Foresighting sustainable irrigation and river health

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CHAPTER 1

Introduction

Background

Early in 1997, the Land and Water Resources R&D Corporation (LWRRDC) decided to experiment with the application of the process of foresighting across a range of its programs. Its purpose in this was to improve the framework within which management, policy and investment decisions were made in dealing with Australia's natural resources. The specific objectives of the foresighting exercises were to:

- identify future scenarios for the use and management of Australia's natural resources (land, water and vegetation);
- consider the implications of these scenarios for changes in the value, condition, and frameworks (political, legal, organisational and socioeconomic) for sustainable management of these resources;
- identify strategies for the future management of LWRRDC's R&D programs to accommodate likely future needs; and
- identify appropriate R&D directions and priorities within these programs to anticipate future information needs.

Initially LWRRDC commissioned a general foresighting exercise to develop broad scenarios relevant to natural resource management issues. This was conducted by the Centre for International Economics (CIE) and the exercise and its results are briefly reported later in this Chapter.

LWRRDC then pursued foresighting exercises to help identify future information and research needs in four specific areas. These areas were dryland salinity, river health, remnant vegetation and sustainable irrigation. The sustainable irrigation and river health areas were subsequently combined resulting in the exercise reported here.

An introduction to foresighting

The key aspect of foresight is its forward looking orientation. Foresight attempts to capture the dynamics of change by placing today's decisions into a context that includes the possible developments of tomorrow. It is not intended to replace more traditional methods of analysis. Rather it seeks to add a new dimension to our thinking.

The process has a number of important characteristics. In particular, it is:

- a way of thinking about the longer term future and how it could differ from the present;
- a means for testing our current views and policy settings; and
- one way of overcoming the difficulties of a static or backward looking analysis.

Foresight acknowledges a range of possible futures. It provides a valuable opportunity to think seriously about significant technical trends and their relationship to socioeconomic needs. Unlike 'forecasting', it does not attempt to estimate or predict what the future will be. Foresight implies an active approach to the future and reflects the belief that the future can be influenced through actions we choose to take today. Many decisions involving investment in science and technology (S&T) have long lead times, which makes it important to have an informed view about the future.

The term Foresight can refer, inter alia,

- to attempts to predict the substantive outcomes of the independent research work of scholars;

- to the activities of research funding agencies in giving priority funding and institutional recognition to specific fields and subfields of research;
- to attempts to predict and influence the transfer of basic S&T and to identify technologies considered critical to the general welfare;
- to the process by which public and private stakeholders seek to improve communication between the various sources of innovation, research and development.

The key components of effective foresighting have been identified, on the basis of experience, to be:

- the role of the facilitator, who needs to be experienced in managing the many tacit elements of the process;
- selection and engagement of the commitment of a wide range of stakeholders;
- involvement of, but not reliance on, appropriate technical experts;
- the generation of scenarios through processes in which the stakeholders are involved, rather than the 'identification' or imposition of scenarios;
- customisation of the foresight process for each application;
- effective processes to integrate scenarios into strategic planning.

Further details, based on the materials distributed to the participants, are included at Annex A.

The CIE report

The CIE study was completed in May 1997 and identified a number of future scenarios for Australian agricultural production and natural resource tradeoffs. These futures were influenced by three major driving variables:

- projections of demand for Australian agricultural products;
- physical constraints on agricultural production (availability of land and water) bearing in mind the deterioration in the resource base as well as technical change;
- which environmental costs are factored into production decisions.

The CIE report provides a range of views on global economic growth which in turn influence the world demand for agricultural products, which can be translated into demand for Australian agricultural products. Long-run aggregate world growth is predicted by CIE to be in the range of 2.3–3.9% per year and will be driven by population growth, the rate of new technological development and its adoption, and the potential of the developing world to 'catch-up' to the developed countries. This last driver of world economic growth is the most influential.

CIE expect the demand for particular agricultural commodities produced in Australia to increase in the future. CIE reports Australia has sufficient availability of land and water to meet world demand for agricultural products over the next 30 years. However, the forecast demand for commodities such as sugar, cotton and horticulture was predicted to significantly increase in the future, and as these crops are likely to be irrigation crops, there may be increasing tension between irrigators for the limited water resource, and tension between irrigators and the environment as the demand for irrigation water increases.

Future decisions regarding agricultural production will depend upon the level of importance placed upon environmental issues by producers. In the future, production decisions will depend upon the cost of the land and the water to the producer and the external environmental cost associated with production (ie. the cost of reduced biodiversity and environmental degradation).

Within the CIE report, three scenarios were developed reflecting the variable importance of environmental issues. The first scenario was 'Economic Growth' which assumed greater importance would be placed upon production objectives in the future by the government as a result of community pressure. The second scenario was 'Conservative Development' which is similar to the current directions being taken to address environmental and production objectives, for example, sustainable development. The third scenario developed by CIE was 'Post Materialism' which envisages massive change in Australian agricultural production systems. The post materialism scenario would involve directing considerable resources to improving the environment at the cost of reduced agricultural production.

Purpose of irrigation and river health exercise

The objectives of the present foresighting exercise were:

- to identify future scenarios for the use and management of Australia's natural resources, particularly as they relate to river and irrigation management;
- to consider the implication of these scenarios for changes in the approach to sustainable management of these resources;
- to identify strategies for the future management of LWRRDC's river and irrigation program;
- to undertake reverse history analyses to identify research and policy areas of significance.

The project was intended to be a major learning exercise regarding foresighting for the LWRRDC Board and management as well as for stakeholders in the irrigation and river health programs. Consequently the project was conducted in a manner that allowed maximum exposure of the many tacit components of foresight.

Principal results from the exercise were envisaged to include both a content and a process dimension. The content outcome was to assist LWRRDC in decision making by providing a framework for strategy development, structuring and managing its R&D programs into sustainable irrigation and river health. The process outcome was to involve LWRRDC personnel and other stakeholders in a greater degree of lateral thinking about the uncertain future and to provide greater understanding and communication between researchers of different disciplines, between researchers and policy/management personnel and engender overall ownership of the process of organising and planning for uncertain futures.

Overview of methods used

The methods used to pursue these objectives and outcomes included:

- preparation of a 'Background' or 'Issues' paper;
- an Expert Workshop, in which major issues were discussed, key drivers and uncertainties identified, and draft scenarios developed;
- a Stakeholder Workshop, in which the scenarios were developed and refined, and the implications for strategy explored;
- a Delphi exercise which allowed participants to assess the nineteen major 'thematic' developments, and the 10 'structural' developments, which emerged from the Stakeholder Workshop.

The background paper on irrigation and river health was prepared with the assistance of a small group of experts and, together with other foresighting material, was used as input to the Expert Workshop. Output from the Expert Workshop was used as input to the larger Stakeholder Workshop. Scenario construction and analysis were used in both workshops.

The one and a half day Stakeholder Workshop was targeted at producing a strategy for LWRRDC's future R&D in the sustainable irrigation and river health areas. Feedback from the Stakeholder Workshop and the results of the Delphi exercise assisted in the development of the R&D strategy.

Layout of report

Chapters 2 and 3 of this report describe the inputs, processes and outputs of the Expert Workshop and Stakeholder Workshop respectively. Assessment of impact and timing of key future developments in I&RH obtained through a Delphi survey of stakeholders after the Stakeholder Workshop is described and results reported in Chapter 4.

Chapter 5 presents the detail and findings of an evaluation exercise designed to assess the process and output performance of the foresighting exercise, and to suggest appropriate modifications in the future use of foresighting by LWRRDC.

Chapter 6 considers implications for an R&D Strategy for LWRRDC, implications of the scenarios for changes, strategies for the future management of LWRRDC's I&RH Programs, reverse history analysis, and research and policy areas of importance.

CHAPTER 2

Expert workshop

Preparation for expert workshop

The objectives of the Expert Workshop were:

- to engage a group of experts to assist with the preparation of a background paper;
- to familiarise these experts with the mechanisms and advantages of foresight processes;
- to develop and refine three scenarios for the future of irrigation and river health through a process based on identified sets of 'key drivers' and 'key uncertainties'; and
- to gain the commitment of the experts to the foresight exercise and process.

Experts were sought in the areas of both sustainable irrigation and river health. A process developed by ACIIC called 'interest mapping' was employed to identify the wide range of 'interests' in irrigation and river health, and on that basis, to identify appropriate experts and stakeholders. Three successive interest maps are presented in Annex C. This led to the identification of other experts in the areas of water policy, climate change and climate forecasting, and agricultural economics. Seven experts were identified in all with five of the seven more closely involved in the preparation of the first draft of the issues paper. Three LWRRDC Program Coordinators and Program Managers (all of whom could be considered experts) also attended the Expert Workshop.

The issues paper was drafted by the consultants with some specific sections left unwritten. Experts were asked to fill these gaps. After the experts produced their sections, a completed first draft of the issues paper was dispatched to each person prior to the Expert Workshop. The issues paper contained a preliminary list of proposed key drivers and key uncertainties (based on the CIE Report and other analysis by the consultants) as well as brief descriptions of three potential future scenarios. (Annex D)

Description of expert workshop

The Expert Workshop was held in Canberra for a full day on 17 October 1997. The morning session was devoted to discussing the issues paper and identifying improvements that could be made.

The first part of the afternoon of the Expert Workshop, after an introduction to the principles and practice of scenario planning, was devoted to defining key drivers and key uncertainties for the future of irrigation and river health. In the second part, three scenarios were constructed in small workshops, based on the key drivers and a different selection of uncertainties (See Annex A for a detailed outline of the stages of the scenario planning process).

Outputs from expert workshop

The suggestions for improvement of the issues paper were a significant output from the Expert Workshop. The revised 'background paper' is reproduced as Annex B.

Another output was an enhanced understanding, and ownership, by the group attending the Expert Workshop, of the foresighting process. This was important as six of the ten participants in the Expert Workshop also attended the Stakeholder Workshop conducted later.

The specific outputs from the working session associated with identifying drivers, uncertainties and developing initial future scenarios are presented in Boxes 1 and 2 and Figure 1.

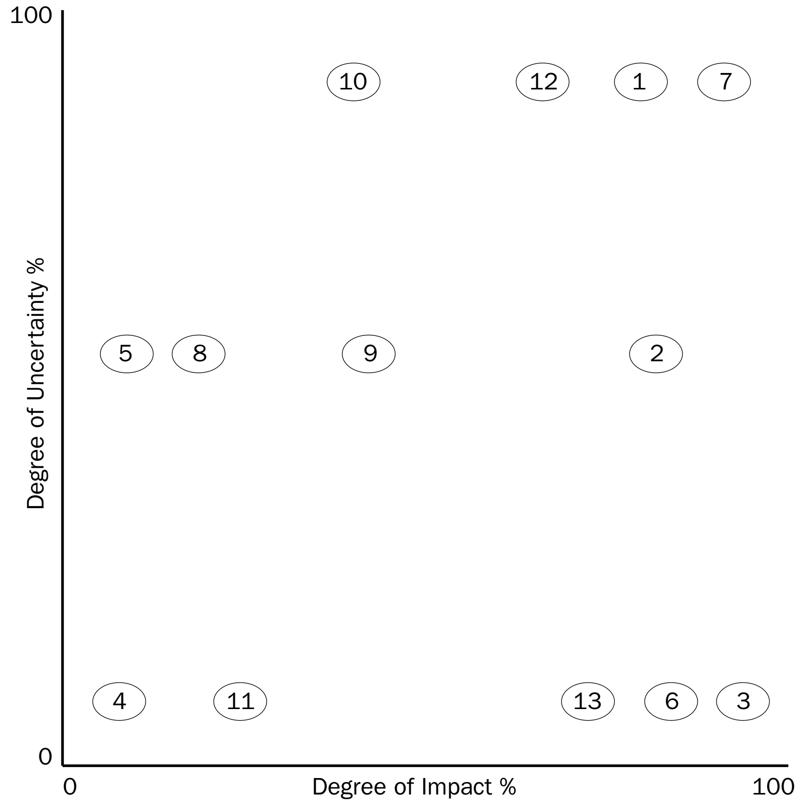
Box 1
Key drivers for 2025 futures for irrigation and river health

1. Derived demand for food and materials (global)
2. Derived demand for environmental goods
3. Demand for water—urban/industrial/agricultural/ecological/recreational/cultural
4. El Nino—’climate change’
5. Water ownership and price
6. Establishment of water markets
7. Knowledge—technical re production/environment
8. Limit to water resource available—spatial/temporal
9. Education—use of information/attitudes
10. Urban/ rural policy—regional development.
11. Devolution of power
12. Movement of people to rural areas
13. Limit to environmental tolerance

Box 2
Key uncertainties—influencing irrigation & river health in 2025

1. Water related human health hazard
2. Extent of significant climate change
3. Collapse of major water storage
4. Exotic disease outbreak in major trading partner
5. Regional conflict in Asia
6. Major trade embargo from greenhouse stance
7. Rapidly spreading exotic and aquatic pest or disease
8. Extent of control of chemical use in agriculture
9. Imposition of global carbon tax
10. Degree of tension—agricultural/rural/urban/regional
11. Collapse of integrated catchment management
12. Activity of green groups
13. Collapse of international capital system.

