Goulburn Broken Land Health Strategy 2017 - 2020

GOULBURN BROKEN
CATCHMENT MANAGEMENT AUTHORITY

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1 What is Land Health?

The health of land is its ability to provide ongoing services to support community and societal aspirations, for example, primary production, conservation and water quality. The concept can be expanded to include aesthetic and spiritual values (Cork *et al* 2012). This definition fits with the concept of resilience; the capacity of a system to absorb stress while continuing to function in a desired way (GB CMA 2013a). This aligns with the Goulburn Broken Regional Catchment Strategy's 2013-19 (RCS) focus on maintaining the resilience of social-ecologial systems so they continue to deliver critical services and values for people and nature (GB CMA 2013a). Ecosystem resilience is critical in supporting productive and sustainable landscapes by providing ecosystem services such as pollination, pest control, native species habitat, healthy soils, clean air and providing an aesthetically pleasing place to live and recreate (GB CMA 2015).

Land health includes many values, including agricultural production, waterway health, biodiversity conservation and more broadly, resilience of landscapes. Land health programs in the Goulburn Broken Catchment recognise the connections between the need for ecosystem resilience and provision of productive land, and as a result, healthy and sustainable communities. While land health activities are currently soil management-focused, projects encourage land managers to consider broader natural resource management outcomes, such as biodiversity conservation and waterway health (GB CMA 2015).

Soil, waterway, wetland and terrestrial habitat works are integrated through projects that recognise the interconnectedness and importance of all elements in creating resilient systems within and beyond the farm fence. Actions that help implement such a systems-based approach include integrated prioritisation of areas for works and integrated management planning for landholders who receive incentives (GB CMA 2015).

In this Strategy, land health is focussed around the Land theme of the Goulburn Broken RCS (GB CMA 2013a) and actions are currently focussed in soil management. Whilst there are links between actions and works for Biodiversity, Water and People, these themes are addressed more directly through their individual sub-strategies.

2 Strategy Purpose

This Strategy is a supporting sub-strategy of the Goulburn Broken RCS 2013-2019 (GB CMA 2013a). It defines land health and outlines strategic priorities and associated actions to guide land health activities that contribute to selected strategic priorities of the RCS.

Regional Catchment Strategy sub-strategies are developed in consultation with government and community organisations and individuals, providing details for investment plans and priorities.

This Strategy is for those with a stake in land health management in the Goulburn Broken Catchment, including regional authorities, Government agencies, community NRM groups, primary and industry groups. Actions are pitched at a high level to allow for flexibility in implementation according to local circumstance. Stakeholders may use this Strategy to inform and plan activities.

3 Background

This Strategy builds on many years of land and soil health action in the Catchment, from soil conservation and acid soil management through to salinity management plans of the 1990s and 2000s. More recent thinking around the importance of the community in program delivery was included in the Goulburn Broken Soil Health Action Plan (2006) and the Goulburn Broken Dryland Landscape Strategy (GB CMA 2009), which this Strategy builds on.

The main outcome currently sought by investors in land health activities is farmers adopting practices that adapt to climate change and improve the quality of the natural resource base to sustain long-term environmental, economic and social benefits for themselves and the broader community. This change in investment from onground incentives, such as land class fencing, to extension, engagement and farmer-led demonstrations and trials continues (GB CMA 2015).

The current RCS builds on almost 30 years of lessons and achievements in catchment management that have given the Goulburn Broken Catchment's communities significant experience and understanding of the management approaches that will make a difference. The approach to catchment management has evolved from a focus on single threats such as salinity in the 1980s to integrated catchment management (salinity, water quality, biodiversity) in the mid-1990s to a focus on valuing outcomes such as ecosystem services (e.g. clean water, productive soils). The focus now is on maintaining the resilience of social-ecological systems so they continue to deliver critical services and values for people and nature (GB CMA 2013a).

There are many land management activities undertaken on both private and public land to improve the condition of natural resources across the catchment (GB CMA 2013b). The focus of land management in this Strategy is on soil condition (GB CMA 2013b).

The purpose of promoting land health and soil condition, as identified in the RCS (GB CMA 2013b), is to:

- Protect the soil capital from the major degrading processes of erosion, organic matter decline, acidification, contamination, compaction, salinisation and biodiversity decline.
- Restore, maintain or enhance ecosystem services from soil, including soil carbon cycling, soil structure stabilisation, soil biological activity and soil hydrology.
- Protect other terrestrial and aquatic assets by reducing the impact of soil acidity, soil sodicity (including soil salinity), and water erosion.

This Strategy will contribute to the following selected 6-year strategic priorities of the RCS:

- Provide adaptive management and leadership (see strategic objective 4. *Practice adaptive management*)
- Adapt to climate variability risks (see strategic objectives 1. *Support development of resilient farming systems* and 3. *Respond to land use change*)
- Respond to and recover from climatic events (see strategic objective 1. *Support development of resilient farming systems)*
- Capture opportunities from a low carbon future (see strategic objective 3. *Respond to land use change*)
- Manage risks to agricultural production (see strategic objectives 1. *Support development of resilient farming systems* and 3. *Respond to land use change*)
- Establish sustainable agricultural practices (see strategic objectives 1. *Support development of resilient farming systems* and 2. *Strengthen partnerships)*
- Increase biodiversity in agricultural land use (see strategic objectives 1. *Support development of resilient farming systems* and 3. *Respond to land use change*)
- Adopt flexible engagement approaches (see strategic objective 2. *Strengthen partnerships*)

4 Land in the Goulburn Broken Catchment

4.1 Soil services that contribute to land health

Soils provide many services that sustain natural, productive and built systems, such as (Bennet *et al* 2010):

Provisioning (lead to benefits)

- Provision of marketable goods - e.g. food, fibre, timber
- Soil structure stabilisation - retention of soil (prevention of loss by wind and water)
- Gas regulation - consumption/emission of atmospheric gases
- Carbon sequestration - net carbon stored in soil
- Water quality regulation - water filtration/purification
- Water yield - water retention and availability
- Water flow regulation - mitigation of e.g. runoff, flooding
- Weather regulation - ameliorate daily extremes in air temperature and moisture
- Remediation of wastes and pollutants - breakdown, immobilisation, or detoxification of excess or harmful organic and inorganic materials
- Disease and pest regulation - control of potential pests and pathogens
- Habitat provision/genetic resource maintenance - habitat for and maintenance of soil biodiversity (genes, species, phyla, functional groups)

Degrading (to levels that decrease services and lead to costs)

- Salinisation - increase in soil soluble salt content
- Acidification - increase in soil acidity
- Wind erosion - loss of soil by wind
- Water erosion - loss of soil by water
- Organic matter decline - decrease in soil organic matter content

This list shows that the services provided by soils are fundamental to human wellbeing and that of our economy and society. Some of the key services are well enough understood, including soil water holding capacity, drainage and soil structure stabilisation. Other critical attributes, such as soil biology, are in the early stages of discovery but knowledge is increasing rapidly and at a critical time when the focus on land management, for both productive and environmental outcomes, is looking more closely at the whole landscape.

