SOUTH AUSTRALIAN MURRAY-DARLING BASIN
NATURAL RESOURCES MANAGEMENT BOARD

Integrated Regional Research Plan

Final Report – October 2006

Australian Government

Government of South Australia
South Australian Murray-Darling Basin Natural Resources Management Board

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For the

South Australian Murray Darling Basin Natural Resource Management Board

Cover photo supplied by Paul Dalby

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Disclaimer

Determining priorities for investment in research is not an exact science. The approach that has been used as the basis of this report was to consult with scientific experts, technical staff from the SAMDB NRM Board and with state agency staff with a long involvement in working on technical programs in the regional areas of South Australia. Every effort was made to get people to the workshop with the appropriate experience and expertise. Some individuals were unable to attend for various reasons, and where the authors felt that they had expertise that was not represented at the workshops, people were interviewed separately. There was not time to follow up with everyone who may have an interest in research in the region however.

The information from the workshops and interviews has been used, along with the experience and knowledge of the authors, to prepare this report. This report should be used as input into a discussion within the SAMDB NRM Board about their priorities for research which, for a range of reasons, may be different from those identified in this report. The report should not be used by the Client or any other person or persons other than for its intended purpose, without further advice from the authors.

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Table of Abbreviations

CMA	Catchment Management Authority
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEH	Department for Environment and Heritage (South Australia)
DPI	Department of Primary Industry (Victoria)
DWLBC	Department of Water, Land and Biodiversity Conservation (in South Australia)
EPA	Environment Protection Authority (South Australia)
I&PC	Investment and Program Committee of the Board (I&PC)
IP	Intellectual Property
INRM	Integrated Natural Resource Management
LWA	Land and Water Australia
MECG	National NRM Monitoring and Evaluation Coordination Group
NAP	National Action Plan
NRM	Natural Resources Management
PIRSA	Primary Industries and Resources South Australia
R&D	Research and Development
SARDI	South Australian Research and Development Institute
SAMDB	South Australian Murray Darling Basin Region
SECWMB	South East Catchment and Water Management Board
STI10	SA State Governments Science, Technology and Innovation Strategic Plan

1. Executive Summary

This Research Plan identifies areas of interest and priority in research for the South Australian Murray Darling Basin (SAMDB) Natural Resources Management (NRM) Board. The Plan identifies priority research themes and topics for investment or co-investment of Board funds. Strategies for attracting co-investment in research are listed. The Plan aims to provide direction for the Board as an initiator and active participant in research and to provide research organisations and individuals with a clear statement on the research interests and priorities of the Board. To ensure the Plan is useful to both the Board and current and potential research partners, five components have been included:

- An overview of past and ongoing research and development;
- Description of major research groups and capability in NRM in South Australia;
- Priority topics for future research and development;
- A guide to maximising the benefits for the Board from participation in research and development; and,
- Steps to implementation of the research plan

The Plan has been developed in consultation with organisations and individuals with ongoing or potential for research partnerships with the Board. Organisations and individuals involved in the development of the plan were selected from a preliminary analysis of research capabilities, track record in delivering quality research outcomes in the past, and ability to attract co-investment and develop research programs.

The management of the natural resources of the SAMDB Region has particular national importance because: a) the region includes the lower end of the River Murray, which is the water source for Adelaide and regional areas in South Australia and b) includes sites of iconic natural heritage such as the RAMSAR listed Chowilla Floodplain and the Lower Lakes and Coorong. Because of the long-established importance of the natural resources of the region, there has already been a significant amount of research undertaken in the region which is described briefly in Appendix E.

The process for developing this Research Plan highlighted a broad range of research topics where further knowledge and understanding could contribute to planning and intervention that would achieve better natural resource management in the region. These research topics need further description, which is outside the scope of this Plan, but all will deliver major benefits by providing the underpinning knowledge that will improve the effectiveness and efficiency of the Board's investments. Prioritisation of critical research themes produced a list of eight high priority and ten medium priority topics (Table 3, Section 7) for development and implementation of research projects, and a range of research topics relating to social and institutional processes that have not yet been prioritised (Appendix N).

Priority Research Topics (from Table 3, Section 7)

- Inventory of biological/ecological assets
- Ecological restoration techniques/works including riparian, Strategic placement of vegetation
- Ecological impacts of different water management strategies in the EMLR
- Monitoring tools for adaptive management
- Tools for improved salt and water balance models for SA Murray
- Reuse of drainage water: Bioaccumulation, saline production of crops and fodder
- Biology, tolerance and adaptation of established and new crop and animal species to extreme temperature, trends in temperature changes and salinity of water/soil
- Biology, tolerance and adaptation of native species to extreme temperature, trends in temperature changes and salinity of water/soil
- Feasibility study for multiple use of water: environment, irrigation, and aquaculture.
- Scenario analysis of the likely future conditions of the NRM region
- Better understanding of groundwater/surface water processes to assist in water allocation planning, particularly fractured rock in EMLR
- Risk identification and management for ecological assets in terrestrial ecosystems
- Siting and design of irrigation systems to reduce water use, salt damage, and robustness to climate conditions, soil conditions
- Understanding of the links between water management, ecosystem management and biodiversity: threatened and iconic species.
- Matching cropping systems to perceived changes in the supply of water: Research and products to support adaptation to higher salt and lower water availability and higher cost scenarios for both high and low value crops.
- Basic ecological processes in terrestrial ecosystems to refine our conceptual models of how terrestrial ecosystems function and respond to pressure
- Tools for trade-off analysis between alternative ecological outcomes and water quality
- Key threatening processes to land resources, what we need to manage in the rangelands

The SAMDB NRM Board will not have sufficient funds to support even the highest priority research topics as listed above in its own right, let alone the over 100 topics listed in Appendices K, L, M & N that were identified at the workshops. To cover the list of topics that the workshop participants suggest will improve the capacity of the Board to effectively deliver its programs, the Board will need to:

- identify research already done that it can make use of and create a culture of continual learning within the Board,
- encourage funding bodies and funding programs to invest in research that it regards as important,
- develop close partnerships with universities to capture student projects in the region on issues of importance,
- carefully co-invest to leverage other funds for research,
- undertake some direct investment in high priority areas where research outputs are required as a matter of urgency.

The recommended next steps to implement this Research Plan are to:

1. Make investing in innovation a part of the business of the SAMDB NRM Board:
    a. Make space for Innovation on the Board's agenda (Include the Research Plan in the overall regional NRM Plan, Report against progress in implementing the Research Plan, Organise presentations on latest research to the Board members and staff);
    b. Assign one person the task of promoting and championing innovation within the SAMDB NRM Board. The authors recommend the appointment of a Research Manager;
    c. Encourage/require continual learning by the staff of the SAMDB NRM Board;
    d. Provide opportunities for the regional community to be informed about the latest research and scientific viewpoints through public seminars and workshops;
    e. Set aside funds for co-investing in research as part of the budgetary process;
    f. Consider the establishment of a River Murray Research Panel
2. Review the priorities identified in Table 3 and research topics in Appendices K, L & M and assign relative priorities of social research in Appendix N;
3. Scope out particular research projects for each of the high priority research topics. For example, Sebastien Lamontagne from CSIRO has identified four discrete research projects that are gaps in the Coorong, Lower Lakes and Murray Mouth Research Program (Appendix O). The IPC could request that the lead organisations identified in Table 3 scope the research topics out in more detail, complete with a budget and identified funding strategy;
4. Prepare a Prospectus of research issues of interest to the SAMDB NRM Board, made available on the website, and send to all research institutions (listed in Appendices A & B) – a draft outline for a Prospectus is attached in Appendix P
5. Utilise the Centre for Natural Resource Management advice and brokering abilities;
6. Request that either the CNRM, or a similar broker, organise a science forum once every two years for researchers and technical experts to present research relevant to the SAMDB region to staff, the community and Board members within the region.

2. Purpose

The purpose of this Research Plan for the South Australian Murray-Darling Basin is to identify research that addresses the key strategic objectives of the Board's NRM Plan and Investment Strategies, and is consistent with the State NRM Plan, State Strategic Plan and State's STI10 Science, technology and innovation vision. The Research Plan recommends priority R&D topics and outlines the role for the Board in future R&D activities.

Opportunities for co-investment and partnerships are identified, and the Plan outlines strategies for resourcing research.

This Plan has been written based on information generated through a consultation process with active researchers in the region and technical experts from state government and the Board.

3. Background

In the 1990's and early 2000's, national NRM Programs such as the Natural Heritage Trust were reluctant to fund research. With the advent of the bilateral agreement for funding under the National Action Plan for Salinity and Water Quality (NAP), South Australian INRM groups were for the first time encouraged to invest in research. This was a result of recognition of the importance of sound scientific knowledge to underpin appropriate investment of resources in the management of natural resources. A greater focus of research has also become necessary with a move to more evidence-based planning processes and evaluation of impact at all scales of investment.

In early 2003, the Centre for Natural Resource Management (Natural Resource Centre of Excellence at the time) established a Working Group to meet with regional INRM Groups to identify research priorities. This Working Group met with the South Australian Murray Darling Basin Integrated Natural Resource Management Group (the 'INRM Group'), and Groups from other regions to identify their priorities for research relevant to the NAP, based on the information needs of their planning processes. The SAMDB INRM Group undertook a R&D prioritisation process during the development of the first Investment Strategy (seeking funding from 1/1/04 to 30/6/04) which fed into the Centre for Natural Resource Management (CNRM) NRM Research Strategic Plan and Innovation Portfolio 2003 – 2008. This prioritisation process identified a number of R&D projects that would assist in improving management of the region's natural resources. A number of these projects have been developed and funded whereas others are still being fully developed prior to attracting funding (Table D4).

With this initial process now largely complete, and as a new Investment Strategy is being written for the 2006/07 financial year, it is timely that the SAMDB NRM Board reconsiders its information needs and research priorities. There has also been significant change in the research environment since 2003. The new e-Water CRC has started, a $140 million Centre that will undertake research on sustainable catchment and river management. The National Water Initiative has been established, a $2 billion Program to improve water management in Australia. A $500 million Living

Murray Initiative is being implemented. South Australia's universities and research agencies have recognised the needs and opportunities inherent in the new NRM arrangements and are primed to work with regional NRM Boards to collaboratively develop exciting new research programs. In short, the stars are aligned for the SAMDB NRM Board to significantly advance its understanding of the natural resources it is charged with managing.

The SAMDB NRM Board recently reviewed research undertaken in the region between 1995 and 2005[1]. The review identified nearly 800 publications that have been compiled in a database that is available online. This review will be an important tool for identifying research already undertaken (Appendix H), research gaps and researchers active in the region (Appendix I). The Board has commissioned the development of an integrated Research Plan:

- That addresses the key strategic objectives of the Board's NRM Plan and Investment Strategies, and is consistent with the State NRM Plan, State Strategic Plan and State's STI10 Science, technology and innovation vision.
- In a format that offers strategic direction to the Board by providing an overview of regional R&D, results of R&D gap analysis, recommendations on future priority R&D and the role of the Board in future R&D activities.
- That identifies opportunities for co-investment and partnerships, resourcing and budgetary implications, and the role of monitoring and evaluation.

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[1] http://www.dwlbc.sa.gov.au/subs/research/search.php

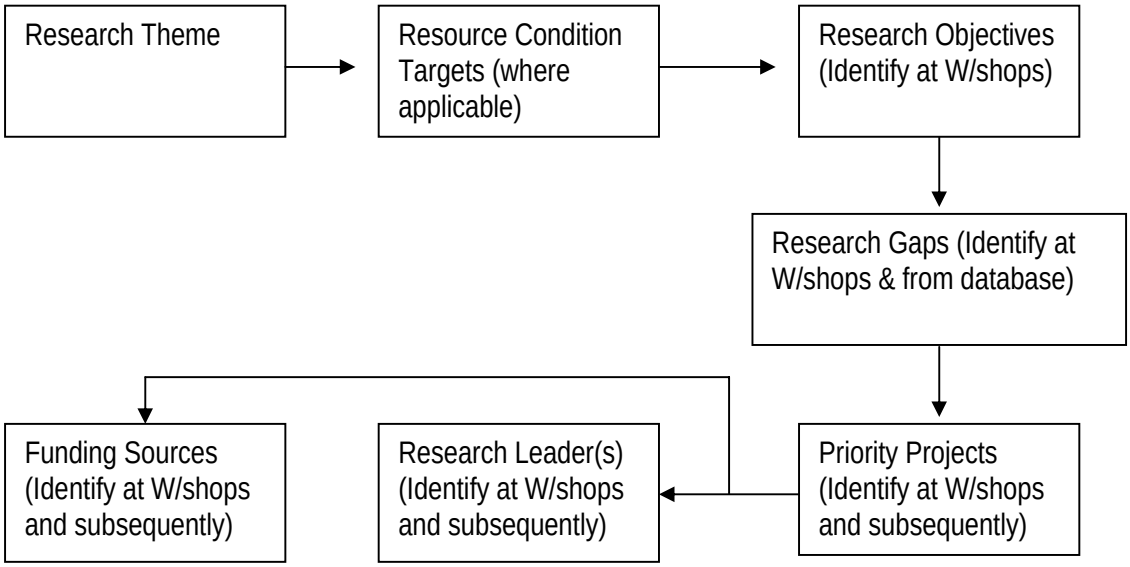
4. Approach and Methodology use to Prepare Research Plan

Key stakeholders of the region were invited to participate in one of four workshops, each of which addressed a number of themes.

- River Systems (River and riverine environments, Irrigation areas)
- Dryland Systems (Dryland cropping, eastern Mt Lofty Ranges)
- Terrestrial Ecosystems (Mallee, EMLR, Rangelands)
- Social Systems (Institutional governance and delivery, social capacity)

Research priorities were identified for each of the themes and integrated into a single research program for the region (Accompanying Document).

The Research Program was constructed within the following framework.



4.1 When is it research?

For the purposes of this report, research is defined as a systematic inquiry or investigation into a subject in order to discover or revise facts, theories and applications. Routine surveillance monitoring is not included in this definition of research, because information from routine monitoring is being collected to inform managers of how a system is functioning, and the interpretation of the data is usually informed by current theories. However, monitoring that has been designed to answer specific questions on the effectiveness of management approaches or techniques (ie adaptive management) is regarded as research, because the intent of adaptive management is to collect information systematically with the purpose of revising current management theories or applications. While it is always preferable to collect information through research and formulate theories in advance of undertaking on ground actions, where action is required as a matter of urgency because of trends in resource condition decline, managers must act immediately, and build research into the management process. This process of adaptive management requires that knowledge is discovered as part of the management process, and new theories built as lessons are learned from implementing on ground actions or policies. The result of this approach is that managers are constantly adapting their theories and approaches as new information comes to the fore and new theories are constructed and changed.

4.2 Background Assessment

A Background Assessment was undertaken to identify:

- other regional, state and national planning processes and how these relate to the development of research priorities for the SAMDB NRM Region (Appendix D);
- the needs of the SAMDB NRM Board for research, based on resource condition targets and existing Research Priorities (Appendix D);
- a list of researchers to invite to the workshops (Appendix I).

This was used to prepare a Background Paper for the participants of the workshop.

4.2.1 Achieving consistency of research priorities at a national, state and regional level

There has been a considerable effort at a national, state and regional level to develop priorities for research activity with the aim of focussing research on areas of strategic importance. Table1 synthesises information from Appendix D and illustrates where there are consistencies between the three levels of priority setting for research into NRM.

The priorities identified by the SAMDB NRM Board are highly consistent with priorities identified in the State NRM Plan, but both of these have not captured the priority of overcoming soil loss and sodicity which is identified as a priority at a national level.

Table 1. Comparison of Research Priority Themes at a National, State and Regional level (Summary of Appendix D)

National Research Priorities	State NRM Plan	SAMDB NRM Plan
Overcoming soil loss, salinity and acidity Sustainable use of Australia's biodiversity Water, a critical resource	Ecosystem processes (understanding causes of problems and resource limits)	Marine and Estuarine Futures Hydrological and Salinity Processes
Sustainable use of Australia's biodiversity	Natural resource repair technologies (lessening symptoms, fixing problems)	Biodiversity Conservation and Restoration
Transforming existing industries Sustainable use of Australia's biodiversity	Financially viable and ecologically sustainable natural resource-based industries	New Industries
	Social and economic issues regarding the use and protection of natural resources	Social and Economic Research
Responding to climate change and variability	Landscape and climate futures	Landscape and Climate Futures
Water – a critical resource	Water and irrigation futures	Water and Irrigation Futures Hydrological and Salinity Processes
	Indicators and evaluation tools to underpin the adaptive management framework required by the Act.	
Reducing and capturing emissions in transport and energy generation		
Developing deep earth resources		

4.2.2 Meeting the Needs of the SAMDB NRM Investment Strategy & Management Plan

A series of workshops were held to identify and define the priority NRM issues for the SAMDB for each of the four broad focus areas:

1. River Dependent Systems (including riverine environment/irrigated agriculture)
2. Rainfed Systems (including cropping & grazing in Mallee, EMLR, arid areas)
3. Social Systems (including Indigenous, social, institutional, governance, delivery)
4. Terrestrial Ecology

The outcomes of the Workshops were to:

- Identify priority themes and questions that require further research; to be classified into research that is already underway and research that requires new investment,
- Identify principle researchers for each research priority
- Identify potential co-investors.

Some key experts were unable to attend the workshops, and their comment and advice were sought in separate interviews. These people are listed in Appendix I and their views are summarised in Appendix O.

