Lake Eyre Basin Rivers Assessment Implementation Plan Project

Milestone 3 Report: Governance arrangements for the LEBRA

Revised December 2009

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Kiri-ganai research

About Kiri-ganai research

Kiri-ganai Research Pty Ltd is a Canberra based company that undertakes consultancy and analytical studies concerned with environmental policy, industry performance, natural resource management and sustainable agriculture. Our strength is in turning knowledge gained from public policy, markets, business operations, science, and research into ideas, options, strategies and response plans for industries, governments, communities and businesses.

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Project team

The LEB River Assessment Implementation Plan Project is managed by Kiri-ganai Research Pty Ltd. The project team comprises Dr Richard Price, Professor Martin Thoms and Dr Samantha Capon. Doug Watkins contributed to the "pressure' indicators section in the appendix.

Acknowledgements

The project team gratefully acknowledges the many individuals who are giving their valuable time, insight and knowledge during meetings with the consultants as this project progresses. We have been impressed by the professionalism of all the people that we have met and spoken to so far, and we trust that their passion and commitment to achieving a positive contribution to the Lake Eyre Basin is reflected in this report.

Disclaimer

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Abbreviations

CAC	Community Advisory Panel
DEWHA	Department of Environment, Water, Heritage & Arts (Cmth)
ESD	Ecological Sustainable Development
GAB	Great Artesian Basin
GABCC	Great Artesian Basin Coordinating Committee
INRM	Integrated natural resource management
LEB	Lake Eyre Basin
LEBIA	Lake Eyre Basin Intergovernmental Agreement
LEBMF	Lake Eyre Basin Ministerial Forum
LEBRA	Lake Eyre Basin Rivers Assessment
MDBA	Murray Darling Basin Authority
NRM	Natural resource management
NRMMC	Natural Resource Management Ministerial Council
NWC	National Water Commission
PSR	Pressure State Response
SAM	Strategic Adaptive Management
SAP	Scientific Advisory Panel
SOG	Senior Officers Group

Overview

This is the third of four reports specified as outputs for the initiative: Lake Eyre Basin Rivers Assessment Implementation Plan Project (see a summary of the Terms-of-Reference under Appendix A). The report outlines suggested governance arrangements for future LEB assessments and provides the outline of a Business Plan in support of the Implementation Plan. Other reports associated with this project include:

- documentation of the achievements of LEB assessments to date;
- a proposed revised LEB assessment process; and
- an implementation plan for future LEB assessments (next report).

The project was commissioned following completion of the LEB Action Plan 2009-2014. That Plan identified the need to consider the governance arrangements appropriate to ensure effective implementation of future LEB assessments and condition reports (Action 5).

In essence, this Implementation Plan Project deals with the governance arrangements by first coming to grips with the assessment requirements necessary to meet LEB ministerial agreement obligations. This is to ensure that structure follows function, tailoring the governance arrangements to meet specific activities and outcomes.

Consultant's observations about current governance and implications for the LEBRA

- The LEBIA does not explicitly deal with the intra-state impacts of the LEB. The implicit assumption is that if partners protect cross-border interests, the condition of the Basin as a whole will be protected. The basis for the assumption lies in the Basin's focus on water resources. The health of the overall LEB relies, in the view of many SAP and other LEB participants, on consideration of both intra and inter-border management.
- The LEB has potential advantages offered by having its own Ministerial-level governance arrangements (the LEB Ministerial Forum), however the arrangements do not share the same head-of-department level of management common to other such inter-governmental forums. Notwithstanding the existence of a Senior Officers Group, the overarching governance arrangements may lack the delegations to ensure that actions are undertaken as rapidly or with the same level of resources that might otherwise be the case. While this is a question for longer-term consideration in respect to broader governance arrangements for the LEB, it does suggest that expectations for resourcing the LEBRA need to be tempered and make best use of existing resources, including partnerships and networks.

- The values articulated by LEB stakeholders span the breadth of the triple bottom line as well as the breadth of natural assets of the Basin. This needs to be taken into account in the governance of the LEBRA implementation process.
- The challenge for the LEBRA of Constitutionally-based NRM arrangements is not so much that resource assessment and ongoing monitoring cannot be undertaken as independent, specifically designated and discrete activities, but rather that the responses to findings about pressures and resource states is more difficult to coordinate. This has implications for building governance arrangements around a LEBRA based on the Pressure-State-Response model as well as on adaptive management principles.
- The LEBRA can, and should, play a pivotal role in alerting the LEBMF to significant issues requiring coordinated policy responses. The LEBRA should also act to provide a clear understanding of the condition of the Basin to help jurisdictional representatives avoid articulating mixed or inconsistent messages. Both these issues are consistent with widely accepted governance principles of evidence-based decision making.
- The LEBRA should act to provide the kind of information required to guide policy and program responses. In many respects, the SOG is in the fortuitous position to influence the conduct of the LEBRA as well as many of the responses to the information it provides. The SOG needs to play a stronger role than it has to date in the LEBRA process to ensure that the assessment process is aligned to the response mechanisms available through its jurisdictional representatives.
- The CAC shares with the SOG a characteristic vital to the successful implementation of the LEBRA within the context of adaptive management as proposed: the capacity to respond, if necessary, to the information provided by the assessments. More importantly, the CAC comprises those interests with the major personal or corporate motivation to respond, and by implication those with the strongest stake in ensuring that the LEBRA is both rigorous and provides information of utilitarian value.
- The SAP's role as prescribed in the LEBIA is to '*provide advice*'. This is consistent with commonly accepted interpretations of good governance; keeping the SAP independent of monitoring performance, so that it can provide advice not only on what ought to be performed, but how it was performed. Maintaining this independence is a principle that should be adopted in the LEBRA governance arrangements.
- Another important role for the SAP in the LEBRA should be to interpret the implications of the findings for further investigation and research.

- The level to which the regional NRM Boards can undertake LEBRA activities hinges not simply on funding availability, but on the level of trust placed in them by government and industry agencies. Their capacity to motivate and focus existing community networks on wider LEB initiatives should be an important element of advancing the adaptive management approach proposed for the LEBRA.
- The LEB Facilitator can play an important part in ensuring that the findings of the LEBRA inform the diverse range of interests in a position to respond. This can be achieved through guiding the knowledge and communication strategies as well as in helping set the agendas for the various bodies such as the SOG, SAP and CAC.
- While it is important that the LEBRA provide the basis for understanding the condition of the LEB to underpin appropriate management responses, it is important it also inform the Knowledge Strategy in respect to progress in being able to answer key research questions.
- The key messages outlined in the LEB Communication Plan need to be reflected in the way the LEBRA is conducted. That said, future key messages need to be informed by the results of the LEBRA.
- The LEBMF's responses to the URS review of the LEBIA provide some guidance in respect to future governance arrangements for the LEBRA. Implicitly, the responses reinforce the imperative to focus on integration at the point-of-practice (i.e. in the implementation of specific activities). Governance arrangements for the LEBRA therefore need to be practical, easy to implement, be seen to 'get on with the job' and be couched in an adaptive framework that ultimately stimulates responses on-the-ground.
- While the response to an adaptive management approach has generally been favourable, it has been viewed by some stakeholders as representing a longer-term aspiration that could compromise the shorter-term imperative of undertaking a comprehensive resource assessment in the LEB. The consultants do not consider that adopting an adaptive management approach to the LEBRA will delay its implementation. Indeed, early conduct of the LEBRA can and should help shape the longer-term adaptive management framework not only for future resource assessments, but also for the wider activities under the LEBIA (i.e. the Knowledge Management Strategy, Communication Strategy, ongoing monitoring etcetera).

Interim recommendations

1. The purpose of the LEBRA should be to gain an understanding of the LEB's condition in order to:
    i. underpin responses to condition, including a range of on-ground management, government and industry policy, enterprise and

personal decision making and local and regional resource planning responses

ii. form consistent messages appropriate to, and encourage constructive dialogue between, specific target audiences about condition, outlook and appropriate responses

iii. guide ongoing research, investigation and monitoring efforts so that they can form a reliable basis for evidence-based responses.

2. The revised LEBRA methods outlined in Section 4 should be adopted as the basis for an Assessment to be undertaken in 2010-2011.

3. Five options for the management and governance of the LEBRA are presented. These options are based around potential foci for the LEBRA and are couched as:

   a) Government leadership
   b) Community leadership
   c) Technical leadership
   d) Collaborative assessment
   e) External assessment

   The consultants recommend the adoption of the collaborative assessment model. This model seeks the establishment of a LEBRA Oversight Group comprising SOG and CAC members, with the SAP providing advice on the terms of reference for the LEBRA and draft assessment reports. The SAP should remain independent of the conduct of the LEBRA.

4. The conduct of the LEBRA, in line with recommendation 3, should be collaborative and utilise the expertise of participating organisations, including the regional NRM groups, to the greatest extent possible. However, terms of reference to coordinate the synthesis of the findings and their implications for appropriate responses should be tendered to a single group accountable to the LEBRA Oversight Group.

5. The terms of reference for the coordination activity outlined in recommendation 4 should include the conduct of interpretation workshops that act to define the required responses to the LEBRA, as well as the vision, objectives, thresholds of potential concern and ongoing monitoring processes required to place future LEBRA activities within a richer adaptive management framework.

Further and more specific recommendations will be formulated following consideration of the technical and governance options outlined in this report at a workshop of the SAP on 11-12 August.

1. Background

Purpose of the report

The Australian Department of the Environment, Water, Heritage and the Arts (DEWHA) requires the development of a Lake Eyre Basin Rivers Assessment Implementation Plan to identify how regular on-going monitoring of key indicators will be implemented within the Lake Eyre Basin Agreement Area. To meet this aim DEWHA has engaged the services of Kiri-ganai Research Pty Ltd to undertake a consultancy for this purpose.

The main objectives of this consultancy are to:

- review the achievements to-date under the Lake Eyre Basin Rivers Assessment (Step 1);
- review the Lake Eyre Basin Rivers Assessment methodology and recommend an approach and key indicators to be monitored, their scale and frequency (including rationale for decisions) (Step 2); and
- support development and documentation of governance arrangements; development of a business model (including the cost of monitoring, managing data and report; funding for future monitoring and possible funding arrangements) (Step 3).

This report is submitted in accordance with the terms of reference for this consultancy and addresses Step 3. It builds on the previous steps by outlining the governance and business arrangements considered necessary for the successful implementation of future resource assessments in the LEB.

Scope of the report

As its highest priority, the draft Five Year Action Plan for the Lake Eyre Basin Intergovernmental Agreement (LEBIA) called for the governing partners of the LEBIA to *re-assess the governance and support arrangements to implement the LEBIA* (Price and Lovett). The draft Action Plan stated that LEB stakeholders gave particularly strong support for this re-assessment (Action 1) to be undertaken as *a priority on which all other actions rely*. The Action Plan approved by the Ministerial Forum in May 2009 provides for the reorganisation of the Senior Officers Group to better drive implementation of LEBMF decisions and engage stakeholders in the process.

This report relates to Action 5 of the Action Plan (Implement the LEB Rivers Assessment – LEBRA – through the preparation of an Implementation Plan). The Implementation Plan consultancy project is limited by its terms of reference to assessing and making recommendations on the governance arrangements appropriate to successfully implementing the LEBRA. Yet in doing this, Kiri-ganai Research has been given some latitude to comment on the wider LEBIA

governance arrangements. This is inevitable as the purpose of any formalised assessment activity in the LEB should:

- align to the vision and mandate of the overarching governance system (the LEBIA);
- inform the range of LEB stakeholders and partners about the condition of the LEB and engage them in caring for its future; and
- intrinsically link with stakeholders' and partners' capacity to respond to assessment findings.

Any limitations or flaws in the wider governance arrangements that act to reduce the value of assessing the condition of the LEB or hinder the efficient conduct of condition assessments must therefore be considered. Above all else, assessment activities are not ends in themselves and must serve clearly specified goals owned and advocated by those to whom responsibility for the future care of the LEB is vested.

That said, this report concentrates on the practical and cost-effective arrangements required to enable the LEBRA to be carried out to meet both current and potential future expectations, while drawing attention to other structural and governance issues.

2. A review of existing governance in the context of the LEBRA

Background: a unique institutional arrangement

The LEBIA is based on signed agreement by the Australian, Queensland, South Australian and Northern Territory governments to:

> *Provide for the development or adoption, and implementation of policies and strategies concerning water and related resources in the Lake Eyre Basin Agreement Area to avoid or eliminate so far as reasonably practicable adverse cross-border impacts.*

The partnership, however, goes beyond the governments' formal Agreement and includes stakeholders as diverse as natural resource management groups, pastoralists, mining and Aboriginal representatives.

As with the two other major cross-boundary basin initiatives in Australia, the Lake Eyre Basin has institutional arrangements that are unique to the Basin. Unlike the Murray Darling Basin, the LEB does not have its own centralised management authority, although it does share the characteristic of having its own dedicated Ministerial overseeing body (the LEB Ministerial Forum). This characteristic differentiates the institutional arrangement from the Great Artesian Basin (GAB) which shares its ministerial arrangements with other non-GAB issues under the Natural Resources Ministerial Council.

The specific LEB institutional arrangements are reviewed below, with consultants' commentary provided about their efficacy in the context of the LEBRA.

Suffice to say at this point, our observation about the broad purpose of the LEBIA quoted above is that it does not explicitly deal with the intra-state impacts of the LEB. The agreements does include clauses (i.e. 2.2 (c-d), 3.1 (f), 4.9, 8.3 and 8.4 (c)) that deal with State/Territory policies and management of natural resources, however, the consultant's interpretation of the Agreement is that these clauses are tied specifically to the overall purpose of the agreement which deals with cross-border issues. The implicit assumption is that if partners protect cross-border interests, the condition of the Basin as a whole will be protected. However, this does not necessarily hold true if degradation is contained within state and territory borders. The basis for the assumption is no doubt inter-related with the Basin's focus on water resources (discussed elsewhere). The health of the overall LEB relies, in our view, on consideration of both intra and inter-border management.

The LEB has potential advantages offered by having its own Ministerial-level governance arrangements (the LEB Ministerial Forum), however the arrangements do not share the same head-of-department level of management common to other such inter-governmental forums. Notwithstanding the existence of a Senior Officers Group, the

overarching governance arrangements may lack the delegations to ensure that actions are undertaken as rapidly or with the same level of resources that might otherwise be the case. While this is a question for longer-term consideration in respect to broader governance arrangements for the LEB, it does suggest that expectations for resourcing the LEBRA need to be tempered and make best use of existing resources, including partnerships and networks.

The vision, principles and values of the Lake Eyre Basin

The purpose of the LEBIA previously stated on page seven above outlines more of what is to be avoided than what is to be achieved in the LEB. In other words, a vision for the LEB is in itself not stated, although the principles underlying the LEBIA which provide an implicit guide about what is to be protected are clearly articulated in Clause 3 of the Agreement:

Consideration of all issues and the making of all decisions under this Agreement will be guided by the following Principles, namely that it be acknowledged:

(a) that the Lake Eyre Basin Agreement Area has important social, environmental, economic and cultural values which need to be conserved and promoted;

(b) that there are landscapes and watercourses in the Lake Eyre Basin Agreement Area that are valuable for aesthetic, wilderness, cultural and tourism purposes;

(c) that naturally variable flow regimes and the maintenance of water quality are fundamental to the health of the aquatic ecosystems in the Lake Eyre Basin Agreement Area;

(d) that the water requirements for ecological processes, biodiversity and ecologically significant areas within the Lake Eyre Basin Agreement Area should be maintained, especially by means of flow variability and seasonality;

(e) that flooding throughout the catchments within the Lake Eyre Basin Agreement Area is beneficial in that it makes a significant contribution to pastoral activities as well as flood plain ecosystem processes;

(f) that the storage and use of water both within and away from watercourses, and the storage and use of water from associated ground water, are all linked and should be considered together, and that water resources throughout catchments within the Lake Eyre Basin Agreement Area should be managed on an integrated basis;

(g) that precautionary approaches need to be taken so as to minimise the impact on known environmental attributes, and reduce the possibility of affecting poorly understood ecological functions;

(h) that natural resource management decisions need to be made within the context of the National Strategy for Ecologically Sustainable Development and relevant national and international obligations;

(i) that the collective local knowledge and experience of the Lake Eyre Basin Agreement Area communities are of significant value; and

(j) that decisions need to be based on the best available scientific and technical information together with the collective local knowledge and experience of communities within the Lake Eyre Basin Agreement Area.

In addition to these principles, values identified by the Ministerial Forum and included in the agreed policies adopted on 25 October 2002 include:

- Maintenance of ecological integrity and natural functioning of in-stream and floodplain ecosystems;
- Viable economic, social, cultural and other activities which do not threaten the above environmental values.

These values are supported directly through the six policies adopted by the ministerial forum dealing with flow regime management, water quality, natural resource management, water use planning, research and monitoring and whole-basin-management.

Values identified by the Lake Eyre Basin community through the previous Community Coordinating Group's strategic plan (2002):

- Sustainable and wise use of natural resources;
- Conserving biodiversity;
- Economic prosperity;
- Respect for and use of local knowledge;
- Outback lifestyle;
- Healthy systems with high ecological integrity;
- Forward looking, vibrant communities;
- Sustainable and diverse regional economy.

Understanding these values in place of a vision is important in underpinning the LEBRA process as it helps define what is to be monitored and assessed, and it helps define which sectoral groups need to be informed about matters specifically of value to them.

The values articulated by LEB stakeholders span the breadth of the triple bottom line as well as the breadth of natural assets of the Basin. This needs to be taken into account in the governance of the LEBRA implementation process.

LEB policy framework and LEBRA implications

The LEB Ministerial Forum (LEBMF) in 2002 adopted five policies to guide the strategies and activities required to achieve the LEBIA's purpose. A sixth policy, making explicit a whole-of-Basin ethos, was adopted in 2004. These policies are listed together with key implementation strategies in

Appendix B, however Table 1 provides a summary of these six policies and their implications for the LEBRA Implementation Plan.

The policies outlined in Table 1 are underpinned by 29 strategies (see Appendix B), which can be broadly categorised into 6 themes: invasive species, water flow and quality, natural resource management planning, infrastructure, data and communication. In 2007, a review of the LEBIA (URS 2007) noted widespread community feedback that the arrangements appeared to rely on goodwill more so than formalised lines of delegation and accountability. The review also drew attention to the responsibility of the States and NT partners to implement many of the policies and strategies through their own jurisdictional powers as assigned under the Constitution, and recommended that this approach not be changed.

The challenge for the LEBRA of Constitutionally-based NRM arrangements is not so much that resource assessment and ongoing monitoring cannot be undertaken as independent, specifically designated and discrete activities, but rather that the responses to findings about pressures and resource states is more difficult to coordinate. This has implications for building governance arrangements around a LEBRA based on the Pressure-State-Response model as well as on adaptive management principles.

Table 1: LEB policies and LEBRA implications

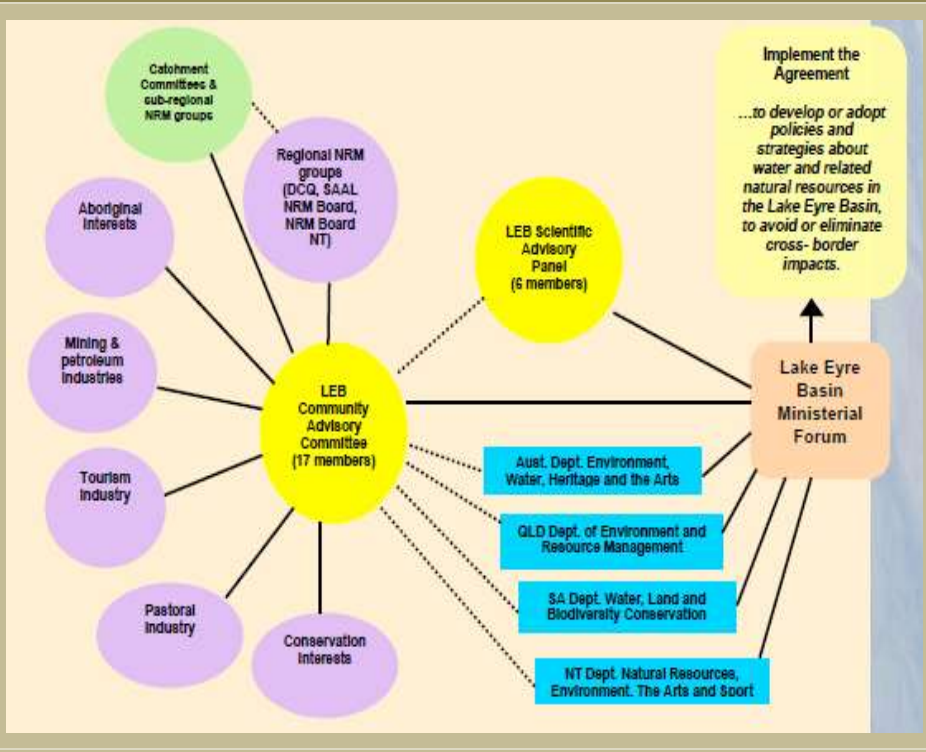
LEB Policy	Implications for the LEBRA Implementation Plan
One: Flow regimes of river systems within the Agreement Area will be managed to protect and maintain the ecological integrity and natural function of in-stream and floodplain ecosystems, and the viability of economic, social, cultural and other activities which do not threaten these environmental values.	'Manage to protect' is the pivotal concept, suggesting the imperative that assessment activities inform management responses. Understanding condition is not enough. While the emphasis is placed on water (flow regimes and quality), a holistic approach is envisaged, reflected in the triple bottom line aspiration articulated in the policy. The Implementation Plan must deal explicitly with linkages between pressure, state and responses within a systems context. A key concept for the LEBRA Plan that must be recognised is that the assessment of PSR linkages must be undertaken at the whole of basin scale
Two: Water quality in the river systems within the Agreement Area will be managed to protect and maintain the ecological integrity and natural function of in-stream and floodplain ecosystems and the viability of economic, social, cultural and other activities which do not threaten these environmental values.	
Three: Water and related natural resources associated with the river systems within the Agreement Area will be managed to protect and maintain the ecological integrity and natural function of in-stream and floodplain ecosystems and the viability of economic, social, cultural and other activities which do not threaten these environmental values.	This policy makes the LEBIA's wider NRM and system responsibilities more explicit.; It reinforces the need for assessing indicators across a range of aquatic, terrestrial and biological indicators as well as social, cultural productive and economic indicators. Recognising the importance of maintaining the natural variability of water and its related natural resources is seen as imperative for managing the biodiversity of the LEB.

LEB Policy	Implications for the LEBRA Implementation Plan
Four: Water resource planning, allocation and management arrangements, including the management of water entitlements, will be compatible with the LEB Agreement. Efficient use of water will be a fundamental principle of water entitlements and utilisation. Water resource development proposals will be assessed to determine their potential impact on river flows and water quality, and compatibility with the Agreement and relevant water resource plans. These assessments will be based on the best available scientific information and local knowledge (including information from other regions in Australia and overseas).	This policy suggests some of the management responses that need to be underpinned by resource assessment data. It introduces the concept and acceptability of local knowledge as a legitimate data source side by side with technical data. Resource assessment methods will need to not only include both scientific and local data, but also detail the means by which distinctly different data sets can be integrated for management purposes, taking into account issues of scale, consistency and reliability, utility and ownership.The policy implies that the consideration of development proposals needs to be cognizant of cross-border implications. Given the inherent variability of natural resources across the LEB at different time scales the incorporation of adaptive management strategies is essential for the any policy development for the basin
Five: Management of water and related natural resources associated with the river systems in the Agreement Area will be guided by the best available scientific information and local knowledge, and by the results of ongoing monitoring and periodic assessment of the condition of these river systems. Targeted research may also be undertaken to address identified knowledge gaps.	This policy complements all other policies by making explicit the need for periodic resource assessment and ongoing monitoring activities to underpin other policy objectives, including management responses to declining resource condition (policies 1-3 and 5) and consideration of new development proposals (policy 3).
Six: Water and related natural resources in the lake Eyre Basin Agreement Area will be managed through a whole-of-basin approach so as to achieve complementary outcomes, through the implementation of state/territory legislation and the plans and associated investment strategies of relevant regional bodies in Queensland, South Australia and the Northern Territory.	This policy reinforces and makes explicit the whole-of-basin approach implied in the previous five policies. It also makes more explicit how management responses are to be implemented (i.e. through partner legislation, planning and investment strategies).