4.2 Land use

The major land uses for each Social-ecological System (SES) identified in the RCS (GB CMA 2013a) are shown in Table 1: and Figure 1. The Upland Slopes SES is dominated by grazing and forestry. Grazing is the major land use in the Productive Plains and the Commuting Hills SESs, although mixed farming and cropping are prominent in the Productive Plains also. The Agricultural Floodplains SES contains the most agriculturally diverse land use including grazing, irrigation, cropping and horticulture. It also contains the greatest urban population. Public land is most prominent in the Southern Forests, Productive Plains and Upland Slopes SESs.

Table 1: Major land uses by Social-ecological System (SES) in the Goulburn Broken Catchment

Social-ecological System	Land use
Agricultural Floodplains	– Grazing 33% – Irrigation 31% (Cropping 18%, Pastures 17%) – Cropping 11% – Horticulture 3%
Commuting Hills	– Grazing 54% (Modified pastures 51%, Native vegetation 3%) – Forestry 24% (Production forestry 21%, Plantation forestry 3%)
Productive Plains	– Grazing 63% (Modified pastures 61%, Native vegetation 2%) – Public land 12% – Cropping 10%
Southern Forests	– Forestry 66% (Production forestry 65%, Plantation forestry 1%) – Public land 24% (Conservation 19%, Other 5%)
Upland Slopes	– Grazing 54% (Modified pastures 51%, Native vegetation 3%) – Forestry 21% (Production forestry 17%, Plantation forestry 4%) – Public land 17% (Nature conservation 8%, Other 9%)

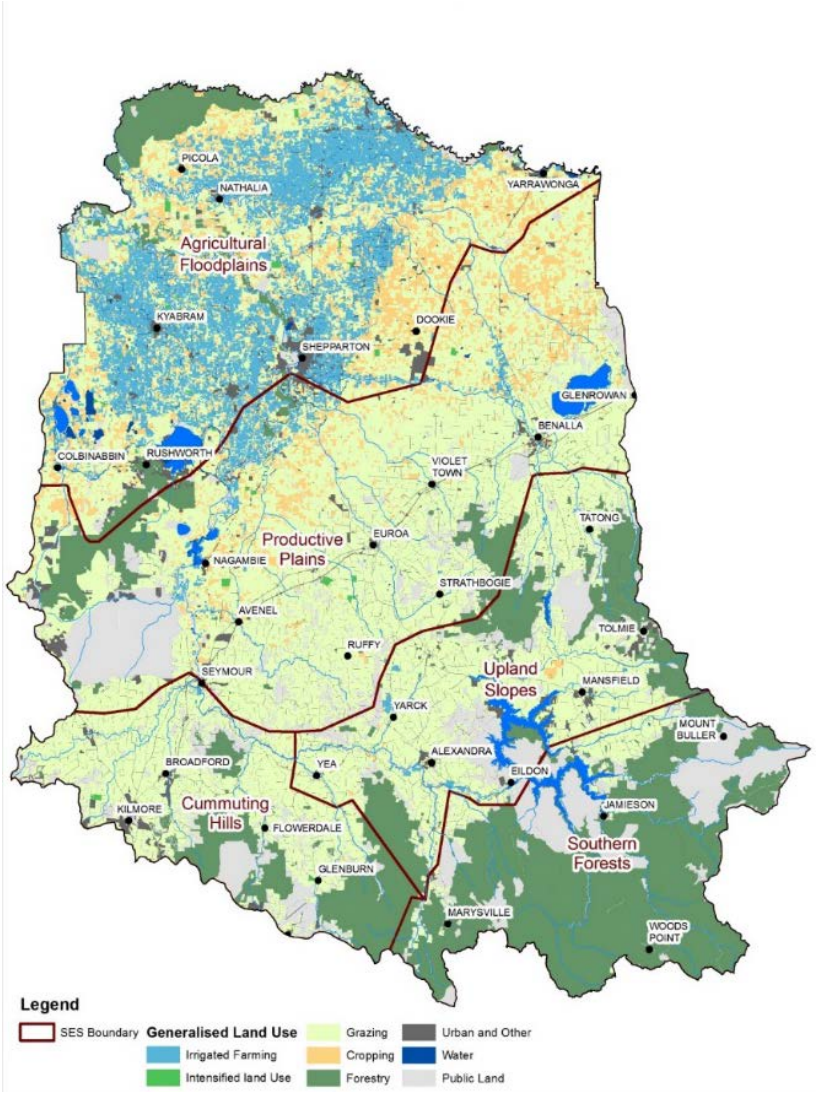
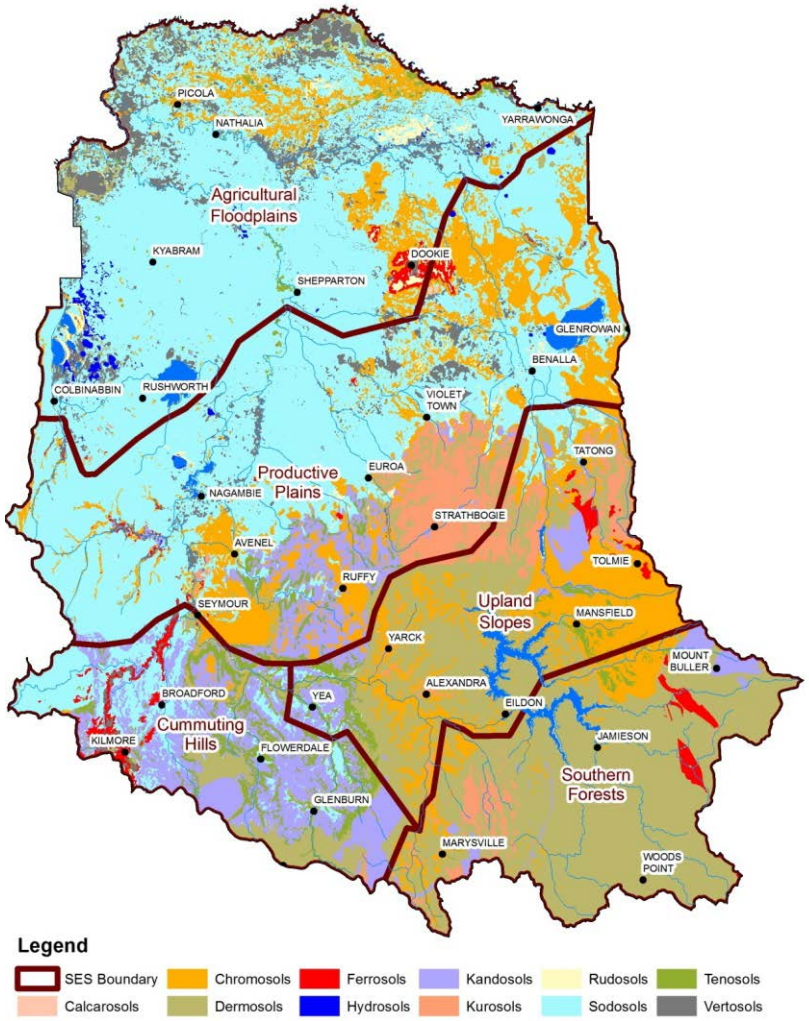


Figure 1: Major land use in each Social-ecological System of the Goulburn Broken Catchment.

