
Emerica.

PROPOSED ACTIONS

Identifying mitigation and adaptation measures for the longer-term

Selecting the right actions to be undertaken to secure the future of the CLLMM site has been based on an extensive review of the science and knowledge of the site, a broad public consultation process, and technical feasibility assessments of likely actions. This process was undertaken methodically through a series of steps.

9.1 The first step

The first step in this process was to identify and collate the many proposals and ideas for addressing the management challenges facing the site. These were drawn from a recent Senate inquiry[68] and extensive community consultation undertaken in April–June 2009 and August–September 2009.

Identifying mitigation and adaptation measures for the longer-term

- *The first step*
- *The second step*
- *The third step*
- *The fourth step*
- *The benefits of this selection process*

9.2 The second step

The second step was to assess the list of proposals using the decision framework depicted in **Figure 9**.

For an explanation of the climate scenarios used for the assessment process see Section 6.4.

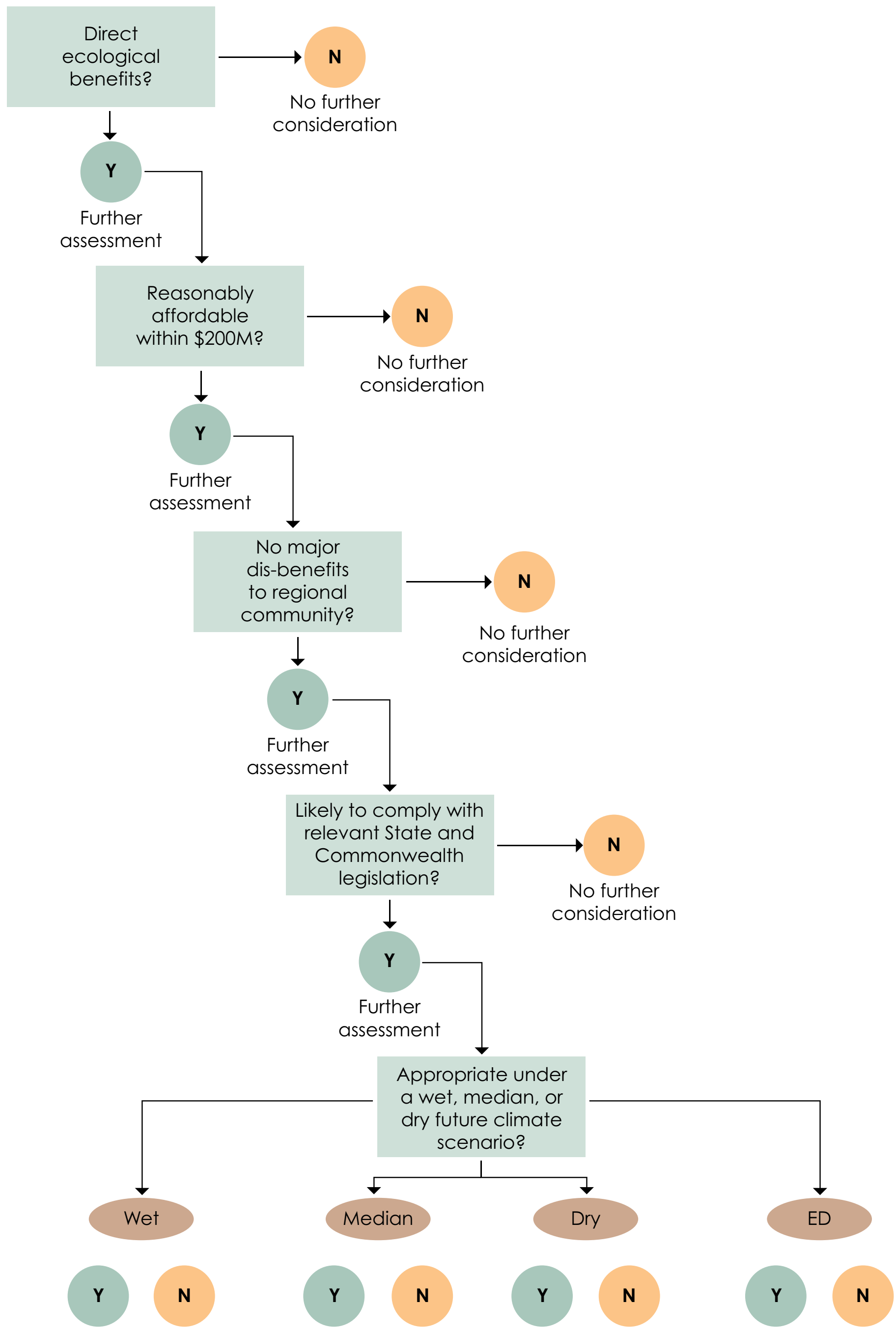


Figure 9. Decision framework for selecting proposals for detailed technical feasibility assessment.

9.3 The third step

The proposals were prioritised using three hierarchical criteria (i.e. criterion 1 was considered the most important, with criterion 3 the least important). The criteria are outlined in **Table 5**.

Criterion number	Criteria	Rationale
1	Actions which provide for ecological benefits during the most 'high risk' situation (i.e. during a dry or extreme-dry future climatic scenario).	These actions would best prevent immediate and irreparable ecological collapse.
2	Actions which provide for ecological benefits across the full range of climatic scenarios.	These actions would best build a resilient ecology, one which is able to adapt and respond to any possible future climate.
3	Actions which provide for ecological benefits under at least one climatic scenario, and no negative effects under the other climatic scenarios.	These actions are identified as 'no regrets' actions.

Table 5. Criteria used to prioritise proposals.

9.4 The fourth step

Proposals prioritised during the third step underwent detailed technical feasibility assessments. These assessments provide detailed analyses of the objective, rationale, critical assumptions and costings of implementing the action or intervention. An overview of this information is provided in Section 10.

9.5 The benefits of the selection process

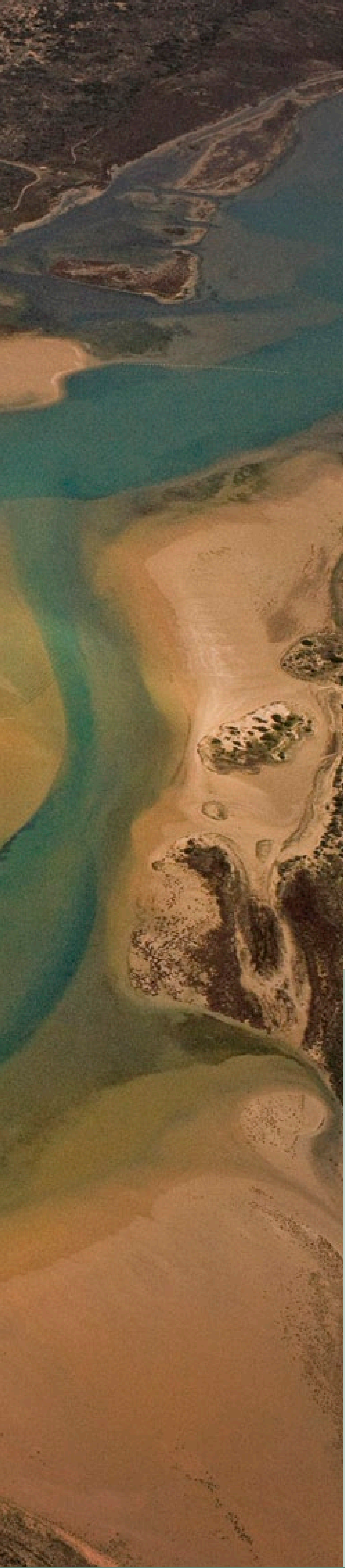
This process has identified management actions that:

- Provide ecological benefits to the site under a range of possible future climatic scenarios, in particular during dry or extremely dry periods
- Are reasonably affordable within the available budget of about $200 million
- Create positive social and economic impacts where possible
- Are technically feasible
- Provide value for money
- Are interdependent and complementary, with actions to be undertaken as a package rather than as stand-alone, and with an emphasis on the total site.

This is considered to be an efficient approach to planning because it does not rely on the development of multiple plans to cover the various climatic scenarios, and recognises the limited capacity to predict climatic conditions. The process outlined includes actions that can be adapted and responsive to prevailing climatic conditions. This is outlined in more detail in Section 11.