The governance framework and LEBRA implications

The current institutional arrangements applying to the LEB can be visualised in Figure 1. The arrangements cover the Intergovernmental Agreement itself, the Ministerial Forum representing the highest level of governance, the Community Advisory Committee and Scientific Advisory panels which provide counsel to the Ministerial Forum and the member Governments. The Figure 1 emphasises the role of the CAC, while the relationship to State and Territory water resource policies and plans is depicted in Figure 2. Each of the constituent parts of the LEB framework are described and reviewed in the context of the LEBRA below.

Figure 1: LEB institutional arrangements



Source: LEBMF (2009)

The Ministerial Forum

The LEBMF comprises Ministerial representation from the Australian, Queensland, South Australian and Northern Territory governments. Dr Mike Kelly, Parliamentary Secretary for Water, representing the Australian Government, chairs the Forum. The Forum meets about once per year, and following consideration of the 2007 LEBIA review, now attempts to align its meetings with those of the Natural Resource Management Ministerial Council. The suggestion that the two Ministerial level bodies combine has been rejected.

Consultations to date suggest that the Ministerial Forum very much relies on the Senior Officers Group (SOG) and the Secretariat to drive its agenda, with advice taken from the Community Advisory Committee (CAC) and Scientific Advisory Panel (SAP). Finding time when all Ministers are available to meet has been problematic at times, although consultations suggest that the level of commitment by Ministers is very high.

The LEBRA can, and should, play a pivotal role in alerting the LEBMF to significant issues requiring coordinated policy responses. The LEBRA should also act to provide a clear understanding of the condition of the Basin to help jurisdictional representatives avoid articulating mixed or inconsistent messages. Both these issues are consistent with widely accepted governance principles of evidence-based decision making.

The Senior Officers Group

The SOG comprises senior governmental officials from the relevant government agencies associated with each LEBMF member.

As previously noted, the LEB Ministerial arrangements are relatively unique in that they are not supported by head-of-department level representation to act as the body assigned to administer implementation of the LEBIA. The material in support of the draft 5 Year Action Plan noted the lack of a clear implementation pathway for the LEBIA, with goodwill and voluntary responses filling the void. To the SOG's credit, such realisation has galvanised it towards accepting a leadership role that had not been articulated for it in the LEBIA but one which is fundamental to the Agreement's success. The 5 Year Pan adopted by the LEB Ministerial Forum formalises this leadership role in the SOG.

The LEBRA should act to provide the kind of information required to guide policy and program responses. In many respects, the SOG is in the fortuitous position to influence the conduct of the LEBRA as well as many of the responses to the information it provides. The SOG needs to play a stronger role than it has to date in the LEBRA process to ensure that the assessment process is aligned to the response mechanisms available through its jurisdictional representatives.

The LEBIA makes specific provision for the establishment of two groups within the terms of the Agreement. One is to provide advice on community matters (Clause 5.10); the other to provide advice on scientific and technical matters (Clause 7.2).

The Community Advisory Committee

The CAC is an important legacy of longstanding community participation in the affairs of the LEB. It comprises representatives of those people and organisations that either live within the LEB (its citizens) or are dependent to some extent on the values of the LEB (its industries and societal stakeholders). The CAC is also an artefact of shifts towards regional governance that have taken place across many western societies over the past two decades (Lawrence 2004), perhaps most prominently in Australia (Lockie and Vanclay 2007).

The CAC shares with the SOG a characteristic vital to the successful implementation of the LEBRA within the context of adaptive management as proposed: the capacity to respond, if necessary, to the information provided by the assessments. More importantly, the CAC comprises those interests with the major personal or corporate motivation to respond, and by implication those with the strongest stake in ensuring that the LEBRA is both rigorous and provides information of utilitarian value.

The Scientific Advisory Panel

The SAP is established by the LEBMF to provide scientific and technical advice relevant to the LEBIA. The areas of expertise are not set out in the

Agreement, however, the existing members cover a wide range of disciplines spanning the natural sciences, and to a lesser extent the social sciences.

The LEBRA receives implicit mention in the Agreement in the context of the SAP's role:

> *The Ministerial Forum may obtain scientific/technical advice in relation to the requirements for the effective monitoring of the condition of the rivers and catchments within the Lake Eyre Basin Agreement Area and the establishment of programs to meet those requirements.* (Clause 7.1)

The SAP's role as prescribed in the LEBIA is to '*provide advice*'. This is consistent with commonly accepted interpretations of good governance; keeping the SAP independent of monitoring performance, so that it can provide advice not only on what ought to be performed, but how it was performed. Maintaining this independence is a principle that should be adopted in the LEBRA governance arrangements.

Another important role for the SAP in the LEBRA should be to interpret the implications of the findings for further investigation and research.

The Regional NRM Boards

Three regional NRM Boards have responsibility for regions within the LEB: The Desert Channels Qld, South Australian Arid Lands NRM Board and the NT NRM Board. In response to a 2007 LEBIA Review recommendation, these Boards each now nominate two members on the CAC, one of whom has to be a Board members. An annual meeting between these NRM Boards and SOG members has also recently been established.

To some extent, the NRM Boards provide a link between government agencies, technical capacity and community engagement. They are involved in both monitoring and on-ground responses to resource condition, although the breadth and depth to which these activities take place is subject to the exigencies of competitive funding topping up limited core capacity.

The level to which the regional NRM Boards can undertake LEBRA activities hinges not simply on funding availability, but on the level of trust placed in them by government and industry agencies. Their capacity to motivate and focus existing community networks on wider LEB initiatives should be an important element of advancing the adaptive management approach proposed for the LEBRA.

The LEB Secretariat

The LEB Secretariat performs two distinct roles; facilitating accountability of LEBIA arrangements through supporting governance, administrative and communication; and facilitating action and progress through coordination, networking and, to a lesser extent, guidance. The LEB Facilitator in particular has a unique role in interacting with each of the

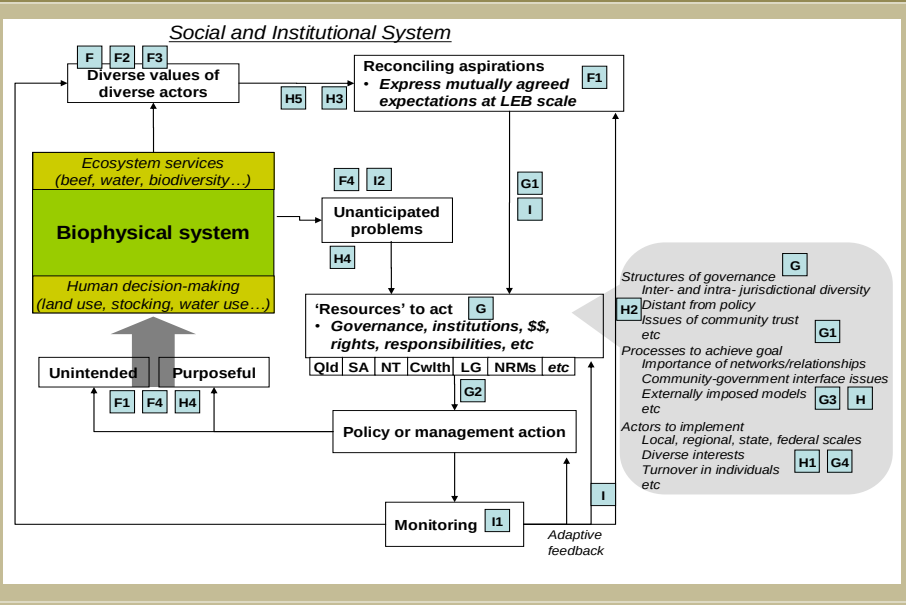
other LEB institutional components by and large in the context of implementation.

The LEB Facilitator can play an important part in ensuring that the findings of the LEBRA inform the diverse range of interests in a position to respond. This can be achieved through guiding the knowledge and communication strategies as well as in helping set the agendas for the various bodies such as the SOG, SAP and CAC.

LEB Knowledge Strategy and LEBRA implications

A Lake Eyre Basin Knowledge Strategy was drafted for the consideration of the LEBMF at its 2009 meeting. The strategy provides a conceptual framework for knowledge building, utilisation and adaptive feedback. The Social and Institutional System framework (Figure 2) is of particular relevance to the LEBRA, and is consistent with the modified LEBRA's attention to adaptive management.

Figure 2: Conceptual framework for institutional relationships in the LEB, expressed as an adaptive learning cycle



Source: LEB SAP (2009)

Within the strategy, a range of knowledge questions are outlined. While these provide guidance for further research in the LEB, they also act to guide ongoing monitoring and assessment activities. The key questions include:

A: What limitations on our understanding of surface and groundwater constrain our ability to manage the surface and groundwater resource of the Basin?

B: What are the impacts of present and future land use (e.g. land clearing, pastoral activities, mining) on quantity and quality of surface and groundwater?

C: How do we measure the health of rivers, waterholes, terminal lakes/wetlands? Can trends be detected?

D: What is the current catchment health (baseline assessment)?

E: What are the implications of changes in ecosystem quality for human use of resources?

F: What are the values and aspirations of key stakeholders across the LEB?*

G: What institutional and governance arrangements will facilitate the best policy and management outcomes for LEB natural resources?

H: What are the best ways of engaging Basin communities in Basin-related NRM?

I: What is the current 'adaptive capacity' of LEB actors in contributing to better NRM outcomes in the Basin, and how can 'adaptive capacity' be improved in the future?

Each of these questions is supplemented by detailed supporting questions (see Appendix C).

While it is important that the LEBRA provide the basis for understanding the condition of the LEB to underpin appropriate management responses, it is important it also inform the Knowledge Strategy in respect to progress in being able to answer key research questions.

LEB Communication Plan and LEBRA implications

The LEB Communication Plan seeks two long-term (5-10 year) outcomes:

Outcome A: Improved public awareness and understanding of the values of the Lake Eyre Basin and the Agreement and the need to protect and properly manage the area; and

Outcome B: A strengthened sense of shared responsibility amongst LEB groups and stakeholders towards the management of the Lake Eyre Basin.

These outcomes are supported by a further set of four short-term outcomes and a range of actions directed towards achieving each (see Appendix D.

The purpose of the LEBRA, set out in Section 4 of this report, includes among other things, gaining an understanding of the condition of the LEB in order to *form consistent messages appropriate to, and encourage constructive dialogue between, specific target audiences about condition, outlook and appropriate responses.*

The link between the LEBRA and the communication strategy becomes clear when the planning and conduct of the LEBRA is consistent with the first four key messages to be delivered through the Communication Plan:

- The Australian, Queensland, South Australian and Northern Territory Governments are working together to protect and manage the Lake Eyre Basin.

- The communities of the Lake Eyre Basin have an important role to play in protecting the culture, biodiversity and environment of this unique region.
- The Lake Eyre Basin is a unique river system which is the home to valuable and diverse flora and fauna.
- The ecological integrity and natural function of in-stream and floodplain ecosystems must be balanced with the viability of economic, social, cultural and other activities in the Basin.

The key messages outlined in the LEB Communication Plan need to be reflected in the way the LEBRA is conducted. That said, future key messages need to be informed by the results of the LEBRA.

Previous reviews considering LEB institutional arrangements

Action Plan perspectives on the current arrangements

The Final Report of the consultancy to develop a draft Five Year Action Plan (the Final Report) has much to say on the overall LEB institutional arrangements, and comments specifically about the extent of effort and goodwill that has been contributed by individuals and organisations to date. It highlights the *strong culture of openness, trust and respect that has developed between groups and people involved . . .* with the view that . . . *sustaining this culture will be vitally important to the success of future governance arrangements under the LEBIA*.

On the other hand, the Final Report notes confusion among stakeholders about the respective roles, responsibilities and relationships of each of the different groups and agencies working on aspects of the LEBIA. The suggestion is made that limited definition of these roles has often resulted in duplication of effort or a disjuncture of activities between groups and agencies.

Concern has been expressed by the regional NRM Boards to the consultants that although they have good coordination mechanisms between the LEB-related Boards, they have more to offer through strengthening their role in the broader LEB partnership arrangements. This is consistent with another view expressed in the Final Report that many stakeholders living in the LEB feel that many of the important decisions about the LEB are made by those living outside the Basin. The concern here was not simply that the role of 'insiders' should be strengthened in the decision-making process, but also that the 'outsiders needed to build their capacity in ways so that they understood the uniqueness of the LEB and the communities within it'. The reconstitution of the Community Advisory Committee to include representation from the three NRM Boards has not fully alleviated these concerns (Andrews: personal communication).

The authors of the Final Report independently came to the same conclusion as the authors of this report that although many of the groups and agencies involved in the arrangements under the LEBIA have a broad

NRM remit, the focus on water resources *would not fulfil the remit of the Agreement, and would deny the body of scientific and experiential knowledge that demonstrates the need to consider land and water resources as part of a whole biophysical and socio-economic landscape* (Price and Lovett 2008). This point has been made forcefully in the first two reports of this LEBRA Implementation Plan project.

The Final Report provides substantial argument for making fundamental changes in some cases, and refinements in others, to the governance arrangements of the LEB. The relevant section of the Final Report can be found as Appendix E of this report. The findings of the Final Report were endorsed and the 5-year Action Plan adopted.

2007 review of the LEBIA by URS Australia

Governance arrangements for the LEBIA were considered in a review undertaken by URS Australia in 2007 (URS 2007). The review was completed as a requirement under the LEBIA that the arrangements be reassessed after five years. Alternative governance models for achieving the purpose set out in the LEBIA were considered, including strengthened ministerial oversight, direct Commonwealth management using constitutional powers, replacement of the LEBIA with NRM programs, broadened focus from water, expansion of the boundaries (to cover the southern Basin in SA and the small area falling into NSW), and strengthened role of regional NRM Boards.

The findings and recommendations of the review follow:

1. <u>INTEGRATED, SUSTAINABLE NRM</u>. The focus in the LEBIA on 'water and related natural resources' does not align with the present day principles of integrated natural resource management (INRM) which underpin Australia's regional NRM model. Over the five years of the Agreement, the emphasis has moved to integrated NRM.

Recommendation 1*: That the Agreement be modified to emphasise 'integrated, sustainable natural resources management' as compared to the present 'water and related natural resources'.*

2. <u>AVOIDANCE OF ADVERSE, CROSS-BORDER IMPACTS</u>. This current focus of the LEBIA falls short of integrated whole-of-catchment management, which represents present day best practice. The focus on adverse cross-border impacts is the reason why the NSW part of the LEB and much of the SA part are excluded from the LEBIA – land management in those parts have no cross-border impacts.

Recommendation 2: *That the boundary of the LEBIA area be expanded to include all of the hydrological LEB.*

3. <u>ENCOMPASSING THE REGIONAL NRM GROUPS</u>. Since the LEBIA came into effect, the national regional NRM delivery model has been established, giving rise to three regional NRM Groups who are responsible for INRM in the Queensland, South Australian and Northern Territory parts of the LEB. Thus these Groups do not formally come within the Agreement and this disconnect runs the risk of (inadvertently)

undermining the Agreement as each Group operations are restricted to the jurisdictional borders.

Recommendation 3: *That the regional NRM Groups be brought within the ambit of the Agreement by:*

i) comprising the CAC from representatives of the regional NRM Boards (Note: The regional NRM groups are themselves representative of a broad spectrum of stakeholders, so this enables the stakeholder-representative nature of the CAC to continue.)*;*

ii) building in formal two-way communications between the LEBMF (and LEB secretariat) and the regional NRM Boards;

iii) establishing the position of one or more LEB Regional Facilitator(s) to facilitate and harmonise the integrated NRM work in the LEB,

iv) aligning the programs of the regional groups with the priorities of the LEB as strongly as is feasible.

4. ROLE AND OPERATION OF THE MINISTERIAL FORUM*.* The Ministerial Forum is seen as an important reflection of the significance that should be accorded the LEB and the LEBIA, and stakeholders want it retained. However, the requirement that it meet in the Basin, whilst desired by community stakeholders as an opportunity to engage with Ministers, is logistically impractical, and disconnects the LEBMF (Lake Eyre Basin Ministerial Forum) from Australia's main NRM decision making process, the NRM Ministerial Council (NRMMC).

Recommendation 4: *That the LEBMF be retained; and that it be brought within the aegis of the NRMMC and not be required to meet in the Basin.*

5. ROLE OF THE SCIENTIFIC ADVISORY PANEL. The SAP has been effective by virtue of the high scientific credibility (and commitment) of its members and its direct access to the LEBMF. It has initiated important research and monitoring activities. More could have been achieved if it had better organisational support. Over the past five years the technical capacities of the jurisdictions' agencies (including the regional NRM Groups) have increased, this should be drawn upon for addressing LEBIA issues.

Recommendation 5*: That SAP be continued as constituted; that it have a strategic advisory role as well as to monitor the effectiveness of the work undertaken to underpin strategic INRM decision making in the Basin, and that the SAP be provided with sufficient support to undertake its work.*

6. RELATIONSHIP WITH THE GREAT ARTESIAN BASIN COORDINATING COMMITTEE. The LEB overlaps the Great Artesian Basin, and the bore capping and piping work being undertaken by the GABCC is improving the condition of the natural resources of the Basin. Community stakeholders are confused between the two groups.

Recommendation 6: *Where appropriate, opportunities be pursued to hold CAC meetings in conjunction with GABCC meetings.*

The LEBMF considered the review and its recommendations as detailed above at its 2008 meeting. The specific responses to each recommendation are outlined in Appendix F.

The LEBMF's responses to the URS review of the LEBIA provide some guidance in respect to future governance arrangements for the LEBRA. Implicitly, the responses reinforce the imperative to focus on integration at the point-of-practice (i.e. in the implementation of specific activities). Governance arrangements for the LEBRA therefore need to be practical, easy to implement, be seen to 'get on with the job' and be couched in an adaptive framework that ultimately stimulates responses on-the-ground.

3. Principles for good governance in the LEB

Good governance

A number of discussions during consultations relating to this project alluded to the need for 'good governance' as the most critical element of ensuring that the LEBRA is effectively implemented. Indeed, the terms of reference guiding our project imply this as well.

A good definition of 'governance', as opposed to a definition of 'good governance', has been posited by one of the SAP members:

Governance (Ostrom 2005) includes:

- *the formal and informal social rules (e.g., property rights) and norms (e.g., equity) that guide the behavior of individuals and groups toward one another and their access to and use of resources and services;*
- *the political system that makes and changes the rules and the policies through which they are implemented; and*
- *organizations and social networks that implement and monitor compliance with the rules.*

Surprisingly, perhaps, there is no simple yet exhaustive definition of good governance, or at least one that is widely accepted. As noted by the Office of the United Nations Commissioner on Human Rights:

> *The term is used with great flexibility; this is an advantage, but also a source of some difficulty at the operational level. Depending on the context and the overriding objective sought, good governance has been said at various times to encompass: full respect of human rights, the rule of law, effective participation, multi-actor partnerships, political pluralism, transparent and accountable processes and institutions, an efficient and effective public sector, legitimacy, access to knowledge, information and education, political empowerment of people, equity, sustainability, and attitudes and values that foster responsibility, solidarity and tolerance.* (OUNHCHR 2007)

No doubt a quote from a major industrial corporation, a not-for-profit voluntary organisation or a government instrumentality would include an equal number, yet a different but overlapping set, of characteristics. Good governance, therefore, may be defined by its context. Stafford Smith (in publication), for example, suggests that governance arrangements involving remote areas such as the LEB require principles that are sensitive to the peoples and settlements of the region, who and which are *generally remote from centres of power and decision-making* (Stafford Smith 2008). Examples of these principles, taken direct from Stafford Smith (in publication) are outlined in Table 2.

Table 2: Successful structural principles and institutional practices for remote governance[a]

Subsidiarity and scale – different operational models in sparsely populated areas
• **balancing** dispersed local residence with a larger-scale representative voice • *allowing different ways of operating in different localities, nested within a regional system that may also differ in detail between regions (**'polycentricity'**)* [b] • locating decision-making responsibility at the closest possible point of connection to the people affected, and making decisions at higher levels *only* when more inclusive matters require such consideration (i.e. '**subsidiarity**') • emphasising relatively **egalitarian relationships** between organisations, groups and kinship units, with each component of the network having relative autonomy while also having nodes of concentrated power and authority within networks (i.e. 'relational autonomy') • *recognising that service delivery may occur at a **different scale** and in different organisations to the governance of that service* [c]
Connectivity and networking – harder yet more important in remote areas
• networking governance so that arrangements encompass **layers** of groups, organisations and communities, each with its own roles, authority and responsibilities • working out governance by **first working out relationships** and shared connections, thereby giving effect to the interconnectedness needed for networked governance • working through the governance **histories** of the constituent social and organisational layers in order to reinforce or develop new connections • **strengthening** the connections (both internal and external) within and between networks, in order to support vulnerable components
Building capacity – particularly lacking or unstable in small communities
• **'nodal' leadership**, where key individuals are able to mobilise, rebuild and sustain networks and resources • **supporting** the capacity, role and responsibility of all the layers in a governance network, not just the 'top' or central levels • *emphasising **downwards accountability** to constituents over upwards accountability to higher level bureaucrats* [d] • a focus on **building** the institutions and internal 'culture of governance' needed within [Indigenous] organisations to sustain practical effectiveness and legitimacy
Sources: [a] Hunt and Smith (2007), Stafford Smith (2008), Stafford Smith & Cribb (2009) [b] Ostrom (1999), Marshall (2008) [c] Stafford Smith *et al*. (2008), Stafford Smith & Cribb (2009) [d] Moran & Elvin (2009)

A workshop of SAP members on 11-12 August 2009 considered the governance principles they would like to see applied to the LEBRA and agreed on the following:

- Transparent
- Efficient
- Clear definition of responsibilities (and rights)
- Responsive
- Accountable
- Inclusive
- Persistent (relevant and accepted)
- Respectful

The final three principles in particular take into account the concepts outlined in Table 2 above.

For the purposes of the LEBRA, it is worth adopting the generalised view where a significant degree of consensus does exist: that good governance relates to political and institutional processes and outcomes that are deemed necessary to achieve the goals of the matter at hand, in this case successful implementation of the LEBRA, in a way consistent with the values articulated by LEB stakeholders (see Section 2) and the SAP (see above).

Taking the SAP's eight principles, Table 3 provides a brief assessment of the LEBIA's performance, based on consultations, and the implications to be considered for implementing the LEBRA.

Table 3: Proposed governance principles in relation to the LEBRA		
Prin-ciple	**Observation**	**Implication for LEBRA**
Transparent	LEBIA-related activities and decisions are publicly accessible via the web, backed by a broad communication strategy. Tenders and financial processes are subject to Governments' strict procurement procedures, which are open and transparent.	Agreed LEBRA methods and governance arrangements should be open for scrutiny and comment.
Efficient	This has not proved the case specifically in the context of the LEBRA, and reflects a gap in clear understanding about who is responsible for what when it comes to implementation.	Roles, responsibilities, relationships and timelines must be very clearly defined.
Responsible	LEB arrangements appear ethical and, to date, untainted by claims of conflicts of interest. Issues about responsibility for implementing activities have hampered by resource constraints and the part-time membership nature of some of the associated structures (i.e. CAC, SAP).	Clear delineation of responsibilities must take into account separation of oversight, performance and review to avoid not only conflict of interest, but possible reinforcement of incorrect assumptions or interpretations about LEBRA methods and findings.
Responsive	Only at the facilitator level is there a capacity to quickly respond to issues, and even then within the limits of delegation. Some agency budgets are subject to the exigencies of external funding, and others have internal competition for funds. Revenue under the LEB budget has not altered since 2000. The link between assessment and capacity to respond to assessments is tenuous.	A clear and adequate budget is required to carry out the LEBRA, with appropriate delegation of authority to respond quickly and adequately to implementation issues that invariably arise. The LEBRA should adopt an adaptive management framework, including in the design of the methods, so that the LEBRA is driven by response as well as condition parameters.
Inclusive	The CAC has acted as a mechanism to ensure some level of inclusiveness. The notion of representation assumes good networks between representatives and their wider stakeholder sector, which is not always the case.	There is considerable resource assessment effort being undertaken across the LEB by some stakeholder groups. Where relevant, these groups should be participating in the LEBRA process and be recognised for it.
Accoun-table	All LEB processes are compliant within the context of government accountability principles and practices.	Clear lines of delegation and authority must exist in the conduct and reporting of the LEBRA.
Persistent	The LEBIA arrangement is approaching its first decade, surviving changes in federal and state governments as well as fundamentally different NRM funding policies.	Governance arrangements, including partnerships, should be based on those likely to have some ongoing certainty and ongoing connection to the community and those that regularly monitor.
Respectful	Distance, both physical and in-terms of decision-making, has been an issue raised by CAC members and NRM Boards. Some CAC members have suggested that the CAC doesn't have the same sense of community connectedness and outreach as the former Coordinating Committee.	A sense of connectedness can come from a sense of collaboration on meaningful activities. The LEBRA needs to be designed to enhance this sense, as well as to enhance the possibility of the findings being acted upon.