The SAMDB NRM Board has prepared an Investment Strategy[2] and Management Plan for natural resources in the region. The Management Plan identifies Resource Condition Targets (RCTs) to be met through investment in NRM in the region (Appendix J) and the Investment Strategy identifies seven Research Themes (Section D5, Appendix D). It is important that these are addressed as part of the process in developing the research priorities. Table 2 below shows which of these Priorities and RCTs will be relevant to each of three workshops. It should be noted that the workshop participants were not expected to just confine the scope of their thinking to the Resource Condition Targets and the existing Research Priorities. It is recognised that these are works in progress, and will change with time, nevertheless, they represent the “priorities” at the present moment and were useful context for the workshops. It should also be noted that there are no RCTs that relate to Social Systems at present.

[2] http://www.dwlbc.sa.gov.au/nrm/boards/samdb/invest.html

Table 2. Relationship between Workshop Foci, Research Priorities and Resource Condition Targets

Workshop Focus	Investment Strategy Research Priority	Relevant Targets
River Dependent Systems	Hydrological and Salinity Processes Marine and Estuarine Futures. Water and Irrigation Futures Biodiversity Conservation and Restoration New Industries Landscape and Climate Futures	1. Maintain and improve the extent and condition of 65% of current floodplain vegetation communities in areas of high priority by 2020 2. By 2020, a 30% reduction in priority areas of floodplain currently affected by salinity from groundwater discharge 3. Maintain and improve the condition and connectedness of 60% of wetlands of high priority by 2020 4. Maintain and improve the condition of 60% of the littoral zone of high priority and high significance by 2020 5. By 2020, improve the habitat in all waters to permit successful recruitment of native fish, particularly Murray Cod, resulting from natural or manipulated flows 6. Recover 30% of water dependent ecosystems from pest infestation and minimize any further infestations by 2020 7. By 2020, to have salinity of water in the River Murray less than 800EC for 95% of the time at Morgan to ensure drinking water standards 8. By 2020, to have salinity of water in the River Murray less than 543EC for 80% of the time at Berri Irrigation Pump Station to ensure drinking water standards 9. By 2020, to have salinity of water in the River Murray less than 770EC for 80% of the time at Murray Bridge Pump Station to ensure drinking water standards 10. The phosphorous concentration in the River Murray is to be less than or equal to 0.05mg/L 90% of the time by 2020 11. The nitrogen concentration in the River Murray is to be less than or equal to 1.0mg/L 90% of the time by 2020 12. The turbidity level in the River Murray is to be equal or less than 80 NTU 90% of the time by 2020 13. Maintain blue green algal levels below the national standard threshold level for all sections of the River Murray and the Lower Lakes by 2020 14. Maintain and improve the stability of river banks, lake edges, sand dunes and cliffs by 2020 15. The Murray mouth open 100% of the time through fresh water outflows with adequate tidal variation to meet the needs of Coorong ecosystems 21. Recover 30 % of quality native vegetation, habitat and agricultural production areas from pest infestation and minimize any further infestations by 2020 22. By 2020 improve or maintain condition of terrestrial native vegetation focusing on identified priority areas and improve condition of 50% of remnant vegetation on private land as well as increasing vegetation cover by 1% in the agricultural region 23. Maintain and improve the conservation status of all threatened National and State listed species and regionally threatened communities and species by 2020 24. By 2020 groundwater resources will not have salinity impacts on land condition and will meet the needs of dependent ecosystems 25. By 2006 to have developed a RCT relative to irrigated and waterlogged land 26. The *E.coli* count in the River Murray is to be less than or equal to 150 EC/100mL for 90% of the time by 2020

Workshop Focus	Investment Strategy Research Priority	Relevant Targets
Rainfed Systems	Biodiversity Conservation and Restoration New Industries Landscape and Climate Futures	5. By 2020, improve the habitat in all waters to permit successful recruitment of native fish, particularly Murray Cod, resulting from natural or manipulated flows 6. Recover 30% of water dependent ecosystems from pest infestation and minimize any further infestations by 2020 16. 30% of flow maintained in watercourses of EMLR to sustain ecosystem function by 2020 17. By 2020 to have constrained the area of salt affected land within the region to 120,000 ha 18. By 2020, reduce the area of agricultural land at risk of wind erosion during June each year by 40% 19. Reduce recharge by improving dryland water use efficiency to 70% across the region by 2020 20. To have an increasing trend in Soil carbon levels in cropping soils leading to improved soil health by 2020 21. Recover 30 % of quality native vegetation, habitat and agricultural production areas from pest infestation and minimize any further infestations by 2020 22. By 2020 improve or maintain condition of terrestrial native vegetation focusing on identified priority areas and improve condition of 50% of remnant vegetation on private land as well as increasing vegetation cover by 1% in the agricultural region 23. Maintain and improve the conservation status of all threatened National and State listed species and regionally threatened communities and species by 2020 24. By 2020 groundwater resources will not have salinity impacts on land condition and will meet the needs of dependent ecosystems
Social Systems	Social and Economic Research Landscape and Climate Futures	

4.2.3 Participants

NRM Board and state government agency staff with a technical interest in research outcomes, and researchers with a track record of publishing relevant research from the region, were invited to workshops to identify future research needs and priorities, and to identify research capabilities and funding sources to undertake the research.

Recently an inventory of publications of research undertaken in the region has been prepared and is available online - http://www.dwlbc.sa.gov.au/subs/research/search.php. This database was used to identify researchers with a strong track record of publications of research undertaken in the region. A summary of this analysis is tabulated in Appendix H.

This list has been used, along with advice from the NRM Board staff, to develop a list of invitees to the workshops series (Appendix I).

4.2.4 Summary of Background Analysis

- It is timely for the SAMDB NRM Board to revisit their Research Priorities for the region, to be consistent with the regional RCTs.
- The existing Research Priority Themes are broadly consistent with other regional, state and national planning processes, with the exception of soil science and management.
- There are experts with a strong interest in the region who are to be invited to a series of regional workshops to develop research priorities for each of four research focus areas:
    1. River Dependent Systems (including riverine environment/irrigated agriculture)
    2. Rainfed Systems (including cropping & grazing in Mallee, EMLR, arid areas)
    3. Social Systems (including Indigenous, social, institutional, governance, delivery)
    4. Terrestrial Ecology

4.3 Workshop Outputs

Participants at the workshops were invited to consider the future status of the regional NRM assets and social capability with and without research. This was done to "lift the view" of the participants from research that they were particularly interested in, to research that would deliver the greatest benefits to the region in improving NRM outcomes.

The participants identified some significant risks to the SAMDB NRM Board in achieving effective and efficient outcomes from its investment that could be better managed by improving their knowledge base through a research program. Some of the significant risks identified were:

- The impact of climate change on the resilience of agricultural and natural systems;
- Lack of knowledge of natural processes will lead to poor outcomes from investment in rehabilitation or conservation, or even unintended, negative consequences of investment;
- Programs are not targeted effectively, due to lack of knowledge of community capacity and attitudes;
- Declining economic profitability from some sectors of the region;
- Continued decline in resource condition, despite investment in NRM.

Participants were then asked to identify research and research outputs (what the Board would get from research: databases of information, decision support systems, improved conceptual models etc) that would help overcome some of these risks and deliver better investment outcomes. They were asked to vote for those that they thought would give the best outcome for the region. This was not done for the Social Systems workshop because there were too few people to vote by the end of the workshop.

The research topics identified from each workshop (n=102) are listed in Appendices K – N. For each Workshop, the research topics are listed under common themes. The topics that received the highest votes are listed in Tables K1, L1, M1 (in Appendices K, L & M), under research that will improve understanding, manage the symptoms of degradation or solve degradation of natural resources. The highest priority research topics are listed in Section 5.3. Research topics identified outside the workshop process, through interviews with key researchers, are listed in Appendix O.

5 Overview of Regional Research and Development

The SAMDB Region has particular national importance because it includes the lower end of the River Murray, which is the water source for Adelaide and regional areas in South Australia.

- The River Murray in this region is the subject of national efforts to improve water quality.
- The wetlands of the River Murray floodplain and the Coorong, Lower Lakes and Murray Mouth are nationally and internationally important ecosystems.
- The irrigation areas along the River Murray and the Mallee dryland cropping areas are important contributors to the economy of South Australia.
- The creeks and streams of the eastern Mt Lofty Ranges are under pressure, and include some rare and threatened communities and species, including native fish species.

A broad overview of the research and key researchers in the region, based on information in the SAMDB NRM Research Database[3] is described in Appendix E. It is not intended to list all of the work that has been completed and published (which can be accessed in more detail through the online database), but rather to broadly outline the focus of past research activities, and to identify some of the most active researchers in the region.

Research themes where previous and ongoing research capability and experience exists are described in Appendix E. The core themes of previous and ongoing research are:

- Hydrology and salt load
- Fish ecology and management
- Wetland ecology
- Coorong, Lower Lakes and Murray Mouth
- Nutrients in River Murray
- Sustainable irrigation
- Dryland farming systems
- Mallee biodiversity
- Rangelands management
- Pest control
- Revegetation
- Eastern Mount Lofty Ranges
- New industries
- Social and economic research
- Futures research

[3] http://www.dwlbc.sa.gov.au/subs/research/search.php

6 Major Research Groups and Capability

There are five main public research providers in South Australia:

- CSIRO (www.csiro.au)
- Flinders University (www.flinders.edu.au)
- SARDI (www.sardi.sa.gov.au)
- University of Adelaide (www.adelaide.edu.au)
- University of South Australia (www.unisa.edu.au)

Each research provider has its own research strengths and rarely do they compete in research in a discrete topic areas.

There is also significant research capability in niches areas within State Government (DEH, DWLBC, Rural Solutions, Australian Water Quality Centre) and the SAMDB NRM Board.

DWLBC has commissioned an audit of research capability in NRM in SA[4] which will not be repeated in this document. However, there are a number of important research groups with a demonstrated track record in delivering research in the SAMDB region, including current and ongoing research. These capabilities and lead researchers of these groups are briefly described in Appendix A. Appendix A is not an exhaustive list of research capability accessible to the Board, but is a summary of dominant and most experienced groups active in research in the region on the core research themes identified in the development of this plan. There are other individual researchers who have a research track-record in the region, and other groups and individuals who have relevant capability, but who as of yet have had little experience undertaking research in the region.

Under the Cooperative Research Centres (CRC) Programme[5], CRCs have been established to bring together researchers and research users. The programme emphasises the importance of collaborative arrangements to maximise the benefits of research through an enhanced process of

[4] Dalby, P. (2005) Discussion Paper: Research in NRM in SA. In Fusion Consulting for DWLBC
[5] https://www.crc.gov.au/Information/default.aspx

utilisation, commercialisation and technology transfer. It also has a strong education component with a focus on producing graduates with skills relevant to industry needs. CRCs bring together research expertise from across the country to focus on research topics of national importance. The CRCs that are relevant to the core research needs of the SAMDB NRM Board are listed in Appendix B.

7 Recommendations on Future Priority R&D

The following recommendations are made following consultation with researchers active in the region, technical staff from the Board, and technical experts from DEH, Rural Solutions and DWLBC.

The recommendations focus on the highest priorities for research identified by the technical and policy experts consulted, and are tabulated in order of Priority and Level of Investment Required (Table 3). Table 3 identifies the geographic scale of interest for the research (regional, state, national) and identifies the Resource Condition Targets (of the SA MDB NRM Board) that the research could help inform. Key research organisations with skills relevant to the research topics are listed.

Priority

The mechanism for assigning the priority level for each research topic was by a secret ballot of the participants at the workshops, although it should be noted that all research topics were identified on the basis that they would all deliver significant benefits to the SAMDB NRM Region and Board.

No prioritisation was undertaken for the Social issues at the workshop (Appendix N) because there were not enough attendees at the time of the secret ballot for a valid vote. Many of these are research areas that would be relevant nationally. Furthermore, no prioritisation was made on research topics identified by interviews held after the workshops. It is recommended that the IPC review all research topics, including those not already prioritised through the workshop process.

Investment Required

As with any investment, the answer to how much resources are required depends largely on how big the problem is, how fast a return on investment is required and what level of ownership in the intellectual property of the final product the investor is seeking. It should be noted that no assessment of investment level required was made for social science topics that were relevant at a state or national level.

Appendix F is a guide to what the Board expects from research organisations based on the willingness and ability of the Board to invest time and money into the research and the timelines for achieving a research outcome.

Geographic scale of research

Research topics are relevant at different jurisdictional scales. Table 3 provides an analysis of whether the research is relevant to and should be undertaken with support from regional, state and/or national levels. The SAMDB NRM Board should focus its investment on research relevant at a regional level, but may decide to co-invest with other regions, research entities or jurisdictions to address state and national issues that could develop generic tools that would be useful at a regional level.

Key Organisations

Different research organisations have different strengths and interests. To assist the NRM Board identify who they should approach to develop the priority research topics, a column in Table 3 identifies those research organisations that are considered to be leaders in the topics listed. This does not mean that other research organisations do not have any capability in these areas. The CNRM, being an independent advisory body, can help identify research capability on behalf of the Board.

The key contacts for the different research agencies are listed in Appendix C.

Co-Investors

The Centre for Natural Resource Management has prepared a report outlining the research funding programs relevant to NRM, their closing dates and where to find more information[6]. However, researchers will also be aware of many of these and may be able to assist in identifying sources of co-investment and funding for research projects.

[6] Dalby, P. (2005) Research funding opportunities for NRM Boards in SA. In Fusion Consulting for DWLBC.

Table 3: Highest priority research topics identified in the workshops

R = Regional scale, S= State scale, N = National Scale, H = High, M = Medium, L = Low

Research Topic	Scale of Interest	Investment Required	Priority	Key organisations
R11.Tools for improved salt and water balance models for SA Murray	R/S/N	M	H	DWLBC CSIRO L&W
R10. Reuse of drainage water: Bioaccumulation, saline production, smart SIS that adds economic value - Crops and technologies for mod-high salt	R/S/N	L	H	SARDI CRC FFS
D2. Ecological impacts of different water management strategies in EMLR	R/S	L	H	Uni Adelaide SARDI
D11. Biology, tolerance and adaptation of established and new crop and animal species to extreme temperature, trends in temperature changes and salinity of water/soil	S/N	L	H	Uni Adelaide SARDI CRC IF
D8. Biology, tolerance and adaptation of native species to extreme temperature, trends in temperature changes and salinity of water/soi	R/S/N	L	H	Uni Adelaide Flinders Uni SARDI Uni SA
D9. & T4 Ecological restoration techniques, Strategic placement of vegetation, Revegetation techniques	S/R	M	H	Uni Adelaide DEH DWLBC CSIRO L&W Rural Solutions
T2. Inventory of biological/ecological assets for terrestrial and aquatic ecosystems	R	M	H	DEH Uni Adelaide Flinders Uni Uni SA SARDI Aquatic Sciences

Research Topic	Scale of Interest	Investment Required	Priority	Key organisations
T1. Monitoring for adaptive management • Tools for providing feedback to managers on the effectiveness of their actions • Large scale "living laboratory" experiments where managers try and number of approaches and compare their effectiveness	R/S/N	M	H	DEH DWLBC Uni Adelaide Flinders Uni Uni SA
R5. Siting and design of irrigation systems to reduce water use, salt damage, robustness to climate conditions, soil conditions - Output: Land suitability with regard to climate interaction	R/S/N	M	M	CSIRO L&W SARDI DWLBC CRC IF Rural Solutions
R3. Understanding of the links between water management, ecosystem management and biodiversity: threatened and iconic spp.	R	M	M	Uni Adelaide DWLBC SARDI
R6. Matching cropping systems to perceived changes in the supply of water: Research and products to support adaptation to higher salt and lower water availability and higher cost scenarios for both high and low value crops.	R/S/N	M	M	SARDI CSIRO L&W Uni Adelaide CRC IF
R29. Scenario analysis of the likely future conditions of the NRM region: Flow across the border and climate	R/S/N	H	M	CSIRO L&W SARDI MDBC CRC IF
R20. Tools for trade-off analysis between alternative ecological outcomes and water quality	R	L	M	Uni Adelaide SARDI AWQC
R18. Feasibility study for multiple use of water: environment, irrigation, aquaculture. Alternative sources of water? Alternative uses for different quality water?	R	H	M	Uni Adelaide SARDI CSIRO L&W CRC IF Rural Solutions

Research Topic	Scale of Interest	Investment Required	Priority	Key organisations
D6. Key threatening processes to land resource, what we need to manage in the rangelands	R/S	L	M	Uni Adelaide Uni SA DWLBC Flinders Uni CRC DK
T3. Risk identification and management for ecological assets in terrestrial ecosystems (other than rangelands – see D6)	R	H	M	DEH Uni Adelaide Flinders Uni Uni SA Rural Solutions
D3. Better understanding of groundwater/surface water processes to assist in water allocation planning, particularly fractured rock in EMLR	S	M	M	DWLBC CSIRO L&W Uni Adelaide e-Water CRC
T5. Basic ecological processes in terrestrial ecosystems to refine our conceptual models of how terrestrial ecosystems function and respond to pressure	S/N	L	M	DEH Uni Adelaide Flinders Uni Uni SA
S21, S22, S23 Mapping community capability, attitudes, demographic trends	R	H		CSIRO L&W Flinders Uni Rural Solutions
S18, S19, S20 Mapping industry and institutional capacity, attitudes, influence, trends	R	H		CSIRO L&W Flinders Uni Uni Adelaide Uni SA
S25. Value “volunteerism” in SAMDB	R	L		Uni Adelaide Flinders Uni
S1. Test incentives and market based instruments before implementing them in practice (eg. Policy “wind tunnel” experiments)	R/S/N	H		CSIRO L&W

