Catchment Management Authority Murrumbidgee

ACT NATURAL RESOURCE MANAGEMENT COUNCIL

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UPPER MURRUMBIDGEE ACTIONS FOR CLEAN WATER PLAN

ACWA PLAN

AUGUST 2012

CARING FOR OUR COUNTRY

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Executive Summary

The Actions for Clean Water (ACWA) Plan is a collaborative, cross-jurisdictional venture involving the Murrumbidgee Catchment Management Authority (CMA), ACT Natural Resource Management Council, Upper Murrumbidgee Catchment Coordinating Committee, Upper Murrumbidgee Waterwatch and ACTEW Water.

Turbidity arising from devegetation, mining, urban development and agriculture over many years, exacerbated by drought and bushfire in the last decade, is of concern for urban water supply, irrigators, rural landholders and tourism operators. This commonality of concern, albeit for differing reasons, provided the basis for a collaborative approach to planning for preventive and corrective action across the catchment.

The ACWA Plan identifies strategies to improve surface water quality and reduce turbidity in the upper Murrumbidgee River catchment. It provides a plan of actions over one, three and ten year time frames.

The Plan covers a range of approaches including on-ground works, education and promotion, plus policy and program development by private sector and government organisations and individuals.

The Plan identifies and ranks major point sources of turbidity. It details interventions to mitigate turbidity generation from them.

Turbidity arising from diffuse sources through less than ideal land management practices are also addressed. The Plan details interventions to ameliorate these practices where possible and thus reduce turbidity and other negative water quality impacts.

The collaborative nature of the ACWA project is reflected in extensive involvement of natural resource management stakeholders in the formulation of the ACWA Plan. An ACWA Advisory Group was established and actively engaged. It comprises representatives from all tiers of government, non-government organisations, scientists, community groups and landholders. This group of experts has actively participated in the development of the Plan. They contributed invaluable additional scientific evidence, stakeholder information, spatial analysis and corporate memories as well as providing major input to fields assessments. Importantly the Advisory Group will continue to be involved in the implementation of the Plan and monitoring its impact.

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Introduction to the ACWA Plan

Aim

The Actions for Clean Water Plan (ACWA Plan) outlines actions to reduce turbidity and improve water quality in the Upper Murrumbidgee River catchment. The ACWA Plan is a strategic document that has been prepared to guide investment across the catchment through identifying high priority actions and supporting initiatives to improve water quality outcomes. The Plan is intended as a guide, supported by technical evidence and knowledge, to inform planning by stakeholders of the Upper Murrumbidgee River catchment to achieve strategic water quality outcomes through turbidity reduction. It is intended that this document will be supported by ongoing work to adopt a multi--stakeholder governance approach to achieving natural resource outcomes.

ACWA Plan Area

The ACWA Plan area is the catchment of the Murrumbidgee River upstream of the confluence of the Murrumbidgee River and the Cotter River. The extent of the Plan area is displayed in Figure 1.

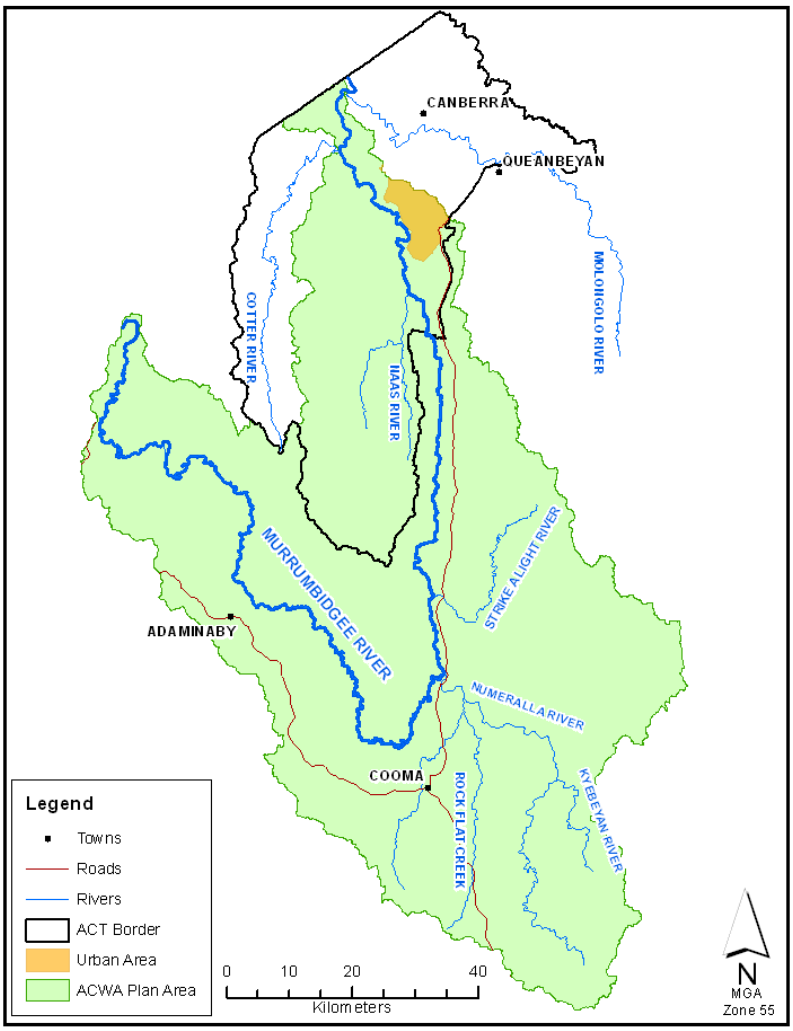


Figure 1 Upper Murrumbidgee River catchment ACWA Plan area

Objectives

The objectives of the ACWA Plan are to:

- Provide an overview of turbidity issues in the Upper Murrumbidgee River catchment and frame the issues that need to be addressed;
- Provide an overview of the Upper Murrumbidgee River catchment and relate the ACWA plan to existing Natural Resource Management (NRM) frameworks in the ACT and NSW;
- Identify point sources of turbidity and develop a prioritised series of management interventions to manage them;
- Identify diffuse sources of turbidity and the potential interventions that might be employed to address them;
- Propose a framework for stakeholder agencies to adaptively manage point sources of turbidity and identify actions for managing catchment-wide turbidity issues.

Scope

SKM was engaged by the Murrumbidgee CMA, on behalf of the partner organisations, to prepare an action plan to enhance surface water quality and reduce turbidity in the Upper Murrumbidgee River catchment. The Plan synthesises relevant research, modelling, published and grey literature, stakeholder knowledge and experience of the catchment; with a targeted assessment of river reaches within the Upper Murrumbidgee River catchment to identify a range of actions to achieve improved water quality. Although there are a number of factors contributing to water quality, including nutrients, this Plan explicitly considers turbidity and the impacts this has on water quality and river health.

Specifically, the Plan identifies high priority point sources of turbidity generation in the catchment and recommends a range of actions to reduce turbidity and soil erosion from these point sources. The Plan also provides an overview of diffuse sources of turbidity generation and actions that may be employed to achieve improved water quality and river health.

To inform future planning, a prioritisation framework was developed to support the adaptive management of the catchment and renewed prioritisation targets as works are undertaken.

This Plan is framed within the existing natural resource management (NRM) context of the Upper Murrumbidgee River catchment. Recommended actions are aligned with the Murrumbidgee Catchment Action Plan and the ACT NRM plan *Bush Capital Legacy*. Ongoing monitoring, strengthened governance arrangements and stakeholder engagement will be important to achieve enduring improvements to catchment and river health. Implementation of the ACWA Plan should be delivered in a complementary manner to the broader NRM actions in the Murrumbidgee landscape to support holistic land management and improved environmental and long term primary production outcomes, as identified by stakeholders of this project.

The ACWA Plan

This plan is split into two distinct parts:

Part A: Provides an overview of the ACWA region, and the origins and impetus. It also outlines the origins of, and actions recommended to reduce turbidity arising from both point (localised) and diffuse (widespread) sources in the Upper Murrumbidgee River catchment.

Part B: Provides the technical overview of the assessment method and resultant identification of point sources of turbidity within the catchment. It also lists actions recommended for each priority point source.

Glossary

The following terms are used throughout this document.

ACWA	Actions for Clean Water.
Accretion	The progressive deposition of sediment at a point.
Alluvial channel	A stream with deformable bed and banks that moves across their floodplain over time. Bank erosion is a natural process of alluvial channel behaviour.
Bed load	Transport of sediment along a stream bed by rolling, sliding or saltation.
Bench	A fine grained sediment deposit which occurs between a river bed and floodplain, attached to the bank.
BMP	Best Management Practice.
Bank erosion	Scour or slumping of a waterway bank caused by energy of the flowing water or saturation of the bank.
Bed lowering	Channel bed erosion resulting in a lowering of the bed and higher banks, initiated by headcuts (these move in the upstream direction).
Cross section	A channel survey that identifies geomorphic units of the channel and floodplain.
Degradation	Channel bed erosion that deepens a channel and can result in channel widening and increased channel capacity.
Diffuse source turbidity	Landscape scale activities that lead to non-discrete point sources of sediment that impact on turbidity.
LWD	Large Woody Debris (LWD) describes wood or snags within a river channel.

Pile fields	Energy retarding structures that are driven into the stream bed to reduce erosion processes.
Point source turbidity	Discrete sources of turbidity which induce significant rates of sedimentation.
Riparian vegetation	Vegetation located on a river or stream bank.
Rock beaching	Energy retarding structures comprised of rocks that are located on stream banks to reduce bank erosion.
Sedimentation	Deposition of material of varying size, away from its original location.
Sodic/ dispersive soils	Sodic soils are those which slake (collapse) and disperse when saturated, due to the presence of excess sodium ions in the soil profile. Exchangeable Sodium Percentage (ESP) is used to define the degree of soil sodicity. The parameters are: non sodic soils – have an ESP of less than 6; sodic soils – have an ESP of 6-14; highly sodic soils have an ESP of greater than 15.
Stream order	A stream numbering system, developed by Strahler, which is used to identify streams and their tributaries. First order streams are defined as the smallest headwater tributaries. Where two first order streams meet, the classification becomes a second order stream. Where two second order streams meet, the classification becomes a third order stream and so on. Stream order only increases at the confluence of two streams with the same order. In situations where two streams with a different order meet, the stream maintains the highest classification.
TSC Act	The Threatened Species Conservation Act 1995 (NSW) protects, conserves and preserves threatened species within NSW. It is based on a threatened species list, which lists species, populations and communities as defined by an independent NSW scientific committee.
Turbidity	Turbidity is a measure of water clarity. It is influenced by the amount of total suspended solids (which includes suspended sediments) in a water column.

PART A:
ACWA PLAN

1 Project Rationale

The ACWA Plan has stemmed from a need to develop actions to manage turbidity generation in the Upper Murrumbidgee River catchment to improve water quality. Prolonged drought conditions, coupled with increasing pressure from urban populations, land use changes, recent floods, and inclusion of supplementary urban water supply sources led to the need to address the issue of declining water quality through increased turbidity in the Upper Murrumbidgee River and its tributaries.

Late in 2009 and early in 2010 several extreme turbidity events in the Murrumbidgee River were recorded by Waterwatch and ACTEW at their water quality monitoring sites. Waterwatch reported the events to the Upper Murrumbidgee Catchment Coordinating Committee (UMCCC), which convened a workshop to investigate causes and possible remedies and/or preventive actions. Following the workshop Waterwatch worked with the Murrumbidgee CMA and the (then) ActewAGL's Source Water Protection Program on immediate action to address the turbidity issues. The UMCCC approached ACTEW and the ACT Natural Resource Management Council about working towards improved catchment health in the longer term. With continuing coordination and goodwill the result was the bringing together of the investors in the ACWA project to develop the ACWA Plan.

The Plan is built on a participatory process that engages local community bodies and relevant stakeholders to action turbidity management in the Upper Murrumbidgee River catchment. It draws on existing strategies arising from earlier planning undertaken in the region. It is complementary to water planning strategies including the upcoming Murrumbidgee CMA Next Generation CAP and NRM planning in the ACT. The ACWA Plan addresses turbidity generation from both point and diffuse sources within the catchment.

1.1 Acknowledgements

This Plan could only have been developed with the significant support of a range of agencies and organisations in addition to the project partners. The partners wish to thank the supporters of the project for their in-kind support, funding, advice and guidance in the development of this Plan.

