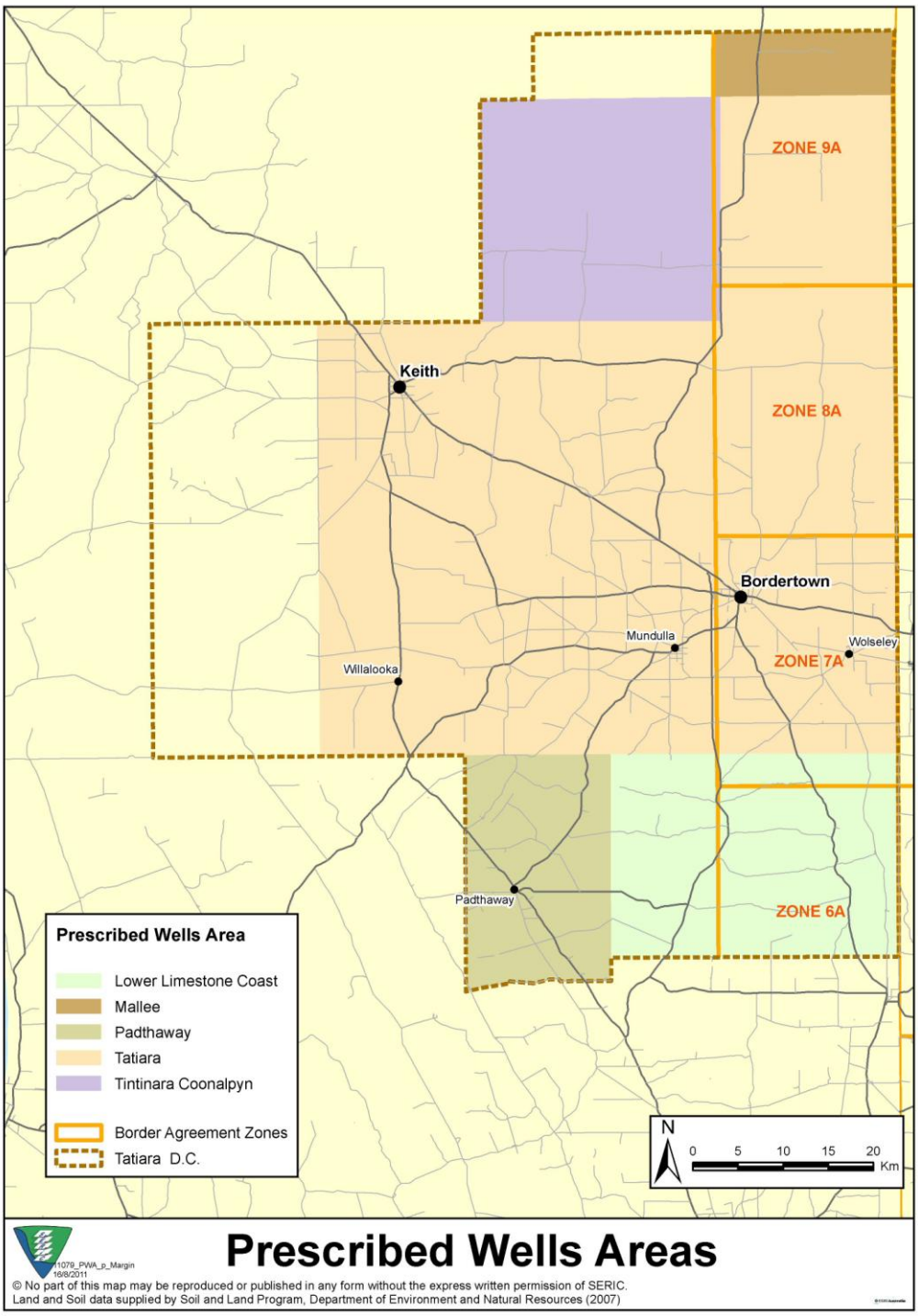


Figure 5: Prescribed Wells Areas within the Tatiara.

1.4.1 Groundwater levels

In the western part of the Tatiara depth to the water table is typically less than a few metres under interdunal areas while beneath the remnant dune ridges depth is often more than 15 metres. In eastern and northern areas depth to the water table increases to more than 40 metres in many parts reflecting the elevated topography.

Trends in water levels in the unconfined aquifer throughout the Tatiara Prescribed Wells Area (PWA) are variable with levels falling in some but not all management areas during the period 2004 – 2009, with observed declines of between 50 mm/year and 560 mm/year. The resource condition trigger for underground waters has been defined as an average decline of greater than 100

mm/year over the preceding five years. Declines in the management areas of Stirling, Willalooka, North Pendleton and Wirrega are greater than the resource condition trigger, suggesting that in these areas current water extraction exceeds vertical recharge (infiltrated rainfall) and subsurface through-flow.

Underground water levels in areas of shallow water tables (Stirling, Willalooka and Wirrega) show a strong correlation with the timing and magnitude of rainfall events. With a series of dry years up to 2011 local recharge has been compromised.

In addition, these decreases can be associated with the compensating increase in extraction that resulted from the situation that the mean annual rainfall for the 1999 – 2008 period at Keith was 402 mm, compared to 459 mm for the 1989 – 1999 period and a long term average (1947 – 2008) of 461 mm.

In the management areas of Cannawigara, Shaugh and Zones 7A and 8A adjacent to the Border, underground water levels had shown a stable or rising trend until 2005, after which declines of between 50 mm/year and 100 mm/year have been recorded in some observation wells. Within these management areas the water table depth exceeds 20 metres and is often much deeper. Therefore a considerable time lag exists for local recharge to reach the unconfined aquifer.

As a consequence of the decline in the groundwater levels in some zones and taking into account the Border Groundwater Agreement, the Tatiara Water Allocation Plan 2010 imposed a schedule of reductions in the quantity of water that may be extracted on a management area basis. The extent of reductions is subject to negotiation and Ministerial review in relation to zones 7A and 8A.

In the Padthaway Prescribed Wells Area the five year water level trend for 2003 – 2007 indicate there has been a general decline in the depth to the water table across the whole area of between 100 mm/year and 400 mm/year. The decline in the Padthaway Range was generally less than 150 mm/year while on the Padthaway Flats it was greater than 150 mm/year, both of which exceed the resource condition trigger of an average decline of 100 mm/year.

However a longer term view for the period 1970 – 2007 in the Range shows a water table rise of between 40 mm/year and 2000 mm/year, which now appears to have reached a plateau. This rise can be attributed to the clearance of native vegetation, the failure of lucerne crops in the late 1970's and an increase in annual dryland cropping. A similar trend in long term water table rise has also been monitored in several elevated parts of the Tatiara PWA.

The depth to the water table on the Flats is between 3 metres and 4.5 metres, and is much less than in the Range, where the water table can be found between 5 metres and 30 metres below ground level.

The Padthaway Water Allocation Plan 2009 also imposes a schedule of reductions to bring allocated licences back to a mandated total Acceptable Level of Extraction of 48,000 ML/year over a five year period.

In the Hundreds of McCallum and Makin (Sherwood management area) in the Tintinara – Coonalpyn Prescribed Wells Area the unconfined aquifer is generally 25 – 50 metres below the surface. Monitoring of observation wells since 2000 shows a stable or very small decline in groundwater levels. The water level trigger of an average decline of 100 mm/year over the preceding five years has not been exceeded and no reduction in extraction is required under the 2012 Water Allocation Plan.

Groundwater levels for selected Tatiara district bores are available on the Department for Water website OBSWELL and are continually updated.

1.4.2 Groundwater salinity

Salinity trends in the unconfined aquifer are not universal due to natural freshwater lenses or high salinity 'hotspots' as well as other influences such as bore casing failures and water recycling via irrigation drainage.

Salt accumulation in the soil is a natural process, but in areas where irrigation water has an appreciable salt load, continued recycling of this water through irrigation can lead to an increase in local groundwater salinity, and a corresponding decrease in soil health. Salts contained in the groundwater are dominated by sodium, producing high sodium adsorption ratios (SARs) in many parts of the Tatiara PWA. In particular, irrigating clay based soils with water of a high SAR poses significant risk to soil structure, reducing both the soil's drainage potential as well as uniformity of drainage. Such declines in soil structure exacerbate accumulation of salts within and below the crop root zone.

A vertical drainage component is a necessary feature of irrigation systems in the Tatiara to move accumulated salt beyond the effective root zone since lateral drainage and disposal is not possible (as might be the case with a riverine system).

Underground water salinity in the Tatiara Prescribed Wells Area varies between 1,000 mg/L in the east, to greater than 8,000 mg/L in the Stirling management area to the west. A resource condition trigger for salinity in the unconfined aquifer has been defined as an average increase of greater than 1% per year over the preceding five years in all management areas.

The salinity trends in the unconfined aquifer have indicated a general increase in salinity within most of the Tatiara PWA of 44 mg/L/year in the ten year period 1999 – 2009. Over the recent five year period (2004 – 2009) the average salinity increased more rapidly by up to 89 mg/L/year.

The most notable increase in groundwater salinity is occurring in the Stirling management area where long term monitoring indicates salinity is increasing at an average rate 50 to 100 mg/L/year with individual observation wells as high as 160 mg/L/year.

The relatively high water use by lucerne and other irrigated crops in the Stirling area has resulted in a substantial salt load accumulating in the soil profile around the root zone of these crops. The accumulated salt dissolves during subsequent irrigation or rainfall recharge and then percolates back into the aquifer. This continuous recycling of underground water results in an overall increase in salinity.

Total groundwater salinity readings in the western area of the Tatiara PWA are inherently high (6,000 – 8,000 mg/L) and pose a threat to the continued use of the water resource for irrigated crop production. Research has shown that lucerne seed and dry matter yields decrease once salinity exceeds 7000 mg/L. Lucerne is at the higher end of salt tolerant crops meaning a switch to alternatives is unlikely. Only flood irrigation or centre pivots fitted with drop tubes which avoid water contacting the plant leaves can be used.

In the management areas of Shaugh, Tatiara and Zone 8A, where the depth to the water table is significantly greater than in the management areas to the west, total groundwater salinity readings are far less and long term salinity increases range from zero to 10 mg/L/year.

The Wirrega management area can be considered as a transition zone between the shallow water table of Stirling and Willalooka, and the deeper water table of the Tatiara management area. Currently the water quality, with respect to salinity, is sufficiently low to allow successful irrigation of a diverse range of crops.

In the Padthaway Prescribed Wells Area the salinity of the underground water has been increasing for more than 20 years under the Flats. Studies which quantified water extraction, irrigation application, crop water use, evaporation and salt accession to the unconfined aquifer concluded

that the historical salinity increase had been predominantly caused by increased recharge due to clearance of native vegetation between the 1950's and 1970's from the Padthaway Range. This historic salt load has then moved out beneath the Flats.

A large quantity of salt still remains in the Range and is predicted to continue to move into the underground water system over the next decades, causing further salinity impacts on the Flats. However this salt store is finite and monitoring shows that parts of the Range have been completely flushed and fresh water is being recharged in its place.

Underground water salinities in the Padthaway Range vary between 1,000 and 1,600 mg/L with an average increase of 2 mg/L/year over the last ten years, but with an average decrease of 11 mg/L/year in the past five years (2003 – 2008).

On the Padthaway Flats underground water is more saline with total readings of up to 3,000 mg/L. An average increase in salinity of 43 mg/L/year over the last ten years and 18 mg/L/year over the last five years (2003 – 2008) has been observed.

In the Hundreds of McCallum and Makin (Sherwood management area) in the Tintinara – Coonalpyn Prescribed Wells Area long term trends show that salinity readings are mainly stable and suitable for a broad range of irrigated crops.

1.4.3 Groundwater dependent ecosystems

Ecosystems dependent upon the groundwater resource become adapted to a particular quantity and quality of water supply, and to receiving it in a specific biannual, annual or inter-annual pattern. Changes in the quality or availability of underground water can reduce an ecosystem's size or affect its biodiversity. However the exact level of dependence on underground water by ecosystems in the Tatiara has not been fully studied.

Water Allocation Plans set out three principles to conserve ecosystems dependent on groundwater.

- No further declines in water table levels, to ensure dependent ecosystems can continue to access the resource.
- No significant increases in underground water salinity, to ensure no detrimental impact on species sensitive to salinity levels.
- Maintenance of lateral through-flow of underground water in order to minimise recycling of irrigation water and provide continual flushing.

When determining allocations for water extraction a total of 10% of available recharge (rainfall) has been determined as a target to provide for environmental requirements in general.

Although not necessarily identified for immediate protection from water use activities a number of wetlands in the South East of South Australia have been noted as being of high ecological importance. In the Tatiara these include Poocher and Moot-Yang-Gunya Swamps and an area known as The Gilgais at Swede Flat. The two swamps are reliant on surface water flows from the Tatiara and Nalang Creeks. Unconfined aquifer levels in the vicinity are between 12 and 37 metres, therefore underground water dependency is of moderate to low likelihood.

In the northern Tatiara (mallee highlands) perched wetlands can occur in isolated depressions surrounded by mallee and heathland vegetation. They can be found in corridors between dunes where drainage is restricted by shallow underlying clay layers. The areas are readily waterlogged following rainfall and are occasionally saline.

Figure 6: Poocher swamp.

1.5 Confined aquifer

Confined aquifers are restricted in their upward movement of water by an impermeable layer or aquitard, often a layer of clay or stone. The confined aquifer in the Tatiara extends across the whole district. It is approximately 60 metres below ground level under the coastal plains, but increasing to 120 to 140 metres below ground level under the mallee highlands.

Water quality within the confined aquifer ranges from 1,300 mg/L near the Victorian border up to 6,000 mg/L near Keith. However monitoring points are sparse.

Recharge to the confined aquifer occurs largely via lateral through-flow, with the main recharge area being the Dundas Plateau on the western face of the Grampians mountains in Victoria. Lateral movement of water in the confined aquifer, generally from east to west, is extremely slow.

While there is some evidence of hydraulic connection between the unconfined and confined aquifers, transfer is thought to be low. The aquitard which separates the two is generally more than 20 metres thick and has a very low permeability.

There are relatively few deep bores penetrating the confined aquifer. Three licences have been issued for industrial and recreational purposes in the Tatiara Prescribed Wells Area.

There remain a number of deep older bores mainly in the Hundreds of Laffer and Stirling. Most have been located, dated and their current use identified, however there are still some wells in this area that have not been logged and which are probably not in use. Many of these were sunk before water regulations required licensing and a set standard of well construction, or the decommissioning of unused or unserviceable wells. These abandoned wells have the potential to leak and allow interchange of water between the more saline unconfined aquifer above and the fresher confined aquifer below. Exchange could be in either direction depending on aquifer pressures. This could be contributing to local salinisation and a rising watertable. Offering assistance to decommission old confined aquifer wells may also help locate those not yet identified.

Water levels in the confined aquifer of the Tatiara PWA are showing an average decline of between 200 mm and 300 mm per year in the Wirrega and Stirling management areas which is above the resource condition trigger of 100 mm/year. In the eastern zones the five year water level trend (2004 – 2009) has shown some decline but has not exceeded the resource condition trigger.

Long term trends in the salinity of the confined aquifer show a stable to moderately increasing condition.

In the Padthaway PWA the confined aquifer is particularly thin (less than 2.5 metres) or nonexistent and is not used as a primary water resource.