Research Topic	Scale of Interest	Investment Required	Priority	Key organisations
S2&S6. Understand farm investment decisions with respect to NRM outcomes. Understand the different responses of people to incentives spatially in the landscape	R/S/N	H		CSIRO L&W Uni Adelaide Uni SA
S7. Assess NRM groups areas likely to respond to NRM change projects	R/S/N	H		Rural Solutions
D15-18. Stock take of methods and tools available for undertaking research to improve social understanding	S/N			Flinders Uni Rural Solutions
S5. Mapping pathways to changed practices in NRM	N			
S9. What could encourage private investment from outside the region to bring about landscape change?	S/N			
S10. What are the handful of approaches for coordinating biophysical, social and economic systems?	N			
S11. Tools to value non-market outcomes	N			
S3,S8 & S13. What other economic tools can replace Benefit:Cost Analysis, which are strongly influenced by time for benefit to emerge and the discount rate used. Non-Market Based Instruments for influencing behaviour change	N			
S14 & 16. Challenge the notion of "self-interest" within communities, and identify the level of "pro-social" behaviour (a willingness to help another person without expecting a reciprocal benefit). Explore institutional alternatives to the dichotomy of public-private rights. Explore the use of community/district accountability frameworks versus individual accountability frameworks	N			
S17. Identify the potential for the "dark side" of volunteerism/community governance	N			

CRC DK = CRC Desert Knowledge, CRC IF = CRC Irrigation Futures, DEH = Department of Environment and Heritage (SA), DWLBC = Department of Water, Land and Biodiversity Conservation, MDBC = Murray Darling Basin Commission, SARDI = South Australian Research and Development Institute

7.1 Strategic Relevance of Priority Research Topics to Other Planning Processes

An analysis of the Priority Research Topics (listed in Table 3) against the Resource Condition Targets (Table 4) illustrates that some targets are the subject of considerable research, while others have not been identified as requiring further research. Those RCTs that have not had research identified are:

- All RCTs relating to water quality, other than salinity (RCTs 10, 11, 12, 13, 26). Justin Brookes from the University of Adelaide has provided some advice on research topics relevant to this area following the workshops.
    - R33, Biogeochemistry of wetlands: When wetlands are watered, primary production increases which results in a deposition of fine and course-sized plant material. This acts as a mulch on the soil and a carbon load to the River when there is a final draw-down. What is the impact of this on the wetland and River systems. How can managers avoid black-water events and minimise the chances of acid build-up (through salt/iron oxide interactions)? (Links to R3)
    - R34. What is the contribution of different “assets” and land systems along the River to nutrient loads?
    - R35. Why is there an acid slug of water along the bottom of the River between Mannum and Tailem Bend?
    - R36. Nitrogen denitrifies the longer it remains in an aquatic system. In a River system with few inputs (like the contained channel of the River Murray), does this mean that the concentration of nitrogen decreases the further you move down the River and what impact does this have on river primary productivity? What are the flow on impacts down the food chain?
- Pest management (RCT 6).

Furthermore, Sebastien Lamontagne from CSIRO has identified gaps in the research activity that is currently underway in the Coorong, Lower Lakes and Murray Mouth:

- R37. The need to determine experimentally the water regime requirements and salt tolerance for key *Ruppia* species in the Coorong.

- R38. Research to improve the water and salt balance models for the Lower Lakes.
- R39. Predict the impact of water regime change on the Lower Lakes wetlands.
- R40. Better understand and quantify the exchanges through the Murray Mouth.

The research topics identified by Drs Brookes and Lamontagne were provided following the workshops and so have not been included in the prioritisation process.

In Appendix D, an in depth analysis of the link between research themes and other planning processes has been made (State Strategic Plan, National Research Priorities, STI10, State NRM Plan, SAMDB NRM Plan). A summary of this analysis has been integrated with the research topics identified to illustrate where the identified Priority Research Topics align with regional, state and national planning processes (Table 5).

Table 4: Research Topic by Resource Condition Target

Research Topic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Inventory of biological/ecological assets																					■	■	■			
Ecological restoration techniques/works including riparian, Strategic placement of vegetation																					■	■	■			
Understand the ecological impacts of different water management strategies within the River Murray system	■	■		■	■		■	■	■																	
Monitoring for adaptive management	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Tools for improved salt and water balance models for SA Murray	■	■		■	■		■	■	■																	
Reuse of drainage water: Bioaccumulation, saline production, smart SIS that adds economic value - Crops and technologies for mod-high salt							■	■	■								■									
Biology, tolerance and adaptation of established and new crop and animal species to extreme temperature, trends in temperature changes and salinity of water/soil																		■	■	■						
Biology, tolerance and adaptation of native species to extreme temperature, trends in temperature changes and salinity of water/soil																							■			
Feasibility study for multiple use of water: environment, irrigation, aquaculture.																										
Scenario analysis of the likely future conditions of the NRM region: Flow across the border and climate																										
Better understanding of groundwater/surface water processes to assist in water allocation planning, particularly fractured rock																										
Risk identification and management																										
Siting and design of irrigation systems to reduce water use, salt damage, robustness to climate conditions, soil conditions - Output: Land suitability with regard to climate interaction																								■		
Understanding of the links between water management, ecosystem management and biodiversity: threatened and iconic spp.	■	■		■	■																		■			
Research and products to support adaptation to higher salt and lower water availability and higher cost scenarios for both high and low value crops.																									■	
Ecological flows in EMLR																■										
Revegetation technologies																										
Basic ecological processes																							■			
Refine our conceptual models																							■			
Tools for trade-off analysis between alternative ecological outcomes and water quality	■	■		■	■																					
Key threatening processes to land resource, what we need to manage in the rangelands																							■			

Table 5: Comparison of Research Priority Themes at a National, State and Regional level

National Research Priorities	State NRM Plan	SAMDB Research Themes	SAMDB Research Priorities
Overcoming soil loss, salinity and acidity Sustainable use of Australia's biodiversity Water – a critical resource	Ecosystem processes (understanding causes of problems and resource limits)	Hydrological and Salinity Processes Marine and Estuarine Futures.	• D3a. Better understanding of groundwater/surface water processes to assist in water allocation planning, particularly fractured rock in EMLR • R3. Understanding of the links between water management, ecosystem management and biodiversity: threatened and iconic species. • D2. Ecological flows in EMLR • R20. Tools for trade-off analysis between alternative ecological outcomes and water quality • D6. Key threatening processes to land resource, what we need to manage in the rangelands
Sustainable use of Australia's biodiversity	Natural resource repair technologies (lessening symptoms, fixing problems)	Biodiversity Conservation and Restoration	• T2. Inventory of biological/ecological assets • D9 & T4 Ecological restoration techniques/works, strategic placement of vegetation, revegetation technologies • T5. Basic edological processes in terrestrial ecosystems to refine our conceptual models of how terrestrial ecosystems function and respond to pressure • T3. Risk identification and management for ecological assets in terrestrial ecosystems
Transforming existing industries Sustainable use of Australia's biodiversity	Financially viable and ecologically sustainable natural resource-based industries	New Industries	• R10. Reuse of drainage water: Bioaccumulation, saline production, smart SIS that adds economic value - Crops and technologies for mod-high salt
	Social and economic issues regarding the use and protection of natural resources	Social and Economic Research	• See Appendix N

National Research Priorities	State NRM Plan	SAMDB Research Themes	SAMDB Research Priorities
Responding to climate change and variability	Landscape and climate futures	Landscape and Climate Futures	• D8. Biology, tolerance and adaptation of native species to extreme temperature, trends in temperature changes and salinity of water/soil • D11. Biology, tolerance and adaptation of established and new crop and animal species to extreme temperature, trends in temperature changes and salinity of water/soil • R29. Scenario analysis of the likely future conditions of the NRM region: Flow across the border and climate • R5. Siting and design of irrigation systems to reduce water use, salt damage, robustness to climate conditions, soil conditions - Output: Land suitability with regard to climate interaction
Water – a critical resource	Water and irrigation futures	Water and Irrigation Futures	• D3b. Understand the ecological impacts of different water management strategies within the River Murray system • R11. Tools for improved salt and water balance models for SA Murray • R18. Feasibility study for multiple use of water: environment, irrigation, aquaculture. • R5. Siting and design of irrigation systems to reduce water use, salt damage, robustness to climate conditions, soil conditions - Output: Land suitability with regard to climate interaction • R5. Matching cropping systems to perceived changes in the supply of water: Research and products to support adaptation to higher salt and lower water availability and higher cost scenarios for both high and low value crops.
	Indicators and evaluation tools to underpin the adaptive management framework required by the Act.		• T1. Monitoring for adaptive management • T3. Risk identification and management for ecological assets in terrestrial ecosystems
Reducing and capturing emissions in transport and energy generation			
Developing deep earth resources			

8 The Role of the Board in Future R&D Activities

The SAMDB NRM Board will not have sufficient funds to support even the highest priority research topics as listed in this Plan in its own right, let alone the over 100 topics listed in Appendices K-O that were identified at the workshops. To cover the list of topics that the workshop participants suggest will improve the capacity of the Board to effectively deliver its programs, the Board will need to:

- identify research already done that it can make use of,
- encourage funding bodies and funding programs to invest in priority research,
- develop close partnerships with universities to capture student projects in the region on issues of importance,
- careful co-investment to leverage other funds for research,
- some direct investment in high priority areas where research outputs are required as a matter of urgency.

The Centre for Natural Resource Management is a critically important partner in achieving these outcomes. The Centre has been established with the specific task of assisting NRM Boards in South Australia to engage with the research sector.

8.1 Creating a Culture of Continual Learning

There is an enormous body of research undertaken both within and outside the region that could help inform the Board, its staff and the broader community on how to best manage natural resources in the region. The Research Database[7] will assist in identifying research and active researchers but it is a tool to help begin searching for information, not the sum of all knowledge.

It is important that the Board, its staff and the broader community are continually updating their knowledge and understanding of the best science available in relation

[7] http://www.dwlbc.sa.gov.au/subs/research/search.php

to the Boards investment program and on ground delivery. This is the best investment the Board can make, because for a small investment, it can access potentially hundreds of millions of dollars of research activity. Such an outcome can be achieved through developing partnerships with researchers and research organisations (see below), and building a culture of continual learning within the organisation. This could include:

- Inviting researchers to speak to the Board and staff about relevant research;
- Organising Community Forums for scientists to interact with the broader community, and share ideas and knowledge;
- Encouraging, or requiring, technical staff to continually update their knowledge by attending workshops, conferences, seminars and short course training as part of their job, and making sure they have the time and access to financial support to attend;
- Employing a Research Manager/Coordinator to build partnerships with research organisations, manage investment and co-investment in research projects, encourage and facilitate continual learning by staff and Board members, attract research funds and activity into the region.

8.2 Engage with Research Already Funded

There are other groups with an interest in research in the SAMDB Region who are investing in research. For example, the CRC irrigation Futures, CSIRO Water for a Healthy Country and the e-Water CRC are all investing in research in the region. These groups will invest in research in the SAMDB region regardless of the SAMDB Priorities. The Board should make themselves aware of these groups by inviting them to speak to the Board to areas of mutual interest. This obviously reduces the need for the Board to invest directly in new research. Some of the key investor groups are listed in Appendix G.

8.3 Developing Individual and Institutional Partnerships

The SAMDB NRM Board can develop partnerships at an individual and institutional level. In doing so, the Board should be cognisant of the fact that scientists and their institutions are not necessarily driven by the need to provide the Board with endless free technical advice. They are researchers who are judged by the quantity and quality of research they undertake. By building relationships that provide benefit to both parties, the Board can expect a fruitful relationship with the research community, which will provide knowledge that can be used to improve the Board's ability to manage natural resources in the SAMDB region. Furthermore, the Board can play an important role in coordinating research in its region from across a number of different research providers and ensure coordination and communication across these groups.

8.3.1 Individual Relationships

Individuals with a passion for research in the region and who are capable researchers will find resources to undertake their research. The Board will obtain great value in cultivating these individuals by:

- Inviting them to speak to the Board and its staff on their research and its implications for the Board's investment;
- Promoting the outcomes of the research of these individuals in newsletters, websites and forums;
- Inviting them to participate in the design of on-ground works in a way that more easily enables scientific analysis;
- Linking them to larger, institutional research programs (see below)
- Where possible, providing support funds for research, either as matching or as the major investor.

8.3.2 Institutional Partnerships

The following organisations and groupings are the principle organisations that the Board should be developing close relationships with. Coordinators and Leaders of these are listed in Appendices A,B and C.

Centre for Natural Resource Management

The Centre for Natural Resource Management (CNRM) has been established specifically to act as a broker between research providers and regional NRM groups in SA. It is unique in Australia in this regard. The CNRM was successful in receiving some funding from the National Action Plan for Salinity and Water Quality which has supported research, much of it in the SAMDB region. A list of the research supported by the CNRM is documented in Table D1.

The CNRM has a Technical Working Group (TWG) with representation from research providers, the State and Commonwealth Governments and the regional NRM Boards. The TWG can help regional groups identify research capability and assess the merit of research proposals.

Tri-State Forum

The SAMDB NRM Region is part of a larger *Lower Murray Region* under the National Action Plan for Salinity and Water Quality, which also includes the Wimmera CMA, Mallee CMA and Lower Murray Darling CMA. Representatives from each of these regions meet regularly to identify opportunities for cooperation and co-investment. It is a useful forum for identifying and co-investing in research projects relevant to the Lower Murray region, that could help off-set some of the costs of research for the SAMDB region.

Murray Darling Basin Commission

The Murray Darling Basin Commission (CMDBC) is the executive arm of the Murray-Darling Basin Ministerial Council and is responsible for:

- managing the River Murray and the Menindee Lakes system of the lower Darling River, and
- advising the Ministerial Council on matters related to the use of the water, land and other environmental resources of the Murray-Darling Basin.

The main functions of the Commission, specified in clause 17 of the Murray-Darling Basin Agreement, are:

- to advise the Ministerial Council in relation to the planning, development and management of the Basin's natural resources;
- to assist Council in developing measures for the equitable, efficient and sustainable use of the Basin's natural resources;
- to coordinate the implementation of, or where directed by Council to implement, those measures; and
- to give effect to any policy or decision of the Ministerial Council.

To effectively undertake its role, the MDBC invests substantially in research and investigation to better understand social, economic and biophysical processes and systems within the Basin. They have invested in the SAMDB region in research related to better understanding salt and water balances, ecological processes and the interaction between the River and irrigation industries.

Water for a Healthy Country

Water for a Healthy Country is one of the six National Research Flagships lead by CSIRO. The Water for a Healthy Country Flagship aims to work with governments,

industries and communities to develop the knowledge needed to substantially improve the way water is used and managed. The River Murray region is one of four focus regions for the Water for a Healthy Country Flagship.

CSIRO are investing significant resources into the Water for a Healthy Country Flagship. For the River Murray region, it has the following research objectives:

- Delivering water savings through efficiency, technology and engineering.
- Assessing environmental responses to changes in river and land-use management.
- Evaluating water management options to sustain the environmental values and health of the Murray lakes, estuary and Coorong.
- Developing practical options for using water more efficiently, equitably and sustainably in the River Murray region
- Maximising agricultural profitability and sustainability while reducing salinisation and protecting biodiversity.
- Addressing environmental, economic and social issues in the Lower Murray region of south-eastern Australia.
- Developing cost-effective revegetation strategies to protect the environment and increase agricultural productivity.

Water for a Healthy Country is already investing heavily in the region, through projects such as ”Coorong, Lower Lakes and Murray Mouth (CLLAMM)” and the “Lower Murray Landscape Futures”, and a closer relationship between the Board and Water for a Healthy Country will be sought to ensure strong integration of the objectives of the two organisations.

Individual Research Institutions

The Board and staff should be aware of the research strengths and capabilities of each of the five main research providers operating in South Australia, and state agencies with technical capability. Research organisations are becoming more aware of the need to engage with their stakeholders,

and the SAMDB NRM Board is an important stakeholder for all of the research providers in SA. Many have re-organised themselves to provide a clear pathway to various groupings of expertise. This has taken the form of establishing research Centres, Clusters, Streams and Institutes.

A River Murray Research Panel?

Professor Keith Walker from the University of Adelaide has had a long-term interest in the ecological processes of the River Murray and the management practices required to ensure the health of the River. He has suggested the establishment of a River Murray Research Panel in South Australia, that involves key researchers from across the research disciplines. The Panel could initiate, promote and implement a range of initiatives in research, education (postgraduate, undergraduate, schools, public and media) and exchanges of specialist advice as necessary. One initiative could be an annual river research symposium for professional people, ideally with refereed, published proceedings. Another could be to develop and maintain a web site. The benefits would be:

- More effective communication between researchers and the Board and staff;
- A forum for providing training and education on the River Murray, including to the broader community (ie. Not just formally enrolled students);
- A forum for developing larger, more integrated research programs like CLLAMM and the Lower Murray Landscape Futures project;
- Improved coordination of research in the region.

The River Murray Institute Research Panel could possibly be based around a Regional Information Centre, and be coordinated by a Research Manager/Coordinator.

8.4 Resourcing, Co-Investment and Budgetary Implications

Research is expensive, risky and can take many years to deliver meaningful results that can be applied. But innovation is the key to achieving sustainable natural resource management, and the Board must engage and invest in research and its dissemination. A guiding principle of the State NRM Plan is:

"Knowledge is power – It is essential to develop and share knowledge and that the understandings of rural, urban, Aboriginal and scientific communities are sought and valued".