4.3 Major soil types and their characteristics

The major soil types for each SES are displayed in Figure 2 and described in Table 2. More detail is contained in the Appendices.



Agricultural Floodplains	Sodosols 74%
Productive Plains	Sodosols 54% Chromosols 21%
Upland Slopes	Dermosols 57% Chromosols 21.4%
Commuting Hills	Kandosols 40% Sodosols 24% Dermosols 15%
Southern Forests	Dermosols 64% Chromosols 15%

Figure 2: Major soil types of the Goulburn Broken Catchment by Social-ecological System (Botta 2015; Hazelton & Murphy 2007; Glendinning 2000).

Table 2: Major soil types of the Goulburn Broken Catchment and their characteristics (Botta 2013)

Major soil type	Description
Sodosols	These dense and poorly structured soils can have significant implications for management affecting soil workability, permeability, crop establishment, moisture availability and erodibility. Root growth and water movement through the profile are commonly restricted. They are associated with salinity and prone to erosion and seeps. They can also contain varying amounts of buckshot gravel (ironstone nodules). In the Goulburn Broken Catchment these soils are mainly associated with intensive agricultural uses such as: • Irrigated agriculture including cropping, dairy, horticulture, and other irrigated industries • Transition agriculture including some of the "new" areas of dryland agriculture associated with changes in the water industry (e.g. dryland cropping) • Dryland cropping • Mixed farming including dryland cropping and grazing enterprises
Kurosols	Kurosols occur predominantly in the uplands where rainfall is higher and consequently so is the leaching. These acidic soils can have significant implications for management affecting soil nutrient availability, crop and pasture establishment, and plant root growth. They are also prone to nutrient leaching.
Chromosols	Chromosols occur throughout the region and can be found on the alluvial riverine plains and throughout the uplands. The surface soil textures of these soils tend to be lighter loamy textures and the depth of the topsoil can vary considerably. This can have significant implications for management, affecting soil workability, permeability, crop establishment, moisture availability and erodibility. The subsoils tend to be clay textured soil and are often mottled in colour indicating restricted drainage.
Kandosols	These soils tend to be poorly structured and can have significant implications for management affecting soil fertility, moisture availability, erodibility and crop establishment. They are mostly well drained and are often referred to as 'earthy' soils. In the Goulburn Broken Catchment these soil types are mainly associated with extensive agricultural uses such as grazing enterprises with cattle and/or sheep but also support small amounts of viticulture and other niche industries.
Dermosols	These soils occur in the upland areas and are most often associated with grazing and public land use. They do not have a strong texture contrast, clay increases with depth, they are usually well drained but can have bleached A2 horizons indicating restricted drainage. They tend to be slightly to moderately acid and have highly variable organic matter content.

4.4 Condition, trends and benchmarks

It is known that human activity has caused soil degradation since European settlement (GB CMA 2013a)…

> *"… soil fertility is decreasing due to a number of factors including acidification, leaching, overuse of fertilisers, salinity, loss of biodiversity, overstocking and grazing pressure and generally unsustainable farming practices" (Colloff, M* in *Binning et al 2001).*

The main emphasis for improving soils is to maintain or restore services such as carbon storage, soil biodiversity and water-holding capacity. These services underpin sustainable land use, fundamental ecological processes and the productive capacity of soils (GB CMA 2015).

However, as land is used and valued in ways that are not always complementary and there is no precise description of what is needed from soils in the future, it is extremely difficult to assess the condition of land; good condition for one purpose might be poor for another (GB CMA 2013a).

From 1990 to now, the components of land condition that are rated to assess Catchment land condition are those that:

- best information is available for;
- relate to existing uses and values; and
- are amenable to management.

Table 3 presents Catchment condition indicators that have been consistently reported in the Goulburn Broken CMA's Annual Reports.

Table 3: Land condition (GB CMA 2015-16 Annual Report)

Investment area	Evidence used	Catchment condition				
		1990 [i]	Certainty of rating	2016	Certainty of rating	3 year trend
Sustainable Irrigation - Water quality	• Phosphorus loads in rivers and streams • Blue-green algal blooms • Salt disposed to the Murray River	Very poor	Low	Satisfactory	High	Improving
Sustainable Irrigation - Watertables	• Watertable salinity and depths • Salinity of environmental features	Poor	High	Satisfactory	High	Improving
Land health including dryland salinity	• Watertable salinity and depths • Salt disposed to the Murray River • Salinity of environmental features • Management systems	Poor	Very low	Satisfactory	Low	Static

i. Ratings for 1990 have been determined using our understanding in 2016 of the situation in 1990.

Through recent investment data on measures of land condition in farmland has been collected, including soil acidity, soil organic carbon and ground cover (see Table 4). This data has been used to determine a baseline for agricultural soils across the Catchment (Table 4, Figure 3). Currently, soil acidity is high across the Catchment, with hotspots in the Commuting Hills, Upland Slopes and Productive Plains, and management remains a significant issue for farmers. Organic carbon levels are low to moderate across the Catchment, with levels highly dependent on land use. Ground cover estimates were largely reported as greater than 70%, however this figure should be interpreted with caution as it is a point in time measurement (GB CMA 2015).