Figure 1
Assessment of degree of uncertainty and impact of key uncertainties



CHAPTER 3

Stakeholder workshop

Identification of stakeholders

Groups of stakeholders associated with sustainable irrigation and river health were identified through the earlier interest mapping exercise. The various groups that were identified included:

Irrigators

Commodity producers (cotton, rice, horticulture, dairying)

Personnel from environmental groups

R&D personnel in the areas of irrigation and river health

Water policy/water regulators/water managers

Irrigation scheme managers

Irrigation equipment manufacturers

Commonwealth and State Government representatives

Consultants

Economists

Media

Lists of stakeholders in each category were identified and telephone calls were made to invite stakeholders to the workshop and informing them of its date and venue. Vigorous efforts were made to persuade invitees to attend, or where not possible, to identify a suitable replacement. However, not all target groups were represented in the final workshop attendees. The target number of participants for the workshop was 30 to 40.

Preparation for the workshop

Participants at the workshop were sent about 10 days before the workshop

- the revised background paper, and
- material specially prepared for the workshop.

The material included the workshop program, background to foresighting, a list of key drivers and uncertainties, and three refined draft scenarios developed by the consultants from the outputs of the expert workshop. A copy of the material sent to the participants before the Stakeholder Workshop is included as Annex E. A list of participants attending the workshop is at Annex F.

Description of stakeholder workshop

The Stakeholder Workshop was held over one and a half days, with the first day commencing at 2 pm. There were 35 participants drawn from various backgrounds within the irrigation and river health areas. The background paper was introduced and participants were asked to identify the most useful purpose and role of the background paper. After an introduction to the foresighting process, there was one working session on the first day and three on the second day. Each of the four working sessions had the following purposes:

SESSION 1

A refinement of the three scenarios presented in the material sent to participants.

SESSION 2

Definition of the state of irrigation and river health in the year 2015 under each of the three scenarios.

SESSION 3

R&D needs and implications under each of the three scenarios

SESSION 4

Common R&D strategies that manifest themselves in each of the three scenarios.

The composition of working groups was constantly changed in order to ensure that the majority of participants worked with a range of people at the workshop as well as grappling with aspects of as many of the three future scenarios as possible.

Outputs from stakeholder workshop

The outputs from the Stakeholder workshop related to the four working sessions above.

The scenarios

On the basis of the operation of all the drivers and a selection of the uncertainties, three distinct scenarios were constructed:

Box 3
Real market rules

1. The demand for food production from 'clean' countries has soared, as the result of the 'Son of Chernobyl' disaster in eastern Europe in 2005, and the continuing fierce trade wars between the European Union and the USA. Australia suffered collateral damage, as the WTO proscribed all forms of subsidy, direct and indirect, for agricultural production.
2. A number of global food companies, together with major local investors, have made major investments in the development of 'greenfield' intensive food production sites, for both European and Asian markets. Factory processes dominate. The products are marketed as "uncontaminated by nature".
3. The growth of this new food industry was enormously stimulated by the 'National Service' system introduced in 2003 to tackle chronic youth unemployment and crime; all 17 year-olds not in employment or study are required to spend a year in 'learn to work' schemes. This has produced a vital cheap labour-force for the industry.
4. The water industry is dominated by a few global companies, along with a number of specialist niche players. The much-touted consortium of irrigators prospered for three years, but ran into capital access problems and was taken over.
5. Price is the sole mechanism for allocation of water. There has bee a considerable differentiation in the range of products, marked by differences in quality, quantity, and reliability of supply. Prices have increased to cover the capital costs of infrastructure upgrade, but been contained by a move to more flexible, lower cost systems.
6. Traditional irrigation areas have gone into major decline, at the same time as the new water-based production has developed. The economic and unemployment outcomes from these are regarded as so important that the environmental regulations operating elsewhere have been relaxed. Dramatically increased yields and value of products have been achieved. Major advances in 'smart' irrigation.
7. Minimal government regulation. Self-regulation through codes of practice. The international campaign against the economically damaging and self-serving arguments of middle-class 'greenies', has dramatically reduced their influence—they are seen as just another self-interested lobby group.
8. Recreational use of rivers, lakes and dams largely abandoned. Medieval pursuits such as duck shooting were banned in 2005, except for very expensive and tightly controlled 'game forests'. Water recreation centres, including virtual fishing, are widespread.

Box 4
Green is goodly

1. A combination of a devastating El Nino from 1997–2002, and a marked rise in variability and intensity of weather patterns led to a national and international reinforcement of environmental over economic values. Green parties swept to power, or held balance of power, in all Australian Governments.
2. A regime of strict regulation has emerged. The evident failure of 'market forces' to protect lives and property, let alone the more intrinsic values of nature, has led to a reduction in their influence. Government is seen as providing the only effective mechanism, and has grown substantially, largely funded through environmental levies and use charges, as opposed to the old income tax system. The commonwealth regulatory agency allocates water rights, and is responsible for monitoring, compliance and penalties.
3. Environmental costs are fully accounted for and internalised, leading to the removal of substantial acreage from agricultural production, and polluting industrial production has largely been closed down. However, the economy and employment have suffered only a small decline due to the emergence of the new 'green' industries.
4. 'Environ-management' is the catchword in the irrigation industry, which has reformed its practices to become an efficient and non-polluting water user, producing high value-added, largely horticultural products, for export. A high level of training is one requirement to get a licence as an irrigator. Ord is a boomtown, which since its establishment in 2001 has grown to a population of 350,000, and is a major tourist destination.
5. The viability of the Australian river systems has started to improve significantly, and is now starting to be compared to that of the good old days in the 1950s, when everyone swam in and picnicked by the rivers. Low impact water sports are booming, and Australia's clean waterways are a major attractor for foreign tourists.

Box 5
Bad is blue-green

1. Since the great El-Nino started in 1997, there was a dramatically increased frequency, distribution, and duration of algal blooms; all lowland rivers have blooms in most areas, and use of river water in the Murray–Darling Basin essentially ceased.
2. The causes are put down to slower moving rivers and prolonged periods of virtual zero flow. Climate change and ozone depletion are thought possible causes for outbreaks of previously unnoticed algae species which produce more virulent toxins. Epidemiological studies indicate increased human health problems indicative of algal toxicity and 'tap water' is no longer trusted. The threat, particularly in the public mind, was dramatically increased by the escape (or was it release?) from Gold Coast Campus of the State University of Queensland of a fatality gene researched for algal control.
3. All water-based activities suffered a serious decline. Commodity production and export plummeted, but was partly replaced by fibre and energy crops.
4. Urgent Government action led to extremely strict regulations about access to water sites, and relocation of riverside populations at high-risk. Real estate prices for waterside and canal-based properties plummeted, leading to a large re-emigration of Victorians from Queensland.
5. Rivers were regarded with fear and hostility. There was a massive education campaign (for some strange reason using bowling balls) to practice 'safe water use'. Practices were scrutinised to limit exposure to water.
6. Adelaide, with no access to the lower Murray, led the shift, of necessity, to a scarcity of water technology culture, though many residents, long accustomed to drinking the shower water, relocated. Large Commonwealth investment was required to manage the change, but was bought at a price—the amalgamation of SA and the NT into a Greater WA.
7. There was a shift in the focus of managing (and constructing) water storage from supply irrigation to the provision of flushing flows.
8. A totally new attitude to water was established in the community. Water usage was dramatically reduced. A new and influential sect emerged which worshipped water as the source of all life. And the international water market continued to grow, with the Snowy Mountain Scheme purchased by Chinese investors, as a source of "pure mountain water", now exported around the world.

State of, and R&D needs for, I&RH in 2015

Under each of these scenarios the state of irrigation and river health in 2015 (Box 6) and the R&D needs for irrigation and river health in 2015 (Box 7) were examined. These R&D needs were analysed to distinguish between the structural characteristics and those addressing thematic issues.

Box 6
State of irrigation & river health in 2015

1. **Market rules scenario**
   - state of rivers highly variable—some clean, some unhealthy
   - major 'Australian' global businesses active in water industry
   - a high level of irrigated food production in the Ord
   - substantial food production by hydroponics
   - high price of water leads to the collapse of intensive water-dependent food production
   - reduction in water consumption leads to cap being lifted by 2010
2. **Green is goodly**
   - in 1998 the cap is tightened to provide for environmental flows
   - an environmental tax (the 'green levy') is added to the Medicare levy; the funds are used to support a massive program of revegetation of catchments
   - polluting industrial products are banned from the river systems and agrichemicals are tightly regulated
   - levee banks are progressively removed ('let the floodplains be floodplains')
   - by 2005, a licence which includes a competency requirement is required to work with water
   - irrigation and private schemes collapsed under the tight water use regime and were taken over by central Government
   - a major relocation of irrigation activity to north-west Australia, but under a regime of 'environ-management'
   - the south-eastern river system has returned to the healthy state of the 1950s, with low impact water sports and recreation booming
   - green industries developed along the river systems, including fishing in the Murray; the clean waterways are a factor in the tourist boom.
3. **Bad is blue-green**
   - the water crisis led to a strong emphasis on flushing flows, which were also used to systematically reduce salinity along the river systems
   - the initial plan to plant 2 billion trees was expanded to 15 billion trees in 2010
   - inland rural areas are in substantial decline, and rural ghettos are formed, the growth in coastal population has produced a strong market for desalination, and non-water based sewage disposal.
   - there has been a major national investment in improved water treatment
   - a major resettlement program is established, with new regions being based on lower exploitation land and water use
   - new water rights trialed, but only for opportunistic harvesting
   - new industries have emerged in association with the tree planting exercise
   - developments are underway to harvest algae
   - boom in bottled drinking water, clean water food production, and clean water recreational centres

Box 7
R&D needs for irrigation & river health in 2015

1. Real market rules

a) Structural

- R&D mostly performed in private sector, on production and monitoring systems
- Government funding for public good research, contracted out through an open tender process; funder and provider separated
- Outputs and outcomes of public good investments reported regularly

b) Thematic

- Monitoring of inputs and outputs; biological/physical/chemical aspects
- Financial/economic policy—international, national, codes of practice, etc
- Quality auditing (claim verification)
- Water use—risk management, climate change
- Social issues eg. consequences of privatisation
- New crop development through genetic research and breeding programs
- Development of standards to manage new irrigation developments
- Environmental processes
- Waste management

2. Green is goodly

a) Structural

- Cap drives process—water audit underway
- Funding of public good R&D programs through green levy; scope for private industry to invest
- Increased collaboration between research providers
- R&D to define safe chemicals, sound chemical management practices, and chemical alternatives

b) Thematic

- New measurements and biophysical models—riparian, wetlands, floodplains, catchments
- Bioeconomic modelling—economic ecological changes
- Socio-economic/political research eg. to provide rational basis for cost-sharing, compensation, to design education and implementation programs, etc.
- Substantial R&D programs in water use efficiency—system analysis, plant requirements, application and re-use, soil/water/plant transpiration modelling, delivery efficiency, etc.

3. Bad is blue-green

a) Structural

- Evolution from 1998–2015, from crisis management, through central control, to a gradual and continuing deregulation;
- This is mirrored in a progressive shift from Commonwealth Government central control through multi-agency involvement, strategic alliance formation between key public and private sector players, and private sector and international investment.
- R&D is initially strongly focused on the tactical and short-term, but progressively shifts towards more strategic and long-term.
- Impact of algal toxins on human health
- Transmission of algal toxins through the food chain

b) *Thematic*

- Water treatment
- Algal bloom dynamics
- Water application optimising technology
- Management and effects of flushing flows
- Alternative dryland foodcrop and production sources
- Tree research—varieties, ecology
- Stream rehabilitation
- Environmental flows—riverine ecology
- Natural resource accounting
- Opportunist water based crops
- Market research for future viable industries
- Social/political research eg. translocation of populations, alternative regionalgovernance structures
- Systems research

R&D strategies for I&RH for LWRRDC

In addition the three groups were asked to develop R&D strategies for LWRRDC which were robust under all three strategies against seven proposed criteria:

- institutional structures
- financial resources
- human resources at sector, disciplinary, etc. level
- primary responsible agent—irrigation and river health sections of LWRRDC; LWRRDC as a whole; and beyond LWRRDC
- relative balance of basic research, strategic research, applied research, development, extension.
- balance of public versus private R&D funding and performance
- extent of networking/alliance formation

Group 1 response

- necessity to maintain public good R&D
- LWRRDC's key roles in facilitating support for and performance of public good research, central coordination of R&D, and strong networking to other RDCs and research groups, public and private
- flexibility the key since futures will change; focus on long-term outcomes, not short-term problems
- move more to participatory R&D and knowledge interchange with users to increase adoption
- capitalise more on existing knowledge, through better networks and alliances
- link existing knowledge into an ecosystem conceptual framework to identify unforeseen consequences
- improve ability to forecast outcomes and consequences of policy and management decisions
- refine techniques to identify where new technology will have the greatest benefit
- become proactive in R&D agenda setting by identifying preferred ecosystem characteristics
- address research base for social issues eg. natural resource accounting, trade-offs between economic and environmental aspects

- restructure education/extension/training to make it more user driven
- promotion of cooperation, collaboration and the public interest, versus competition and private interests

Group 2 response

The key to LWRRDC's performance is for it to be outcome driven, with a focus on delivery and implementation.