This principle underpins the importance of research in developing knowledge that can be used by the participants in NRM. The Plan recognises that "science, technology and innovation are critical to continually improve NRM".

This section does not recommend an amount that the Board should invest into research. Rather, it proposes some principles for investment and identifies the proportion of investment in research required to deliver short and long term outcomes. A final decision on funds to be invested in research should be identified in the Investment Strategy.

8.5 Principles for Investment in Research

1. Invest first in learning from research already published or underway.

Section 8.1 discusses the importance of creating a culture of continual learning within the Board, and makes some recommendations on how to achieve this. The authors re-iterate here that this is the most efficient use of the Board's limited funds.

2. Leverage investment wherever possible

The Board will be able to attract at least matching funds for any investment it makes in research, and should be able to achieve much higher leverage, so that it is investing between 10% and 20% of funds into integrated research programs. To do this, the Board needs to build strong partnerships with research providers (see Section 8.2) and make use of research funding sources identified in the CNRM report[8]. An exception to this rule is if the research is required urgently, and there is not enough time to apply for or seek matching funds. Consideration of the lag-phase in developing research programs should be considered during the first stages of project development.

3. Always go for the best quality you can find

The research sector is like any other sector, and there is a wide range of capability and creativity. It is not always easy however, to identify research talent and capability. Some poor researchers are excellent communicators and project managers, but deliver very little in the way of useful innovation. Others can have brilliant minds, but be poor communicators and uninterested in the problems of real world, management and decision making. The Board should seek to build relationships with research individuals and groups who are good communicators, can demonstrate a strong track record in delivering innovative research and have

[8] Dalby, P. (2005) Research funding opportunities for NRM Boards in SA. In Fusion Consulting for DWLBC.

an interest and passion for research topics that align with the interests of the Board.

Being able to measure the track record of a scientist is itself an inexact science. In organisations that have a primary focus on research (like CSIRO, the universities and SARDI), good researchers will usually attract external resources consistently and build long standing relationships with funding agencies. In academic institutions, as a general rule of thumb good researchers publish an average of two or more papers per year in international journals. It is much harder to judge the quality of scientists in organisations such as DWLBC and DEH who are not under the same pressures to attract external funds and publish research results for peer review. It is also more difficult to judge the abilities of early career researchers who have had less opportunity to establish a track record. Another way to gauge a researcher's ability is to carry out a "referee check", and talk to other scientists in Australia in a similar field. This should be done with great caution, as there are many strong alliances and jealousies in Australian science, so a broad cross section of people should be contacted, and exuberant praise or criticism should be interpreted with care. Finally, you may be able to find out from other "customers" those researchers that have worked well for them and about the ability of these researchers to deliver on time and produce and communicate useful results.

Expectations of students

Students are by definition usually un-tried and un-tested. While high quality researchers may attract higher quality students, there is really no way of knowing exactly how a student will perform in advance. Sponsoring student research can be a great way of getting research done at a low cost, but care should be taken about how much responsibility and guidance is given to the student. For critically important research projects, where the results are required urgently, it is

suggested that the Board invest more resources and employ a researcher with a strong track record.

4. Larger, integrated research programs are more efficient at delivering an integrated understanding of processes than lots of small, disconnected projects

Programs of research are coherent and well connected collections of projects that aim to deliver major improvements in knowledge. They can be funded as one off projects like CLLAMM, The Lower Murray Landscape Futures and the Mallee Sustainable Farming Systems trial. These larger projects are likely to carry out research at "full scale", that is, at the management scale that the Board is interested in. Trying to extrapolate results from experiments in laboratories/small areas to large regions is fraught with difficulties and potential misinterpretation. Larger, integrated projects are more likely to attract the best scientists and major co-investment. However, larger and more integrated projects also have significant management risks attached to them. This larger scale of research activity is a relatively recent phenomena in Australia, and research organisations are still developing management systems and cultures to be able to deliver them effectively. The Board should seek to have some high level oversight for these projects to make sure that the partners work well together to deliver the defined objectives of the project.

Programs of research can also be done over time, as resources permit. Well organised scientists will fit many small projects and consultancies into a broader "framework" of work that they believe will deliver major improvements in knowledge.

The Board should be seeking to engage with and develop these larger, integrated programs, either as a co-investor into a single large projects, or in funding smaller projects that fit into a larger intended program of work.

Small, consultancy-scale projects still have their place, and can deliver excellent outcomes for a relatively small investment, and should be part of the mix of investment the Board makes.

5. Aim for continuous improvement and learning

The Board needs answers now on how to manage natural resources in the region. Some scientists can find it difficult to give a "best guess" answer on the most appropriate management strategies, without understanding the system in great detail. Both have a legitimate point of view, but pragmatically, the Board needs to get the best advice it can at any moment in time and cannot always wait for research to generate clear and unambiguous answers. The Board can build trust with scientists by adopting the principle of "adaptive management" or continuous improvement by agreeing to continue to improve its knowledge base by working with scientists and technical experts. On-ground action programs could be designed to enable scientific evaluation of different implementation strategies. For example, a number of different wetlands management strategies could be implemented through the Living Murray Initiative, in a replicated series of trials. By doing so, scientists can statistically compare the different strategies, so the Living Murray Initiative would itself become a large-scale experiment that would attract scientific interest.

6. Build long term partnerships with individuals and institutions committed to you and your region

Section 8.3 explores a number of strategies for building long term partnerships with individuals and institutions.

7. Build a balanced portfolio of research activity

While the Board should focus the majority of its own resources on investing in research that will deliver results with particular relevance for the region, the Board may also benefit in participating as partners in research across regions (eg.

Lower Murray Landscape Futures), across the state and at a national scale – as long as the research will deliver benefits to the Board and the regional community in enhancing their ability to manage natural resources in the region. The CNRM in particular should be able to help broker these wider partnerships for research. Where the Board requires outcomes in short timeframes to answer specific questions, it would be reasonable for the Board to require researchers to report regularly on milestones and have payments tied to the delivery of outputs. For research that will generate more general information that will build the knowledge base of the region and its processes, and where the Board is a minor co-investor in the research, a more hands off approach to managing research outputs would be more appropriate.

8. Solve problems

Research can improve our general understanding of the process that govern the natural world. This is very important research that is required to underpin more focus and applied research that could help improve the management of the natural world. The role of the Board is to focus much more heavily on investing in research that will solve their immediate problems.

9. The Immediate Next Steps

The recommended next steps to implement this Research Plan are to:

1. Make investing in innovation a part of the business of the SAMDB NRM Board:
    a. Make space for Innovation on the Board's agenda (Include the Research Plan in the overall regional NRM Plan, Report against progress in implementing the Research Plan, Organise presentations on latest research to the Board members and staff);
    b. Assign one person the task of promoting and championing innovation within the SAMDB NRM Board. The authors recommend the appointment of a Research Manager;
    c. Encourage/require continual learning by the staff of the SAMDB NRM Board;
    d. Provide opportunities for the regional community to be informed about the latest research and scientific viewpoints through public seminars and workshops;
    e. Set aside funds for co-investing in research as part of the budgetary process;
    f. Consider the establishment of a River Murray Research Panel
2. Review the priorities identified in Table 3 and research topics in Appendices K, L & M and assign relative priorities of social research in Appendix N;
3. Scope out particular research projects for each of the high priority research topics. For example, Sebastien Lamontagne from CSIRO has identified four discrete research projects that are gaps in the Coorong, Lower Lakes and Murray Mouth Research Program (Appendix O). The IPC could request that the lead organisations identified in Table 3 scope the research topics out in more detail, complete with a budget and identified funding strategy;
4. Prepare a Prospectus of research issues of interest to the SAMDB NRM Board, made available on the website, and send to all research institutions (listed in Appendices A & B) – a draft outline for a Prospectus is attached in Appendix P
5. Utilise the Centre for Natural Resource Management advice and brokering abilities;
6. Request that either the CNRM, or a similar broker, organise a science forum once every two years for researchers and technical experts to present research relevant to the SAMDB region to staff, the community and Board members within the region.

Appendix A. Major Research Groupings in NRM in SA

Research Grouping	Capabilities	Key Contact	Contact Details
Centre for Natural Resource Management	Broker research between NRM Boards and research organisations and funding bodies	Paul Jupp	jupp.paul@saugov.sa.gov.au
CSIRO Land and Water			
Surface Water & Groundwater Interactions	Groundwater, surface water and salinity modelling	Glen Walker	glen.walker@csiro.au
Society, Economy & Policy	Economic and policy analysis	Geoff Syme	geoff.syme@csiro.au
State Government			
DEH, Biological Survey	Survey of native plant and animal abundance and distribution	Rob Brandle	brandle.robert@saugov.sa.gov.au
DWLBC Groundwater group	Groundwater modelling	Steve Barnett	barnett.steven@saugov.sa.gov.au
DWLBC, Animal and Plant Pest Control	Weed and Vertebrate Pest Management	John Virtue; Bob Henzell	virtue.john@saugov.sa.gov.au
SARDI Aquaculture	Aquaculture using saline resources	Steve Clarke	clarke.steven2@saugov.sa.gov.au
SARDI Aquatic Sciences	Fish biology, ecology and management	Qifeng Ye	ye.qifeng@saugov.sa.gov.au
SARDI Entomology	Invertebrate pest control	Dennis Hopkins	hopkins.dennis@saugtov.sa.gov.au
SARDI Horticulture	Horticultural pest control	Trevor Wicks	wicks.trevor@saugov.sa.gov.au
SARDI Irrigation	Sustainable irrigation systems	Gerrit Schrale	schrale.gerrit@saugov.sa.gov.au
Rural Solutions	Social research		pirsa.ruralsolutions@saugov.sa.gov.au
AWQC	Analysis of water quality	Chris Saint	chris.saint@sawater.com.au

Research Grouping	Capabilities	Key Contact	Contact Details
University of Adelaide			
Terrestrial ecology	Terrestrial ecology in Mallee, Coorong ecology	David Paton	david.paton@adelaide.edu.au
Pathology and Entomology	Weed and invertebrate pest biology and control	Mike Keller	mike.keller@adelaide.edu.au
River Murray Lab	River and wetland ecology Nutrient dynamics	Keith Walker Justin Brookes	keith.walker@adelaide.edu.au justin.brookes@adelaide.edu.au
Water Research Cluster, Uni Adelaide	1. Integrated regional water management; 2. Soil water interactions for sustainable ecosystems; 3. Management of ecosystems through improved understanding, allocation and use of water; 4. Optimised efficiency of water delivery, use, treatment and re-use;	Paul Dalby Coordinator	paul.dalby@adelaide.edu.au
Sustainability Research Cluster, Uni Adelaide	Build multidisciplinary research teams with the breadth of expertise to develop and deliver integrated solutions for sustainable development issues	Jackie Venning, Coordinator	jackie.venning@adelaide.edu.au
Flinders University			
BioKnowledge, Flinders University	Emphasize a multidisciplinary and collaborative approach in providing and interpreting information on the diverse processes that affect the conservation and functioning of Australia's biodiversity and landscapes.	Duncan Mackay Director Michael Schwarz Director	duncan.mackay@flinders.edu.au michael.schwarz@flinders.edu.au
Flinders Research Centre for Coastal & Catchment Environments	The Centre undertakes and funds collaborative research into the improved monitoring and management of the vital health of coastal and water catchment ecosystems in South Australia and elsewhere.	Howard Fallowfield Director	howard.fallowfield@flinders.edu.au

Research Grouping	Capabilities	Key Contact	Contact Details
University of South Australia			
Centre for Water Science and Systems	Water and waste water treatment, water reuse, desalination, water utilisation from the River Murray and the provision of water services for rural and desert communities	Simon Beecham Acting Director	simon.beecham@unisa.edu.au
Collaborative groupings			
CLLAMM	Hydrology, hydrodynamics and ecology of the Coorong, Lower Lakes and Murray Mouth	Sebastien Lamontagne Mike Geddes	sebastien.lamontagne@csiro.au mike.geddes@adelaide.edu.au
Florasearch	Economically viable perennial production systems	Mike Bennell	bennell.michael@saugov.sa.gov.au
Lower Murray Landscape Futures	Integrated futures modelling	Thea Williams Glen Walker	thea.williams@adelaide.edu.au glen.walker@csiro.au
Mallee Sustainable Farming Systems Project	Sustainable dryland farming systems in the Mallee region of SA, Vic and NSW	David Roget	david.roget@csiro.au
ARC Research Network: Environmental sciences	How best to describe Australia's current biodiversity and the biological and environmental history leading up to the present. Develop ability to predict the impacts of environmental change on biodiversity to assist management decisions.	Bob Hill Director	robert.hill@adelaide.edu.au
Water for a Healthy Country – River Murray node	Develop the knowledge needed to substantially improve the way water is used and managed along the River Murray	Sarah Ryan Director	sarah.ryan@csiro.au

Appendix B. Cooperative Research Centres in SA

CRC Desert Knowledge	A national research network linking Aboriginal and local knowledge with science and education to improve desert livelihoods	http://www.desertknowledge.com.au/
CRC Plant Based Management of Dryland Salinity	Through an improved understanding of the way natural and agricultural ecosystems work, the CRC will provide new plant-based land use systems that lessen the economic, environmental and social impacts of dryland salinity and thereby help to sustain rural communities.	http://www.crcsalinity.com/index.php
e-Water CRC	Builds and supports decision systems and models for total water cycle management in urban and rural catchments, integrating water quality and quantity, stream ecology and economics.	http://www.ewatercrc.com.au/
CRC Water Quality and Treatment	Research on iissues relating to water quality management and health risk reduction, from catchment and reservoir management and water treatment to the distribution of drinking water to consumers' taps.	http://www.waterquality.crc.org.au/
CRC Irrigation Futures	Cooperative research and training networks and programs which continuously improve irrigation policy, tools, practices and processes to: * double irrigation water use productivity * improve profitability for commercial irrigation enterprises and * protect and enhance landscapes and the environment	http://www.irrigationfutures.org.au/
Weeds CRC	Research to inform strategies to reduce the risks posed by current and new weed incursions	http://www.weeds.crc.org.au/index_flash.html

Appendix C. Key Contacts and Brokers in Research Organisations

Organisation	Key contact person	Contact details
CRC Irrigation Futures	Wayne Meyer, Research Director	wayne.meyer@csiro.au 08 8303 8439
CRC Desert Knowledge	Maarten Ryder, Program Leader	maarten.ryder@csiro.au 08 8303 8534
CRC Plant Based Management of Dryland Salinity	Glen Gale, Node Manager for South Australia	gale.glen@saugov.sa.gov.au 08 303 9345
e-Water CRC	Ed Pikusa, Leader River and Catchment Restoration Toolkit	pikusa.edward@saugov.sa.gov.au 08 8463 6984
CSIRO L&W	Glen Walker, Stream Leader Warwick McDonald, Science Director, Water for a Healthy Country Flagship	glen.walker@csiro.au 08 8303 8743 warwick.mcdonald@csiro.au 02 6246 5926
Flinders University	Duncan Mackay, Director, BioKnowledge	duncan.mackay@flinders.edu.au 08 8201 2528
University of Adelaide	Paul Dalby, Facilitator of Water Research Cluster Jackie Venning, Coordinator of Sustainability Cluster Prof. Bob Hill, Head of School of Earth and Environmental Science	paul.dalby@adelaide.edu.au 08 8303 6697 jackie.venning@adelaide.edu.au 08 8303 4870 robert.hill@adelaide.edu.au 08 8303 5597
University of South Australia	Bruce Perkin, Business Manager	bruce.perkin@unisa.edu.au 08 8302 3565

Organisation	Key contact person	Contact details
SARDI	Rob Thomas, Chief Scientist Sustainable Systems	thomas.r@saugov.sa.gov.au 08 8303 9417
DWLBC	Fraser McLeod, Director Knowledge and Information	macleod.fraser@saugov.sa.gov.au 8463 6800
DEH	Peter Alexander, Manager Biodiversity Conservation	alexander.peter@saugov.sa.gov.au 08 8222 9311
MDBC	Stephen Sunderland, Manager, Natural Resource Information	stephen.sunderland@mdbc.gov.au 02 6279 0519

Appendix D. Consistency with Other Regional, State and National Priority Setting Processes

The following section describes state and national priority setting processes, and identifies consistencies and areas of common interest with setting research priorities for the SAMDB region. These processes are:

- National Research Priorities
- State Science and Technology Innovation Plan
- State Strategic Plan
- State NRM plan
- SAMDB NRM Investment Strategy

D1. National Research Priorities

Australia's national research priorities were announced by the Prime Minister in late 2002 and were enhanced and refined in 2003 to take greater account of the contributions of social sciences and humanities research[9]. The national research priorities are thematic and are underpinned by 'priority goals'. There are four national research priorities and their associated priority goals:

- An Environmentally Sustainable Australia;
- Promoting and Maintaining Good Health;
- Frontier Technologies for Building and Transforming Australian Industries; and
- Safeguarding Australia.

Under "An Environmentally Sustainable Australia", there are seven priority areas for research:

1. Water – a critical resource
2. Transforming existing industries

[9] http://www.dest.gov.au/sectors/research_sector/policies_issues_reviews/key_issues/national_research_priorities/default.htm

3. Overcoming soil loss, salinity and acidity
4. Reducing and capturing emissions in transport and energy generation
5. Sustainable use of Australia's biodiversity
6. Developing deep earth resources
7. Responding to climate change and variability

D2. State's Science and Technology Innovation Plan

The State's Science and Technology Innovation Plan is called STI10 (http://www.innovation.sa.gov.au/sti/10_year_vision). The Vision for STI10 identifies six outcomes from investment in innovative research, one of which is, "*to protect our natural resources*", which is consistent with the objective of the SAMDB NRM Board to develop research priorities for NRM in its region to focus investment in research and innovation on those areas that will deliver the greatest benefit to NRM management in the region.