Pressure-State-Response approach to the LEBRA: implications for governance

Describing the pressures bearing on the condition of the LEB is an important element of a comprehensive assessment of the LEB. The Pressure-State-Response (PSR) framework provides a broader context for assessing the pressures that various activities place on the Basin. The PSR approach was developed by the OECD and is now widely used. The model considers that human activities exert pressures on the environment that affect its quality and the quantity of natural resources (state). Society then responds to these changes through environmental, general economic and sectoral policies, and through changes in awareness and behaviour or activities (societal response). Often, decisions are targeted not at the original pressures, but at the symptoms exhibited by the changed state. Without considering the pressures, and the driving forces behind them, such measures are almost always doomed to failure.

In Australia the PSR model, and variations on it, are used in State of the Environment reporting by governments at the local, state and national level. "Indicators" are the essential components of these models, but often data is lacking to demonstrate trends over time (Williams et al. 2001). Table 4 outlines the key pressures on the LEB.

Table 4: Pressures and sources of pressure on the LEB

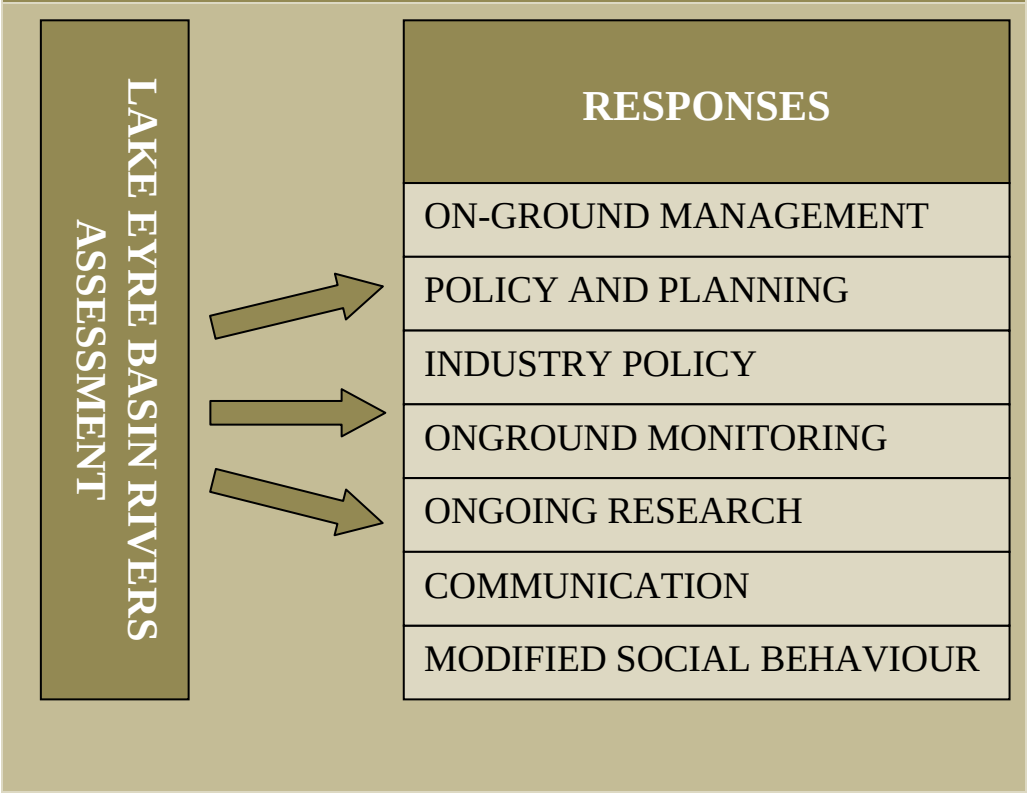
Broad pressure (Beeton et al 2006)	Sources of pressure in LEB
Vegetation clearance and modification	Agricultural production; some mining; some tourism, some light industry
Altered fire regimes	Agricultural production
Altered hydrology	Agricultural production; some mining
Trampling and compaction	Agricultural production; some mining; some tourism
Invasive species	Agricultural production; some tourism
Pollution (water, soil and air)	Mining; some agricultural production, some tourism, some light industry
Disease and pathogens (minor issue)	Some agricultural production
Climate change	Agricultural production; some mining; some tourism, some localised light industry
Direct decline of biodiversity from harvest (minor)	Some agricultural production (kangaroo harvest)

Pressures identified specifically in the State of Basin report 2008 include:

- Major water development proposals including mining and irrigation
- Cumulative impacts of minor water developments (including bores) and diversions
- Intensified land use around waterholes
- Presence and spread of introduced pest plants and animals, especially their impact on waterholes
- Isolation of floodplains through levee construction or roadway embankments
- Impacts of pastoral activities, tourism and mining
- Intensified surface water extraction and drawdown
- Impacts of climate change on water resources
- Modification of basin catchments, such as vegetation clearance and inappropriate grazing, soil management and cropping practices
- Stocking rivers and waterholes with non-local fish species.

The PSR approach, together with an adaptive management approach (see next section) is embedded into the revised LEBRA methods set out in Section 4. One implication of the approach is that it squarely positions the LEBRA in terms of informing responses to the impacts imposed by various pressures. Examples of responses a well conducted LEBRA can elicit are outlined in Figure 3.

Figure 3: Responses the LEBRA should seek to elicit



With a need for the LEBRA to have utilitarian practicality, the SAP at its workshop on 11-12 August 2009 agreed to the following purpose of the LEBRA:

> The purpose of the LEBRA is to gain an understanding of the LEB's condition in order to:
>
> - **underpin responses to condition**, including a range of on-ground management, government and industry policy, enterprise and personal decision making and local and regional resource planning responses
> - **form consistent messages** appropriate to, and encourage constructive dialogue between, specific target audiences about condition, outlook and appropriate responses
> - **guide ongoing research, investigation and monitoring** efforts so that they can form a reliable basis for evidence-based responses.
>
> The participating government, community, industry and research partners will support this purpose by engaging in an adaptive management process. This process involves collaboration in undertaking the Rivers Assessment, interpreting its results in terms of required responses, influencing the implementation of responses and evaluating these responses.

It is simply not possible to expect that the conduct of a resource assessment in the LEB will indeed elicit the range of responses outlined in Figure 4 across the community and breadth of stakeholders. Other than putting in place regulatory regimes, most responses will be voluntary in nature. Voluntary responses by amorphous stakeholder groups without clear stakeholder identification, communication, encouragement and, in many cases, incentives, are likely to be limited. For that reason, it is important that the governance arrangements for the LEBRA take into account appropriate conduits to turn the 'amorphous' in the 'tangible' in respect to eliciting responses to LEBRA findings. Within the current structure supporting the LEBIA, these conduits are considered in Table 5.

Table 5: Conduits to desired responses to LEBRA findings

Desired response	Conduit to desired response
On-ground management	CAC; Regional NRM boards
Policy and planning	LEBMF; SOG; CAC; Regional NRM boards
Industry policy	Community Advisory Committee
On-ground monitoring	SOG; CAC; SAP; Regional NRM boards
Ongoing research	SAP; SOG; Regional NRM boards
Communication	Secretariat; LEBMF; Regional NRM boards
Modified social behaviour	CAC; Regional NRM boards

The means by which the response conduits outlined in Table 5 operate is dealt with in detail in Section 5.

Adaptive management and LEBRA governance

Previous reports submitted in respect of this project have advocated an adaptive management approach to the LEBRA. This is consistent with LEBIA policies, and is implicitly dealt with in the preceding section where the purpose of the LEBRA is viewed in the context of strategic responses.

While the response to an adaptive management approach has generally been favourable, it has been viewed by some stakeholders as representing a longer-term aspiration that could compromise the shorter-term imperative of undertaking a comprehensive resource assessment in the LEB. The consultants do not consider that adopting an adaptive management approach to the LEBRA will delay its implementation. Indeed, early conduct of the LEBRA can and should help shape the longer-term adaptive management framework not only for future resource assessments, but also for the wider activities under the LEBIA. In this sense, we advocate an adaptive management approach to the LEBRA, the LEB Knowledge Strategy, the LEB Communication Plan and to LEBIA policy formulation.

Adaptive management is new to neither environmental management nor resource assessment. Holling and Walters in the 1970s, for example, developed the Adaptive Environmental and Assessment Management (AEAM) approach to watershed management (Holling 1978), and this in turn has been adapted in various permutations for national park and more regionalised forms of management.

Strategic Adaptive Management (SAM) offers a framework for natural resource management and decision making in environmental, social and institutional situations characterized by variability, uncertainty, incomplete knowledge and multiple stakeholders. Three key tenets form the basis for the management and decision-making process in SAM: strategic and value-based planning based on scientific and societal needs and values; a learning by doing approach to management planning; and, participatory engagement of all stakeholders to serve their needs, access their inputs and secure their cooperation (Rogers *et al* 2008).

SAM offers six fundamental principles that may form components of a framework for managing and monitoring resilience in landscapes such as the LEB:

1. All stakeholders are involved in the process of developing a vision for the desired state of riverine landscape condition.
2. A vision for the desired state of riverine landscape condition is translated into an objectives hierarchy.
3. TPCs (Thresholds of Potential Concern) are generated to define acceptable levels of change in riverine landscape form and function.

4. Research and observations of landscape form and function are used to audit and understand river ecosystem condition in relation to TPCs.
5. Management interventions are an accepted part of ecosystem processes but only occur in context of TPCs.
6. Learning by doing is an essential part of SAM: knowledge of ecosystems is constantly reviewed in order to update TPCs and management options.

Each of these principles is described here in terms of implementation (cf Rogers 2008):

1. Developing the vision

The description of the desired state involves developing a shared vision of the system, translating that vision into ecosystem objectives/outcomes and generating a set of thresholds of potential concern. Visioning involves understanding, with stakeholders, the social, economic and ecological context of the system to be managed, and the principles/values that guide management. Developing a broadly acceptable vision of the future is a precursor to knowing what responses are required to resource assessments (Rogers *et al* 2008).

2. Translating the vision into ecosystem objectives/outcomes

Develop an 'objectives hierarchy' that documents the sequential reasoning used in translating a broad societal values-based vision into science-based ecosystem outcomes.

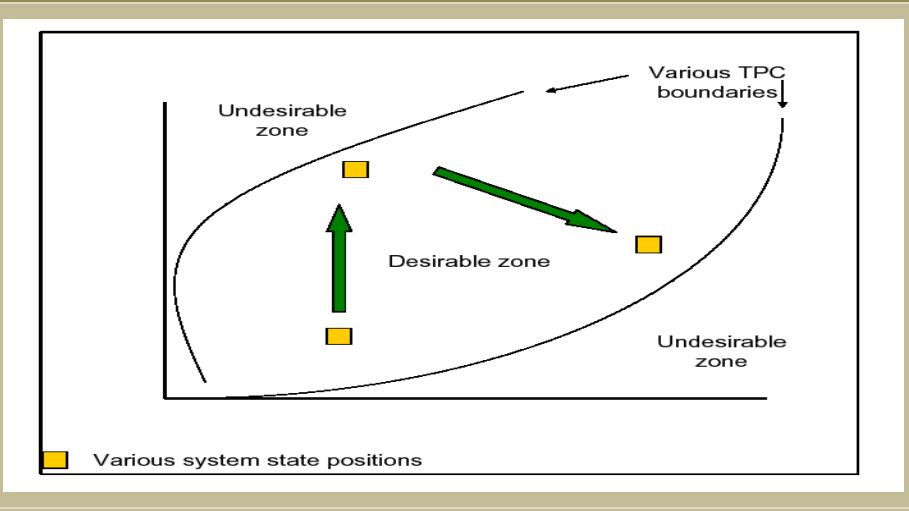
3. Generate a set of TPCs to define the acceptable levels of change in ecosystem / biodiversity composition, structure and function

The desired state refers to a range of varying conditions, acknowledging that ecosystems are variable and heterogeneous in time and space. The desired outcomes of management are therefore expressed as limits of acceptable change – termed TPCs(Figure 4). Thresholds of potential concern (TPCs) are upper and lower levels of change in selected indicators. If TPCs are reached it is very likely that the desired state will not be achieved or will not be able to be achieved into the future (Rogers *et al* 2008).

4. Research, monitor and audit achievements

Research practices highlight that the choice of paradigms, methods and scales of observation must be set within the context of managing resilience. Use a range of research projects, traditional monitoring, modelling and surveys to understand system response to natural flux and management intervention. Weigh this against the desired outcomes.

Figure 4: Thresholds of potential concern (TPCs) as boundaries of the desired state



Source: **After Rogers *et al* (2008)**

5. Develop a plan to achieve or maintain the desired state

Expect the unexpected – Use a variety of tools (scenario planning, systems thinking, models, historical records, etc.) to scope the range, and likely spatiotemporal limits, of unusual events and their implications for management towards the desired future conditions (Rogers *et al* 2008).

Scope the range of management options – Scoping is undertaken to achieve the desired future conditions and predict (formally or informally) their likely outcomes under different scenarios (Rogers *et al* 2008).

Select the best options – In co-operation with stakeholders decide which management options provide the best potential learning opportunities, and social-ecological system outcomes (Rogers *et al* 2008).

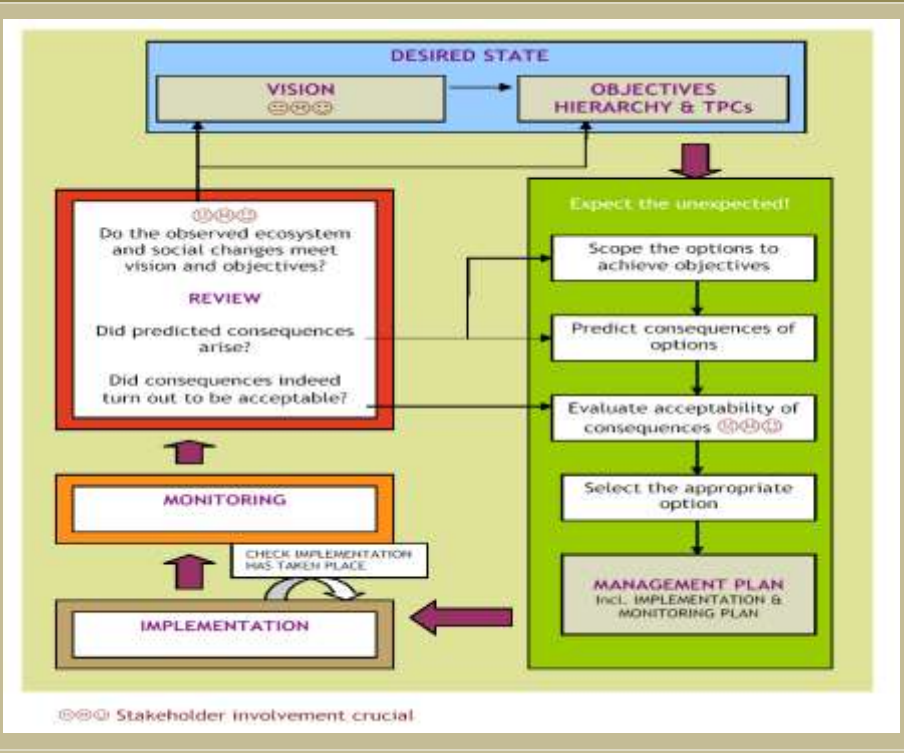
Implement, monitor and adapt - Implement the planned management interventions. In reflecting on implementation ask: Is thinking and action congruent with principles, values and vision? What does knowledge gained tell us about (1) our understanding of the ecosystem, (2) its responses, (3) how realistic are the desired outcomes and (4) how useful are the processes used to achieve them?

6. Participatory learning

Participation should not be compartmentalised so that it starts and ends with any one of the preceding five activity areas. The adaptive cycle relies on continuity of involvement and the constant comparison of data against experience.

The relationship between these six principles, in the context of a strategic adaptive management process, can be seen in Figure 5.

Figure 5: The Strategic Adaptive Management (SAM) process

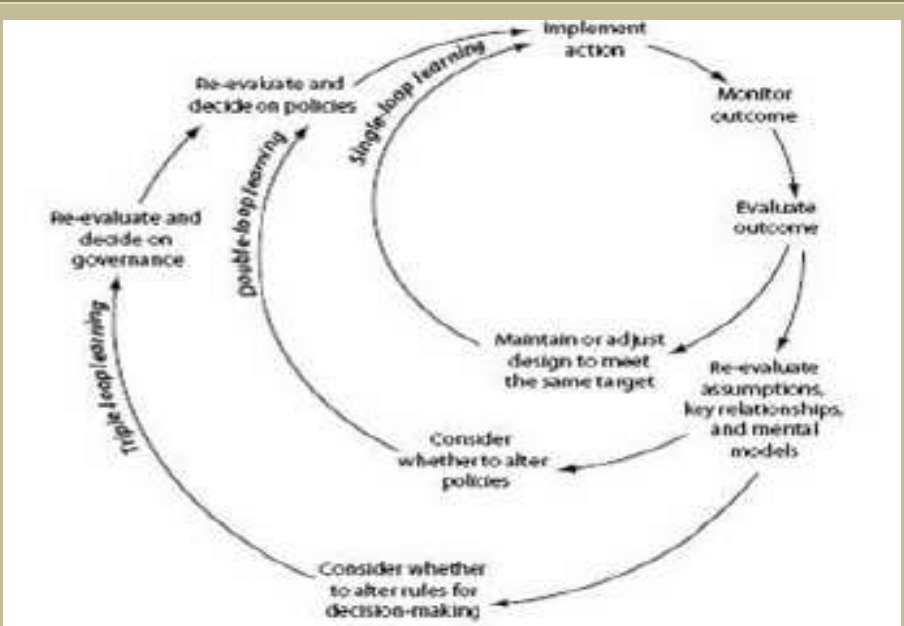


Source: **After Rogers *et al* (2008)**

Triple loop learning and LEBRA governance

At its August Workshop, the SAP recommended that the LEBRA adopt a triple loop learning approach, which takes the SAM approach and adds additional considerations as to whether norms, institutions and paradigms need altering through fundamental changes to governance arrangements (see Figure 6).

Figure 6: Aspects of triple loop learning



Source: **Chapin et al. 2009**

The implications of this approach go beyond the governance arrangements for the LEBRA itself. It does suggest, however, that the broader LEBIA governance arrangements may not require immediate, or at least radical, modification until such time as feedback provided by the conduct of the LEBRA suggests what appropriate governance measures need to be taken.

4. The revised LEBRA methodology

Purpose of the LEBRA

The purpose of the LEBRA is to gain an understanding of the LEB's condition in order to:

- **underpin responses to condition**, including a range of on-ground management, government and industry policy, enterprise and personal decision making and local and regional resource planning responses
- **form consistent messages** appropriate to, and encourage constructive dialogue between, specific target audiences about condition, outlook and appropriate responses
- **guide ongoing research, investigation and monitoring** efforts so that they can form a reliable basis for evidence-based responses.

The participating government, community, industry and research partners will support this purpose by engaging in an adaptive management process. This process involves collaboration in undertaking the Rivers Assessment, interpreting its results in terms of required responses, influencing the implementation of responses and evaluating these responses.

Taking a resilience approach to the LEBRA

It is widely acknowledged that Australian river landscapes are under pressure and continue to degrade under existing management practices. This is not surprising. Landscapes and ecosystems are moving targets characterized by episodic change, patchiness, variability, multiple scales of operation and multiple stable states in both the social and biophysical domains (Gunderson and Holling 2002). Time and time again, landscapes and ecosystems managed for some type of equilibrium carrying capacity have been thwarted by surprise events, changes in thresholds and market failures (Carpenter and Folke 2006). Time and time again it has been shown that optimizing efficiency to deliver a defined benefit does not lead to sustainability, but rather to collapse (Walker and Salt 2006). New ideas are required to improve the management and monitoring of Australian river landscapes and ecosystems. Resilience Thinking provides one umbrella under which to consider the future management of river ecosystems.

Resilience is the amount of change a system can undergo (its capacity to absorb disturbance) and remain within the same regime that essentially retains the same function, structure and feedbacks (Walker and Salt 2006). Resilience Thinking seeks to determine how societies, economies and ecosystems can be managed to confer resilience, that is, how to maintain the capacity of a system to absorb disturbance without changing to a different state.

Resilience Thinking offers nine fundamental principles that may form components of a framework for managing and monitoring the resilience of the Lake Eyre Basin:

1. Recognition of the potential for alternate stable states to exist within riverine landscapes.
2. Recognition that riverine landscapes properties can vary significantly within a stable state.
3. Riverine landscapes properties can display significant spatial and temporal variability at different scales within a stable state.
4. Thresholds do exist within riverine landscapes and act as tipping points between alternate stable states.
5. Thresholds exist at multiple scales but not all result in a shift to an alternate state.
6. Slow variables are important in driving regime shifts.
7. Riverine landscapes cycle through adaptive loops and their position within the loop sets their form and function.
8. Riverine landscapes are essentially social-ecological systems integrating ecosystems and human society.
9. Managing and monitoring riverine landscapes for resilience requires adaptability or the capacity to adapt to and influence change.

There are two additional approaches that are complementary to Resilience Thinking, which provide different components of a framework for managing and monitoring of resilience in riverine landscapes. The ecosystem approach focuses on the interactions among ecological entities and their environments, and thus, takes an encompassing and synthetic view of nature rather than a fragmented view (Likens 1992). The ecosystem approach recognizes the influences of disturbance, scale spatial heterogeneity and spatial variability on the relationships between ecological entities and their environments. Contemporary views of ecosystems also view humans as a keystone species within the ecosystem.

The ecosystem approach offers six fundamental principles that may form components of a framework for managing and monitoring resilience in riverine landscapes:

1. Variability and heterogeneity are fundamental drivers of pattern and process in riverine landscapes.
2. Fluxes and cycling of materials and energy are important drivers of riverine landscapes.
3. Riverine landscapes are hierarchically organised whereby patterns and processes must be viewed at different scales.
4. Understanding riverine landscapes requires a focus on interactions between different disciplinary elements (e.g. biological, chemical geomorphological, hydrological, social and economic).

5. Riverine landscapes can be understood via causal or correlative approaches: the choice of method depends on prior knowledge and the scale of focus.
6. Humans are keystone elements of riverine landscapes: they are drivers of change and users of ecosystem goods and services.

Proposed indicators and methods

The proposed revised indicators and methods for the LEBRA are outlined in Appendix H.

An important role for the river scientist in determining the resilience, health or condition of river systems is to identify and employ appropriate indicators. This task is often not easy as indicators must be unambiguous in terms of their response to the threats to river health. Because environmental river processes interact in complex ways the task of measuring river health is often difficult. Finding a single robust, sensitive indicator is unlikely (Fairweather 1999) and some trade-offs are needed. Occasionally, indicators may be chosen because they are `charismatic' and it may be a species that has a high public profile (e.g. platypus) or is readily associated with a sensitive high profile issue (e.g. cyanobacteria – blue green algae). Indicators must be able to be validated.

In practice, the choice of an indicator, or group of indicators, often reflects personal bias, technical considerations, and constraints of knowledge. There are three types of indicators: those that are early warning indicators that signify impending decline in health; compliance indicators that reveal deviations from acceptable limits; and diagnostic indicators that show the causes of the deviations (Cairns and McCormick 1992). Most of the suite of indicators used by the various state jurisdictions for river monitoring in the Lake Eyre Basin is for compliance purposes and not directly applicable for use in assessing the condition of highly variable large systems.

Three contemporary approaches for selecting indicators of river health have been identified by Fairweather (1999). The first group of approaches essentially represent a haphazard selection of indicators from divergent perspectives, such as chemistry or biology. Here the selection of indicators is based on personal biases of managers and politicians. Second, there is the adoption of a single perspective that is either better developed, favoured by circumstance or seen as an umbrella for protecting other sets of values (e.g. the Australian River Assessment System – 'AusRivAS'). Synthetic approaches that integrate distinct perspectives, such as in the Sustainable Rivers Audit of the Murray Darling Basin, represent the third group. Of these Fairweather (1999) suggests the synthetic approach may best suit the current requirements of determining river health in large, highly variable Australian river systems. This type of approach requires a larger suite of variables to be used and integrated but is heavily scale-dependent (Townsend and Riley 1999). The selection of appropriate spatial and temporal scales for measures (indicators) of river condition is crucial.