Table 4: Agricultural land condition thresholds and 2012-13 Catchment rating

Measure of land condition	Identified threshold	2012-13 Catchment rating
Soil acidity (soil pH)	>4.8-5.0 in $CaCl_2$	Poor (pH($CaCl_2$) 4.7, n[i] 744)
Soil organic carbon (%)	≥2% annual cropland ≥5% pasture, permanent plantings	Low (OC 2.7%, n[i] 744)
Ground cover (%)	>70%, 100% of the time	Good[ii] (86.6%, n[i] 644)

[i] n is the number of samples

[ii] Ground cover assessment is a point in time measurement between Spring 2011 and Spring 2012

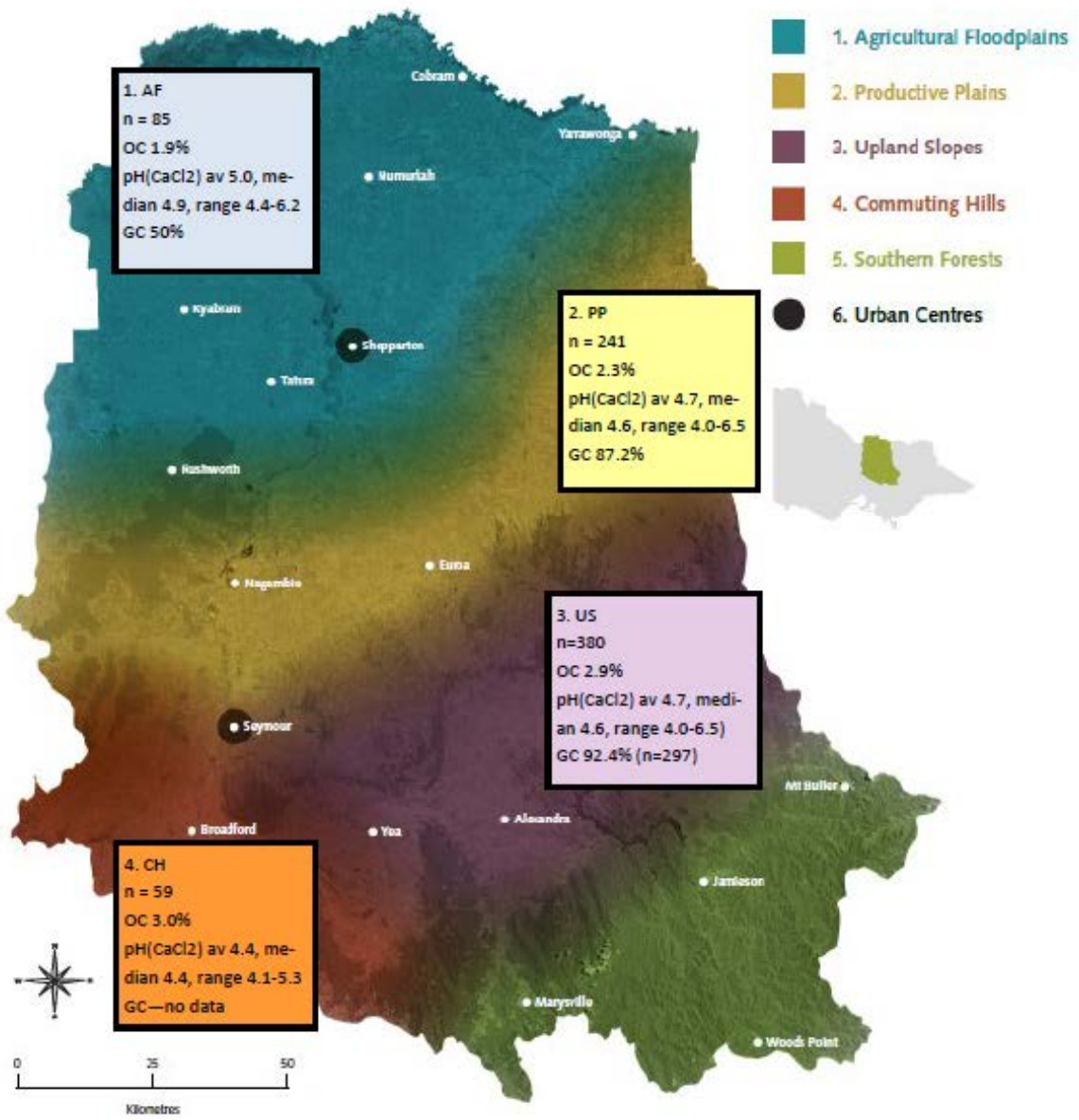


Figure 3: Soil test data presented by Social-ecological system. Text boxes present soil pH and organic carbon (OC) soil test information and visually-assessed ground cover (GC) data as collected by farmers in 2011-2012 as part of the Beyond SoilCare project. Catchment wide, n 744; OC 2.7%; pH($CaCl_2$) 4.7; GC 86.6%) (*n 644), where n is the number of samples.*

There is an opportunity to improve benchmarks for the biological, chemical and physical state of soils. The benchmarks highlighted above and in common use are the chemical analysis of soils for crop and pasture production (Table 4, Figure 3), and these largely do not reflect an holistic approach to land health.

Whilst unquantified catchment-wide, soil structural decline, lack of perennial ground cover and incompatible farming and civil infrastructure create and/or exacerbate soil erosion on farms, affecting productivity and leading to offsite impacts. Engagement with land managers is good, and whilst arresting erosion is a priority for most, it is often prioritised against more immediate farm costs; hence gully, tunnel and sheet erosion are still a feature throughout the Productive Plains, Upland Slopes and Commuting Hills SESs. Biodiversity plantings have had multiple benefits where land managers have fenced-off and revegetated erosion gullies or steep slopes for soil protection and vegetation connectivity across their farms. Whilst the local benefits of these works are clear, for the most part, land managers can only undertake such works with grant support (GB CMA 2015).

5 Strategic Approach

Past land development, urbanisation and agricultural practice have put pressure on the ability of the natural environment to provide services necessary to sustain agricultural production and healthy landscapes (Eadie & Stone 2013). Increasing pressure to produce more from soils that are continuing to lose vital services, such as stored carbon, will place extra demands on the system.

The strategic approach guiding land health activities in the Catchment is to:

- Promote improved productivity through the promotion of land management practices that increase the resilience of the whole farm.
- Integrate land manager observations with current science, acknowledging that knowledge of both is incomplete and while the answers are not always known, the process to aid new knowledge is facilitated.
- Continue to define soil health and develop understanding of soils as a whole, particularly soil biology, and further develop measures of condition.

5.1 Resilience focus

Resilience is the ability of people and the environment to absorb stress while continuing to function in a desired way (GB CMA 2013a).

The focus for land health activities in the Catchment is on continuing to build understanding of the drivers of and pressures on soil condition. This informs the development of management options aimed at ensuring soils continue to provide services that underpin land health within identified thresholds, services that people and nature rely on.

"*The ecosystem services provided by land and soil underpin sustainable land use and fundamental ecological processes in the Catchment for rural communities*" (GB CMA 2013b, pg. 11).

The services of main focus are:

- Soil stability
- Soil water holding capacity and retention
- Soil carbon sequestration
- Soil biodiversity and biological functions
- Soil chemistry and its impact on provision of services from soil

As previously mentioned some of these services are well researched and understood, such as management of soil stability and improving soil water holding capacity. Others like carbon sequestration and soil biodiversity are only partly understood.