1.2 Project Partners

Partners in delivering and funding this Plan are the Murrumbidgee CMA, Upper Murrumbidgee Catchment Coordinating Committee, Upper Murrumbidgee Waterwatch, ACTEW Water and the ACT Natural Resource Management Council. Representatives of the partners comprised the ACWA Management Committee which advised and directed SKM in preparing the Plan.

1.3 ACWA Advisory Group

The ACWA Plan would have been significantly less comprehensive and authoritative without the active collaboration of members of the ACWA Advisory Group, whose members are outlined in Table 1.

Table 1 Murrumbidgee ACWA Plan Advisory Group

Project Advisory Group	
ACTEW Water	ACT Environment & Sustainable Development Directorate
ACT Natural Resources Management Council	ACT Parks & Conservation Service
ACT Rural Landholders Association	Australian National University (ANU)
Bush Heritage Australia	Cooma-Monaro Shire Council
Cooma Region Waterwatch	CSIRO
Greening Australia (ACT Capital Region)	Kosciusko to the Coast
Molonglo Catchment Group	Murray Darling Basin Authority
Murrumbidgee Catchment Management Authority	NSW Crown Lands
NSW Office of Environment & Heritage	NSW Office of Water
NSW Department of Trade & Investment	Numeralla and District Landcare Group
Queanbeyan City Council	Snowy Scientific Committee
Soil & Land Conservation Pty Ltd	University of Canberra
Upper Murrumbidgee Catchment Coordinating Committee	Upper Murrumbidgee Landcare Committee
Upper Murrumbidgee Waterwatch	

1.4 Partner roles

Throughout the project, to develop the Plan, the ACWA Advisory Group was consulted for local knowledge, expertise, advice and guidance. Through this direct engagement the Plan has thus been developed in light of existing knowledge, work and understandings of stakeholders within the catchment.

Consultation was undertaken with:

- Scientific groups/ bodies;
- Government agencies;
- NRM bodies; and
- Community- based groups of landholders including; Landcare, landholders and environment groups.

Two formal consultations were undertaken with the ACWA Advisory Group to inform this Plan:

- A workshop with the ACWA Advisory Group in May 2011 to identify site-specific issues and to outline the prioritisation process to be employed; and
- Two workshops held in Cooma and Queanbeyan in which the draft prioritisation document was presented and whole-of-catchment issues identified.

The Plan incorporates stakeholder input on both point and diffuse sources of turbidity, and on site-specific and broader actions to deal with them.

1.5 Location

The Upper Murrumbidgee River catchment for the purposes of this Plan extends from just north-west of Canberra, south along the Murrumbidgee River towards Cooma and then west past Adaminaby. The catchment is diverse; being home to the urban centres of Canberra, Cooma and Adaminaby and supporting enterprises in various economic sectors. The scale of the catchment considered in this ACWA Plan is illustrated in Figure 1.

1.6 The Upper Murrumbidgee River catchment

The Upper Murrumbidgee River catchment is subject to a diverse climate, ranging from alpine regions to sub-alpine plains, with the ACWA Plan area covering an area of approximately 6400 km^2. The upper catchment centres on the sub-alpine Brindabella and Namadgi National Parks, with the river flowing north and meeting with the major tributaries of the Numeralla, Bredbo, Strike a Light, Naas, Cotter and Molongo Rivers. The region above the Cotter confluence is the focus of the Plan.

1.6.1 Environmental values

There are a series of highly valued environments in the Upper Murrumbidgee catchment. These include a scattering of wetlands, including the RAMSAR listed Ginini and Cheyenne Flats wetlands. The Upper Murrumbidgee also hosts a number of other important wetlands including the Big Badja and Yaouk swamps which support numerous migratory birds and wildlife and are listed as nationally significant[1].

The Plan area is located wholly within South Eastern Highlands Bioregion which has altitudinal variation supporting a diverse range of vegetation communities. Among these, there are 36 endangered and 50 vulnerable flora species listed under the NSW *Threatened Species Conservation Act 1995*(TSC Act). There are 88 TSC Act-listed fauna species in the bioregion, including the endangered Regent Honeyeater[2].

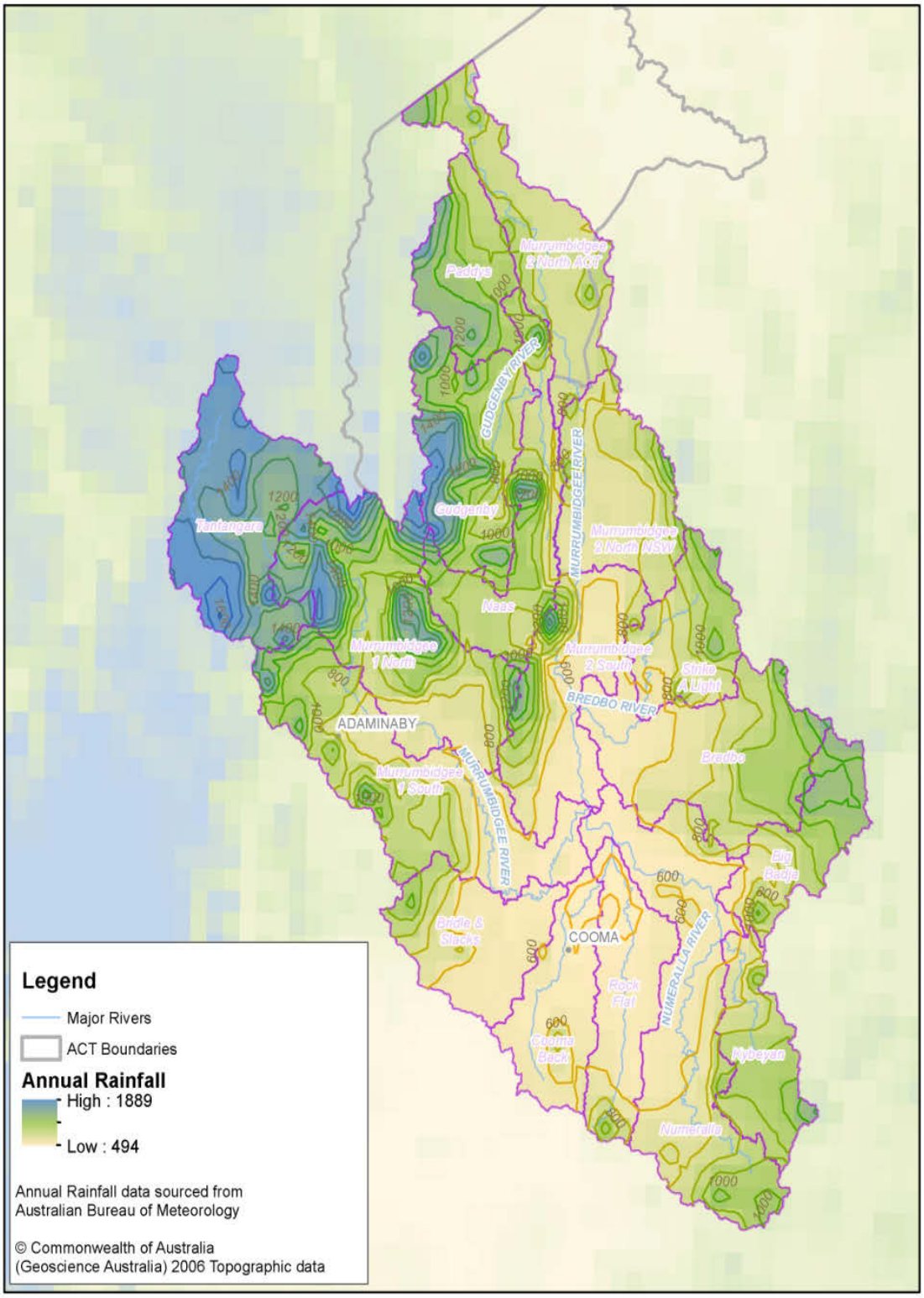
1.6.2 Climate

The climate of the Plan area is classified as temperate and is characterised by mild summers and cold winters, with relatively uniform rainfall year-round. Within the temperate range the climate is diverse across the project area, ranging from alpine and sub-alpine areas in the south through to a milder continental climate in the north around Canberra. Rainfall varies across the Plan area with mean annual rainfall exceeding 1600 mm/yr in the south-west of the plan area through to less than

[1] Murrumbidgee CMA Catchment Action Plan, Wetlands of the Murrumbidgee
[2] NSW Office of Environment and Heritage (2011) South Eastern Highland Bioregional overview, http://www.environment.nsw.gov.au/resources/nature/southEasternHighlands.pdf, Accessed July 2012

500 mm/yr in the south-east (see Figure 2). The main townships have annual rainfall values ranging between 644.4mm (Canberra), 536.8mm (Cooma) and 689.3mm (Adaminaby) with an average modelled runoff of 54mm (around 15.7% of total runoff within the Murray Darling Basin) across the broader Murrumbidgee region[3].

[3] CSIRO (2008): Water Availability in the Murrumbidgee: A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project.



ACWA Plan – Average Annual Rainfall

Figure 2 Average annual rainfall, ACWA Plan

Temperature also varies across the Plan area, with a broader range in temperature experienced in winter months. Figure 3 shows the average mean maximum and minimum temperatures for Cooma and Tuggeranong. In Summer months, the mean maximum hovers just above 25° C, with mean minimum temperatures just below 15° C on average for Tuggeranong and just above 10°C for Cooma. In winter, the range in temperature is around 15° C for both stations. Typically the mean maximum reaches around 12-14° C during Winter, reaching mean minimum temperatures of between +1 and -2.8°C between the months of June and August.

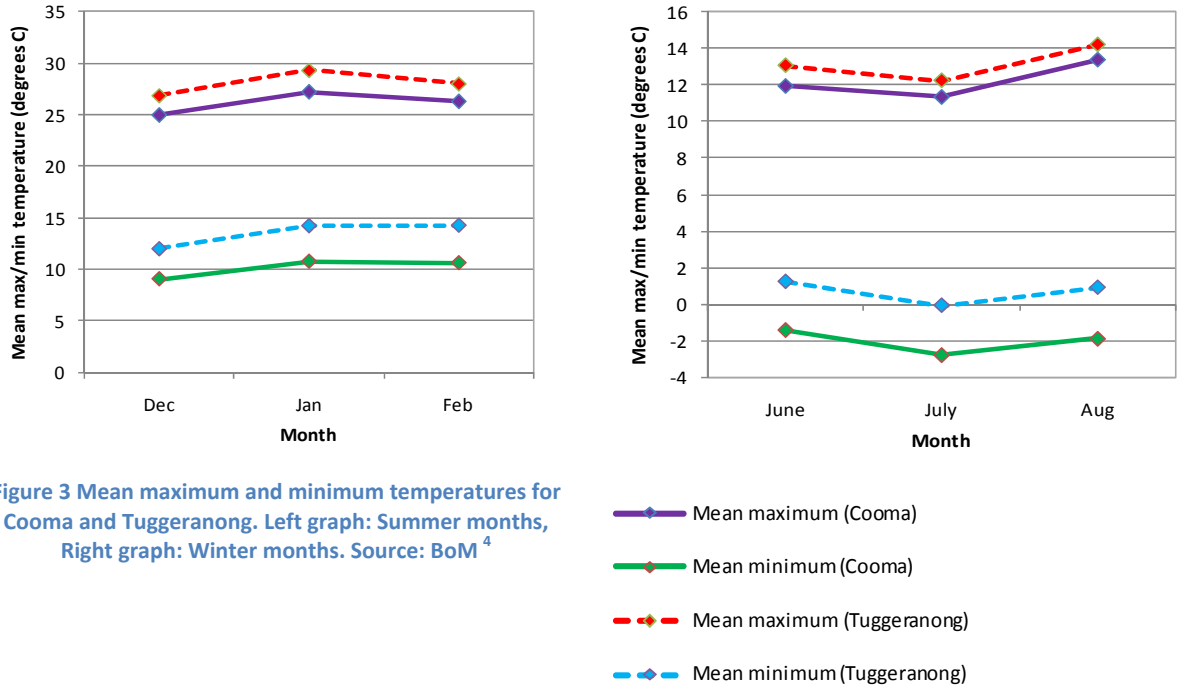


Figure 3 Mean maximum and minimum temperatures for Cooma and Tuggeranong. Left graph: Summer months, Right graph: Winter months. Source: BoM [4]

A significant corridor of land within the Plan area is subject to low rainfall. This region predominantly features dryland grazing enterprises which are less reliant on high rainfall. Recent dry conditions in parts of the catchment may be further exacerbated by the impacts of climate change. Climate change is projected to lead to temperature increases of between 1.25° C and 1.75° C by 2030 and 2050 respectively[5]. Rainfall projections illustrate greater variability, with changes between -7.5% and +7.5% by 2030. By 2050, these changes may be up to between -15% and +15%[6]. Drier conditions could affect the level of groundcover and riparian vegetation, and increase soil erosion. Projected changes in the frequency, intensity and duration of rainfall may also exacerbate turbidity generation within the plan area.