Commonly measurements are spot samples (e.g. concentration, abundance, species richness) and the assessment of river health is based on changes in ecological processes. Many have comments that this will not be appropriate in river systems where process events operate at large spatial and temporal scales.

Indicators recommended to be included in assessing the condition of the Lake Eyre Basin are summarised in Table 6 and outlined in full in Appendix H. These indicators are grouped according to the components of hydrology, physical form of waterholes, biota and water quality and landscape factors. Critically, and consistent with the PSR approach proposed, they are also contextualised by the relevant pressures on the LEB and the desired responses to findings in relation to each indicator.

Table 6: Indicators to be included in the Lake Eyre Basin Implementation Plan

Indicator	Links to pressures/drivers/risks
Fish Assemblages	
Species richness	- overall indicator of fish assemblage condition - narrow range but should be relatively stable at regional and within-catchment scales - changes indicate anthropogenic disturbance
Abundance	- broad ranges and sensitive to antecedent flow conditions - increases indicate recruitment - decrease indicate mortality during disconnection phase
Abundance of alien species	- narrow range and relatively stable - increases indicate changed conditions (e.g. increase number of weirs pools) - increased number of species indicates new introductions (eg. common carp & tilapia)
Recruitment	- indicates successful spawning - broad range depending on antecedent flow conditions - absence of recruitment in most species in any year should indicate anthropogenic disturbance
Population size structure	- indicator of past recruitment - truncated length frequencies may indicate fishing pressure
Abundance of detritivores	- sensitive to antecedent flow conditions
Prevalence of disease	- may be useful as warning of poor waterhole condition
Waterbirds	
Total abundance of colonial waterbirds	- overall indicator of waterbird assemblage condition - changes may indicate altered water quality or flow regime
Species richness of colonial waterbirds	- reflects changes in flooding regime
Abundance of functional groups of waterbirds	- reflects changes in flooding regime - reflects condition of habitat and food supply
Community composition	- overall indicator of waterbird assemblage condition - changes may indicate altered water quality or flow regime
Presence/absence of particular species (e.g. threatened species)	- reflects changes in flooding regime
Abundance of breeding birds	- sensitive to antecedent flow conditions - reflects condition of habitat, e.g. lignum and reed swamps
Species richness of breeding birds	- sensitive to antecedent flow conditions - reflects condition of habitat, e.g. lignum and reed swamps

Indicator	Links to pressures/drivers/risks
Vegetation (riparian)	
% cover of 3-5 dominant woody species in upper (e.g. red gum, coolabah, river cooba) and middle (e.g. lignum) layers	- changes may indicate altered flow regime or anthropogenic disturbance
% herbaceous ground cover	- sensitive to antecedent flow conditions
% cover aquatic vegetation (submerged, floating, emergent)	- sensitive to antecedent flow conditions
% cover of exotics	- changes may indicate altered water quality or flow regime or anthropogenic disturbance
Native regeneration	- reflects changes in flooding regime
Width of riparian zone	- changes may indicate altered flooding regime or anthropogenic disturbance
Longitudinal connectivity	- changes may indicate altered flooding regime or anthropogenic disturbance
Vegetation (wetland)	
Floristic composition	- sensitive to antecedent flow conditions - changes may indicate altered flow regime, water quality or anthropogenic disturbance - changes may indicate impacts of exotic species
Species richness	- sensitive to antecedent flow conditions - changes may indicate altered water quality or flow regime or anthropogenic disturbance - changes may indicate impacts of exotic species
% canopy cover	- changes may indicate altered flooding regime or anthropogenic disturbance
% foliage cover of understorey species	- sensitive to antecedent flow conditions - changes may indicate altered water quality or flow regime or anthropogenic disturbance - changes may indicate impacts of exotic species
Foliage cover	- changes may indicate altered flooding regime or anthropogenic disturbance
Height ranges of vegetation layers (trees, shrubs, understorey)	- changes may indicate altered flooding regime or anthropogenic disturbance
Tree vigour	- changes may indicate altered flooding regime, water quality or anthropogenic disturbance
Population size structure	- changes may indicate altered flooding regime or anthropogenic disturbance
Physical habitat	
Physical diversity	- indictor of flow and sediment variability - loss of physical habitat diversity will may be deleterious to aquatic biota
Channel instability	- indicator of overgrazing and land use and may be deleterious to aquatic biota

Indicator	Links to pressures/drivers/risks
Water quality	
Conductivity	- indictor of salinity - elevated salinities may be deleterious to aquatic biota
pH	- extreme pH may be deleterious to aquatic biota
Dissolved oxygen (diel range)	- highly significant for aquatic biota - high DO levels during and levels close to zero in the evening may indicate a high pollution load
Turbidity	- indicator of amount of suspended solids in water - influences light penetration and primary production - decreases in turbidity may result in increased primary productivity
Water temperature (diel range)	- highly significant for aquatic biota
Hydrology	
Total surface water availability	- Water resources development - Climate change - Land use change
Water storage capacity	- Water resources development
Water licensing	- Water resources development
Filling of terminal lakes	- Water resources development - Climate change - Floodplain development - Land use change - Presence of in-channel structures
Floodplain inundation	- Water resources development - Climate change - Floodplain development - Land use change
In- channel events	- Water resources development - Climate change - Floodplain development - Land use change - Presence of in-channel structures
Persistence of key waterholes	- Water resources development - Climate change

5. Options for the management and governance of the LEBRA

Preliminary

Five options for the management and governance of the LEBRA are presented in this section and were considered by the SAP at its 11-12 August 2009 workshop. These options are based around potential foci for the LEBRA. In reality, if the LEBRA is to adopt the strategic adaptive management principles outlined in Section 3, which includes taking a participatory approach to the assessment, then no matter what form of governance is applied to the LEBRA, similar groups will be involved. The foci, therefore, relates as much to the organisational culture and values that flavour the assessment as it does to the administrative / hierarchical systems that apply. For that reason, the options are couched as:

1) Government leadership
2) Community leadership
3) Technical leadership
4) Collaborative assessment
5) External assessment

A summary of these options is outlined in Table 7, with detail on each provided below. This is followed by the preferred model refined at the workshop.

Government leadership option

Quintessential characteristic

This option is based on the premise that the LEBRA is a legitimate and expected role for government. In the absence of a single authority to manage the LEB, the option assumes the public is looking towards government leadership to fill the institutional void. Governments are already taking this role through the LEBIA. This option extends the role to overseeing the conduct of the LEBRA.

Another important argument for this option is that the findings of the LEBRA are likely to have policy and program management implications. This option strengthens the government's stake in the findings and adds to the likelihood that policy related recommendations would be rigorously considered and, if desirable, pursued.

Coordination hub

This option looks to the SOG to act as the central hub to oversee and administer the LEBRA on behalf of the LEBMF. The SOG should be directly accountable to the LEBMF.

Delegations

Under this option, the SOG participants would lever internal resources, directing to the extent possible technical staff to undertake the

assessment. Gaps in expertise would be filled by contracting to regional NRM groups and/or third part research organisations. Coordination would be provided either by one agency on behalf of the others, or through an externally contracted coordinator.

Variation
Rather than utilise its members own internal resources, the SOG would simply act as an oversight group and fully contract specific assessment activities to external providers.

Reporting requirements
The SOG would present the Assessment report to the LEBMF, taking into account the views of constituent government partners, the SAP and the CAC.

Role of SAP
The SAP would remain independent of the process, providing advice to the SOG in relation to:

- the terms of reference for the performance of the LEBRA, including its methodology and reporting arrangements;
- the capacity of the team proposed by the SOG to carry out the LEBRA;
- draft reports of the LEBRA;
- the SOG's report and recommendations to the LEBMF on completion of the LEBRA;
- stimulating ongoing research and monitoring responses as identified by the LEBRA.

Members of the SAP would not be eligible to undertake any part of the assessment under this option unless there was no other option, in which case participating members would not be involved in providing formal advice or reviewing material in relation to the LEBRA.

NRM group role
The SOG under this option would be encouraged to utilise and or supplement the on-ground expertise and activities of the three regional NRM groups. These groups would participate in undertaking the assessment as well as stimulating responses to the findings through their networks.

Scientific review and quality assurance
As the SAP is deemed to be independent under this option, it would take the lead in coordinating a response to drafts and findings of the assessment. The SAP could if it deemed so necessary seek further peer review of any or all aspects of the LEBRA.

Links
In establishing the assessment team, the SOG would seek to use the best available internal expertise to undertake each component of the LEBRA. External links would apply where such expertise does not exist internally, or is otherwise unavailable.

As with all options, this option would seek to involve community and industry level participants in the assessment process so as to shorten the

span between investigation, findings and responses. Preferably these groups would have a role in the interpretation of the findings, particularly in the context of required management responses.

Specific target links will be identified when a preferred option has been selected for implementation.

R&D issues
The identification of R&D issues needs to be written into the terms-of-reference for the LEBRA. The SAP and other external scientific peer reviewers should also consider R&D implications of draft and final LEBRA reports.

Limitations
This option has the appearance of a top-down approach, no matter how collaborative or participatory the processes adopted by the SOG may be.

Community leadership option

Quintessential characteristic
This option is based on the premise that the LEB arrangements have been borne from longstanding community passion for their environment and that local communities, including indigenous peoples, and industries have the most immediate stake in its condition.

The option also takes into account that regional stakeholder groups have an unmatched level of local knowledge and expertise as well as historically unprecedented levels of professionalism; quite capable of undertaking or at least overseeing rigorous resource assessment.

Perhaps most importantly, the community option best meets the adaptive management approach proposed for the LEBRA, shortening the gaps between deriving understanding and acting upon it.

Coordination hub
This option looks to the CAC to act as the central hub to oversee and administer the LEBRA on behalf of the LEBMF. The CAC should be directly accountable to the LEBMF via the Secretariat.

Delegations
Under this option, the CAC participants would lever internal resources, directing to the extent possible technical staff of the regional NRM bodies, industry groups and local indigenous and Landcare networks to undertake the assessment. Gaps in expertise would be filled by contracting to third part research organisations. Coordination would be provided either by one agency on behalf of the others, or through an externally contracted coordinator.

Variation
Rather than utilise its members own internal resources, the CAC would simply act as an oversight group and fully contract specific assessment activities to external providers, including agencies linked to participating governments.

Reporting requirements
The CAC would present the Assessment report to the LEBMF, taking into account the views of the SAP and the SOG.

Role of SAP
The SAP would remain independent of the process, providing advice to the CAC in relation to:

- the terms of reference for the performance of the LEBRA, including its methodology and reporting arrangements;
- the capacity of the team proposed by the CAC to carry out the LEBRA;
- draft reports of the LEBRA;
- the CAC's report and recommendations to the LEBMF on completion of the LEBRA;
- stimulating ongoing research and monitoring responses as identified by the LEBRA.

Members of the SAP would not be eligible to undertake any part of the assessment under this option unless there was no other option, in which case participating members would not be involved in providing formal advice or reviewing material in relation to the LEBRA.

NRM group role
This option places the three regional NRM groups at the very centre of the LEBRA. These groups would participate in undertaking the assessment as well as stimulating responses to the findings through their networks.

Scientific review and quality assurance
As the SAP is deemed to be independent under this option, it would take the lead in coordinating a response to drafts and findings of the assessment. The SAP could if it deemed so necessary seek further peer review of any or all aspects of the LEBRA.

Links
In establishing the assessment team, the CAC would seek to use the best available member expertise to undertake each component of the LEBRA. External links would apply where such expertise does not exist internally, or is otherwise unavailable.

As with all options, this option would seek to involve community and industry level participants in the assessment process so as to shorten the span between investigation, findings and responses. Preferably these groups would have a role in the interpretation of the findings, particularly in the context of required management responses.

Specific target links will be identified when a preferred option has been selected for implementation.

R&D issues
The identification of R&D issues needs to be written into the terms-of-reference for the LEBRA. External scientific peer reviewers should also consider R&D implications of draft and final LEBRA reports.

Limitations
This option seeks substantial commitment from many groups that operate largely on a voluntary basis, or are otherwise preoccupied with their day-to-day professional responsibilities.

Technical leadership option

Quintessential characteristic
This option is based on the premise that the LEBRA is essentially a technical assessment and is most efficiently undertaken by the range of technical experts qualified to carry out what amounts to a wide range of disciplinary and interdisciplinary activities and challenges.

Coordination hub
This option looks to the SAP to act as the central hub to oversee and administer the LEBRA on behalf of the LEBMF. The SAP should be directly accountable to the LEBMF via the Secretariat.

Delegations
Under this option, the SAP participants would lever internal resources, directing to the extent possible technical staff of the SAP representatives organisations to undertake the assessment. Gaps in expertise would be filled by contracting to third part research organisations. Coordination would be provided either by one agency on behalf of the others, or through an externally contracted coordinator.

Variation
Rather than utilise its members own internal resources, the SAP would simply act as an oversight group and fully contract specific assessment activities to external providers, including agencies linked to participating governments.

Reporting requirements
The SAP would present the Assessment report to the LEBMF, taking into account the views of the CAC and the SOG.

Role of SAP
The SAP would not be able to remain independent of the process as it would be directly involved in undertaking the LEBRA or overseeing its implementation. That said, it would have a central role in:

- drafting the terms of reference for the performance of the LEBRA, including its methodology and reporting arrangements;
- delegating roles to technical experts to carry out the LEBRA;
- drafting reports of the LEBRA;
- reporting to the LEBMF on completion of the LEBRA;
- stimulating ongoing research and monitoring responses as identified by the LEBRA.

NRM group role
The SAP under this option would be encouraged to utilise and or supplement the on-ground expertise and activities of the three regional NRM groups. These groups would participate in undertaking the

assessment as well as stimulating responses to the findings through their networks.

Scientific review and quality assurance
As the SAP is not deemed to be independent under this option, peer review by non-participating research groups would be required.

Links
In establishing the assessment team, the SAP would seek to use the best available internal expertise to undertake each component of the LEBRA. External links would apply where such expertise does not exist internally, or is otherwise unavailable.

As with all options, this option would seek to involve community and industry level participants in the assessment process so as to shorten the span between investigation, findings and responses. Preferably these groups would have a role in the interpretation of the findings, particularly in the context of required management responses.

Specific target links will be identified when a preferred option has been selected for implementation.

R&D issues
The identification of R&D issues needs to be written into the terms-of-reference for the LEBRA. The SAP and other external scientific peer reviewers should also consider R&D implications of draft and final LEBRA reports.

Limitations
This option has the appearance of a technocratic, ivory-tower approach, no matter how collaborative or participatory the processes adopted by the SAP may be. It is the option most vulnerable to complaints of conflicts of interest. Members of the SAP are extremely busy on other matters in their professional life, and the commitment to undertake the LEBRA may be too great.

Collaborative assessment option

Quintessential characteristic
This option is based on the premise that the broader the involvement in the LEBRA, the more likely it is to simulate the range of responses relevant to its findings. The option seeks to utilise the full range of existing participants under the LEBIA within a coordinated framework. The option includes the advantages of most other options, and most easily addresses the limitations.

Coordination hub
This option looks to the CAC and SOG to form a LEBRA Oversight Group LEBRAOG) comprising representatives of each of the two bodies. This Group would act as the central hub to oversee and administer the LEBRA on behalf of the LEBMF. The LEBROAG should be directly accountable to the LEBMF.

Delegations

Under this option, the LEBROAG participants would lever the internal resources of all participating parties other than those associated with the SAP members. Gaps in expertise would be filled by contracting to third party research organisations. Coordination would be provided either by one agency on behalf of the others, or through an externally contracted coordinator.

Variation

Rather than utilise the internal resources of member organisations, the LEBRAOG would fully contract specific assessment activities to external providers, including agencies linked to participating governments.

Reporting requirements

The LEBRAOG would present the Assessment report to the LEBMF, taking into account the views of constituent government partners, the SAP and the SOG. The LEBRAOG would disband following acceptance of the report.

Role of SAP

The SAP would remain independent of the process, providing advice to the CAC in relation to:

- the terms of reference for the performance of the LEBRA, including its methodology and reporting arrangements;
- the capacity of the team proposed by the LEBRAOG to carry out the LEBRA;
- draft reports of the LEBRA;
- the LEBRAOG's report and recommendations to the LEBMF on completion of the LEBRA;
- stimulating ongoing research and monitoring responses as identified by the LEBRA.

Members of the SAP would not be eligible to undertake any part of the assessment under this option unless there was no other option, in which case participating members would not be involved in providing formal advice or reviewing material in relation to the LEBRA.

NRM group role

The LEBRAOG under this option would be encouraged to utilise and or supplement the on-ground expertise and activities of the three regional NRM groups. These groups would participate in undertaking the assessment as well as stimulating responses to the findings through their networks.

Scientific review and quality assurance

As the SAP is deemed to be independent under this option, it would take the lead in coordinating a response to drafts and findings of the assessment. The SAP could if it deemed so necessary seek further peer review of any or all aspects of the LEBRA.

Links

In establishing the assessment team, the LEBRAOG would seek to use the best available internal expertise to undertake each component of the

LEBRA. External links would apply where such expertise does not exist internally, or is otherwise unavailable.

As with all options, this option would seek to involve community and industry level participants in the assessment process so as to shorten the span between investigation, findings and responses. Preferably these groups would have a role in the interpretation of the findings, particularly in the context of required management responses.

Specific target links will be identified when a preferred option has been selected for implementation.

R&D issues
The identification of R&D issues needs to be written into the terms-of-reference for the LEBRA. The SAP and other external scientific peer reviewers should also consider R&D implications of draft and final LEBRA reports.

Limitations
This option establishes yet another structure, albeit temporarily (for the life of an assessment), under the LEBIA and may appear cumbersome.

External assessment option

Quintessential characteristic
This option is based on the premise that a totally independent 'audit' process would appear to eliminate all conflicts of interest in respect to receiving resources to undertake the assessment, interpreting the results and providing fearless recommendations based upon the findings.

Coordination hub
This option looks to the LEBMF to negotiate with a third party to undertake the LEBRA and report directly to it upon completion. The Third party should be directly accountable to the LEBMF via the Secretariat.

Delegations
Under this option, a third party would respond to terms of reference set out by the LEBMF with limited involvement of LEB participating organisations.

Variation
Rather than utilise its own internal resources, the contracted third party would act as an oversight group and fully contract specific assessment activities to both internal and external providers.

Reporting requirements
The contracted third party would present the Assessment report to the LEBMF, taking into account the views of constituent government partners, the SAP, CAC and the SOG.

Role of SAP
The SAP would remain independent of the process, providing advice to the LEBMF in relation to:

- the terms of reference for the performance of the LEBRA, including its methodology and reporting arrangements;

- the capacity of the third party proposed by the LEBMF to carry out the LEBRA;
- draft reports of the LEBRA;
- the contracted third party's report and recommendations to the LEBMF on completion of the LEBRA;
- stimulating ongoing research and monitoring responses as identified by the LEBRA.

Members of the SAP would not be eligible to undertake any part of the assessment under this option unless there was no other option, in which case participating members would not be involved in providing formal advice or reviewing material in relation to the LEBRA.

NRM group role

The involvement of the NRM groups would be left to the third party to determine.

Scientific review and quality assurance

As the SAP is deemed to be independent under this option, it would take the lead in coordinating a response to drafts and findings of the assessment. The SAP could if it deemed so necessary seek further peer review of any or all aspects of the LEBRA.

Links

In contracting an external assessment team, the LEBMF would encourage the third party to consult with LEB associated stakeholders to the greatest extent possible.

Specific target links will be identified when a preferred option has been selected for implementation.

R&D issues

The identification of R&D issues needs to be written into the terms-of-reference for the LEBRA. The SAP and other external scientific peer reviewers should also consider R&D implications of draft and final LEBRA reports.

Limitations

This option does not encourage the sense of ownership that is central to the adaptive management approach advocated by the consultants.

Table 7: Summary of options for the governance of the LEBRA

Option	Quintessential characteristic	Coordination hub[a]	Key delegations[b]		Variations
			Primary	Secondary	
Government leadership	Legitimate and expected government role	Senior Officers Group	State and NT technical officers	Regional NRM group officers and contracted third parties, including CSIRO, universities etc.	Open tender for project teams to form and undertake the assessment process to tightly defined-specification; Commissioned research team created for the specific purpose of undertaking the assessment reporting to SOG
Community leadership	Community ownership and direction	Community Advisory Committee	Regional NRM group officers	State and NT technical officers and contracted third parties, including CSIRO, universities etc.	Open tender for project teams to form and undertake the assessment process to tightly defined-specification; Commissioned research team created for the specific purpose of undertaking the assessment reporting to CAC
Technical leadership	Scientific rigour and independence	Scientific Advisory Panel	Commissioned research team created for the specific purpose of undertaking the assessment	All non-commissioned groups.	Open tender for project teams to form and undertake the assessment process to tightly defined-specification;
Collaborative assessment	Coordinated partner review	LEB Resource Assessment Working Group (new) comprising representatives of SOG, CAC and SAP	Internal participants	All non-commissioned groups.	Open tender for project teams to form and undertake the assessment process to tightly defined-specification
External assessment	Independent non-partner review	National Water Commission or other externally nominated body	Commissioned external research team	All non-commissioned groups.	Open tender for project teams to form and undertake the assessment process to tightly defined-specification

[a] Overseeing group on behalf of LEB MF
[b] Those responsible for doing the assessment

6. The recommended model and timeline

The collaborative model

The SAP advocates an adaptive management approach to the conduct of the LEBRA that seeks to take into account adaptive responses to the range of pressures across the Lake Eyre Basin. Three options in particular lend themselves to this approach, depending on their implementation. These are the government leadership, community leadership and collaborative assessment approaches.

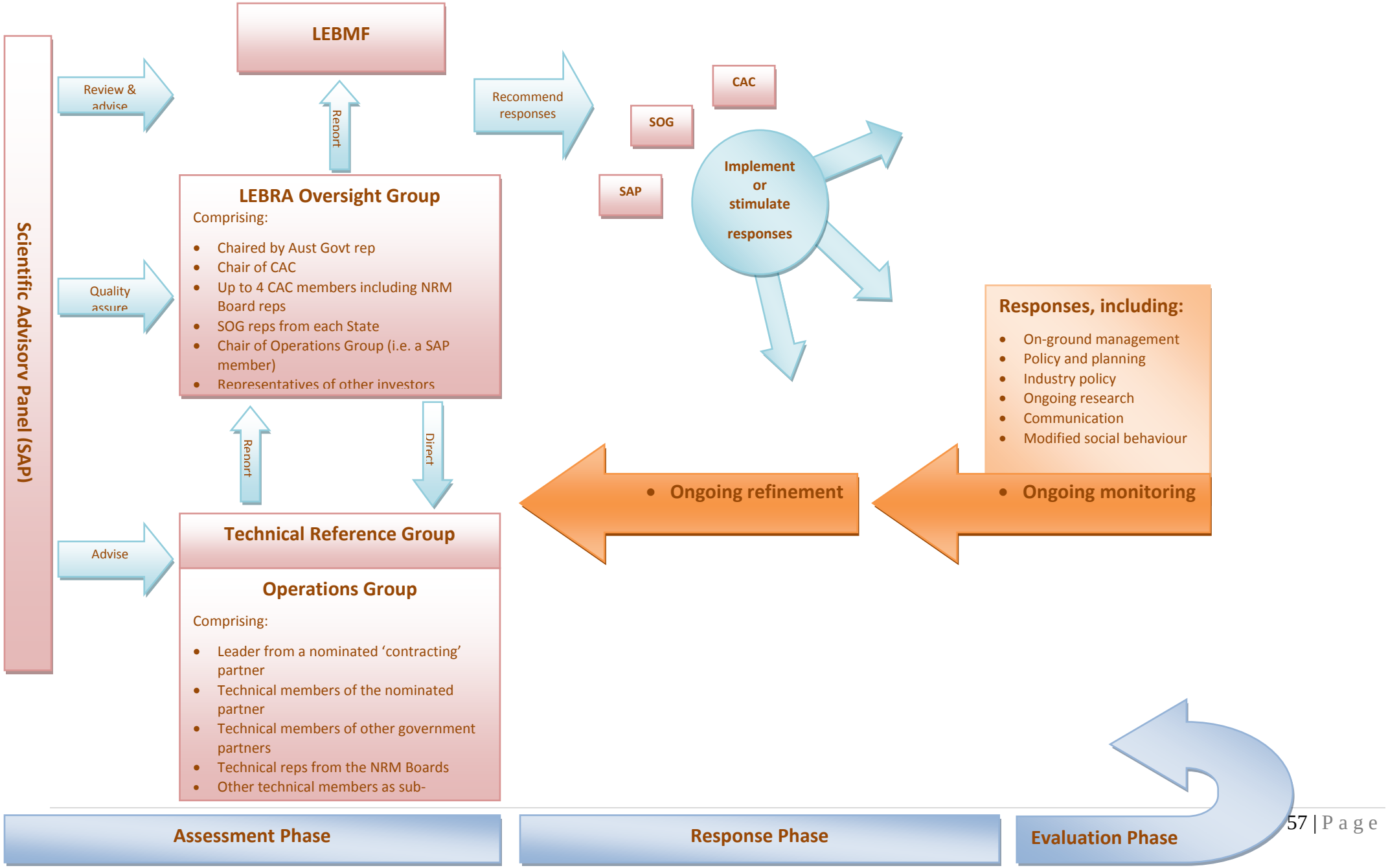
Because of the extensive relationships that take place across the LEB as well as the range of stakeholders that need to be engaged in the response process, the SAP prefers a collaborative approach modified somewhat from that described in Section 5. Figure 7 outlines a flowchart of processes associated with this option.