Other management actions considered

Some of the management actions considered were found to be unsuitable for ecological or economic reasons (i.e. they exceeded the budget of about $200 million currently available for the site). A description of the key actions in this category can be found in Appendix 4.



PROPOSED ACTIONS

Priority management actions (2010 – 2014)

While this plan is indeed a plan for the long-term, the time horizon adopted in detailed planning for the management actions at the site started with a worst-case climate scenario for the next five years.

The success of planned actions in ensuring a healthy, productive and resilient wetland system relies on improved freshwater flows into the Lower Lakes. As indicated earlier, there is no substitute for adequate volumes of freshwater to ensure the site's healthy future. Implementation of the Basin Plan, with its emphasis on environmental outcomes, from about 2012, is the most significant initiative that can contribute to a sustainable future.

Priority management actions (2010 – 2014)

- *Environmental water management actions*
- *Priority mitigation measures*
- *Priority mitigation and adaptation measures*
- *Priority adaptation measures*
- *Enabling measures*

10.1 Environmental water-management actions

The health of the CLLMM site is dependent on what is happening across the entire Murray-Darling Basin. It is the responsibility of all Basin governments and whole-of-basin solutions are required. Over-allocation throughout the entire Murray-Darling Basin has been a factor in the ecological degradation of the Lower Lakes and Coorong under historical climate. Current water-sharing agreements do not ensure that the environmental water needs of the site are met during dry periods and times of drought. Climate change may exacerbate this situation.

The key long-term management action is to secure adequate freshwater and to ensure monitoring is in place to demonstrate that the flow is sufficient to support the desired ecological character. Without adequate freshwater flows, the long-term future of the site as a Wetland of International Importance is at risk. The proposed management actions aim to maintain the ecosystem in a state from which recovery to a healthy, productive and resilient wetland is possible. Without the return of freshwater flows the success of the proposed actions will be compromised.

Options for securing adequate freshwater include establishing sustainable diversion limits throughout the Basin through the Murray-Darling Basin Plan, securing environmental entitlements through the Commonwealth Environmental Water Holder and The Living Murray initiatives, and better management of unregulated flow events for environmental outcomes.

The Basin Plan, under the *Water Act 2007,* must incorporate provisions that return the Basin to sustainable levels of extraction. The *Water Act 2007* provides for setting environmentally sustainable limits on the amount of water that can be taken in the future from Basin water resources. It also identifies key environmental water assets and functions, and environmental water requirements across the Basin, including the CLLMM site.

An environmental watering plan that sets environmental objectives for Murray-Darling Basin wetlands, including the CLLMM site, is being developed as part of the Basin Plan.

The environmental watering plan must specify:

- The overall environmental objectives for the water dependent ecosystems of the Murray-Darling Basin
- Targets by which to measure progress towards achieving the environmental objectives specified above
- An environmental management framework for planned environmental water and held environmental water
- The methods to identify environmental assets in the Murray-Darling Basin that will require environmental watering
- The principles to be applied and methods to be used to determine the priorities for applying environmental water
- The principles to be applied in environmental watering.

Under the Water for the Future program, the Australian Government is purchasing water entitlements that will become available for Murray-Darling Basin ecological assets. Water availability is currently limited but the Commonwealth's environmental water holdings are expected to increase significantly in coming years.

The Commonwealth Environmental Water Holder makes decisions on the use of the Commonwealth's environmental water holdings. A whole-of-basin approach is taken in deciding where to use water. The priority assigned to watering actions is based on an assessment against publicly available criteria and on advice from a committee of scientific experts, the Environmental Water Scientific Advisory Committee. In the summer of 2010, Lake Albert was selected by the Commonwealth Environmental Water Holder to receive 20 GL of Commonwealth water.

As an Icon Site, the CLLMM site has been identified as a priority wetland in the Murray-Darling Basin and may receive environmental water through The Living Murray initiative. The Living Murray's first step aimed to recover 500 GL of water for the Icon Sites by 2009, but the actual volume of water available through the initiative depends on water allocations. With the current suite of water recovery measures, up to 485 GL of water will be available to share between the six Icon Sites. The CLLMM site was allocated 48 GL from The Living Murray initiative in the summer of 2010 and received some water over the last 12 months for several refuge sites around the lakes.

Use of The Living Murray water is determined by New South Wales, Victorian, South Australian, Australian Capital Territory and Australian Governments (parties to The Living Murray Intergovernmental Agreement), through the Murray-Darling Basin Authority Environmental Watering Group. They develop an annual environmental watering plan to prioritise use of The Living Murray water each year and allocate through agreed decisions in response to water bids.

The South Australian River Murray Environmental Manager is the primary decision maker on environmental water within South Australia and has the responsibility for managing, allocating and delivering environmental water for the River Murray in South Australia. It utilises an environmental watering framework to develop annual environmental watering proposals subject to monitoring outcomes and water availability.

In order to avert irreversible environmental damage, South Australia aims to secure a water reserve to enable it to enhance environmental water delivery to ecological assets including the CLLMM site. Subject to inflows during 2009-10, the South Australian Government agreed to allocate at least 120 GL to a Lower Lakes environmental reserve (in addition to 50 GL purchased during 2008-09). Delivery is underway, according to an optimised delivery pattern.

South Australia will continue to actively bid for environmental water from both the Commonwealth Environmental Water Holder and The Living Murray. While the water potentially available from The Living Murray and Commonwealth Environmental Water Holder is not sufficient to provide all the CLLMM site's environmental requirements, any additional water can make an important difference to the site during this crisis period where the main focus is to prevent acidification and salinisation.

To achieve a management strategy that will help the site recover beyond the drought, the South Australian Government will work with the Australian Government and the Murray-Darling Basin Authority to develop an agreed strategy for the provision of an annual environmental water allocation to the CLLMM site.

In addition, South Australia is working with the Murray-Darling Basin Authority and other Basin states to develop the Murray-Darling Basin Plan, which will identify environmentally sustainable levels of take across the Basin. Further negotiation will also occur in relation to the Murray-Darling Basin Agreement that will deliver better environmental outcomes for the site.

Until environmental water needs and sustainable diversion limits are met, there are other actions that will feasibly and cost effectively:

- Reduce the rate of ecological degradation
- Remediate damaged areas
- Prevent immediate and permanent ecological collapse
- Maintain the ecosystem until conditions improve
- Build a resilient ecology at the site to adapt and respond to a drier climate.

These actions also take into account the complex nature of the ecology of the CLLMM site. For this reason, it is unlikely that one action alone will be sufficient, and many actions are dependent upon others. In considering what is required to address the many threats to the site and their impacts and consequences, the following actions should therefore be considered as a package rather than stand-alone actions.

The actions that follow adopt the ***mitigation***, ***adaptation*** and ***enabling*** terminology of Section 8.

Figure 10 indicates that the further lake levels decline, the more management actions need to be implemented, thereby increasing management costs. Therefore, the key long-term management action is to secure adequate freshwater and prevent further decline in lake levels.