1.6 Remnant vegetation

Approximately 20 percent of the Tatiara is covered by remnant vegetation of which nearly half is within the Ngarkat Conservation Park complex. Remnant areas outside of Ngarkat are contained in approximately 4,300 blocks scattered throughout the district. Of these blocks 50 percent are less than 2.3 hectares each, meaning they are subject to pressure from 'edge effects' including pest animals, weeds, grazing, nutrient enrichment and erosion.

Figure 7: Heathland scrub, Ngarkat Conservation Park.

In addition to the blocks of remnant vegetation there are significant areas that were originally 'parkland cleared', meaning that a portion of the large trees were left during development to provide shade and shelter for livestock. However these single, sparse and isolated trees inevitably suffer from stress and declining health, often leading to their death.

Roadside vegetation also represents a key component of the remaining remnants in the Tatiara and in many areas provides critical connecting corridors for flora and fauna. The Tatiara District Council maintains a Roadside Vegetation Policy and is advised by the Tatiara Roadside Vegetation Management Group.

The vegetation types of the district are diverse and contain plants with varying fire, water and salinity tolerances. This makes these habitats both fragile and adaptable. Many of these plants are rare due to extensive clearing of scrub in other parts of South Australia. Ngarkat alone has 119 known species of conservation significance.

Remnant vegetation benefits from periodic burning to promote regeneration and nutrient recycling but with much of the remaining stands in small areas or as narrow roadside strips fire as a management option adjacent fenced agricultural land is not always possible or practical.

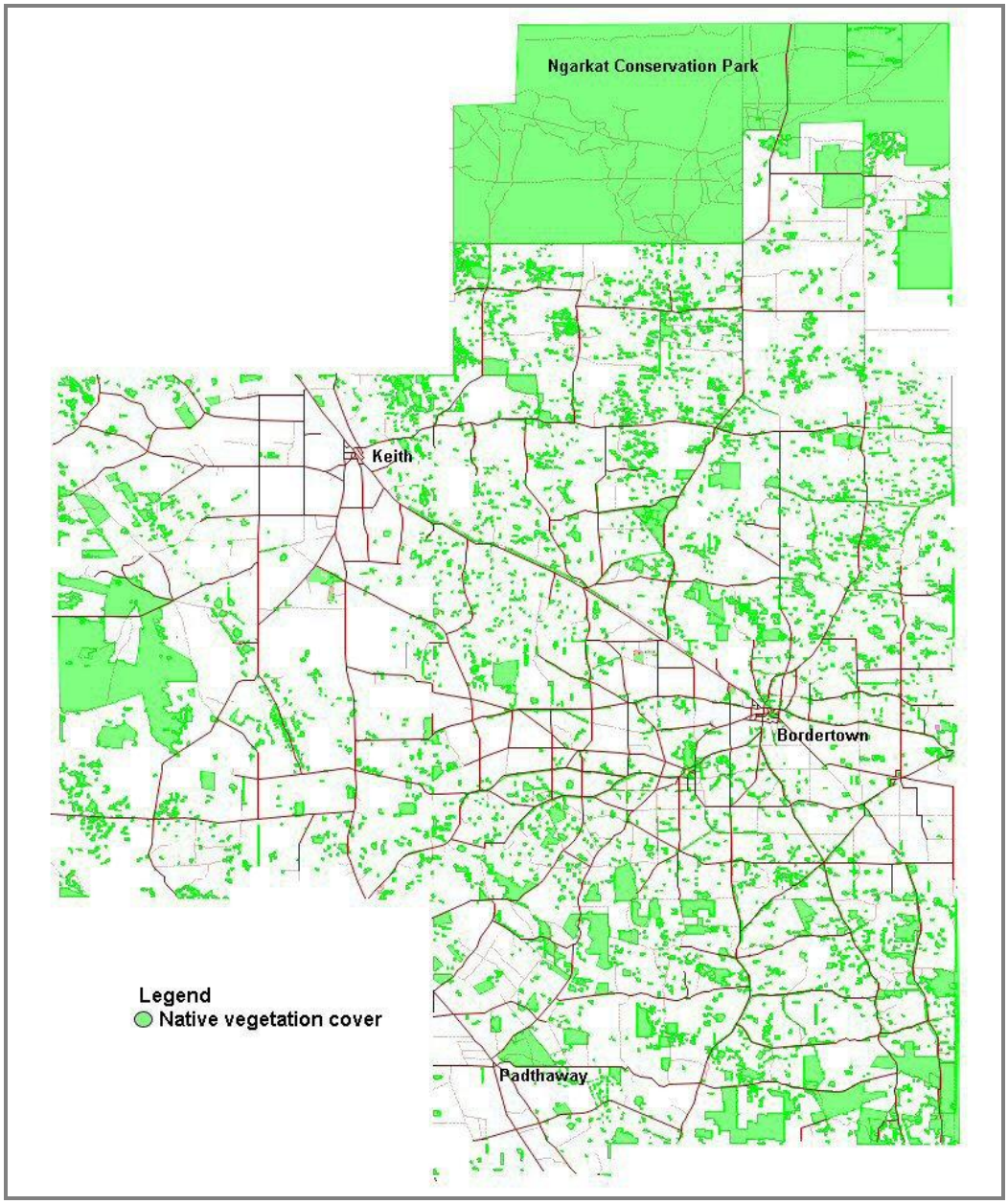


Figure 8: Remnant vegetation in the Tatiara.

1.7 Biodiversity assets

The diversity of our native plants and animals is part of our natural heritage. Native vegetation and biological diversity are essential for the maintenance of the earth's life-support systems. Healthy functioning ecosystems maintain air quality, rainfall patterns, fresh water, soil formation, cycling of nutrients and disposal of wastes. A diverse array of animal and plant species means that landscapes are resilient, able to recover from natural disasters such as drought or fire and have the potential to adapt to an evolving climate.

A number of key biodiversity assets occur within the Tatiara and are listed below.

- Aquatic ecosystems including numerous wetlands on the coastal plains.
- The swamps, gilgais and fresh water creeks in the highland area.
- Various woodland and native vegetation communities including the nationally listed Grey Box grassy woodlands and Buloke woodlands.

- Areas within the national reserve system including Conservation Parks, Reserves and Heritage Agreement sites.
- Local landforms of interest and significance eg granite outcrops and Swedes Flat.
- Preserved grassland communities eg Wolseley common.
- Remnant native vegetation within the Mundulla common, Aboriginal reserve at Bordertown and along undisturbed roadsides throughout the district.
- Identified habitats of endangered species of flora and fauna.

Many small areas of importance are held in stewardship on private lands.

2. Community resources

The community is a key component of the Natural Resources Plan for the Tatiara. Members of the community contribute knowledge, commitment and experience to ensure action can be implemented on issues which have been identified for attention. The capacity of people to contribute depends on a range of factors including stage-of-life, education, employment, awareness of issues, cultural attitudes and the financial viability of agricultural enterprises.

2.1 Population and services

The population of the Tatiara is approximately 7,000 people with about half living in the towns of Bordertown and Keith and the remainder in smaller settlements or on farms.

Data from the Australian Bureau of Statistics suggests the population is stagnant while the median age is increasing.

The Tatiara District Council provides a range of local government services and programs in the area while the state and commonwealth governments have a role in education, health and other social and economic support. Schools provide classes to year 12 level and some Technical and Further Education (TAFE) courses are available.

The community is actively engaged within the two main towns which contain a range of social and service groups. Examples include Country Fire Service, St Johns Ambulance, State Emergency Service, Agricultural Bureau, Women in Agriculture and Business, support committees for public buildings and facilities, service organisations, sporting clubs and a range of niche interest networks.

Figure 9: Involving school students in natural resource projects.

2.2 Agricultural economy

The Tatiara district is based on an agricultural economy valued at around $280M per annum (2011 farm gate estimate), although agricultural production can vary widely from year to year.

Dryland cropping covers about 20% of the district's developed land each year and there are around one million head of livestock (sheep and cattle).

Crops grown are mainly cereals (wheat, barley, oats), along with pulse crops (lupins, peas, beans, lentils, chickpeas) and oilseeds (canola). Dryland pastures are grown for grazing, hay and seed production.

Despite the small area covered by irrigation (approximately 5.5%), it forms a significant part of the Tatiara's economy. There are over 25,400 ha of irrigated crops, of which about one third is used for lucerne seed production. Other irrigated crops include winegrapes, potatoes, onions, olives, pasture and grass seeds, other types of vegetables and pasture for grazing or hay. In dry years the farm gate value of irrigated production may be up to 50% of the district's agricultural total.

The Tatiara is a centre for the apiary industry, where honey bees acting as pollinators are a key component of lucerne production. Large tracts of native vegetation also support the honey industry.

In addition to the direct value of agriculture, there are a number of local businesses that rely on or supply services to farming. These include machinery dealerships, trucking and transport, fertiliser and fuel distributors, real estate and livestock agencies, oat milling, seed cleaning and marketing and abattoirs.

Some mining exploration has been undertaken in search of mineral sands and rare earth metals but no commercial mines have been developed. However several quarry sites are in use for the extraction of road making materials and concrete aggregate.

The Tatiara lies on the main Adelaide to Melbourne transport corridor (road and rail) with road connections to the south (Naracoorte and Mount Gambier) and north to the Mallee and Riverland regions.

2.3 Aboriginal heritage

All landscapes in the region are extremely important to Aboriginal people today, just as they were prior to European settlement. Aboriginal people, including the Ngarkat and Potaruwutj, were the original natural resource managers of the landscape that sustained the family groups that once lived in, or passed through, the Tatiara.

There are several Aboriginal heritage sites of known social significance including a reserve at Bordertown. Other sites include the Pinkie Tree, a large Red Gum in Poocher Swamp said to be once used as a living shelter. Poocher Swamp itself is a site of importance for Aboriginal people.

Sites of particular significance to people with kinship and ancestral ties to the area may include meeting areas, burial grounds and campsites. These sites often contain middens, hearthstones and evidence of stone tool making, e.g. scrapers, blades, points, axes and grindstones. The tools are made from a range of minerals such as granite, quartz, flint, silcrete and volcanic materials.

Many of these sites are associated with water supplies and usually include swamps, soaks, creeks and runaway holes. There are cultural rules and taboos that relate to how and when different aboriginal groups may enter or use these areas.

The original inhabitants of the South East had complicated trading structures that evolved to suit the needs of each group. A number of trading routes ran through the Tatiara and include those from Lake Hindmarsh in the northern Wimmera of Victoria through to the Murray River.

The most traceable item traded into this area was stone for making tools, while the local people used fibres of rushes and the bark of stringy-bark trees to make string and rope-like products. The Bordertown area was particularly known for fine basket making.

Evidence of the early Aboriginal populations can be found around sand lunettes and along the Tatiara and Nalang creeks. Stone artefacts indicate the location of campsites. Scars can still be seen on 'shield trees' where the bark was removed.

It is important to note that Aboriginal heritage is protected at both State and Commonwealth level. The *Aboriginal Heritage Act 1988* protects Aboriginal remains, sites and objects of significance to the anthropology, history culture and archaeology of Aboriginal people. People who find an Aboriginal site, object or remains are required to report the finding to the Aboriginal Heritage Branch of the Department of Premier and Cabinet.

2.4 European heritage

The Tatiara district was settled by Europeans in two stages. The heavier, more fertile soils around Bordertown, Mundulla, Wolseley and Padthaway were cleared for grazing beginning in the 1840's and in the years that followed crops were introduced. Development accelerated with the completion of the Melbourne to Adelaide railway line in 1886.

During the late 1800's there were a number of extensive Pastoral leases granted by the Colonial Government eg Cannawigara, Nalang, Binnum, Swedes Flat, Padthaway.

Police Inspector Tolmer pioneered a track from Adelaide to the Mount Alexander goldfields in Victoria which passed though the Tatiara. By 1852 Government wells and direction indicators where erected along this route.

Keith was surveyed in 1889 but remained a small farming community based on the local better soils of the Keith-Monkoora plain until the 1940's when the role of trace elements was discovered that allowed the development of the surrounding sandy heath country. The AMP development scheme during the 1950's opened up large areas of grazing land with lucerne as the preferred pasture species. This use of trace elements (copper, cobalt, zinc and molybdenum) along with phosphate fertilisers transformed what was originally known as the Ninety Mile Desert.

In 1944, the CSIRO recommended the Padthaway district for horticultural production due to its rich terra rossa soil and underground water supply but it was not until 1964 that the first commercial vineyard was established.

3. Natural resource management issues

A range of issues that impact on the natural resources of the Tatiara are identified and discussed in the following sections. Brief descriptions of the issues are provided and various management actions are suggested that may lead to the remedy or amelioration of problems.

3.1 Dryland salinity

A huge amount of salt is stored in the subsurface soils underlying parts of the Tatiara. Historically this salt was accumulated when the area was originally covered with seawater. In the Mallee highland zone the salt is held at depth while on the Coastal plains it is much closer to the surface.

A dryland salinity problem emerges when the salts are mobilised and carried upwards by a rising water table and surface evaporation.

Due to the hydraulic contours of the aquifer, salts are also translocated from beneath the highlands to the plains. A simple example is the effect of salts moving from the Padthaway ranges to the flats, although this process is in operation on a much larger scale, albeit slowly, across other parts of the Tatiara as well.

In the western area originally the deep rooted native vegetation cover kept the watertables at depth by providing a balance between rainfall recharge and evapotranspiration. However with clearance of scrublands and their replacement with shallow rooted annual crops and pastures, this balance is disrupted and more rainfall reaches the watertable causing a general rise bringing the dissolved salts closer to the surface. The widespread sowing of lucerne in the ranges when the land was first cleared assisted in keeping watertables in check, however the pasture aphid invasions of the late 1970's and the dramatic loss of susceptible lucerne stands at that time led to a general watertable rise and a rapid spread of dryland salinity in adjacent low lying areas.

The topography of the region formed by the ancient coastlines means that areas to the west and south west contain parallel landscapes of salty flats and range country. The salty flats have a shallow watertable which is often exposed as chains of interdunal swamps. Where the summer – autumn watertable is within two metres of the soil surface the effects of dryland salinity are likely to be most severe. Groundwater is drawn up through the soil profile by capillary action, eventually evaporating as it reaches the surface, leaving the salts at or near the topsoil root zone.

The Upper South East Dryland Salinity and Flood Management Program is designed to remove excess surface water and saline groundwater from the salty flats on the Coastal plains and direct it into the Coorong or out to sea via the Blackford drain. However the lateral effects of the drains in reducing adjacent dryland salinity on pasture land are still being assessed due to a run of dry years.

Historically, the higher areas of the Tatiara have been somewhat immune to the water balance and salinity issues affecting the lower lying areas of the district. The highland areas are considered a potential long-term contributor to the low-lying dryland salinity problem but can have issues of localised surface salinity and waterlogging due to subsurface clay lenses. In general, the greater the depth to groundwater, the greater the salt stored in the profile and the longer the delay between scrub clearance and a noticeable salinity impact. It is evident that the depth to water and the type of soil profile is a significant influencing factor on groundwater salinity increase brought about by changed land use. The lag time between water entering the soil profile and emerging in the deep saturated zone can be in the order of 10 – 20 years, or more where there is a significant depth of clay between ground level and the aquifer. As a result, the impacts of land use change and subsequent recharge may not be evident as groundwater induced salinity for many years.