INSTITUTIONAL FRAME FOR RESEARCH

- ill-defined and rapidly changing; balance/conflict between public provision and market delivery
- LWRRDC as purchaser and broker for public good researcher, with some responsibility for client satisfaction
- need to achieve improved integration, through centralised or national R&D framework for natural resource management, development of models or tools (eg. catchment trials)
- need to achieve improved delivery, through integrating the findings arising from the considerable investment through LWRRDC across projects and programs
- need to develop a much stronger capacity in policy and socio-economic research, both individuals and teams

FINANCIAL RESOURCES

- needs expanding beyond small core funding from government plus direct stakeholder support, through a 'catchment water levy' on all consumed water (sharing a public good resource)
- develop regional funding while maintaining national level
- build alliances with Environment Australia, AFFA, and with commodity RDCs to jointly fund relevant projects

RESPONSIBLE AGENT

- need to build alliances across all boundaries, while maintaining unique role

BALANCE OF FUNDING

- variability and balance across issues needs to be retained

ALLIANCES/NETWORKS

- a fundamental role, which should be maintained and extended, particularly with MDBC (catchment-based interactive program)

EVALUATION OF PERFORMANCE

- ensure relationship with customers is healthy, partners need to be champions, build links between researchers and the community (engage the community as in Landcare?), make sure research delivers back into the system.

Group 3 response

- LWRRDC's key role is in facilitation and coordination—this should be increased with MDBC, commodity RDCs, CSIRO, other Govt agencies; a prescribed % of funds should be diverted from R&D projects to pursue this
- set target of all irrigators to change to BMP (or ISO 14000) and provide education/training support

- potential threat of lack of appropriate postgraduate skills in future—form partnership with appropriate education provider/government agencies, industry authorities
- key skill gaps—socio-economic/R&D interface, policy research, biological processes in rivers, environmental flows
- fundings needs to be expanded, through access to commodity R&D funds and a stronger, more united voice from the I/RH community—LWRRDC role?; in addition an equitable levy on all water users (the urban population should pay!)

From the analysis generated under the scenarios a list of 19 potential thematic priorities and 10 potential structural priorities over the twenty year period was produced. The validity and impact of these potential priorities and the constraints on their achievement were examined through a Delphi survey (Chapter 4).

CHAPTER 4

Assessment of impact and timing of key future developments in I&RH

Description of Delphi process

The Delphi survey is another foresight tool, relying on the independent polling of a wide group of interested people. It has been used principally in foresighting in recent years to establish and estimate the likely date of establishment of various technological developments, their likely impact, and the constraint upon their realisation. (For example, see U. Gupta and R. Clarke, 'Theory and Applications of the Delphi Technique: A Bibliography (1975–1994)', Technological Forecasting and Social Change, vol 53, pp 185–211, 1996).

Of the 35 participants, 18 returned a completed form; this response rate is well within the acceptable level for Delphi surveys, though the standard deviations for some responses are rather high. The distribution of the 18 respondents between I&RH reflected the overall makeup of the group, and hence no extra bias would appear to have been added. Hence the findings should be regarded as indicative, rather than statistically conclusive.

Delphi results

Results are presented in terms of the average estimate of the level of impact, the average year in which the event is likely to occur, and constraints on the event occurring. The workshop responses (Box 7, Chapter 3) were separated into thematic and structural categories.

Thematic events are concerned with research or policy themes or priorities, whereas structural events focus more on infrastructural capacity, such as skills and training, and are more associated with strategy development.

This technique has been adapted in this study as a means for establishing, in a more objective manner, the relative importance of the various thematic and structural developments and policies which emerged from the more qualitative scenario process. The survey distributed to all stakeholder participants is included at Annex G.

The detailed responses are assembled in Annex H.

Thematic developments and priorities

A general view of the data is that almost all thematic impacts were positive, and none were strongly negative. Occurrence dates were on average from seven to ten years ahead (with irrigation events being noticeably 'closer' than river health events), with a few exceptions of events to occur within five years—a comprehensive program on waterborne diseases by 2001, substantial R&D programs in water use and efficiency by 2002, and substantial R&D programs on revegetation and its effects by 2003.

In general S&T capability was rated as from good to average, with important variations. In contrast, innovation capacity, industrial capability, and environmental management capability generally varied from average to poor.

Three categories of constraint dominated responses—technological feasibility, which can be addressed through R&D, lack of funding support, which is open to government action, and economic viability—essentially a matter of costs and prices.

The 10 highest impact thematic events are listed in order of impact in Table 1. All had an impact between 1.1 and 1.5, which translates as an impact between very positive and moderately positive.

Table 1
Highest impact thematic 'events'

Event	Brief Event Description	Impact[a]	Standard Deviation	Occurrence	Current S&T Capability	Other Current Capability[b]	Constraints
14	Smart Irrigation	1.1 (I)	0.35	2004	Good	Average-good	Economic viability
4	Zero Water Pollution	1.1(RH)	0.35	2011	Average-good	Average	Economic viability Technological feasibility
17	Environmental flows and riverine ecology understood	1.2 (RH)	0.41	2007	Good	Average	Lack of funds
15	Understanding of Management and effects of flushing flows	1.3 (RH)	0.49	2006	Average	Average -Poor	Lack of funds
5	Comp. biophysical models for riparian systems	1.4 (RH)	0.51	2007	Good	Average -Poor	Lack of funds Technological feasibility
10	Substantial R&D programs in water use and efficiency	1.4 (I)	0.63	2001	Good	Good-Average	—
7	Comp. biophysical models for catchments	1.5 (RH)	0.52	2008	Good-Average	Poor-Average	Lack of funds Technological feasibility
6	Comp. biophysical models for wetlands & floodplains	1.5 (RH)	0.52	2008	Good-Average	Average	Lack of funds
16	Substantial R&D on revegetation	1.5 (RH)	0.52	2003	Good	Average	—
19	Preferred ecosystem characteristics agreed	1.5 (RH)	0.65	2007	Average	Poor	—

(a) The impact scale varied from 1= highly positive through to 3=neutral to 5=highly negative; I = Irrigation, RH= River Health.

(b) Other= Innovation, Industry and Environmental Management

The most notable finding is that of these high positive impact events, eight were in the area of river health, and only two in irrigation. The views emerging from the workshop scenario process and refined through the Delphi survey were that a greater impact of identified changes would be made on river health than on irrigation. A higher level of comparability of impact between irrigation and river health arises when the impact was rated as relatively low (greater than 2.0). This would suggest that river health research is still in a relatively immature of newly developing phase, where new R&D can make a significant impact. In contrast, irrigation is more mature and well-researched, and R&D is likely to have only incremental effects.

High impact thematic events which are seen as realisable in the medium term (2004–2008) are:

- event 14—the establishment of smart irrigation;
- event 17—environmental flows and riverine ecology substantially understood;
- event 15—flushing flows understood and managed;
- event 5—biophysical models established for riparian systems;
- event 10—substantial R&D programs in water use and efficiency.

In the longer term, waste management regulations delivering zero pollution (event 4), and biophysical models for catchment systems (event 7) and wetlands and floodplain systems (event 6) are achievable.

Closer analysis can be conducted of the impact, the realisation date, the infrastructural capability, and the constraints for each event, by consulting the full data analysis in Annex H.

Four events stood out as having contrasting impacts on irrigation and river health, in each case low for the former and high for the latter. These were:

- event 4—waste management regulations delivering zero pollution;
- event 16—substantial R&D program on revegetation;
- event 17—environmental flows and riverine ecology understood; and
- event 18—ecosystem theory sufficiently developed for predictive capability

Combining the impact scores (a rough measure of the combined impact on both irrigation and river health) produces the following ranking of high impact developments:

- event 14—smart irrigation as best practice (1.5 average impact);
- event 10—substantial R&D programs in water use and efficiency (1.6 average impact);
- event 1—effective management regimes for I&RH (1.7 average Impact);
- event 7—biophysical models for catchment systems (1.8 average impact)
- event 5—biophysical models for riparian systems (1.8 average impact)

Apart from the first two events this is a significantly different ranking from that of the single category impact list. One policy implication is that if the view is that priority should be given to achieving changes that have the maximum positive impact on both irrigation and river health, the priorities might be formulated from the above list. Alternatively, if the objective is to have the greatest impact, whether irrigation or river health, then the rankings in Table 1 should provide input to priorities.

Low **total** impact events (ie. developments which would be less attractive to pursue) included:

- event 12—commercial availability of desalination;
- event 13—establishment of an R&D program on waterborne diseases; and
- event 9—strong capability in socio-economic and policy research related to I&RH.

The last of these findings presents an interesting challenge, as the scenario process identified precisely this capability as crucial for addressing future challenges. This apparent anomaly, and its interpretation, will be explored further in Chapter 6.

Regardless, the combined processes of scenario planning and Delphi survey would appear to have produced an interesting basis for considering priority setting for future R&D—an outcome that was beyond the terms of reference of this project.

Structural developments and priorities

Table 2 presents data concerning the top four structural impact events, with an impact factor up to 1.7.

Table 2
Highest impact structural 'events'

Event	Description	Impact[a]	Standard Deviation	Occurrence	Constraints
26	flushing flows established	1.4 (RH)	0.50	2005	Economic viability
20	natural resource accounting in use	1.6 (RH)	0.93	2005	Social/env acceptability Reg/policy standards
21	water levy established	1.7 (RH)	0.51	2004	Social/env acceptability Reg/policy standards
22	substantial R&D funding from commodity RDCs	1.7 (I)	0.61	2004	—

(a) The impact scale varied from 1= highly positive through to 3=neutral to 5=highly negative; I = Irrigation, RH= River Health.

Again the predominant emphasis is on river health. The top two of the top four impacts are associated with river health while the other two are concerned with both irrigation and river health. The only substantial negative impact was associated with the proposition of the majority of irrigated production being relocated to north-western Australia—an understandable response from the stakeholders with interests in existing south-eastern irrigation areas.

In general, structural events were seen as being realised sooner than thematic events, perhaps reflecting the time horizon of structural, and ultimately political, investments. Constraints varied, and hence there is a need to examine each event separately; however the major constraints, somewhat different from those applying to thematic events, were social/environmental acceptability, regulatory/policy standards, and economic viability. Clearly, structural events are seen as being much more constrained by the processes and forces of government.

Evaluation

Methods

Both process and content outcomes were systematically evaluated throughout the various stages of the foresight project. In addition to eliciting feedback through telephone and face-to-face discussions with experts and stakeholders, and regular telephone contact with members of the Steering Committee, a series of formal evaluation procedures were applied at various stages throughout the foresighting process. As well as providing feedback on the overall exercise, the evaluation material provided valuable content for use and validation of other material used in the development of strategies for LWRRDC.

These formal evaluation procedures were:

1. Identification of key issues, major drivers and possible futures of irrigation and river health, and expectations of the workshop, by experts prior to the workshop;
2. Evaluation of, and amendments to, background paper;
3. Identification of changes in views of experts at end of workshop;
4. Evaluation of process by experts at end of workshop;
5. Identification of the most important areas of R&D for irrigation and river health (I&RH) by stakeholders prior to the workshop;
6. The key elements of a strategy to promote appropriate R&D to support I&RH over the next 20 years;
7. Evaluation of foresight process and quality of outcomes, by stakeholders at the end of the workshop;
8. Evaluation of, and amendments to, summary report of workshop.

Results of evaluation exercises

Pre-workshop expert views

The Expert Workshop participants were asked first to project some newspaper headlines addressing I&RH issues in 2010. This was designed primarily to assist people to move away from the constraints of the present. Responses included:

"Water quality in dramatic decline"

"Record price paid for water entitlement"

"Community in uproar over inadequate river flows"

"Irrigation industry in south-east in progressive decline"

"Irrigated production up by 30%, leading export drive"

"Water wars erupt over competition for scarce water"

These 'headlines' reveal a strong concern about the future economic and environmental viability of the water system in Australia. They are also fairly predictable from present knowledge.

Key issues for I&RH to 2010 were identified, in the following ranked order:

1. Increasing competition for water between irrigation, environmental needs, and urban demands.
2. Environmental flows.
3. Declining water quality.

4. Increased efficiency of water use.
5. Increasingly environmentally sensitive irrigation methods and practices.

Other, more specific issues that rated a mention included river planning, ecologically sustainable development (ESD) for new irrigation developments, rehabilitation of 'old' irrigation developments, dryland salinity management, nutrient management, declining biodiversity, and increased cooperation between the different sectors.

The **major driver of I&RH to 2010** was identified as community attitudes towards water quality and river health, and the trade-off that emerges between economic and environmental values. Other major drivers are water price, particularly in a regime of 'user pays', climate change, and the removal of impediments to the trade of water.

Expectations of the workshop were, in descending frequency:

1. Identifying/developing appropriate scenarios of the future of I&RH.
2. Establishing the implications for appropriate R&D programs.
3. Revision of the issues paper.
4. Learning from and influencing the foresight process.
5. Highlighting the links between I&RH.

Evaluation of the issues paper

The discussion provided varying views about the purpose and title of the issues paper. Comments in this regard are reported in the responses to Question 7 given later in this chapter. The most important change arising from the Expert Workshop was to integrate the discussion of common issues between irrigation and river health and group all issues into four categories:

- Water quantity and water use
- Water quality
- Condition of riparian vegetation
- Incidence of foreign biota

Other useful suggestions applied in the final draft were to give more emphasis to a state-response framework, entitle the paper a 'background paper' rather than an 'issues paper', and the inclusion of a diagram relating the various issues.