Lake level (metres AHD)	Environmental water allocation	Diverting freshwater from the South-East to the Coorong	Manage variable lake levels	Construction/installation of fishways	Vegetation plantings (& associated activities)	Maintenance of an open Murray Mouth	Coorong salinity reduction program	Protecting Critical Environmental Assets	Translocation of *Ruppia*	Acid sulfate soil treatments	Lake Albert water level management	Restore lakefront habitat at Meningie	Temporary weir near Pomanda Island	Introduction of seawater
0.8	•	•	•	•	•									
0.75	•	•	•	•	•									
0.7	•	•	•	•	•									
0.6	•	•	•	•	•									
0.5	•	•	•	•	•									
0.4	•	•	•	•	•									
0.3	•	•	•	•	•									
0.2	•	•		•	•	•	•	•	•					
0.1	•	•		•	•	•	•	•	•					
0	•	•		•	•	•	•	•	•	•				
-0.1	•	•			•	•	•	•	•	•				
-0.2	•	•			•	•	•	•	•	•	•	•		
-0.3	•	•			•	•	•	•	•	•	•	•		
-0.4	•	•			•	•	•	•	•	•	•	•		
-0.5	•	•			•	•	•	•	•	•	•	•		
-0.6	•	•			•	•	•	•	•	•	•	•		
-0.7	•	•			•	•	•	•	•	•	•	•		
-0.8	•	•			•	•	•	•	•	•	•	•		
-0.9	•	•			•	•	•	•	•	•	•	•		
-1	•	•			•	•	•	•	•	•	•	•		
-1.1	•	•			•	•	•	•	•	•	•	•		
-1.2	•	•			•	•	•	•	•	•	•	•		
-1.3	•	•			•	•	•	•	•	•	•	•		
-1.4	•	•			•	•	•	•	•	•	•	•		
-1.5	•	•			•	•	•	•	•	•	•	•		
-1.6	•	•			•	•	•	•	•	•	•	•	•	•
-1.7	•	•			•	•	•	•	•	•	•	•	•	•
-1.8	•	•			•	•	•	•	•	•	•	•	•	•
-1.9	•	•			•	•	•	•	•	•	•	•	•	•
-2	•	•			•	•	•	•	•	•	•	•	•	•
-2.1	•	•			•	•	•	•	•	•	•	•	•	•
-2.2	•	•			•	•	•	•	•	•	•	•	•	•
-2.3	•	•			•	•	•	•	•	•	•	•	•	•
-2.4	•	•			•	•	•	•	•	•	•	•	•	•
-2.5	•	•			•	•	•	•	•	•	•	•	•	•
-2.6	•	•			•	•	•	•	•	•	•	•	•	•
-2.7	•	•			•	•	•	•	•	•	•	•	•	•
-2.8	•	•			•	•	•	•	•	•	•	•	•	•
-2.9	•	•			•	•	•	•	•	•	•	•	•	•
-3	•	•			•	•	•	•	•	•	•	•	•	•

Figure 10. As lake levels decline more management actions will be necessary, thereby increasing costs.

10.2 Priority mitigation measures

10.2.1 Maintenance of an open Murray Mouth

Maintaining an open Murray Mouth is critical for maintaining a healthy Coorong and Lower Lakes environment. Under normal flow situations, the Coorong is fed with freshwater from the River Murray and Lake Alexandrina as it drains to the Murray Mouth through the barrages. But in dry periods – with no flow over the barrages to the seaward side and the Coorong – the primary water input to the Coorong is seawater through the Murray Mouth. Since 2002, barrage flows have been inadequate for an open Murray Mouth without management intervention.

Mitigation measures to keep the Murray Mouth open will maintain the ecosystem in a state from which a return to a healthy, productive and resilient wetland future is still possible.

This action is one of three complementary measures designed to improve the health of the Coorong. The other two related actions are described in Sections 10.2.2 and 10.4.1.

The benefits of an open Murray Mouth include that it:

- Maintains tidal variation and salinity levels conducive to the ecology in the Coorong and estuary
- Allows cool, well oxygenated seawater into the Coorong to assist in the life cycle of the key species at the site
- Discharges salt and other pollutants accumulated from the entire Murray-Darling Basin to the sea.

The current dredging program has been in place at the Murray Mouth since 2002 and is currently operated and funded by the Murray-Darling Basin Authority. It is funded to continue until June 2014. To ensure that dredging remains the best value for money and effective option, the technical feasibility of this activity was examined with a number of alternative options.

Based on this assessment, the continuation of dredging at the current level of effort remains the preferred option in the current circumstances for the following reasons:

- The current program is meeting the key performance indicators
- When there are insufficient flows through the barrages to maintain an open Murray Mouth, dredging is the least expensive solution to achieving an open Murray Mouth
- The current dredging effort cost significantly less over the previous three years and investigations into how to further reduce and refine spending continue
- Dredging offers a high level of flexibility and adaptability through its contract operating regimes
- Dredging offers a less invasive and less permanent construction alternative than other options.

In a snapshot

Location of activity: Murray Mouth.

Activity addresses: the lack of connectivity between the Lower Lakes, the Coorong and the sea, elevated salinity and ecosystem degradation arising from low inflows.

For more information, see: *Managing salinity in the Coorong – maintaining an open Murray Mouth Technical Feasibility Assessment.*[5]

10.2.2 Managing salinity in the Coorong – pumping hypersaline water out of the Southern Lagoon

This action is one of three complementary actions designed to improve the health of the Coorong and is required whenever River Murray flows are not sufficient to maintain an open Murray Mouth. Salinity levels in parts of the Coorong are currently about five times higher than seawater. This action, together with the maintenance of the Murray Mouth and the diversion of South-East drainage flows to the Coorong, will reduce salinity in the South Lagoon, slow or prevent a future increase in salinity levels and maintain connectivity between the Coorong and the sea.

Currently the salt loads of the South Lagoon are so high that in the absence of other intervention, a major flood in the River Murray with barrage flows in excess of 10,000 GL would be required to restore target salinities. This action is a one-off intervention aimed at reducing salinity by exporting salt out of the system.

The benefits of this action include:

- Immediate reductions in salinity in the North and South Lagoon of the Coorong
- Promoting the ecological recovery of the South Lagoon by reducing salinities to within target levels for the tassel/chrinomid/hardyhead ecosystem
- Increased ability of seagrasses to populate (and allowing for the transplanting of native aquatic plants)
- Return of waterbirds and fish in the Coorong.

There have been concerns that this pumping could lead to a higher level of dredging to maintain an open Murray Mouth, due to increased transport of sand with the inflows of replacement seawater through the Murray Mouth. Recent modelling suggests that the pumping is likely to have a very small impact on the efficiency of the Murray Mouth dredging program. It must be noted that pumping alone does not offer a permanent solution to the current condition of the Coorong. Regular, freshwater flows over the barrages, combined with increased freshwater flows from the South-East, are the only permanent solution.

The benefits of pumping hypersaline water from the South Lagoon could be increased by dredging the sills at Parnka Point, between the Coorong's North and South Lagoons. This area acts as a natural constriction between the two lagoons at times of low water levels. By dredging the sills at this point, the width and depth of the channel can be increased to allow greater movement of water between the two lagoons, thereby:

- Improving ecological connectivity
- Improving water mixing thus reducing the salinity of the South Lagoon
- Assisting the transition to a complex estuarine ecology that supports improved ecological character.

Greater connectivity and water mixing are important to help manage the salinity gradient. To understand the benefits and risks of dredging the sills at Parnka Point, further feasibility assessment is needed and detailed flow measurements are required once pumping commences. This data can then be used to further assess the need for dredging the sills at Parnka Point and the installation of temporary regulators to maintain water levels, including heritage, technical and ecological implications.

In a snapshot

Location of activity: South Lagoon of the Coorong.

Activity addresses: the lack of connectivity between the Lower Lakes, Coorong and the sea, elevated salinity in the Coorong and substantial ecosystem degradation arising from low inflows.

For more information see: Managing salinity in the *Coorong – pumping hypersaline water out of the Southern Lagoon Technical Feasibility Assessment.*[3]

10.2.3 Limestone dosing

Limestone dosing is expected to play a critical role in the continuing management of acid sulfate soils. Limestone dosing is one of three complementary measures aimed at managing acid sulfate soils. The other actions include those described in 10.2.4 and 10.2.5.

The nature of this treatment allows it to be used for emergency management of areas of high acidity risk. Limestone can be applied quickly through the construction of limestone barriers, applying limestone slurry or aerial dosing.

Limestone dosing trials have been conducted at Currency Creek and Finniss River. Trials have generally been successful at raising low pH levels, particularly when applied using aerial dosing methods. Aerial dosing has proven effective at treating water acidity in inaccessible or remote areas. Key strengths of limestone dosing have included:

- Identification of a variety of limestone application methods
- Indications that the action provides flexibility and suits an adaptive management approach
- Proof that limestone addition is an effective tool for managing acid sulfate soils.

The continuing process for implementation is:

- Continued monitoring of pH levels throughout the site to ensure that acidity does not exceed prescribed thresholds
- Limestone application in acid sulfate soil hotspots as required
- Refining the techniques for large-scale delivery of limestone.