At this stage there is still a lot to learn about the condition of soils and benchmarks of soil condition that are needed to identify thresholds of high confidence and develop robust targets. Appendix 2 briefly describes the major soil types of each Social-Ecological System and the services they provide.

5.2 Strategic objectives

The diagram below summarises the Strategy framework. The 3-year Strategic Objectives, including actions, are outlined in detail in the following sections.

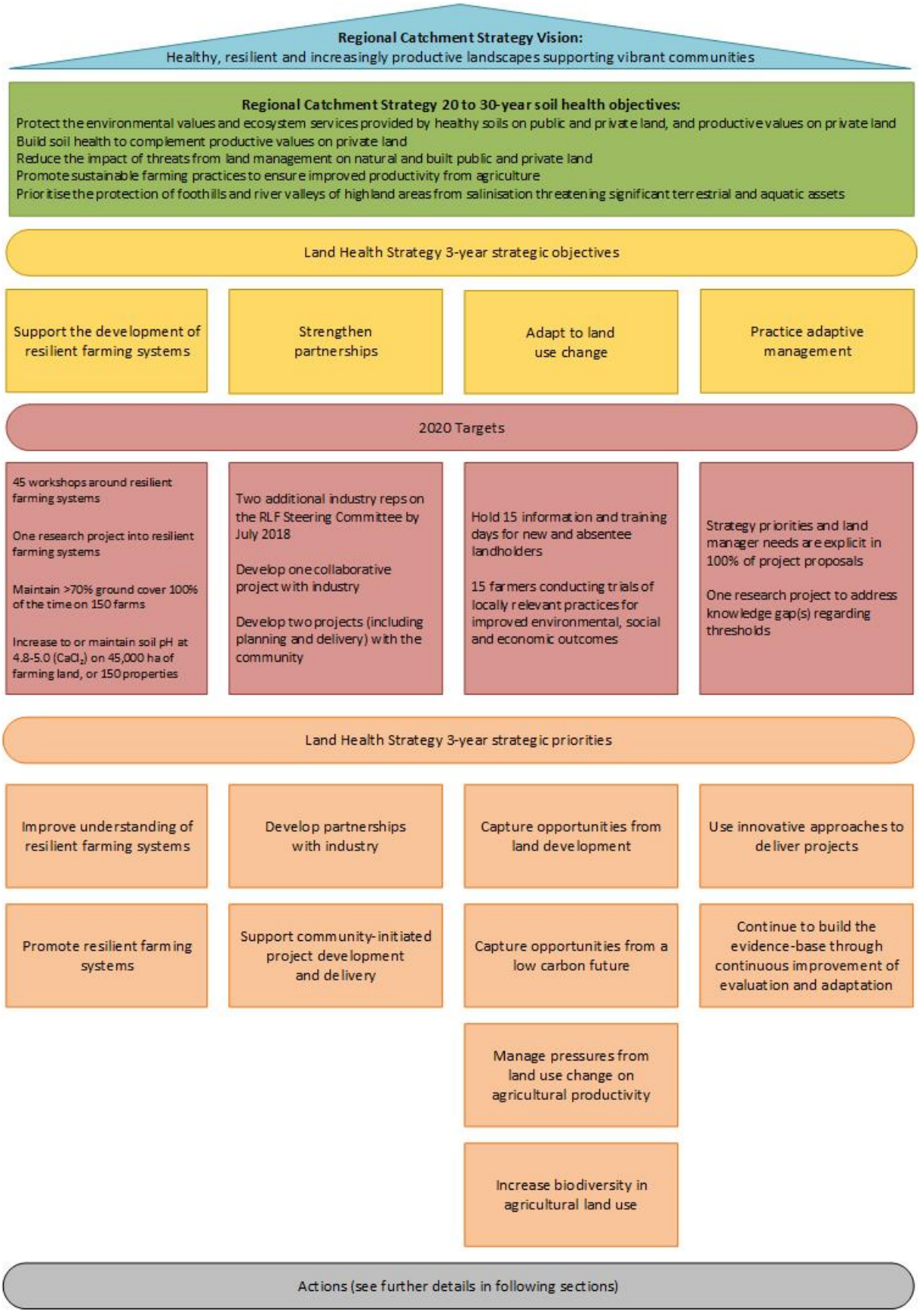


Figure 4: Goulburn Broken Land Health Strategy Framework.

5.2.1 Strategic objective 1. Support the development of resilient farming systems

Major events such as bushfires, drought, floods and the global financial crisis have tested the Goulburn Broken Catchment's communities and natural resource systems in recent years (GB CMA 2013a).

Supporting the development of resilient farming systems aims to facilitate meeting the needs of a developed economy through agricultural enterprises that have the capacity to adapt to drivers of change and are integrated with the natural environment.

Targets
• Facilitate 45 workshops to share knowledge around resilient farming systems by 2020
• Initiate one research project into resilient farming systems focusing on grazing and water management by 2020
• Maintain >70% ground cover 100% of the time on 150 agricultural properties
• Increase to or maintain soil pH at 4.8-5.0 ($CaCl_2$) on 45,000 ha of farming land, or 150 properties

Strategic priorities		Actions		SES
1.1	Improve understanding of resilient farming systems	1.1.1	Investigate the need and opportunity to introduce new commodities to maintain productive viability	All
		1.1.2	Explore opportunities for strengthening the farm planning program through broadening the base of service providers to include social and economic aspects of farming systems, including new technologies	All
		1.1.3	Investigate the impact of land management on the diversity and function of soil biology and soil biodiversity	All
		1.1.4	Involve land managers, community groups and industry bodies in identifying future trends, drivers and pressures that will impact on land health	All
		1.1.5	Undertake a dryland land use climate change vulnerability assessment	PP, CH, US
1.2	Promote resilient farming systems	1.2.1	Create awareness and acceptance of land management practices that enhance provision of soil ecosystem services and are integrated with improved natural resource outcomes at the property, SES and catchment scales	All
		1.2.2	Support farmers to plan for and implement flood, fire and drought response and recovery	All
		1.2.3	Implement landholder stewardship programs to reinstate perennial vegetation in hill country to reduce flash run-off, flood, erosion and water quality impacts of extreme rainfall events predicted under climate change	PP, US, CH (especially Yea River Catchment)

5.2.2 Strategic objective 2. Strengthen partnerships

The Catchment's systems are influenced and managed by many individuals, communities and organisations, meaning that much of the work required to achieve the 50-year vision for the Catchment will be undertaken by many parties. Strong relationships between partners in natural resource management (NRM) are critical to ensuring everyone is working complementarily towards an agreed management approach. A strong community agency partnership fostered in the late 1980s remains a feature of NRM in the Catchment today (GB CMA 2013a). Regional and local NRM groups need to continue to work with the community, who do a lot of work through their own initiative, to share information and resources to achieve mutually agreed outcomes.