This preferred option sees the creation of a LEBRA Oversight Group made up of representatives of the SOG, CAC and other potential investors, to oversee the contracting and implementation of the resource assessment. The assessment itself would be undertaken by an Operations Group, lead by one contracted party on behalf of a consortium and guided by a Technical Reference Group. The SAP remains independent of this process although provides advice to each group at critical stages as required, as well as to the LEBMF in respect to confidence in the final report. Details of the role and composition of each of these groups is outlined in Table 8.

Table 8: Suggested composition and roles of LEBRA parties

Group	Composition	Role
LEBRA Oversight Group (LOG)	Aust Govt rep (LOG Chair) Chair of CAC SOG reps (x4) NRM Board reps (x3) Reps of other major investors Chair of Operations Group	- Governance and due diligence - Drivers - Guiding engagement, TCP and SAM - Strategy of data management – where - Annual reporting to Min Forum informed by Ops Group Annual Report - Comms role to stakeholders - persistence - Assessment (State of LEB) to Min Forum & SAM outcomes
Technical Reference Group	Independent Chair by SAP Senior reps of Ops Group agencies	- Ongoing scientific steerage and coordination
Operations Group	The full assessment team as identified by the LOG and sub-contracted by the lead assessment agency	- Undertake monitoring and analysis - Periodic reporting (4 yr assessment) - Preparation of annual tech/data report
Scientific Advisory Panel	As currently composed	- Advice to LOG , Ops Group and LEBMF at critical stage

Figure 7: Flow chart of the Collaborative Assessment option process for the LEBRA



The timeline

The SAP recommends the following timeline in respect to the conduct of and ongoing monitoring associated with the LEBRA:

Preliminary

End Sept 2009
Seven components delivered by Kiri-ganai Research (see Section 6), including:

- defined conceptual models
- rough TPCs
- rough budget and potential co-contributors
- rough implementation design

End Oct 2009
Commitment by Government (Ministerial Forum) to project – (i.e. $ plus programme); business case; agreement by SOG at Alice Springs Meeting

Identification of Implementation Group membership/ Technical Group; terms of reference; by SOG at Alice Springs Meeting

Nov 2009
Sign-off by SOG on membership of Implementation Group/ Technical Group

April 2010
Agreement by Ministers on Rivers Assessment Implementation -

Jan-Mar 2010
Implementation Group/ Technical Group convene workshop(s)

- Review Conceptual models/
- Develop objective hierarchy/ context/
- TPCs
- Detailed monitoring design (stratification, frequency of sampling, analysis etc)

Assess projects and prioritise/ access additional funding

Identify data storage options and outputs

Coordination of tendering/ contracting/ output

Implementation

The implementation of the LEBRA takes into account a ten-year assessment horizon envisaged in the LEBIA, as well as annual monitoring and reporting activities (see Table 9).

Table 9: Suggested implementation timeline for the LEBRA

Dates	Base monitoring programme	Assessment process	Evaluation and feedback (learning)
March 2010	Project specification		Convene workshop(s) for development of conceptual models/ objective hierarchies/ context/ TPCs; preliminary analysis of available data
June-Sept 2010	Tendering and contracting – "identifying deliverer"; Implementation Group decides on "contractors"		Ensuring engagement in projects and interest; succession plans
Dec 2010	Implementation by "contractors"		
Year 1 - 2011	Annual reporting on each component/ feedback to TPCs, objectives, study design	Implementation Group decides on assessment of base monitoring programme	Annual reporting - Stakeholders, Implementation Group, Ministers
	Annual data collation and synthesis		
Phase 1			
Year 2- 2012	Annual reporting on each component/ feedback to TPCs, objectives, study design	Preliminary data analysis and methodology review and development for integration	Review design methodology, using collected data; reviewing TPCs
		Implementation Group Assessment of other research priorities	Annual reporting - Stakeholders, Implementation Group, Ministers
	Biennial analysis and specification of potential baselines for each component	Status relative to TPCs; and assessment of whether any relevance for management	Influence relevant management
2013	Implementation of other research priorities	Implementation Group assessment of budget for other research priorities	Review design methodology, using collected data
	Annual reporting on each component/ feedback to TPCs, objectives, study design		Annual reporting - Stakeholders, Implementation Group, Ministers
End of Initial Phase- 2014	End of initial phase and assessment of ongoing programme with synthesis of all component data	Full assessment by Implementation Group (trial run)	Major review of design methodology, using collected data and timely decision on direction of Phase 2
Phase 2			
2015- 2017	Annual reporting		Review design methodology, using collected data
Final reporting – 2018	Final report for each component. Synthesis report integrated for Rivers Assessment	Full assessment for reporting to Ministers and Community	Major review of design methodology, using collected data and timely decision on direction of next phase; Review Institutional Arrangements

7. Next steps

The next report (final report) will cover the business and implementation plans for the LEBRA, building on the governance arrangements, indicators and budgets, preferred model and timelines set out in this report. The timing for this is 30 September 2009, with a draft prepared by 15 September in time for SOC consideration and feedback.

The implementation plan and business plan will be provided as free-standing reports along with the final report, and will be brief but clear documents.

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Appendix A: Terms of Reference

LEB Rivers Assessment Implementation Plan

The Department of Environment, Water, Heritage and the Arts requires the development of a Lake Eyre Basin Rivers Assessment Implementation Plan (Implementation Plan) to identify how regular on-going monitoring of key indicators of the condition of river ecosystems and catchments will be implemented within the Lake Eyre Basin Intergovernmental Agreement Area. The process of developing the Plan will involve:

1) Review of achievements to date under the Lake Eyre Basin (LEB) Rivers Assessment (Milestone 1)

a. A number of activities have been undertaken as part of the LEB Rivers Assessment to date. As part of developing the Implementation Plan, reports from these activities are to be reviewed and recommendations incorporated into the Plan for future on-going monitoring.

b. The Service Provider is to provide a draft report to the Department, for review and comment, indicating how the recommendations have been considered. The Service Provider will be required to address all comments received and provide a final document to the Department. The report should include, but is not limited to:

- the title of the report addressed;
- how the recommendations have been considered in developing the Methodology/Implementation Plan;
- any further action required.

2) An agreed LEB Rivers Assessment Methodology (Milestone 2)

As part of developing the Implementation Plan, the Service Provider is to finalise a methodology for monitoring that can be undertaken immediately, recognising that there will be a need for continued research and development of some indicators for future use.

This task will require the Service Provider to perform services including but not limited to:

a) identify the monitoring already being undertaken within the Lake Eyre Basin which will be included in the Implementation Plan;
b) identify the recommendations from previous LEBRA work that will be included in the Implementation Plan;
c) identify the indicators that were suggested in Method for Assessing the Health of Lake Eyre Basin Rivers that will be included in the Implementation Plan;
d) identify linkages with national monitoring, evaluation and reporting frameworks;
e) identify monitoring actions that can be undertaken immediately – summarise their methods and costs;

f) identify monitoring actions that require further research and development; and
g) advise on the appropriateness of reporting on a ten year basis or other timeframe.

3) Support development and documentation of governance arrangements (Milestone 3)

The Implementation Plan should briefly review the current responsibilities of the jurisdictions with the Agreement area and make recommendations on the options for governance associated with ongoing monitoring. The Service Provider is to provide a draft written report to the Department indicating suggested governance arrangements which includes but is not limited to:

a) reporting requirements;
b) the role of the Lake Eyre Basin Scientific Advisory Panel;
c) the role of Government officers;
d) the role of Regional Natural Resource Management groups;
e) links with Bureau of Meteorology;
f) scientific review of the program;
g) Quality assurance/quality control;
h) research and development issues independent of the assessment.

4) Development of a business model (Milestone 4)

The LEBRA Implementation Plan is to include an outline of how the monitoring activities will be funded or supported.

The Service Provider is to provide a draft report to the Department, for review and comment, indicating suggested governance arrangements. The Service Provider will be required to address all comments received and provide a final document to the Department. The report should include, but is not limited to:

a) the organisation committed to providing funding or support;
b) the funding or support to be provided;
c) the source of the funding or support; and
d) duration of commitment

5) LEB Rivers Assessment Implementation Plan (Milestone 5)

Using information from Milestone Reports 2, 3 and 4 the Service Provider will prepare a draft LEB Rivers Assessment Implementation Plan. The Service Provider will be required to address all comments received and provide a final document to the Department. Detail on what is to be included in the Implementation Plan is to be discussed with the Steering Committee.

6) Workshop (Milestone 6)

After completion of Milestone 5 the Service Provider is required to organise and participate at a workshop with relevant stakeholders. The location and duration of the workshop will be determined by the Steering Committee and the Service Provider together, and may include participation of some stakeholders by telephone. The services that will be required include, but are not limited to:

a) Organisation of the workshop (location to be agreed with the Steering Committee, will be a capital city).
b) Attendance and presentation at the workshop which will include:
    - outlining the approach undertaken to develop the Implementation Plan;
    - feedback received from stakeholders;
    - commitment to regular on-going monitoring of key indicators of the condition of river ecosystems and catchments.

Appendix B: LEBIA policies and key strategies

1. River Flows Policy

'Flow regimes of river systems within the Agreement Area will be managed to protect and maintain the ecological integrity and natural function of in-stream and floodplain ecosystems, and the viability of economic, social, cultural and other activities which do not threaten these environmental values.'

Strategy 1: Scope the need for convergence and/or alignment of legislation, policy and planning for water resource management in different jurisdictions.

Strategy 2: Encourage best practice in road and other engineering works that have potential to significantly affect the distribution and timing of river flows.

2. Water Quality Policy

'Water quality in the river systems within the Agreement Area will be managed to protect and maintain the ecological integrity and natural function of in-stream and floodplain ecosystems and the viability of economic, social, cultural and other activities which do not threaten these environmental values.'

Strategy 3: Coordinate water quality monitoring and data management frameworks across jurisdictions to enable data collation, analysis, comparison and reporting at regional, catchment and whole-of-basin scales.

3. Water and Related Natural Resources Policy

'Water and related natural resources associated with the river systems within the Agreement Area will be managed to protect and maintain the ecological integrity and natural function of in-stream and floodplain ecosystems and the viability of economic, social, cultural and other activities which do not threaten these environmental values.'

Strategy 4: Promote the need for natural resource management decisions to take account of potential impacts on other parts of the system.

Strategy 5: Identify opportunities for improved coordination and consistency of approach to aquatic and terrestrial weed and feral animal management activities.

4. Existing Entitlements and Water Resource Development Policy

'Water resource planning, allocation and management arrangements, including the management of water entitlements, will be compatible with the Lake Eyre Basin Agreement. Efficient use of water will be a fundamental principle of water entitlements and utilisation. Water resource development proposals will be assessed to determine their potential impact on river flows and water quality, and compatibility with the Agreement and relevant water resource plans. These assessments will be based on the best available scientific information and local knowledge (including information from other regions in Australia and overseas).'

Strategy 6: Develop principles to guide the comprehensive assessment of water resource development proposals in the Agreement Area, in particular their appropriateness for Lake Eyre Basin river systems and catchments.

5. Research and Monitoring Policy

'Management of water and related natural resources associated with the river systems in the Agreement Area will be guided by the best available scientific information and local knowledge, and by the results of ongoing monitoring and periodic assessment of the condition of these river systems. Targeted research may also be undertaken to address identified knowledge gaps.'

Strategy 7: Promote the integration of the LEB Rivers Assessment outcomes into water and related natural resource management decision-making.

Strategy 8: Engaging non-Indigenous and Indigenous stakeholders to ensure that local knowledge is recognised and utilised in assessment and management of the Basin.

6. Whole of Basin Approach Policy

'Water and related natural resources in the Lake Eyre Basin Agreement Area will be managed through a whole-of-basin approach so as to achieve complementary outcomes, through the implementation of state/territory legislation and the plans and associated investment strategies of relevant regional bodies in Queensland, South Australia and the Northern Territory.'

Strategy 9: The Communications Strategy will include annual reporting to the Basin community through the Ministerial Forum on progress in implementing policies, strategies and other activities under the Agreement.

Strategy 10: Develop and implement a communication strategy to raise public awareness of the LEB Agreement and the work of the Ministerial Forum, the CAC and the SAP.

Strategy 11: Scope the need for consistent and complementary data management frameworks across jurisdictions to enable data collation, analysis, comparison and reporting at regional, catchment and whole-of-basin scales.

Strategy 12: Improving community and other stakeholder access to data and information on the economic, social, environmental and heritage values of the Basin, including Internet based systems.

Appendix C: Summary of Knowledge Strategy questions

A: What limitations on our understanding of surface and groundwater constrain our ability to manage the surface and groundwater resource of the Basin?
- A1: How might climate change affect rainfall variability and temperature, and hence flow patterns and persistence of water bodies?
- A2: Where and how are groundwater and surface water systems connected? To what degree is the persistence of water holes dependent on surface flows?
- A3: How should we manage waterholes – grazing, abstractions, groundwater linkages

B: What are the impacts of present and future land use (e.g. land clearing, pastoral activities, mining) on quantity and quality of surface and groundwater?
- B1: What are the changes in catchment and river health that are not yet evident but are likely to occur over the next 30 years from decisions already taken?
- B2: What are the impacts of levees, road/rail links on water flow and the health of floodplains
- B3: What are the impacts of present and likely future land use on run-off within the catchment?

C: How do we measure the health of rivers, waterholes, terminal lakes/wetlands? Can trends be detected?
- C1: Where are the key aquatic refugia, what are the processes that sustain them and what are the threatening processes?
- C2: What threatened (aquatic) species and communities exist, where are they, and what are the threatening processes?
- C3: What are the risks (to aquatic systems) from non-endemic species – present and potential? Where are they?
- C4: What are the likely impacts of water use on aquatic biodiversity and river health?

D: What is the current catchment health (baseline assessment)?
- D1: Where are salinity hazards and impacts of vegetation management on shallow groundwater?

E: What are the implications of changes in ecosystem quality for human use of resources?
- E1: What are the risks posed for human consumption by changes in water quality?

F: What are the values and aspirations of key stakeholders across the LEB?*
- F1: How might these values and aspirations affect future landscapes and development in the Basin? Are these aspirations different from those outside the Basin?

- F2: What are the values associated with water – particularly from an Indigenous perspective?
- F3: What are the creation/dreamtime stories that are attached to Basin springs, water bodies and other waterways?
- F4: How will different future scenarios affect LEB communities and how might communities respond?

G: What institutional and governance arrangements will facilitate the best policy and management outcomes for LEB natural resources?

- G1: What are the best mechanisms for ensuring that agreed aspirations guide future planning in the Basin?
- G2: What are the best spatial, time and societal scales for planning and implementing different aspects of NRM?
- G3: What institutional arrangements enhance, or detract from, community/government interactions relating to NRM in the Basin?
- G4: What form of 'actor' (partnership, regional body, government etc) could best drive whole-of-Basin action?

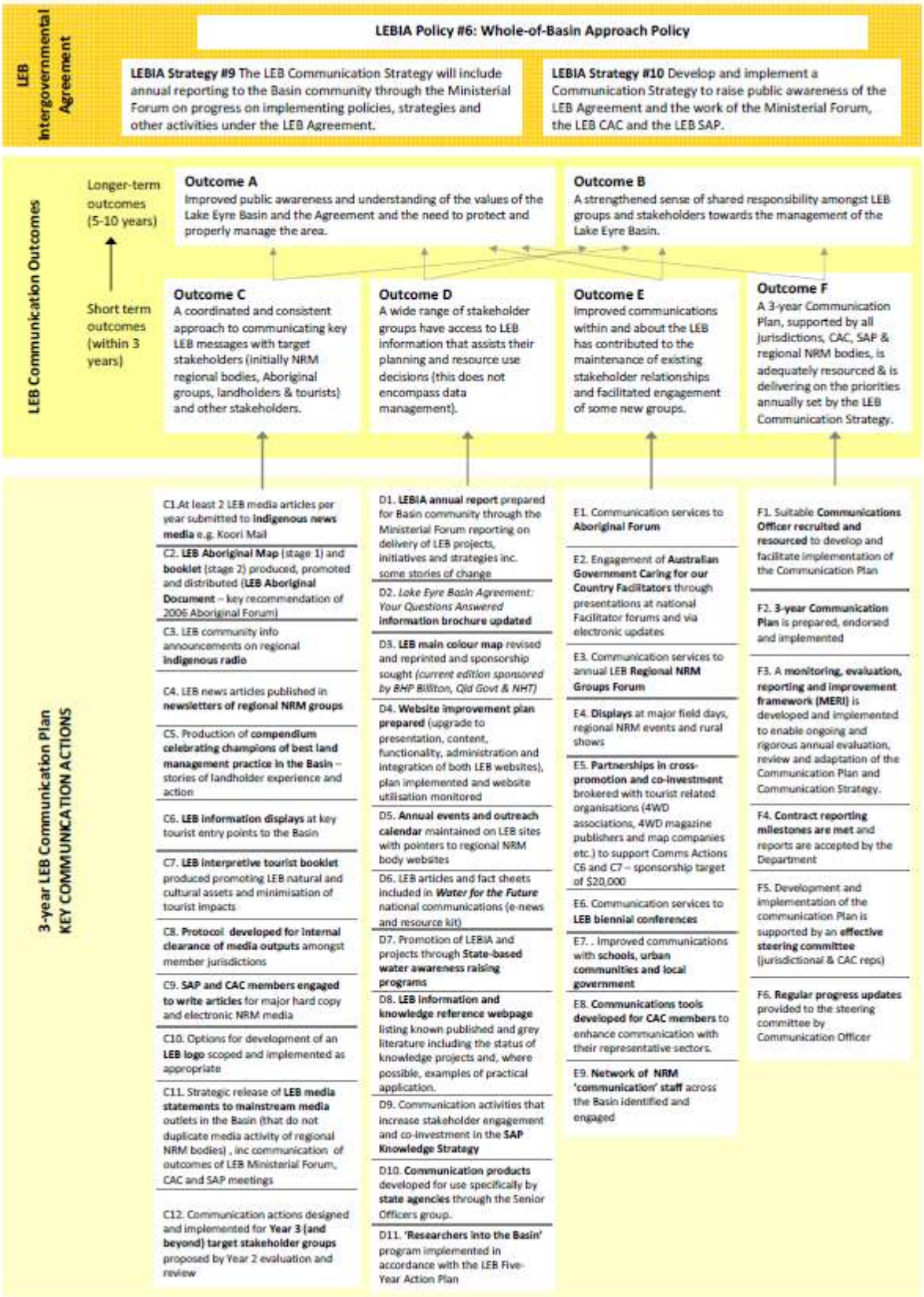
H: What are the best ways of engaging Basin communities in Basin-related NRM?

- H1: What enhances/ diminishes the legitimacy of key players in the Basin in influencing change?
- H2: What can be done to improve engagement between community, policy makers and industry in Basin-related NRM?
- H3: How can Indigenous engagement in water planning be facilitated?
- H4: How should tourism be managed around springs, waterholes and other waterways?
- H5: How can tourists be best informed about the cultural history of the LEB and the management of cultural sites?

I: What is the current 'adaptive capacity' of LEB actors in contributing to better NRM outcomes in the Basin, and how can 'adaptive capacity' be improved in the future?

- I1: What are the best ways of monitoring critical elements of social change in the Basin?
- I2: Are there socio-economic costs that must be borne by the LEB community as a consequence of expected changes?

Appendix D: LEB communication plan



Appendix E: Action Plan recommendations on LEB governance

HIGHEST PRIORITY ACTION

ACTION 1 Re-assess the governance and support arrangements to implement the LEBIA

Outcome: Revised governance arrangements, built on clearly defined roles and responsibilities and strong relationships between communities and governments. Arrangements will include a defined delegated authority to implement Ministerial Forum (MF) decisions and facilitate direct and timely commitment of resources to undertake the work required.

What Re-assess governance and support arrangements to ensure that decisions can be implemented quickly and effectively.

Why The Lake Eyre Basin Intergovernmental Agreement (LEBIA) states that the MF is responsible for the implementation of the Agreement (section 5.8), but is silent about how exactly this will be achieved — there is no stated delegation of this authority. In practice, and varying for different issues, a combination of people drawn from the Senior Officers, other jurisdictional agencies and their staff, the Chairs and members of the Community Advisory Committee (CAC) and Scientific Advisory Panel (SAP), the LEB CAC Facilitator and LEB Secretariat, NRM Boards, and other organisations with knowledge or skills in NRM-related topics (such as R&D providers), are involved in implementing decisions. Responsibilities and accountabilities among these people within the LEBIA framework are fluid and often ill-defined. The Agreement lacks a body or group with clear responsibility and executive authority to implement MF decisions and allocate the resources required to achieve them. This issue is critical to meeting the LEBIA objectives, and is therefore given first priority in this draft Action Plan. It is perhaps the underlying reason for the view commonly expressed during the consultation process that while there are lots of meetings and plans in relation to the LEB, but there is “precious little action on the ground yet”.

Direct responsibility for NRM in the LEB rests with the states and territory, acting through their own agencies and programs, and through regional NRM Boards and Catchment Committees and their priorities and programs; this is where the prime responsibility for implementing the LEBIA objectives lies. The Australian Government has an important role in helping to coordinate activities across jurisdictions, ensuring links with national polices and programs, managing its own land, and coordinating with international agreements and obligations. Together, these are the groups able to direct resources to implement the LEBIA and which therefore have a key role in responding to MF decisions.

Part IV of the Agreement spells out the difference in responsibilities of the states and territory in comparison with those of the Australian Government, although this may have become somewhat blurred over time. It was stated during the consultations that responsibilities between the various groups and people involved under the LEBIA are not well-defined and there tends to be a

focus on detail rather than long term strategy, in part due to the complexity of negotiating progress between many parties and (potentially) competing interests and perspectives. As a result, some processes needed to achieve the LEBIA objectives are not yet completely developed; for example, comments by other jurisdictions on proposed water allocation and management plans are advisory, and while they may be taken into consideration through goodwill, there is no agreed process for negotiating a cross-jurisdictional, 'whole of Basin plan' that examines an entire riverine system from upper catchment to discharge features.

As well, the volume and complexity of information needed for the advisory function may now exceed the remit and capacity of a part-time CAC and SAP. While the members of these groups are fully engaged on LEB matters when they meet, they cannot be expected to individually have either the time or the technical skills required to deal with all the issues that will come before them if the LEBIA objectives are to be achieved. The consultation process for this Action Plan provided evidence of this. The roles and functions of these groups are laid out in their respective Operating Protocols, and it seems clear that to meet these, both groups will require a higher level of support than is currently available to collect, collate and analyse data, and to develop and present options for decision and advice to MF.

The need for greater focus on effective and timely implementation of the LEBIA objectives, and for further technical support of the CAC and SAP, will likely necessitate a re-assessment of current support arrangements. The roles of the LEB CAC Facilitator and LEB Communications Officer may need further definition, as may the priorities and funding of the Communications Plan (see Action 3), and the role of the LEB Secretariat.