There are some ecological risks from the proposed action including potential negative effects on water bodies as well as aquatic plants and animals, but these need to be considered in the context of the much greater risk of not treating or trying to prevent acidification. The negative impacts of limestone application are considered less significant than the effects of untreated acidification; not treating acidity is likely to result in complete ecosystem collapse. These potential effects will be monitored and managed as part of an emergency response monitoring program that will form part of a wider monitoring program that is being developed for the entire CLLMM site. Monitoring includes ambient water quality monitoring at set locations to identify water quality trends and areas of concern, and event water quality monitoring which is used to inform the type and suitability of management actions necessary to mitigate acidification risks. Using the monitoring information, site managers are able to apply the correct amount of limestone to neutralise acid water.

In a snapshot

Location of activity: Lake Albert, Lake Alexandrina and the tributaries.

Activity addresses: acid sulfate soils arising from low inflows.

For more information see: *Treating Acid Sulfate Soils Technical Feasibility Assessment.*[69]

Limestone barriers can be constructed to intercept acidic waters (Currency Creek, 2009).

10.2.4 Installation of sub-surface barriers

Sub-surface barriers are designed to manage areas of high acid sulfate soils risk by increasing soil moisture. This limits the oxidation of pyritic soils and prevents acidity moving to the remaining water body. Several locations at the CLLMM site have been identified as possibly benefiting from this action. Trials are underway to ascertain the feasibility of this approach.

Construction of sub-surface barriers typically includes the excavation of trenches that are then filled with a control material that helps retain sub-surface groundwater. Trials are determining the most effective method of barrier construction, but processes may include:

- Sub-surface bentonite slurry wall
- Sub-surface trench backfilled with dry bentonite
- Surface and sub-surface impermeable barriers.

Sub-surface barriers have been considered for specific locations in Lake Albert and Lake Alexandrina. If successful, the barrier approach could be designed and installed in other areas of the region.

The trials of this approach are intended to determine whether the barriers will increase the retention of sub-surface moisture and saturation of soils with groundwater, thus reducing the rate of oxidation of pyritic soils and the amount of acidity formed.

In a snapshot

Location of activity: Lake Albert, Lake Alexandrina and the tributaries.

Activity addresses: acid sulfate soils arising from low inflows.

For more information see: *Treating Acid Sulfate Soils Technical Feasibility Assessment.*[69]

10.2.5 Lake Albert water level management

With Lake Albert water levels at critically low levels, this management action proposes the pumping of up to 90 GL of water from Lake Alexandrina to Lake Albert between January and June 2010. Initially the project proposed to pump 35 GL of water from Lake Alexandrina to Lake Albert, however the New South Wales floods in early 2010 increased the volume pumped to 56 GL. Pumping is not expected to impact on water levels in Lake Alexandrina due to the large volume of the lake. This project includes the stabilisation of the Narrung bund, the installation of pumps and pipes and the commencement and monitoring of pumping activity to ensure requirements are fulfilled.

The future management of the Narrung Narrows will be assessed in conjunction with the Ngarrindjeri, the community and all three levels of government, when there is a greater understanding of future Lake Albert freshwater flows and water levels. This assessment will consider the water flow between the lakes and fish passageway.

The lake level will be maintained to ensure that the high-risk acid sulfate soils are kept inundated.

Exposed lakebed will be managed by alternative methods such as limestone dosing (Section 10.2.3) and vegetation plantings (Section 10.3.1) to minimise the potential for large-scale acidification of the lake.

The pumping of water into Lake Albert, with no significant change to the Narrung bund, is seen as the most appropriate course of action for the immediate-term, due to:

- The perceived urgency for the summer of 2009-2010, demonstrated by water level modelling
- The very high risk of large-scale acidification in Lake Albert if water levels drop too low.

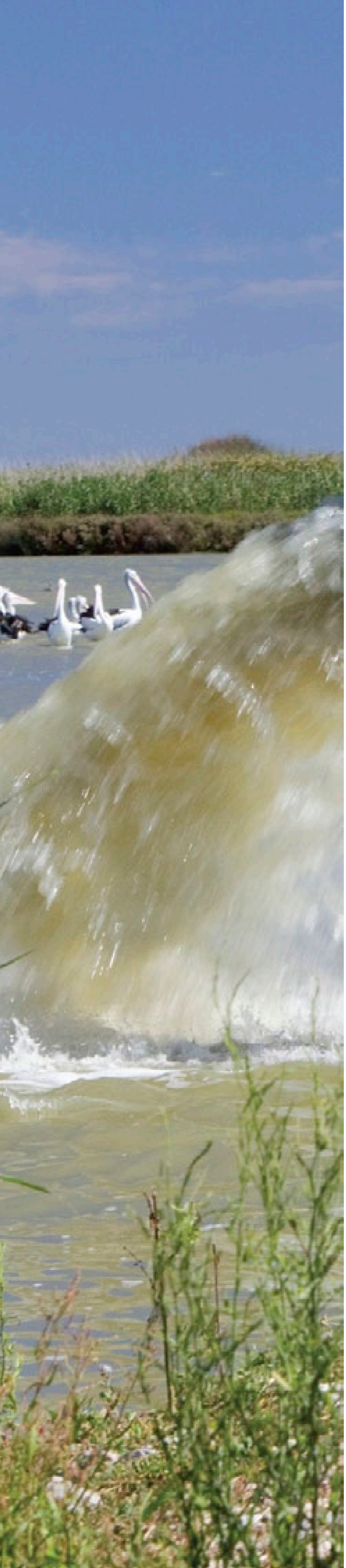
Alternative options (e.g. different quantities of water to be pumped) will be considered based on the conditions that may arise in the future.

In a snapshot

Location of activity: At the Narrung Narrows between Lake Albert and Lake Alexandrina (for the benefit of Lake Albert).

Activity addresses: acid sulfate soils, elevated salinity and ecosystem degradation arising from low inflows.

For more information see: *Managing Water Levels in Lake Albert to Prevent Acidification Technical Feasibility Assessment.*[70]



10.3 Priority mitigation and adaptation measures

10.3.1 Vegetation plantings

Vast areas of previously inundated sediment at the CLLMM site are becoming exposed due to declining water levels. These exposed sediments are creating the following impacts:

- Vulnerability to wind erosion
- Creation of health and environmental issues from dust
- Prevention of the regeneration of flora
- Loss of habitat
- An environment which is unappealing aesthetically to the community and tourists
- Releasing acidity into the ecosystem.

This action proposes the large-scale vegetation of exposed sediments at the following locations:

- Currency Creek, Finniss River and Goolwa Channel
- Lake Albert
- Lake Alexandrina
- Barrages and around islands.

Specific site selection will be based on environmental condition, current land use, site access and fencing requirements. The approach will be adaptive and involve a combination of activities such as direct seeding, machine seeding and tube stock planting. Species selection will be determined by factors such as moisture availability, sun exposure, soil type, salinity and acidity. A combination of native and non-native plant species will be utilised with the objective of stabilising the soil and then contributing to the ecological value of each site selected.

The action is technically feasible. Large-scale revegetation has been used successfully and widely to rehabilitate many types of land, including degraded farming land, saline sites and extractive industry sites. Wherever possible the action will leverage existing farming and revegetation machinery and operations. The action will also involve numerous community nurseries to ensure large-scale cost-effective production of the selected species. The Australian Government will initially fund the vegetation works as part of a $10 million Bioremediation and Revegetation Project.

The benefits of vegetation plantings include:

- Binding surface soils together to reduce erosion
- Encouraging the growth of soil-based bacteria that can inhibit and reverse the mobilisation of acidity in the soils, and keep the soils in an inert state
- Providing habitat for other native flora and fauna
- The first step in creating resilient wetlands.

The necessary fencing, weed and vermin control measures undertaken as part of this activity will increase the likelihood of remediation success. **Table 6** shows proposed fencing works in 2010.

Location	Coverage
Currency Creek, Finniss River and Goolwa Channel	40 km
Barrages and islands	30 km
Lake Albert	60 km
Lake Alexandrina	135 km

Table 6. Proposed fencing works 2010.

In a snapshot

Location of activity: Lake Albert, Lake Alexandrina, Goolwa Channel and around Hindmarsh Island.

Activity addresses: ecosystem degradation and acid sulfate soils arising from low inflows.