To encourage the growth of an innovative culture and to deliver the Vision of STI10, the Plan identifies the need for the following:

1. Excellent and distinctive R&D capability and reputation
2. Growth of nationally and internationally competitive industries
3. Establish research and innovation precincts
4. Strategic leadership by the State Government
5. Develop a strong culture of innovation
6. Organisations to have a willingness to invest in innovation
7. A whole of government commitment to STI10
8. Targeted and relevant STI education and skills development
9. Community awareness and engagement
10. Efficient management and monitoring of performance.

The SAMDB NRM Board through initiating this project is demonstrating a strong culture of innovation (5) and a willingness to invest in innovation (6), become part of a whole of government

commitment to STI10 (7) and are creating greater community awareness and engagement in the innovation process by bringing researchers, government and community together to discuss research needs in NRM (9). As such, the SAMDB NRM Board can demonstrate a clear commitment to delivering the objectives of STI10, to the full extent it is able, through the development of the SAMDB NRM Research Plan.

D3. State's Strategic Plan

South Australia's Strategic Plan is aimed at improving the well being and prosperity of South Australians. The State Strategic Plan is a template against which all investment by the State Government is supposed to fit within. Over the next 10 years the Strategic Plan aims to reach 84 measurable targets. Some have already been achieved, while others will require many years of focused attention. There are six Objectives of the State Strategic Plan:
Objective 1: Growing Prosperity
Objective 2: Improving Wellbeing
Objective 3: Attaining Sustainability
Objective 4: Fostering Creativity
Objective 5: Building Communities
Objective 6: Expanding Opportunity

Two of these are relevant to the development of research priorities for investment in NRM-related research in the SAMDB: Objective 3 Attaining Sustainability and Objective 4 Fostering Creativity. The following text-boxes quote the Key Points, Relevant Targets and Actions identified in the State Strategic Plan for the two Objectives relevant to this project.

It is clear from this analysis that setting priorities for research in NRM for the SAMDB is highly consistent with the State Strategic Plan, and that the outcome of the project should particularly support restoring flows to the River Murray, incorporating biodiversity values into land-based rural businesses and to encourage landholders to protect and manage their local remnant vegetation. Any increased investment in R&D that results from this process will support the objectives of the State Strategic Plan.

Objective 3: Attaining Sustainability

Key Points

Our priority is to make South Australia world-renowned for being clean, green and sustainable. This will boost community wellbeing, safeguard future generations and contribute to our State's prosperity. The focus will be on protecting our biodiversity, securing sustainable water and energy supplies, and minimising waste.

* Foster a culture of sustainability
* Raise environmental profile globally
* Seek creative solutions to environmental issues
* Reinforce our 'clean and green' image for food and wine exports
* Meet the challenges of water management – especially the River Murray
* Stimulate growth of environmental business
* Show national leadership in environmental management

Relevant Targets to SAMDB NRM Board

The River Murray: Increase environmental flows by 500 GL in the Murray-Darling and major tributaries by 2008 as a first step towards improving sustainability in the Murray-Darling Basin, with a longer-term target to reach 1500 GL by 2018. (T3.1)

Greenhouse emissions: Achieve the Kyoto target during the first commitment period (2008 - 12). (T3.3)

Land biodiversity: Have five well-established biodiversity corridors linking public and private lands across the state by 2010. (T3.4)

Native vegetation: Any clearance of native vegetation being offset by significant biodiversity benefit by 2005. (T3.6)

Integrate native vegetation/biodiversity management in South Australia's eight Natural Resource Management regional plans by 2010. (T3.7)

Lose no species. (T3.8)

Objective 3: Attaining Sustainability

Priority Actions relevant to SAMDB NRM Board

Restore environmental flows to major rivers across the Murray-Darling Basin.

Primary responsibility: Commonwealth Government, State Governments, industry and community

Incorporate biodiversity values into rural businesses operated by landholders.

Primary responsibility: Landholders

Encourage private landholders to protect remnant vegetation from further decline and to actively manage their local resource.

Primary responsibility: State Government

Objective 4: Fostering Creativity

Key Points

Our priority is to reinforce South Australia as a place that thrives on creativity and innovation. This capacity to do things differently will be one of the keys to achieving all of our objectives. The focus will be on fostering a culture of creativity, on developing creative, innovative and enterprising people, on investing in science and research, and in innovation infrastructure, and on converting ideas into practice.

* Build on our creative heritage
* Foster a culture of creativity - vital for economic growth
* Encourage innovation, which will drive productivity growth and create new jobs
* Apply science and technology to boost innovation
* Encourage creativity and enterprise in our young people
* Support creativity with commercial reality

Relevant Targets to SAMDB NRM Board

Exceed the national average of business expenditure on research and development (as a percentage of GSP) and approach the OECD average within 10 years

Business to increase investment in research and development and identify opportunities for commercialising public sector R&D

Priority Actions relevant to SAMDB NRM Board

None

D4. State NRM Plan

The State NRM Plan establishes a 50 year vision and charts key directions for NRM over the next five years. A guiding principle of the State NRM Plan is:

"Knowledge is power – It is essential to develop and share knowledge and that the understandings of rural, urban, Aboriginal and scientific communities are sought and valued".

This principle underpins the importance of research in developing knowledge that can be used by the participants in NRM. The Plan recognises that "science, technology and innovation are critical to continually improve NRM".

Some key knowledge gaps identified in the State NRM Plan are:

- ecosystem processes (understanding causes of problems and resource limits)
- natural resource repair technologies (lessening symptoms, fixing problems)
- financially viable and ecologically sustainable natural resource-based industries
- social and economic issues regarding the use and protection of natural resources
- landscape and climate futures
- water and irrigation futures
- indicators and evaluation tools to underpin the adaptive management framework required by the Act.

D5. SAMDB NRM Investment Strategy

The SAMDB NRM Investment Strategy acknowledges that people leading the management of natural resources in the SAMDB need good information and proven technologies to assist in decision-making processes.

The Strategy notes that R&D performance relevant to the region is dependant on the NRM Board's capacity to identify appropriate projects and relative experience and expertise of those engaged to undertake the work. The SA MDB NRM Board is in the process of establishing a R&D working group to provide specialist input on R&D assessment and direction that is consistent with the regional NRM plan, investment strategies and on-ground actions.

Seven themes for research have been recognized, these being:

- Landscape and Climate Futures
- Water and Irrigation Futures
- New Industries
- Social and Economic Research
- Hydrological and Salinity Processes
- Biodiversity Conservation and Restoration
- Marine and Estuarine Futures.

It is recognized that the some knowledge gaps will be better addressed by a national research effort, whilst others of more specific relevance will be better addressed by State and regional investigations.

The focus for 2005/2006 & 2007/08 (Investment Strategy Phase 4) is to utilise the R&D review and gap analysis outcomes to establish a range of longer-term research actions as well as provide for 'short-term' actions in order to address and resolve issues arising from within the other programs

being implemented through the Investment Strategy. The approach adopted will permit both better integration of future R&D actions and establish a level of ongoing opportunity for R&D practitioners focusing on actions applicable to natural resource management outcomes in this region.

Proposed Actions of the SAMDB NRM Investment Strategy

Identification of future short and long-term R&D priorities following the identification of R&D gaps, through consultation with key regional stakeholders and via the Reference Groups involved in the Investment Strategy development process.

The following list of projects identifies areas of research where the SAMDB is already active. Other major research projects that are underway that have relevance to the region are listed in Table 5.

Table D1. List of current SA MDB R&D projects facilitated by the SA Centre for Natural Resource Management and funded by NAP

Project name	Status	Comment/Description
Lower Murray Landscape Futures	Stage 1 - Approved, funded and completed Stage 2 - Approved and funded	First phase of this project developed the process and modules to visualise the future. Second phase is a pilot project proposed as a proof of concept for the Landscape Futures program. This pilot will focus on the future landscapes of the Mallee region, and in particular on the shape of those future landscapes.
Managing horticulture under a more saline environment	Approved and funded	The salinity in the River Murray is expected to rise with the result being more frequent and longer period of high River salinity. Creation of water trading has seen the price of water rise and a reduction in the annual application rates to perennial crop. The reduction in irrigation applications coincides with an increase in the use of deeper rooting rootstocks. Sustained horticultural production in the future will require new techniques.

Project name	Status	Comment/Description
Development of Multipurpose Biomass Industries for the South Australian Murray Mallee	Approved and funded	This project will contribute information critical for the development and establishment of new industries based on multi-product biomass in low rainfall agricultural areas of SA with the purpose of providing a commercial driver for broad scale revegetation with deep rooted perennial species for recharge control.
Establishment of Aquaculture Parks aligned to major saline groundwater interception schemes in South Australia	Stage 1 - Approved, funded and completed Stage 2 – Approved and funded	This research project will evaluate the commercial aquaculture potential of selected species and culture systems using ground water from the Woolpunda/Waikerie/Qualco Salinity Interception Scheme (SIS) that discharges into the Stockyard Plains Disposal Basin (SPDB). Specifically, this project will establish an integrated R&D, demonstration and training facility near Waikerie. This facility will be used to undertake research to provide the information required to attract private sector investment in potential commercial farms
Practical land use options for sustaining water quality in the South East Region of South Australia	Approved and funded	The water resource in the South East region consists of significant groundwater resources that are wide spread and generally of a high quality. SENRCC have documented the regions important resources and the key threats to water quality that have the potential to degrade the resources, which could adversely affect agriculture, processing, and tourism industries.
Salinity Impacts on Lower Murray horticulture. Application and knowledge transfer of tri state salinity impact of Lower Murray Horticulture Project	Proposal accepted and funding recommended	Awaiting final approval from Joint Steering Committee.
The application of airborne geophysics top the design of saline groundwater interception schemes, groundwater recharge prediction and floodplain salinity management – Riverland South Australia	Proposal accepted and funding recommended	Awaiting final approval from Joint Steering Committee.

Project name	Status	Comment/Description
Sensitivity analysis of Models used to predict the effects of policy decisions on salinity levels in the River Murray	Proposal accepted and funding recommended	Awaiting final approval from Joint Steering Committee.
Sustainable production of biodiesel from micro algae utilising saline water from the salt interception schemes and saline aquifers in the Lower Murray	Proposal accepted and funding recommended	Awaiting final approval from Joint Steering Committee.
Water Use efficiency gains of grapevines and citrus using subsurface irrigation	Proposal accepted and funding recommended	Awaiting final approval from Joint Steering Committee.
Developing reliable model of drainage production from irrigated horticulture at farm and district level	Proposal accepted and funding recommended	Awaiting final approval from Joint Steering Committee.
Mallee dryland grazing systems – lucerne and new perennial legumes	Proposal accepted and funding recommended	Awaiting final approval from Joint Steering Committee.
Response of the River Murray floodplain to flooding and groundwater management	Proposal accepted and funding recommended	Awaiting final approval from Joint Steering Committee.
Surface water-groundwater interactions in River Murray wetlands and implications for water quality and ecology	Proposal accepted and funding recommended	Awaiting final approval from Joint Steering Committee.
Determining the impact of salinity and hydrology on larval fish recruitment in the Chowilla Anabranch System	Proposal accepted and funding recommended	Awaiting final approval from Joint Steering Committee.

Project name	Status	Comment/Description
Influence of irrigation and fertiliser management in movement of water and nutrients within and below the root zone of vines for sustainable grape production – integration of a SA Riverland site into a National Project	Proposal accepted and funding recommended	Awaiting final approval from Joint Steering Committee.
Influences of salinity and water quality on the recruitment dynamic of fishes in the Lower River Murray – larval distribution in relation to habitats	Proposal accepted and funding recommended	Awaiting final approval from Joint Steering Committee.
Understanding and managing the potential impacts of climate change and variability on the MDB economy and ecology and social structure	Proposal accepted and funding recommended	Awaiting final approval from Joint Steering Committee

Table 5. Research Projects funded outside the SAMDB NRM Board/ CNRM Partnership

Project Title	Chief Investigator	Lead Agency	Comments
Coorong Lower Lakes and Murray Mouth	Sebastien Lamontagne Mike Geddes	CSIRO University of Adelaide	A major project funded by CSIRO Water for a Healthy Country that includes a $2.2 M project to be delivered by a cross-institutional, cross-agency team from University of Adelaide, Flinders University and SARDI.

Appendix E. Description of R&D undertaken in SAMDB Region since 1995

E.1 Hydrology and salt load

The national and state governments, as well as the River Murray Catchment and Water Management Board, have invested significant funds to better understand the hydrological dynamics of the river, irrigation areas and dryland cropping areas to improve the ability to reduce salt load moving into the River. The benefits of this research have been to identify those parts of the system that contribute the greatest salt load to the River, which has helped to identify where to invest to reduce this salt load. Scientists who have published extensively in this area include:

- Steve Barnett and group (DWLBC)
- Ian Jolly, Peter Cook, Glen Walker, Andy Herzceg (CSIRO Land and Water)
- Graeme Heinson (University of Adelaide)

E.2 Fish ecology and management

The construction of weirs along the River Murray has impeded the migration of native fish species. Qifeng Ye (SARDI) and Keith Walker (University of Adelaide) have lead much of the research to identify the impacts of waterway management on native fish species and made suggestions from their research on removing the impediments to fish movement.

Students at the University of Adelaide have carried out numerous studies into the biology and ecology of fish in the River Murray channels and wetlands. Mike Hammer, a PhD student at the University of Adelaide, has undertaken many studies cataloguing fish distribution throughout the SAMDB NRM region.

SARDI have a major research program on commercial fisheries, including the River Murray system in South Australia (Qifeng Ye is the leader of this Program).

E.3 Wetland ecology

There has been some investment by governments and the previous Catchment Board into understanding the ecological dynamics of wetlands along the River Murray floodplain. A significant contribution to this research has been made by Keith Walker and George Ganf (University of Adelaide) and their honours and post-graduate students, many of whom now work for DWLBC or the new SAMDB NRM Board. DWLBC have undertaken and commissioned work to understand the salinity impact of flooding wetlands. There is a major gap in our understanding of how flooding wetlands influences nutrient dynamics in wetlands and back into the River Murray.

E.4 Coorong, Lower Lakes and Murray Mouth

A group of active researchers on the systems of the Coorong, Lower Lakes and Murray Mouth region have recently joined forces to apply for funds under the CSIRO Cluster Program and CSIRO Water for a Healthy Country Flagship to undertake an integrated study of the hydro-dynamics and ecology of the Coorong, Lower Lakes and Murray Mouth. This was successfully funded (the total value of research is over $7M) and will build upon the significant volume of work already undertaken in the area, resulting in a substantial improvement in knowledge of the system and how best to manage it. There will still be some research that is required that was not funded by the CSIRO Cluster Program and this is identified later in the report. The key researchers are:

- Mike Geddes, David Paton, Peter Gell, Keith Walker, George Ganf, Bronwyn Gillanders, Justin Brookes (University of Adelaide)
- Sebastien Lamontagne (CSIRO Land and Water)
- Qifeng Ye, Jason Tanner, Dale McNeil (SARDI)
- Peter Fairweather, Sabine Dittman (Flinders University)

Other researchers with a strong publication record in this area include:

- Bob Bourman (University of SA) and David Walker (University of Adelaide) on the geomorphology and hydrology of the Mouth
- Mike Burch (SA Water) on nutrients in the Lakes

The South East NRM Board have an interest in the Coorong and may be willing to co-invest in research on this system.

E.5 Nutrients in River Murray

The Australian Water Quality Centre (AWQC) in SA Water undertake regular surveys of water quality in the River Murray. Mike Burch from AWQC leads much of this research and Karla Billington from EPA and Melissa Bradley from the SAMDB Board have undertaken risk assessment analyses for water quality along the River. Chris Saint (AWQC) has lead research on faecal coliforms in drainage water from irrigated areas in the Lower Murray area.

Studies on nutrient run-off, particularly phosphorus run-off, from dairies in the Lower Murray have been undertaken by Nigel Fleming (SARDI)

Justin Brookes (University of Adelaide) and Mike Burch (SA Water) have developed a better understanding of the dynamics of cyanobacteria within the River Murray. David Lewis (University of Adelaide) is currently surveying water quality in parts of the River Murray with funding from EPA, SA Water and the SAMDB NRM Board.

E.6 Sustainable Irrigation

Gerrit Schrale, Mike McCarthy and Rob Stevens from SARDI and Tony Adam's group in Rural Solutions are undertaking research to better manage salt in irrigation systems in SA. Peter Dry from the University of Adelaide and staff from Rural Solutions have developed the partial root-zone drying irrigation system. The CRC Irrigation Futures are a major research grouping in irrigation research with a core interest in irrigation-related research along the River Murray system.

E.7 Dryland farming systems

The Mallee Sustainable Farming System Project[10] funded through GRDC[11] and NHT has been a major focus of activity for dryland farming systems research in the region over the last decade. The Project has a board made up of farmers and researchers, and has extension committees in SA, Victoria and NSW. The research is largely based in CSIRO and has been lead by David Roget from CSIRO Land and Water and involved:

- Gupta Vadakattu, Rick Llewellyn, Bill Davoren, Jeff Baldock (CSIRO),
- Gary O'Leary (DPI Victoria),
- Jack Desboilles (University of SA).

Victor Sadras was heavily involved in this project, but has since moved to SARDI.

Steve Barnett (DWLBC) and CSIRO Land and Water have undertaken studies on groundwater flows, recharge and salinity in the Murray Mallee region.