Drier conditions, along with soils with limitations and projected increased rainfall intensity have the potential to contribute to a higher risk of erosion in this region with resultant increased turbidity generation. This scenario is further detailed in Part B of this Plan.

[4] BoM Climate data, Cooma Visitors Centre 070278 and Tuggeranong (Isabella Plains) AWS 070339
[5] CSIRO (2012) Climate Change in Australia, NSW/ACT climate profile. High emissions scenarios, 50th percentile outputs compared to 1980-1999 averages, Accessed July 2012
[6] CSIRO (2012) Climate Change in Australia, NSW/ACT climate profile. High emissions scenarios, 10th and 90th percentile outputs compared to 1980-1999 averages, Accessed July 2012

1.6.3 Water

The NSW Government has prepared Water Sharing Plans for most regulated river basins in the State. Water Sharing Plans establish rules for sharing water between the environmental needs of the river or aquifer and water users, and also between different types of water use such as town supply, rural domestic supply, stock watering, industry and irrigation. Water Sharing Plans outline water sharing arrangements within the broader Murrumbidgee region, with NSW obtaining a 2341 GL surface water diversion cap across the Murrumbidgee. The ACT annual Murray Darling Basin Cap of 40 GL was agreed to in 2008, with a 75% growth factor to account for increased populations in Canberra and Queanbeyan. The Snowy Mountains Hydro-electric Scheme diverts approximately one tenth of all surface water available across the Murrumbidgee catchment. The Snowy Scheme greatly affects flows in the Upper Murrumbidgee through the presence of significant storages, notably the Tantangara Dam.

Environmental and demographic changes are driving the need for the NSW and ACT Governments to improve water efficiency, increase security and invest in water sharing arrangements to deliver on water needs within the broader region.

1.6.4 Catchment characteristics

Among the major land uses of the region, dryland grazing and cropping are predominant, with other industries such as softwood plantations also present within the Upper Murrumbidgee River catchment.

The Murrumbidgee CMA and ACT Natural Resource Management Council, along with their NRM partners, deliver targeted programs in the region which protect, enhance and restore environmental values. The ACWA Plan is a collaborative effort to address turbidity generation within the region to deliver on a number of the many water quality goals of governments, NRM organisations and the community.

1.7 ACT urban water security

Until recently, the ACT had sourced its water from the Queanbeyan River (Googong Reservoir) in NSW and the Cotter River (Cotter, Bendora and Corin Reservoirs) in the ACT. The water supply system had evolved since the formation of the ACT. The impact of the 2003 Canberra bushfires on the ACT's water supply catchments and the extended drought from 2001-2009 made it clear that:

- Existing storages were insufficient to supply the future needs of populations of the ACT and Queanbeyan
- Extreme weather events were increasing the cost of treating water in these catchments
- It would not be possible to extract more water from these catchments without further increasing environmental stress on the Queanbeyan and Cotter catchments

An extensive investigation was undertaken to identify potential options to enhance water security for Canberra. The Murrumbidgee River was identified as a third highly reliable source which could be harvested to augment supply to the ACT. One of the four options implemented as part of the ACT Water Security Plan was the construction of a pumping station on the Murrumbidgee River near Angle Crossing and a pipeline to transfer water into Googong Reservoir. Water Licences were purchased and it is intended to access the water from Tantangara Reservoir through an agreement

with Snowy Hydro. These entitlements will be utilised when there is a requirement to supplement the existing water sources for the ACT. The ACT water supply system is illustrated in Figure 4 (below).

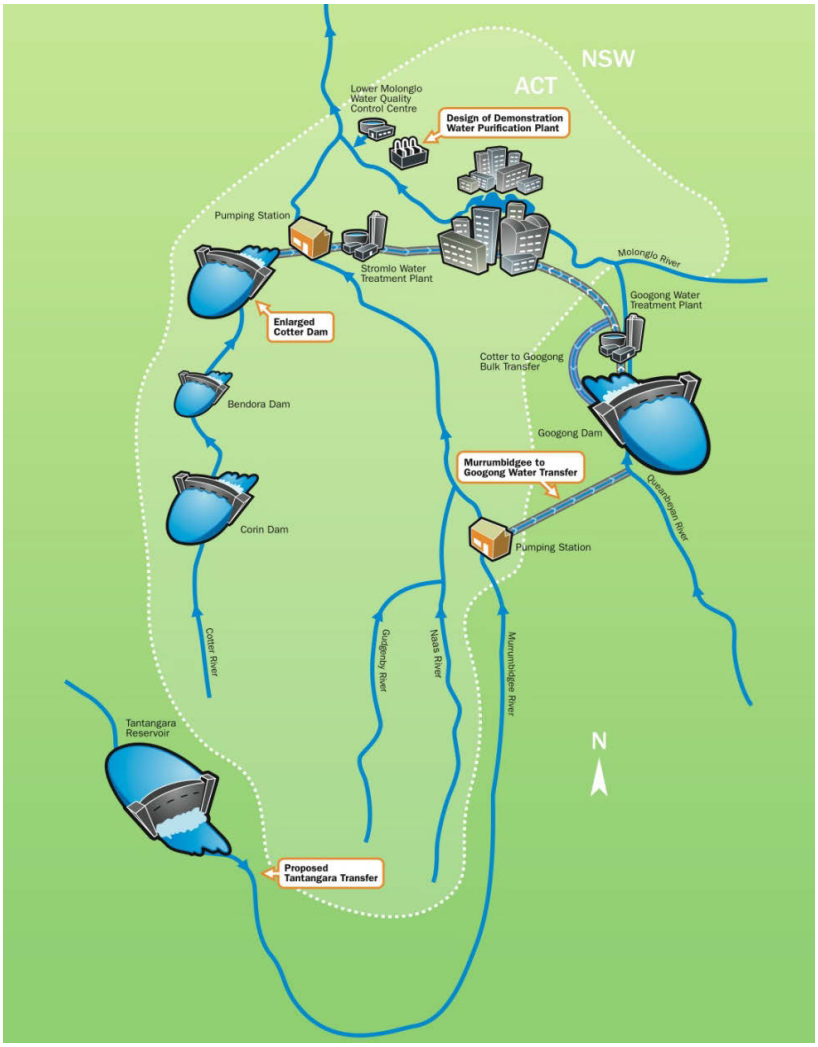


Figure 4 ACT Catchment and water supply system[7]

1.8 Region demographics and industry

Around 10,000 people reside in the Cooma-Monaro local government area[8] and another 7,180 reside in the Snowy River Shire[9], with many small townships dotted within the Plan area. The wider region is home to over 350,000, with approximately 323,000 people centred on Canberra alone[10].

The population works in a variety of industries including public administration, construction, financial and recreational service provision, agriculture, forestry, retail and manufacturing. There is a variety of land uses in the region which contribute to the need for complementary natural resource management and interjurisdictional collaboration within the catchment. Significant operations in the

[7] http://www.actew.com.au/Water%20and%20Sewerage%20Systems/ACT%20Water%20Supply%20System/ACT%20Water%20Supply%20Map.aspx, Accessed July 2012
[8] ABS Census data 2006: Cooma-Monaro LGA, http://www.censusdata.abs.gov.au/, Accessed June 2012
[9] ABS Census data 2006: Snowy River LGA, http://www.censusdata.abs.gov.au/, Accessed June 2012
[10] ABS Census data 2006: ACT statistical area, http://www.censusdata.abs.gov.au/, Accessed June 2012

region include native and plantation forestry, irrigation agriculture, horticulture and dryland grazing, quarrying and extraction to supply local construction and road management.

Conservation land constitutes a significant portion of the land within the Upper Murrumbidgee River catchment.

1.9 Turbidity and its impacts

Turbidity is a significant water quality issue that has social, economic and environmental implications. Among these impacts, turbidity can[11]:

- Increase the cost of water treatment for consumptive purposes;
- Increase maintenance requirements of pumps and other infrastructure;
- Reduce water clarity and consequently, affect aquatic plant and plankton growth and macro invertebrate composition;
- Be associated with nutrient and pathogen transfer through the catchment;
- Impact on surface water temperature;
- Alter instream aquatic environments, leading to loss of habitat; and
- Reduce economic opportunities for activities such as tourism associated with the catchments waterways (i.e. swimming, canoeing).

Although there are a number of factors contributing to water quality, including nutrients, this Plan is concerned principally with turbidity and the impacts this has on water quality.

1.10 Drivers of change

The population of the Canberra region is rapidly increasing, placing more pressure on waterways and the catchment's environmental assets. Large population and land use changes are driving the need for more resource management interventions and investment in large scale management projects. Turbidity generation is a pressing issue given that the Murrumbidgee River catchment is prone to active erosion and sediment mobilisation. Therefore in summary the key drivers for developing management actions to address turbidity more broadly are:

- Population changes;
- Land use and land use changes; and
- Climate and climatic shifts driving drought and flooding conditions.

1.11 The ACWA Plan

The ACWA Plan has been developed to reduce turbidity generation within the Upper Murrumbidgee River catchment. The report outlines actions to achieve this outcome, as presented through:

- The Strategic context of the ACWA Plan in **Chapter** 2.
- The drivers and sources of turbidity generation in **Chapter** 3.
- The process for identifying actions and developing the ACWA Plan in **Chapter** 4.

11 ANRA (2009) National overview of surface water quality issues, http://www.anra.gov.au/topics/water/quality/, Accessed June 2012

- **Chapter** 5 which summarises the actions of the ACWA Plan to achieve reduced turbidity generation within the catchment.

2 Strategic Context

2.1 Regional NRM planning

In NSW natural resource management in the Upper Murrumbidgee River catchment is framed primarily by the Murrumbidgee Catchment Action Plan (CAP). The CAP sets the strategic direction for the region and incorporates the integrated catchment management context in which the ACWA Plan sits. The CAP has been developed in consultation with the community, government and non-government organisations and sets tangible targets and direction for investment for enhanced natural resource outcomes. The Plan is enhanced by stakeholders and groups who work across borders including the UMCCC, Upper Murrumbidgee Waterwatch and ACTEW Corporation and those organisations funded by the ACT Natural Resource Management Council/ACT Government who work in NSW collaboratively to achieve better environmental outcomes.

Under the CAP, the ACWA Plan is framed to help in achieving the following targets[12,13]:

- Removing barriers to natural resource management adoption. By 2016 the capacity of the community to improve natural resource management will be increased by addressing risks and impediments and capitalising on drivers and opportunities.
- Partnering private land owners and Landcare. By 2016 the Murrumbidgee CMA is fostering partnerships with private landholders, land managers, Landcare and the community to encourage natural resource management practices that are consistent with the Murrumbidgee Catchment Action Plan and Traditional Owner cultural heritage values.
- Knowledge and skills. Annually enhance the knowledge and skills of 300 farm businesses, local government and the wider community.
- Structures for river bank stability. By 2016 control stream bank and gully erosion using structural control works along 50 km of those stream reaches that yield the highest sediment and nutrient loads.
- Manage aquatic habitat. By 2016 establish, maintain and improve 20 km of native aquatic habitat along degraded sections of the Murrumbidgee River and/or its tributaries.

The ACT Natural Resources Management Council is a non-statutory Council which provides advice to the ACT Minister for the Environment and Sustainable Development on investment in natural resource management. The Council is funded under the Australian Government's Caring for our Country program and is guided by the ACT's NRM plan - Bush Capital Legacy.

The Bush Capital Legacy outlines several targets relevant to the ACWA Plan. These include the following intermediate targets of[14]:

- *Water supply catchments:* Revegetation and better road management in the lower Cotter stabilises sediment movement to streams in the lower Cotter catchment at below pre-bushfire levels.

[12] Request for Offer- ACWA Plan Project Brief (2011)
[13] Murrumbidgee CMA (2008) Murrumbidgee Catchment Action Plan, State of NSW
[14] ACT Natural Resource Management Council (2009) Bush Capital Legacy: ACT NRM Plan

- *Surface water quality:* Surface water quality in all rivers, streams and lakes is 'fit for purpose' for 90% of the time with respect to the Water Quality Standards as defined in the *Environment Protection Regulations 2005* (2015).