Figure 10: Salinity affected landscape in the Hundred of Laffer.

Within the Tatiara, no built up areas appear to be at risk from urban salinity. This risk is further reduced by recent below average annual rainfall and nearby irrigation drawdowns. If the district were to experience an extended wetter than average period, or if irrigation was to cease due to increasing salinities, urban salinity may become an issue of concern. However some road surfaces in the western region of the Council area have been affected by rising water tables leading to extra maintenance.

Managing the issue

- Adoption and re-establishment of salt tolerant pasture species on drained low-lying land.
- Continuing research on alternative pasture legumes suitable for saline soils eg Messina.
- Re-establishment of deep rooted perennial pasture species on high ground, preferably lucerne, to minimise annual recharge. This may include clay spreading on the dune rises.
- Use of perennial fodder shrubs.
- Retention, rehabilitation or re-establishment of native vegetation.
- Grazing management practices that maximise summer – autumn groundcover.
- Investigation of other land uses such as inland aquaculture and biomass production.

3.2 Irrigation salinity

Surface (flood) irrigation is the main irrigation method used in the western Tatiara due to a combination of cost, terrain and underground water salinity. Centre pivot systems are used in the eastern area and where there are lower salinities and undulating terrain. Dripper systems are used in vineyards and olive plantations.

In areas where irrigation water has an appreciable salt load, and flood systems are used, continued recycling of this water through the irrigation process can lead to an increase in the local unconfined aquifer salinity and the soil root zone. In turn, a larger drainage component of water is required per irrigation event to move accumulated salt beyond the root zone resulting in low net irrigation efficiency levels. These processes tend to work against each other, since when groundwater salinities are high, extra drainage is required and thus more water is recycled at the

same location. Eventually irrigation bays may need to be decommissioned until such time as rainfall provides flushing of the soil salts and a refreshing of the local aquifer.

Recent studies have shown salinity increases in the Stirling management zone of approximately 85 mg/L/year as a result of flood irrigation activity. Without a significant change in irrigation practices, groundwater salinity has the potential to increase by 500 – 1,000 mg/L in the Keith area over the next ten years. As a result, the groundwater resource in much of the Hundred of Stirling may become unusable for current irrigation practices within 10 – 20 years.

Lucerne has a relatively high salt tolerance compared to other irrigated crops and has been successfully grown using the higher salinity ground waters in the western Tatiara. However there are currently no alternative crops available once salinity in the irrigation system becomes so great that the economic performance of lucerne is compromised.

Managing the issue

- Monitoring of both water and soil salinity levels and selection of suitable crop types.
- Improved irrigation efficiency using scheduling methods that take into account daily evapotranspiration (ETo) and rainfall, soil moisture content and crop growth stage.
- Periodic resting of flood irrigation bays to allow natural flushing by rainfall – often in conjunction with growing a relatively salt tolerant cereal such as barley.

3.3 Runaway holes and drainage bores

Runaway holes (or sink holes) are surface cavities through the limestone which provide direct drainage to the unconfined aquifer, while drainage bores are man-made and work in a similar manner.

A number of runaway holes are scattered throughout the district, mostly west and north of Bordertown. They usually terminate a flood path, or artificial drain from an adjacent creek or swamp. In a number of cases land development has altered original flows. Work undertaken by the Cannawigara Water Conservation Region Inc, Tatiara District Council, South East NRM Board and the South Eastern Water Conservation and Drainage Board over the last 30 years has enhanced the area's natural runaway holes by cleaning out sediment and providing stone sills to reduce silting and providing channels and gates to allow recharge without flooding of co-operating landholders.

Runaway holes and drainage bores can provide rapid fresh water recharge to the aquifer at times of excessive rainfall events as well as acting as a flood mitigation mechanism.

Managing the issue

- Fencing to exclude livestock (and for human safety).
- Continue to "plumb" runaway holes into the riparian system.
- Monitor inflows and quality of recharge and maintain clear flow paths.
- Encourage retention of groundcover through conservative grazing and stubble retention in the flood zone approaching runaway holes and drainage bores.
- Education through interpretive signage of the flow paths.
- Support further studies on the role of runaway holes and drainage bores and their connection to aquifers.

Figure 11: Runaway hole in the Cannawigara district.

3.4 Wind erosion

Wind erosion is the major cause of soil erosion in the Tatiara. The removal or absence of ground cover, usually associated with non-wetting sands are the main predisposing factors.

Over the last decade the Department of Environment and Natural Resources Land Condition Monitoring Survey has shown a steady increase in the relative period of protection (measured as days per year of adequate ground cover) on susceptible soils. This improvement can be attributed to improved land management practices despite a number of below average rainfall years.

Where wind erosion takes hold, rehabilitation costs can be very expensive, as drifts can cover roads, fences and adjoining productive land. Removal of sand from impacted areas requires significant earthworks and soil stabilisation measures, sometimes costing more than the original land value.

An emerging problem is associated with the rotational cropping under centre pivot irrigators of potatoes and other vegetable crops on the deep sand country in the northern Tatiara.

Figure 12: Wind eroded sand ridge.

Managing the issue

- Earthworks may be required to fill in blowouts or level steep ridges prior to stabilisation.
- Clay spreading and re-establishment of lucerne or other deep rooted perennial vegetation on susceptible soils.
- Use of minimum tillage farming practices and stubble retention. Burning of stubbles should be avoided.
- Strategic establishment of wind breaks.
- Sowing (and irrigating for establishment) of post harvest cereal crops following potatoes and onions under centre pivots.
- Use of fodder shrubs in alley farming plantations sown on the contour and/or against prevailing winds.
- Fencing off high risk areas and the exclusion of livestock.
- Rabbit control programs.
- Use of polymers and other soil stabilising agents.
- Revegetation of unproductive sites.
- Use of alternative surface covers such as waste wool, old hay or water damaged grain.
- Use of hay or straw on smaller areas.

3.5 Soil pH (acidity and alkalinity)

The Tatiara contains soils that measure both acid and alkaline on the pH scale. Acidity is more likely associated with deep sands and sands over clay in the north and west of the area, whereas the heavier soils around the Bordertown, Wolseley and Mundulla are often alkaline. However where salinity is a problem or when under intense irrigation, sands can turn alkaline.

Higher rainfall areas with siliceous sands that contain little clay, low buffering ability and no free lime are generally more likely to be acidic.

Across large areas of the Tatiara most soils are mildly acid in their natural state but certain farming practices can lead to a further acidification. Factors which can result in a lowering of pH include nitrogen fixation by leguminous pastures, particularly subclovers, organic matter build up and the use of traditional phosphatic, high analysis and nitrogeneous fertilisers. These processes are not always slow and may take less than several decades to occur.

Managing the issue

- Application of lime or gypsum to soils of pH 5.5 (water) or less.
- Clay spreading on acid sands to improve soil buffering ability.
- Selecting crop and pasture species suitable for the soil pH.

Plant species	pH range (water)	Plant species	pH range (water)
Lucerne	6.0 – 8.5	Sub clover	5.2 – 7.5
Strawberry clover	6.6 – 8.5	Annual medic	6.5 – 8.2
Lupins	5.0 – 7.0	Field peas	6.5 – 8.2
Faba beans	7.0 – 8.5	Wheat	6.0 – 8.0
Oats	4.5 – 7.5	Barley	6.0 – 8.5
Canola	6.5 – 8.0	Grapes	6.5 – 8.0
Potatoes	4.5 – 7.0	Phalaris	6.0 – 8.5

3.6 Non-wetting sands

Water repellence is caused by natural plant-derived waxes which coat soil particles. This coating prevents water evenly penetrating or wetting up the soil profile. Rainfall gravitates into depressions on the soil surface where it pools and either evaporates or infiltrates slowly through the pore spaces and root canals. This results in uneven wetting and patchy germination of crops and pastures. Opportunistic weed species such as Silver grass are likely to gain a hold under these circumstances and the potential for wind erosion is increased. The problem is widespread on the sandy soils of the Tatiara.

Water repellence is usually low in virgin soils but increases following development with permanent pastures and cropping. Sands supporting old stands of lucerne and perennial veldt grass are often strongly water repellent.

Managing the issue

- Clay spreading and incorporation.
- Delving and spading where subsurface clay is present.
- Sowing in furrows using wider tyne spacings (35 cm) and press wheels. This may also involve spraying a wetting agent in the furrows at the time of sowing.
- Working on the contour to ensure rain is trapped where it falls.
- Growing perennial pastures which don't rely on annual regermination.

3.7 Sodic soils and waterlogging

Waterlogging induced by sodic subsoils can be a particular problem on some cropping soils and sands over clay of the eastern Tatiara.

The original soils were once saline. Long term leaching by rainfall has flushed the chloride and left the sodium from the historic sea salts bound to the subsurface clay particles. The affected clay particles separate (disperse) when wet, increasing the shrink-swell properties of the soil and destroying soil structure. This decreases water adsorption ability and vertical drainage, leading to waterlogging at the surface after heavy rainfall events.

Waterlogging causes oxygen deficiency in the root zone which retards plant growth and compromises crop and pasture productivity. Plants growing in waterlogged soils have increased susceptibility to root diseases and reduced nutrient uptake ability. Waterlogged soils are prone to compaction by livestock, machinery and vehicle traffic, creating further problems with the timing of cropping operations.

Gypsum applications provide an exchange mechanism where sodium bound to the clay particles is replaced by calcium and subsequently reducing the dispersive nature of the clay.

Retention of crop residues or addition of soil organic matter (stubble incorporation) can assist in treating or preventing soil problems, as the presence of organic matter helps prevent the soil aggregates from separating, maintains soil moisture levels and decreases shrink-swell effects.

Managing the issue

- Spreading of gypsum as a soil conditioner.
- Deep ripping to break up the subsurface clay layer with an application of gypsum in the rip line (banding).
- Adoption of cropping systems that increase soil organic matter and improve soil biota status.
- Delving or spading to mix the soil layers.

The situation is slightly different when considering the impacts and management of sodic soils under flood irrigation. Irrigation water in the Tatiara is variously saline with much water high in sodium salts, but also high in calcium and magnesium. This water chemistry balance of the mineral components can act to reduce the sodicity of subsurface clays and provide improved drainage. However with spray and drip systems, due to the lower volumes involved, this effect may not be apparent.

3.8 Water erosion

Water erosion in the district is generally isolated to a small area of sloping ground along the Tatiara and Nalang Creeks. This area consists of undulating red brown earths and is highly productive cropping country. In the past traditional fallow-based cultivation systems left paddocks prone to water erosion during high intensity rainfall events and on some properties contour banks were constructed to control run-off.

Water erosion may also occur in areas of steep non-wetting sand dunes as most of the rainfall runs off and rilling or channelling can occur.

Managing the issue

- Contour banks and/or cultivation across the slope can reduce runoff.
- Permanently grassed waterways.
- More recently the adoption of minimum tillage cropping and stubble retention have largely overcome the problem.

3.9 Soil structure, biota and fertility

Soil structural and fertility problems in the Tatiara are variable and depend on a range of factors such as the basic soil type, crop and rotational history, fertiliser practices and grazing pressure.

Soil structure is defined as the way soil particles are bound into aggregates. Good structure allows the free movement of air, water and nutrients, enhances germination and emergence of plants and allows healthy growth. Poor structure results in slow rainfall infiltration, waterlogging, stunted root growth, erosion risk and reduced plant production.

Soil structural problems can be in the topsoil (eg hard setting or surface crusting) or they can occur in the lower layers (eg sodic subsurface clays).

Soil fertility decline is an issue on many soil types in the Tatiara. The majority of soils are lightly textured and are inherently low in a number of key nutrients eg phosphorus and nitrogen, and several trace elements eg copper and zinc. Under grazing, maintenance applications of phosphorus averaging 6 kgP/ha/year in the north and 10 kgP/ha/year in the south are required. The application of phosphorus promotes the growth of legumes which build up the nitrogen and organic matter content of the soil. Under cropping conditions application rates of phosphorus and nitrogen fertilisers should be determined by estimating the crop yield and taking into account the previous paddock history.

The application of fertiliser to run-down pastures on water repellent sands is economically questionable. The alternative is likely to involve clay spreading or delving and the establishment of new pasture cultivars.

Soil fertility is also related to animal production. Copper, cobalt and selenium are all deficient in some soils of the Tatiara and may need to be provided as direct supplements to sheep and cattle.

Nutrients are lost to the system by product removal, leaching and fixation in the soil. The following table illustrates how much phosphorus is removed by selected enterprises.

Product	Kg of phosphorus
Hay (5 tonnes)	
Cereal or grass hay	8
Lucerne hay	12
Grain (2 tonnes)	
Wheat, barley oats	6
Field peas, lupins	8
Canola	10
Wool (5 kg greasy)	0.02
Milk (1000 litres)	1.0
Meat (50 kg liveweight)	0.4

Maintaining fertile soils ensures more production can be obtained from less land and increased plant growth reduces rainfall recharge. However over-application of fertilisers may cause pollution of surrounding water bodies, increased greenhouse gas emissions, detrimental effects to native vegetation and flow-on effects to human health.

Nitrogen enrichment of the unconfined aquifer is occurring throughout the Tatiara. The area of most concern is around Keith as a result of the intensive irrigation of lucerne. Statistics from the SA Environment Protection Authority groundwater testing of bores at Keith are provided in the table below. While the nitrogen loads do not exceed those for human health (potable water) the nitrogen concentrations are generally in excess of ecosystem health guidelines.

Parameter	Nitrate (N) mg/L	Nitrite (N) mg/L	Total N (N) mg/L	Total P (P) mg/L
Average	3.54	0.01	3.71	0.03
Median	2.35	0.00	2.51	0.02
Max	12.85	0.16	13.12	0.34
Min	0.06	0.00	0.16	0.01
Upper level for human health	10.0	0.01		

Most environmental discharges of nitrogen from agricultural enterprises are unintentional and diffuse. Sources include leachate from legume based pastures and pulse crops, run-off from stock yards, and septic waste systems.

The ability of nutrients to move off-farm within the district suggests that other agricultural chemicals could follow similar migration paths. In the absence of sufficient data, measures to reduce nutrient contamination of water tables could also be expected to reduce contamination risks from other agricultural chemicals.

Intensive animal keeping is undertaken on some farms under licensing and monitoring requirements from the EPA (eg piggeries). Disposal lagoons are usually required to have clay liners to restrict nutrient leaching into the unconfined aquifer.

Soil biota

Modern farming practices can have an influence on the balance of soil microflora and fauna. Some soils are more sensitive than others. Productivity and resilience to climatic stresses can be detrimentally affected by management practices that reduce soil biota.

In a balanced soil, plants grow in an active and vibrant environment. The mineral content of the soil and its physical structure are important for their well-being, but it is the life in the earth that provides access to its fertility. Without the activities of soil organisms, organic materials would accumulate and litter the soil surface, and there would be no food for plants. The soil biota includes:

- Megafauna: eg rabbits and rodents.
- Macrofauna: eg dung beetles, earthworms, other beetles, slugs, snails and ants.
- Mesofauna: eg mites.
- Microfauna and Microflora: eg yeasts, bacteria, fungi and protozoa.