Changes in expert's views at workshop end

At the end of the workshop, participants were asked to identify changes in their views that had emerged as a result of the day's process.

Six **new key issues** were identified:

1. Transformation of the water system through restoration of river flow regimes, reduced pollution by nutrients, pesticides and sediment, rehabilitation of riparian vegetation, improved efficiency of irrigation, more appropriate crop species, and a reconstruction of the irrigation industry.
2. Mechanisms to internalise externalities.
3. The threat of exotic biota, whether pests or diseases, with possible human health implications.
4. International environmental regulation.
5. The cost of infrastructure maintenance, repair and development, and who pays.
6. Private ownership of water (water as a global industry).

Only one substantially new **driver** emerged: irrigation-based development of north-western Australia.

Evaluation of workshop process and outcomes

Participants in the expert workshop were also asked to evaluate the workshop process and the outcomes achieved. There was a universally positive view of the process, with regard to both the scenario development and the preliminary consideration of implications for R&D. A representative comment was "broadened my appreciation of the array of factors that could influence I&RH into the future".

The only concerns were about the extent to which economic values appeared to dominate social values, the challenge of achieving consensus on key drivers from such a diverse array of experts, and an expression of relief that "it was good to see some R&D directions appearing at the end of the process, as it was not obvious we were going to get to this as you go through".

The other major class of comment emphasised that the process had provided a very valuable "bridge" between irrigation issues and river health issues, and the importance of considering key issues as they affect both components.

Identification of the most important areas for R&D on I&RH

In order to provide a benchmark of stakeholder views of the most important areas for R&D on I&RH over the next twenty years, participants were asked to list these prior to the workshop.

The most common views and their frequencies are presented in Table 3. This table shows that environmental flows, water use efficiency and water quality requirements are seen as the most important thematic areas for research and development and extension.

Table 3

R&D area	Frequency
Environmental flows (requirements, ecosystem resilience, effect of river regulation).	14
Water use efficiency	10
Water quality requirements, effects of nutrients and chemicals, minimising exports off farm	10
Water availability and allocation including security	4
Wastewater use	3
Policy and regulatory frameworks (effectiveness, analytical)	3
Habitat investigations (availability, protection, processes affecting habitat)	3
Rising watertables and salinity in irrigation districts (managing, reducing accessions, defining regional limits)	3
Sustainability and ESD principles	3

Identification of key elements of a strategy to promote appropriate R&D to support I&RH

In a similar way, stakeholders were asked to identify, prior to the workshop, key elements of an appropriate strategy. Table 4 shows that by far the most important element is the improvement of communication with and participation of all relevant stakeholders in direction setting.

Table 4

Key elements of strategies	Frequency
Improvement of communication with and participation of all relevant stakeholders in direction setting	16
Establish a recognition of the financial interaction between river health and irrigation	7
Establish higher levels of coordination between relevant R&D supporting and performing organisations in priority setting for and funding of irrigation and river health-related R&D	7
More effective and widespread application of existing knowledge	6
Establishing an improved funding base for irrigation and river health related R&D	6
Improve public awareness about the value of water and water-assisted commercial activity	4
Engage in more systematic planning for the future of irrigation and river health	4

Evaluation of foresight process and quality of outcomes by stakeholders at the end of the workshop

Question 1: Overall view of foresighting process

Comments	Frequency
Strongly positive view—(thought provoking, stimulating, mind stretching; gives a process that allows ideas to come out without threat, removes the politics of the development of new directions)	6
Moderately positive view—(interesting, time restricted more positive outcome, low energy levels at end, difficult to get away from present and into future)	4
Overall negative view—(not successful as insufficient time (2), participants had difficulty in placing themselves in future (2))	4
Process modification comments	2
Total	16

On this basis, at least ten of the sixteen stakeholders who completed the evaluation found the foresight process to be of value, and to provide ideas and insights not readily available by other means.

Question 2: Process outcomes and content outcomes

Comment	Frequency
Positive content outcome only (R&D areas, importance of facilitation and coordination, ideas for R&D strategies, identifying common strategy elements, framework for R&D strategy, identification of threats, funding deficiency)	9
Positive process outcome only (wide view encouraged, awareness of possible futures, different approach to setting priorities, working outside existing views of world, exploring new areas of thinking, networking, understanding of method)	7
Limited process outcome (perceptions hard to change)	1
Positive content outcome (identification of broad strategy areas, identification of R&D areas) plus positive process outcomes (improved understanding of LWRRDC relevance, expansion of horizons)	2
Total	19

Most respondents focused on either process or content outcomes, though they were asked to identify both. This presumably reflects their prime interest. Overall, outcomes were rated almost unanimously as positive.

Question 3: Usefulness for setting research priorities in future

Comment	Frequency
Yes (hold at five yearly intervals, hold along similar lines to current workshop, use at program level, use same group rather than experts and stakeholders; yes, because all the ideas can be put in; lets preconceptions be challenged without initial commitment; yes, by examining potential different patterns and common concerns of a range of stakeholders)	10
No (only useful for setting strategies)	1
Limited (only sets the scene, need more coaching with the process, need more visionary approach, need other priority setting approaches also, use smaller group for priorities)	5
Total	16

Note: Responses to Question 3 may have varied between those that interpreted the question to mean could the foresighting process 'in the same workshop' result in prioritising R&D areas versus another interpretation which was could the process be used in an additional exercise

Hence, the value of the foresight approach for priority setting was broadly supported, but for some it may be more appropriate in providing the framework and possibilities, with priority setting following by a more traditional method.

Question 4: Did the process lead to priorities different from those expected?

Comment	Frequency
Positive content outcome only (R&D areas, importance of facilitation and coordination, ideas for R&D strategies, identifying common strategy elements, framework for R&D strategy, identification of threats, funding deficiency)	9
Significantly different (some priorities specific to river health were new, no priorities on biophysical sustainability of irrigation emerged, emphasis on socioeconomic and public policy research was new, emphasis on changed water use and integrated environmental management was new, socio-economic factors in adapting to social change and water quality monitoring were new)	6
Not significantly different	8
Other (not really but socioeconomic framework was new, priorities similar but strategies were different)	3
Total	17

These findings support the view that the foresight process both enables existing ideas to be tested, and provides for the generation of some new ideas.

Question 5: Strategies different from those identified at beginning

Comment	Frequency
Significantly different (more R&D bodies involved in setting research agenda, greater emphasis on coordination and facilitation, reinforced need for LWRRDC, strategy to promote collaboration, involvement of key stakeholders, importance of extension and evaluation)	8
Not significantly different (envisaged more vision, similar to current LWRRDC strategy, exception was levy raising issue)	6
Other (no solution on how to achieve integration, similar strategies emerged but confirmation via a different route was encouraging)	2
Total	16

These comments demonstrate that at least 8 of the 16 respondents believed that the strategies emerging from the process were different to those held beforehand and that the strategy development emerging from the process was perhaps more important than the priorities.

Question 6: More effective application of foresight to set R&D priorities

Comment	Frequency
Need to focus on specific R&D areas	1
Better testing for reality and need to follow through	1
Broader and wider regional coverage by participants	1
Allow more time	1
More quantitative information about the future	1
More focus	1
Allow groups to rewrite their own scenarios	1
More debate on different factors that underpin the scenarios	1
Choose participants familiar with process	1
Keep focus on believable scenarios	1
Use same team for whole process	1
More structure to balancing scenario priorities and building R&D strategy	1
More detailed approach to priorities at end	1
Scenarios too prescriptive at end — could have involved expert group more	1
Difficult for some people to 'get into' scenarios	1
Total	15

The responses to this question cover a very wide range of suggested improvements to the application of scenario planning to R&D priority-setting. Most could be encompassed in minor revisions to logistics. A key tension appears to be between having sufficient time for the process, and attracting the engagement of busy people.

Question 7: Comments on background paper

Comment	Frequency
Positive content outcome only (R&D areas, importance of facilitation and coordination, ideas for R&D strategies, identifying common strategy elements, framework for R&D strategy, identification of threats, funding deficiency)	9
Positive (pretty fair summary of issues, good stimulus, very good, generally OK, good resource document, good overview and easy to read, covers lots of the issues, clear concise and readable, job well done)	10
Reserved (needed to be more confrontational and challenging, useful content and structure but diagram not used effectively in process and not clear how paper related to the exercise)	2
Negative (did not get it before workshop, information was too general, value limited as participants come with own biases)	3
Total	15

Overall the background paper was received favourably but the role of the background paper, and therefore its content, and how the information contained is used in the process, could be further developed.

Evaluation of summary report of workshop

A small number of participants in the stakeholder workshop, largely experts, provided comments on the summary paper. Most found it an accurate and effective record of the Workshop, and two identified some omissions.

Areas for possible improvement in the application of scenario planning

- The 'Issues Paper' was designed to provide all stakeholders at the Workshop, with their varying expertise and interests, with a common understanding of the "technical facts". Such a report, which has proved valuable and unproblematic in exercises involving a very wide and varied range of people, presented more of a challenge to the relative experts involved in this exercise, who sought to modify and refine various elements. The title 'Issues Paper' also presented some difficulties, in that it was interpreted as a definitive treatment of key issues. The title 'Background Paper' should be preferred in future, and the purpose of the paper precisely defined and communicated.
- The Background Paper was intended largely as a resource. However, in practice not all participants had read the paper and it was not actively used as a resource during the Stakeholder Workshop. The consultants intentionally avoided extensive reference to the paper at the beginning of the workshop, to avoid the possibility of extensive discussion based on its precise accuracy, for which there was no time, nor would have contributed positively to (and may have seriously disrupted) the foresight process. Nevertheless, a means to more effectively integrate the background paper into the workshop processes would be appropriate.
- The appropriate time to commit to scenario development and subsequent strategic planning is always a matter of some difficulty. If the process is too long, participants and organisations are unwilling to commit their resources. On the other hand, participants often find the day-and-a-half allocated to this workshop, both for fully developing and 'owning' the scenarios, and to develop strategic outcomes, inadequate. In particular, given the problem of addressing R&D strategies at the end of a demanding day, the most appropriate model for a scenario workshop might well be:
  - Introduction to scenario planning and preliminary scenario construction—half day
  - Scenario development, background document review and strategy development—1 day
  - Strategy refinement—half day
- There may be potential merit in attempting to link scenarios developed at the Expert Workshop to those at the Stakeholder Workshop. For example, the Expert Workshop could have developed a series of futures, which could have been grouped as to their similarity and representative scenarios developed. The representative scenarios could have been used as the starting points at the Stakeholder Workshop, where they would be refined further.

CHAPTER 6

Implications for an R&D strategy for LWRRDC

Implications of the scenarios for changes in the approach to sustainable management of irrigation and river health

The elements of the three scenarios constructed in this project (Chapter 3, Boxes 3–5), reflected, respectively, a dominance of market forces, a strong environmental concern, and emergence of a perceived waterborne human health hazard together with the state of I&RH identified under these scenarios to 2015 (Chapter 3, Box 6), they raise a number of implications for the most appropriate approach to sustainable management of these resources.

These include:

- the need to allow for sudden and dramatic changes in the water supply and use system;
- the possibility of the water industry moving into private ownership, with consequent exposure to market forces and globalisation;
- a substantial relocation and restructuring of irrigated agricultural production in Australia;
- emphasis on horticultural production from irrigated areas
- the development of much more water efficient irrigation processes and plants;
- community and hence political pressure to restore rivers and water systems to "their natural state";
- the increasing use of "flushing flows";
- intense competition for water between irrigation (or food production), urban demands and environmental needs (and desires);
- declining water quality;
- a salinity crisis; and
- the emergence of a waterborne human health scare.

Strategies for the future management of LWRRDC's I&RH programs

From the workshop processes and the responses produced, and in particular the strategies that the workshop groups developed designed to be robust under all three scenarios (see 'R&D Strategies for I&RH for LWRRDC' on page 13), six key generic elements of an R&D strategy for LWRRDC were derived by the consultants and included in the Workshop Summary Report.

These six elements encompassed the various suggestions made by stakeholders prior to the Workshop (see 'Results of Evaluation Exercises' on pages 20–25), as it turned out. However, they are much more than a simple repetition of views already held. New components were identified, a new level of importance or emphasis was placed on a number of elements, and a much stronger consensus emerged as to what were the crucial components.

The **six key generic elements of the R&D strategy** that emerged from the workshop were:

1. **The key roles of LWRRDC are as a purchaser and broker for public good research, central coordination of R&D and facilitation of strong networking between other research producers and users, both public and private.**

   This element compared closely with the by far most frequently identified key element of strategy prior to the Workshop: "Improvement of communication with and participation of all relevant stakeholders in direction setting". There was almost universal agreement that LWRRDC was the appropriate body to have responsibility for addressing the major challenges of I&RH (this at a time when the future of the organisation was under threat as a consequence of the recommendations of the Mortimer Report).

   But there is a need for LWRRDC to show stronger visible leadership, and to seek to shape the environment for transforming irrigation and river health. This foresight exercise, to the extent it brought together representatives of communities who might not commonly join to address such issues, was seen as an example to be followed.