In addition, there are a number of strategies/Action Plans related to the ACWA Plan, including:

- Think water, act water – a strategy for sustainable water resource management;
- Weathering the Change Draft Action Plan 2;
- ACT Aquatic Species and Riparian Zone Conservation Strategy (Action Plan No. 29) (and various threatened species action plans);
- Upper Murrumbidgee Demonstration Reach Implementation Plan;
- NSW Natural Resources Monitoring, Evaluation and Reporting Strategy 2010 – 2015; and
- Murrumbidgee CMA Communications and Community Engagement Strategy.

The ACWA Plan has been developed in collaboration with stakeholders to draw on their knowledge of the catchment/study area, of natural resource management issues in the catchment of existing programs and strategies and effectively align the Plan within the current NRM framework. Ongoing work of the project partners will deliver governance arrangements in support of delivery of the ACWA Plan.

2.2 Conceptual model

In keeping with the Murrumbidgee CMA CAP, the ACWA Plan has been developed using a state-transition model which focuses on changes in the landscape which affect the state of the catchment. The ACWA Plan thus concentrates on maintaining the current state of assets within the catchment by implementing actions to reduce point and diffuse sources of turbidity generation. An overview of this approach is presented in Figure 5.

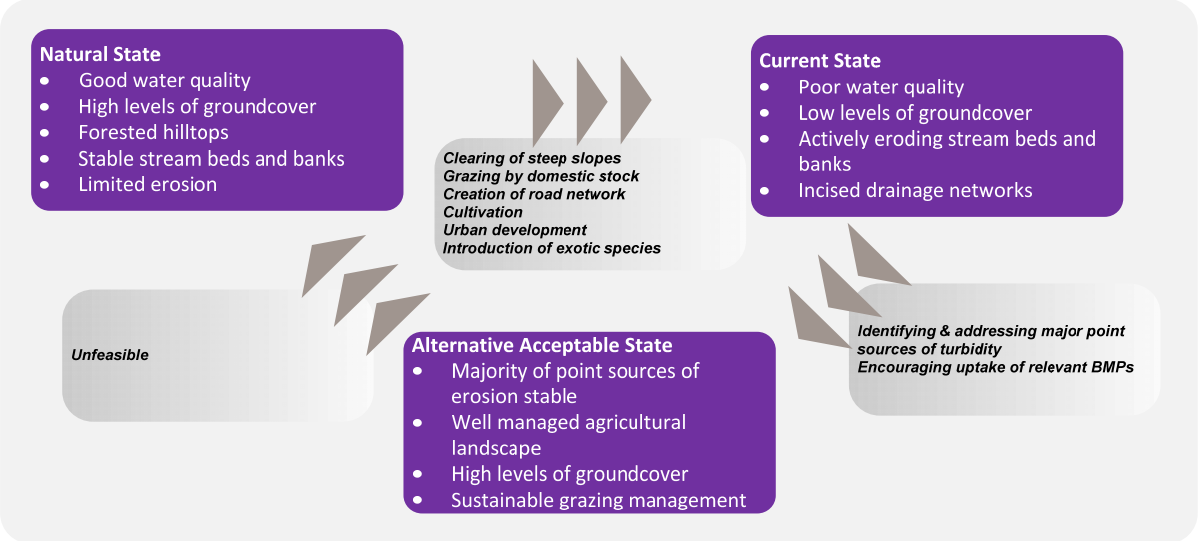


Figure 5 State-transition conceptual model of turbidity generation processes

Chapter 4 describes the current state and contributing factors to turbidity generation in the Upper Murrumbidgee River catchment. Chapter 5 presents the actions under this Plan to manage turbidity generation to achieve an alternative acceptable state within the catchment.

3 Turbidity generation

Turbidity generation is a natural process, which can be affected by rainfall and catchment runoff; catchment soil erosion; bed and bank erosion; loss of riparian vegetation; waterway type. Soil types and land management techniques can exacerbate sediment mobilisation and adversely impact water quality. Highly turbid water can affect environmental assets, such as aquatic fauna and flora. Sources of turbidity generation vary across wet and dry years, with point sources typically more significant during drought conditions[15]. Diffuse sources of turbidity on the other hand are generated continually as the land erodes through catchment processes and will be transported when surface runoff occurs. It is therefore important to consider both sources of turbidity[16]. The ACWA Plan considers both point and diffuse sources of turbidity in the Upper Murrumbidgee River catchment. Through this project, a series of prioritised point source sites of turbidity generation have been identified assessed and actions to reduce point source erosion are proposed.

3.1 Diffuse source

Diffuse sources of turbidity can mobilise large volumes of sediments through processes such as erosion due to groundcover loss or unsealed road runoff. A range of diffuse sources of turbidity generation are present throughout the Upper Murrumbidgee River catchment. The *NSW Diffuse Source Water Pollution Strategy* (DSWPS) provides a framework for coordinating efforts in reducing diffuse source water pollution and establishing a process for sharing information and fostering partnerships to maximise pollution management benefits[17]. A key component of the strategy is the involvement of key natural resource management stakeholders. This framework of the DSWPS of coordinating efforts and involving key NRM stakeholders is a major principle of the ACWA Plan. Those diffuse sources listed below were highlighted in consultations with the ACWA Advisory Group and are specifically addressed in this Plan:

- Degradation of riparian zones;
- Unsealed roads;
- Poor rural land management, including poor stock and crop management;
- Inappropriate and/or misuse of fragile soils; and
- Sand/gravel extraction.

The ways in which land is managed has a significant impact on the level of turbidity generation. Other factors such as climatic conditions can also affect this. This variability through time requires that a range of management approaches are identified which effectively address the multiple causes of diffuse source pollution specific to a catchment. Moreover, in most cases it will be a combination of these management actions which will produce the best effect rather than one applied in isolation.

[15] MDBC (2009) http://www2.mdbc.gov.au/nrm/water_issues/water_quality.html, Accessed July 2012
[16] Department of Environment and Climate Change NSW (2009) NSW Diffuse Source Water Pollution Strategy
[17] Department of Environment and Climate Change NSW (2009) NSW Diffuse Source Water Pollution Strategy

3.2 Point source

Point sources of turbidity represent localised erosion processes. These include bank, gully, hillslope and creek bed erosion. These are typically geomorphic processes associated with rivers and streams and require site-based interventions. The processes behind point source turbidity generation are described in detail in Chapter 3 (Part B).

4 Process for developing the ACWA Plan

4.1 Identifying erosion risk

The first step in formulating actions is to identify point and diffuse sources of turbidity.

Areas of high erosion risk in the Upper Murrumbidgee River catchment generally share similar broad characteristics in terms of soil vulnerability (fragility) and climate. Point sources of turbidity (locations of active erosion) are generally more prevalent in these areas and rates of diffuse turbidity generation are also likely to be higher.

As described in Part B of this Plan, vulnerable areas of the catchment (Management Units), as defined by their soil type and climate, are highlighted through the erosion risk assessment process as part of this project.

The process of identifying erosion risk in the Plan area is broadly described in the following section.

4.2 Process of identifying point source sites of turbidity

The ACWA Plan area totals approximately 6,400 km^2 with a multitude of turbidity sources being distributed throughout the Plan area and the 18,775 km of waterway present.

The targeting of erosion hotspots (i.e. active point sources), particularly those that are well connected to the stream network, has been shown to dramatically reduce the cost of achieving significant reductions in catchment sediment yields[18].

Consequently this Plan gives priority to sites of active erosion in the catchment that are closely connected to the stream network, particularly in reference to locations of potable water extraction.

The process undertaken in order to identify locations of active erosion within the Plan area is summarised in the following figure with further detail provided below.

[18] Rutherfurd, I, Anderson, B and Ladson, A, Lovett, S. & Price, P. (eds) (2007). Principles for riparian lands management. Land & Water Resources Research & Development Corporation Australia, Canberra. PP 112

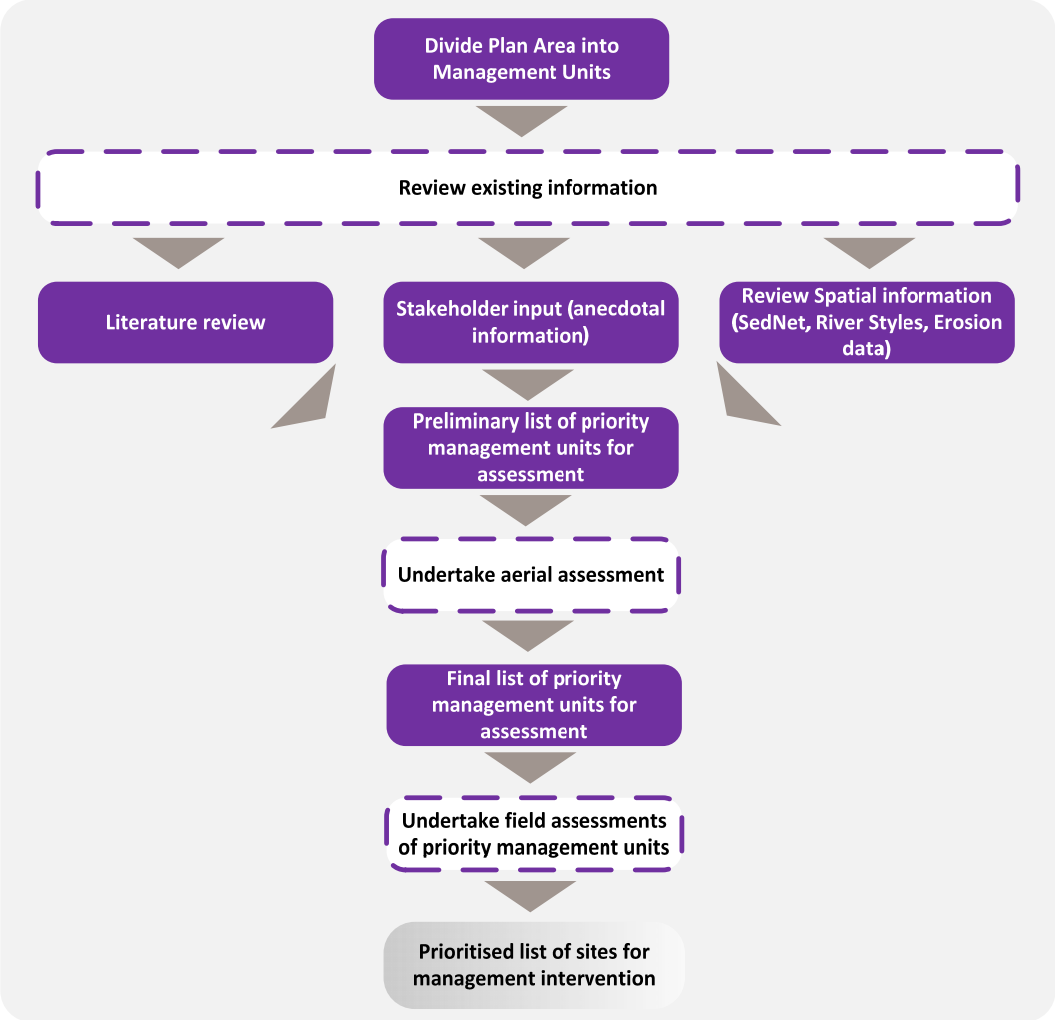


Figure 6 Point source investigation prioritisation process

Key elements of the prioritisation process are as follows:

Division of ACWA Plan area into Management Units – In order to manage issues of scale the Plan area (6,400 km^2) was divided into 17 management units (refer to Figure 13). These management units are broadly based upon those used in the sub-catchments defined by the Murrumbidgee CMA for the Plan area. These have then been further divided to allow for a ready comparison of different parts of the plan area to be undertaken. Each management unit typically has consistent geomorphic characteristics and is based around a single sub-catchment (refer to Part B, Chapter 2).

Review of Existing Information – This was undertaken in three parts. Firstly a review was undertaken of relevant literature, secondly relevant spatial datasets were reviewed and finally catchment stakeholder knowledge was obtained through the ACWA Advisory Group and assessed.

Preliminary List of Management Units for Assessment – Once the review of published literature, spatial information and stakeholder knowledge was completed a preliminary prioritisation of Management Units was undertaken, based on erosivity of each Unit. The outcomes of this preliminary prioritisation process are presented in Chapter 5.

Aerial Assessment of Plan Area – A helicopter based, aerial assessment of the Plan Area was completed in March 2012 to test the outcomes of the preliminary prioritisation process. The

information collected during this assessment was used to amend and finalise the list of Management Units for further assessment.

Field Assessment of Management Units – Field assessments of key sites within priority Management Units was completed in March 2012. Site specific data was collected to allow for the risk assessment framework (site prioritisation process) to be undertaken.