Of these, bacteria and fungi play key roles in maintaining a healthy soil. They act as decomposers that break down organic materials to produce detritus and other minute products. Soil detritivores like earthworms ingest detritus, decompose it and release nutients back to the soil.

Managing the issue

- Increase organic matter levels through stubble retention or the use of green manure crops.
- Minimise the destruction of soil aggregates through less frequent tillage and the use of less aggressive implements such as narrow points.
- Promote the development of stable soil pores through the use of deep rooted pastures and/or crop species and the encouragement of soil organisms such as bacteria and earth worms.
- Awareness of the potential affect on soil biota of modern farming practices and chemical use.

3.10 Native vegetation, biodiversity and loss of habitat

Areas of native vegetation or unique ecological communities occur in several forms eg:

- Conservation parks and reserves including areas of native grassland,
- As roadside vegetation,
- On-farm remnants and Heritage Agreement areas,
- Revegetated zones as plantations or shelter belts,
- And as scattered or isolated trees and shrubs.

Each provides habitat for local fauna and flora species in some way.

Significant ecological communities and biodiversity assets

The *Commonwealth Environment Protection and Biodiversity Conservation Act (1999)* lists a number of protected communities and species that occur in the Tatiara. These are shown in the following table. In addition to matters of Commonwealth importance there are a number of other issues of state and regional significance as documented in the *South East Biodiversity Plan (1999)*.

Description	Status	Location	Threats
Threatened ecological communities			
Buloke Woodlands of the Riverina and Murray Darling Depression Bioregions	Endangered	Bordertown & Mundulla	Clearance, grazing, weed invasion
Grey Box Grassy Woodlands and derived native grasslands of South-eastern Australia	Endangered	Bordertown & Mundulla	Clearance, grazing, weed invasion

Description	Status	Location	Threats
Threatened species			
Red-tailed Black-Cockatoo (south-eastern)	Endangered Migrant	Areas south of Bordertown	Removal of roosting and feeding trees
Swift Parrot	Endangered	Bordertown & Naracoorte	Clearance
Malleefowl	Vulnerable	Ngarkat, Gum Lagoon, Desert Camp	Clearance, inappropriate fire regimes, predation
Red-lored Whistler	Vulnerable	Ngarkat	Clearance of understory
Western Whipbird (eastern)	Vulnerable	Makin / McCallum	Fragmented habitat, inappropriate fire regimes
Mallee Emu-wren	Endangered	Carcuma & Ngarkat	Fragmented habitat, inappropriate fire regimes
Plains Wanderer	Vulnerable	Ngarkat	Loss of habitat
Grey –header Flying-fox	Vulnerable	Migratory	Loss of habitat
White-throated Needletail	Migratory		
Rainbow Bee-eater	Migratory	Permanent water	
Great Egret	Migratory		Loss of habitat, drainage of wetlands
Cattle Egret	Migratory		Loss of habitat, drainage of wetlands
Latham's Snipe	Migratory		Loss of habitat, drainage of wetlands
Fork-tailed Swift	Migratory		
Australian Painted Snipe	Migratory		Loss of habitat, drainage of wetlands
Southern Bell Frog	Vulnerable	Mundulla, Keith, Southern areas of District	Drainage or salinsation of wetlands
Jumping-jack Wattle	Endangered	Bordertown & Abadeur CP.	Clearance, weed invasion, grazing
Monarto Mintbush	Endangered	Mount Monster	Clearance, weed invasion, grazing
Metallic Sun-orchid	Endangered	Desert Camp & Padthaway	Clearance, weed invasion, grazing
Coloured Spider-orchid	Endangered	Bangham & Padthaway	Clearance, weed invasion, grazing
Southern Pipewort	Endangered	Bangham	Clearance, weed invasion, grazing
Hairy-pod Wattle	Vulnerable	Bordertown	Clearance, weed invasion, grazing
Elegant Spider-orchid	Vulnerable	Bangham & Padthaway	Clearance, weed invasion, grazing
Winter Spider-orchid	Vulnerable	Central Tatiara	Clearance, weed invasion, grazing
Clover Glycine	Vulnerable	Padthaway	Grazing of grassy woodlands
Sandhill Greedhood	Vulnerable	Tatiara	Clearance, weed invasion, grazing
Large-fruit Groundsel	Vulnerable	Gum Lagoon	Changes in hyrological and fire regimes, clearance
Silver Daisy-bush	Vulnerable	Sandy rises	Clearance, weed invasion, grazing
Lowan Phebalium	Vulnerable	Senior, Shaugh, Ngarkat	Inappropriate fire regimes
Spiral Sun-orchid	Vulnerable	Southwest of Keith	Clearance, weed invasion, grazing

The Tatiara contains two Key Biodiversity Areas identified in the South East Region Natural Resources Management Plan that are considered to be under threat. These are the Keith – Willalooka Area and the Mundulla – Bordertown – Wolseley Area. These areas are considered to contain species and ecosystems at threat of extinction in the short term (<50 years) unless action is taken to conserve existing habitats and restore native vegetation cover. In addition the Desert Camp – Bangham Area is classified as a Large Remnant Area that contains significant blocks of high habitat value remnant vegetation, sufficient to sustain populations of most local fauna species in the longer term.

The district is a significant South Australian location of the Buloke (*Allocasaurina leuhmannii)* Woodlands and the Grey Box (*Eucalyptus macrocarpa)* Grassy Woodlands. Both communities occur on heavy cracking clays of the Wimmera landscape zone, mainly around Bordertown, Mundulla and Frances. These communities predominantly remain as small areas on private land and along roadsides in the Tatiara, supporting a number of regionally threatened plants and animals, including the iconic Bush-stone Curlew. The two woodland communities have a high level of threat from weed invasion, grazing and roadside maintenance.

The Bush-stone Curlew is an iconic species that relies on Grassy woodlands. Bordertown and Mundulla support the largest collections of this species in the South East. Recovery work has been undertaken by Department of Environment and Natural Resources to stabilise these populations.

The Mallee heathlands are also a major ecosystem within the Tatiara, being the natural habitat of the Mallee fowl and a wide range of endangered and vulnerable flora species. For example the Mount Monster area has over 80% of the remaining nationally endangered Monarto Mintbush.

In 2012 the Australian government recognised one of the rarest and most elusive wetland types for national protection. These wetlands are seasonal and are known by several common names – crab hole country, melon holes and gilgais. The areas fill with water in winter and spring and typically dry out by late summer. They rely on local rainfall and are usually very shallow. The vegetation community is mostly open, damp and grassy, supporting a unique range of herbaceous species that flourish in the wet and die down in dry periods.

A relatively unknown aspect of the Tatiara's biodiversity resource is the presence and distribution of stygofauna (animals which live in groundwater). Recent collection of stygofauna samples in the southern Tatiara has led to the discovery of six new species.

Many nationally threatened plant species, ecological communities and significant remnant vegetation in the Tatiara occurs along roadsides. The Tatiara District Council with assistance from the Department of Environment and Natural Resources has implemented a Roadside Marker Scheme on Council maintained roads to complement the Department of Planning, Transport and Infrastructure strategies on state managed highways. This initiative guides Council staff on important locations and the associated management implications for each site.

Threats to biodiversity and habitat

Threats to biodiversity and habitat in the Tatiara are diverse, ranging from climate change, clearance, edge effects, bush fires, grazing, weed infestation, pest animals, nutrient enrichment, chemical contamination, erosion and salinity as well as human activities such as recreational vehicles. Many of these issues are universal in that they are common to most agricultural districts state wide. One aspect that was first identified in the Tatiara is Mundulla Yellows, a die-back condition of various species of eucalypts.

The cause of Mundulla Yellows is not known. Research has concentrated on a contagious biological agent such as a virus. A chemical or physical action such as soil compaction, nutrient enrichment or salinity may also have a predisposing role. No definitive conditions have yet been identified.

Affected trees show a progressive yellowing and die-back in the crown, with an estimated duration of 5 to 15 years from the first appearance to the death of the whole tree. The age of the tree does not seem to a factor in the likelihood of infection, however the provenance (region of origin) of eucalypt seedlings appears to have some impact on their resistance to the Mundulla Yellows syndrome.

From a practical point of view, treatment options once the symptoms are visible are limited. Pruning or removal of infected trees does not seem to slow down the spread of the syndrome, as the cause of the disease is present long before the symptoms appear.

Redgums adjacent roadsides have also been shown to suffer from lime induced sclerosis as a result of crushed limestone used as road making material. The concentrated lime can also alter or destroy soil microflora populations in the vicinity and is believed to be a contributing edge effect to roadside vegetation decline.

Fragmented landscapes, scattered paddock trees and isolated remnants

Much of the remnant vegetation in the Tatiara is contained in small blocks apart from the Ngarkat complex. Fragmented habitats come under stress due to edge effects such as chemical and fertiliser drift, weed invasion and higher pest animal populations.

Scattered, paddock or isolated trees refer to the native trees remaining on land that is predominantly used for agriculture. Scattered trees occur at varying densities in the landscape and generally reflect the pattern of tree removal. Where trees of high density remain they may also provide some indication of the original woodland structure, however this structure is usually biased towards old trees and the young trees typical of intact woodlands are notably absent. Paddock trees persist within a variety of land uses including grazing, cropping and viticulture but are often under stress. Roadside and isolated paddock trees are also vulnerable to insect attack from lerps (*Psyllids*) and borers. This has been particularly noticeable along the Riddoch Highway south of Keith and in the Willalooka area, especially among Pink Gums.

Dead trees are a natural part of the landscape and provide important habitat for a number of fauna species, including nesting and roosting. A particular example is the Red-tailed Black-cockatoo.

Connecting corridors

Connecting corridors of native vegetation play a key role in preserving and enhancing the biodiversity of the region. Corridors usually consist of roadside vegetation but may also involve connected patches of remnant or replanted scrubland that allow the movement or migration of local fauna and flora.

However roadside vegetation corridors also run the risk of harbouring rabbit and weed populations if left unmanaged.

Inappropriate fire regimes

The Tatiara district is made up of many large public and private remnant vegetation blocks. These landscapes require an appropriate fire regime to maintain functional animal and plant populations and the ecosystems they inhabit. The *Fire Management Plan Reserves of the South East 2010-2020* and *Fire Management Plan for Ngarkat Region 2009-2019* have been developed to provide direction for fire management activities through strategies for risk minimisation and bush fire suppression. DEWNR is undertaking an active prescribed burning program predominantly on reserves for the general protection of life, property and environmental values.

Landholder interest in prescribed burning on private property is gaining momentum. However, it is important to be aware of the *Native Vegetation Act 1991*, as burning is considered clearance if it is not for ecological purposes or is a hazard reduction burn more than 20m wide around a structure.

For further information regarding prescribed burning on private properties contact the DEWNR South East Regional Office at Mount Gambier.

Managing the issue

- Active preservation of native vegetation, wetland and riparian habitats by fencing to exclude livestock and control weeds and pest animals.
- Continued research into the cause of Mundulla Yellows.
- Restoration of regionally threatened grassy woodlands.
- Fencing and weed control of selected areas with the potential for natural regeneration eg adjacent to swamps or soakage zones.
- Minimisation of drift or migration of agricultural chemicals and artificial fertilisers.
- Practices that minimise recharge to prevent water table rise in saline affected areas.
- Re-establishment of areas of mixed species native vegetation as plantations or shelter belts, preferably with seed or seedlings sourced locally.
- Prescribed burning in Conservation parks and reserves to facilitate natural regeneration and the recycling of nutrients.
- Providing connecting corridors between areas of native vegetation to allow movement and migration of local fauna.
- Allow some buildup of fallen twigs, branches and leaf litter around trees to encourage biota.
- Identification and implementation of appropriate methods for the management of native grasslands.
- Implementation of specific management plans for vulnerable species eg Monarto mint bush.
- Implementation of the Roadside Marker Scheme across all Council roads to improve roadside vegetation management.
- Appropriate grazing practices on pasture land that control growth and reduce fire fuel loads.
- Community education programs on the value of a biodiverse environment.

3.11 Pest plants

The state government through the Department of Environment and Natural Resources maintains a list of Declared Plants in South Australia. Declared plants are significant weed threats to primary production, industries, natural environments and public safety. Not all of the listed weeds are known to be present in the South East Region or the Tatiara District.

The South East Natural Resources Management Board through its network of Authorised Officers has conducted a regional threat assessment to determine weeds of local importance and a scale of actions to be implemented in their control or eradication.

The main weeds requiring attention in the Tatiara are shown in the following table.

Creepers	Bridal creeper
	Bridal veil
	Dodders
Grasses	African lovegrass
	Coolatai grass
	Innocent weed
Herbs	Bathurst burr
	Caltrop

	Cape tulip
	Cut leaf mignonette
	False caper
	Horehound
	Khaki weed
	Lincoln weed
	One leaf cape tulip
	Onion weed
	Salvation jane
	Silverleaf nightshade
	Skeleton weed
	Yellow burr weed
Shrubs and trees	Boneseed
	Feral olives
	African boxthorn

Other non-declared weeds may pose particular environmental or economic threats eg silver grass in grazing enterprises and bedstraw, radish or sorrel in dryland cropping. A particular threat is uncontrolled weeds on public land or crown land, especially areas that are proximate to agricultural pursuits. Changing patterns of land use, reduced regard for troublesome weeds and lack of resolve in weed management has increased the problem. Agricultural systems that focus on reduced tillage may be jeopardised by infestations of herbicide resistant weeds.

Impacts from pest plants can also include livestock illness or death from poisoning, loss of biodiversity due to competition and increased fire risk.

The *South East Pest Management Strategy (2009)* available from the South East Natural Resources Management Board provides a comprehensive matrix of weed threats in relation to land uses and land classes including grazing, native vegetation, cropping, forestry, aquatic, urban, irrigation and horticulture.

The weed risk assessment process used by the regional NRM Board aims to determine the invasiveness, impacts and potential distribution for each species. Invasiveness is used as an indicator of a plant's rate of spread, with faster spreading species being considered more important for urgent control.

Land use and land classes are important factors in the capacity of an individual weed species or combination of species to dominate a landscape. For example some individual weeds might be confined to irrigation areas or particular soil types.

There are a number of conflicts of interest for pest plants across land uses. What is grown as a production/agricultural species in one land use may be a significant pest plant in another land use. For example Veldt grass, Tall wheat grass and Phalaris were planted as pasture grasses but now threaten native vegetation and grassland communities.

Weed infestation poses a major threat to biodiversity. Most environmental weeds have been introduced through agriculture or as garden plants and may impact on areas of remnant vegetation by displacing native plants, competing for nutrients, changing the chemistry of the soil and increasing fire fuel loads. Woody weeds such as Aleppo pines, olives, *Acacia saligna* and boneseed are also a threat to native vegetation, particularly along roadsides.

Managing the issue

- Landholders have a legislated responsibility to control and manage declared weeds on their property and adjoining roadways. Public utilities and corporations are also deemed to be landholders for areas under their stewardship eg rail line corridors, District Council public lands and other sites managed by state or commonwealth agencies.
- Where a landholder repeatedly fails to control a weed infestation the regional Natural Resource Management Board may take action and charge the landholder for the costs incurred.
- Declared pest plants cannot be introduced, moved or sold via products within the region. Landholders must take action to prevent the spread of weeds and weed seeds on or in livestock, machinery, hay and grains.
- Influencing and encouraging the training and accreditation of additional weed control contractors.
- Active monitoring of previous controlled sites eg Olives, Golden dodder.
- Engaging the community with education programs in the identification of weed species, control and management, their threats to the environment and economic or social impacts of their spread.
- Excessive spray drift can impact on biodiversity and human health. Care must be taken when spraying weeds (or protecting crops and pastures) to ensure that overspray does not adversely affect adjacent residences, areas of native vegetation or nearby susceptible crops.