2. **Given the uncertainty over, and the ill-defined and rapidly changing nature of the irrigation-river health dynamics and context, and the continuing tension between public provision and market delivery, it is essential that LWRRDC combine structural and program flexibility with a focus on long-term outcomes.**

   The scenario planning exercise itself emphasised the need to address uncertainty and rapid change. The appropriate stance, and strategy for LWRRDC, under these circumstances, is to combine a focus on the longer term future, with the delivery of applicable knowledge and procedures through highly flexible mechanisms, capable of rapid re-focussing given the emergence of new information and issues.

3. **It is essential to expand the resource base for irrigation and river health R&D through encouraging a more united voice from the irrigation and river health community, developing access to commodity R&D funds, building alliances with other users and research funders and developing the arguments for a broadly based levy on all water users.**

   It was considered crucial that the constituency and resources to support I&RH R&D and implementation be substantially broadened beyond those that have been traditionally associated with LWRRDC. This should be pursued firstly by encouraging and leading the irrigation and the river health communities to recognise their interdependencies and common cause, and to develop and promulgate a common message.

   Secondly, LWRRDC should build stronger linkages with researchers in fields currently peripheral to I&RH, but which might have considerable potential. A prime example was biology and medical researchers in the area of waterborne human health hazards.

   Thirdly, LWRRDC could pursue more vigorously the engagement of the commodity R&D Corporations in collaborative R&D on issues of shared interest, and to develop a powerful rationale for the introduction of a water use levy, part of which could flow to support relevant R&D.

   The increased funding of commodity R&D corporations for irrigation and river health R&D was also rated as a very high impact structural development by the Delphi survey, with a realisation date of 2004.

4. **Emphasis needs to be placed on building much stronger linkages with customers, both through providing access to existing knowledge and new R&D results through better networks and a higher level of participatory R&D. This may require support for the integration of findings across a range of projects or fields to make them more accessible.**

   While the generation of new knowledge will remain important, the greatest improvement in the state of I&RH, and the development of the capability to deal with future problems, is seen as being achieved through the better application of existing knowledge, techniques and practices. This emphasis was reflected in concerns over skill levels (see below), and in the possibility of "a qualification with a competency component is necessary to obtain a water allocation/licence" (Delphi 'event' No 27).

   This element of the strategy is also reflected in the relative supporting capabilities reported in the Delphi survey (Chapter 4). While S&T capability was rated as from good to average, innovation capacity, and industrial and environmental management capability ranged from average to poor. The greatest improvement therefore may be achieved by addressing the areas of education and management, rather than R&D in the narrow sense.

5. **Develop and facilitate a stronger capacity in policy and socio-economic research in order to address a wide range of social issues which underlie economic and environmental aspects of irrigation and river health.**

   The scenario process identified precisely this capability as crucial for addressing the many socio-economic and policy issues facing the future of I&RH; indeed, the future problems were seen as being far more socio-economic than technological—an area in which LWRRDC has not invested to any great extent.

   Interestingly, when tested in the Delphi survey, it was ranked about 20th of 38 possible events, in terms of impact, and was seen as affecting both irrigation and river health to a similar extent. Apparently, when it came to ranking developments, the generally highly valued shift in emphasis towards socio-economic factors in group discussion was scored lower than other technological and scientific developments on an individual basis.

6. **Develop a capability to analyse the skill availability across all fields relevant to irrigation and river health to identify gaps to ensure that user perspectives are taken account of and where appropriate to broker appropriate supply arrangements.**

   There was a general concern to support the development of an appropriate skill base, as commented on above.

Reverse history analysis

The following provides a chronological account of some of the events associated with the three scenarios. The associated R&D area and the expected timing of these events gives some measure of priority and urgency that LWRRDC might want to attribute to each area in the development of its future R&D program.

2015+ **Event 28** The majority of irrigated production is located in north-west Australia.

- That the majority of irrigated production being relocated to the north-west Australia did not occur for such a long period of time may reflect a mixture of the relatively slow speed in which such industries are changed in major ways and also a recognition of the economic/commercial and inevitably political limitations on such a shift.

2012 **Event 12** Desalination has become a commercial product.

- The time span of 15 years for the commercialisation of desalinisation represents a realistic assessment of the time period taken for a new technology to come into regular use; nevertheless developing a preliminary research capability to assess and comprehend developments in desalinisation may well be appropriate for LWRRDC and would need to have been initiated some ten years previously.

2011 **Event 2** Climate change dynamics understood and effects confidently predicted.

Event 4 Waste management regulations require, and achieve, zero water pollution.

Event 25 Majority of R&D on I&RH conducted in the private sector.

- The understanding of climate change dynamics is based on a continuing intensive period of research over the past 20 years where LWRRDC became involved in supporting those elements which apply particularly to I&RH.
- The progressive introduction and tightening of waste management regulations and a strong program of research to reduce run-off and contamination of water from agricultural use led to the achievement of zero water pollution by 2011.
- At the same time the outsourcing of both R&D and the management of issues of I&RH has led to the majority of this R&D being conducted by the private sector.

2010 **Event 18** Ecosystem conceptual framework sufficiently developed to allow accurate identification of 'unforeseen' consequences.

- This development was based on fundamental research over a period of 10 to 15 years.

2008 **Event 3** New low water use crops are on the market.

	Event 6	Comprehensive biophysical models, and supporting data are established for wetlands and floodplains systems.
	Event 7	Comprehensive biophysical models, and supporting data are established for catchment systems.
	Event 8	There is a comprehensive program of bio-economic modelling, addressing economic and ecological aspects.
	Event 11	The technology of water treatment allows total purification.
	Event 23	Legislation passed to require all irrigators to move towards MBP or ISO 14000.
	Event 27	A qualification with a competency component is necessary to obtain a water allocation/licence.
	Event 5	Comprehensive biophysical models, and supporting data are established for riparian systems.
	Event 17	Environmental flows and riverine ecology are substantially understood.

- 2008, 10 years on from the scenario exercises, was the most frequent estimate of when events would be realised. That new low water use crops are on the market reflects a long period of investment in genetic and other research to develop these new plant types.
- The patient investment in fundamental and strategic R&D has paid off with the development of a dramatically improved understanding and management capability for IR&H in the period 2006–2008; these include the achievement of comprehensive biophysical models and supporting data for wetlands and floodplain systems, for riparian systems (in 2007), for catchment systems, for bio-economic models addressing economic and ecological aspects, for identifying preferred ecosystem characteristics, and for flushing flows.
- The achievement of technology of water treatment allowing total water purification is rested primarily on major technological developments occurring overseas, but LWWRDC played a useful watching role in assessing the development of this technology and bringing it to the attention of potential users. In addition structural changes to improve the quality and performance of irrigation has led to the requirement for ISO 14000 and a new level of competency in water management.

2007	**Event 19**	Preferred ecosystem characteristics identified and agreed.
2006	**Event 15**	An understanding has been developed about the management and effects of flushing flows.
2005	**Event 1**	Effective risk management regimes established for I&RH.
	Event 9	There is a strong program and capability in socio-economic and policy research related to I&RH.

	Event 20	Natural resource accounting developed and in use to decide trade-offs between economic and environmental goals.
	Event 26	Flushing flows are an established component of river health management.

- Establishment of effective risk management regimes reflects the significant program of R&D on risk management strategies supported by LWRRDC.
- The investment in broadening LWRRDC's R&D focus from primarily technological issues to wider socio-economic and policy research issues led to a strong capability by 2005.
- Development of natural resource accounting required an intensive effort primarily involving agricultural and environmental economists in the period 1998–2005.
- The achievement of flushing flows as an established component of river health management, and an understanding of their effects achieved in 2005–2006, was based on an extensive campaign of education, awareness raising and attitude change overseen by LWRRDC.

2004	**Event 14**	'Smart' irrigation has been established as best practice.
	Event 21	Water levy established, part of which funds flow to R&D.
	Event 22	Substantial R&D funding from commodity RDCs to irrigation and river health (I&RH).
	Event 24	Significant postgraduate training capability in I&RH established.

- Introduction of smart irrigation was primarily based on technologies developed overseas, but an effective program of technology evaluation and application assessment conducted by LWRRDC was crucial in its rapid adoption in Australia.
- The campaign by LWRRDC and others to increase awareness and concern about the state of water systems in Australia led to the acceptance of the introduction of a water levy, part of which funds R&D, as well as providing the basis for an increased commitment of funding from the commodity R&D corporations to I&RH issues.
- As part of this development a significant postgraduate training capability has been established in a small number of universities.

2003	**Event 16**	There is a substantial R&D program on revegetation and its effects.
	Event 29	LWWRDC has established its role as a recognised national leader, coordinator and integrator of a total irrigation and river health R&D effort.

- LWRRDC committed significant resources to establishing an R&D program on revegetation in the late 1990s.
- As part of its commitment to achieve a higher profile in matters of I&RH and publicising them to a wider community and governments, LWRRDC is now recognised as the national leader in matters of I&RH, which are seen as crucial to the future of the nation.

2002	**Event 10**	There are substantial R&D programs in water use and efficiency. • LWRRDC's program in water use and efficiency R&D were strengthened significantly over the period 1998–2002 and significant progress has been made.
2001	**Event 13**	A comprehensive R&D program on waterborne diseases and pests is established. • Through collaboration with the National Health and Medical Research Council, and in response to increasing concern by water suppliers, a comprehensive R&D program on waterborne diseases and pests was established.

Research and policy areas of importance

The identification of R&D priorities was not a primary objective of the foresighting exercise. However, a number of R&D areas of importance have emerged as a result of the various processes undertaken within the study.

Firstly, the three strong thematic priorities identified by stakeholders prior to the Workshop were environmental flows, water use efficiency, and water quality improvement (Table 3).

Secondly, the Delphi survey (Chapter 4) has rated the broader list of thematic developments which emerged from the workshop, in terms of impact, proximity (date of occurrence) and constraints. While no precise ranking, and hence strict priorities could be established, these data (Table 1) show a somewhat similar, but also different emphasis. The top four developments, in terms of impact, are smart irrigation, zero water pollution (but not to be achieved until 2011), environmental flows and riverine ecology understood, and management and effects of flushing flows understood. It may be appropriate for LWRRDC to assess its current priorities against the full set of thematic priorities assessed by the Delphi survey.

While the top priority was related to an irrigation impact, it was reported in Chapter 4 that eight of the 10 largest impacts were in the river health area. If the likelihood of events occurring are related to R&D input, then the river health R&D area might be considered a more fruitful area of R&D than that associated with irrigation. If this implication is pursued, one explanation could be that irrigation R&D is in a more mature phase than river health R&D where the marginal returns to further investment may be higher (the S curve theory). This may be relevant if the river health R&D is as feasible as irrigation R&D and can produce results that lead to the high impact events.

However, it was obvious from 'Thematic Developments and Priorities' (see page 16) that some events and associated R&D areas of investment would have significant impacts on both irrigation and river health. Any exercise in assessing the relative investment in the two areas would necessitate some subjective valuation of the relative worth of outcomes relating to each area of irrigation and river health. This tradeoff and how it is handled was seen as one of the key drivers for the future of irrigation and river health in the Expert Workshop.

There was strong support at the Expert Workshop for LWRRDC's decision to consider both irrigation and river health together in the foresighting exercise. The foresighting process as conducted highlighted the interactions between the two areas and some participants reported benefits from the interfacing of the two R&D areas. However, no direction developed from the integration for LWRRDC to merge the two programs in any way. Accountability to different 'industries' in each area and the politics and mechanics of funding would work against any combined program.

It might have been concluded from the outcomes of the exercise that policy areas relating to irrigation and river health were somewhat neglected in comparison with R&D policies, strategies and priorities, except for a high priority given to socioeconomic and policy R&D. This relative stress was more likely related to the exercise having an R&D rather than policy focus since the exercise was sponsored by LWRRDC. Also, the composition of the participant types in both workshops probably had a bias in relation to R&D compared with policy. The issues of R&D versus education, integration of information, and participative R&D were all raised but the difficulty of how science could integrate with policy, and the factors affecting changes in government policies required for various futures were given less coverage. These areas may have been considered too difficult, or fruitless.

Although several scenarios mentioned increased irrigation in northern Australia, there was little emphasis in the Stakeholder Workshop on the relative irrigation and river health priorities between the north and the south. This was interesting given that the Expert Workshop participants considered the massive size of the water resources in the north and the difference in current development between north and south river systems to be of considerable importance. This may have reflected the make-up of the Stakeholder Workshop participants, or perhaps the conflict between irrigation and river health in the north is not considered a threat by the experts present.

LWRRDC could consider strengthening linkages with RIRDC's new plant products program in relation to crop and new industry waster use. Linkages with other R&D corporations to ascertain whether any coordination/facilitation is required in relation to the various efforts aimed at developing new plants with water use efficiency characteristics (eg. breeding program synergies etc) could also be pursued.