E.8 Mallee biodiversity

David Paton (University of Adelaide) and his students as well as staff from DEH are the main contributors to published knowledge on biodiversity in the Mallee region. DEH have a focus on biological surveys and David Paton's group has been predominantly interested in the management of bird populations and fire management in National Parks.

There seem to be some fundamental gaps in basic knowledge of the abundance, distribution and trends in abundance of different native species in the region, which may hamper the ability to identify priorities for action in managing biodiversity.

[10] http://www.msfp.org.au/
[11] Grains Research and Development Corporation

E.9 Rangelands management

There seems to be little in the way of research underway in the rangelands area of the SAMDB region. Mike Bull (Flinders University) has been studying the ecology of lizards and their ticks in the region for a number of decades. Jose Facelli (University of Adelaide) has an interest in grasslands and Fleur Tiver (University of SA) has undertaken research on weed invasion and grazing impact on rangeland systems.

E.10 Pest Control

The CRC Weeds has focussed and coordinated much of the weed control research over the past 14 years. The organisations with the most capability in this area of research are the University of Adelaide and DWLBC.

- Jeanine Baker, Gurjeet Gill, Angela Wakelin, Peter Boutsalis, Alireza Marefa, Glen McDonald, Chris Preston, Jose Facelli, Vallesamy Ganeshan, Robin St. John-Sweeting (University of Adelaide)
- John Virtue (DWLBC)

The University of Adelaide and DWLBC have research capability in vertebrate pest control.

- Phil Stott (University of Adelaide)
- Bob Henzell, Greg Mutze (DWLBC)

SARDI and the University of Adelaide have the majority of the research capability in SA on invertebrate pest and disease control.

- Eileen Scott, Otto Schmidt, Amanda Able, Satish Dogra, John Randles, Mike Keller, Nicole Thompson, Dagma Hanold (University of Adelaide)
- Greg Baker, Tony Burfield, Gabriella Caon, Vanessa Cockington, Nancy Cunningham, Ken Henry, Dennis Hopkins, Dijana Jevremov, Bill Kimber, Nola Lucas, Nathan Luke, Kym Perry, Kevin Powis, Cathy Smallridge (SARDI)

E.11 Revegetation

There have been a number of studies investigating the most appropriate sites for revegetation to manage groundwater recharge:

- Glen Walker, Peter Cook, Brett Bryan and Neville Crossman (CSIRO Land and Water)
- Trevor Dooley (Rural Solutions)
- Steve Barnett (DWLBC)
- Peter Bullman (previously PIRSA, now a private consultant)

Jeff Connor and John Ward (CSIRO Land and Water) have explored policy options and market based instruments for encouraging revegetation in the region.

A major project (Florasearch) funded under the CRC Plant Based Management of Dryland Salinity aims to identify production systems based on perennial vegetation that could compete with other land uses economically. The key researchers are Mike Bennell, Trevor Hobbs (DWLBC) and Ian Nurberg (University of Adelaide).

David Paton and his students (University of Adelaide) have assessed the habitat value of different revegetation sites and types.

John Virtue (DWLBC) has assessed the risk of invasion (weediness) of different revegetation programs and the plant species used for revegetation, soil stabilisation and fodder.

E.12 Eastern Mount Lofty Ranges

A major issue for natural resource management in the eastern Mount Lofty Ranges (EMLR) is to provide sufficient flows of water to maintain ecological processes in creeks and streams. Information is required on ecological processes in streams, fish biology and ecology and an analysis of flow to creeks and streams from surface- and ground-water sources.

- George Ganf and Keith Walker (University of Adelaide) and their students have undertaken significant work on the ecology of the riparian systems in the EMLR. Darren Hicks and Paul McEvoy (AWQC) have undertaken a project to identify water requirements of the Tookayerta Catchment. This work has been supported by the River Murray Catchment and Water Management Board.
- Jim Cox and Chris Smitt (CSIRO Land and Water) and Steve Barnett, Glenn Harrington, D. Zulfic and Kumar Savadamuthu (DWLBC) have undertaken surface water and groundwater assessments in the EMLR
- Jim Cox and Rob Fitzpatrick (CSIRO Land and Water) have undertaken research on the causes of water and soil degradation in the area.

E.13 New Industries

New industries may help manage the symptoms of degradation (for example by making economic use of saline water resources) or address the causes (eg. Reduce recharge, provide alternative crops to diversify income/protect soil). Research has explored:

- Options for including perennial plants in the landscape that provide a similar profit to annual systems (Mike Bennell, Trevor Hobbs – DWLBC, Ian Nuberg – University of Adelaide)
- The feasibility and economic potential of using irrigation drainage water for aquaculture (Tim Flowers, Steve Clarke – SARDI)
- The technical and economic feasibility of extracting minerals from salt extracted from saline groundwater or irrigation drainage water (CSIRO Minerals).

SARDI is developing two new programs in this research area:

- Production of feedstock for bio-diesel from mustard/canola or micro-algae (Kevin Williams)
- Biosaline agriculture: using irrigation drainage water to grow salt tolerant crops and fodder (Gerrit Schrale). Jim Townsend from Micromet Pty Ltd and John Leake from NyPa Pty Ltd are two commercial interests in developing an industry in this area.

The CRC Plant Based Management of Dryland Salinity have a major focus on developing new, perennial based systems for dryland areas, to combat salinity in particular. Their major investment in the SAMDB is through the Florasearch project.

Developing new production systems based on perennial plants that are reliable and economically sustainable are a key missing component of what would otherwise be sustainable farming systems in the dryland Mallee farming region.

E.14 Social and economic research

It has only been recently that there has been a systematic analysis of social and economic options and impacts in relation to natural resource management. There have been a number of studies undertaken on the economic impacts and options for natural resource management programs in the SAMDB region, mostly by CSIRO Land and Water (ARCWIS):

- Jeff Connor, John Ward, Mike Young, Brett Bryan.

Blair Nancarrow and Geoff Syme from CSIRO Land and Water have undertaken research on social fairness of water trading and allocation.

E.15 Futures research

The Land Technologies Alliance (LTA) is a partnership between DWLBC, CSIRO Land and Water, SARDI, University of Adelaide and DPI Victoria. The LTA obtained funding from the Centre for Natural Resource Management to fund a project to:

- Analyse the impact of existing regional plans and investment strategies on natural resources, with consideration given to community well-being (social, economic and environmental outcomes); and,
- Explore future options and scenarios for the Lower Murray in partnership with stakeholders in the region. This is intended to lead to improved outcomes from investment by regional planning groups, communities, industry and government.

The project is a major collaboration between three states, four regional groups and three research agencies. It is nearing its completion (2007). The main researchers participating in the project are:

1. Thea Williams (University of Adelaide)
7. Glen Walker, Rebecca Doble, E. Wang, Ian Jolly, Brett Bryan, John Ward, Jeff Connor, Chris Smith, Blair Nancarrow (CSIRO)
8. Martin Blumi, Richard MacEwan, Steven Williams (DPI Victoria)
9. Matthew Miles (DWLBC)

Appendix F. Low, Medium and High Levels of Investment in Research

Generally, the lower the levels of commitment from the Board, the less control it has over the direction, timing and ownership of the research, and conversely, the more it is prepared to commit, the greater control the Board will have over the research and any ownership of IP (intellectual property) (See Table F1).

For Low levels of investment, the Board is likely to be either a supporter of a project funded substantially by a third party, or a tertiary student is involved in delivering the majority of the research outputs. Appendix G describes how students can be funded (by the University or ARC Linkage) and what the Board would be expected to provide in each case. By offering only low levels of investment, the Board risks research not being done at all, or done to a lower standard and/or over longer timeframes. However, as part of a mix of investments, the Board as a minor partner and co-investor can encourage research to be done across a broad spectrum, that over time builds a better understanding of the region and its processes.

For medium levels of investment, the Board is gaining more control over the timing, quality and direction of the research compared to low levels of investment. Because the Board is usually seeking co-investment from other partners, it will still not have total control over all aspects of the research and may have to compromise some aspects of the research direction and/or timing. With careful planning, the Board should be able to direct most of its investment in partnership with others, seeking co-investment from the variety of funding sources listed in Appendix G.

When the Board is the major investor in research, or is participating in a large, integrated research project, it can expect high levels of quality outputs, delivered in commercial timeframes and in a direction that is of high relevance to the Board. By careful planning and building strong relationships with research institutions, the Board can minimise the number of high level investments it has to make. These investments should be made where the results are required in a short timeframe, where there are no obvious co-investors and where the outcomes of the research will deliver major improvements in the efficiency and effectiveness of immediate investment decisions the Board is required to make.

Table F1: What can the Board expect from High. Medium and Low levels of investment?[12]

	Investment Level		
	Low	**Medium**	**High**
Investment options	• Staff time to identify research needs and monitor outputs • $0 to $5,000 (<25% of research costs)	• Staff time of to identify research needs and monitor outputs • $5,000 to $50,000 (20-50% of research costs)	• High level of collaboration with research organisation • 50% to 100% of full research costs
What sorts of problems	• Simple problems that require little new capital investment to solve • Non-urgent problems	• More complex problems that require leading experts • Where capital investment in equipment is required • More urgent problems	• Highly complex problems • Major capital investment required to undertake research • Urgent problems • Where IP must be controlled
Time-scale for results	• Not in a "commercial" timeframe. • Nine months (Honours project) to three years for PhD project • Quality of research dependent on quality of student	• 1-6 months for straight forward consultancies • 2-3 years for major research projects • High level of quality	• "Commercial" timeframes for results • High level of quality
Level of ownership	• The University where the student is enrolled generally holds ownership of IP, depending on the relative contribution of the partners	• Dependent on level of investment by the partners, but most common outcome is that research organisation controls IP	• "Purchaser" generally controls IP, depending on relative contribution to research costs
Options for Co-Investment	• University funded scholarships for honours and PhD students • Australian Research Council Linkage Grants for PhD students ARC Discovery Grants	• Australian Research Council Linkage Grants • Industry Research and Development Corporations • Federal Government Grants (NAP, NHT, NLP Innovation Grants)	• Direct contracting • Direct co-investment with other parties

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[12] Adapted from "Research Cooperation with the University of Adelaide: A 'How To' Guide for Industry", University of Adelaide, 2006.

Appendix G. Research Funding Options

This Table summarises information to be found in a CNRM report on funding opportunities in NRM[13].

Funding scheme	Description	Expectations of the Board
University funded research students	Universities have internal funds for honours and PhD students	• Identify research areas of interest • Provide access to field sites and equipment • Top-up funding and access to regional expertise may attract students and their supervisors
ARC Discovery	Research grants for high quality research. Pays full marginal cost of research[14]. Only university academics can apply.	• Identify research areas of interest • Provide access to field sites and equipment
ARC Linkage	Approximately 70% of marginal costs of research paid to University academics. Only university academics may apply. Requires industry co-investment	• 30% of the marginal costs of research • Access to field sites
CSIRO Flagships	CSIRO invests directly in research through its Flagship Program. Water for a Healthy Country Flagship already invests heavily in the SAMDB Region.	• Strategic advice on what research would be of value • Participation in Steering Committees and Technical Advisory Groups
Federal government research and development corporations	The Federal Government funds numerous Research and Development Corporations[15].	• Identify research areas of interest • Co-investment by the Board will increase chances of successful funding
Murray Darling Basin Commission	The MDBC funds significant numbers of investigations to underpin the development of more sustainable approaches to managing water resources in the MDBC	• Identify areas of potential co-investment with the MDBC
AusIndustry	The Federal Government funds commercialisation of research through a variety of funding programs under AusIndustry	• Identification of how the technology will be commercialised
State government	The State Government (DWLBC, PIRSA, DEH) invests in research internally and purchases research from external providers	• Co-investment • Identification of research priorities
Private research funds	There are a variety of private philanthropic trusts that will invest in research	• Identification of research priorities • Co-investment by the Board will increase chances of successful funding

[13] Dalby, P. (2005) Research funding opportunities for NRM Boards in SA. In Fusion Consulting for DWLBC.
[14] For ARC grants, the University does not charge the full cost of research. Salaries of staff and overhead costs of students and post-doctoiral fellows are provided by the University as their in-kind contribution to the research
[15] Land and Water Australia, Rural Industries Research and Development Corporation, Grains Research and Development Corporation, other rural-industry linked research and development corporations

Appendix H. Review of SAMDB NRM Research Database

The SAMDB NRM Research Database was used to identify researchers who were particularly active in publishing research in particular fields. The result of this analysis is documented in Table B1. This analysis has been used to identify invitees to the workshops.

Table H1. Most common authors for particular research areas in the SAMDB NRM Research Database

Search Words	Author	Publications	Institution	Research Area
River	Keith Walker	72	UoA	River and wetland health
	Glen Walker	51	CSIRO	Salt balance of R. Murray, impact of water on floodplains
	Ian Jolly	40	CSIRO	Salt balance of R. Murray
	Phil Davies	38	CSIRO	Salt and water balance, EMLR
	David Paton	30	UoA	Conservation biology, Fire, Coorong
	Fred Leaney	26	CSIRO	Salinity, groundwater movement
	Mike Burch	22	SA Water	Water quality, blue-green algae
	Justin Brookes	15	UoA	Water quality, blue-green algae
	Sebastien Lamontagne	14	CSIRO	Acid-sulphate soils, hydrology
	Andy Herczeg	12	CSIRO	Salinity, groundwater movement
	Ian Overton	11	CSIRO	Vegetation and water balance studies of Chowilla
	Qifeng Ye	10	SARDI	Fish biology and management
	Mike Young	8	UoA	Institutional arrangements
	Bob Bourman	8	UniSA	Murray Mouth
	Steve Barnett	8	DWLBC	Salinity, groundwater movement
	Peter Cook	7	CSIRO	Salinity, groundwater movement
Irrigation	Peter Dry	15	UoA	Partial rootzone drying
	Mike McCarthy	8	SARDI	Partial rootzone drying
	Steve Barnett	8	DWLBC	Hydrology
	Rob Stevens	6	SARDI	Salinity impact on grapes
	Wayne Meyer	5	CSIRO	Sustainable Irrigation
Irrigation	Tony Adams	5	PIRSA	Water use efficiency
	Fred Leaney	5	CSIRO	Groundwater salinisation
	Nigel Fleming	3	SARDI	Nutrients loads lower Murray
	Gerrit Schrale	3	SARDI	Leaching efficiencies
Mallee	David Roget	40	CSIRO	Sustainable Farming Systems
	Victor Sadras	22	SARDI	Sustainable Farming Systems
	Vadakattu	19	CSIRO	Soil biology under dryland cropping

Search Words	Author	Publications	Institution	Research Area
	Gupta			
	David Paton	17	UoA	Conservation biology, fire
	Steve Barnett	13	DWLBC	Salinity, groundwater movement
	Gary O'Leary	10	CSIRO	Subsoil constraints
	Peter Cook	7	CSIRO	Salinity, groundwater movement
EMLR	Rob Fitzpatrick	57	CSIRO	Acid sulphate soils, water logging, salinity
	Jim Cox	40	CSIRO	water and soil degradation, salinity, phosphorous movement in cathcments
	Phil Davies	38	CSIRO	Salt and water balance EMLR
	Chris Smitt	11	PIRSA	Salt balance EMLR
	Angus Bremer Water M.C.	8		Impact of irrigation in EMLR
	Mike Hammer	4	UoA	Fish biology and management in EMLR
22. Improve or maintain condition of native vegetation				
	John Ward	3	CSIRO	Market based instruments
	David Paton	5	UoA	Conservation Biology
	Jeff Connor	4	CSIRO	Market based instruments
Weed	John Virtue	1	CRC Weeds	Weed risk assessment
Economic	Mike Young	4	UoA	Economic and social impact of water reform along R. Murray
	John Ward	2	CSIRO	Economics of revegetation strategies
	Brett Bryan	2	CSIRO	Valuing landuse change
	Doug Young	2	PIRSA	Economic evaluation
Social	Hassall & Associates	2	Hassall & Associates	Social impact assessment
	Mike Young	2	UoA	Economic and social impact of water reform along R. Murray
Indigenous		1	Ngarrindjeri Ramsar W.G .	Ngarrindjeri perspectives