Preventing weed spread in native vegetation

- Minimising tracks, roads and firebreaks within areas of native vegetation.
- Preventing man-made drains from discharging into areas of scrub.
- Excluding grazing animals and controlling pest animals.
- Avoiding fertiliser drift into areas of vegetation.

Figure 13: Acacia saligna invading an area of heathland mallee.

3.12 Pest animals

Feral animals, including deer, foxes, goats, rabbits and hares are a significant land management problem throughout the Tatiara, due to their ability to spread weed seeds, damage fences, prey on native species, cause soil erosion, eat crops or decrease the carrying capacity of pasture land.

Feral dogs and cats also pose threats due to predation. Rats and mice can also cause problems if seasonal or environmental conditions favour an increase in their population.

Opportunistic native animals such as Emus, Kangaroos and Corellas regularly utilise the improved pastures, crops and freely available water that exist on agricultural land. At times this may cause them to congregate and become over-abundant within an area. They can cause long-term land management issues.

In a similar manner to weeds, pest animals are subject to a risk-threat analysis as outlined in the *South East Pest Management Strategy (2009).*

Managing the issue

- Similar to weeds as described above.
- When populations of pest animals in an area rise to levels requiring a coordinated control effort, Authorised Officers can plan and undertake neighbourhood baiting, culling or other management programs.
- Any poisoning programs require permissions and notifications via an Authorised Officer of the regional Natural Resources Management Board.
- Trimming back of Stringybark clusters and canopies to reduce the haven for rabbits.

Note: The Natural Resources Plan for the Tatiara (LAP Plan) does not carry legislative authority for the control of Pest weeds and Pest animals under the *South Australian Natural Resources Management Act (2004)*. Any actions undertaken as a result of this plan will be in conjunction with, or in support of, the South East Natural Resources Management Board and its Authorised Officers.

3.13 Greenhouse gas emissions

Agriculture, forestry and fishing are estimated to contribute approximately 12% of South Australia's net greenhouse gas emissions.

Within the agricultural sector the production of food and fibre products inevitably results in the release of greenhouse gasses while other parts of the system, including forestry, tree crops, perennial pastures and improved land management practices, account for a significant portion of carbon sequestration processes. All growing plants draw in carbon dioxide from the atmosphere via photosynthesis.

Ruminant animals; cattle and sheep, are the major contributors to the agricultural sector's emissions, while animal wastes and manure also play a role. In all, the livestock industries release about three-quarters of agricultural greenhouse gasses as part of the food production cycle.

The role of soils and artificial fertilisers is varied. The use of nitrogenous fertilisers can result in a net emissions release while farming practices that involve soil organic matter build-up and stubble incorporation commonly sequester carbon and nitrogen. The nitrogen fertilisation of crops can be better managed by split seasonal applications or foliar sprays.

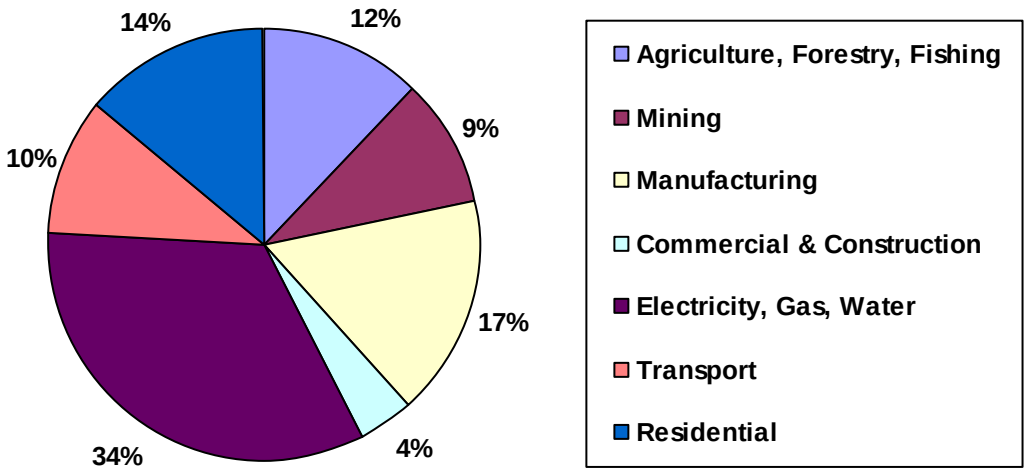


Figure 14: Components of net greenhouse gas emissions by sector, South Australia 2009.

Soil carbon

Benefits of increased soil carbon have been reported to include a wide range of soil and catchment health aspects. Quantification of these benefits is difficult as they vary from site to site. However improving soil carbon status can:

- reduce erosion and sedimentation,
- reduce soil acidification,
- reduce recharge to groundwaters and alleviate soil salinity,
- decrease surface waterlogging potential,
- increase soil moisture retention,
- increase crop and pasture productivity,
- potentially reduce atmospheric carbon dioxide,
- possibly provide a future income stream from carbon trading.

Livestock emissions

Ruminant livestock emit significant quantities of methane and nitrous oxide as by-products of their anaerobic digestive systems.

Gas emissions are kept to a minimum when stock are provided with a balanced intake of the energy, protein and fibre components in their diet. Making rapid changes in the diet of grazing or hand-fed ruminants requires the rumen micro-organisms to adjust and this jeopardises feed conversion efficiency and triggers the release of extra greenhouse gases. Prolonged grazing of energy and protein-poor pastures and stubbles also exacerbates the problem.

Seasonal variation in pasture quantity and quality on offer cannot be avoided in most grazing enterprises. However some evidence exists that perennial pastures such as lucerne provide an overall better feed balance than annual pasture systems. Given the other benefits of lucerne as a pasture species in large areas of the Tatiara this provides some small relief in reducing greenhouse gas emissions at the local level.

The practice of supplementary feeding sheep and cattle during the late summer and autumn period (or feedlotting in extremely dry years) not only maintains animal productivity but also contributes to an improved annual dietary balance.

Progress to date

Although the contribution of agriculture to national greenhouse gas emissions may seen large, progress in reducing the proportion attributable to the sector has been made. Since 1990 the combined emissions for Agriculture and Landuse change, including forestry, has fallen by approximately 40% while those for the other sectors in the National Greenhouse Gas Inventory have risen by approximately 30%.

Managing the issue

- Adoption of farming practices that maintain and improve the soil carbon bank eg minimum tillage, stubble retention and avoidance of burning crop residues.
- Soil modification techniques that improve water holding capacity and/or drainage eg clay spreading, delving and the use of gypsum or lime to improve soil structure and reduce soil acidity.
- The use of perennial pastures for grazing animals on non-cropping country.
- Supplementary feeding of ruminant livestock during late summer and autumn.
- Additional tree and shrub planting as block plantations, shelter belts and connecting corridors.
- Preservation and rehabilitation of remnant vegetation.
- A re-evaluation of the economic potential for farm forestry enterprises in lower rainfall zones which may also involve biofuel or biomass production.
- Further research into the ability of soils, pastures and cropping systems to sequester carbon and other greenhouse gases.
- Aiming for an overall balance of farm business economic and environmental sustainability.

3.14 Climate change and variability

Climate variability is an ongoing and ever-present phenomenon. Human populations, along with their farming practices, have been continually adapting to environmental circumstances.

Debate in recent years has focussed on the causes, extent and consequences of climate change over the last century both globally and within Australia. This Plan takes no position on the cause of climate change but recognises that changes are occurring and will need to be managed.

Responses to climate variability should be directed towards adaption and resilience within farm businesses and the community. Actions will cover a wide range of mechanisms such as water harvesting and storage, crop and urban plantings, animal types and welfare, energy sources and consumption, community awareness and education and a continual search for new opportunities to utilise our natural resource assets.

Although reliable and continuous long term weather records are sparse within the Tatiara some analysis has been undertaken that also includes neighbouring districts. The CSIRO (2006) has produced a South Australian report on climatic modelling that projects forward a number of years on a regional basis, while the South Australian Research and Development Institute (SARDI) has considered a number of adaptive strategies for agriculture under a changing climate.

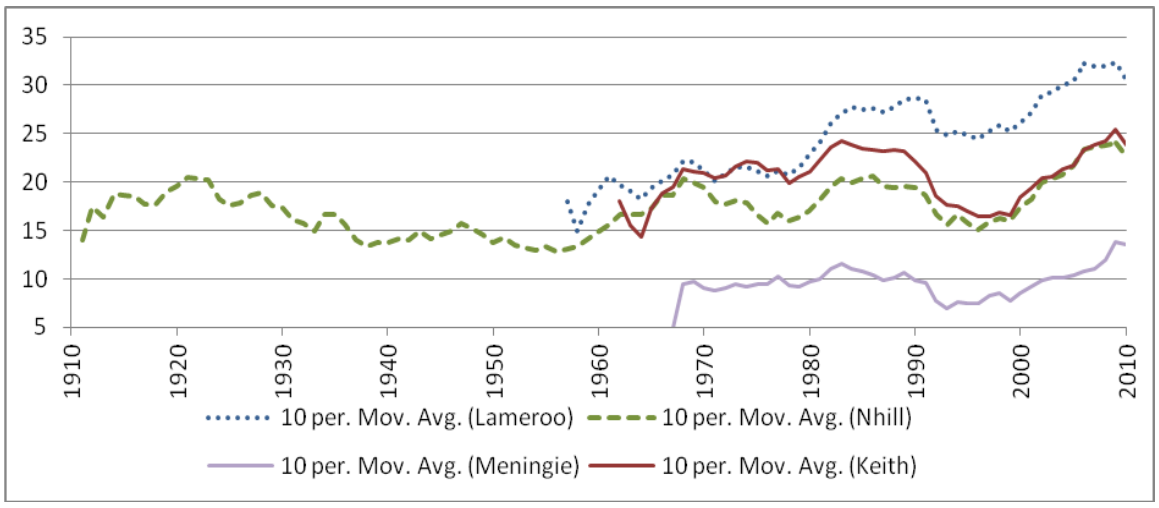
With much put forward about the effects of global warming, the main difference proposed by climate change scientists is an increased variability in weather patterns. This means that some regions are going to have more frosts, some are going to have more heatwaves and some areas will have both. Seasonal rainfall patterns may be altered with some regions receiving more and others less. The frequency, distribution and intensity of individual rainfall events are also likely to change.

Local data

(a) Temperature

Changes in daily variability or extremes do not show up in weekly or monthly temperature averages. This requires both daily maximum and minimum data. Such temperature data is somewhat hard to come by, particularly with daily readings over 50 years or more. The nearest two sites with more than 50 years of suitable data are Nhill (VIC) and Lameroo (SA).

The graph below shows the frequency of days over 35 ^{o}C at Lameroo, Meningie, Nhill and Keith, using a ten year moving average, with Nhill providing the longest continuous dataset. All sites show an increasing number of hot days since the mid 1990s (right hand side of the graph) and a general trend upward since the mid 1950s.



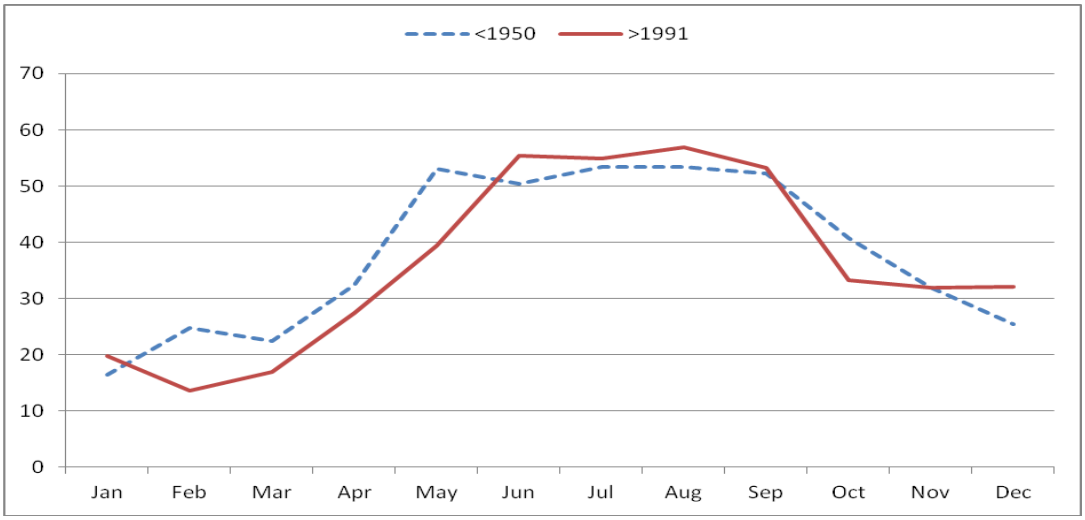
The threshold was selected because of the effect that these temperatures have on crops and animals. Temperatures above 35 ^{o}C generally decrease plant and animal productivity. Temperatures above 40 ^{o}C can cause heat stress in livestock, photosynthesis in temperate zone plants can cease and field crops can be triggered to mature early. At the other end of the scale a reduction in the number of below zero minimum temperature days can detrimentally affect potential budding and fruit set in a range of horticultural crops.

(b) Rainfall

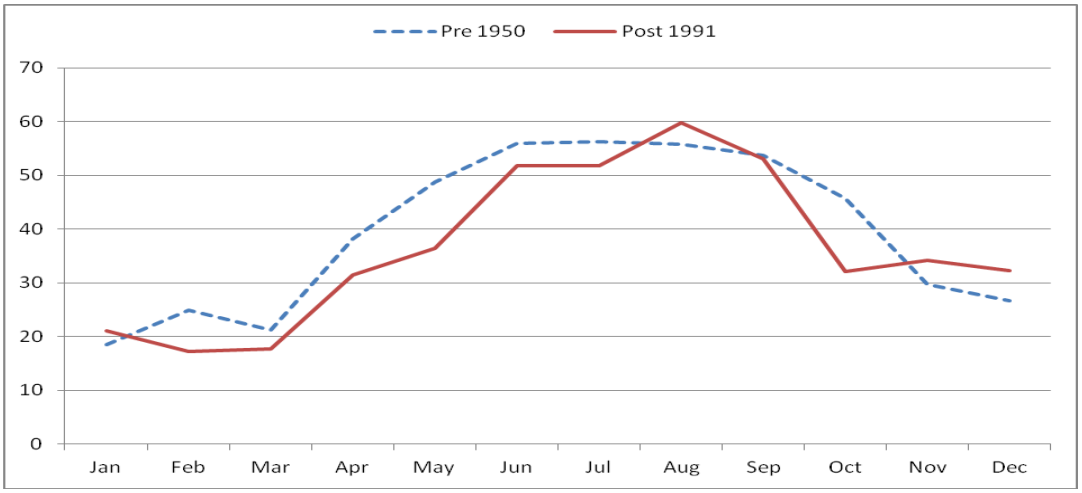
Rainfall data from selected Tatiara recording stations provides a longer time span covering the years from 1900 to the present. Data is presented as an east-west transect for Wolseley and Keith.