Part of further developing relationships is establishing and maintaining good communication channels. The Goulburn Broken CMA and partners have worked hard to develop communication channels by keeping messages simple, consistent and provided to the community through their preferred media and communication outlets. This work now needs to be complemented utilising newer forms of communication, in a diverse response that reflects the diversity of our community.

Being heavily reliant on funds from a small number of investors poses a risk to the integrity and longevity of land health initiatives. This can partly be addressed by focusing on activities that have a significant flow-on effect in the community and by diversifying the funding base through integration across NRM themes, such as biodiversity. Broadening the funding base also requires that the scope of land health encompasses a wide range of interests and community and funding imperatives, and not be limited to traditional funding streams. The Goulburn Broken CMA needs to continue to work with partners both within and beyond the Catchment to have the impact desired and to appeal to investors looking at outcomes on a large scale.

Targets
• Two additional industry representatives on the Regional Landcare Facilitator Steering Committee by July 2018
• Develop one collaborative project with industry by 2020
• Develop two projects (including planning and delivery) with the community by 2020

Strategic priorities		Actions		SES
2.1	Develop partnerships with industry	2.1.1	Explore opportunities for new partnerships and joint partnerships	All
		2.1.2	Explore new investment opportunities and service delivery models	All
2.2	Support local community-initiated project development and delivery	2.2.1	Work with the community to develop resilient land use and management systems	AF, PP, US, CH
		2.2.2	Involve the community in the development of projects, including service delivery	AF, PP, US, CH
		2.2.3	Involve the community in developing the evidence base for improved land health	AF, PP, US, CH
		2.2.4	Promote peer to peer learning amongst land managers	All
		2.2.5	Support land manager-directed demonstration trials and workshops	AF, PP, US, CH
		2.2.6	Review engagement approaches and identify new ways to engage different types of land managers	All

5.2.3 Strategic objective 3. Adapt to land use change

Land use changes continue across the Catchment in response to short term pressures such as drought, fire, flood and the global financial crisis, and long term pressures such as ageing farmers and increasing competing demands for land resources between farming, lifestyle and urban land use driven by ongoing population growth and migration into and within the Catchment (GB CMA 2013a).

The ongoing significant challenge will be to balance environmental, social and economic needs as land use change continues and to manage this change so natural resources, such as soils, can continue to deliver services of high value to people and nature (GB CMA 2013a).

Targets
• Hold 15 information and training days for new and absentee landholders by 2020
• 15 farmers conducting trials of locally relevant practices for improved environmental, social and economic outcomes by 2020

Strategic priorities		Actions		SES
3.1	Capture opportunities from land development	3.1.1	Deliver farm planning to integrate ecological and agricultural productivity benefits	AF, PP, US, CH
		3.1.2	Promote land use capability assessments and implementation, including use and management of water	AF, PP, US, CH
		3.1.3	Design and implement peri-urban and lifestyle landholder NRM programs to encourage such landholders to engage in measures to manage soil health and remnant vegetation and to develop the skills and capacity for implementation drawing on the success of past programs such as the Victorian Government's Services and Information for New Landholders program	PP, US, CH
		3.1.4	Work with land use planning authorities to aim to match new development with appropriate areas of land	All
3.2	Capture opportunities from a low carbon future	3.2.1	Support carbon farming projects that have NRM, social and economic benefits informed by the Climate Change Adaptation Plan for NRM in the Goulburn Broken Catchment, 2016	AF, PP, US, CH
3.3	Manage pressures from land use change on agricultural productivity	3.3.1	Develop processes and tools to assess the risk of land use change, including peri-urban and urban development, in consultation with the Victorian Government, local government and VFF	AF, PP, US, CH
3.4	Increase biodiversity in agricultural land use	3.4.1	Create awareness and acceptance of land management practices that minimise pressures on natural systems	All
		3.4.2	Identify environmental stewardship opportunities for land managers	All
		3.4.3	Work with landholders to enhance biodiversity on private land and build understanding of its contribution to sustainable and profitable farming	All

5.2.4 Strategic objective 4. Practice adaptive management

The historical reliance on the technical proficiency of service agents needs to be broadened to better reflect the complexity of the operating environment. Working with the community to change attitudes and develop good relationships requires an appreciation of the personal motivations of landholders and a recognition of their commitment to improving land condition as they see it. To do this requires NRM practitioners to expand the skills and resources to engage the community at multiple levels of interest and to focus on the whole property as a system and not simply a production unit.

The management of programs needs to be constantly bolstered by improved evidence of impacts and outcomes from different management regimes and also the causal impacts of degradation. Land health programs need to continue the commitment to the collection and analysis of information that supports program logic and provides evidence of the impact of programs.

Targets
• Strategy priorities and land manager needs are explicit in 100% of project proposals
• One research project to address knowledge gap(s) regarding thresholds by 2020

Strategic priorities		Actions		SES
4.1	Use innovative approaches to deliver projects	4.1.1	Build community and agency capacity to respond together to drivers of change	All
		4.1.2	Consider the latest research findings and industry trends in the development and implementation of tools to facilitate change	All
		4.1.3	Focus on activities that meet land manager needs within the scope of investment profiles	All
4.2	Continue to build the evidence-base through continuous improvement of evaluation and adaptation	4.2.1	Research knowledge gaps to inform decision making based on thresholds and tipping points	AF, PP, US, CH
		4.2.2	Develop baseline and benchmarks for land condition	AF, PP, US, CH
		4.2.3	Investigate valuing services provided by land	AF, PP, US, CH
		4.2.4	Monitor the effectiveness of investment processes and project development	All

6 Evaluation and Adaptation

NRM planners will reconsider and adjust the direction set in this Strategy as circumstances require.

Major challenges for evaluation, decision-making and adaptation come from:

- the complex system of people and nature, including a highly integrated and changing operating environment
- uncertainties about the risks to the resilience of the social-ecological system, including uncertainties in measuring system elements and progress in managing them
- the increasing pace of socio-economic, climate, land and water management, and technology changes
- the inherent difficulty in going from 'action to traction': developing well thought-out actions is one task; making actions happen is another (GB CMA in prep.)

Given these challenges, the Goulburn Broken CMA formalised a 'resilience approach' in the RCS 2013-19, increasing the emphasis on adaptive management that had been evolving since the late 1980s (GB CMA in prep.). Adaptive management requires the right people to be focused on making decisions about the right problems at the right time. Timely decisions require partners to have shared agreement on appropriate responses, often in advance of a circumstance arising, which demands significant investment in nurturing relationships: timely changes are often as much about organisational and cross-organisational culture as the quality of any written plan.