Several options to improve governance and support arrangements were discussed during the consultation process. They are responses to perceived problems in implementing decisions, in gaining access to technical information and skills, and in having adequate support to achieve LEBIA objectives (the issue of LEBIA resources is discussed in more detail in Action 7). The options discussed during the consultations were:

1. That a LEB Ministerial Forum Standing Committee be established, analogous to the NRM or Primary Industries standing committees and comprising the heads of the relevant jurisdictional agencies. This Committee would consider and decide how MF decisions can best be implemented and commit the resources required. This group could meet at the same time or immediately following the MF. Its role would be to ensure that decisions made under the LEBIA are reflected in jurisdictional policies, programs and priorities, including those of government agencies and those of NRM boards and their catchment committees. This would be a pro-active role to ensure the prompt implementation of MF decisions and reporting on progress; it would include implementation of the draft LEB Five Year Action Plan if it is approved by MF.

2. That the Senior Officers Group (SOG) is reorganised and constituted to undertake the role described. This would require that its members are sufficiently senior to be able to drive the implementation process within

jurisdictions (including across agencies and regional bodies) and to commit resources. It is important to ensure that MF decisions and priorities are reflected in jurisdictional policies, programs and priorities for NRM and those of NRM Boards and Catchment Committees as this is the mechanism by which resources other than the limited LEBIA budget can be aligned with, and support the Agreement's objectives. The Group might include the CAC chair, and the chairs or CEOs of the NRM Boards; together, they would represent the main organisations able to plan and commit resources to implement MF decisions and the LEBIA itself. The Group's executive role would need to be spelt out clearly in an Operating Protocol. It might need to meet more often than at present, and it would require a greater time commitment of its members, especially for its chair who would be required to lead the Group. Reporting and accountability requirements would need to be considered, as would chairing arrangements (for example, a two-year period rotating between the members, or a part-time appointed executive chair) and secretariat support.

3. That the Chair of the CAC be made a part-time paid position with up to 50 days per year purchased under the LEBIA funding. This would enable the Chair to devote more time to directly negotiating the timely implementation of MF decisions. Other CAC members could also be paid to assist as required, with all such paid days to be the subject of minuted decisions of the CAC as a group. At the same time, the level of technical/professional support for both the CAC and SAP would be upgraded to a full-time position. The skills required of this person would include knowledge of the LEB and NRM issues, as well as high level negotiation and project management experience. An additional part-time position may then be required (or the work could be contracted out) for a person to undertake all the administrative tasks associated with organising CAC and SAP meetings, to ensure that the Facilitator's time is spent on more technically demanding tasks and that the increasing workload of the CAC and SAP can be completed in a timely manner (see Action 7). Expanding the role of the chair into implementing MF decisions would seem to go beyond a purely advisory role for the CAC (or at least for its Chair and possibly some members), however, community knowledge and involvement in proposing and implementing MF decisions is a key requirement of the LEBIA. A partial alternative would be for the CAC Chair to join and advise the SOG.

4. That a cross-jurisdictional group of people with technical expertise and knowledge of the Basin's natural resources and the history of their use, be established to consider the technical and practical aspects of proposed developments and changes in resource use and management. This group would have access to technical support as required (e.g. in data collation), and could be established as a standing technical committee of the CAC or the SAP, or established as required to assess major proposals or plans. In either case, it would be necessary to purchase sufficient time of the members to ensure that the required analyses were completed promptly. The group could provide a detailed and public analysis and response to all major changes in resource use (including but not limited to water allocation and management plans), and its endorsement would be required before such changes could be approved by the MF. This option was suggested as a way of getting several of the LEBIA

objectives put into action, although it was pointed out that it does not deal with other governance-related issues.

5. That a 'Lake Eyre Basin Authority' or equivalent body be established. Many stakeholders supported this option, with the 'body' governed by a Board representing the LEB community and jurisdictions. The organisation would have its own rolling triennial budget and powers to commit funds to implement MF decisions. Some respondents considered this option to be the only way in which a truly Basin-wide approach to NRM is likely to be achieved, and recognition given to the wider international agreements (e.g. RAMSAR) to which Australia is a signatory.

Addressing this governance issue is not only crucial to meeting the LEBIA objectives, but is also vital for the future of the LEB and its natural resources. It was touched on, but not analysed in detail, by the 2007 Review of the Lake Eyre Basin Intergovernmental Agreement. Some of the options above would have significant implications for jurisdictions' internal decision processes; one offers a means of bringing the NRM Boards into the decision-making and implementation processes as active participants. It was stated during consultations that these issues need to be resolved before the LEB Five Year Action Plan can be put into practice.

As a result of the strong emphasis placed on this topic by stakeholders, it is proposed that improving the governance arrangements for the LEBIA be addressed as soon as practical. This should include mapping of jurisdictional responsibilities as they relate to the LEBIA, an examination of structures needed to ensure that MF decisions can be implemented fully and promptly, and consideration of whether existing governance arrangements are adequate to survive changes in governments and policies.

Option 2 appears the most practical and cost-effective way of providing a source of executive authority to implement MF decisions, and could be established without delay. At the MF meeting of April 2008, the SOG was delegated some authority to authorise projects and expenditures. This delegation of authority under the Agreement may require additional formalisation to define its scope, the appropriate membership of the 'Group', an operating protocol (including members' time commitment, chairing, meeting schedule and reporting to MF), and its links with CAC and SAP. Once this is determined, the current consideration of the operating protocols of the LEB advisory bodies and LEB Secretariat, as well as discussion about the roles of LEB staff, could proceed on a firm basis and be completed without delay. Together with some of the Actions outlined later (e.g. Action 7 which proposes additional technical/professional support for the CAC and SAP), this would provide an improved and clearer structure for timely and effective decision-making and implementation of the LEBIA objectives and strategies.

When Re-assessment to be undertaken during the period December 2008 to February 2009. This could be achieved by discussion at the meeting of jurisdictions and NRM Boards proposed for February 2009, to consider and finalise improved arrangements for implementing the LEBIA. Recommendations

from that meeting could then be considered by the MF at its meeting in April 2009.

Who The people best able to undertake this re-assessment are those knowledgeable about, and working within, the LEBIA. This includes the existing SOG, chair of the CAC, chairs or CEOs of NRM Boards, the LEB CAC Facilitator and LEB Secretariat.

Resources required No additional funding required. Some time of the LEB Secretariat and LEB CAC Facilitator may be required, as well as a meeting (preferably face-to-face) of the SOG with CAC chair and NRM Board chairs/CEOs. It is suggested that jurisdictions be asked to provide a summary of their institutional responsibilities as they relate to the implementation of the LEBIA (this could be a simple diagram showing the organisations and their linkages and funding sources).

Monitoring and evaluation Recommendations considered by MF in April 2009. Summary of any changes reported to CAC, SAP, NRM Boards and their catchment committees and to the wider LEB community by 30 June 2009.

LEB Strategies addressed 1, 3, 5, 6, 11

Concluding comments Several respondents ranked this proposed Action as their highest priority. Although Option 5 (establishment of a 'Lake Eyre Basin Authority') was considered by some as the preferred long-term aim, it was recognised that there would be many issues to be considered before this could be achieved. Option 2 was seen to be a practical way forward in the short term. Issues to be addressed in implementing Option 2 include:

• There should be a formal delegation of authority by the MF to the SOG to enable the Group to make decisions and approve expenditures under the LEBIA. This could be achieved by MF continuing to make strategic decisions about Actions and indicative budgets, with the SOG then formally responsible for implementing those decisions.

• Members of the SOG should be sufficiently senior to not only represent their jurisdiction or organisation, but also to be able to make commitments in relation to agreed Actions.

• A key role of SOG members is to ensure that agreed LEB Actions are reflected as *comments* in jurisdictional and organisational NRM policies, programs and forward budgets. Several respondents saw this as crucial to establishing a wider base of support and collaboration for LEB activities, rather than solely relying on the LEBIA annual budget.

• The SOG should be expanded to include a senior representative of each of the NRM Boards that cover the LEB, as well as the Chair of the CAC. Given the interest expressed by the NSW Western CMA in greater involvement in LEB activities, consideration should be given to inviting a senior representative to join the SOG *ex officio* and to explore the potential for a formal NSW presence. It is anticipated that much of the work of the SOG will be conducted by telephone conference and e-mail.

• Several respondents emphasised that the CAC and SAP have been established as advisory, not executive, bodies and that their members are part-time and cannot be expected to take direct responsibility for implementing the LEBIA. If the role outlined for the SOG is realised, the roles of the CAC and SAP will also become better-defined. The memberships and roles of all three should be defined clearly in their respective Operating Protocols, a process that is currently underway.

• The meeting of jurisdictions and NRM Boards proposed for February 2009 would provide an ideal opportunity to discuss and finalise improved governance arrangements for implementing the LEBIA, with recommendations from that meeting to be considered by MF at its meeting in April 2008.

In the remainder of this draft Action Plan, it is assumed that the revised role and membership proposed for the SOG is implemented in full; this is reflected in the "Who" and "Resources" sections of each of the proposed Actions.

Appendix F: Recommendations and Ministerial Forum agreed responses to the 2007 review of the LEBIA

1. INTEGRATED, SUSTAINABLE NRM. The focus in the LEBIA on 'water and related natural resources' does not align with the present day principles of integrated natural resource management (INRM) which underpin Australia's regional NRM model. Over the five years of the Agreement, the emphasis has moved to integrated NRM.

Recommendation 1: That the Agreement be modified to emphasise 'integrated, sustainable natural resources management' as compared to the present 'water and related natural resources'.

RESPONSE: While the need for INRM is fully recognised, modification of the LEBIA is not required.

'Water and related natural resources' provides a proper focus for LEBIA activities without being overly restrictive. Broadening the focus to INRM would make it generally more difficult to differentiate the LEBIA from NRM work being undertaken at the regional level or cross-regional approaches being taken to address broader issues (for example, issues affecting rangelands broadly, such as feral animals and weeds).

Rather, effort is required to ensure that the work being undertaken in support of the LEBIA is fully integrated into regional and multi-regional approaches (and vice versa) so that NRM issues are dealt with in an integrated way (see Recommendation 3).

Consideration of broader issues to achieve LEBIA outcomes will continue. For example, social and economic factors have significant implications in the management of water resources.

2. AVOIDANCE OF ADVERSE, CROSS-BORDER IMPACTS. This current focus of the LEBIA falls short of integrated whole-of-catchment management, which represents present day best practice. The focus on adverse cross-border impacts is the reason why the NSW part of the LEB and much of the SA part are excluded from the LEBIA – land management in those parts have no cross-border impacts.

Recommendation 2: That the boundary of the LEBIA area be expanded to include all of the hydrological LEB.

RESPONSE: Not agreed at this time. The boundary of the LEBIA was reviewed in 2006 and an amended boundary (incorporating a larger portion of the South Australian part of the LEB) was agreed by the LEB Ministerial Forum in January 2007. An amendment to the LEBIA, (Schedule 3) reflecting the boundary change, is currently being progressed. In addition, the NSW Government declined an invitation to become a signatory to the LEBIA in January 2008.

Future expansion of the LEBIA area is possible if there are compelling reasons or a state desire to so do. The CAC and the SAP both note that inclusion of the whole hydrological LEB within the LEBIA is desirable in the long term.

3. ENCOMPASSING THE REGIONAL NRM GROUPS. Since the LEBIA came into effect, the national regional NRM delivery model has been established, giving rise to three regional NRM Groups who are responsible for INRM in the Queensland, South Australian and Northern Territory parts of the LEB. Thus these Groups do not formally come within the Agreement and this disconnect runs the risk of (inadvertently) undermining the Agreement as each Group operations are restricted to the jurisdictional borders.

Recommendation 3: That the regional NRM Groups be brought within the ambit of the Agreement by:

i) comprising the CAC from representatives of the regional NRM Boards (Note: The regional NRM groups are themselves representative of a broad spectrum of stakeholders, so this enables the stakeholder-representative nature of the CAC to continue.);

RESPONSE: It is agreed that Desert Channels Qld, South Australian Arid Lands Natural Resources Management Board, and the Northern Territory NRM Board should each provide two representatives on the CAC. At least one representative should be a Board member, with provision being made for the Boards to each nominate up to one non-Board member. (This would allow, for example, the Darwin-based Northern Territory NRM Board to select a person from the Lake Eyre Basin part of the Territory to be a member of the CAC.)

NRM Board representation, however, will not necessarily cover all interests detailed in Section 5.11.1 of the Agreement and representation will also be required for Aboriginal, mining, petroleum, conservation and tourism interests.

The role of representatives should be clarified in the CAC operating protocol, including ensuring strong linkages between the CAC and NRM Boards.

ii) building in formal two-way communications between the LEBMF (and LEB secretariat) and the regional NRM Boards;

RESPONSE: This recommendation is supported. Apart from requiring NRM Board representation on the CAC, parties will determine other appropriate approach(es) to build communication, including consideration of:

- development of a five-year LEB Action Plan with clear responsibilities and reporting arrangements specified;
- recognition in each state/territory NHT3 (now Caring for Our Country) Bilateral Agreement of the need to consider cross-border impacts and projects;
- an annual meeting of NRM Regional Boards and the LEB jurisdiction officers to discuss LEB issues; and
- annual reporting by NRM Boards to LEBMF of achievements on LEB cross-border issues.

iii) by establishing the position of one or more LEB Regional Facilitator(s) to facilitate and harmonise the integrated NRM work in the LEB,

RESPONSE: Not agreed at this time. The approach proposed in 3 ii) above should ensure liaison on LEB cross-border issues by Regional NRM Boards and reporting to LEBMF. The significant resources required for additional facilitator/s do not appear to be justified at this time. The CAC noted that the development of the LEB Action Plan might require this issue to be reconsidered.

iv) by aligning the programs of the regional groups with the priorities of the LEB as strongly as is feasible.

RESPONSE: This recommendation can be achieved through the approaches proposed for consideration in 3 ii) above.

4. ROLE AND OPERATION OF THE MINISTERIAL FORUM. The Ministerial Forum is seen as an important reflection of the significance that should be accorded the LEB and the LEBIA, and stakeholders want it retained. However, the requirement that it meet in the Basin, whilst desired by community stakeholders as an opportunity to engage with Ministers, is logistically impractical, and disconnects the LEBMF (Lake Eyre Basin Ministerial Forum) from Australia's main NRM decision making process, the NRM Ministerial Council (NRMMC).

Recommendation 4: That the LEBMF be retained; and that it be brought within the aegis of the NRMMC and not be required to meet in the Basin (page 3)

RESPONSE: Agree that the LEBMF should be retained. The Agreement does not require Ministerial Forum to meet within the Basin and community stakeholders, while considering it desirable to meet in the LEB, accept that it is logistically difficult for Ministers to come together in remote locations.

More importantly, the LEBMF should remain separate from the NRMMC decision-making process. However, for operational efficiency, it is proposed that LEBMF meet immediately before or after NRMMC meetings.

5. ROLE OF THE SCIENTIFIC ADVISORY PANEL. The SAP has been effective by virtue of the high scientific credibility (and commitment) of its members and its direct access to the LEBMF. It has initiated important research and monitoring activities. More could have been achieved if it had better organisational support. Over the past five years the technical capacities of the jurisdictions' agencies (including the regional NRM Groups) have increased, this should be drawn upon for addressing LEBIA issues.

Recommendation 5: That SAP be continued as constituted; that it has a strategic advisory role as well as to monitor the effectiveness of the work undertaken to underpin strategic INRM decision making in the Basin, and that the SAP be provided with sufficient support to undertake its work.

RESPONSE: It is agreed that the SAP should continue as currently constituted. Membership of the SAP should reflect the strategic priorities identified for the LEB, including coverage of emerging issues.

The SAP should continue to focus on its remit under LEBIA to provide 'scientific and/or technical advice (sought by the Ministerial Forum) in relation to the identification of requirements for the effective monitoring of the condition of

the rivers and catchments within the Lake Eyre Basin Agreement Area and the establishment of programs to meet those requirements'.

In so doing, the SAP should monitor the effectiveness of on-going research in the LEB and provide advice to the Ministerial Forum and the CAC on the types of new work that would assist in fulfilling the goals of the proposed LEB Action Plan.

It is agreed that the SAP should be provided with additional organisational and administrative support, for example, from the Lake Eyre Basin Facilitator, to enable it to better undertake its work.

These enhancements will ensure an appropriate level of scientific input into Basin decision making.

6. RELATIONSHIP WITH THE GREAT ARTESIAN BASIN COORDINATING COMMITTEE. The LEB overlaps the Great Artesian Basin, and the bore capping and piping work being undertaken by the GABCC is improving the condition of the natural resources of the Basin. Community stakeholders are confused between the two groups.

Recommendation 6: Where appropriate, opportunities be pursued to hold CAC meetings in conjunction with GABCC meetings.

RESPONSE: Agreed. Where appropriate, meetings of the CAC should be held in conjunction with meetings of the Great Artesian Basin Coordinating Committee. A joint meeting of the GABCC, LEB CAC and SAP was held on 12 March 2008.

Appendix G: Stakeholders consulted to date

Place	Name	Organisation
Canberra	Derek White	Dept of Environment, Water, Heritage & Arts
	Don Blackmore	World Bank
	Craig James	Desert Knowledge CRC
	Tim Fisher	Minister Wong's Office
	Mark Sjolander	Parliamentary Sec. Kelly's Office
	Doug Watkins	Wetlands International
	Mark Stafford Smith	CSIRO Sustainable Ecosystems
Brisbane	Stuart Bunn	Griffith University
	Fran Sheldon*	
	Stephen Balcombe	
	Satish Choy	Dept of Environment & Resource Management
	Bill Reurich	
	Peter Old	
Longreach	Vol Norris	LEB Facilitator
	Angus Emmott	LEB Community Advisory C'tee
	David Phelps	Dept of Employment, Economic Development & Innovation (formerly DPIF)
	Luw Markey	
	Mike Chuk	Desert Channels Qld Inc
	Vanessa Bailey	
	Alun Hoggett	
Adelaide	Ben Fee	Dept of Water, Lands & Biodiversity Conservation
	Dale Lewis	
	Henry Manchini	
	Glynn Schulze	
	Jenny Cleary	South Australian Arid Lands (SAAL) NRM Board
	Kirrilie Rowe	
Alice Springs	Ian Fox	Dept of Natural Resources, Environment, the Arts and Sport
	John Wischusen	Geoscience Australia
	Richard Walsh	Centralian Land Management Assoc
	Hugh Pringle	Bush Heritage Australia
Darwin	Kate Andrews*	NT NRM Board
Sydney	John Porter	University of New South Wales

* Teleconference

Appendix H: The revised LEBRA methods

This appendix is taken from Section 7 of Milestone Report 2 for this project. Table numbers are consistent with that report and, as with other appendixes, have not been renumbered in terms of this report.

Starts here>

The following outlines those monitoring actions that can be undertaken immediately and the methods for the collection of these data. It is pertinent to note that the components recommended represent a combination of 'controlling or slow variables', 'responding or fast variables' and potential drivers of change that can be used to assess resilience of the river ecosystems within the Lake Eyre Basin. This list does not represent as exhaustive list as there is much Research and Development to be undertaken. The six components recommended are Physical Habitat, Fish, Waterbirds, Riparian Vegetation (controlling variables), Water Quality (responding or fast variable) and Hydrology (both a driver of change and a controlling variable). In order for hydrology to be used as a controlling variable, a catchment based hydrological model would need to be constructed. This hydrological model would then enable the effects of climate and land use to be assessed on the spatial and temporal availability of water throughout the Lake Eyre Basin. Detailed for each of these six components are:

- the value and pressures to the component
- drivers and risks to the component as well as management actions to be taken
- a list of indicators for each component
- recommended sampling methods, including frequency and scale of sampling
- analysis and reporting methods and the costs of undertaking this monitoring exercise.

Fish assemblage diversity indicator

(Waterholes and wetlands theme, Waterholes and Wetland Biodiversity Attribute)

Acknowledgements

Stephen Balcombe, ARI, Griffith University

Values

- iconic element
- cultural significance
- indicator of cumulative aquatic ecosystem condition

Pressures, drivers, risks and management actions

Table 3: Links with pressures, drivers, risks and actions: Fish assemblage set

Pressure / driver / risk	Potential impacts	Level of risk
Water resource development		
• floodplain harvesting	• creation of barriers to fish movement across floodplain channels	High
• damming	• reduced habitat complexity of waterholes • reduced connectivity between waterholes • form barriers fish movement	High
• water extraction	• alterations to amount and quality of habitat • removal of juvenile life stages	Moderate - High
• pumping from shallow groundwater	• alterations to amount and quality of habitat • removal of juvenile life stages	Moderate - High
Grazing		
• floodplain grazing during dry phase	• altered water quality (increased nutrients) • reductions in primary productivity through trampling of algal 'bath-tub ring'	Moderate
• total grazing on floodplain	• altered soil structure, nutrient content and vegetation may influence amount & quality of food for fish on re-flooding. • changes to amount and quality of nursery habitat in riparian and floodplain areas	Moderate
Tourism		
• tourism during dry phase	• increased nutrient inputs • removal of woody debris and vegetation (for firewood)	Moderate
• recreational fishing	• reductions in refugial fish stocks and potential to re-populate satellite waterholes following flows/floods • removal of large-bodied adults and recruitment potential • use of non-LEB live bait may introduce alien fish and invertebrates	Moderate

Pressure / driver / risk	Potential impacts	Level of risk
Fishing		
• overfishing	• reductions of refugial fish stocks	Moderate
• introduced species	• shifts in fish assemblages	Moderate
• failure to recognise key species, e.g. Cooper catfish, Finke goby and Finke hardyhead.	• shifts in fish assemblages	Low - Moderate
• translocation of native fish from other basins	• shifts in fish assemblages	Low - Moderate
Other		
• road crossings and culverts	• local threat to fish assemblages and ecological functioning of waterholes	Low
• toxic impacts of stock vaccination via faeces	• reductions in water quality	Uncertain at present
• feral animals	• as for grazing	Uncertain at present
• climate change	• altered ecological functioning of waterholes	Moderate - High

(Sourced from information in McNeil et al. 2006)

Alignment with national reporting frameworks

1. FARWH

- Aquatic biota index

2. National Framework for NRM Standards and Targets

- Fish community assemblages (Integrity of inland aquatic ecosystems (rivers and other wetlands): river condition)
- Significant native species and ecological communities
- Ecologically significant invasive species

Specific indicators

Table 4: Specific indicators for Fish Assemblages set

Indicator	Links to pressures/drivers/risks
Species richness	- overall indicator of fish assemblage condition - narrow range but should be relatively stable at regional and within-catchment scales - changes indicate anthropogenic disturbance
Abundance	- broad ranges and sensitive to antecedent flow conditions - increases indicate recruitment - decrease indicate mortality during disconnection phase
Abundance of alien species	- narrow range and relatively stable - increases indicate changed conditions (e.g. increase number of weirs pools) - increased number of species indicates new introductions (eg. common carp & tilapia)

Indicator	Links to pressures/drivers/risks
Recruitment	- indicates successful spawning - broad range depending on antecedent flow conditions - absence of recruitment in most species in any year should indicate anthropogenic disturbance
Population size structure	- indicator of past recruitment - truncated length frequencies may indicate fishing pressure
Abundance of detritivores	- sensitive to antecedent flow conditions
Prevalence of disease	- may be useful as warning of poor waterhole condition

(Sourced from information in McNeil et al. 2006)

Sampling

Sampling methods

A combination of seine, fyke and dip nets may be used depending on the amount of surface water present at the time of survey (McNeil & Reid, 2008). Standard mesh sizes and inlet diameters should be selected and fyke nets should be set overnight (c. 15 hours). Fish from emptied nets should be identified to species, measured (standard length in mm), visually inspected for signs of external disease and returned to the water alive.

Water quality parameters should be measured in conjunction with fish sampling (see below).

Sampling frequency

Sampling should be conducted twice a year; once near the end of the dry season (November) and once after the wet season recedes (March/April). This will enable assessment of fish assemblage resistance, i.e. tolerance of dry and disconnected conditions, and resilience, i.e. response to flows or floods (McNeil et al. 2006).

Spatial scale of sampling

The spatial arrangement of sites should be broadly based on recommendations provided by Sheldon et al. (2005) with each catchment divided into 3 regions as appropriate; Headwaters, River Channels & Waterholes and Terminating Wetlands. Sheldon et al. (2005) recommend a minimum of i) 20 sites across all of the headwater zones of the Thompson, Barcoo, Georgina and Diamantina Rivers, ii) 50 sites across the River Channels & Waterholes zone of the Cooper channel country, lower Cooper, Diamantina channel country, lower Diamantina and the western rivers, including the Neales, and iii) 10 terminal wetland sites including Lake Galilee, Buchanan and Yamma Yamma in Queensland and Lakes Frome, Blanche and Eyre in South Australia.