Prioritised list of sites for Management Intervention - The site prioritisation process was completed for all sites assessed in the field and for those sites where the risk rating was seen to be either extreme or very high. Recommendations include a brief description of the condition assessment and the associated management intervention (refer to Part B, Chapter 5).

4.3 Process for identifying diffuse sources of turbidity

The complexity of diffuse sources of water pollution means that a scientific uncertainty often exists as to the relative contribution of different sources in a catchment. However there is sufficient scientific understanding of the causes and effects and of diffuse source water pollutants to determine the management approach needed to address this issue[19].

Hence this Plan considers diffuse sources of turbidity generation within the broader context of land management processes in the Plan area in recognition of the fact that these two are often related and that they can be variable in time and space. In this way the Plan describes a generic model for diffuse source turbidity, qualified with locally specific catchment information (gathered through the ACWA Advisory Group and review of existing literature) which can then be used as a locally relevant foundation for supporting future diffuse source turbidity assessment and decision-making. The following section outlines common land uses which contribute to turbidity generation in the Upper Murrumbidgee River catchment and describes how interventions and different land management practices may assist in reducing turbidity associated with each land use and different land management practices may assist in reducing turbidity. Chapter 5 describes the actions proposed to address these diffuse sources of turbidity generation.

4.3.1 Degradation of riparian zones

The health and extent of riparian vegetation can have a significant influence on the level of sedimentation in adjacent waterways. Degraded riparian vegetation is a key source of turbidity through bank erosion and is a focus area for managing diffuse sources of turbidity. Factors leading to bank erosion due to riparian vegetation degradation include[20]:

- Removal of natural vegetation;
- Planting of exotic species, such as willows; and
- Stock grazing in riparian areas.

Among other impacts of degraded riparian vegetation is the loss of banks, infrastructure damage, aquatic habitat degradation (due to increased sedimentation) and increased flooding potential.

[19] Department of Environment and Climate Change NSW (2009) NSW Diffuse Source Water Pollution Strategy
[20] Land & Water Resources Research & Development Corporation (1999) Riparian Management Technical Guidelines, Volume 2: On-ground Management Tools and Techniques

Appropriate management of the riparian zones of the waterways within the Plan area will assist in the management of water quality by reducing background rates of bed and bank erosion and thus turbidity generation.

4.3.2 Unsealed roads

The maintenance and design of unsealed roads can contribute greatly to the level of turbidity generated within the catchment. Within the Plan area unsealed roads are managed by a range of organisations including Cooma-Monaro Shire Council, Snowy River Shire Council, the ACT and NSW governments, Forests NSW and private landholders.

An example of the extent of this issue is the existence in Cooma-Monaro Shire alone of over 700 km of unsealed road with over 2,000 waterway crossings on these roads.

Overland flows and heavy rainfall erode unsealed roads and causing large sediment movement which can subsequently enter waterways, resulting in increased turbidity. The level of long-term erosion and sedimentation from unsealed roads is dependent upon the location, climate, topography, soil type and drainage at the site[21].

Roads that pose the greatest risk to water quality are those that are in close proximity to waterways and drainage lines (e.g. those with waterway crossings or those constructed adjacent to waterways) and roads with steep gradients.

Sediment reduction measures should be implemented at the design, planning, construction and maintenance phases of unsealed roads design and construction to minimise turbidity generation.

4.3.3 Rural land management

The way that land is managed can greatly influence the water quality in adjacent and downstream waterways. Rural lands within the Plan area are managed for a range of purposes. Agriculture is dominated by large areas of dryland cropping and grazing with smaller areas of irrigated cropping also present. Forestry is also present with the Plan area.

Among the factors that affect the level of turbidity generation are:

- The poor groundcover, high levels of sediment can be mobilised from degraded and bare landscapes and entrained in run-off.
- Stock management practices, which can include stock grazing in riparian areas, and other sensitive areas which can promote bank erosion and intensive grazing techniques which can degrade groundcover.
- Forestry operation practices, which can reduce groundcover, clear zones adjacent to waterways and alter drainage, encouraging greater levels of sediment mobilisation.
- Farming management practices, including excessive irrigation, broadacre cropping, land clearing and earthworks can increase the potential for mobilisation of sediment.

[21] Department of Environment and Climate Change NSW (2008): Managing Urban Stormwater- Soils and Construction, Volume 2C- Unsealed Roads

Increasing groundcover and riparian vegetation reduces turbidity levels in receiving waterways by slowing the overland movement of rainfall runoff and increasing sediment deposition across the land before it enters waterways[22].

Extended periods of drought and/or excessively high stocking rates are key contributors to groundcover decline. Managing groundcover levels (particularly through drought periods) is a key element of improved rural land management. Landholder and land manager engagement, awareness raising and regulation all play a role in managing rural land to reduce the level of turbidity generated.

4.3.4 Inappropriate management of soils with limitations

Sheet erosion of soils is another diffuse source of turbidity in the Plan area. Soils with physical and chemical limitations can be a large source of sediment, which is transported through runoff across the landscape. This eroded material is commonly composed of silt and clay sized particles which, once entrained, can remain suspended in streams even during periods of low flow. The rate of erosion depends on a range of factors including the characteristics of particular soil types, rainfall, intensity of rain events, groundcover and landuse.

The Land and Soil Capability class system captures differences in soil properties and categorises the land according to its capacity to sustain agriculture. It is an eight class systems which examines a range of limitations including climate, topography, soil depth and soil physical and chemical properties. For the purposes of this document, only the factors which have the potential to impact on turbidity have been examined.

Within the Plan area, the following soil limitations have the potential to contribute to turbidity:

- Sodic soils – Although sodicity is commonly associated with point sources of sediment, structural decline of soils through agricultural use can result in the development of sodic soils. This is a gradual process and slightly sodic soils can yield sediment across large areas of the landscape, without the formation of gullies. This is particularly the case when groundcover is not maintained and the soil is sodic in the upper part of the profile.
- Low fertility or acidic soils – The capacity to grow plants in these soils can be limited. Areas affected by low fertility or acidity do not respond well to higher intensity land use. Lower groundcover percentages and increased potential for erosion are common where these soils have been managed outside their limitations.
- Steep slopes – These sites are more prone to sheet erosion and mass movement, particularly when groundcover is not maintained or land use is inappropriate. There is significant potential for sheet erosion to occur on these sites and contribute to turbidity.
- Shallow and rocky soils – The capacity to grow plants in these soils can be limited. Lower groundcover percentages and increased potential for erosion are common where these soils have been managed outside their limitations.

The split of soils with limitations across management units is shown in Table 2.

[22] Department of Environment and Climate Change NSW (2009) NSW Diffuse Source Water Pollution Strategy

Table 2 Land and Soil Capability Classification of management units
(as a percentage of soils within each management unit)

Management Unit	Soils with Slight limitations to Agricultural Production	Soils with Moderate Limitations to Agricultural Production	Soils with Severe Limitations to Agricultural Production	Soils with Very Severe Limitations to Agricultural Production	Soils with Extremely Severe Limitations to Agricultural Production	Soils only suited to management for conservation
Big Badja	0.0	0.4	40.2	42.4	13.7	3.2
Bredbo	0.0	3.6	28.2	32.9	35.4	0.0
Bridle & Slacks	0.3	27.0	59.1	7.6	5.4	0.6
Cooma Back	3.1	63.4	7.2	26.3	0.0	0.0
Gudgenby	0.0	17.4	5.1	2.8	74.8	0.0
Kybeyan	0.0	0.4	64.6	7.4	27.7	0.0
Murrumbidgee 1 North	0.2	7.3	12.2	39.0	41.3	0.0
Murrumbidgee 1 South	0.1	6.9	37.4	40.3	14.1	1.1
Murrumbidgee 2 North ACT	0.0	29.0	5.9	33.2	31.3	0.3
Murrumbidgee 2 North NSW	0.0	8.5	14.7	14.9	60.3	1.4
Murrumbidgee 2 South	0.3	9.2	19.3	28.4	41.8	0.7
Naas	0.0	10.0	13.8	4.7	71.4	0.0
Numeralla	0.2	12.9	31.2	27.2	28.4	0.0
Paddys	0.0	25.0	1.4	1.9	71.6	0.0
Rock Flat	2.8	47.3	10.3	37.9	0.9	0.8
Strike A Light	0.0	0.2	8.1	18.0	73.7	0.0
Tantangara	2.5	6.3	29.1	29.6	28.2	0.0

More than 95 percent of the soils in the Plan area have moderate to extremely severe limitations to agricultural use, although the limiting factor is not specified.[23,24] The distribution of these is outlined in Figure 7.

Whilst the Priority Management Units for assessment were derived via a different process there is a strong correlation between the final Priority ranking and the distribution of soils defined as 'Soils with Extremely Severe Limitations to Agricultural Production.

[23] Central West Catchment Management Authority (2008) *Land and Soil Capability - How We Safely Manage the Land,* Wellington NSW, PP32

[24] Bowman, G. (2005) *Land and Soil Capability Tool Reference Guide,* Version 1.4a, Department of Natural Resources NSW, PP 28

Soils with limitations across the ACWA Plan Area

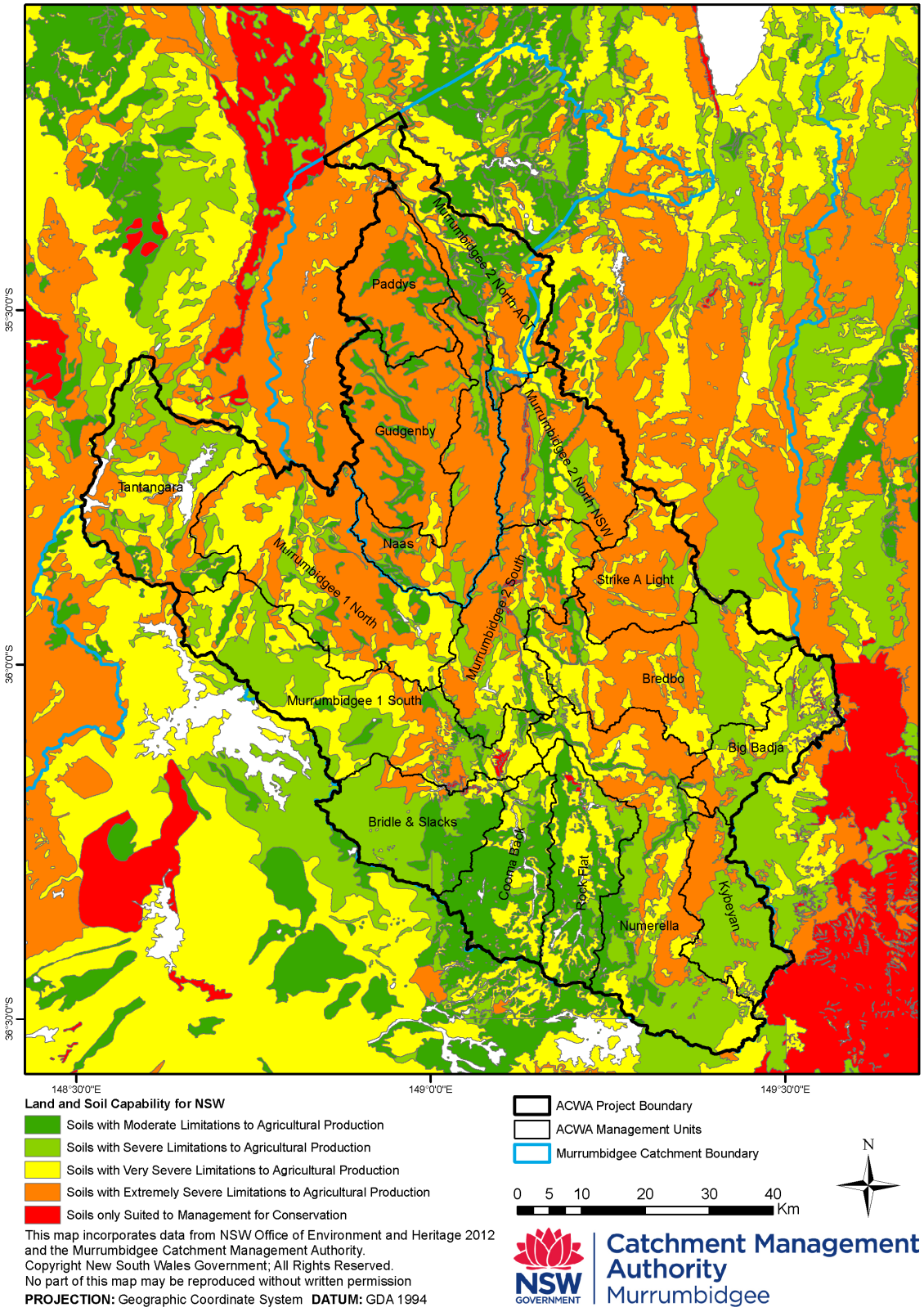


Figure 7 Soil limitations in the ACWA Plan area, Source: NSW Murrumbidgee CMA

Soil types within the catchment, as described in Chapter 5, are important indicators for priority areas of soil conservation intervention. Soils should be managed within their capability and in a manner which does not cause degradation.