In summary, the essence of the strategies for LWRRDC emanating from this foresighting exercise are captured in the six elements presented on page 28. These were:

- Develop a stronger national leadership role in coordination of R&D and networking and search for improved mechanisms to achieve these ends.
- Maintain program flexibility with a focus on long-term outcomes.
- Pursue more secure funding for irrigation and river health particularly through the continued advocacy to industry of a water related levy on water users and convincing industry and commodity R&D corporations to allocate more monies to irrigation and river health R&D.
- Continue to advocate participative (involving users) research, encourage greater emphasis on integration of findings from all R&D efforts and ensure that education and management aspects regarding the use of knowledge are not neglected.
- Develop and facilitate a stronger capacity in policy and socio-economic R&D
- Develop and promote necessary availability of skills.

Abbreviations

ACIIC	Australian Centre for Innovation and International Competitiveness Ltd
BMP	Best Management Practice
CIE	Centre for International Economics
AFFA	Agriculture Fisheries and Forestry—Australia
ESD	Ecologically Sustainable Development
I&RH	Irrigation and River Health
LWRRDC	Land and Water Resources Research and Development Corporation
MDBC	Murray–Darling Basin Commission
NH&MRC	National Health and Medical Research Council
R&D	Research and Development
RDCs	Research and Development corporations
RH	River Health
S&T	Science and Technology

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Important aspects of foresighting

What is scenario planning-based foresight?

Scenarios are not about predicting the future; rather they are about perceiving the future in the present (Schwartz, P., The Art of the Long View)

That **foresight is not an exercise in forecasting cannot be over-emphasised**. Rather, it is a mechanism for visioning possible futures, and for managing in the face of the unavoidable uncertainty.

On the basis of a range of foresight studies, the following generalisations have emerged:

What are scenarios?

- scenarios are coherent pictures of alternative futures;
- scenarios are not predictions or forecasts of the future, nor are they science fiction stories;
- scenarios are stories about the future which comprise a number of plots which bind together the elements of the scenario;
- plots within a scenario are based on the key variables and critical uncertainties in the organisation's external environment; and
- in good scenarios, plot lines intercept.

Scenarios address:

- issues trends and events in the current environment that are of concern to the organisation's decision-makers;
- elements in the environment that are determinable and somewhat predictable—pre-determined events or variables; and
- elements in the environment that are more uncertain, trend breakers that affect a system in unpredictable ways, but with understandable dynamics—turning points in the business, political or social environment, identifiable in the present, though often as early, weak signals of change.

Tests of a good scenario:

- it is plausible to a critical mass of managers and/or stakeholders;
- it is internally consistent;
- it is relevant to the topic or issue of interest;
- it is recognisable from signals of the present—weak signals of change;
- it is challenging, containing some elements of surprise or novelty in directions where the organisation's vision needs to be stretched;
- it is linked to existing organisational mental maps; and
- it should not be novel in every respect.

The following box provides a general description of the characteristics and use of scenario analysis, written by one of the pioneers of the technique with the Royal Dutch/Shell group of companies.

Using scenarios to navigate the future

PETER SCHWARTZ

Today's organisations face tremendous structural change and uncertainty: globalisation, multiculturalism, internal diversity, technological revolution, and decisions with huge consequences and risks. Anticipating the future in this volatile environment calls for more than systematic analysis; it also demands creativity insight and intuition. Scenarios—stories about possible futures—combine these elements into a foundation for robust strategies. The test of a good scenario is not whether it portrays the future accurately but whether it enables an organisation to learn and adapt.

A scenario is a tool for ordering one's perceptions about alternative future environments in which today's decisions might be played out. In practice, scenarios resemble a set of stories, written or spoken, built carefully around constructed plots. Stories are an old way of organising knowledge; when used as planning tools, they defy denial by encouraging—in fact, requiring—the willing suspension of disbelief. Stories can express multiple perspectives on complex events; scenarios give meaning to these events.

Scenarios are powerful planning tools precisely because the future is unpredictable. Unlike traditional forecasting or market research, scenarios present alternative images instead of extrapolating current trends from the present. Scenarios also embrace qualitative perspectives and the potential for sharp discontinuities that econometric models exclude. Consequently, creating scenarios requires decision-makers to quester their broadest assumptions about the way the world works so they can foresee decisions that might be missed or denied. Within the organisation scenarios provide a common vocabulary and an effective basis for communicating complex—sometimes paradoxical—conditions and options.

Despite its story-like qualities, scenario planning follows systematic and recognisable phases. The process is highly interactive, intense, and imaginative. It begins by isolating the decision to be made, rigorously challenging the mental maps that shape one's perceptions and hunting and gathering information, often from unorthodox sources. The next steps are more analytical: identifying the driving forces (social, economic, political, and technological); the pre-determined elements (ie. what is inevitable, like many demographic factors that are already in the pipeline); and the critical uncertainties (ie. what is unpredictable or a matter of choice such as public opinion). These factors are then prioritised according to importance and uncertainty.

These exercises culminate in two or three carefully constructed scenario 'plots'. If the scenarios are to function as learning tools, the lessons they teach must be based on issues critical to the success of the focal decision. Moreover, only a few scenarios can be fully developed and remembered; each should represent a plausible alternative future, not a best case, worst case and 'most likely' continuum. Once the scenarios have been fleshed out and woven into a narrative, the team identifies their implications and the leading indicators to be monitored on an ongoing basis.

Good scenarios are plausible and surprising; they have the power to break old stereotypes; and their creators assume ownership and put them to work. Using scenarios is rehearsing the future; by recognising the warning signs and the drama that is unfolding one can avoid surprises, adapt and act effectively. Decisions which have been pre-tested against a range of what fate may offer are more likely to stand the test of time, produce robust and resilient strategies, and create distinct competitive advantage. Ultimately, the end result of scenario planning is not a more accurate picture of tomorrow but better decisions about the future.

Stages of scenario analysis

Stage One—Identify the *focal issue, objectives* of the exercise, *timeframe*, and appropriate *participants*

The selection of participants is a crucial component of the process, as it is their collective knowledge, experience, and willingness to consider alternative futures which provides the major resource for scenario analysis. it is important to include a sprinkling of 'outsiders', whether by employment, expertise or interest, to provide a breadth of perspective.

Stage Two—Environmental analysis

This stage is designed to engage participants in identifying the many possible issues and factors that might have some influence on the topic, to develop a shared knowledge of available data relevant to the topics, and of issues and trends in the current environment which might be relevant.

The key to this stage is education for the team. The subsequent scenario development is shaped by what is in the team's heads, not the material available on paper. The choice of assumptions is strongly shaped by this stage.

Stage Three—Identify and characterise key predictable variables

On the basis of the discussion in the previous stage, the task is one of developing a substantial list of the sorts of factors, or variables, which, within the time frame, are likely to have a significant impact on the topic, and which are, at least in principle, predictable.

The sort of question that might be asked is 'What are the crucial factors in 2010 I need to know about in order to be able to formulate an effective strategy *now*.'

Some general categories, are:

- demography—population and its characteristics;
- resources—food, water, energy, materials, human;
- environment—sustainability, pressures, disasters;
- governance and geo-political trends—globalisation, regionalisation, national sovereignty, role and structure of governments;
- economics—regional economies, debt and savings, living standards, finance and trade;
- industry and employment—rise of service industries, multi-national, multi-domestic and global operations, information and communication technology in business, changing form and location of work;
- social trends in inflation, employment, crime and security, tolerance, multi-culturalism, gender equity, education, health care.

There are two particular challenges:

- to free participants from their preconceptions and to cast their focus for enough beyond their current concerns;
- to focus on the **external** environment rather than factors inside the organisation, and its future.

Stage Four—Identify critical uncertainties

What are the critical uncertainties, representing possible discontinuities, or step changes, which could have a major impact on the topic? One approach is cast forward to 2010, and imagine what might be the '*if only I had know that*' factors.

This can be effectively approached by a combination of wide environmental analysis (what political, technological, social, economy, environmental, etc changes might be important; what if...?) and fast brainstorming.

Stage Five—Clustering of variables

A large number of variables are simply unmanageable in scenario analysis. The next stage is to reduce this large number to a more manageable set, through clustering those variables which describe different aspects of the same core factor.

Examine the lists of determinable and uncertain variables, and group them together whenever they have a common focus. This will require the development of a suitable label for a cluster of variables.

Stage Six—Ranking of variables to establish key driving forces.

The first part of this stages is to rank the predictable variables according to their relative importance.

The second and more difficult challenge is to rank the critical uncertainties, according to the degree of importance for the outcome of the topic, and the degree of uncertainty surrounding these factors and trends.

It is important to note that in scenario analysis, it is the degree of uncertainty, rather than the degree of likelihood that is crucial. Highly certain factors should be included in the predictable list. It is the small set of high impact, high uncertainty factors around which the alternative scenarios can be formulated.

On the basis of those considerations a set of key driving forces can be established.

Stage Seven—Selection of scenario logics

In this highly creative stage the objective is to develop a set of scenario logics that will assist in determining the number and characteristics of scenarios to be developed.

One approach is to identify the key areas along which the scenarios could differ, with an emphasis on issues basic to the success of the local decision, and which offer decision-makers significantly different potential strategies. A useful device can be to consider the combination of high/low positions on each axis.

Stage Eight—Development of scenarios

The development and fleshing out of a scenario can be effectively achieved by the following sequence of steps:

- using the key driving forces, develop strings of causally linked events *that might happen*;
- continue this process examining each key factor and trend identified in Stages Two, Three and Four, not just the driving forces;
- a useful approach is to identify events as a series of dated newspaper headlines;
- weave the process together in the form of a narrative, considering questions such as, how would the world get from here to there, or what events might be necessary to make the endpoint of the scenario plausible; the aim is to produce the outline of a plot, not a full script. Do not include, at this stage, considerations for your own organisations.
- develop a short (200–300 word) description of the scenario, and some appropriate, preferably catchy, title.

Stage Nine—Assessment of scenario coherence

Assessment of the coherence of the scenario is carried out by critical examination of its logic, identification of key events or tuning points, and linkages with the greatest weakness. The scenario should also be checked against the full set of critical variables to ensure coverage and consistency. Under each scenario, each variable should have a clear and logical outcome which is different from that in the other scenarios.

Stage Ten—Assessment of implications of scenarios for strategic planning

Implications are examined by returning to the focal issue. What emerges as the consequences under each scenario? What vulnerabilities have been revealed? What kind of strategies might be robust under all scenarios?

At this point, this organisation’s interests and capabilities are introduced. The scenarios can be integrated with the strategic planning process by carrying out the traditional SWOT analysis for the organisation in the topic area against each scenario. This analysis, together with one of potential competitor positioning, may be used to generate a series of options.

ANNEX B

Background paper for applying foresighting to irrigation and river health

1. Introduction

This background paper provides a brief analysis of the major economic, environmental and technological challenges and opportunities facing sustainable irrigation and river health. This summary provides an information base to underpin the principal objective of the foresighting exercise—the construction of scenarios of possible and preferred futures.

The paper begins with presenting some broad background trends and then identifies the principal stakeholders concerned with irrigation and river health. The paper then focuses on four key issues including water quantity and water use, water quality, the condition of riparian vegetation and the incidence of foreign biota. Responses to these issues by industry, government and through R&D are then considered. Section 6 introduces the issues of climate change and seasonal forecasting and their implications. Section 7 raises questions of processes for change that a foresighting process may need to consider. The paper concludes with a summary of scenarios for Australian agriculture and natural resources from a previous broader foresighting study.

2. Background trends

There has been an increasing emphasis over the past few decades on protecting the environment in which we live. This emphasis is relevant to water quality, preservation of biodiversity through protecting native vegetation or endangered species, or simply maintaining clean air free from smoke, odours and other dangerous substances or, on a global scale, the avoidance of change in terms of destruction of the ozone layer or global warming.

Over the past decade there has been particular recognition that the freshwater resource that sustains life on planet Earth is finite. Increasing competition for this resource from population growth, industry, agriculture, and the environment has magnified the issue of its scarcity. This scarcity dimension has been driven by a number of forces including alternative uses of water allocations from existing surface water storages, the preservation or expansion of existing storages, or direct extraction and use of water from groundwaters or rivers and streams. While the end-use conflict for scarce water resources continues, there has been the increasing realisation that Australians need to be more efficient with respect to water use. That is, there is a need to extract greater utility from a litre of water than hitherto.

There is increasing acceptance of the principles of a user pays system so that water is used in its highest value activities. While a market-based approach may assist in application of this principle, difficulties still exist in both the specification of relationships in the water system associated with habitat quality and ecological processes as well as specifying values attached to the various uses for water.

Water consumption for household and domestic purposes is regarded as a necessity. The competition for water among other uses including irrigation, power generation, industrial use and the environment is increasing.

Population growth, industrial growth and the advent of modern technological processes in industry have been increasingly impacting upon the Australian environment over past decades. The impacts have included deteriorating water quality with increasing sediment, nutrients and chemicals entering waterways. Studies examining the contributing sources of sediment, nutrients and chemicals in waterways have suggested that some originates from natural processes, some from the everyday presence of increasing numbers of people and their support structures and appliances, some from industry and some from land use practices including agriculture. The overall balance of causation varies depending on the particular location and the type of substance involved. Nevertheless, production systems in some agricultural industries have become increasingly intensive with higher levels of fertiliser and pesticide use, intensive feeding systems and feed lots and increased grazing pressures in some animal production systems. Such changes have increased the focus on agricultural systems as sources of unwanted materials in waterways.