Sampling should be conducted from waterbodies (or sites) within representative reaches that comprise a permanent waterhole (persistently sampled) and several semi-permanent satellite waterholes (which may change

between sampling events depending on water levels) (McNeil et al. 2006). At least 2, but preferably 3, representative reaches should be sampled within each region in each catchment. In terminal wetlands that do not have clusters of lakes or waterholes, multiple representative sites should be included. Additionally, critical or potentially impacted sites should be included, e.g. waterholes around Longreach or Innamincka.

Table 5 provides an indication of the potential spatial arrangement of fish monitoring sites. Site selection would need to be finalised prior to the commencement of sampling.

Analysis and reporting

Prior to analysis combined samples from fyke and seine nets should be standardised to set durations or areas respectively in order to describe abundance (see Balcombe & Kerezy, 2008).

For each representative reach (or critical site) at each survey time, the following variables should be calculated:

- species richness
- abundance/proportion of each taxon present (including alien species)
- size distributions of common taxa (plots)
- abundance/proportion of detritivores present
- the proportion of individuals in each taxon exhibiting signs of disease

Data across sites should also be scaled-up to region and catchment for the following variables:

- species richness
- abundance/proportion of each taxon present (including alien species)
- frequencies of length/size classes of common taxa
- abundance/proportion of detritivores present
- the proportion of individuals in each taxon exhibiting signs of disease

Assessment of variables should then be based on the fish trajectory model (FTM) developed for the LEBRA as described in McNeil et al. (2006) and Humphries et al. (2007) and demonstrated in Queensland (Balcombe & Kerezy, 2008) and South Australia (McNeil & Reid, 2008).

Table 5. Spatial arrangement of fish monitoring sites

Catchment	Region	# Representative Reaches	# Sites	Potential reaches / critical sites for inclusion
Cooper	Thompson headwaters	2-3	~ 5	- Aramac Springs (DIWA) - Cauckingburra Swamp (DIWA) - upper Thomson River at 'Camoola Park' (historic QNRM Water quality monitoring sites: Sheldon et al. 2005) - Aramac Creek (historic QNRM Water quality monitoring sites: Sheldon et al. 2005)
	Barcoo headwaters	2-3	~ 5	- upper Barcoo River at Blackall (historic QNRM Water quality monitoring sites: Sheldon et al. 2005)
	Channel Country river channels & waterholes	3-4	~ 15	- Cooper Ck – Wilson River junction (DIWA) - Cooper Ck Overflow Swamps – Windorah (DIWA) - Cooper Ck Swamps – Nappa Merrie (DIWA) - Longreach township - CRCFE Dryland Refugia Sites
	Lower Cooper river channels & waterholes	2-3	~ 8	- Strzelecki Creek Wetland System (DIWA) - Innamincka township - ARIDFLO sites
	Terminal wetlands	n.a.	~ 5	- Lake Buchanan (DIWA) - Lake Galillee (DIWA) - Lake Cuddapan (DIWA) - Lake Yamma Yamma (DIWA) - Lake Blanche (part of Strzelecki Ck system, DIWA)
Diamantina / Georgina	Diamantina headwaters	2-3	~ 5	- Elizabeth Springs (DIWA)
	Georgina headwaters	2-3	~ 5	- Austral Limestone Aggregation (DIWA)
	Channel Country river channels & waterholes	3	~ 15	- Birdsville-Durrie Waterholes Aggregation (DIWA) - Diamantina Lakes Area (DIWA) - Diamantina Overflow Swamp – Durrie Station (DIWA) - Georgina River – King Creek Floodout (DIWA) - Mulligan River – Wheeler Creek junction (DIWA) - Muncoonie Lakes Area (DIWA) - Toko Gorge and Waterhole (DIWA)
	Lower Diamantina / Georgina river channels & waterholes	2	~ 8	- Diamantina River Wetland System (DIWA) - ARIDFLO sites
	Terminal wetlands	n.a.	~ 5	- Coongie Lakes (Ramsar, DIWA) - Lake Constance (DIWA) - Moondah Lake – Shallow Lake Aggregation (DIWA) - Lake Mipia Area (DIWA) - Lake Phillipi (DIWA

Catchment	Region	# Representative Reaches	# Sites	Potential reaches / critical sites for inclusion
				- Lake Torquinie Area (DIWA) - Lake Eyre (DIWA)
Western Rivers	Channels & waterholes	1-2	~ 4	
	Terminating wetlands	1-2	n.a.	- Lake Frome (Inland Saline Lakes: DIWA)
Total # sites in headwater regions			**~ 20**	
Total # sites in river channels & waterholes region			**~ 50**	
Total # sites in terminating wetlands			**~ 12**	
TOTAL # sites			**~ 82**	

Table 6: Costs for Fish Assemblage set

Item	Estimated cost	# of days	Total	Frequency	Annual Total
Field preparation					
Final site selection (workshop?)				once at beginning of monitoring programme	$15,000
Field surveys					
Field staff	$1,000 per day ($500 p.p. per day x 2 field staff)	90 days per sampling date (1.5 days per site (including travel) x 82 sites + extra travel time	$90,000	twice per year	$180,000
Accommodation	$140 per night ($70 p.p. per night x 2 staff)	90 nights per sampling date	$12,600	twice per year	$25,200
Consumables (food etc.)	$100 per day ($50 p.p. per day)	90 days	$9,000	twice per year	$18,000
Travel	$15,000 (20,000 km @ $0.75 km) N.B. mileage estimate for 2 cars travelling from Brisbane (6,000 km trip) & 2 cars travelling from Adelaide (4,000 km trip)	-	$15,000	twice per year	$30,000
Field equipment				once at beginning	$10,000
Total Field Survey costs			**$126,600 per sampling date**		**$263,200 per year (+$10,000 initially)**
Data analysis & reporting					
Data entry	$500 per day (2 x junior staff)	10 days	$5,000	twice per year	$10,000
Data analysis	$1,000 per day (2 x senior staff)	10 days	$10,000	twice per year	$20,000
Report preparation	$1,000 per day (2 x senior staff)	10 days	$10,000	twice per year	$20,000
Total data analysis & reporting			**$25,000 per sampling date**		**$50,000 per year**
TOTAL			**$151,600 per sampling date**		**$313,200 per year (+$25,000 initially)**

(N.B. The above staff and time requirements and costs are based on advice provided by Dr. Stephen Balcombe, ARI, Griffith University)

Colonial waterbirds diversity and breeding indicator

(Waterholes and wetlands theme, Waterholes and Wetland Biodiversity Attribute)

Acknowledgements:

John Porter, Australian Rivers & Wetlands Group, University of New South Wales

Values

- iconic element
- cultural and political significance
- indicator of broad-scale environmental health
- existence of long-term data sets for trends-based analyses

Pressures, drivers, risks and management actions

Table 7: Links with pressures, drivers, risks and actions: Waterbird set

Pressure / driver / risk	Potential impacts	Level of risk
Water resource development		
• reduction of flows to wetlands	• reductions in waterbird abundance, diversity and breeding	Moderate - High
• reduced durations and depths of wetland flooding	• reductions in waterbird abundance, diversity and breeding	Moderate - High
• conversion of floodplain lakes to storages	• reductions in waterbird abundance, diversity and breeding	Moderate - High
Grazing		
• vegetation management (e.g. lignum burning, clearing)	• reduced quantity and quality of nesting habitat	Moderate
Tourism		
• tourism during dry phase	• disturbance of waterbirds at refugial sites	Low
Other		
• invasive species	• potential colonisation of wetland habitats and reduction of primary productivity and food availability	Low - Moderate
• climate change	• altered ecological functioning of wetlands	Moderate - High

(Sourced from information in Kingsford & Porter 2008)

Alignment with national reporting frameworks

1. FARWH

- Aquatic biota index

2. National Framework for Natural Resource Management Standards and Targets

- Significant native species and ecological communities
- Ecologically significant invasive species

Specific indicators

Table 8: Specific indicators for Waterbird set

Indicator	Links to pressures/drivers/risks
total abundance of colonial waterbirds	- overall indicator of waterbird assemblage condition - changes may indicate altered water quality or flow regime
species richness of colonial waterbirds	- reflects changes in flooding regime
abundance of functional groups of waterbirds	- reflects changes in flooding regime - reflects condition of habitat and food supply
community composition	- overall indicator of waterbird assemblage condition - changes may indicate altered water quality or flow regime
presence/absence of particular species (e.g. threatened species)	- reflects changes in flooding regime
abundance of breeding birds	- sensitive to antecedent flow conditions - reflects condition of habitat, e.g. lignum and reed swamps
species richness of breeding birds	- sensitive to antecedent flow conditions - reflects condition of habitat, e.g. lignum and reed swamps

(Sourced from information in Kingsford & Porter 2008)

Existing monitoring

The Aerial survey of waterbirds in eastern Australia, currently managed by NSW DECC and executed by the Australian Rivers and Wetlands Group at the University of New South Wales, has been conducted annually in October since 1983. One of the ten 30 km wide survey bands passes through Lake Eyre and the lower Cooper and some other significant wetlands in the eastern part of the basin, e.g. Lake Galilee, are also covered by this survey. A list of other waterbird monitoring data from historical surveys, mostly at finer spatial resolutions, is provided in Kingsford and Porter (2008).

Sampling

Sampling methods

Waterbirds should be monitored using aerial surveys following the existing methodology currently employed in the ongoing Aerial survey of waterbirds in eastern Australia (see Kingsford & Porter 2008 for a summary). Kingsford & Porter (2008) also recommend monitoring of key breeding events using additional on-ground surveys. Whilst likely to be very valuable and informative, these are considerably more expensive than aerial surveys and are not included in this initial proposal for immediate monitoring.

Sampling frequency

Aerial surveys should be conducted once a year during the spring period (October) and more frequently in years with significant flow events. It is recommended that the current eastern aerial survey which is conducted in October be extended to incorporate wetlands of known significance for waterbirds in the parts of the Lake Eyre Basin not currently covered by the survey. In wet years, it is proposed that an additional stand-alone aerial survey of flooded wetlands in the basin also be undertaken in order to monitor breeding colonies. This would be best conducted a month or two following maximum wetland inundation, e.g. March or April. The proposed timing of these surveys would also allow comparisons between waterbird and fish monitoring data.

Spatial scale of sampling

Waterbirds should be monitored at the wetland scale. Wetlands significant to waterbirds in the Lake Eyre Basin are reasonably well known (*pers comm.* John Porter) from previous aerial surveys, e.g. eastern aerial survey, 2008 National Waterbirds Survey and additional surveys within the basin as listed in Kingsford and Porter (2008). The survey would concentrate on wetlands listed in the Directory of Important Wetlands (see Table X above) and those known to support high concentrations of waterbirds following inundation, e.g. Lake Eyre, Lake Galilee, Lake Hope, Lakes Torquinie and Mubmleberry, Lake Machattie, Lakes Koolivoo and Mippia (Kingsford & Porter, 2008).

Analysis and reporting

Analysis and reporting could be done at wetland, catchment and whole-of-basin scales.

Costs

The following costs have been developed in consultation with Dr. John Porter of the Australian Rivers & Wetlands Unit at the University of NSW.

Table 9: Costs for Waterbirds set

Item	Estimated cost	Annual Total
Expansion of existing eastern aerial waterbird survey (October annually)		
Aircraft & pilot	$450 hr x approx. x ~ 30 hrs (+30 % multiplier)	$17,550
Project coordinator (0.5 FTP – surveys, data entry, analysis & reporting)	$60,00 (+ 30 % multiplier)	$78,000
Survey staff	$1000 p.p. per day x 2 staff members x 3 days (+ 30 % multiplier) (salary and travel expenses)	$7,800
Total for expansion of existing survey		**$103,350**
Stand-alone survey in wet years (March/April)		
Aircraft & pilot	$450 hr x approx. x ~ 96 hrs (+30 % multiplier)	$56,160
Project coordinator (0.5 FTP – surveys, data entry, analysis & reporting)	already covered by expansion of existing survey (above)	$0
Survey staff	$1000 p.p. per day x 2 staff members x 12 days (+ 30 % multiplier) (salary and travel expenses)	$31,200
Total for expansion of existing survey	**$103,350**	**$87,360**
TOTAL	**in dry year** **in wet year**	**$103,350** **$190,710**

Riparian vegetation structure indicator

(Riparian and floodplain theme, Riparian and Floodplain Biodiversity Attribute)

Values

- iconic
- social and cultural significance
- economic importance
- significant for ecosystem function

Links with pressures, drivers, risks and management actions

Table 10: Links with pressures, drivers, risks and actions: Vegetation set (riparian)

Pressure / driver / risk	Potential impacts	Level of risk
Water resource development		
• altered hydrological regimes	• changes in composition, structure and condition of riparian vegetation communities • declining condition and mortality of structural perennial species, i.e. red gums, coolabah, lignum, reeds • reduced recruitment in woody species • increased invasion by exotic species • encroachment by mesic and xeric species	High
• pumping from shallow groundwater	• changes in composition, structure and condition of ground-water dependent/influenced communities	Moderate
Grazing		
• floodplain grazing during dry phase	• changes in composition, structure and condition of riparian vegetation communities • reduced recruitment of riparian trees	Moderate - High
Tourism		
• tourism during dry phase	• removal of vegetation • introduction of exotic species	Moderate
Other		
• road crossings and culverts	• altered flooding patterns may result in changes in composition, structure and condition of riparian vegetation communities	Low
• feral animals	• as for grazing	Uncertain at present
• climate change	• altered ecological functioning of waterholes and wetlands	Moderate - High

Alignment with national reporting frameworks

1. FARWH

- Fringing zone index

2. National Framework for Natural Resource Management Standards and Targets

- Riparian vegetation community assemblages (Integrity of inland aquatic ecosystems (rivers and other wetlands): river condition)

- Vegetation (Integrity of inland aquatic ecosystems (rivers and other wetlands): wetland condition)
- Significant native species and ecological communities
- Ecologically significant invasive species

Specific indicators

Table 11: Specific indicators for Vegetation set (riparian)

Indicator	Links to pressures/drivers/risks
% cover of 3-5 dominant woody species in upper (e.g. red gum, coolabah, river cooba) and middle (e.g. lignum) layers	- changes may indicate altered flow regime or anthropogenic disturbance
% herbaceous ground cover	- sensitive to antecedent flow conditions
% cover aquatic vegetation (submerged, floating, emergent)	- sensitive to antecedent flow conditions
% cover of exotics	- changes may indicate altered water quality or flow regime or anthropogenic disturbance
native regeneration	- reflects changes in flooding regime
width of riparian zone	- changes may indicate altered flooding regime or anthropogenic disturbance
longitudinal connectivity	- changes may indicate altered flooding regime or anthropogenic disturbance

(Adapted from Appendix A, River Condition Indicator Status: http://www.nrm.gov.au/publications/factsheets/me-indicators/index.html)

N.B. It should be noted that the above indicators, recommended by the NRM Standards and Targets, differ slightly from those in the most recent Index of Stream Condition. A decision on final indicator selection will be necessary prior to initiation of monitoring and may depend on expertise of field staff.

Sampling

Sampling methods

Sampling methods should follow those developed for the Index of Stream Condition, until a nationally applicable monitoring technique, currently under review, is developed (see Victorian DSE, 2006. Index of Stream Condition: User's Manual 2nd edition).

Spatial scale of sampling

Riparian vegetation structure should be surveyed at the site or waterbody level in conjunction with fish sampling.

Sampling frequency

Riparian vegetation structure should be surveyed annually in conjunction with March/April fish sampling, i.e. following recession of floodwaters.

Analysis and reporting

Analysis and reporting should follow methods developed for the index of Stream Condition as per 'Streamside Zone sub-index' (see ISC Factsheets http://www.ourwater.vic.gov.au/monitoring/river-health/isc/resources).

Costs

It is recommended that riparian vegetation structure be assessed in conjunction with fish surveys. As most of the specific indicators require minimal training, an additional staff member could join fish survey teams. Due to the timing of fish survey activities, field staff could then assist each other as required. This would also reduce travel costs significantly. Reporting and analysis would need to be conducted separately.

Table 12: Costs for Vegetation set (riparian)

Item	Estimated cost	Annual Total
Field surveys		
Staff (1 additional staff member on fish surveys)	$500 per day x 90 days (1.5 days per site (including travel) x 82 sites + extra travel time (salary and travel expenses)	$45,000
Travel	$0 if accompanying fish survey team	**$45,000**
Data analysis and reporting		
Staff	~0.25 FTP + on-costs	$30,000
TOTAL		**$75,000**

Wetland vegetation condition indicator (DIWA wetlands)

(Riparian and floodplain theme, Riparian and Floodplain Biodiversity Attribute)

Background

The state and territory governments have identified 33 nationally important wetland complexes covering over 5 million ha within the LEB (Directory of Important Wetlands in Australia). These are:

Aramac Springs, Austral Limestone Aggregation, Birdsville - Durrie Waterholes Aggregation, Cauckingburra Swamp, Coongie Lakes, Cooper Creek - Wilson River Junction, Cooper Creek Overflow Swamps - Windorah, Cooper Creek Swamps - Nappa Merrie, Dalhousie Springs, Diamantina Lakes Area, Diamantina Overflow Swamp - Durrie Station, Diamantina River Wetland System, Elizabeth Springs, Finke River Headwater Gorges System, Georgina River - King Creek Floodout, Inland Saline Lakes, Lake Buchanan, Lake Constance, Lake Cuddapan, Lake Eyre, Lake Eyre Mound Springs, Lake Galilee, Lake Mipia Area, Lake Phillipi, Lake Torquinie Area, Lake Yamma Yamma, Mitchell Swamp, Moonda Lake - Shallow Lake Aggregation, Mulligan River - Wheeler Creek Junction, Muncoonie Lakes Area, Strzelecki Creek Wetland System, Sturt National Park Wetlands, Toko Gorge and Waterhole.

Two of these wetlands (Coongie Lakes and Lake Pinaroo) are listed under the Ramsar Convention on Wetlands of International Importance.

Values

- iconic
- social and cultural significance
- economic and political importance
- significant for ecosystem function

Alignment with national reporting frameworks

1. FARWH

- Fringing zone index

2. National Framework for Natural Resource Management Standards and Targets

- Riparian vegetation community assemblages (Integrity of inland aquatic ecosystems (rivers and other wetlands): river condition)
- Vegetation (Integrity of inland aquatic ecosystems (rivers and other wetlands): wetland condition)
- Significant native species and ecological communities
- Ecologically significant invasive species

Links with pressures, drivers, risks and management actions

Table 13: Links with pressures, drivers, risks and actions: Vegetation set (wetland)

Pressure / driver / risk	Potential impacts	Level of risk
Water resource development		
• altered hydrological regimes	• changes in composition, structure and condition of riparian vegetation communities • declining condition and mortality of structural perennial species, i.e. red gums, coolabah, lignum, reeds • reduced recruitment in woody species • increased invasion by exotic species • encroachment by mesic and xeric species	High
• pumping from shallow groundwater	• changes in composition, structure and condition of ground-water dependent/influenced communities	Moderate
Grazing		
• floodplain grazing during dry phase	• changes in composition, structure and condition of riparian vegetation communities • reduced recruitment of riparian trees	Moderate - High
Tourism		
• tourism during dry phase	• removal of vegetation • introduction of exotic species	Moderate
Other		
• road crossings and culverts	• altered flooding patterns may result in changes in composition, structure and condition of riparian vegetation communities	Low
• feral animals	• as for grazing	Uncertain at present
• climate change	• altered ecological functioning of waterholes and wetlands	Moderate - High

Specific indicators

Table 14: Specific indicators for Vegetation set (wetland)

Indicator	Links to pressures/drivers/risks
Floristic composition	- sensitive to antecedent flow conditions - changes may indicate altered flow regime, water quality or anthropogenic disturbance - changes may indicate impacts of exotic species
species richness	- sensitive to antecedent flow conditions - changes may indicate altered water quality or flow regime or anthropogenic disturbance - changes may indicate impacts of exotic species
% canopy cover	- changes may indicate altered flooding regime or anthropogenic disturbance
% foliage cover of understorey species	- sensitive to antecedent flow conditions - changes may indicate altered water quality or flow regime or anthropogenic disturbance - changes may indicate impacts of exotic species
foliage cover	- changes may indicate altered flooding regime or anthropogenic disturbance
height ranges of vegetation layers (trees, shrubs, understorey)	- changes may indicate altered flooding regime or anthropogenic disturbance
tree vigour	- changes may indicate altered flooding regime, water quality or anthropogenic disturbance
population size structure	- changes may indicate altered flooding regime or anthropogenic disturbance

(Adapted Wetland Ecosystem Condition: Vegetation - Indicator Status: http://www.nrm.gov.au/publications/factsheets/me-indicators/index.html)

Sampling

Sampling methods

Sampling methods should follow those described in detail in the Wetland Ecosystem Condition: Vegetation - Indicator Status fact sheet (part of the National Framework for Natural Resource Management Standards and Targets) available at: http://www.nrm.gov.au/publications/factsheets/me-indicators/index.html.

In summary, these methods involve surveying between 3 and 6 permanently established transects running from upland areas into the lowest elevations of the wetland, preferably where emergent macrophytes are present. The number and location of transects per wetland will depend on its vegetation diversity and should be selected from aerial photos etc. prior to the first field survey. Transects should comprise contiguous 20m x 20m quadrats in which measurements will be taken at varying scales including % canopy cover, % cover of understorey speciesand DBH of trees.

Spatial scale of sampling

Wetland vegetation composition should be conducted in all of the wetlands listed in the Directory of Important Wetlands.

Sampling frequency

Wetland vegetation condition should be surveyed annually. The timing of surveys may vary depending on hydrological conditions but should be conducted at the same time of year where possible. An April survey date may be appropriate for many wetlands in the Lake Eyre Basin as this should enable access following floodwater recession whilst still allowing surveys of flood-responsive vegetation to occur.

Analysis and reporting

Analysis and reporting will need to be conducted at the scale of individual wetlands.

Table 15: Costs for Vegetation set (wetland)

(Based on 28 DIWA wetland sites.)

Item	Estimated cost	# of days	Annual Total
Field preparation			
Transect selection using aerial photos etc.	0.5 days per wetland x $500 per day		$14,000 (once at beginning)
Field surveys			
Field staff	$1,000 per day ($500 p.p. per day x 2 field staff)	90 days (3 days per wetland (including travel) x 28 sites + extra travel time	$90,000
Accommodation	$140 per night ($70 p.p. per night x 2 staff)	90 nights	$12,600
Consumables (food etc.)	$100 per day ($50 p.p. per day)	90 days	$9,000
Travel	$12,000 (20,000 km @ $0.75 km) N.B. mileage estimate for 2 cars travelling from Brisbane (6,000 km trip) & 1 car travelling from Adelaide (4,000 km trip)	-	$12,000
Field equipment			$5,000
Total Field Survey costs			**$128,600**
Data analysis & reporting			
Data entry	$500 per day (2 x junior staff)	10 days	$10,000
Data analysis	$1,000 per day (2 x senior staff)	10 days	$20,000
Report preparation	$1,000 per day (2 x senior staff)	10 days	$20,000
Total data analysis & reporting			**$50,000**
TOTAL			**$178,600** **per year (+$14,000 initially)**

Physical habitat indicator

(Physical form theme,* Channel system integrity and erosion potential/land use/ landscape change *Attribute)

Values

- maintenance of healthy aquatic ecosystems
- contributes to social, cultural and aesthetic values of channels and waterholes
- potential indicator of climate change and anthropogenic disturbance including land use

Links with pressures, drivers, risks and management actions

Table 16: Links with pressures, drivers, risks and actions: Physical Habitat set

Pressure / driver / risk	Potential impacts	Level of risk
Water resource development		
• water storage and diversion	• changes in the flow regime resulting from alterations in in-stream flows and floodplain inundation and therefore changes to sediment regime • loss of physical diversity within the channel network and on key floodplain surfaces	Moderate - High
• construction of barriers across floodplain surfaces and within the channel network	• interruptions to the natural flow and sediment regime within the channel network and across key floodplain surfaces	Moderate - High
Land use change		
• shift from grazing to cropping	• altered water quality in channels and wetlands as a result of changes in runoff patterns and nutrient and sediment supply	Moderate
• overgrazing on floodplain	• altered soil structure, nutrient content and vegetation may influence nutrient and sediment loads entering channels and wetlands	Moderate
Other		
• feral animals	• as for grazing	Uncertain at present
• climate change	• altered flow and sediment regimes resulting from changed runoff and flow patterns and sediment and nutrient loads	Moderate - High

(Sourced from information in Parsons et al. 2004)

Alignment with national reporting frameworks

1. FARWH

- Physical form index

Specific indicators

Table 17: Specific indicators for Physical Habitat set

Indicator	Links to pressures/drivers/risks
Physical diversity	- indictor of flow and sediment variability - loss of physical habitat diversity will may be deleterious to aquatic biota
Channel instability	- indicator of overgrazing and land use and may be deleterious to aquatic biota

(Sourced from information in Parsons et al. 2004)

Existing monitoring

At present, there is no routine collection of physical habitat in the Lake Eyre Basin.