The following charts provide a visual impression of the differences in rainfall between the 1900-1950 period and 1991-2010. As can be noted, there are differences between sites, however some general observations can be made across the Tatiara. The autumn break is occurring later and in most cases, this is accompanied by an earlier spring close to the growing season. However the CSIRO reports that due to the high natural variability of rainfall on decade and longer time scales it is difficult to distinguish statistically significant long-term trends.

Both sites had a decrease in average annual rainfall in the period post 1991. This varied from 21.5mm (Keith) and 39mm (Wolseley).



Keith average monthly rainfall (mm).



Wolseley average monthly rainfall (mm).

CSIRO modelling

The CSIRO's 2006 report *Climate change under enhanced greenhouse conditions in South Australia* examined historical records and a range of climate change scenarios. The results of 13 computer models were studied that projected forward a number of decades. The main findings are discussed as follows.

Atmospheric greenhouse gases play a key role in driving the climate and its variability although debate continues as to their full effect. Climate change will have impacts on water supply, floods, agricultural systems, forestry, biodiversity and habitat. Extreme weather events are more likely. Higher temperatures and lower rainfall could lead to an increase in the frequency of drought and the risk and severity of bushfires.

From 1910 to 2005, South Australia's average surface temperature increased by 0.96°C, with the minimum temperature increasing by 1.13°C and the maximum temperature by 0.79°C. Since 1950, South Australia's average temperature has increased by 1.1°C, the minimum by 1.01°C and the maximum by 1.2°C. Compared with national trends, South Australian maximum temperature indicates a faster rate of increase, while minimum temperate shows a slower rise. In general, the frequency of extremely warm days and nights has increased while that of extremely cool days and nights has decreased.

In the absence of policies and programs that reduce greenhouse gas emissions it is predicted that by 2030, areas within 200 km of the coast will warm by 0.2 to 1.6°C and the region 200 to 600 km inland from the coast would warm by 0.4 to 1.6°C, with spring and summer showing greater warming than winter and autumn.

Projected rainfall changes are more complex and variable. By 2030 areas within 200 km of the coast could see rainfall changes of between -15% and zero, while the regions further inland could show changes between -15 and +7%. There are significant differences in likely changes among the seasons. Summer and autumn show both increases and deceases, but decreased rainfall dominates the winter and spring months. Individual rainfall events, although less frequent, may be more intense.

The South Australian Government commissioned CSIRO to make projections of temperature and rainfall changes for the eight Natural Resource Management Board regions across the state. The estimates for the South East are shown in the following tables.

Range of warming (°C) by 2030 – South East region.

Region	Annual	Summer	Autumn	Winter	Spring
South East	0.4 to 1.1	0.4 to 1.4	0.4 to 1.2	0.3 to 1.0	0.4 to 1.2

Range of rainfall changes in percentage by 2030 – South East region.

Region	Annual	Summer	Autumn	Winter	Spring
South East	-10 to -1	-11 to +4	-7 to +2	-9 to 0	-19 to -2

Managing the issue

- Assessing the perceived benefits to individual landholders of the recently legislated Carbon Farming Initiative.
- Adopting farming systems that maximise crop and pasture water use efficiency.
- Contribute to carbon sequestration by the maintenance of remnant vegetation and the establishment of new areas of native vegetation or farm forestry enterprises.
- Encourage the research into, and be alert to the practical benefits of, advances in soil carbon sequestration.

- Adaptive farm management practices that can accommodate a shorter growing season. This may involve time of sowing and developments in plant breeding.
- Assessment of the economic benefits of growing different crop and pasture species, including crops for biomass or biofuel production.
- Consideration of different genotypes of grazing animals.

3.15 Water security

The Water Allocation Plans for Tatiara, Padthaway and Tintinara-Coonalpyn aim to provide sustainability in the use of the district's groundwater resources. In addition almost all residences, both urban and on farms, capture rainwater for domestic use.

However a number of farms, particularly in the Hundreds of Laffer, Petherick and Pendleton, and allotments in the township of Keith are reliant on pipeline water supplied from the Murray River.

The cost of this water has been rising steadily and the state government has announced further price increases of up to 50%. This is a significant price shock to grazing enterprises especially those running beef cattle or prime lambs and threatens their economic viability. These properties mostly overlie a saline aquifer that is unsuitable for stock water and no readily available alternative supply currently exists.

Apart from the economic impact of rising water prices other effects are lower potential stocking rates with mainly Merino wethers run on a pastoral basis, capital depreciation due to reduced land values and loss of employment opportunities.

If landholders are forced to switch enterprises to a more cropping focus there is a severe risk of widespread land degradation, particularly associated with wind erosion, salinity impacts, inappropriate cropping practices on vulnerable soil types and loss of previously built up soil structure and fertility.

Managing the issue

- Ongoing implementation and review of Water Allocation Plans.
- Evaluation of on-farm desalination plants.
- Implementation of leak detection programs and equipment.
- Privately pumped and reticulated water supplied from further inland where the groundwater quality is satisfactory.
- Investigation of shandying methods combining pipeline and local aquifer sourced water.
- Investigation of water harvesting schemes such as clay or poly-lined local catchments.
- Continued provision of a water salinity testing service for landholders.
- Investigation of the potential for recycling runoff and storm water in township areas eg Keith.
- Support continued negotiations to resolve issues and points of difference that have arisen between the Border Groundwater Agreement and the Tatiara Water Allocation Plan.

3.16 Matching land use with land capability

Matching land capability with farming enterprises is a key factor in maintaining a sustainable agricultural system. This is an evolving process and has been underway since the Tatiara was first settled. Much progress has been made in differentiating particular soil types for cropping, grazing or irrigation enterprises, or to be left undeveloped. Advances in soil enhancement practices, alternative crop and pasture species, tillage machinery, pest and weed management, grazing

systems, land class fencing and the application of suitable stocking rates have all contributed to a more stable landscape and less areas of erosion and degradation.

Knowledge, experience and a widespread landcare ethic are attributes that need to be captured, maintained and fostered in the community for this progress to continue. Threats are usually external and may involve commodity price cycles, climate variability and drought, government policy settings, input cost increases and changing land ownership.

Training and awareness in farm planning is seen as an important step in ensuring that land is used within its capabilities. This involves financial aspects of the business as well as its built infrastructure and inherent natural assets or limitations.

Managing the issue

- Training opportunities such as Property Management Planning courses and workshops.
- Access to mapping products and aerial photographs (including Google Earth) to assist in differentiating land classes and provide guidance for fencing and subdivision.
- Access to unbiased technical knowledge and expertise in assessing soil health, structure, nutrient and trace element status.
- Reliable weather forecasting both short and long term.
- Credible sources of information on farming practices and systems.
- Continued government funding for on-ground and other works that enhance productivity, protect sites, rehabilitate degraded areas and provide general public benefits.

3.17 Social infrastructure

Productive communities are essential for sustainable land management. Viable communities get involved in issues, take care of their resources and support innovative practices. Throughout Australia it has been shown that it is individuals and the community as a whole that are the key drivers of change in environmental and natural resource management.

To maintain an informed and engaged community suitable social infrastructure must be present. This involves access to education and health services, a local media, efficient transport and the availability of reliable and cheap communications including broadband. People must want to live in the area and know that their lifestyle and economic aspirations will be met.

Volunteerism is a critical part of the mix. Without volunteers active in the community little will be achieved at the ground level. The willingness of people volunteering to support local programs will depend on such factors as stage of career, time availability, interest in civic affairs, health and wellbeing, the need for social interaction and family circumstances. A common problem in smaller communities is that the roles often fall on “the same old faces” who eventually reach a point of burn-out.

Governments need to supply essential services so that the community can grow and prosper, and this includes paying attention to natural assets and the environment.

Like many rural areas, the Tatiara is faced with the challenge of an ageing population and a rural – urban drift of both young people seeking education and employment opportunities, and retirees moving to coastal locations or larger centres where health and other services are more readily available.

Managing the issue

- Celebration and reward of volunteers (not necessarily monetary).
- Training opportunities in civic affairs and rural leadership.
- Programs that aim to provide youth employment and retention in the region.
- Active support of regional economic development initiatives including tourism.
- Continued publicity of local achievements.
- Business and social mentoring programs.
- Adequate and accessible outreach in health, welfare, employment, further education and other essential services.
- Access to sound statistical data to support planning and infrastructure projects.
- Provision of support for on-ground works that takes into account the social needs of landholders as well as the technical advice required for successful implementation.
- Relentlessly pursuing the needs of rural communities with higher levels of government.

3.18 Economic impacts

Farm businesses are subject to a number of economic impacts that work against stability of income from year to year eg commodity price cycles, seasonal conditions, exchange rate fluctuations and harvest outputs in competitor countries. At the same time a continuous cost-price squeeze on agricultural enterprises forces farmers to innovate and find ways for ongoing improvement in productivity against a finite resource base. These impacts are not confined to farmers alone but flow through to the local economy and the provision of goods, services and employment.

These pressures present risks to landscape integrity and biodiversity that may be seen as areas of degradation, erosion, uncontrolled weeds and pests or soil structure and fertility decline, along with other negative environmental effects.

The implementation of best practice land management operations will at times appear haphazard and uncoordinated but this is likely to be the result of profit variability in individual farm businesses.

Sustainability needs to take into account the triple bottom line of economic, social and environmental interactions. All must be adequately nurtured for the whole to work as a viable system.

The Natural Resources Plan for the Tatiara seeks a balanced program of works and projects that support a sustainable approach to land management involving both the agricultural industry and concerned citizens in partnership for the future.

4. Issues and themes

The following issues have been identified that warrant ongoing and future attention within the Tatiara. They are grouped into 6 general themes.

Land and soils

Dryland salinity
Irrigation salinity
Wind erosion
Soil pH (acidity and alkalinity)
Non-wetting sands
Sodic soils and waterlogging
Water erosion
Soil structure, biota and fertility
Matching land use with land capability

Water and aquifers

Runaway holes and drainage bores
Water security
Aquifer extraction, recharge and salinity status
Watercourses and wetlands

Vegetation and biodiversity

Native vegetation, biodiversity and loss of habitat
Remnant vegetation preservation

Agricultural and environmental protection

Pest plants
Pest animals

Climate challenges

Greenhouse gas emissions
Climate change and variability

Social and economic

Social infrastructure
Indigenous heritage
Economic impacts
Community engagement, education and awareness

It is anticipated that these themes and issues, along with selected management options for each, will be addressed by the Coorong Tatiara Local Action Plan Project as funding opportunities arise. Where appropriate, partnerships will be sought with other natural resource management agencies at the regional or state level. It is not feasible to address all the identified issues at the same time however the list provides guidance for a broad program of works and community projects. The list is not exhaustive and it is expected that other issues are likely to emerge in the future.

5. Linkage to the South East Natural Resources Board Plan

The *South East Natural Resources Management Board Plan 2010* establishes a hierarchy of Resource Condition and Management Action Targets (RCTs and MATs) for addressing its Goals concerning the future direction of regional resource management.

The Themes identified in the Natural Resources Plan for the Tatiara can be linked to the Board's Goals and Resource Condition Targets as shown in the following table.

SENRM Board Goals or Resource Condition Targets	**Tatiara Themes**
The condition and extent of habitats will be improved	Vegetation and biodiversity
The condition of land will be improved	Land and soils Agricultural and environmental protection
The involvement of community members in NRM activities will be increased	Social and economic
Ground and surface water systems will be maintained or improved	Water and aquifers
Resilient and adaptive industries	Climate challenges

Management Action Targets are defined as five to seven year outcomes from a range of activities that contribute to a longer-term change in the condition of a natural resource. These targets are designed to reflect the collaborative effects of a range of financial and human resource investments. Each MAT may contribute to more than one Resource Condition Target. Investments towards achieving the MATs and RCTs in the South East Region of South Australia may be combined from among different sources, agencies and community organisations. Therefore the Coorong Tatiara Local Action Plan Project has a role in partnering with the South East Natural Resources Management Board, and other agencies, to achieve common or similar outcomes.

The Tatiara Themes can be linked with the Board's MATs as shown in the following table.

Tatiara Themes	**SENRM Board Management Action Targets**
Land and soils	Understanding land use change Improving salt-affected landscapes Ameliorating acidification Improving soil condition Improving water use through soils Increasing perennial plant systems Understanding soil disease Understanding effects of agriculture Protecting land from erosion
Water and aquifers	Understanding water resources Improving water quality Retaining water in the landscape Acknowledging environmental water needs Managing water within sustainable limits Adapting water management Adopting sustainable irrigation
Vegetation and biodiversity	Improving native vegetation Managing priority habitats Managing threatened species Improving habitat connectivity

Tatiara Themes	SENRM Board Management Action Targets
	Reviewing species of concern Supporting biodiversity on private land Protecting habitats through formal agreements
Agricultural and environmental protection	Reducing key invasive species Managing pests Responding to new pests
Climate challenges	Adapting to climate change Building resilience in a changing climate
Social and economic	Involving primary producers Supporting community groups and volunteers Engaging schools Increasing community awareness Respecting Aboriginal issues Developing a regional knowledge system Maintain skills, knowledge and funding

6. Ongoing and proposed Action Plan

The Coorong Tatiara Local Action Plan Project undertakes a range of activities in fulfilling its role. A number of these are ongoing based on previously identified needs and available funding, while others are derived from this plan and represent future initiatives.

To date the major source of funding for the Local Action Plan is the Federal Government's *Caring For Our Country* program with smaller local contributions from the Tatiara and Coorong District Councils.

A key role of the project is to keep abreast of new and emerging sources of funds to support the implementation of the plan. Government programs for natural resource management and sustainable agriculture continually evolve through time and Local Action Plan groups need to be adaptable to changing circumstances and policy agendas. At the time of writing the Federal Government has indicated that community funds will be made available to facilitate the implementation of the *Carbon Farming Initiative* however this still awaits the development of some further details.

The following tables describe work in progress and a number of projects for which funding will be sought when opportunities arise.