Appendix I. Attendees to Workshops

Table I1. Invitees to River Systems Workshop

River Systems Workshop Invitees	Attended
Keith Walker, University of Adelaide	!
Glen Walker, CSIRO Land & Water	x
Ian Jolly, CSIRO Land & Water	
Fred Leaney, CSIRO Land & Water	
Mike Burch, AWQC – SA Water	
Justin Brookes, University of Adelaide	!
Sebastien Lamontagne, CSIRO Land & Water	x
Andy Herczeg, CSIRO Land & Water	
Ian Overton, CSIRO Land & Water	
Qifeng Ye, SARDI	x
Mike Young, University of Adelaide	
Bob Bourman, University of SA	
Tony Adams, Rural Solutions	
Gerrit Schrale, SARDI	x
Mardi Van der Wielen, SAMDB NRMB	
Rob Thomas, SARDI	
Phil Cole, DWLBC	!
Peter Dry, University of Adelaide	
Mike McCarthy, SARDI	
Rob Stevens, SARDI	x
Wayne Meyer, CRC Irrigation Futures	x
Ben Bruce. DWLBC	
John Wood, EPA	
Peter Waanders, SAMDB NRMB	x
Dan Meldrum, SAMDB NRMB	x
Nigel Long, SAFF	x
John Bourne, DWLBC	x
Lisien Loan, EPA	
Jason Higham, Rural Solutions	x

x = attended, ! = did not attend but was interviewed, - = Interview pending

Table I2. Invitees to Dryland Systems Workshop

Dryland Systems Workshop Invitees	Attended
Rob Fitzpatrick, CSIRO Land & Water	
David Roget, CSIRO Land & Water	!
Jim Cox, CSIRO Land & Water	
Victor Sadras, SARDI	x
Vadakattu Gupta, CSIRO Land & Water	x
David Paton, University of Adelaide	
Steve Barnett, DWLBC	x
Chris Smitt, DWLBC	
Gary O'Leary, CSIRO Land & Water	
Peter Cook, CSIRO Land & Water	
Mike Hammer, University of Adelaide	x
Mike Burnell, DWLBC	
Peter Butler, DWLBC	x
Jeff Connor, CSIRO Land & Water	
John Virtue, CRC Weeds	
Phil Davies, CSIRO Land & Water	
Nigel Long, SAFF	x
Rebecca Arnold, SAMDB NRMB	x
Sarah Kuchel, SAMDB NRMB	x
Mardi Van der Wielen, SAMDB NRMB	x
Vicki Hawker, SAMDB NRMB	
Dale McNeil, SARDI	x
Jeff Foulkes, PIRSA	

x = attended, ! = did not attend but was interviewed, - = Interview pending

Table I3: Invitees to Terrestrial Ecosystems Workshop

Terrestrial Ecosystems	Attended
David Paton, University of Adelaide	x
Michael Bull, Flinders University	-
Jose Facelli, University of Adelaide	x
Nigel Willoughby, Dept Environment and Heritage	x
Peter Cale, Dept. Environment and Heritage	x
Lisa Mensforth, SAMDB NRMB	x
Peter Copley, Dept. Environment and Heritage	
Fleur Tiver, University of SA	!
Wendy Stubbs, Dept. Environment and Heritage	
Mardi ven der Wielen, SAMDB NRMB	
Peter Waanders, SAMDB NRMB	
Dan Meldrum, SAMDB NRMB	
Rebecca Arnold, SAMDB NRMB	
Sarah Kuchel, SAMDB NRMB	
Amy Lee, SAMDB NRMB	
Amy Goodman, SAMDB NRMB	

x = attended, ! = did not attend but was interviewed, - = Interview pending

Table I4: Invitees to Social Systems Workshop

Social Systems Workshop Invitees	Attended
Jeff Connor, CSIRO Land & Water	
John Ward, CSIRO Land & Water	x
Meryl Pearce. Flinders University	
Tiffany Morrison, Flinders University	
Peter Butler, DWLBC	x
Michael Deering, DWLBC	
Phil Cole, DWLBC	x
John Johnson, SAMDB NRMB	
Dan Meldrum, SAMDB NRMB	
Tamara McPherson, SAMDB NRMB	
Amy Goodman, SAMDB NRMB	
Lib Hylton Keele, PIRSA	x
Nigel Long, SAFF	
Andrew Lowe, DEH	
Graeme Hugo's group, University of Adelaide	
Jenny Cleary, PIRSA	
Jason Downs, PIRSA	

x = attended, ! = did not attend but was interviewed, - = Interview pending

Appendix J. Resource Condition Targets

From the SA Murray Darling Basin Natural Resources Management Board Investment Strategy 2006/07 to 07/08

1. Maintain and improve the extent and condition of 65% of current floodplain vegetation communities in areas of high priority by 2020
2. By 2020, a 30% reduction in priority areas of floodplain currently affected by salinity from groundwater discharge
3. Maintain and improve the condition and connectedness of 60% of wetlands of high priority by 2020
4. Maintain and improve the condition of 60% of the littoral zone of high priority and high significance by 2020
5. By 2020, improve the habitat in all waters to permit successful recruitment of native fish, particularly Murray Cod, resulting from natural or manipulated flows
6. Recover 30% of water dependent ecosystems from pest infestation and minimize any further infestations by 2020
7. By 2020, to have salinity of water in the River Murray less than 800EC for 95% of the time at Morgan to ensure drinking water standards
8. By 2020, to have salinity of water in the River Murray less than 543EC for 80% of the time at Berri Irrigation Pump Station to ensure drinking water standards
9. By 2020, to have salinity of water in the River Murray less than 770EC for 80% of the time at Murray Bridge Pump Station to ensure drinking water standards
10. The phosphorous concentration in the River Murray is to be less than or equal to 0.05mg/L 90% of the time by 2020
11. The nitrogen concentration in the River Murray is to be less than or equal to 1.0mg/L 90% of the time by 2020
12. The turbidity level in the River Murray is to be equal or less than 80 NTU 90% of the time by 2020
13. Maintain blue green algal levels below the national standard threshold level for all sections of the River Murray and the Lower Lakes by 2020
14. Maintain and improve the stability of river banks, lake edges, sand dunes and cliffs by 2020
15. The Murray mouth open 100% of the time through fresh water outflows with adequate tidal variation to meet the needs of Coorong ecosystems
16. 30% of flow maintained in watercourses of EMLR to sustain ecosystem function by 2020
17. By 2020 to have constrained the area of salt affected land within the region to 120,000 ha
18. By 2020, reduce the area of agricultural land at risk of wind erosion during June each year by 40%
19. Reduce recharge by improving dryland water use efficiency to 70% across the region by 2020
20. To have an increasing trend in Soil carbon levels in cropping soils leading to improved soil health by 2020
21. Recover 30 % of quality native vegetation, habitat and agricultural production areas from pest infestation and minimize any further infestations by 2020
22. By 2020 improve or maintain condition of terrestrial native vegetation focusing on identified priority areas and improve condition of 50% of remnant vegetation on private land as well as increasing vegetation cover by 1% in the agricultural region
23. Maintain and improve the conservation status of all threatened National and State listed species and regionally threatened communities and species by 2020
24. By 2020 groundwater resources will not have salinity impacts on land condition and will meet the needs of dependent ecosystems
25. By 2006 to have developed a RCT relative to irrigated and waterlogged land
26. The *E.coli* count in the River Murray is to be less than or equal to 150 EC/100mL for 90% of the time by 2020

Appendix K. Workshop Outputs – River Systems

Underpinning research

- R1. The impact of anthropogenic (human/interaction) on fish and aquatic populations (eg. recreational fishing)
- R2. Fish biology/ecology of SA pops
- R3. Understanding of the links between water management, ecosystem management and biodiversity (threatened and iconic spp)
  - Water management, key habitats, water quality
- R4. Identification and location of ecological assets (habitat)

Irrigation Systems

- R5. Siting and design of irrigation systems to reduce water use, salt damage, robustness to climate conditions, soil conditions
  - Output: Land suitability with regard to climate interaction
- R6. Matching cropping systems to perceived changes in the supply of water
  - Research and products to support adaptation to higher salt and lower water availability and higher cost scenarios (high and low value crops)
- R7. Test options for the productive use of saline water (disposal and engineering) to reduce volumes of saline water
  - Bio-concentration tools

Managing Drainage Water

- R8. Minimise drainage from irrigation; Optimise irrigation efficiency. What is the sustainable irrigation drainage rate required to ensure salt does not accumulate in the surface soil?
- R9. Develop guidelines for the selection of green-fields development sites to minimise off-site impacts and drainage requirements
- R10. Reuse of drainage water: Bioaccumulation, saline production, smart SIS that adds economic value
  - Crops and technologies for mod-high salt

Salt balance models

- R11. Tools for improved salt and water balance models for SA Murray
  - Salt & water balance and salt storage in river corridor
  - Tool for design scenarios to maintain neutral salt & water balances (SIS, flooding etc)
- R12. Understand the full implications of NRM salinity mitigation measures (sulfidic, salt disposal into rivers, weeds)

- R13. Best use of 1:25 year flood to manage flushing of salt
  - Salt transport model under different flows

Riverine Systems Outputs

- R14. Flow guidelines for sustainable fish management (eg Murray Cod)
- R15. Targeted control tools for invasive species
- R16. Population model for fish management
- R17. Risk assessment for alternative investment options
- R18. Feasibility study for multiple use of water (environment, irrigation, aquaculture)
  - Alternative sources of water
  - Alternative uses for different quality water
- R19. Integrated GIS model (multi-criteria, multi-layered) of riverine ecosystems
- R20. Tools for trade-off analysis between alternative ecological outcomes
  - Quality and connectedness of ecological habitats (includes dryland systems)
- R21. Trade-offs between water quality and ecological conditions
  - DSS to identify opps of water of different quality to achieve environmental outcomes
  - Tools for managing wetlands under higher salt scenarios: Irrigation technologies, engineering systems, flood utlisation scheme, systems that reduce the salinity impact of big and small floods
- R22. Knowledge to preserve/save current ecosystems
  - DSS to protect the long term viability of icon sites
- R23. What are the options for ecological restoration for retirement/restoration of Lower Murray Swamps
- R24. What are the current dis-incentives and possible incentives to attract investment from the private sector in aquatic habitat protection

Other

- R25. Application of research through pilot studies to prove new technologies
- R26. Feasibility study to improve water quality in the Blanchetown to Wellington section of River
  - Eg. weir at Wellington
- R27. Socio-economic impact of a changing river
- R28. Development of a model to understand the interaction of the Estuarine/Marine/Freshwater interaction
- R29. Scenario analysis of the likely future conditions of the NRM region
  - Flow across the border and climate
- R30. Biotechnology solutions to water quality/salinity

Table K1: Research Priorities Identified at the River Systems Workshop

[Votes for each research issue in square brackets] Only votes greater than two are shown. There was some clumping of votes that were for similar issues/outputs.

(*Research Theme in round brackets and italics*)

Understanding the system	Addressing the Symptoms of Degradation	Solving the Problem of Degradation
[10] R11. Tools for improved salt and water balance models for SA Murray (*Salt balance models*)	[9] R10. Reuse of drainage water: Bioaccumulation, saline production, smart SIS that adds economic value - Crops and technologies for mod-high salt (*Managing drainage water*)	[4] R5. Siting and design of irrigation systems to reduce water use, salt damage, robustness to climate conditions, soil conditions - Output: Land suitability with regard to climate interaction (*Irrigation Systems*)
[4] R3. Understanding of the links between water management, ecosystem management and biodiversity: threatened and iconic spp) (*Underpinning research*)	[5] R6. Research and products to support adaptation to higher salt and lower water availability and higher cost scenarios for both high and low value crops. (*Irrigation Systems*)	
[4] R29. Scenario analysis of the likely future conditions of the NRM region: Flow across the border and climate (*Other*)	[5] R20. Tools for trade-off analysis between alternative ecological outcomes and water quality (*Riverine Systems*)	
	[4] R18. Feasibility study for multiple use of water: environment, irrigation, aquaculture. (*Riverine Systems*)	

Socio-economic research identified

R31. [2] What are the current dis-incentives and possible incentives to attract investment from the private sector in aquatic habitat protection [Similar to S3,8,13)

R32. [1] Socio-economic impact of a changing river

Appendix L. Workshop Outputs – Dryland Systems

Resource Condition Targets

- D1. Are these the right RCTs? Eg soil carbon
  - Identify the implications of delivering existing RCTs (Lower Murray Landscape Futures)
  - Have an understanding of existing resource status and trends

Water management in EMLR

- D2. Ecological impacts of different water management strategies in EMLR
  - Understand the flow regimes prior to the recent decline in resources
  - Need to understand the biological processes of priority water dependent systems in the EMLR
  - Decision support system to feed into the water allocation planning processes that describes the ecological impacts of different water regimes and water quality
- D3. Better understanding of groundwater/surface water processes to assist in water allocation planning, particularly fractured rock (big NWI) in EMLR
  - Maps of the groundwater base-flow and recharge sources relative to key ecological assets (eg. Black Swamp)
  - A conceptual model that quantifies the sustainable yield of groundwater resources, particularly fractured rock systems
  - Prioritised inventory of key ecological assets

Wind erosion, soil health

- D4. Key threatening processes to soil resource, what we need to manage in mixed farming systems
  - Evaluation of regional benefits of different soil management approaches
  - Evaluation of the economic and environmental benefits of precision agriculture
- D5. What management decisions will result in a long term increase in soil carbon
  - A better understanding of the role of soil carbon in improving soil functional capability, not all carbon is equal, what is a “sustainable” level of soil carbon? What do we need to do to increase “good soil carbon”?
- D6. Key threatening processes to land resource, what we need to manage in the rangelands
  - Improved techniques for feral and abundant native species control to reduce grazing pressure and control the spread of weeds (eg. Bio-control)
  - Analysis of the potential for eco-tourism for pest control (include follow up)

Condition and extent of native vegetation, Threatened species

- D7. Better understanding of the threats and impacts on different ecosystems from climate change and land use
- D8. Biology, tolerance and adaptation of native species to extreme temperature, trends in temperature changes and salinity of water/soil (native flora, fauna)
  - Scoping Study
  - Risk analysis: Identify species most prone to risk from extreme temperature
  - Risk analysis: Expansion/retraction of invasive species with climate changes, including impact on bio-control mechanisms
- D9. Ecological restoration techniques/works including riparian, Strategic placement of vegetation
  - Compare and quantify outcomes from restoration (are we restoring ecological systems?)
  - Develop restoration techniques
  - Identify how to prioritise for ecological restoration
- D10. Improved management techniques for invasives and other threats (bio-control)

New farming systems

- D11. Biology, tolerance and adaptation of species to extreme temperature, trends in temperature changes and salinity of water/soil (crops, invasives, microbes)
  - Scoping Study
  - Risk analysis: Identify species most prone to risk from extreme temperature
    - Grapevines, Fish, Cereals, Other food crops,
  - Risk analysis: Expansion/retraction of invasive species with climate changes, including impact on bio-control mechanisms
  - Commercially viable and sustainable alternative perennial enterprises (under climate change scenarios)
- D12. Biological threats to and requirements of new and modified farming systems and natural systems (pathogens, insects etc)
- D13. New technologies to support alternative new enterprises
- D14. Set up rotations to maximise water use efficiency
  - Florasearch
  - Mallee Sustainable Farming Systems Program
  - New CRC Future Farming Systems
  - Carbon Prospect (from WA)
  - Olives?
  - Identify research priorities coming out of these projects

Social understanding

- D15. Community attitudes and aspirations, what does it take for the community to improve their management of natural resources? [Same as S2 & S6]
  - CRC Desert Knowledge
  - Document what influences the decisions of the community to invest in NRM (or otherwise)
  - What are the broader community prepared to pay for improved NRM
- D16. Market based incentives, social and economic research to the barriers to market based approaches [Same as S3,8 & 13]
- D17. Understand why people are not implementing farming to land capability and other risk management techniques [Same as S2 & S6]
- D18. How do landholders make business investment and management decisions? What information do they access? In what format? At what point in their life etc… [Same as S2 & S6]

NOTE: This group did not prioritise the social understanding group of research topics, leaving this analysis to the Social Workshop

Weather forecasting

- D19. Improving gaps in weather forecasting and drought proofing
  - National Academy of Science will review
  - Managing Climate Variability Program

Table L1: Research Priorities Identified at the Dryland Systems Workshop

[Votes for each research issue in square brackets] Only votes greater than two are shown. There was some clumping of votes that were for similar issues/outputs.
(*Research Theme in round brackets and italics*)

Understanding the system	Addressing the Symptoms of Degradation	Solving the Problem of Degradation
[13] D2. Ecological impacts of different water management strategies in EMLR • Understand the flow regimes prior to the recent decline in resources (2) • Need to understand the biological processes of priority water dependent systems in the EMLR • DSS to feed into the water allocation planning processes that describes the ecological impacts of different water regimes and water quality *(Water management in EMLR)*	[12] D11. Biology, tolerance and adaptation of established and new crop and animal species to extreme temperature, trends in temperature changes and salinity of water/soil • Risk analysis: Identify species most prone to risk from extreme temperature • Risk analysis: Expansion/retraction of invasive species with climate changes, including impact on bio-control • Commercially viable and sustainable alternative perennial enterprises under climate change scenarios *(New Farming Systems)*	[8] D9. Ecological restoration techniques/works including riparian, Strategic placement of vegetation *(Condition and extent of native vegetation, threatened species)* [3] D6. Key threatening processes to land resource, what we need to manage in the rangelands – Improved techniques for feral and abundant native species control to reduce grazing pressure and control the spread of weeds (eg. Bio-control) – Analysis of the potential for eco-tourism for pest control (include follow up) *(Wind Erosion, soil health)*
[5] D3. Better understanding of groundwater/surface water processes to assist in water allocation planning, particularly fractured rock (big NWI) *(Water management in EMLR)*	[8] D8. Biology, tolerance and adaptation of native species to extreme temperature, trends in temperature changes and salinity of water/soil *(Condition and extent of native vegetation, threatened species)*	

Socio-economic research identified

[6] Community attitudes and aspirations, what does it take for the community to improve their management of natural resources? – Same as S2 & S6

Appendix M. Workshop Outputs – Terrestrial Ecosystems

T1. Monitoring for adaptive management 7

- How to define realistic, measurable ecological outcomes at landscape scales and how to measure progress against these
- Monitoring methodology to enable reporting against RCTs
- Developing effective monitoring of management to allow for modification and refinement of that management
- Adaptive management experiments at “realistic” scales to assess different on-ground actions
- Assessment of past on-ground actions (outcomes, not auditing)
- Process needed for measuring condition that relates to ecological state

T2. Inventory of Assets 6

- Consolidate existing information for better planning
- Biological inventory assessments that determine the current state
- Priority asset identification: to bridge the gap between resource condition targets and on ground delivery
- Identification of key knowledge gaps with respect to threats, assets and delivery of on-ground actions

T3. Risk identification and management 4

- Identification of risks to assets
- Methods of threat abatement (weeds, fire, landscape/habitat degradation, introduced predators, climate change)
- Trend studies of both listed and unlisted species to determine trajectory
- How does the resilience of key systems change in response to climate change (return following disturbance) - Note: related to D8
- Methodology for risk assessment and review of programs in context of climate change - Note: related to D8

T4. Revegetation Technologies 4

- Revegetation strategies that lead to vegetation that regenerates (soil microbial symbionts, genetic population structures, soil-plant feedback

T5. Basic ecological processes 4

- Basic autoecological studies of targeted species at multiple scales to refine our conceptual models of the systems
- Ecosystem processes in fragmented landscapes
- Scaling up processes from patch to catchment
- Vegetation dynamics in fragmented habitats (including spread of invasive species, population dynamics, population genetics)

T6. How do ecological communities respond to drought? How should we manage them in response? 2

Management Technologies 1

- T7. Technologies for pest/weed management
- T8. Technologies for management actions (fire)`

T9. What are useful surrogates for biodiversity? 1

T10. What focal targets can be used to help achieve “no species loss” in the SAMDB landscape?