For more information see: *Vegetation Program Technical Feasibility Assessment.*[71]

10.3.2 Meningie lakefront habitat restoration

Meningie is the gateway township to the Coorong National Park and is a popular recreational bird-watching, boating and tourist destination. Low water levels in Lake Albert have significantly reduced the aesthetics and ecological values of the foreshore. Based on examples of successful projects in other areas, the development of lakefront habitat at Meningie is proposed to help to restore a more appealing environment.

Detailed feasibility assessments of the Meningie foreshore and trials of local vegetation indicate that the area is suitable for this management action, which aims to generate habitats for local and migratory wildlife and native plant species. This measure is currently in a conceptual design phase.

The action proposes the restoration of habitat and breeding areas through selective planting, interpretive paths and signage plus viewing platforms.

The Meningie wetland proposal aims to achieve the following outcomes:

- Prevent further exposure of acid sulfate soils in the area adjacent to the Meningie township
- Rehabilitate the areas exposed currently and enable the site to respond when lake levels increase
- Create ecological resilience at the site and provide habitat for fauna and flora
- Increase knowledge and understanding in the community regarding wetlands.

In a snapshot

Location of activity: Lake Albert, adjacent to Meningie.

Activity addresses: ecosystem degradation and acid sulfate soils arising from low inflows, amenity issues.

For more information see: *Treating Acid Sulfate Soils Technical Feasibility Assessment.*[69]

Southern purple spotted gudgeon.

10.3.3 Protecting Critical Environmental Assets Program

This management action aims to protect critical environmental assets through the active management of threatened species populations, unique to the CLLMM region. In the first instance, it involves captive breeding and/or translocation of fish between captivity and the wild, depending upon the site conditions within the CLLMM region. Other threatened species will be considered as required.

On-ground management actions include:

- Environmental watering
- Maintenance of refuge habitats
- The rescue of endangered and threatened species
- The establishment of captive breeding programs
- The identification of surrogate refuge sites as a medium-term option for the protection of threatened species.

The project will be adopted across a range of high-priority sites as identified by a specifically designed matrix tool.

As well as protecting the various species from the effects of acidification, heavy metals in the soils, decreased levels of dissolved oxygen and high salinity, this action will ensure compliance with the national implementation of recovery plans.

Fish species initially included are:

- Yarra pygmy perch
- Murray hardyhead
- Southern pygmy perch
- River blackfish
- Southern purple-spotted gudgeon.

In a snapshot

Location of activity: Coorong, Lake Alexandrina, Lake Albert and tributaries.

Activity addresses: ecosystem degradation arising from low water levels, acid sulfate soils, and artificial structures.

For more information see: *Protecting Critical Environmental Assets Program – Critical Fish Habitat and Refuge Technical Feasibility Assessment.*[72]

10.3.4 Translocation of large-fruit tassel *(Ruppia megacarpa)* and tuberous tassel *(Ruppia tuberosa)*

Transplanting of tassel is planned when Coorong salinity levels improve. As a keystone water plant, tassel provides habitat and food for many biological components of the ecosystem.

Increased salinity and altered water levels have reduced numbers of this plant at the site. Transplanting tassel successfully is heavily reliant on appropriate hydrology and salinity levels. Combined with separate management actions 10.2.1 and 10.4.1, successful transplanting of tassel will help:

- Support the re-establishment of vegetation communities
- Increase habitat coverage and complexity for macroinvertebrates and migratory birds.

In a snapshot

Location of activity: in the North and South Lagoon of the Coorong.

Activity addresses: the lack of connectivity between the Lower Lakes, Coorong and the sea, elevated salinity and ecosystem degradation arising from low inflows.

For more information see: *Ruppia Translocation in the Coorong Technical Feasibility Assessment.*[73]

10.4 Priority adaptation measures

10.4.1 Diverting freshwater from the South-East to the Coorong

Historically, flows from the South-East have played an important role in the maintenance of ecologically appropriate salinities within the Coorong's South Lagoon. These flows currently discharge directly into the ocean via artificial drains, to prevent the inundation of developed land in the lower and upper South-East.

The action proposes using a combination of natural watercourses, an engineered floodway system (including regulators at diversion points along the flow paths) and existing drains, to divert water from the lower South-East towards the Coorong's South Lagoon.

This action will reduce rising salinity levels in the Coorong's South Lagoon and is one of three complementary measures to manage Coorong salinity levels. The related actions are management actions 10.2.1 and 10.2.2. The benefits of this measure are:

- Reduced salinity by the supply of a median of 32 GL per year of freshwater from the South-East to the Coorong
- Enhanced ecosystem resilience
- Greater flexibility for Coorong management by supplying an additional water source to the South Lagoon
- Potential to restore, improve and provide long-term support to a considerable area of wetland habitat, for example, to ensure salinities remain within the target range for the long-term health of the tassel/chironomid/hardyhead system
- Restoring flows to the wetlands of the upper south-east of South Australia.

Feasibility studies funded by the Murray-Darling Basin Authority in 2007/08 and 2008/09 have shown the action to be technically feasible. Further detailed studies are underway, including feasibility studies funded by Murray Futures, to determine the viability of the project, but further investigations are required before implementation.

The action is complementary to the Restoring Flows to the Wetlands of the Upper South-East of South Australia program, funded by the Australian Government's Water for the Future program and the Upper South-East Flood Management and Dryland Salinity Program.

The action is one of few options that delivers additional freshwater to the site and surrounding wetland environments. It helps address the decline in ecological health of the Coorong by reducing salinity, but is only part of the approach required to restore the Coorong ecosystem and an appropriate level of end-of-system flows.

In a snapshot

Location of activity: South Lagoon of the Coorong.

Activity addresses: the lack of connectivity between the Coorong and South-East wetland system, elevated salinity and ecosystem degradation arising from low inflows and the artificial disconnection of the Coorong from the South-East wetlands.

For more information see: *Managing Salinity in the Coorong-restoring freshwater flows from the South-East Technical Feasibility Assessment.*[3]

10.4.2 Construction/installation of fishways

Fishways help to re-establish connectivity between the individual parts of the site by allowing greater water mixing and movement of biota. When connectivity of once-linked waterways is lost due to low water levels and no or limited water mixing, diadromous fish and other biota are unable to travel between the different habitats they rely on throughout their lifecycles.

Construction of fishways is proposed for up to eight sites within the CLLMM site. The action will assist in preparing the site for recovery and will facilitate estuarine ecological processes. While the role of fishways may be restricted during low water levels, this is the best time for their installation as they are cheaper and easier to construct.

This management action has several objectives:

- To protect and retain native fish species within their natural range at the barrages of Tauwitchere, Goolwa and Mundoo
- To monitor and undertake research on the effectiveness of the structures in ensuring the passage of native fish species
- To ensure that the fishways are properly maintained and operated to maintain their effectiveness.

Different fishway options are available and selection will take into account the specific requirements of each site. The proposed fishway program is building on the existing Hume to the Sea native fish program, implemented by the former Murray-Darling Basin Commission. Proposed works include constructing rock ramps, new fish locks, fish culverts, vertical slots and the removal of structures that obstruct the passage of fish.

In a snapshot

Location of activity: at up to eight sites, principally through the barrages.

Activity addresses: the lack of connectivity between various components of the system and ecosystem degradation arising from low inflows.

For more information see: *Restoring Fish Passage Technical Feasibility Assessment.*[74]

10.4.3 Manage variable lake levels

Before the current situation within the Lower Lakes, the primary objective of water level management had been to facilitate water extraction from the Lower Lakes, rather than achieve specific ecological objectives.

Now that human use of water can be provided in most instances from the new pipeline projects funded by the Australian Government through the Murray Futures program, it is possible to consider operating the Lower Lakes at more variable levels for enhanced environmental outcomes.

The benefits of managing the lakes at variable levels include:

- Increased and greater diversity of aquatic vegetation, fish, invertebrates, frogs and birds in the Lower Lakes
- Wetlands fringing the Lower Lakes that can cope with greater variability in future water availability
- Reduced system water requirements through reduced evaporative losses.