4.3.5 Sand/gravel extraction

Gravel and sand extraction operations can provide positive and detrimental effects to waterways. Within the Plan area, a series of extractive industries currently operate. Turbidity impacts associated with extractive activities may include[25]:

- Disturbance to bed and banks of waterways;
- Increased erosion from cleared areas;
- Increased sediment mobilisation through the introduction of unsealed roadways; and
- Increase in sediment transport through the use of machinery during wet weather.

Other impacts of extractive operations can include flow regime alteration, degradation/loss of aquatic habitat, and other water quality impacts such as stratification of water and chemical contamination from equipment.

An example of the impacts of extraction in the Plan area is evident on the Bredbo River. By lowering a gravel bar adjacent to the river, headward erosion has been initiated on a connected side gully, thus creating significant instabilities. This is discussed in Part B of the ACWA Plan.

Extractive operations should employ best management practices, in line with regulatory requirements to reduce sediment mobilisation and turbidity generation.

[25] Agriculture and Resource Management Council of Australia and New Zealand (2000) National Water Quality Management Strategy: Rural Land Uses and Water Quality, Agriculture and Resource Management Council of Australia and New Zealand, and Australian and New Zealand Environment and Conservation Council

5 ACWA Management Actions

The following sections outline actions to better manage point and diffuse sources of turbidity generation in the Plan area, which are intended to be complementary. These are intended to guide the actions of stakeholders to achieve reduced turbidity outcomes for improved water quality. This will require a holistic approach, through implementation of a suite of actions, as presented in section 5.4.

5.1 Point sources

Under the prioritisation framework used in this assessment, approximately 60 point sources of turbidity were assessed. The highest priority point source issues for the Upper Murrumbidgee River catchment are outlined in Table 3.

Table 3 Priority Point Source Sites

Risk	Sites
Extreme (64-125)	Bank Erosion Lower Buchan Creek (Site 2) Gully, Bed & Bank Erosion Buchan Creek (Site 3) Channel Deepening Bredbo Gully (Site 4) Sediment Transfer Bredbo River Gully (Site 5) Bank Erosion Spring Station Creek (Site 20) Bank Erosion Lanyon Canyon (Site 34) Bank Erosion Murrumbucca Creek (Site 40) Bed & Bank Erosion Naas River (Site 41) Sediment Transport Naas River Tributary (Site 42) Bank Erosion Naas River (Site 43) Bank Erosion Naas River (Site 45) Bank Erosion Tidbinbilla Creek (Site 51)
Very High (43-63)	Gully Erosion Stockyard Creek (Site 1) Bank Erosion Lower Cooma Creek (Site 18) Bank Erosion Lower Gudgenby River (Site 19) Bank Erosion Gudgenby River (Site 21) Bank Erosion Honeysuckle Creek (Site 23) Bank Erosion Murrumbidgee River (Site 38) Sediment Transport Naas Tributary Gully (Site 44) Bank Erosion Lower Rose Valley (Site 50)

Part B of the Plan describes in detail the site conditions and assessments undertaken.

The prioritisation process revealed several management units and sub-catchments which contain multiple sites assessed as extreme and very high risk (see Part B of the Plan). To effectively treat the key point source turbidity generation issues in these management units it is likely that work programmes at the larger reach and sub-catchment scale will be required in these catchments.

In several management units, multiple erosion sites are present and some of the issues noted during the site assessments appear to be endemic across large scales. Should the focus of works only be on individual sites or small reaches a reduction in turbidity generation will be achieved, however some of the underlying issues such as high prevalence of soils with limitations that may be triggering these issues will not be addressed.

Examples include the Naas Management Unit, the Bredbo Management Unit and parts of the Numeralla Management Unit.

Action 1. Detailed works and activities plan

Prepare detailed works and activities plans for each of the very high erosion risk Management Units (Naas, Bredbo and Numeralla Management Units). These plans will be based on additional detailed desktop and field investigations and will include comprehensive works programs (including riparian management activities) for priority Management Units. These plans will include riparian management activities and provide for the further assessment and mitigation of diffuse source turbidity generation at the sub-catchment scale.

5.2 Diffuse sources

Diffuse sources of turbidity require a suite of management actions to address the causes of high fine sediment loads across the Plan area. Actions relating to the promotion of best management practices and enhanced regulatory enforcement are presented for the following diffuse sources of turbidity.

5.2.1 Degradation of riparian zones

Information relating to the condition of riparian vegetation is variable across the Plan area with specific studies having historically been undertaken on the Murrumbidgee River but with less attention paid to tributary streams.

The ACT Government in 2007 conducted a survey of riparian vegetation and habitat for the length of the incised Murrumbidgee River valley in the ACT[26]. The aim of this project was to identify the extent and condition of the riverine vegetation communities. This study found that the state of the riparian zone vegetation in the ACT section of the Murrumbidgee River was generally poor. Intact areas of riparian shrubland were present within bedrock dominated gorge areas, however the structural integrity of most of the riparian zone has been compromised in various ways. The ground layer is invariably dominated by introduced species and mid-strata species are often absent from areas with established canopy species. In other places, canopy species survive only as remnants of what were

[26] ACT Department of Territory and Municipal Services (2009). *Survey of Vegetation and Habitat in Key Riparian Zones: Murrumbidgee River, ACT (Technical Report 22)*. ACT Government, Canberra.

likely to have been extensive ecological communities. Catchment land use and altered water resource allocation continues to affect river hydrology and base flows have become lower and flooding more infrequent compared to pre-European levels.

Other parts of the Plan area have not had this extent of survey and focus on riparian condition. It is believed that intact riparian zones do exist in rocky/steep country such as areas below Tantangara Dam (including Binjura NR) and several gorges near Scottsdale, Michelago and Gigerline and Red Rocks (Luke Johnson pers comm. 2012). However it would be reasonable to assume that based on similar histories of landuse and disturbance and the anecdotal evidence during the ACWA project consultation that the condition of extensive lengths of riparian zones is also poor.

Whilst erosion is occurring, it is believed to be at significantly lower rates than for the nominated point erosion locations[27]. Regardless, appropriate management of the riparian zones of the waterways in the Plan area can reduce background erosion rates and thereby assist in the management of a diffuse turbidity source.

The appropriate management of riparian zones will result in decreased rates of erosion and sediment generation. It involves a range of measures to keep riparian land in good condition. These include:

- Retention of native riparian vegetation and active management of introduced plant species;
- Revegetation of degraded riparian areas; and
- Control and management of domestic stock access to riparian zones.

Well managed riparian zones can have additional benefits beyond potential reductions in turbidity generation such as sustaining biodiversity values (both aquatic and terrestrial), they can provide a source of timber as habitat for aquatic species and they can provide a buffer to streams against nutrient-rich runoff from adjacent lands.

In total there are approximately 18,775 km of waterways in the Upper Murrumbidgee River catchment. Management of the riparian zones of these waterways will vary according to their scale, location in the catchment and their existing conditions. The distribution of waterways of different scales within the catchment is outlined in Table 4.

Table 4 Waterway distribution in the Upper Murrumbidgee catchment

Stream Description	Stream Order Classes	Length (km)
Headwater Streams	Stream Orders 1, 2 & 3	15,975
Medium Streams	Stream Orders 4, 5 & 6	1,920
Rivers	Stream Orders 7 & 8	880

The current condition of riparian zones throughout the Plan area is highly variable and is dependent upon a range of factors including catchment location, land tenure and adjacent land use. This variability was clearly evident during the stream assessments.

[27] Abernethy, B. & Rutherford, I (1999). Guidelines for Stabilising Streambanks with Riparian Vegetation (Technical Report 99/10). Cooperative Research Centre for Catchment Hydrology.

Given the length of waterway present in the Plan area the costs associated with implementing better riparian land management practices throughout the plan area would be considerable. The focus of the Plan is to improve water quality by reducing turbidity. In keeping with this, one approach to riparian management would be to target those areas in the catchment in the poorest condition where improved riparian management is likely to have the largest benefit in terms of reducing turbidity.

An example of such a location is the Numeralla catchment where poor quality riparian zones were typically encountered during field assessments. An indication of the potential scale of riparian management works in this catchment is included in Table 5.

Table 5 Numeralla catchment potential scale of riparian works

Sub Catchment	Waterway Length(km)	Assumed Waterway Length (km) *	Area to be revegetated (ha)#
Numeralla	2,400	2,880	11,520

** assumes that only 60% of the waterway needs fencing, but that fencing is required on both sides of the river/stream*
#assumes a 40 metre wide riparian zone to be established

Given the scale of potential riparian management works it will be necessary to undertake a survey to confirm the extent and locations where these works are required.

Action 2. Target riparian management activities in priority sub-catchments

Identify and target riparian management activities in priority sub-catchments, as identified in Part B. Align existing riparian revegetation incentives and works with 'greatest gain' sub-catchments where vegetation is most likely to be successful. Consider expanding existing programs to better manage erosion across the Plan area.

5.2.2 Unsealed roads

Whilst it is recognised that runoff from unsealed roads is a significant contributor of turbidity the quantification of this impact is beyond the scope of this Plan. Within the Plan area unsealed roads are managed by a range of organisations including Cooma-Monaro Shire Council, Snowy River Shire Council, the ACT and NSW governments, Forests NSW and private landholders. These roads are maintained to a variety of standards dependent upon their purpose and primary manager.

A demonstration of scale is drawn in the example of Cooma-Monaro Shire Council (CMSC) which has jurisdiction over in excess of 700 km of unsealed roads. Approximately 80 to 85% of CMSC lies within the Plan area. The length of unsealed roads and number of river crossings in the ACT section of the Plan has not been calculated.

Sediment management is a consideration for rural road managers who are often in a position of minimising road maintenance costs at the expense of incorporating design elements to reduce sediment movement. Measures to reduce sediment generation are implemented differently across the range of road asset managers, who employ various best management practices according to their respective jurisdiction and the category of road being managed.

Broadly, the management of erosion and sediment control on unsealed roads pertains to[28]:

- Controlling water flow away from the unsealed road using drainage techniques;
- Reducing water flows to below erosive levels and providing for erosion control measures such as drain and channel linings;
- Designing for appropriate batter design, including grades and stabilisation measures; and
- Ensuring culvert inlets and outlets are protected, including use of energy dissipation measures.

An example of improving road management practices is the Cooma-Monaro Shire Council. As an asset manager, the Council is working towards developing a road asset management plan, expected by mid-2012. The plan would detail the Council's road management practices and intents[29].

Current best management practice for unsealed roads for improved turbidity outcomes are currently considered through Erosion and Sediment Control Plans which outlines approaches to the construction, design and operation of unsealed roads. An Erosion and Sediment Control Plan should consider the following, adapted from[30]:

- Route selection;
- Longitudinal grade;
- Clearing width;
- Batters;
- Surface and cross drainage;
- Drainage line crossings, including culverts, bridges and causeways;
- Revegetation and stabilisation planning and implementation;
- Road surface and fill material;
- Sediment basins;
- Site management;
- Control measures; and
- Maintenance and monitoring plans.

Forestry roads

In the ACT roads for forestry purposes are governed by the Code of Practice for timber harvesting and a Pollution Control Licence issued under the *Protection of the Environment Operations Act* (POEO Act), for roads associated with active harvesting operations. The NSW Code of Practice for timber operations states that runoff must disperse and discharge away from bare soil and that road drainage structures must be kept in good working order. Limitations are placed on the acceptable distances for surface flows with respect to the drainage spacing on that road surface. All operations

[28] Department of Environment and Climate Change NSW (2008): Managing Urban Stormwater- Soils and Construction, Volume 2C- Unsealed Roads

[29] Cooma-Monaro Management Plan 2011/2012, http://www.envcomm.act.gov.au/soe/soe2004/Cooma-Monaro/infrastructure.htm

[30] Department of Environment and Climate Change NSW (2008): Managing Urban Stormwater- Soils and Construction, Volume 2C- Unsealed Roads

must be operated within these limits. Licensees are responsible for drainage repairs[31]. The Code also specifies that additional sediment control may be required in dry conditions.