This Strategy focuses on the Goulburn Broken RCS's three to six-yearly and annual planning cycles as shown in Figure 5. Each decision in the cycle is informed by different evidence, as shown in Table 6.

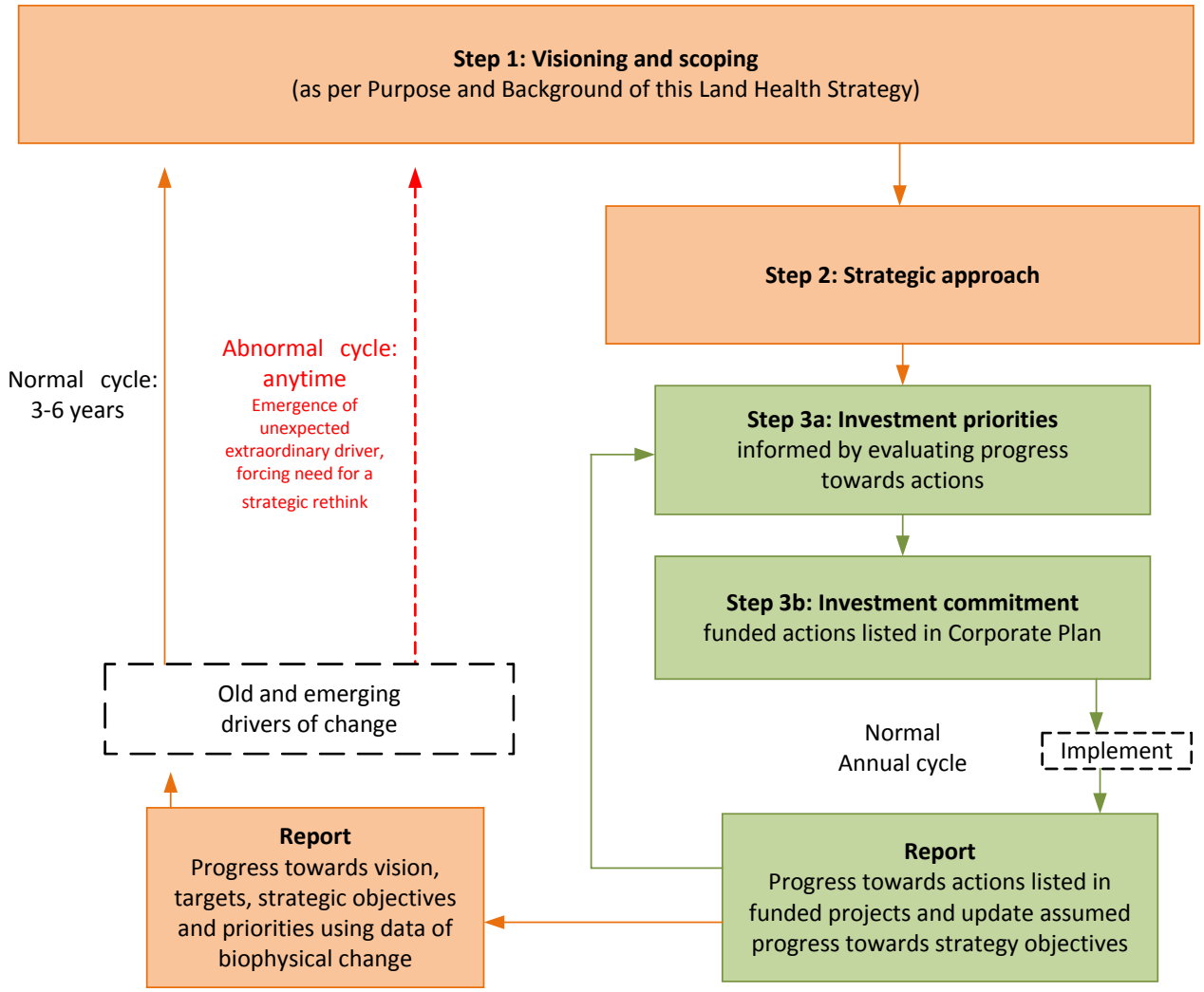


Figure 5: Goulburn Broken RCS planning cycles, showing how it is applied to this Land Health Strategy (GB CMA 2013a).

Table 5: Land Health Strategy evaluation process checklist aligned with planning cycle steps

Planning cycle step		Evaluation action		Key evaluation questions to be considered annually[i]	Items of evidence in answering key evaluation questions
1a) **1b)**	**Annual report** **Detailed background reports**	1 2	Complete a snapshot report of *Land Health Strategy* implementation within the Goulburn Broken CMA's annual report. Prepare detailed reports for various issues, according to a continually updated evaluation schedule.	What progress was made this year? What progress has been made in implementing the *Land Health Strategy* to date? What are the risks to the future of the Catchment in terms of land health? Any new risks? What next steps does *Land Health Strategy* need to take?	Achievements (outputs completed against funded targets) Achievements (including government-funded and other fund-source) onground output achievements against actions (listed in Land Health Strategy) Drivers of change (including shifts in circumstances) Risks and opportunities ('catchment condition' related to critical attributes and their thresholds; future scenarios and preventable and unavoidable system transformations)
2)	**Adaptive plan**	3	Update the 2017 *Land Health Strategy* in 2020.	Do the strategic priorities need to change?	Community values RCS vision (alignment with Land Health Strategy) Progress against targets and actions Assumptions that link outputs to outcomes (long-term goals)[ii] Governance arrangements (including partnerships) Capacity to deliver (including social, organisational and individual) Trade-offs and synergies (including benefit/cost)
3)	**Annual plan**	4	Prepare an annual plan based on received funds each year.	Do investment priorities need to change this year?	Government priorities (resources available) Partnership agreements
Implement					

i. Key evaluation questions are considered annually, but levels of detail and processes in answering them vary significantly, according to circumstances, including current risks and opportunities and availability (and costs) of evidence.

ii. The equation: Outcomes = Outputs x Assumptions is used as the basis for understanding progress and identifying knowledge gaps for research.

Source: Derived from Shepparton Irrigation Region Land and Water Management Plan (SIRPPIC 2015)

While the evidence in Table 5 can be quite detailed and vary with resources available to gather it, the Goulburn Broken CMA uses its annual report to consistently present information across investment themes. This includes a narrative of progress, supported by evidence, at three levels, as shown in Table 6.