However, Lower Lakes water level management must be considered within the wider context of water level management downstream of Lock 1. As the River Murray and Lower Lakes from Lock 1 at Blanchetown downstream to the barrages comprise one weir pool, it follows that when lake levels are lowered, levels in the River Murray channel recede. Experience has shown that when lake levels are too low, upstream effects may include the partial drying of wetlands, and, at very low levels, the stranding (or partial stranding) of irrigation infrastructure.

Work is underway to identify the site's ecosystem water requirements. This work builds on the operational principles and guidelines developed for the Living Murray Icon Site Program and will ascertain the best minimum and maximum water level management 'envelopes' for the lakes from an environmental perspective.

These issues are yet to be fully explored, with implementation only possible when lake and water flows return to suitable levels.

In a snapshot

Location of activity: Lakes Alexandrina and Albert.

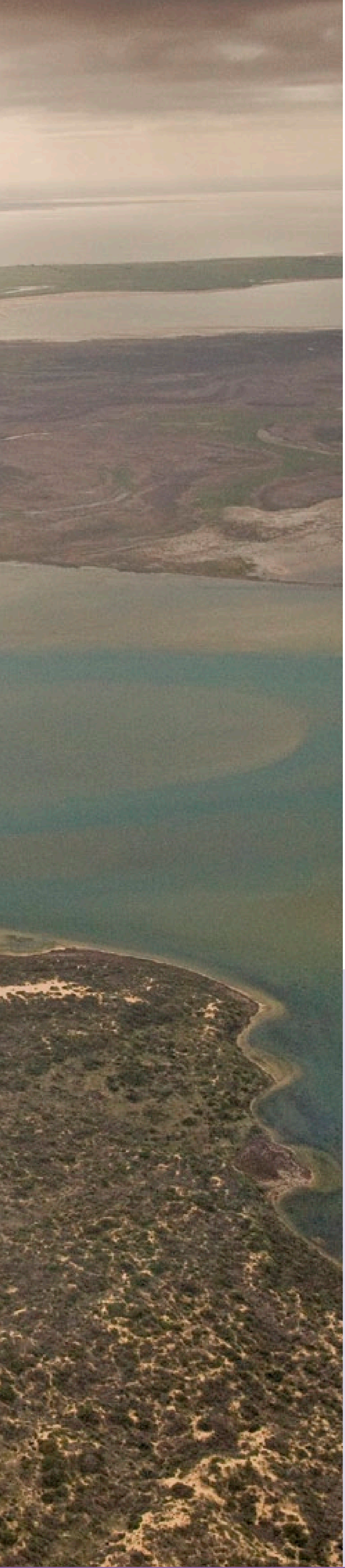
Activity addresses: ecosystem degradation resulting from uniform water levels.

For more information see: *Managing Water Levels in the Lakes to Improve Ecological Health Technical Feasibility Assessment.*[4]

10.5 Enabling measures

Enabling actions are those taken to support mitigation and adaptation actions. Without these enabling actions, other measures would not be possible. They include:

- Implementing an adaptive management regime (Section 11)
- Ensuring appropriate governance arrangements involving the community, and continuing to develop partnerships with the Ngarrindjeri (Section 12).



Managing the site as one complex, interconnected ecosystem

Effective management of the CLLMM site begins with an understanding that the ecological components of the site are interconnected. None can be managed in isolation. Therefore, while any particular management action may appear to target only one area of the site, the action must take into account its impact on the other components, so that the overall result is a healthy, productive and resilient wetland system.

To assist in our understanding of the interconnectedness of the components of this site, and the potential implications of the management actions, process models or diagrams[75] have been developed for each of the water bodies. These diagrams depict how a particular management action may affect an ecosystem (see Appendix 5 for an example). Such models form the basis for the appropriate application of adaptive management.

Managing the site as one complex, interconnected ecosystem

- *How to deal with uncertainty*
- *Reviewing the appropriateness of our management response*
- *Adjusting our management response to changing climatic conditions*
- *Applying adaptive management in the CLLMM region*
- *What can be expected in the next five years?*

11.1 How to deal with uncertainty

The size and complexity of the site and the natural seasonal fluctuations that it faces mean there is not a complete information base (e.g. one covering changes in river regulation, changes in climate, and responses by the ecosystem) from which to choose appropriate management actions.

Any enduring management response for the site must contain a mechanism for dealing with a high degree of uncertainty about the future and ways to improve the understanding of the effect of any management decisions, and have the flexibility for change in response to new information.

Adaptive management provides such a rigorous mechanism – using the best available knowledge while at the same time learning by doing.[76] Learning is then fully incorporated into decision-making and management decisions are improved over time.

Adaptive management is not a trial-and-error approach. Instead, monitoring is designed to measure the actual outcome of a particular management response and compare it with the expected outcome. A strong connection between scientific investigation and management decision-making is an essential component of adaptive management. Management-focused research improves the understanding of how the system operates and changes over time.

There are six steps in the adaptive management process:

1. Plan management actions
2. Implement the plan
3. Monitor the activities and performance of the environment (or the research)
4. Analyse the outcomes against the expectations
5. Adapt the plan of action (or research)
6. Learn from the activities.

Figure 11 shows how the steps use knowledge gained during implementation to improve site management and focus research on the priority knowledge gaps.

By applying the adaptive management framework presented in **Figure 11**, positive ecological, cultural, social and economic outcomes can be achieved – despite the complexity of the CLLMM site and anticipated challenges.

For the CLLMM site, learning will occur through monitoring the individual management actions under a variety of environmental conditions, testing the expected response of ecosystems to specific actions, and targeting research to fill key knowledge gaps.

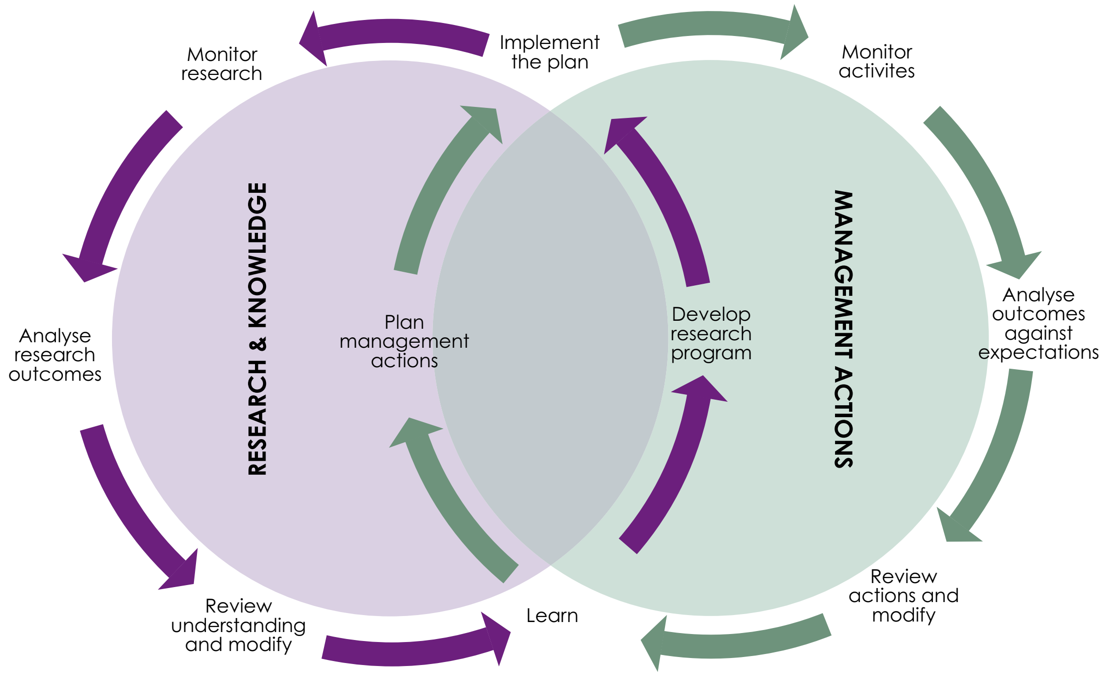


Figure 11. The six steps involved in the adaptive management process and how they are integrated with the research and knowledge, and management sectors.

11.2 Reviewing the appropriateness of our management response

Two formal cycles of review have been defined for the CLLMM site – an annual review of short-term plans and actions, and a three-yearly strategic review that includes assessing the overall process.