Among other actions to manage sediment control are appropriate drainage, use of energy-dissipating structures and silt traps, avoidance of drainage over erodible soils, appropriate stream crossings, drainage structures away from streams discharging onto undisturbed vegetation or appropriate sediment control structures and low sediment gravel surfacing on bridge or culvert approaches.

NSW road managers must follow regulatory requirements under the *Environmental Planning and Assessment Act 1979* (among others), which requires that road construction projects develop Erosion and Sediment Control Plans (ESCPs) as outlined above, which identify specific measures for the road to minimise erosion and sediment generation. Specific guidance on the development of the ESCPs is provided in Department of Environment and Climate Change NSW (2008): Managing Urban Stormwater- Soils and Construction, Volume 2C-Unsealed Roads. Improved outcomes for turbidity generation from unsealed roads may be gained through direct engagement with road managers to determine how best to support and implement BMPs through their current practices.

Action 3. Engage with road managers in priority sub-catchments to improve BMP uptake for turbidity outcomes

Engage with road managers in priority sub-catchments to identify the opportunities and barriers to greater uptake of BMPs for reduced turbidity outcomes. Determine if greater support, information or engagement would achieve tangible reductions in turbidity generation on unsealed roads within the scope of Plan outcomes. Utilise support or engagement mechanisms where opportunities exist to improve uptake of BMPs for turbidity outcomes among road managers.

5.2.3 Rural land management

While national parks and reserves protect the headwaters of the Upper Murrumbidgee catchment, they are scattered disparately across the Plan area. In many, the reserve system has been applied to land that is otherwise incapable of being used commercially[32]. Of some note is the arrangement of Travelling Stock Reserves (TSR). Though historically set aside to provide for the movement of stock overland, TSRs now lock up important fragments of ecologically sensitive plant and animal communities[33].

Given the large area of rural land that falls within the Plan area, best management practices are imperative in order to reduce turbidity. Some of the rural management issues potentially contributing to turbidity in the ACWA Plan area are briefly outlined below.

Agricultural Practices

Though not large in area, cropping and horticultural activities are important land use activities in the Plan area[34] as they often occupy alluvial flats that have direct connectivity to drainage lines and

[31] NSW Forestry Practices Code (2005)- part 1, Timber Harvesting in Forests NSW Plantations- Roads
[32] ActewAGL (2011). Land Cover and Land Use within the Upper Murrumbidgee Abstraction. ActewAGL, Canberra
[33] Livestock Health and Pest Authorities (undated) http://www.lhpa.org.au/travelling-stock-reserves, Accessed August 2012
[34] ActewAGL (2011). Land Cover and Land Use within the Upper Murrumbidgee Abstraction. ActewAGL, Canberra

waterways. Commonly grown crops include lucerne, oats and triticale; horticultural crops include broccoli, olives, grapes, and fruit trees. The largest single area of irrigated cropping and horticulture within the Plan area is located at the confluence of the Murrumbidgee River and Numeralla River just north of Cooma. Other areas of irrigation occur on the Murrumbidgee River near Adaminaby, upstream of the village of Bredbo on the Bredbo River, at Chakola on the Numeralla River and on the alluvial flats upstream of the village of Numeralla on the Numeralla River. Dryland cropping is commonplace on alluvial flats where water supply is intermittent. It is also regular practice to graze domestic stock on these areas.

The Plan area is dominated by grassland and woodland areas that have been used since European settlement to graze cattle and sheep. Stocking rates were traditionally kept low by pastoralist to address the extremes of climate in the catchment. Stock numbers and densities declined during the drought conditions of the 2000s, however there is potential for livestock densities to return to the former stocking rates as drought conditions ease.

The grazing of domestic stock, mostly cattle and sheep is commonplace throughout the Plan area on the native and secondary grasslands and woodlands in the catchment. Preferred sites for grazing are typically valley floors, moderate slopes and undulating terrain. There is little evidence of grazing on steeper slopes or in heavily timbered country (see Table 6).

Table 6 Class descriptions and aggregations for each of the eight land condition classes within the ACWA Plan area. Source: ActewAGL 2011.

Description	Area (km^2)
Water	22.3
Dominantly woody vegetation - Very low risk to water quality	3755.8
Grasslands and swamps – Very low risk to water quality with dense cover and typically ungrazed	487.2
Grasslands - Moderate cover, low risk to water quality	1244.0
Open grasslands - moderate cover, potential risk to water quality	694.8
Bare ground or heavily grazed pasture, High risk to water quality	509.3
Urban	51.5

Land actively grazed was reported by ActewAGL in 2011[35]. The following figures are aggregations of varying stocking densities, occurring on both improved pasture and native grasslands and represent the dominant livestock present:

- Cattle grazing 68,405 Ha.
- Sheep grazing 205,686 Ha.
- Grazing by other herds (Llamas, ostrich and goats etc) 546 Ha.
- Cropping extends to 2116 Ha.

[35] ActewAGL (2011). Land Cover and Land Use within the Upper Murrumbidgee Abstraction. ActewAGL, Canberra

The 2011 report observes that cattle grazing occupies the greatest area of moderate to high risk land condition categories and this is closely followed by sheep grazing on improved pasture. This may be considered a turbidity risk as these areas are typically found on the flood plains where connectivity to the drainage network is high.

Vegetation planning for rural landscapes is supported through existing NRM programs and tools, such as Property Vegetation Plans (PVPs) in NSW. PVPs are also useful tools for landholder management of properties to encourage and enhance vegetation on site. PVPs are voluntary, legally-binding plans prepared between a landholder and a CMA. PVPs are required for any clearing applications in NSW[36] and for many incentives schemes. The Murrumbidgee CMA provides support in developing PVPs and can assign an officer to assist in on site assessment and PVP proposals free of charge[37].

In the ACT, Land Management Agreements identify features and areas having special conservation value and set out management measures required to achieve agreed conservation outcomes on rural leases. Land Management Agreements are reviewed at 5 year intervals.

Forestry Best Management Practices

The Forests NSW Forestry Practice Code outlines best management practices for timber harvesting. It specifies expectations relating to establishment, planning, operation and maintenance of sites, including operations, forest roads and fire trails. The Code outlines that activities should be achieved with minimal disturbance to the site and on drainage features. This includes[38]:

- Not spreading by-product within 10m of drainage feature protection areas;
- Reduce earthworks and locate tracks at elevation to reduce topsoil disturbance;
- Retain groundcover, use slash to cover the track and use cross-fall drainage;
- Use stable material for drainage structures and space drainage as per the Code;
- Adhere to requirements for operation in the buffer and five-metre zones to reduce erosion in drainage feature protection areas (areas adjacent to wetlands, rivers and drainage areas); and
- Operations are subject to wet conditions requirements and limits, which may require stoppages to reduce erosion potential particularly from rutting.

All forestry operations should abide by the relevant Practice Code.

Plantation forestry within the catchment is historically not well established with the oldest plantations only a little over a decade old. Plantation forestry across the Plan area is relatively insignificant in the amount of land in use (approximately 3400 Ha)[39].

In terms of addressing turbidity in the ACWA Plan area, key gains in terms of reduced turbidity generation can be made through closer engagement and support to landholders and land managers. Targeted programs that work directly with landholders should be tailored in priority sub-catchments to reduce large-scale sediment mobilisation across degraded landscapes. Improved farming management practices that reflect land capability would reduce turbidity in the ACWA Plan area.

[36] http://www.environment.nsw.gov.au/vegetation/pvp.htm
[37] http://www.murrumbidgee.cma.nsw.gov.au/services/native-vegetation/propertyvegetation-plans.aspx, Accessed July 2012
[38] NSW Forestry Practices Code (2005)- part 1, Timber Harvesting in Forests NSW Plantations
[39] ActewAGL (2011). Land Cover and Land Use within the Upper Murrumbidgee Abstraction. ActewAGL, Canberra

Action 4. Develop a targeted land management program for priority sub-catchments

Develop a targeted program for landholders and land managers that captures landscape scale turbidity generation issues on agricultural lands. The program would incorporate support for decision-making around:

- Land capability decision making (soil management);
- Stock grazing management (including exclusion from riparian zones and management for improved groundcover);
- Erosion, drainage and land clearing management; and
- Property vegetation planning (including co-benefits of enhanced vegetation).

The program should be tailored and promoted to landholders within priority sub-catchments for optimal turbidity outcomes. The program should explore ways to increase uptake of existing programs among landholders.

5.2.4 Management of soils within limitations

A large proportion of the Plan area contains soils that have significant potential to release fine sediment and hence contribute to downstream turbidity. Land managers throughout the Plan area should consider soil limitations encourage activities which reduce the potential for the mobilisation of sediment into the stream systems.

At present, a range of Government Agencies have some responsibility for the issue of soil conservation. In NSW these include the Soil Services Division of the Office of Environment and Heritage, the Soil Conservation Service in the Department of Primary Industries and the Catchment Management Authorities. In the ACT soil conservation is the responsibility of Territory and Municipal Services Directorate.

Specific activities can be undertaken to address the soil limitations present in the Plan area. These are as follows:

- Sodic soils – The degree of sodicity will dictate the type of actions which are appropriate in these soils. Where agricultural practices have contributed to sodicity, a change in management can reduce the impact. This can include: stubble retention; minimal cultivation; direct seeding; use of fertilisers and ameliorants; longer crop rotations; and grazing to minimise traffic and maintain biomass and groundcover.
- Low fertility or acidic soils – An understanding of the distribution of acidic soils is important to target lower impact agricultural activities to the soils which are less capable of sustaining production. Regular monitoring and where necessary the application of fertilisers and ameliorants is necessary to improve understanding of fertility decline and reduce its impacts.
- Steep slopes – Agricultural production on these sites should be limited to grazing, which should be only be undertaken where it is possible to maintain groundcover.
- Shallow and rocky soils – Cultivation of this land is typically not sustainable and grazing should only be undertaken where it is possible to maintain groundcover.

Although the distribution of soils with limitations is reasonably well understood, the specific nature of these limitations is not. Further understanding of soil limitations in the Plan area would enhance the capacity to target specific activities to the sites where there will be the greatest impact on turbidity[40,41].

Action 5. Develop support material for soil capability in support of wider communication programs

Develop a factsheet outlining 'soils with limitations' soil locations, capabilities (particularly sodic/dispersive soils) and conservation practices. Promote the factsheet on stakeholder websites, through landholder engagement (as part of Action 4) and through the communication strategy (Action 9). Material could be obtained through soil conservation managers in ACT and NSW jurisdictions to support the material development.

5.2.5 Sand/gravel extraction

A range of sand and/or gravel extraction enterprises are located throughout the Plan area. The materials produced are used in the building and construction sectors throughout the region.

The following sand and gravel extraction sites have been identified as part of the Plan preparation:

- Michelago (Gravel extraction), Murrumbidgee 2 South NSW Management Unit.
- Bredbo (Gravel extraction), Bredbo Management Unit.
- Nimmitabel (Gravel extraction), Numeralla Management Unit.
- Billilingra (Sand extraction), Numeralla Management Unit.
- Colinton (Sand extraction), Numeralla Management Unit.
- Rose Valley (Sand extraction), Numeralla Management Unit.
- Bredbo (Sand extraction at three locations), Bredbo Management Unit.

Sand and gravel extraction should follow best management practices outlined by government agencies, which include[42].

Development of an erosion and sediment control strategy (ESCS) for the planning, operation and rehabilitation stages of the operation.

- Assess and plan for soil and water management for a project at the planning stage.
- Plan for erosion and sediment control at the design stage to reflect site constraints.
- Minimise disturbance to soil sensitive aquatic & riparian areas.
- Conserve soils for rehabilitation.
- Control up-slope water to direct it away from disturbed areas.
- Rehabilitate disturbed land as soon as practically possible.

[40] Central West Catchment Management Authority (2008) *Land and Soil Capability - How We Safely Manage the Land,* Wellington NSW, PP 32

[41] Bowman, G. (2005) *Land and Soil Capability Tool Reference Guide,* Version 1.4a, Department of Natural Resources NSW, PP 28

[42] Department of Environment & Climate Change (2008) Managing Urban Stormwater: Soils and Construction, Volume 2E Mines and Quarries

Planning and design phase

- Design drainage systems to reflect the life of the operation.
- Minimise runoff.

Operational phase

- Minimise disturbance extent and duration, protect/enhance revegetate non-operation disturbed areas with native vegetation suited to site.
- Ensure temporary and permanent earthworks to create landforms that minimise erosion risks.
- Stabilise land shortly after earthworks.
- Design for temporary surface-water collection and disposal systems.