T11. Understand interactions between different threats (drought, fire, weeds etc.)

Table M1 Research Priorities Identified at the Terrestrial Ecosystems Workshop

[Votes for each research issue in square brackets] Only votes greater than two are shown. There was some clumping of votes that were for similar issues/outputs.

(*Research Theme in round brackets and italics*)

Understanding the system	Addressing the Symptoms of Degradation	Solving the Problem of Degradation
[6] T2. Inventory of assets • Consolidate existing information for better planning • Biological inventory assessments that determine the current state • Priority asset identification: to bridge the gap between resource condition targets and on ground delivery • Identification of key knowledge gaps with respect to threats, assets and delivery of on-ground actions	[4] T3. Risk identification and management • Identification of risks to assets • Methods of threat abatement (weeds, fire, landscape/habitat degradation, introduced predators, climate change) • How does the resilience of key systems change in response to climate change • Trend studies of both listed and unlisted species to determine trajectory • Methodology for risk assessment and review of programs in context of climate change	[7] T1. Monitoring for adaptive management • Tools for providing feedback to managers on the effectiveness of their actions • Large scale "living laboratory" experiments where managers try and number of approaches and compare their effectiveness
[4] T5. Basic ecological processes • Refine our conceptual models • Ecosystem processes in fragmented landscapes • Scaling up processes from patch to catchment • Vegetation dynamics in fragmented habitats		[4] T4. Revegetation technologies • Revegetation strategies that lead to vegetation that regenerates (soil microbial symbionts, genetic population structures, soil-plant feedback

Appendix N. Workshop Outputs – Social Systems

State/National Research Issues

- S1. Policy "wind tunnel" experiments using experimental economics
- S2. Understand farm investment decisions with respect to NRM outcomes (what will be the triggers for investment? What are the investment cycles?) [Relates to S6]
- S3. Develop reward models for NRM targets [Relates to S8 & S13]
- S4. A "horses for courses guide to the mix and sequence of Market Based Instruments for NRM [NOTE: This is not research]
- S5. Mapping pathways to changed practices in NRM
- S6. Understand the different responses of people to incentives spatially in the landscape [Relates to S2]
- S7. Assess NRM groups areas likely to respond to NRM change projects
- S8. Non-Market Based Instruments for influencing behaviour change [Relates to S3 &S13]
- S9. What could encourage private investment from outside the region to bring about landscape change?
- S10, What are the handful of approaches for coordinating biophysical, social and economic systems?
- S11. Tools to value non-market outcomes
- S12. Visualisation tools to demonstrate behavioural responses [This is not research]
- S13. What other economic tools can replace Benefit:Cost Analysis, which are strongly influenced by time for benefit to emerge and the discount rate used [Relates to S3 & S8]
- S14. Challenge the notion of "self-interest" within communities, and identify the level of "pro-social" behaviour (a willingness to help another person without expecting a reciprocal benefit) [Relates to S16]
- S15. Explore institutional alternatives to the dichotomy of public-private rights
- S16. Explore the use of community/district accountability frameworks versus individual accountability frameworks [Relates to S14]

- S17. Identify the potential for the “dark side” of volunteerism/community governance

Regional Research Issues Particularly Relevant to SAMDB

- S18. Report on social and industry trends
- S19. Change profile by industry: who is moving in, who is moving out?
- S20. Understand the sectoral influences and roles in NRM decisions/policy (Australian Government, State Government, Local Government, Industry. NGO, Community, Landholder)
- S21. Social capability mapping by sector
- S22. Identification of community perceptions of and attitudes to risk
- S23. Network influence mapping to inform change management
- S24. A knowledge “hub” to access the latest learnings on NRM underpinnings
- S25. Value “volunteerism” in SAMDB
- S26. Identify synergy opportunities with other sectors. What are the opportunities for other sectors to achieve their interests by engaging with the NRM process in a way that helps improve the outcomes for NRM.
- S27. Stocktake of what incentive/behavioural change tools have been developed

Use students to undertake these areas of research

What would the SAMDB Region be like if they were able to improve their understanding of social systems?

- No need for more research
- Community understand and support for priority projects
- Meaningful measures of social acceptance and capability
- Regulatory tools have a science base
- Better sense of the priority of an action
- Robust testing of policy instruments BEFORE they are implemented, and the likely outcome already known
- Actions based on what can be shown to be achievable
- Much more rapid delivery of NRM outcomes
- Policy instruments and delivery protocols matched to regional motivations
- Layered policy delivery according to community needs x sector
- Capability of the community is well understood and NRM policy delivered appropriately
- Link explicitly a management action with an NRM target
- Willingness by the community to try/adopt new approaches and sharing of experiences
- Community is open to change (social/economic)
- Correcting institutional pathologies
- Social trends have informed future thinking and planning as much as Resource Condition Targets
- Industry/Local Government/Australian Government/State Government partnerships are as much socially based as place based
- Creation of novel hybrid instruments (flexible design)
- Reduced cost per NRM outcome
- Avoid wasted effort
- Action taken at the right scale
- Optimal economy of scale for NRM activities/investment
- Reduced perverse outcomes. Avoid spill-overs into non-NRM areas
- People gain energy and well-being from engaging in the NRM process
- Coordination across agencies
- NRM becomes “business as usual”

What would the SAMDB Region be like if they do not improve their understanding of social systems?

- Create yet more documents and policy that never achieve intended outcomes
- Programs not targeted to people's needs and wants
- Rationale for funding/not funding local or individual project not understood or accepted
- Risk of over-surveyed community, because always re-inventing the wheel
- Some key asset management goals not accepted locally
- Community expectations not met
- Increasing exposure of vulnerable communities/ecosystem: reducing resilience, capability to adapt
- Fear of climate change impacts
- Community effort/concern over continued decline of the rural community
- National competitive funds go to the most advanced region, not the one with the highest need
- Lost opportunity for federal funding due to mixed messages
- Moving goalposts of policy directions leading to disillusionment
- Mixed messages to policy makers form the region
- Lack of coordination between delivery agencies
- Increasingly costly and complex NRM solutions
- Pay more for an action that is required
- Failure to capture opportunity (ie New industries)
- Not packaging targets in a business opportunity framework
- Public funding addictions
- "funding dependent" action
- Risk of responding to 2006 business/industry, not 2026
- Non-compatible policy/implementation units of analysis
- Small-scale on-ground actions with minimal outcomes
- Unable to deliver district/regional level outcomes
- Farm-centric approach rather than catchment approaches
- Low willingness and capacity to participate
- Perverse outcomes surprises – crowding out
- Risk community's NRM effort segregating: Individuals choosing not to be involved

- Segmentation of NRM community and isolation of the champions
- Burnt out and disillusioned community champions
- Failure to acknowledge volunteer input

Appendix O. Advice and ideas collected from interviews and by submission

A number of key experts were unable to attend the workshop, but their experience and knowledge of important natural resource systems within the SAMDB NRM region was regarded as being too important to miss. These were:

- Phil Cole (DWLBC), sustainability of irrigation along the River Murray
- David Roget (CSIRO), dryland farming systems in the Mallee
- Keith Walker (Uni Adelaide), ecology of River Murray and wetlands
- Justin Brookes (Uni Adelaide), nutrient dynamics in the River Murray

Sebastien Lamontagne (CSIRO) is leading a major scientific study of the Coorong, Lower Lakes and Murray Mouth and provided official, written advice outside on the workshop process on research still required in the Coorong, Lower Murray and Murray Mouth system (see letter below).

Where the research topics identified by these researchers has been listed during the workshops, the research topic has been identified in brackets at the end of each description. Where the idea has not been identified elsewhere, a new research topic number has been allocated to the beginning of each description.

Phil Cole (DWLBC)

1. Sustaining an irrigation industry when there is declining water availability
    - There are numerous threats to water availability(climate variability, fires etc)
    - Understand the link between crop production and quality with water usage and efficiency (R6)
2. Off-site impact of irrigation
    - No coordinated management of the 50-60GL of water sitting in the system every year in SA
    - What is the sustainable irrigation drainage rate required to ensure salt does not accumulate in the surface soil? How should the drainage water be managed to "close" the system? (R8)
3. Living in a higher salinity environment
    - There are large volumes of salt upstream in the catchment
    - The MDBC suggests that salinity will be rising over the next 50 years
    - The Living Murray should displace salt off the floodplain
    - Drainage water out of irrigation schemes already being used for irrigation
    - Can we concentrate the salt? Are there opportunities to make profit out of saline water? (R7, R10)
    - What is the impact of higher salinity water on conventional crops (R6)?

David Roget (CSIRO)

High intensity cropping is working well: economically sustainable, minimises wind erosion. However, the system is leaky: water and nitrogen are moving past the rootzone. Also, herbicide resistance in grassy weeds is bound to emerge sooner or later. The Mallee needs a viable perennial phase to soak up nitrogen and water that has moved past the rootzone, and provide a grass-weed break. This is an issue the CRC Plant Based Management of Dryland Salinity should be working on. (D14)

D20. There is a problem of stock management on the larger paddocks that have been set up for high intensity cropping. As a result, sheep are congregating on the sandy rises and reducing surface cover, increasing erosion risk. Research could be done to improve stock management on large paddocks to reduce the risk of wind erosion.

Note on soil carbon: Sandy soils to not protect soil carbon, so it is difficult to get soil carbon to build up. To maintain soil fertility and provide enough soil carbon to maintain good soil structure, Mallee systems need high carbon inputs every year; that is, they need a high production of plant matter for as long a period as possible over the year. High intensity cropping systems with a perennial phase would seem to be the best option to maintain annual carbon inputs at the moment.

Keith Walker (Uni Adelaide)

Keith Walker suggested the establishment of a River Murray Institute to coordinate research in the SAMDB region (or beyond).

“Even in the comparatively small resource-management community of South Australia, there are many agencies (e.g. government, universities, LAP groups, catchment water management boards, the NRM board and a variety of community/special interest groups) with interests relating to the Lower River Murray.

Communications and cross-links between these groups could be improved. Without meaning to introduce another level of bureaucracy or management, it may be worthwhile to consider a cluster-style panel, after the research clusters developed by The University of Adelaide. The panel could initiate, promote and implement a range of initiatives in research, education (postgraduate, undergraduate, schools, public and media) and exchanges of specialist advice as necessary. A cluster would require energetic inputs from a small number of motivated, representative people. One initiative could be an annual river research symposium for professional people, ideally with refereed, published proceedings. Another could be to develop and maintain a web site.”

Justin Brookes (Uni Adelaide)

There has been very little consideration about the impact of nutrients and carbon that flow out of wetlands following an artificial wetting cycle and draw-down. This could have significant impacts on the primary productivity of the River Murray, and may even risk causing blue-green algal outbreaks. (Links to R3, R18, R21)

R33, Biogeochemistry of wetlands: When wetlands are watered, primary production increases which results in a deposition of fine and course-sized plant material. This acts as a mulch on the soil and a carbon load to the River when there is a final draw-down. What is the impact of this on the wetland and River systems. How can managers avoid black-water events and minimise the chances of acid build-up (through salt/iron oxide interactions)? (Links to R3)

R34. What is the contribution of different “assets” and land systems along the River to nutrient loads?

R35. Why is there an acid slug of water along the bottom of the River between Mannum and Tailem Bend?

R36. Nitrogen denitrifies the longer it remains in an aquatic system. In a River system with few inputs (like the contained channel of the River Murray), does this mean that the concentration of nitrogen decreases the further you move down the River and what impact does this have on river primary productivity? What are the flow on impacts down the food chain?

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SA Murray-Darling Basin NRM Board
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14 July 2006

Re: Water for a Healthy Country Research in the Coorong, Lower Lakes and Murray Mouth region

Dear Paul,

Following on the workshop you hosted on July 7, here is a brief statement on the activities of Water for a Healthy Country (WfHC) in the Coorong, Lower Lakes and Murray Mouth (CLLAMM) region, and potential areas for research that we have recently identified.

"Water for a Healthy Country" is one of CSIRO's "research flagships" – an initiative to help focus our efforts on topics of national significance. The Flagship has numerous activities in the Murray Basin (see www.csiro.au) including a program to develop a decision-support framework to maximise the environmental outcomes from water management in the CLLAMM region.

Through a Flagship Collaboration Fund Cluster Grant, a range of key ecological research projects will occur over the next three years in the CLLAMM region in partnership with several other research institutions (see attached document describing the "CLLAMMecology" Cluster). The Cluster's activities will start in the 2006-07 financial year and, over its three years, will be an investment of over $5m by CSIRO and its partners.

The detailed outputs and research program for the Cluster are currently being finalised in partnership with the SA Lower Murray Coordinating Committee.

While our proposed research program is quite comprehensive, we could not cover a number of outstanding research topics for the CLLAMM region. Four of these would include:

R37. 1. The need to determine experimentally the water regime requirements and the salt tolerance for key *Ruppia* species in the Coorong. *Ruppia* provides to most significant habitat and food source for several key waterbird and fish species in the Coorong lagoons, but how *Ruppia* species will response to future USE drainage operations and barrage releases is unclear;

R38. 2. The need to improve the water and salt balances for the Lower Lakes. Because the amount of water available for environmental flows will be limited under even the currently most optimistic scenarios, an accurate water balance is required to plan future management actions, such as barrage operations, with greater certainty. In general, the water balance for

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the whole SA section of the Murray-Darling is not very accurate (that is, off by up to several hundred GL/year) – with the cumulative error in water balance estimates most acutely felt in the CLLAMM region.

3. The need to predict the impact of water regime change on Lower Lakes wetlands. It has been proposed that more active water level manipulations could be used to improve wader habitat in the Lower Lakes. However, how this will impact the wetland systems around the margin of the lakes, including habitats for endangered species like the pygmy perch, is unclear.
4. The need to better understand and quantify exchanges through the Murray Mouth. The successful dredging program has meant that there is currently strong tidal and surge-induced flushing in and out of the Murray Mouth. To help quantify the benefits from dredging operations, we need to quantify water exchange and identify the biological exchanges that accompany it, which may include migrating adult fish and the larvae and juveniles of fish, invertebrates, phytoplankton and plant propagules.

A research project for Topic #1 was developed by the Cluster but could not be supported by the Collaboration Fund. The Board should consider directly contacting the CLLAMMecology Cluster Leader (Mike Geddes, University of Adelaide) to obtain more information on this and other potential ecological research projects for the region.

Topics 2 and 3 include a series of knowledge gaps that could be addressed through a more elaborated program. In collaboration with the board and other management agencies, the Flagship would be interested to develop such a research program on these issues.

Discussions for research on Topic #4 have already occurred between Mike Geddes and scientists based at Flinders University – the board can contact Dr. Geddes directly for more information.

Please inform the board to get in touch with the Science Director for Water for a Healthy Country (Warwick McDonald) or myself for further information about the Flagship program. Dr. Geddes and I would be delighted to brief the Board in more details about the proposed research program for CLLAMMecology.

Sincerely,

Dr. Sébastien Lamontagne
Leader
CLLAMM Project
CSIRO Land and Water
Sebastien.lamontagne@csiro.au

Cc: Dr. Mike Geddes, CLLAMMecology Cluster Leader
Dr. Warwick McDonald, Water for a Healthy Country Science Director

Australian Science Australia's

Appendix P – Draft Outline for a Prospectus of Research in SAMDB NRM Region

Introduction

- Description of the SAMDB NRM region
- Description of the purpose of the SAMDB Board under the Act
- Identify the purpose of the NRM Plan and Investment Strategy
- Identify the need for research as described in the State NRM Plan and other state strategic planning documents

Purpose of Prospectus

To provide research organisations with:

- a guide as to the research areas of interest to the Board;
- an indicative indication of the level of investment, if any, the Board is willing to make on particular research topics;
- project briefs for projects of particular interest to the Board.

Research Areas of Interest

A list of all research areas of interest, ranked according to their relative priority. Identify people within the Board who should be contacted for further information.

Flag issues of state and national importance that the Board would like other investors to invest in (eg. State governments, Industry R&D Corporations, CRCs, CSIRO).

Priority Research Projects

A portfolio of two page (or so) briefs of priority research projects (no more than 20 or so) with a description of the purpose, urgency, priority and desired scale of proposed research. An indication of the Board's willingness to invest would also be useful.

List a primary contact for further information

Links to Strategic Planning

An Appendix showing how the research areas of interest and priority research projects are aligned to the SAMDB NRM Plan, State NRM Plan and National Research Priorities