The annual review will focus on the more immediate plans and actions and will evaluate the management of the previous year to:

- Determine whether planned actions have been completed
- Evaluate the success of actions
- Determine if actions should continue, be discontinued, or modified
- Assess new circumstances that may require management, such as continuing dry conditions or changes in water inflows.

The annual review will also incorporate planning for the following year, based on predictions of River Murray inflows.

The three-yearly strategic review will make a broader assessment of the overall success of the management of the CLLMM site.

This review provides the opportunity to re-assess:

- Management goals for the site
- Strategies for achieving these goals
- Monitoring and research priorities within the region.

Within this cycle, the adaptive management arrangements themselves will be reviewed to ensure that the principle of improved management over time is being achieved.

11.3 Adjusting the management response to changing climatic conditions

The priority management actions for 2010-2014 were chosen (Sections 9 and 10) because of the existing condition of the site and the likelihood of a poor climate outlook.

Regardless of conditions that are encountered in any one season, the best available management response, drawing from this list of actions, can be constructed. If, for example, conditions were to improve from the worst-case dry scenario, the mix of management measures will be reconsidered and revised to be more appropriate for wetter conditions.

Each measure will have a carefully defined target including the proposed start and end triggers directly associated with ecological site conditions.

How long the current dry conditions will endure, or when freshwater inflows will resume at more normal levels, is unknown. Because of this uncertainty, it is impossible to accurately predict how long many of the mitigation actions will be required. For example, if river inflows improve at some future time, it will be possible to scale back some of the acid sulfate soil treatment measures (as the acidification risk will have reduced). Equally, with improved water levels, it will be possible to scale back some of the vegetation plantings as there will be fewer exposed lakebeds prone to wind erosion. Over time, with improved freshwater inflows, a greater emphasis can be placed on those actions that build a resilient ecology at the site – for example, the management of lake levels at variable levels, and the redirection of freshwater from the South-East.

In this way, the mix of measures undertaken at the site will change, over time, depending on changing ecological conditions. If freshwater flows recommence, mitigation measures will gradually cease as the condition of the site improves, and adaptation measures will become the focus. If the current dry conditions continue, current mitigation measures will continue.

By defining when each measure should be undertaken and when it should cease, including any measures upon which it depends, management of the site will occur in a manner that is appropriate, whether the future is wet, dry or extremely dry. Adaptive management provides a framework to maximise the ecological condition of the CLLMM region whatever the future holds.

11.4 Applying adaptive management in the CLLMM region

As the adaptive management framework is progressively implemented across the CLLMM region, decisions regarding the most appropriate management measures will be made, using the framework outlined. Three specific elements of the framework are also under development:

- A monitoring and evaluation plan linking condition monitoring and management.
- A research plan outlining the key areas for targeted research. Documentation standards will be based on the International Organization for Standardization framework for environmental management (ISO: 14000) to enable standardisation of recording information.
- The structure of the CLLMM Project will be based around the key 'plan-do-monitor' aspects of adaptive management. A Technical Advisory Group will be established as part of site governance (Section 12) to ensure that decisions are based on the best available technical and scientific advice.

An example of adaptive management in the CLLMM region, relating to salinity in the South Lagoon of the Coorong, is detailed in Appendix 6.

11.5 What can be expected in the next five years?

As indicated in Section 11.3 the exact mix of management actions used at any one time will depend on the precise conditions at the time and the best understanding of the outcomes of those actions.

The following is an outline of how the future *might* unfold at the site, assuming a continuation of the current dry conditions as the starting point. (Refer also to Appendix 7 for an outline of one such implementation schedule and Appendix 8 for an indication of how the mix of management actions will vary depending on the climate.)

11.5.1 Summer 2009-10

In the past three years we have seen unprecedented lows in water inflow to the Lower Lakes. Lake Alexandrina has dropped steadily each summer reaching approximately -1.0 metre AHD in 2009 and again in 2010. In mid 2009, lake levels of -1.0 metre AHD were predicted to be a worst case scenario. Winter 2009 had *better than worst case* direct rainfall, and *better than worst case* inflows from the River Murray were received over the summer months due to the provision of additional water.

The first priority for the extra water was to prevent high risk soils from drying out and acidifying. The greatest risk was identified in Lake Albert with its central core of clayey soils. The pumping of extra water into Lake Albert commenced in early 2010.

At least 150-200 km² of soils were exposed to air over summer. Most of these generated acidity in the soils, but had a limited impact only on the alkalinity levels in the lake bodies. There was wind-blown sand from these exposed areas, however wide-scale plantings on exposed soil conducted in 2009 assisted in stabilising these soils throughout the summer.

11.5.2 Autumn 2010

In autumn of 2010, widespread seeding of those soils exposed over summer is planned. This may be an area of 150-200 km², depending on the evaporation losses from the Lower Lakes through summer. The seeding will be timed to make the most of the autumn rains and produce a cover crop over winter/spring 2010 – thus holding the soil and feeding the carbon cycle, encouraging bioremediation. Where seeding occurred in the 2009 trials, a second layer of crop will be planted, building upon the previous year's achievements.

The autumn and winter rains will pose challenges as rewetting mobilises acidity in the soils exposed over summer. Acid hotspots will be created in some areas. If there are substantial flows or downpours, the two lakes will experience additional acid loads. Their natural alkalinity should deal with the majority of the acidity in 2010; however, some limestone treatment may be required as a supplement. The construction of the Goolwa temporary flow regulators in 2009 will have prevented any substantial acid formation and mobilisation in that area through the summer, as the minimum water level in this pool is planned to have been held at no lower than 0.0 metres AHD.

Fish kills are predicted in Lake Albert as the lake's salinity rises due to evaporation. Other contributing factors to a possible fish kill include low dissolved oxygen levels, blue-green algae and poor water quality.

11.5.3 Winter 2010 onwards

The extent of inflows from the Murray-Darling Basin will determine how conditions develop in the latter part of 2010 and during 2011. If inflows are sufficient to hold the lakes at levels no lower than those for summer 2009-2010 then the situation should not deteriorate. Any improvements in lake water level should ideally be gradual, to enable rewetting of exposed soils to occur in a managed way and for the resultant mobilised acidity to be dealt with by the lakes' alkalinity, or added limestone or bioremediation processes.

However, if low inflows lead to further lowering in lake levels, the scientific investigations currently underway will be particularly relevant. These will provide valuable information on whether the use of seawater is possible as a last resort. It is known that seawater can provide additional alkalinity and saturation of soils. However, depending on the extent of acidification that has already occurred in the soils, the addition of seawater may generate additional acidity and metal releases. The additional salinity introduced by seawater will also pose problems for the life forms in the lake and for the nature of its eventual recovery.

In the event no other suitable option can be identified there may be no choice but to dry the lakes and continue with a process of bioremediation on the exposed soils. There will be practical limits to the extent to which limestone can be used as a treatment option. If these circumstances arise, the process of rewetting the lakes will be extremely challenging – attempting to refill them slowly so that acid releases can be managed. Recovery will take many years.

If inflows are not sufficient for improvement in the water levels, but not so low that the lakes fall below the level at which they acidify, the approach will be to try and 'buy another winter' each year with freshwater, and supplement with bioremediation, limestone and other complementary actions as appropriate, depending on local rainfall events and inflows upstream on a year-by-year basis.

Ideally, however, the improved inflows of 2009 will continue in 2010 and gradually restore the site. As this occurs, the various management actions can take effect. Flows through the barrages will start to flush the salt load in the Lower Lakes and refresh the Coorong. Fish can be restored to the site from their ex-situ storages. The pumping of hypersaline water out of the South Lagoon to the sea will have assisted the translocation of tassel to the South Lagoon, and fish and bird life will return to the Coorong.

With improved inflows, as the Basin Plan begins to have effect, environmental flows at levels sufficient to maintain the environmental values of the site should return.


PUBLIC JETTY

PROPOSED ACTIONS

Governance

12.1 Purpose of governance arrangements

As described earlier in this plan, the CLLMM site has significance for many people and organisations: its Traditional Owners – the Ngarrindjeri; Australian, state and local governments; business and community members.

The South Australian Government has consulted widely in the development of the Long-Term Plan. Governance arrangements for implementation will build on the decision-making processes, relationships and momentum established during development.