Rehabilitation phase

- Minimise long-term erosion, including effective revegetation at the site.
- Continue management after initial rehabilitation works.

Extraction operations should plan and implement erosion and sediment control strategies to reflect site constraints and conditions. Further guidance is provided in DECC (2008) Managing Urban Stormwater: Soils and Construction, Volume 2E Mines and quarries[43].

All extraction operations should follow regulations of the relevant jurisdiction. Under the ACT *Environment Protection Act 1997* the extraction of more than 100m^3 of material (other than water) from a waterway is a Class A activity listed under Schedule 1 and therefore requires an Environmental Authorisation. Depending on the amount of material that is extracted each year, the extraction operation may require an environment protection licence, under the *Protection of the Environment Operations Act, 1997* (NSW). In NSW, licences are administered by the NSW DPI and are generally bound by permissive occupancy terms[44]. Larger operations in NSW may be required to obtain a lease under the *Environmental Planning and Assessment Act 1979* (EP&A Act). In addition, NSW has a sand and gravel extraction policy for non tidal rivers which outlines expectations relating to extraction and its associated environmental issues.

Further, an array of management strategies are identified in the policy, which predominantly include provisions for assessment within the environmental impact assessment process (through the NSW EP&A Act) and implementation of robust monitoring programs across extractive operations. In 2007, *the State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries)* was gazetted to complement the EP&A Act and provide for impact assessment and environmental management of extractive activities. All extractive operations need to adhere to relevant jurisdiction regulation and planning requirements.

[43] DECC NSW (2008) Managing Urban Stormwater: Soils and Construction, Volume 2E Mines and quarries
[44] http://www.lpma.nsw.gov.au/crown_lands/leases/licences, Accessed April 2012

Action 6. Review extraction operations for ESCS implementation to support uptake

Undertake a review of all extraction operations in the Plan area to determine that existing operations are being undertaken in line with their current licence conditions and are aligned with Erosion and Sediment Control Strategies (ESCSs). Where licence conditions do not require stringent ESCS implementation, liaise with licensing authorities to seek to modify licence conditions.

5.3 Whole-of-catchment

The following recommendations address actions which are to be implemented over the entire plan area. They support the actions for diffuse and point sources as outlined in sections 5.1 and 5.2.

5.3.1 Coordination of ACWA implementation

The preparation of the Plan has involved a significant degree of cooperation from organisations within NSW and the ACT. It is anticipated that implementation of the ACWA Plan will require similar cross-agency and cross-jurisdictional coordination across multiple years. In order to facilitate the implementation of the Plan a governance model will be required that accommodates the large range of organisations potentially involved in plan implementation, the range of potential funding sources, the legislative basis for organisational involvement and the two jurisdictions involved.

Similarly the ACWA Plan recommends a range of activities and actions are undertaken to address point and diffuse sources of turbidity generation. These relate to a broad range of issues across the entirety of the plan area including both NSW and the ACT. Coordination of plan implementation will be an important element to ensure that Plan objectives are met and that engagement with the broad range of plan stakeholders is maintained.

Action 7. Develop an ACWA plan governance and implementation plan

The ACWA Partners are committed to the implementation of the Plan. This includes the development of a Plan governance and implementation plan. This would include an agreed governance model for plan implementation that considers the complex multi agency and cross-jurisdictional aspects of the ACWA project. The coordination of projects and activities of the ACWA Plan would be incorporated in the governance and implementation plan to ensure elements of the Plan are implemented.

5.3.2 Improved turbidity monitoring

The monitoring of turbidity in the Plan area is currently undertaken by a range of organisations in both the ACT and in NSW. In NSW water quality monitoring is undertaken by a range of agencies (NSW Office of Water, State Water and MDBA) with the data consolidated on the waterinfo.nsw.gov.au website. This data is a combination of real-time data and information that is derived by sampling. In the ACT water quality information is collected by ACTEW and the ACT Environment and Sustainable Development Directorate (ESDD). Again the data collected is a

combination of real-time and sampled data. In the ACT water quality data is not consolidated at a single location. In both jurisdictions water quality data is also collected by community members via the Waterwatch program and consists solely of sampled data.

Water Quality data is collected and managed by multiple agencies throughout the Plan area with little coordination between those agencies undertaking the monitoring. To address the effectiveness of the implementation of the Plan additional emphasis needs to be placed on the coordinated collection and management of water quality data to ensure that the appropriate parameters are being monitored in the correct locations at the best times. Through the development of an interagency and cross jurisdictional turbidity monitoring plan, there is significant benefit in considering the broader opportunities of standardising relevant monitoring methods and datasets. Stakeholders should consider how water quality datasets are collected, managed and supported across NSW and the ACT to improve cohesion and use. This would also deliver benefits in future cross jurisdictional planning and works.

Action 8. Develop a strategic turbidity monitoring plan for the ACWA plan area

Develop a strategic turbidity monitoring plan for the Plan area to improve the understanding of locations of turbidity generation and to allow for a review of the effectiveness of plan implementation.

Through the turbidity monitoring plan development, identify opportunities for the standardisation of relevant datasets between organisations and agencies involved in water quality monitoring between NSW and ACT jurisdictions.

5.3.3 Community engagement and education programmes

The origins of the Plan lay within community concern at perceived deterioration in water quality in the Murrumbidgee River and its tributaries. As the plan has been developed there has been a significant ongoing involvement of the community through the ACWA Advisory group. Maintenance of engagement with the community through plan implementation will be vital as the catchment community will have a significant role in delivering key elements of the plan. Existing community engagement initiatives such as Waterwatch provide an ideal avenue for engagement with the community on water quality issues in the region.

Similarly, a key element of ACWA implementation will relate to community capacity building in terms of improved understanding of environmental management issues. A strategy to deliver an integrated community education program should be developed to ensure that this occurs.

Action 9. Develop a communication strategy for ACWA plan implementation

Develop a communication strategy for Plan implementation. The communication strategy will include elements relating to the promotion of the Plan, its implementation and education initiatives, such as supporting information factsheets, for the broader catchment community to improve environmental management. Consider using existing networks for communicating the ACWA project and related initiatives to the community including landholders, land managers, Upper Murrumbidgee catchment Traditional Owners in NSW and the ACT and Aboriginal Land Councils.

5.3.4 Development of a monitoring and evaluation plan

A cross-jurisdictional monitoring and evaluation plan should be developed to support and inform the responses to point and diffuse turbidity sources within the plan area. To ensure complementary data collection and management practices are adopted, the NSW and ACT governments and representing agencies will need to collaboratively design and implement the monitoring plan.

In recognition that turbidity factors such as soil and climatic conditions change over time, the plan should be framed adaptively to not only monitor and identify sources of ongoing or new turbidity, but to report on the successes of the plan and adapt management actions to address changes within the catchment. This will enable turbidity reduction actions emanating from the Plan to remain relevant and responsive to needs within the plan area.

Action 10. Develop a cross-jurisdictional monitoring and evaluation plan for the ACWA area

Develop a cross jurisdictional monitoring and evaluation plan for the Plan. The monitoring and evaluation plan should be prioritised and implemented to ensure that the success of Plan can be adequately measured.

The plan should be developed by implementing agencies to reflect capacity and needs and should be designed to be responsive. This will enable the activities of the Plan to be adaptive to changes in the catchment and of other factors, such as resources and knowledge.

5.4 Summary of ACWA actions

The following table provides a summary of ACWA actions across point source, diffuse source and whole-of-catchment to reduce turbidity generation in the Plan area. These are designed as a complementary set of actions and although each should deliver reduced turbidity outcomes, optimal outcomes would be achieved through concurrent implementation.

Actions have been framed around three timeframes:

- Immediate term: the next 1-3 years
- Medium term: 3-10 years
- Ongoing: actions that are important for the long term success of the project

Point source actions are listed in Table 7, with diffuse source actions in Table 8. Table 9 contains the whole-of-catchment ACWA actions.

Table 7 Point source ACWA actions

Point source	Action	Timeframe
Action 1. Detailed works and activities plan	Prepare detailed works and activities plans for each of the very high erosion risk Management Units (Naas, Bredbo and Numeralla Management Units). These plans will be based on additional detailed desktop and field investigations and will include comprehensive works programs (including riparian management activities) for priority Management Units. These plans will include riparian management activities and provide for the further assessment and mitigation of diffuse source turbidity generation at the sub-catchment scale.	Immediate term

Table 8 Diffuse source ACWA actions

Diffuse source	Action	Timeframe
Action 2. Target riparian management activities in priority sub-catchments	Identify and target riparian management activities in priority sub-catchments, as identified in Part B. Align existing riparian revegetation incentives and works with 'greatest gain' sub-catchments where vegetation is most likely to be successful. Consider expanding existing programs to better manage erosion across the Plan area.	Ongoing
Action 3. Engage with road managers in priority sub-catchments to improve BMP uptake for turbidity outcomes	Engage with road managers in priority sub-catchments to identify the opportunities and barriers to greater uptake of BMPs for reduced turbidity outcomes. Determine if greater support, information or engagement would achieve tangible reductions in turbidity generation on unsealed roads within the scope of Plan outcomes. Utilise support or engagement mechanisms where opportunities exist to improve uptake of BMPs for turbidity outcomes among road managers.	Immediate term
Action 4. Develop a targeted agricultural management program for priority sub-catchments	Develop a targeted program for landholders and land managers that captures landscape scale turbidity generation issues on agricultural lands. The program would incorporate support for decision-making around: ▪ Land capability decision making (soil management) ▪ Stock grazing management (including exclusion from riparian zones and management for improved groundcover) ▪ Erosion, drainage and land clearing management ▪ Property vegetation planning (including cobenefits of enhanced vegetation) The program should be tailored and promoted to landholders within priority sub-catchments for optimal turbidity outcomes. The program should explore ways to increase uptake of existing programs among landholders.	Immediate term

Action 5. Develop support material for soil capability in support of wider communication programs	Develop a factsheet outlining 'soils with limitations' soil locations, capabilities (particularly sodic/dispersive soils) and conservation practices. Promote the factsheet on stakeholder websites, through landholder engagement (as part of Action 4) and through the communication strategy (Action 9). Material could be obtained through soil conservation managers in ACT and NSW jurisdictions to support the material development.	Immediate term
Action 6. Review extraction operations for ESCS implementation to support uptake	Undertake a review of all extraction operations in the Plan area to determine that existing operations are being undertaken in line with their current licence conditions and are aligned with Erosion and Sediment Control Strategies (ESCSs). Where licence conditions do not require stringent ESCS implementation, liaise with licensing authorities to seek to modify licence conditions.	Medium term

Table 9 Whole-of-catchment ACWA actions

Whole-of-catchment	Action	Timeframe
Action 7. Develop an ACWA plan governance and implementation plan	The ACWA Partners are committed to the implementation of the Plan. This includes the development of a Plan governance and implementation plan. This would include an agreed governance model for plan implementation that considers the complex multi agency and cross-jurisdictional aspects of the ACWA project. The coordination of projects and activities of the ACWA Plan would be incorporated in the governance and implementation plan to ensure elements of the Plan are implemented.	Immediate term
Action 8. Develop a strategic turbidity monitoring plan for the ACWA plan area	Develop a strategic turbidity monitoring plan for the Plan area to improve the understanding of locations of turbidity generation and to allow for a review of the effectiveness of plan implementation. Through the turbidity monitoring plan development, identify opportunities for the standardisation of relevant datasets between organisations and agencies involved in water quality monitoring between NSW and ACT jurisdictions.	Immediate term
Action 9. Develop a communication strategy for ACWA plan implementation	Develop a communication strategy for Plan implementation. The communication strategy will include elements relating to the promotion of the Plan, its implementation and education initiatives, such as supporting information factsheets, for the broader catchment community to improve environmental management. Consider using existing networks for communicating the ACWA project and related initiatives to the community including landholders, land managers, Upper Murrumbidgee catchment Traditional Owners in NSW and the ACT and Aboriginal Land Councils.	Immediate term

Action 10. Develop a cross-jurisdictional monitoring and evaluation plan for the ACWA area	Develop a cross jurisdictional monitoring and evaluation plan for the Plan. The monitoring and evaluation plan should be prioritised and implemented to ensure that the success of Plan can be adequately measured. The plan should be developed by implementing agencies to reflect capacity and needs and should be designed to be responsive. This will enable the activities of the Plan to be adaptive to changes in the catchment and of other factors, such as resources and knowledge..	Immediate term