One of the responses to these pressures is the development of further knowledge so that improved choices can be made by society. But the seeking of knowledge has also come under pressure with increasing focus on accountability in research planning and management over the past decade. There has been increasing pressure from industry to seek returns for R&D investment that are equivalent to other investment alternatives. Governments and semi-government organisations have also been under pressure to manage their R&D portfolios in a more focused and outcome-orientated manner. Combined with the recognition that strategic R&D funding is usually a long-term investment, this has encouraged more emphasis on strategic planning to guide the composition of the R&D investment portfolio under management. In turn, this has stimulated more analysis on what R&D is undertaken and where it is likely to lead. The recent interest in foresighting is a response to achieve a higher level of understanding and more effective planning to meet some of the difficult questions to be faced.

3. Definition of stakeholders

The major groups of stakeholders associated with irrigation include:

- irrigators and their representative bodies,
- those servicing the irrigation sector through water management and water delivery,
- those associated with irrigation equipment and infrastructure,
- those servicing the sector through R&D and advice to irrigators,
- those people in the community whose livelihoods and interests are impacted upon (both positively and adversely) by externalities from irrigation,
- those associated with water policy and dealing with externalities from irrigation, and
- those servicing the sector through education and training.

The major groups of stakeholders associated with river health include:

- those concerned for the conservation of the environment in a general sense,
- those concerned for the loss of habitat and biodiversity,
- those industrial and human consumers of water that have to pay more for their water as a result of a deterioration in river health,
- those associated with commercial and recreational fishing,
- irrigators and other water users concerned with deteriorating water quality and blue-green algae outbreaks,
- those servicing the sector through R&D and advice to environmental managers,
- those concerned with environmental policy, and
- those servicing the sector through education and training.

4. Principal issues

Stakeholders associated with irrigation and river health share a number of common concerns and issues. The principal issues currently being faced by these stakeholder groups are related to, or driven by:

- water quantity and water use
- water quality
- condition of riparian vegetation
- incidence of foreign biota

Diagram 1 on page 55 highlights some of the relationships surrounding these four issues in considering issues associated with irrigation and river health. Both water quantity and water quality are critical to irrigation and river health. Irrigation farming is strongly associated with water extraction and river regulation and therefore with disturbance of flows that sustain the natural environment. Water quality is critical in maintaining a habitat that is conducive to natural ecosystems and biodiversity, as well as contributing to human use, health and recreational opportunities and aesthetic values. The condition of riparian vegetation and the incidence of foreign plant and animal species are affected by agricultural practices, grazing industries and management of livestock. A healthy riparian zone is crucial to water quality and ecosystem health, and invasive plants and grasses degrade both the river environment and agricultural drainage systems and infrastructure.

The impact of these issues and the type of response required may vary according to the existing state of regulation and development of the water resource. Three states of regulation and development are suggested in Table 1:

Table 1
National water resources

State of regulation and development	Proportion of total water (% by volume)	Examples
Unregulated and unlikely to be developed	70	north WA, NT, central and northern Queensland
Unregulated with potential for development	10	NE coast, Tas
Partially regulated and developed	14	east coast, Tas
Regulated and highly developed	6	SE Mainland, south-west WA

The following summary focuses on the four principal issues identified above with most attention given to water quantity and water use.

Water quantity and water use

Irrigated agriculture each year contributes about $9 billion in farm gate value, with further flow on effects of about $24 billion to the national economy (1992/93 values). Many communities and regional economies are dependent on irrigation.

Agricultural commodities produced under irrigation are some of the more profitable industries in primary production at present (eg. wine and some other horticultural crops, sugar, rice, and cotton). On the other hand, it is disputed whether most large scale irrigation schemes established in Australia in the past would be considered economic if full cost recovery for water supply had been implemented.

There are plans in place to increase stored water for irrigation in the future. Such plans are particularly topical in Queensland and the north of Western Australia. Proponents of new water storages based on horticulture, cotton and sugar claim that such storages are desirable investments for governments and industry, but the likely future profitability is disputed by those concerned with the environment as well as many economic rationalists. Within the Murray–Darling Basin, the water resource available for irrigation has been recognised as being fully, if not overly, committed and the focus is sharing of water resources and efficient use.

Where groundwater has been used extensively for irrigation such as in Queensland, there have been instances of over-use with impacts of reduced availability and, in some instances, saline intrusion into caneland.

The user pays concept is being accepted in most irrigation areas. However, there is still the uncertainty of future price rises in both regulated water schemes and unregulated waterways in various states. Also, the capture and storage of water on-farm is outside the scope of many existing water charging regimes.

Economic viability of irrigation industries depends very much on the economics of production of the various commodities produced under irrigation. With the increasing use of free market forces in water, irrigation water use will shift towards those commodities that can afford higher water prices. This change raises a number of issues in terms of irrigation technology, water delivery systems, and infrastructure reconstruction decisions. Given the life of infrastructure is about 40 to 100 years, long-term planning is required to ensure viability of irrigation areas and likely design and service requirements over this time period.

Maintenance and replacement of infrastructure (eg. pumping stations, distribution channels, drainage channels) for irrigation systems is an issue in all irrigation areas. The COAG agreement requires all irrigation authorities to set aside money for future renewal of irrigation infrastructure including major storages. This may represent 30 to 50% of the cost of irrigation water based on the Victorian experience. There is currently no uniform basis between states as to the financial systems for funding future renewal although this is being addressed as part of the COAG agenda. At a regional level decisions on maintenance and replacement also depend in part on irrigation and farm technological change and associated rural adjustment.

There are substantial benefits associated with a move away from vertically integrated irrigation utilities, managed by central bureaucracies. Benefits include greater accountability to customers through Boards of Management and Water Services Committees, improved financial management and accountability and improved efficiency of operation. In particular, as the irrigation authorities move from the development focus of the past century to a more sustainable irrigation industry, the management and advisory structures are in place to meet the challenges of water reform, while continuing to provide appropriate and cost effective services to customers.

The new structures provide opportunities for research corporations to involve irrigators in setting the strategic direction for research. However, the corporatisation and privatisation of water agencies that has been undertaken in most states has fragmented the R&D effort within each state. There has been some concern that expected productivity gains, greater focus on local issues, and more efficient use of capital from the changes to water authorities and agencies will not compensate for the effect on national capabilities and that fragmentation will erode the national skills base via downsizing and removal of a critical mass for R&D in some areas.

A number of attempts have been made to establish a more effective Australian Irrigation Council (AIC), but such a body is still not strong. The AIC is the peak body representing the interests of irrigation at a national level. The Irrigation Association of Australia (IAA), National Farmers' Federation (NFF) and the Australian National Committee on Irrigation and Drainage (ANCID) are represented on the Council. The IAA represents equipment manufacturers and ANCID represents the state agencies and water supply authorities. Irrigators are represented by NFF but fragmentation along commodity lines can often pose difficulties.

There has been a concerted effort to reform and strengthen the AIC in the last two years. Problems with each of the member bodies has limited the effectiveness of the AIC as a national peak body to date. There is evidence that the lack of a credible national organisation for the irrigation sector has been a disadvantage since coherent lobbying for Government support is lacking.

Irrigators face a perception among many communities that irrigation is an intensive land use that is responsible for deterioration of water quality and use of water for irrigation denies other uses of water (particularly environmental uses) to be realised. Indeed one of the most contentious issues facing the irrigation sector is that present and prospective large-scale irrigation schemes and extensive water capture for on-farm storage, even during high flows, impact on river flow regimes and the health of river ecosystems.

The biota and ecologies of Australian rivers are adapted to the natural variation in river flows caused by variable rainfall events, droughts etc. River health measured by the ecology of systems both within the river itself and associated wetland and floodplain ecosystems is affected severely by flow impediments and extraction from rivers for various purposes, particularly irrigation. Ascertaining what flow regimes are required to maintain ecological systems is an issue currently facing the research community, river management and policy development. Favourable water regimes must include the appropriate quantities, timing, frequency and duration of flows. Information on how robust river ecologies might be to flow changes and disturbances is scarce. Further, assessing the impact on associated ecosystems in billabongs, floodplains and wetlands is difficult. Both areas of concern require significant input from hydrologists and geomorphologists.

Disturbances to the flow regimes of rivers also have serious impacts on river and estuarine fisheries. Reduced stream flows cause loss of habitat and water quality problems (eg. high salinity, low dissolved oxygen). High flows delivered along a river when it usually has a low flow can damage breeding habitat and prevent fish from spawning. Over time there is a loss of species diversity in whole sections of rivers. Recent research has shown that very high flows influence fish catches in estuaries and nearshore waters, and the removal or dampening of these flood flows causes long-term loss of productivity. Dams, weirs and barrages across river channels prevent upstream migrations of fish to important habitats, and fish moving downstream can also be affected. Many fish ladders do not function efficiently under naturally variable flow regimes, and need substantial improvements in design to suit Australian conditions.

Water quality

Water quality issues associated with increased salinity, sediment, nutrients and chemicals reaching waterways are key influences on river health. Both irrigated areas and rainfed agriculture can contribute to exports of salts, nutrients, chemicals and sediment to rivers.

Of significant concern to many irrigation areas are rising groundwater tables due to accession to groundwater through irrigation and rainfall. Accession to groundwater may result in salinisation and waterlogging particularly in the lower parts of the landscape. In the Murray River irrigation areas, rapidly rising watertables have already caused, and will continue to cause, declining productivity in the next 30 years. The cost to the community will be large. Significant resources are being spent at present to slow the rate of salinisation and to protect particular areas. However, the lower lying areas are likely to be worst affected as will wetlands, remnant native vegetation and associated ecological systems.

Land clearing and removal of deep-rooted tree species results in increased accession to groundwater, particularly in rainfed areas of river catchments. Areas of dryland salinity in the Murray–Darling Basin catchment are increasing at an alarming rate and will result in deterioration of the water quality available for irrigation and the environment. This will further compound salinity problems in irrigation areas and have a profound effect on the riverine environment. Animal industries can also affect water quality as can land clearing and cropping practices where sediment can be removed from disturbed land and be transported into waterways.

Increased presence of salts, nutrients, chemicals and sediment can have significant effects on the water quality and biota of rivers and streams and biodiversity may suffer. One of the more visible effects of ecological changes are blue-green algal blooms, which result from a number of contributing factors thought to include phosphorus and nitrogen levels in waterways, water temperature, rate of flow of the water, and bacterial levels. Both irrigation and rainfed farming may contribute to the incidence of algal blooms by influencing one or more of these causal factors.

The difficulties of identifying and quantifying sources of sediment, nutrients and agricultural chemicals are significant. Exports of sediment, chemicals and nutrients can be measured more accurately from irrigated farming areas than from non-irrigated farming areas. Some progress has been made in identifying farm and non-farm sources of sediments, nutrients and some chemicals, but there is still much uncertainty in defining the relative contribution made by farming practices to levels of these substances in rivers. However, it is thought that land use practices including vegetation clearing, cultivation and management practices, and grazing industries contribute to the overall levels.

Riparian vegetation

Riparian vegetation is under threat from practices such as vegetation clearing and burning, river straightening and removal of debris (snags), disease and dieback. Grazing industries can damage riparian vegetation and stream banks by allowing cattle free access to streams for drinking water, resulting in destruction of riparian habitats and increased levels of sediment and nutrients entering rivers. Clearing and decline of riparian vegetation reduces the beneficial ecological functions of a healthy riparian zone. These include the buffering role of vegetation which helps to reduce the input of sediments, nutrients and pesticides to waterways, and the provision of shade over streams hence reducing growth of nuisance algae and plants. A sensitive new measure of river health based on the balance between photosynthesis and respiration is directly related to the extent of riparian zone and shading. Riparian vegetation is an important source of energy (leaves, insects) to stream food webs, and large woody debris provides habitat and spawning sites for aquatic invertebrates and fish. The vegetated riparian zone also provides habitat for terrestrial animals and birds, and corridors for the movements of wildlife in the broader landscape.

As well as these intrinsic ecological advantages, there are practical agricultural benefits to be gained from conserving and restoring riparian vegetation. Riparian zones and wetlands act as sponges, soaking up water and minimising flood peaks following heavy rainfall. They help reduce soil loss from bank erosion and from runoff, which can be three to four orders of magnitude higher from farming land than from natural forest. Well vegetated riparian zones along natural waterways increase the abundance of beneficial insects in adjacent crops. In cane growing areas, the establishment of shade trees in harbourage areas used by cane rats prevents sunlight penetration to ground level and impedes grass and weed growth. This can provide a long-term solution to rat control and replace less effective and costly control measures (slashing, grazing, burning of grasses, spraying with herbicides, and use of rodenticides).

Foreign biota

Foreign aquatic species are having a significant effect on the ecology of Australia's rivers. Aquatic plants, invertebrates and fish introduced to Australia from other countries, or moved into rivers where they do not occur naturally, can cause significant environmental problems in rivers, wetlands and estuaries.

The common carp is one of the worst pest species in terms of its effects on river health and the condition of irrigation channels. Carp undermines the banks of irrigation channels and is thought to be a significant factor in the accelerated deterioration seen in some districts. Carp contributes to the nutrient and sediment levels in streams and its feeding behaviour can destroy water plants and aquatic habitat. Introduced fish species including carp threaten some of Australia's most endangered native fish species. They can compete with important commercial and recreational species for food and habitat or prey upon their young.