Current ongoing program (2011-2012)

Actions and Themes	Land & Soils	Water & Aquifers	Vegetation & Biodiversity	Agricultural & Environmental Protection	Climate Challenges	Social & Economic
On-Ground Works						
Clay spreading	☑					
Perennial pastures including dryland lucerne	☑					
Salt tolerant pastures and pastures after drainage	☑		☑			
Fodder shrubs			☑			
Native windbreaks and revegetation			☑		☑	
Farm forestry			☑		☑	
Stabilising sand drift and levelling blowouts	☑					
Landclass fencing	☑			☑		
Fencing remnant vegetation and wetlands			☑	☑		
Protection of threatened flora and fauna			☑	☑		
Decommissioning leaking and abandoned confined aquifer bores		☑				
Salinity testing of stock and irrigation water		☑				
Evaluation and demonstration of leak detection methods for on-farm pipelines and water infrastructure		☑				
Provision of technical support for implementation of on-ground works	☑	☑	☑			
Education and Awareness						
Newsletters, fact sheets and media content						☑
Support for workshops, seminars and field days						☑
Youth, schools and volunteer program			☑			☑

Actions and Themes	Land & Soils	Water & Aquifers	Vegetation & Biodiversity	Agricultural & Environmental Protection	Climate Challenges	Social & Economic
Community group support						☑
Signage, display materials and country shows						☑
Promotion and coordination of multi-agency natural resource management programs at the district level						☑
Partnerships						
Fodder shrub evaluation in lower rainfall areas	☑		☑			
Feral animal control				☑		
Weed identification and control				☑		
Monitoring aquifer levels and salinity status		☑				
Natural resource management policy advice and development through membership of other organisations and committees				☑		☑
Irrigation water use efficiency and access to automatic weather station data		☑			☑	
Coordination of small grant schemes to ensure effective distribution of funds						☑
Promotion of sustainable agricultural practices and technologies	☑				☑	
Working with indigenous community groups to assist achieve their objectives						☑
Monitoring and Reporting						
Statutory reporting to funding agencies						☑
Local reporting to District Councils and Natural Resource Management Boards						☑

Proposed additional initiatives (2012 >)

Actions and Themes	Land & Soils	Water & Aquifers	Vegetation & Biodiversity	Agricultural & Environmental Protection	Climate Challenges	Social & Economic
On-Ground Works						
Liming to adjust soil pH	☑					
Gypsum application on sodic soils	☑					
Expanded leak detection program for on-farm pipelines and water infrastructure		☑				
Evaluation of alternative fertilisers	☑					
On-farm mapping to determine suitable clay sources for spreading and erosion control	☑					
Education and Awareness						
Provision of practical and economic information on the recently legislated Carbon Farming Initiative					☑	☑
Provision of information on alternative stock water supplies for mains water users		☑				
Property Management Planning workshops which include consideration of water security and carbon farming		☑			☑	☑
Partnerships						
Investigate the potential for biofuel and biomass production			☑		☑	
Training and accreditation of weed control and revegetation contractors			☑	☑		
Assist with trials or demonstrations of more resilient crops, pastures and livestock	☑				☑	
Investigate and promote opportunities for soil carbon sequestration as data becomes available	☑				☑	

Actions and Themes	Land & Soils	Water & Aquifers	Vegetation & Biodiversity	Agricultural & Environmental Protection	Climate Challenges	Social & Economic
Provide assistance to control sleeper weeds which may become problems in an evolving climate				☑	☑	
Support further studies on the role of runaway holes and drainage bores and their connection to aquifers		☑				
Support continued research on alternative pasture legumes suitable for saline soils	☑					
Monitoring and Reporting						
Monitor any adverse impacts on the landscape resulting from enterprise changes brought about by climate variability or water security issues	☑	☑	☑	☑	☑	
Responding to Future Events and Issues As state and federal government structures change it is expected that the LAP could assume a greater role in partnering to respond to future events and issues at the local level.						
Threat mitigation eg pest plants or animals, climate variability, tree disease and species decline			☑	☑	☑	
Disaster management and recovery eg drought or fire	☑		☑		☑	☑
Biosecurity eg insect invasion				☑		

☑ May indicate one or more Action x Theme.

Implementation strategies

The Coorong Tatiara Local Action Plan Project aims to continue to implement its program of activities via a suite of on-ground works, partnerships with other natural resource management organisations or agencies, engagement and encouragement of volunteers and interaction with youth, schools and indigenous communities.

The on-ground works program provides incentive funding to landholders to undertake a range of conservation activities on their properties (see above). Expressions of Interest are called for annually and applications for funding are assessed against a work plan presented by the landholder, funds available for distribution and deemed public-private benefits.

More information on the application process and incentive guidelines can be obtained online from the Council website at: www.tatiara.sa.gov.au

Provision of incentive payments to landholders undertaking on-ground works are based on cost sharing arrangements that have been derived from analyses of community versus private benefits that the works are likely to provide. Where the works deliver significant private benefit to the landholder then the proportion of incentive funding offered reduces considerably. For example, the provision of minimal incentive payments for deep rooted perennial pasture or clay spreading are made on the basis that they retard groundwater recharge and therefore reduce the impacts of dryland salinity on a regional scale. At the same time these practices provide direct productivity gains to the individual farm. On the other hand incentive funding rates for fencing off and managing areas of remnant native vegetation (habitat) reflect a greater public benefit.

In accepting incentive funding, landholders must be prepared to enter into a binding agreement that describes various rules concerning the on-ground works, such as the length of the project, access for inspections, a photographic record and other criteria associated with the expenditure of public funds on private land.

In an endeavour to ensure the success of landholders work plans the LAP Project through its staff, steering committee and other contacts makes available technical advice to individuals or more widely via field days, workshops, publications and the media.

Activities and funding rates available for on-ground works incentive payments are likely to change year by year as a result of the total funds available to the LAP program, external funding priorities and local demand.

Currently the Coorong Tatiara LAP Project supports a number of activities in local schools including:

- Revegetation and plant propagation projects,
- Plant identification workshops,
- Indigenous food gardens,
- Water Watch,
- Weed Warriors,
- South East Environmental Education Working Group.

7. Indicators of success

For the plan to be viable a number of key performance indicators need to be met. Some will be short term while others may extend over several years. The indicators provide a guide to factors that can be measured along the way.

Financial

- The amount of external funds attracted to the district for use in implementing the plan.

On-ground works

- Hectares of land or kilometres of fencing covered by the on-ground works component. Eg clay spreading, perennial and saltland pastures, fodder shrubs, windbreaks and revegetation, sand drift stabilisation, protection of remnant vegetation and wetlands.
- The number of landholders implementing on-ground works options via the financial incentives on offer.
- The estimated value of landholder funds invested in on-ground works as their share of total costs.
- New on-ground works options planned, funded, established and implemented.
- Hectare, kilometre or dollar measures of the plan's contribution to community based environmental projects.
- Number of leaking or abandoned bores decommissioned.

Education and awareness

- The numbers or newsletters, fact sheets, media articles and other publications produced and distributed.
- The number of field days, seminars and other public events conducted and the number of landholders, students or other interested persons attending.
- An estimate of volunteer hours contributed to community natural resource management activities.

Partnerships

- The number and scope of partnership programs conducted in natural resource management and sustainable agriculture within the district via the Local Action Plan Committee.
- Sharing and utilising data collected by other agencies or organisations to demonstrate the effectiveness of the plan.

Guiding principles

To achieve success of the plan several guiding principles need to be addressed. The principles set the scene for community support and involvement.

- Engagement with landowners and other stakeholders in improving their understanding and commitment to acting on issues raised in the plan.
- Continued community education and awareness of natural resource management and sustainable agriculture practices and developments.
- Utilisation and promotion of current research, existing experience and local knowledge from a wide range of sources in addressing matters of importance.

- Co-ordination and input to other land management groups, agencies or organisations operating in the district to ensure that programs and demonstrations are set up with suitable levels of community involvement and local relevance.
- The distribution of public funds to private landholders via incentive payments for on-ground works should be based on a principle of community benefit. Eg reduced groundwater recharge, minimising erosion or salinity potential, enhancing biodiversity or other district and regional scale influences.
- A flexible approach and an ability to adapt to changing circumstances concerning environmental issues, community structures, government and partner agencies and opportunities for funding.

8. Gallery of best practice

The photographs below illustrate some of the projects that have been undertaken to address various natural resource management issues.

Figure 15: Clay spread across a sand rise.

Figure 16: Drainage to alleviate salinity.

Figure 17: A farm forestry plantation.

Figure 18: Fodder shrubs for stock feed.

Figure 19: Levelling a blow out before seeding.

Figure 20: Removing boxthorn.

Figure 21: Ripping rabbit warrens.

Figure 22: Patch of revegetation.

Figure 23: Preservation of wetlands.

Figure 24: Hydrological studies.

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Appendix 1

District Natural Resource Management Framework

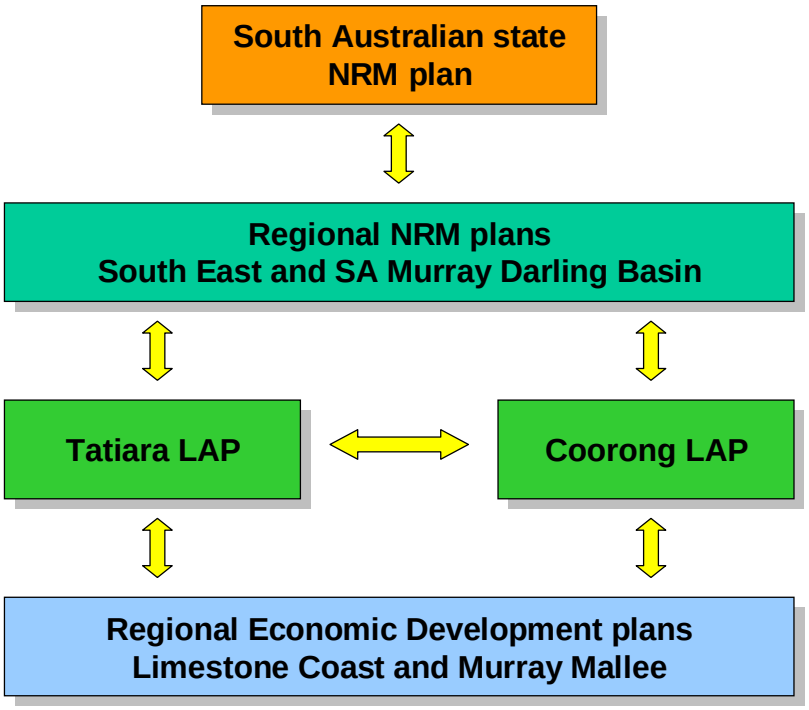
The Natural Resources Plan for the Tatiara (also referred to as a Local Action Plan) has been prepared in parallel with the revised Local Action Plan for the Coorong District.

The plan is a community driven document. It has been developed by local people who bring a range of experiences to the task.

Both the Tatiara and Coorong District Councils have established committees under Section 41 of the South Australian Local Government Act to advise on and administer aspects of natural resource management in their areas.

The Councils jointly sponsor the Coorong Tatiara Local Action Plan Project which currently employs three staff based at Tintinara.

The committees link with state level natural resource management policies and programs via the South East Natural Resources Management Board and the South Australian Murray Darling Basin Natural Resources Management Board.



The legislative framework governing natural resource management continues to evolve over time. A key role of the Tatiara LAP Committee is to keep up to date on these changes at both state and commonwealth levels, create alliances and seek funding opportunities to address issues identified in this plan. Partnering, coordination and cooperation are essential aspects for the integrated delivery of regional natural resource management outcomes.

Key connections

The Tatiara LAP Committee as sponsor of this plan has primary working relationships with several other bodies or organisations at the local level:

- The Tatiara District Council - from which it derives its charter.
- The Coorong Local Action Plan Committee – with which it shares a steering role in supporting the Coorong Tatiara Local Action Plan Project.
- The South East Natural Resources Management Board and its Northern Advisory Group.

Appendix 2

Soil types and resource condition maps

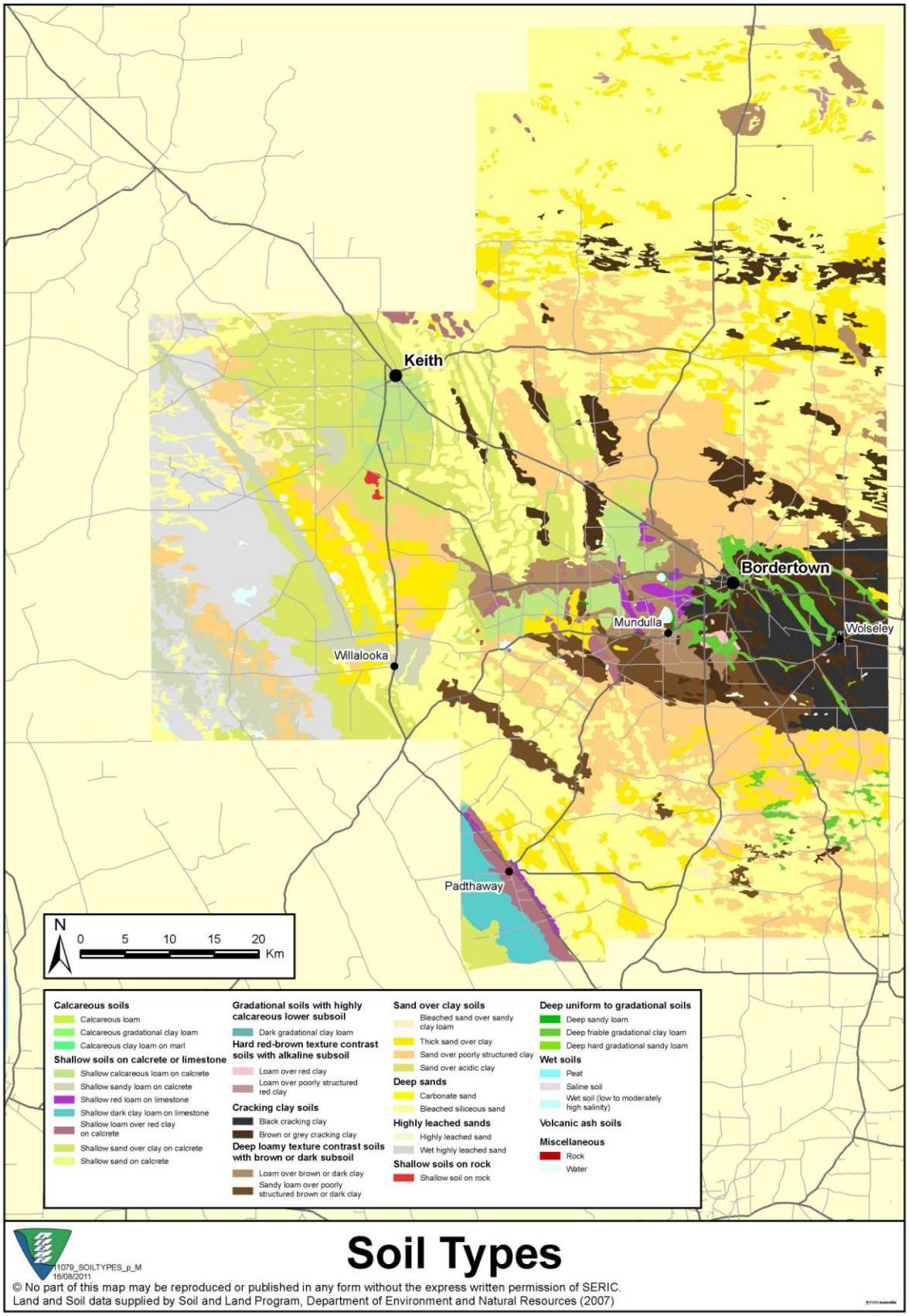


Figure 25: Soil types within the Tatiara.