The project governance arrangements for the CLLMM site will ensure:

- Accountability for project delivery rests with a single organisation and is clear and transparent
- Strong, relevant and timely communication across the project between the Australian Government (primary funder), the South Australian Government, the Ngarrindjeri, key stakeholders and the community
- Alignment with Australian and South Australian Government objectives and priorities
- Sound and responsible financial management over the life of the project
- Identification and mitigation of risks throughout the life of the project
- Sound scientific and technical information is gathered and used.

Governance

- *Purpose of governance arrangements*
- *Context for governance arrangements*

12.2 Context for governance arrangements

The CLLMM Project forms part of the overall Murray Futures program, for which the Minister is signatory to the Funding Deed. The Murray Futures program includes a number of projects – amounting to $610 million in all – and is overseen by a Murray Futures South Australian Priority Projects Steering Committee comprising State and Australian Government officers. In order to meet the requirements of the Commonwealth-State funding deed, the delivery of the Murray Futures program in South Australia will be managed by the Commissioner for Water Security (and Executive Director Murray Futures, in the Office for Water Security).

The nature of the project means there are many links between agencies in all levels of government and their programs, in addition to key community bodies, for advice, endorsement of proposed decisions and for decision-making. As examples:

- The CLLMM site is part of the River Murray and is therefore linked to the policies, programs and operations of the Murray-Darling Basin Ministerial Council and the Murray-Darling Basin Authority. This includes programs such as The Living Murray and Icon Site management which are delivered through the SA Murray-Darling Basin Natural Resource Management (NRM) Board.
- The need for adequate supplies of fresh water to sustain it means that the CLLMM site is a key topic for South Australian water policy (through South Australia's Water Security Council, Lower Murray Action Group, and the SA Murray-Darling Basin NRM Board) and broader River Murray policy (through the High-Level Steering Committee of the Murray-Darling Basin Authority).
- Lowered water levels in recent years mean that the current reduced state of the CLLMM site is of profound importance to the Ngarrindjeri Traditional Owners with whom a Kungun Ngarrindjeri Yunnan Agreement has been developed to progress remediation projects.
- Its significance as a Ramsar wetland – a Wetland of International Importance and the subject of three agreements relating to migratory birds – means that it is of considerable interest to the Department of the Environment, Water, Heritage and the Arts (DEWHA) and the South Australian Ramsar Task Force – involving community and government oversight of the Coorong and Lakes Alexandrina and Albert Ramsar Management Plan.
- The large scale of the project involves policy and project decisions at many levels – Cabinet, Minister, Chief Executive, Director and project.

There are numerous other bodies (often community-based) with interests in the way in which the site is managed, particularly for consultation purposes. These include the Lower Murray Drought Reference Group, and two groups hosted by the Murray-Darling Basin NRM Board, an Icon Site Community Reference Committee and a Scientific Advisory Committee.

The Australian Government's interests for CLLMM projects will be managed through the Intergovernmenal Project Board. The Murray Futures Steering Committee has general oversight of all Murray Futures programs.

Arrangements are in place for consultation with Ngarrindjeri through the Kungun Ngarrindjeri Yunnan Agreement. A Community Advisory Board will provide community views on the implementation of management actions and their environmental, economic and social impact. In addition, community reference groups will be established when required, and vary in size, membership and character depending on the nature and timeframes associated with their issues or projects.

The key elements of the proposed governance structure are depicted in **Figure 12**. The governance arrangements can be classified into four components that encompass different roles and responsibilities as follows:

1. Strategic governance (SA Minister)
2. Decision-makers (Murray Futures, CLLMM Intergovernmental Project Board)
3. Options analysis and recommendations (CLLMM Intergovernmental Working Group, CLLMM Project Steering Committee)
4. Advisors and collaborators (Kungun Ngarrindjeri Yunnan Agreement, Water Security Council and Technical Group, Community Advisory Board).

Governance of the project and adaptive management will be strongly integrated. Governance will include strong links between the Australian and SA Governments to: monitor the overall progress of management actions that have been agreed for funding; monitor compliance with respective obligations between the Australian Government and the state; provide a forum for independent review of issues as they arise; and consider matters referred to it by proponents of management actions. Strong links will also be fostered between governance and the CLLMM Project teams who will undertake day-to-day management of the project, provide research, monitoring and reporting against management objectives, as well as undertake policy development and planning.

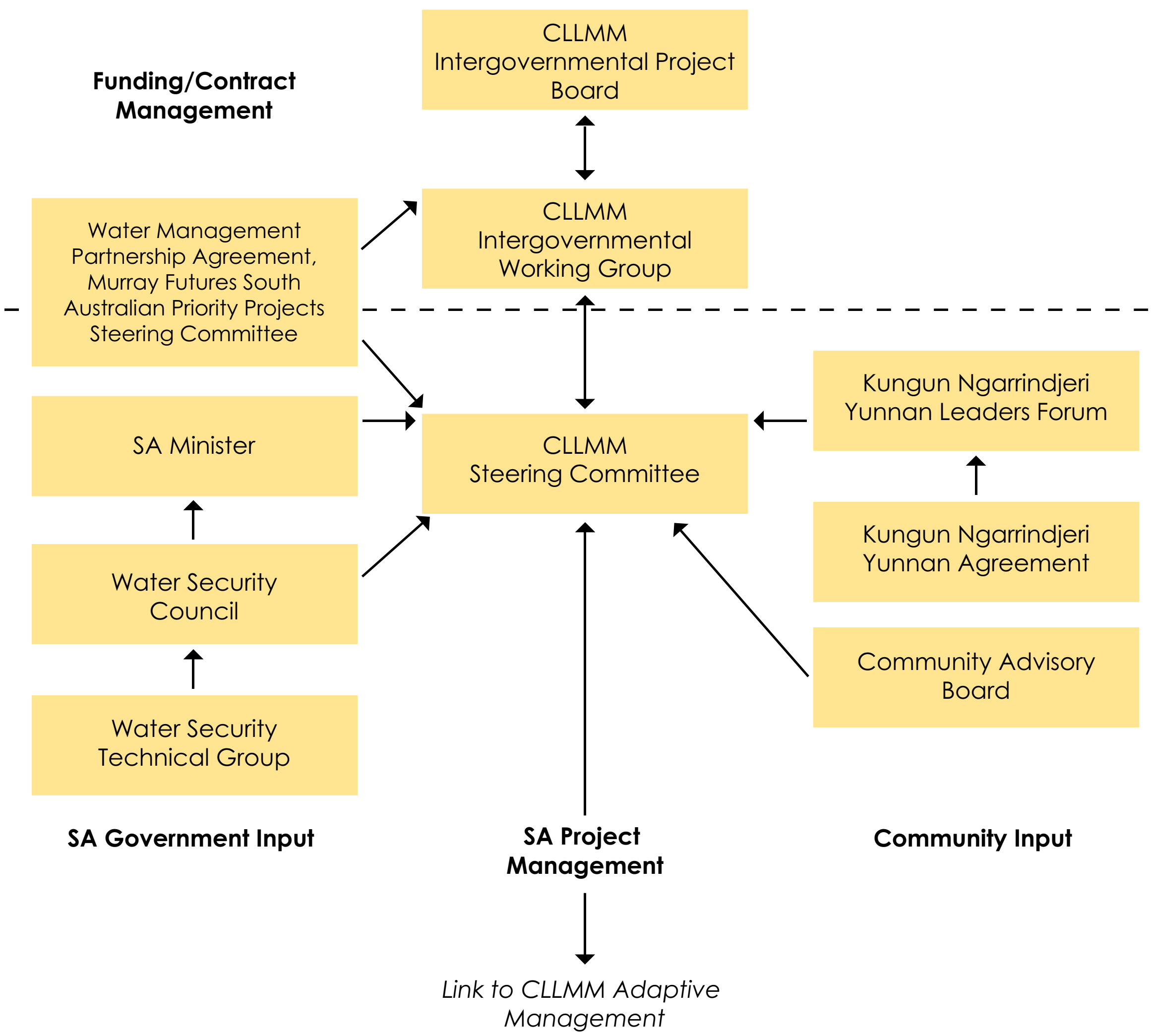


Figure 12. Proposed governance arrangements.