Table 6: Evidence for three levels of decision-making

Evaluation level	Evaluation terminology	Typical questions used to focus evaluation	Examples of evidence to inform evaluation
1	Annual performance	How did we go this year against what we said we would do?	Outputs (onground works and capacity building actions or tasks) achieved and funds spent against targets set in the Corporate Plan
2	Long-term strategy implementation progress	How have we gone against what we said we would do when we wrote the (various) strategies? How effective were the implemented measures?	Outputs and assumptions of their impact listed in strategies
3	Catchment condition change	What 'shape' is the issue we are managing in now? Was the original strategy appropriate? Have circumstances (such as new knowledge or different weather patterns) changed sufficiently to warrant a revised strategy? Does the investment mix need to be modified?	Resource condition; trends; tipping points; indicators of resilience, adaptation and transformation responses

Source: Goulburn Broken CMA Annual Report 2015-16 (GB CMA 2016)

Actions:

1. An annual review of progress based on Table 5 should be prepared by the Goulburn Broken CMA's Land and Biodiversity Program, in collaboration with partners, to inform:
   - A report on annual performance, long-term strategy implementation progress and catchment condition in the Goulburn Broken CMA's Annual Report.
   - Identification of 'hot issues' (by considering risks and opportunities).
   - Priorities for the forthcoming year (based especially on annual evaluations of progress in implementing actions listed in section 5 of this Strategy).

2. Consistent with Figure 4, a detailed review of this strategy should be undertaken in approximately 2020.

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Appendix 1: Soil types in the Goulburn Broken Catchment

(Botta 2015; Glendinning 2000; Hazelton & Murphy 2007; Peverill *et al*. 1999)

While much data has been collected across Australia through land and soil surveys and geomorphic studies it is important to recognise that survey coverage is incomplete (McKenzie, 2004). Survey of soil chemical and physical properties is expensive so soil maps generally model the potential distribution of soil types using more readily accessible parameters such as soil morphology, landform, geology and vegetation (McKenzie, 2004). Soil properties can be highly variable over short distances, for example within paddocks, thus soil maps should be interpreted with care as soil type maps are generally not ground-truthed.

Sodosols

Sodosols are widespread in the Goulburn Broken Catchment Management Region. They are generally found on the extensive Riverine Plains north of the uplands (and the Hume Highway) and the low hills and rises east of Heathcote. Sodosols have a strong texture contrast between surface (A) horizons (topsoils) and subsoil (B) horizons and the subsoil horizons are classed as sodic. This means the subsoils have exchangeable sodium percentages of more than 6%. These soils are prone to disperse when wet and generally set hard when dry.

Dermosols

These soils lack texture contrast down the profile and have a deep, well-structured subsoil. They occur mostly in the wetter, upland areas east of Yea to Mansfield and to the Dividing Range and are also found scattered through the Strathbogie Tablelands.

Dermosols can be further subdivided based on the colour of the upper 20cm of their subsoil – red, brown, yellow, grey and black.

The red Dermosols are located closer to the Dividing Range in the wetter areas, have high organic matter in the topsoil, and strongly acidic subsoils. The brown, yellow and grey Dermosols are generally located in the drier areas.

Many of the Dermosols around Alexandra are sodic at depth with salinity problems in some areas.

The major use of these soils is for permanent pasture/grazing and timber in the higher areas closer to the Dividing Range.

Kandosols

Kandosols are non-texture contrast soils (with little or only a gradual increase in clay content with depth) that have massive (i.e. weakly to non-structured) subsoils (B horizons). These soils can vary from stony, hard setting soils to deeper friable soils. Some may have a bleached or very pale subsurface (A2) horizon. Kandosols can be divided into groups (into Suborders) based on the colour of the upper 20 cm of the subsoil (i.e. Red, Brown, Yellow, Grey and Black).

These soils are located in the Upland areas, particularly close to the Dividing Range as well as the western Strathbogie Ranges and the Yea to Broadford area (where they are associated with Yellow Chromosols).

These soils tend to be poorly structured and can have significant implications for management affecting soil fertility, moisture availability, erodibility and crop establishment. They are mostly well drained and are often referred to as 'earthy' soils

In the Goulburn Broken Catchment these soil types are mainly associated with extensive agricultural uses such as grazing enterprises but also support small amounts of viticulture and other niche industries.

Chromosols

Chromosols are soils that display a strong texture contrast between surface (A) horizons and subsoil (B) horizons. The upper part of the subsoil ranges from slightly acid to alkaline (pH >5.5 measured in water) but is not sodic like sodosols. Chromosols can be divided into groups (Suborders) based on the colour of the upper 20 cm of the subsoil (i.e. Red, Brown, Yellow, Grey and Black).

Chromosols occur throughout the region and can be found on the alluvial Riverine Plains and the uplands. The dominant occurrences of this soil type are north, east and west (sporadic occurrences only) of Benalla, east of Seymour and the Mansfield area.

The surface soil textures of these soils tend to be lighter loamy textures and the depth of the topsoil can vary considerably. This can have significant implications for management; affecting soil workability, permeability, crop establishment, moisture availability and erodibility. The subsoils tend to be clay textured soil and are often mottled in colour indicating restricted drainage.

Kurosols

Kurosols are soils that display a strong texture contrast between surface (A) horizons and subsoil (B) horizons. Surface soil textures tend to be lighter loamy textures and the subsoils tend to be clay textured soil. The upper part of the subsoil is strongly acid. This means the pH (measured in 1:5 soil to water) is less than 5.5. Kurosols can be divided into groups (Suborders) based on the colour of the upper 20 cm of the subsoil (i.e. into Red, Brown, Yellow, Grey and Black).

Kurosols occur predominantly in the uplands where rainfall is higher and consequently so is the leaching. In the Goulburn Broken region, Red Kurosols occur at higher elevations and areas of higher rainfall, such as in the Strathbogie Ranges and south east of Alexandra. Yellow and Brown Kurosols occur mainly in the granite areas to the south of Euroa and to the east of Seymour. There are also minor occurrences north of Seymour.

These acidic soils can have significant implications for management; affecting soil nutrient availability, crop and pasture establishment, and plant root growth. They are also prone to nutrient leaching.

Appendix 2: Major soil types and their associated services by Social-ecological System

(Botta 2015; Hazelton & Murphy 2007; Glendinning 2000)

SES	Soil types	Services
Agricultural Floodplains	Sodosols 74%	• Soil stability • Soil water holding capacity and retention • Soil carbon sequestration • Soil biodiversity and biological functions
Commuting Hills	Kandosols 40% Sodosols 24% Dermosols 15%	• Soil stability • Soil carbon sequestration • Soil biodiversity and biological functions • Soil chemistry and its impact on provision of soil ecosystem services
Productive Plains	Sodosols 54% Chromosols 21%	• Soil stability • Soil water holding capacity and retention • Soil carbon sequestration • Soil biodiversity and biological functions
Southern Forests	Dermosols 64% Chromosols 15%	• Soil stability • Soil biodiversity and biological functions
Upland Slopes	Dermosols 57% Chromosols 21.4%	• Soil stability • Soil carbon sequestration • Soil biodiversity and biological functions • Soil chemistry and its impact on provision of soil ecosystem services