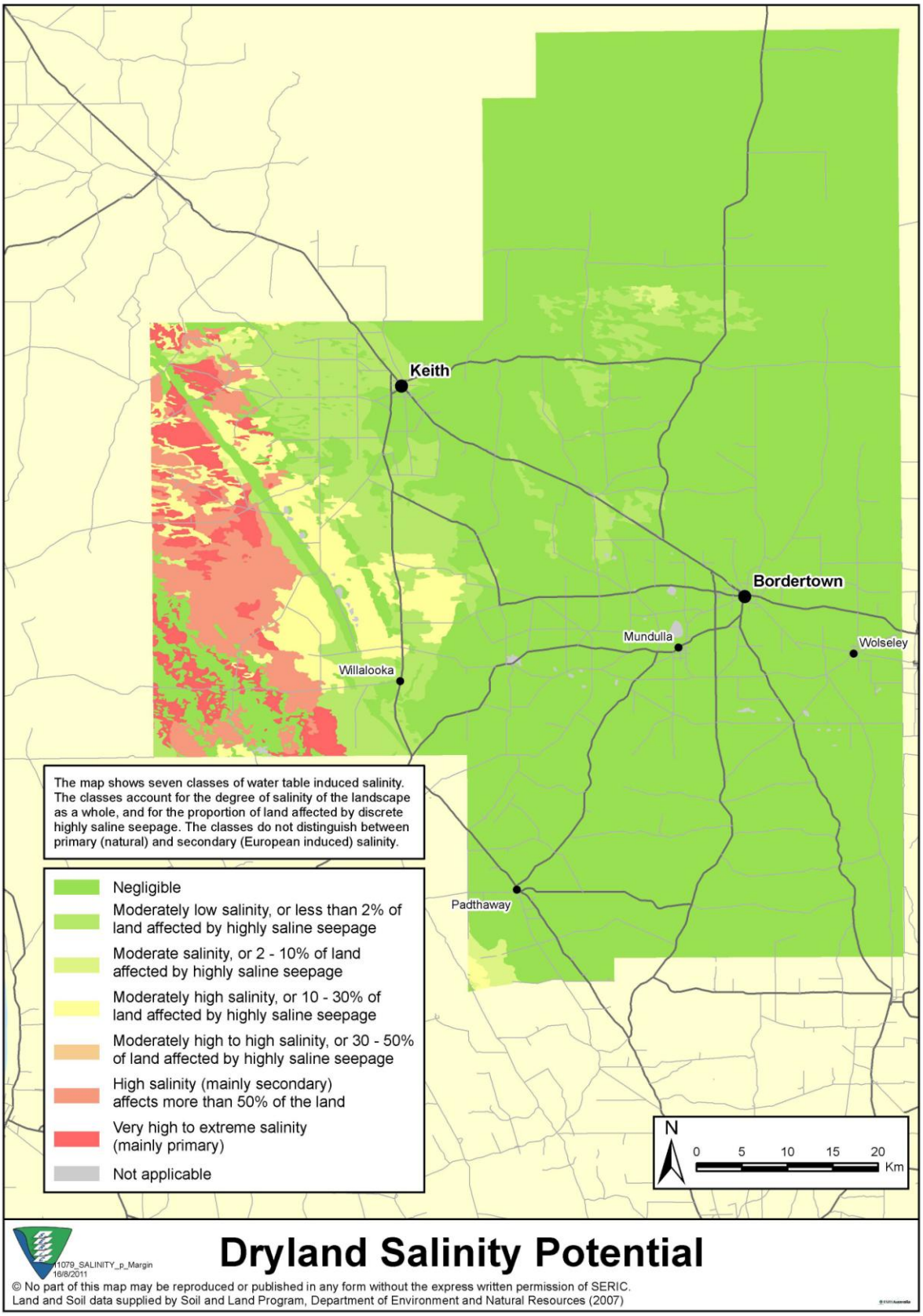


Figure 26: Dryland salinity potential.

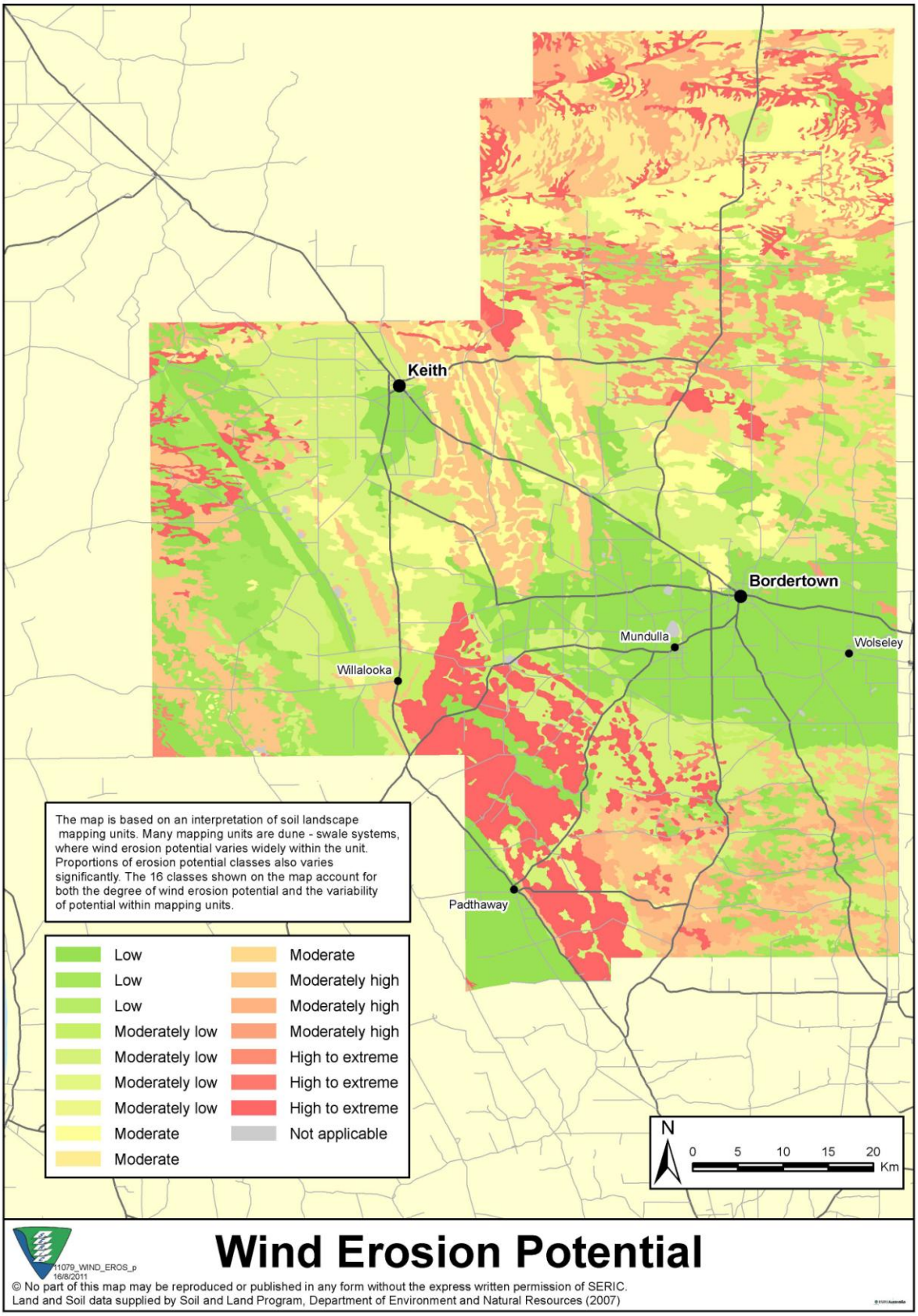


Figure 27: Wind erosion potential.

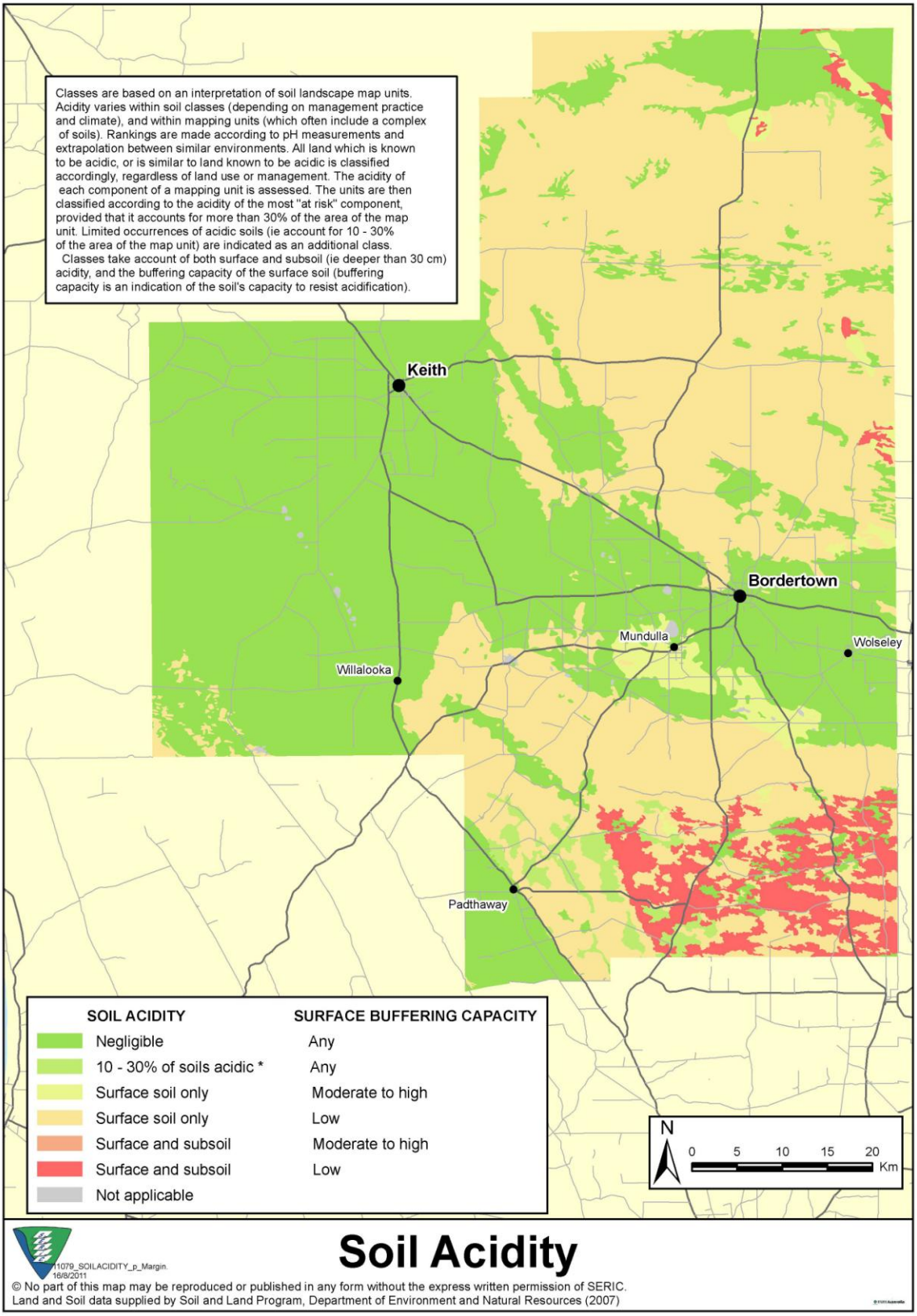


Figure 28: Soil acidity and surface buffering capacity.

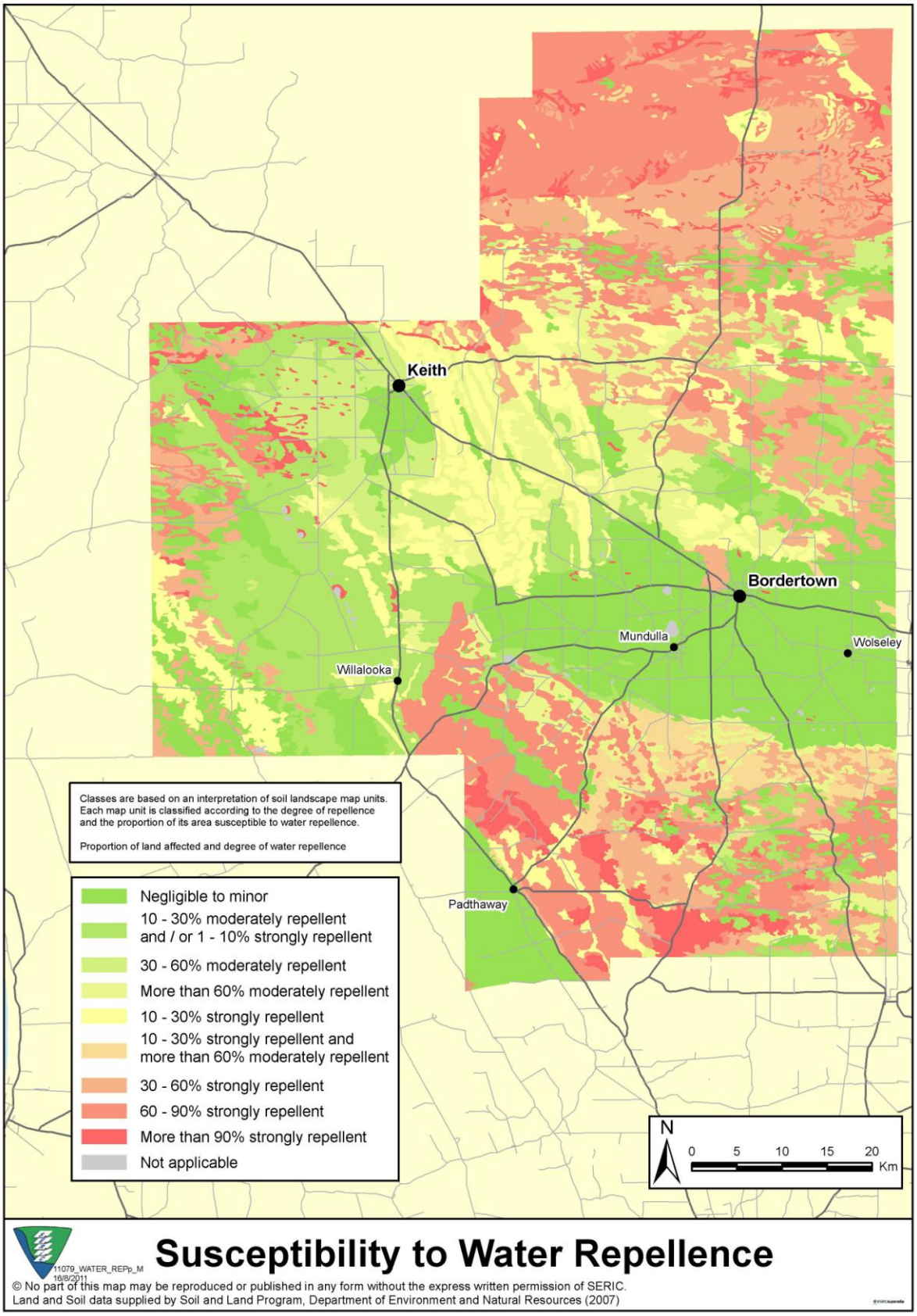


Figure 29: Soil susceptibility to water repellence.

Appendix 3

Tatiara Local Action Plan Committee Members

Chair	Adrian Barber	8755 1097
Council elected member	Robert Mock	8752 2743
Council staff	Rocky Callisto	8752 1044
Project manager	Graham Gates	0427 572 330
Project staff	Tracey Strugnell	0427 750 050
	Samantha Blight	0447 900 001
Members	Miles Hannemann	8756 7043
	Josie Jackson	8757 8276
	David Altus	8754 2048
	Tony Hedges	8755 1917
	Trevor Thomas	8753 2265
	John Matthews	8752 1371
	Anna Smart	0407 566 065

Coorong Tatiara Local Action Plan