Sampling

Sampling methods

The proposed water quality monitoring programme recommended here comprises two components:

1. Physical habitat should be sampled in conjunction with fish sampling at each survey time. The physical habitat protocol of Parsons et al., (2004) is recommended. Basic measurements of channel stability and the presence/absence of physical habitat units can be measured in the field using hand-held surveying equipment.

2. It is also recommended that data from any rapid biological assessment program be assessed for their quality to supplement the proposed fish sampling sites.

Sampling frequency

Sampling in waterholes should be conducted once a year in conjunction with fish sampling.

Spatial scale of sampling

The first component of the physical habitat sampling should be conducted at the site or waterbody level in conjunction with fish sampling.

Additionally, it is recommended that electrical conductivity and temperature probes be installed in several of the re-opened gauges in Queensland which are currently only recording river heights and rainfall. Of the 11 new sites in the Queensland portion of the LEB, 9 were historically operated as water quality monitoring sites. It has been suggested that it would be appropriate to install water quality probes at around 2 to 3 of these sites initially with preference for sites at the lower end of the catchments, e.g. Nappa Merrie, Diamantina Lakes and Barcoo River at Retreat.

Analysis and reporting

Analysis and reporting of waterhole scale data may be conducted in conjunction with that relating to fish surveys in order to assess possible linkages. Data from any additional studies through out the basin would be incorporated into the analysis and reporting framework currently implemented in that State. Collation and analysis of

physical habitat data from 1. fish monitoring, 2. Queensland rapid biological assessment sites and 3. South Australian rapid biological assessment sites could be incorporated if undertaken and this would require collation and analysis at a catchment and basin scale within the reporting timeframe of the LEBRA.

Costs

Costs of sampling in waterholes should be minimal as measurements can be taken in conjunction with fish sampling. Equipment, e.g. theodolites, may present an initial expense depending on the access of these to fish sampling project teams. There may be an additional cost for data analysis and reporting beyond the scope of the fish monitoring programme. An estimate of costs associated with this component based on advice provided by researchers experienced with rapid physical habitat surveys, is provided below.

Table 18: Costs for Physical Habitat set

Item	Estimated cost	Total	Frequency	Annual Total
Equipment	$10,000 per survey item	$10,000	once at beginning of monitoring programme	$5,000
Staff (3 people required)	$500 p.p. per day (salary and travel expenses)	$13,500	once at beginning of monitoring programme	$13,500
Total Installation costs		**$23,500**		**$18,500**

Water quality indicator

Acknowledgements:

Bill Reurich, QLD Department of Environment and Resource Management

Peter Old, QLD Department of Environment and Resource Management

Values

- maintenance of healthy aquatic ecosystems
- contributes to social, cultural and aesthetic values of channels and waterholes
- potential early indicator of anthropogenic disturbance
- existence of long-term data sets for trends-based analyses

Links with pressures, drivers, risks and management actions

Table 19: Links with pressures, drivers, risks and actions: Water Quality set

Pressure / driver / risk	Potential impacts	Level of risk
Water resource development		
• water storage and diversion	• changes in water quality resulting from alterations in in-stream flows and floodplain inundation and therefore sediment and nutrient loads	Moderate - High
• change in depth of alluvial groundwater	• alterations to quality of water in refugial waterholes	Moderate
Land use change		
• shift from grazing to cropping	• altered water quality in channels and wetlands as a result of changes in runoff patterns and nutrient and sediment supply	Moderate
• overgrazing on floodplain	• altered soil structure, nutrient content and vegetation may influence nutrient and sediment loads entering channels and wetlands	Moderate
Tourism		
• tourism during dry phase	• increased nutrient inputs	Moderate
Other		
• toxic impacts of stock vaccination via faeces	• reductions in water quality	Uncertain at present
• feral animals	• as for grazing	Uncertain at present
• climate change	• altered water quality resulting from changed runoff and flow patterns and sediment and nutrient loads	Moderate - High

(Sourced from information in Sheldon et al. 2005)

Alignment with national reporting frameworks

1. FARWH

- Water quality index

2. National Framework for Natural Resource Management Standards and Targets

- Water quality (Integrity of inland aquatic ecosystems (rivers and other wetlands): river condition)
- Dissolved oxygen and temperature (Wetland ecosystem condition)
- Transparency (Wetland ecosystem condition)
- Turbidity (Turbidity/suspended particulate matter in aquatic environments)
- Electrical conductivity (Surface water salinity in freshwater aquatic environments)

Specific indicators

Table 20: Specific indicators for Water Quality set

Indicator	Links to pressures/drivers/risks
conductivity	- indictor of salinity - elevated salinities may be deleterious to aquatic biota
pH	- extreme pH may be deleterious to aquatic biota
dissolved oxygen (diel range)	- highly significant for aquatic biota - high DO levels during and levels close to zero in the evening may indicate a high pollution load
turbidity	- indicator of amount of suspended solids in water - influences light penetration and primary production - decreases in turbidity may result in increased primary productivity
water temperature (diel range)	- highly significant for aquatic biota

(Sourced from information in Sheldon et al. 2006)

Existing monitoring

At present, the Queensland Department of Environment and Resource Management continuously monitor conductivity and temperature (as well as river height and rainfall) at a single location in the Queensland portion of the Lake Eyre Basin: Thompson River @ Longreach (003202A). A further 11 sites have operational instantaneous river height and rainfall gauges. There is historic water quality data available for 9 of these sites.

In South Australia, water quality is currently assessed by the EPA for 7 sites in the Lake Eyre Basin: Cooper Creek, Warburton Creek, Yardaparinna Creek, Neales River, Margaret Creek, Mount Chambers Creek and Arakola Creek. Water quality parameters, including oxidised nitrogen, total nitrogen, total phosphours, soluble phosphorus, turbidity and salinity, are measured every 3 months in these remote locations.

Sampling

Sampling methods

The proposed water quality monitoring programme recommended here comprises two components:

1. Water quality should be sampled in conjunction with fish sampling during each survey time. Conductivity, pH and turbidity can be measured in the field using hand-held probes and diel ranges in dissolved oxygen and water temperature can be measured over 24 hours using probes and data loggers.

2. It is also recommended that additional water quality monitoring probes be installed in the Queensland portion of the Lake Eyre Basin to supplement the existing network of gauges and enable the assessment of long-term trends through analyses against historic data. As per the remainder of Queensland's water quality monitoring network, these should comprise in situ electrical conductivity and temperature probes.

Sampling frequency

Sampling in waterholes should be conducted twice per year in conjunction with fish sampling. Water quality monitoring via in situ probes will occur continuously.

Spatial scale of sampling

The first component of water quality sampling should be conducted at the site or waterbody level in conjunction with fish sampling. Additionally, it is recommended that electrical conductivity and temperature probes be installed in several of the re-opened gauges in Queensland which are currently only recording river heights and rainfall. Of the 11 new sites in the Queensland portion of the LEB, 9 were historically operated as water quality monitoring sites. It has been suggested that it would be appropriate to install water quality probes at around 2 to 3 of these sites initially with preference for sites at the lower end of the catchments, e.g. Nappa Merrie, Diamantina Lakes and Barcoo River at Retreat.

Analysis and reporting

Analysis and reporting of waterhole scale data may be conducted in conjunction with that relating to fish surveys in order to assess possible linkages. Data from any additional water quality monitoring stations in Queensland would be incorporated into the analysis and reporting framework currently implemented in that State. Collation and analysis of water quality data from 1. fish monitoring, 2. Queensland water quality monitoring sites and 3. South Australian water quality monitoring sites would require collation and analysis at a catchment and basin scale within the reporting timeframe of the LEBRA, i.e. once every 10 years.

Costs

Costs of sampling in waterholes should be minimal as measurements can be taken in conjunction with fish sampling. Equipment, e.g. probes and data loggers, may present an initial expense depending on the access of these to fish sampling project

teams. There may be an additional cost for data analysis and reporting beyond the scope of the fish monitoring programme. An estimate of costs associated with the installation and maintenance of additional water quality probes in Queensland, based on advice provided by staff members of QLD Department of Environment and Resource Management, is provided below.

Table 21: Costs for Water Quality set

Item	Estimated cost	Total	Frequency	Annual Total
Installation of probes (3)				
Equipment	$15,000 per probe	$45,000 (3 new probes)	once at beginning of monitoring programme	$45,000
Staff (3 people required)	$500 p.p. per day (salary and travel expenses)	$13,500 (3 days per probe including travel)	once at beginning of monitoring programme	$13,500
Total Installation costs		**$58,500**		**$58,500**
Maintenance and calibration				
Staff and travel	$1,000 per day ($500 p.p. per day x 2 field staff x 1 probe per day)	$3,000	annually	$3,000
Equipment	$1,000 per probe	$3,000	annually	$63,000
Total Maintenance costs		**$6,000 per year**		**$6,000 per year**
TOTAL				**$6,000 per year (+$58,500 initially)**

Hydrology indicator

Acknowledgements

Tony Ladson, Erwin Weinmann, Justin Costelloe, John Tilleard

Values

- maintenance of healthy aquatic and floodplain ecosystems
- contributes to social, cultural and aesthetic values of floodplains, channels and waterholes
- potential indicator of anthropogenic disturbance, especially climate, land use and floodplain
- existence of long-term data sets for some trend-based analyses

Links with pressures, drivers, risks and management actions

Table 22: Links with pressures, drivers, risks and actions: Hydrology set

Pressure / driver / risk	Potential impacts	Level of risk
Water resource development		
• water storage and diversion	• changes in the spatial and temporal availability of water through the basin resulting from alterations in in-channel flows and floodplain inundation • reduced filling of terminal lakes and wetlands	High
• pumping from water holes	• alterations to the availability of water in refugial waterholes	High
Land use change		
• vegetation structure changes via mining, grazing and other development	• changes in the spatial and temporal availability of water • less water for waterhole filling	Moderate
• floodplain developments	• altered patterns of floodplain inundation	Moderate
Other		
• climate change	• altered water availability resulting from changed runoff and flow patterns	High

Alignment with national reporting frameworks

1. FARWH

- Hydrological change

Specific indicators

Table 23: Specific indicators for Hydrology set

Indicator	Links to pressures/drivers/risks
Total surface water availability	- Water resources development - Climate change - Land use change
Water storage capacity	- Water resources development
Water licensing	- Water resources development
Filling of terminal lakes	- Water resources development - Climate change - Floodplain development - Land use change - Presence of in-channel structures
Floodplain inundation	- Water resources development - Climate change - Floodplain development - Land use change
In- channel events	- Water resources development - Climate change - Floodplain development - Land use change - Presence of in-channel structures
Persistence of key waterholes	- Water resources development - Climate change

Existing monitoring

Water surface information has been collected at over 150 locations throughout the Lake Eyre Basin and the available data are of variable quality, length of record and availability. These networks include:

- • Stream monitoring stations maintained by the governments of South Australia, Queensland and Northern Territory;
- • Flood warning stations maintained by the Bureau of Meteorology;
- • Sites established as part of the Arid Flow Project to investigate floodplain, waterhole and wetland ecology;
- • Sites used in the Dryland Refugia Project to investigate waterhole ecology; and,
- • A hydrologic network set up by Santos Ltd for the specific purpose of warning of flood threats to mining infrastructure.

Stream monitoring stations are specifically set up to provide long term records of flow information. These are reviewed in detail in the report *Hydrology of Lake Eyre Basin* (HLEB) including, length of record, and adequacy of gauging. Much of the stream monitoring data are available via the internet. According to HLEB, there are only 17 stations in the Lake Eyre Basin with at least 10 years of record and only 12

stations have at least 20 years of record. In order to undertake a valid statistical analysis of the frequency of floods at least 30 years of data are recommended by the Institution of Australian Engineers. The HLEB also includes an assessment of accuracy of flow information at these gauging stations in terms of how adequately the streams are rated. Only four gauges had good high flow ratings: Cooper Creek at Nappa Merrie (003103a), Cooper Creek at Callamurra Water Hole (AW003501), Thomson River at Longreach (003202A) and Thomson River at Stonehenge (003202A). It may be appropriate to improve the high flow ratings at other gauges (see section 7). Three gauges have recently been reinstated which is consistent with the recommendations of the HLEB report: Diamantina River at Diamantina Lakes, Burke River at Boulia and Georgina River at Roxborough Downs.

In addition to the state network of water level recorders, a series of 17 water level loggers have been installed by the ARIDFLO Project in three sub catchments of the Lake Eyre Basin in South Australia.

Sampling

Sampling methods

It is proposed that two types of surface water monitoring should occur in the Lake Eyre Basin:

A network of surface water level recorders should be used to determine flows at various locations through out the Basin. The number, location and type of measurements required for monitoring depend on the specific issues to be addressed, the variability of the natural system, and of course, the available budget. For efficient and cost-effective operation of the networks that serve the Rivers Assessment Program, it is desirable that these networks be integrated with monitoring networks set up and operated for other purposes. Ladson et al., (2008) proposes the following priorities for the hydrology network in the Lake Eyre Basin.

Priority 1:

Highest priority sites are those that assist in the understanding large scale hydrology of the multi-channel, ecologically diverse reaches of the Cooper Creek, Diamantina River and Georgina Rivers. Good flow data is required at the upstream and downstream ends of these reaches.

- Cooper - Improve the high flow rating of the Barcoo River at Retreat. The other sites on the Cooper are probably adequate.
- Diamantina – continue with the re-establishment of the site Diamantina River at Diamantina Lakes, in particular, the high flow rating at this site needs to be improved and data needs to be brought online (data from this site are not currently accessible via the Queensland Watershed database).
- Georgina (upstream) – continue restablishment of gauging stations, Georgina River at Roxborough Downs and Burke River at Boulia. We understand that stage data are currently being collected and telemetered from these sites, but

the information is not accessible via the Queensland Watershed database. The publicly available records for these sites suggest they ceased operation in 1988. Additional work will be required to establish reliable ratings at these sites.

- Georgina (downstream) – a new site is required at the downstream end of the multichannel reach of the Georgia River. We recommend that the gauging station, Eyre Creek at Glenglyle, be reestablished as it has about 20 years of data before ceasing operation in about 1990. This site should incorporate telemetry, via satellite phone if necessary, and 'sensor to web' technology.
- In addition, remotely sensed data on flood pattern and extent should be captured as this can guide hydrologic modelling and ecological assessment of these reaches.

Priority 2:

Priority 2 sites should be established to monitor land use influences on the hydrology of the Lake Eyre Basin. These influences include activities such as mining and catchment clearing in the headwaters of Cooper Creek, Diamantina River and Georgina River. These sites need to be located in areas where impacts are greatest so that there is the highest change of detecting changes. There would need to be further work to identify areas with the highest land use and the best sites for monitoring, but the following should be considered:

- Torrens Creek at Torrens Creek (003206A) – reinstate
- Mistake Creek at Wololla (003305A) - reinstate
- Diamantina at Tulmur (002903) – install

Priority 3:

Other monitoring sites could include:

1. Neales River near Algebukina Bridge (or Macumba River at Macumba Station) (AW004104) – install full gauging stations (currently stage measurements are recorded). These sites are importance because these western LEB tributaries are poorly gauged. The Neales site is an excellent location to measure flows and there is a ecologically important wetland nearby. There may also be some high flow information available this site from debris line surveys undertaken in the 1980s.

2. A series of water recorders for determining the persistence of key wetlands and waterholes through out the Lake Eyre Basin. Here the similar procedures as in the Arid Flow project where low cost stage loggers are set up and downloaded during site visits.

Priority sites could include:

- Durrie waterholes aggregation, Birdsville
- Cooper Creek Overflow swamps, Windorah
- Cooper Creek – Wilson River Junction

- Diamantina Overflow Swamp, Durrie Station
- Georgina River, King Creek Floodout
- Mulligan River – Wheeler Creek junction

  These sites would need to be confirmed with ecologists. In addition, the existing Arid Flow sites should be continued.

Sampling frequency

Technological improvements have meant that daily readings can now be obtained from most sensors. Issues concerned with instrumental servicing and calibration are dealt with below.

Analysis and reporting

Analysis and reporting of waterhole scale data may be conducted in conjunction with that relating to fish surveys in order to assess possible linkages. Data from any additional water quality monitoring stations in Queensland would be incorporated into the analysis and reporting framework currently implemented in that State. Collation and analysis of water quality data from 1. fish monitoring, 2. Queensland water quality monitoring sites and 3. South Australian water quality monitoring sites would require collation and analysis at a catchment and basin scale within the reporting timeframe of the LEBRA, i.e. once every 10 years.

Costs

Typical costs for the hydrological monitoring component are listed in Table *. These are approximate as actual costs will be dependant upon site conditions and remoteness. It is recommended that monitoring to be done by the state agencies and the data collected should also be handled by the state agencies and incorporated into their databases. In general, site visits by technical staff are much more costly than the purchase price of instruments. Reliable sensors, data loggers and telemetry systems, even if they have a higher initial cost, may be a way of reducing the total cost of measuring systems.

Two types of sites should be considered. Long term sites with ‘sensor to web’ technology i.e. where data are collected, telemetered via satellite phone if necessary, and made available in the internet in close to real time. These sites would require development of rating curves. In addition there should be a larger number of cheaper sites where stage is measured but where data are not telemetered. These sites would be similar to the existing arid flow sites. The selection process for any new instrumentation and the techniques to undertake the actual measurements would benefit from technical advice from experts drawn from all the jurisdiction covering the Lake Eyre Basin.

Table 24: Costs for Hydrology set

(Typical costs for monitoring system components)

No.	Item	Cost
1	Field visit by a team of two people	$2,000 per day x3sites x 4 sub-basins x 2people
2	Satellite phone modem	$2,000 to $3,000
3	Satellite phone network access and phone calls	$1,000 per year
4	Data logger	$1,000 to $10,000 x 12
5	Sensor	$1,000 to $5,000 x12
6	Set up costs for high quality long-term gauging site that	$20,000 to $100,000 depending on stream size, remoteness, and chosen equipment. (est $60k x 12 – some exist, but need upgrading)
7	High flow gauging of a remote site e.g. Diamantina River at Diamantina Lakes	$30,000 This includes helicopter access
8	Set up costs for 'project' sites e.g. an Aridflo sites. These could be used to monitor a series of waterholes	$40,000 for 10 sites within a radius of a few hundred kilometres.
9	Analysis	30 days $36k

Pressure Indicators

The indicators listed in the previous section will provide an assessment of the "condition" of the aquatic ecosystems of the LEB. However these indicators do not provide information on what activities may be causing the changes in condition. To address this issue an additional set of "pressure indicators" have been developed to provide a context of the major changes in landuse and land management impacting on the aquatic ecosystems of the LEB.

The key pressures impacting of the condition of the aquatic ecosystems of the LAB have been identified in the development of the condition indicators (Table 3, 7, 10, 13, 16, 19 and 22). The high and moderate pressures identified are:

- Land use changes impacting on water use
- Management of grazing lands
- Tourism
- Invasive species
- Climate Change

Table 25 Key pressures, impacting activities and indicators

Pressures	Impacting activities associated with the pressure	Indicator areas
Land use changes, especially those impacting on water use • Irrigated agriculture • Intensification of grazing • Mining and petroleum extraction • Road construction • Earthworks to harvest water	Water extraction, water storage and diversion, construction of barriers across floodplain surfaces and within the channel network, damming, conversion of floodplain lakes to storages, floodplain harvesting, pumping from shallow groundwater, pumping from water holes	Development applications, Environmental Impact Assessments, water permits issued, updates of water management plans
Management of grazing lands	Increased grazing pressure, vegetation management	Vegetation cover, burnt areas
Tourism	Recreational visitors, localized fishing impacts	Number of visitors
Invasive species	Establishment/spread of exotic animal and plant species (on the floodplains)	Occurrence of Weeds of National Importance, exotic fish species
Climate Change	Changes in the amount and pattern of rainfall and the associated changes in river flows, intensity of storm events	National level conclusions on changes in climate

Existing Monitoring

While the state indicators are to be assessed on the basis of data collected during field programs, a more cost effective approach can be used for the pressure indicators. Government agencies have existing procedures and programs that collect information on many of the pressures in the LEB. Accordingly, the approach will be collate the information available on changes in relation to each pressure.

Reporting

Information on the pressure indicators will be collated and reported in the mid-term and 5 years reports.

Costs

Costs will be limited to the time involved in identifying and collating information on the pressures.

Table 26 Costs for Pressure Indicators

Item	Estimated Cost	Total	Frequency	Total
Data collation and reporting				
Initial identification of data sets	$1000 / day * 20 days	$20 000	Year 2	$20 000
Collation of information	$1000 / day * 15 days	$10 000	Mid term and Final Assessment	$20 000
Report preparation	$1000 / day * 15 days	$15 000	Mid term and Final Assessment	$30 000

Setting Thresholds of Potential Concern (TPCs)

An important component of natural resource management is to ensure the maintenance of determinants that influence all vital attributes of the system under consideration. This must then involve listing all the determinants of, and the constraints and threats to, the condensed list of vital attributes. Determinants are those factors or processes that determine, strengthen or ensure persistence, while threats are those factors or processes that threaten, erode or inhibit these attributes or their determinants. Threats can also be factors within, or outside, a partnership that undermine its values and inhibit the pursuit of the mission or future desired state. Knowledge of the environmental and cultural "goods and services" the system has the potential to deliver is essential part of this process.

Development of a desired state is important in nay natural resource management exercise and is one based on a vision for a set of desired future ecosystem conditions. It is important to note that this refers to a 'desired set of varying conditions' rather than a static state. Ecosystem conditions are not fixed but inherently dynamic. We cannot aim to achieve specific and unchanging ecosystem conditions, but only to maintain natural variation and processes as the basis for ecosystem resilience – resilient ecosystems are able to absorb environmental stressors without undergoing an irreversible change in their state.

Some changes are undesirable as they form part of a long-term trend moving the ecosystem away from the desired state to another less preferred state. Over time this trend may become irreversible. The desired outcomes of management are therefore expressed as limits of acceptable change – termed Thresholds of Potential Concern (TPCs). TPCs are upper and lower levels of change in selected indicators. If TPCs are reached it is very likely that the desired state will not be achieved or will not be able to be achieved into the future.

In essence TPCs should be seen as red flags to managers warning that management intervention could be necessary to defend the desired state. They also indicate what management actions should be done, where it should occur and when the actions should take place. Modelling is also used to predict the results of future monitoring and thus give early warning that a TPC is likely to be breached. Indeed, any management process that is working towards the rehabilitation of a desired state, TPCs represent achievable goals for management to work toward. A collective of TPCs represent a multidimensional envelope in which natural resource managers and stakeholders wish the system to

remain, “bouncing around” as much as possible, without going to the undesirable zone.

Examples of possible Thresholds of Potential Concern for the Lake Eyre Basin are provided in Table 25.

Table 27. **Examples of Thresholds of Potential Concern for the Lake Eyre Basin**

Trigger	Thresholds exceeded or expected to be exceeded
Reduction in waterhole persistence	Significant change in the cumulative duration of water availability within the key waterholes of the Lake Eyre Basin
In-channel flow events or flow pulses	Significant change in the flow duration curve of no flow events for gauging within the Lake Eyre Basin
Total surface water availability	Reduction in total annual volume of surface water expected from catchment rainfall at key gauging stations located throughout the Lake Eyre Basin
Silt and pollutant release episode from upstream mining operation	Increased turbidity in waterholes resulting in fish kills
River sedimentation	Loss of physical habitat diversity between and within waterholes
Change in community of native fish	- New occurrence of an alien fish with a high index of potential threat - Significant change in size distribution of fish communities within the individual sub catchments of the Lake Eyre Basin
Change in riparian vegetation structure	- New occurrence of an alien plant with a high index of potential threat