Aquatic plants from South America, especially water hyacinth and Salvinia, and grasses (eg. Para grass and Hymenachne) cause water quality problems, loss of aquatic habitat, and reduced biodiversity. In the south, exotic weeds such as arrowhead are spreading at an alarming rate, choking irrigation channels and resulting in increased operating costs. Fears are held regarding alligator weed which has been detected in some locations in Victoria, but has not yet spread to waterways and irrigation channels.

5. Responses to Issues

An excellent account of the issues and sub-issues facing Australia's inland waters is given in Chapter 7 of 'Australia: State of the Environment, 1996'. A key table in the report that defines the issues and sub-issues and the response to each issue (and the effectiveness of the responses) is attached at the end of this background paper.

Industry and policy responses

Water policy in Australia is in a period of transition as water economies mature. Under general COAG principles each state is developing water policies to deal with issues of water allocation, pricing, and environmental flows.

The concept of capacity sharing is being given serious consideration as a method of sharing water resources held in storage between states and between irrigation areas within states. The concept of allowing overdraw and underdraw of water entitlement in NSW is a simple form of capacity sharing. In Victoria, capacity sharing at an individual level has been considered, but in general it is considered the benefits do not justify the additional complexity involved.

It could be argued that given the level of announced allocations (or equivalent) in various river basins, water has been over-allocated to extractive use. Principles of equity and environmental justice may justify the removal or reduction of existing water allocations to increase the proportion of water for environmental use. Legislation in most states contains statements promoting the welfare of the state as a whole. Meeting demand for environmental water requirements may be deemed important for state welfare.

Traditional water pricing policies have been based upon social and development objectives rather than commercial returns. As institutions become more commercially focused and concern for the efficient use of water increases there has been movement towards the user-pays philosophy for water pricing.

The price of some irrigation licences has increased in the past few years. Water harvesting entitlements have been introduced and there is increasing use of water auctions. The original concept of water allocation tied to land area has been only slowly revised despite considerable advance in knowledge of crop water use. Allocative policy based on that water actually required to grow crops within a season would provide the right signals for water use efficiency. Transfer of water entitlement from one property to another is now becoming common practice in many jurisdictions. The divorce of 'ownership of land' and 'right to extract and use water', will lead to water resources being used in a more effective and efficient manner.

A spirit of cooperation exists between water authorities to allow interstate trading, where physically possible, in the future. A major constraint to water trading between states is progress toward meeting full cost recovery targets established under COAG. Where an irrigation area is yet to meet targets established under COAG, the price of the water will be lower, and this may stimulate an inappropriate transfer of water from areas where COAG targets have been met. A uniform playing field for transfer is one prerequisite for permanent water trading between states.

The third major water policy issue involves environmental flows. The general policy response to environmental flows has been in terms of a bulk water allocation such as that for the Macquarie Marshes in NSW. Capacity sharing appears to provide suitable flexibility for environmental water managers to supply environmental flows as conditions dictate. As markets for water develop, trade in environmental water may become more common and it may also be possible to improve environmental flows through the market in a revenue-neutral manner after an initial allocation of water.

Policy mechanisms for sharing water between extractive users and the environment include:

- Block allocations for environmental use and revising current water release rules from dams
- Reducing the level of announced allocation
- Recouping unutilised and underutilised water allocations
- Purchasing water allocations for environmental use
- Restructuring the water allocations to capacity sharing with appropriate environment shares.

The main difficulty in the allocation of water for environmental use is determining the appropriate quantity, quality and timing of supply. While there are many significant research programs underway in Australia to develop suitable methodologies to model riverine ecosystems, the main problem currently facing Australia is the lack of biological and ecological understanding of the flow requirements of many Australian riverine environments.

Wetland policies and management strategies have been developed by the Australian Government, the Murray–Darling Basin Commission, and State/Territory agencies.

Policy response to water quality degradation has tended towards regulation of point source emissions and investigation of tradeable emission permit systems. Non-point source emission in agricultural regions has focused on farm management practices and farm chemicals entering river systems.

Activities to prevent or slow irrigation induced salinity and to protect some areas include water reuse systems on farms, farm and community drainage systems, groundwater control through pumping and tile drainage, and the use of disposal basins for irrigation drainage water.

Because of the uncertainty surrounding the sources of sediment, nutrients, and in some cases chemicals, the farming industry has been reluctant to take any significant responsibility for water quality changes, pointing out that other sources of these intrusions are usually more important. However, the threat of regulation of farm practices as well as 'good citizen' attitudes, have elicited positive responses from some industry groups.

Some agricultural industries are developing guidelines for 'best management practices' or codes of practice that will minimise the interaction between land and water use and river health. Such guidelines focus on minimising off-farm exports of sediment, nutrients and chemicals. While it is generally recognised that a best practice approach will contribute to reducing exports, the questions remain of the overall efficacy of the best practice approach and the proportion of land managers that will adopt best practice without further inducement.

The catchment approach to water quality and indeed other river health issues is of critical importance. Catchment approaches require a different organisational framework to an industry based approach. Movements such as ICM (Integrated Catchment Management), Landcare and Rivercare are integral to the response by the landowners in a catchment framework. Governments have been placing significant emphasis on these models to create awareness, develop plans on a catchment basis and to deliver support for agreed and desirable change. The geographical variability and speed with which this is happening, and indeed the overall effectiveness of this support, is continually being questioned.

Most Australian responses to environmental matters in the past have been through regulation which has been *ad hoc* and varied from state to state/territory. Current policy responses and limitations associated with irrigation and river health include:

- increasing use of economic instruments for allocation of water resources
- increasing recognition of water allocations as separate entities from land
- direct allocation of water to environmental use
- increasing cost-sharing arrangements between governments and land and water users (the development of land and water management plans has been the major vehicle for action on environmental issues at a local level)
- variable progress is being made through duty of care, codes of practice or best practice guideline development by farmers.
- limited internalisation of externalities

The most constraining factors in developing appropriate policies in many of these areas lie in a lack of scientific knowledge, the tradeoff between people-orientated and economic efficiency goals, tradeoffs between the long-term and the short-term, and the absence of an agreed value system for environmental outcomes.

R&D responses

R&D for the irrigation sector is supported by state agencies, CSIRO, the Murray–Darling Basin Commission (MDBC), and the LWRRDC-managed National Program for Irrigation Research and Development (NPIRD), and by the private sector including irrigation equipment manufacturers. Other R&D relevant to irrigation is funded through the commodity focused R&D corporations.

The NPIRD is funded by LWRRDC, two State Governments that still have an administrative role in irrigation, and irrigators through water rates collected by rural water authorities and corporations. While the NPIRD has been successful in developing a focus for R&D in irrigation issues at a national level, it is a relatively small program and does not have a satisfactory funding base as there is no statutory levy in place to ensure a continuing program. This lack of commitment from the irrigation sector is interpreted as a failure by the sector to invest in its own future.

R&D initiatives associated with river health include those of the state agencies, CSIRO, and the Murray–Darling Basin Commission, as well as those sponsored by LWRRDC. The R&D programs associated with LWRRDC in partnership with other agencies include:

- the National River Health Program (LWRRDC and Environment Australia)
- the National Wetlands R&D Program (LWRRDC and Environment Australia)
- the National Eutrophication Management Program (LWRRDC and MDBC)
- Minimising the Riverine Environmental Impact of Pesticides (LWRRDC, MDBC and CRDC)
- the Riparian Program (LWRRDC and State agencies)

Responses to many of the river health issues are manifest on a national scale through the National River Health Program (NRHP) supported by LWRRDC and Environment Australia. The program consists of three subprograms:

- environmental flows,
- monitoring river health initiative, and
- river restoration (support through Rivercare initiatives under the Natural Heritage Trust)

Together, the R&D effort addresses in various ways most, if not all, of the issues previously identified. Many strategic planning initiatives and workshops have contributed to the R&D approaches and priorities presently in existence.

Three comments on the overall R&D effort follow. The first is associated with the plethora of funding and research provider organisations all seeking a visible niche. A degree of coordination is occurring but this itself at times can be time consuming and distracting. The second issue is the long time period usually involved in generating knowledge from R&D in the areas of natural resources and the environment. The third issue is the concern that much R&D output does not always appear to be translated into effective outcomes for natural resource and environmental management.

6. Climate change and seasonal forecasting

Two areas that might impact on river health and irrigation in the future are those of climate change and seasonal forecasting.

Climate change

Since mid-century, mean temperatures in Australia have increased by about 1°C (daily minimum) and about 0.6°C (daily maximum). In 1995 the Intergovernmental Panel on Climate Change gave a best estimate of an increase in global mean temperature of 2°C by 2100 and concluded “the balance of evidence suggests a discernible human influence on global climate”.

CSIRO's Division of Atmospheric Research scenario is:

> *'By the year 2030, northern coastal regions may experience an increase of up to 1°C. Southern coastal regions may warm by up to 1.5°C. Inland areas are likely to warm slightly more than coastal regions.*
>
> *Changes in rainfall are much harder to predict than temperature. By the year 2030, winter rainfall in southern Australia may decrease by up to 10%. Summer rainfall over Australia may increase or decrease by up to 10%. More hot days are expected, fewer frosts and less snow. In regions where rainfall increases, more floods are anticipated. In parts of the country where rainfall remains the same or decreases, increased evaporation may lead to drier conditions.'*

Higher temperatures are likely to result in a more vigorous hydrological cycle. For example, estimates of return periods such as a 1 in a 100 design flood may be halved. The non-linear nature of the climate system implies the chance of 'surprises'—large and sudden shifts compared to gentle trends.

Reduced frosts and increased temperature will change the geographic range of some crops, for example cotton southwards and cane sugar inland. Another contrasting example is for a low warming scenario to have little impact on pome fruit vernalisation. One study has suggested that a major change may be for horticulture to shift south to cooler temperatures.

A wide range of impacts is possible with respect to algal blooms, pests and diseases, particularly where outbreaks depend on unusual weather or where the geographic range is extended. Slow adaptation of ecological systems may require increased water allocations under climate change scenarios.

Seasonal forecasting technologies

Current seasonal rainfall forecasts are typically issued on a monthly basis for the season three months ahead. This is the limit generally for Southern Oscillation Index (SOI) based forecasts using statistical approaches and with an autumn predictability gap when skill is poor. There are situations such as this year (1997) when the SOI is extreme and forecasts up to six months ahead may have skill. There are also suggestions that if stream-flow rather than rainfall is forecast, six months may sometimes be skilful because of amplification of the signal and greater persistence in stream-flow. Other seasonal forecasting techniques such as those based on sea surface temperature or on general circulation models have the potential to improve seasonal forecasts in the future.

The Climate Variability in Agriculture R&D Program (LWRRDC) is currently funding a project which will enable streamflow to be forecast directly using the SOI-based AUSTRALIAN RAINMAN package. The project will report on the value of forecasts to water agencies and irrigators in managing risk and provide products for both. The forecasts may allow agencies to manage more accurately to a given reliability and give irrigators the tools to more accurately assess likely availability of additional allocations.

7. Processes for change

The foregoing has briefly described some of the issues and challenges being faced by water and river managers, those forming relevant policies and the research community. As R&D is a long-term investment, it is important that the most effective R&D program is set in place over the next decade. The R&D program will provide knowledge that may affect the future. But, of perhaps greater importance is the wider context in which irrigation and river health are set. Many of the factors that affect the relevance of the R&D undertaken in the next decade will be determined through other forces and decisions undertaken. It is these future scenarios that can be addressed through foresighting so that greater insight into the relevance of current R&D investments many be gained.

In this broader context, at least the following need to be considered:

- the interaction between science and policy
- the societal values that are placed on material versus environmental outcomes
- how knowledge is used and how values are formed within the general community
- the political process

Science is often seen by policy makers as an inward-looking culture bound activity that does not communicate effectively with end users and stakeholders. In general, scientists are fragmented in a disciplinary sense and have not been very successful in developing options; they are either disinterested or find it difficult to tease out policy implications from their results. On the other hand policy makers, as seen by scientists do not plan for useful interaction with scientists. Input is usually sought quickly when policy drafts are at an advanced stage. There is a degree of mistrust and feeling that policy decisions are often made with incomplete scientific information.

It may be argued that political structures are important in influencing how responses to the issues described earlier are handled. For example, is the existing three tiered structure of government conducive to efficient and effective policy in irrigation and river health? Are the catchment issues too difficult to accommodate with our current government structures or within a fourth tier of government?

Is there any likelihood that there will be any general change in mood of the populace towards the value of economic growth and materialism compared with values associated with the environment and its conservation? Are political processes as we know them likely to change significantly in terms of shifting balances of power with respect to economic growth and the environment? The green movement is already changing as mainstream policy development takes on more and more of former green policies. What will be the role and stance of the green movement in the future?

Policy changes often are precipitated by catastrophic events that highlight the vulnerability of society (for example, the 1996 Australian gun laws). Are there such future-shaping events likely or possible in the realm of irrigation and river health?

Will policy process development require more scientifically based information than it has in the past in order for rational policies to be developed? Or will the political process appeal more to people's subjective feelings and priorities and even become more emotional than previously?

8. Commodity demand and a previous foresighting framework

A preliminary and broader foresighting exercise carried out earlier in 1997 by the Centre for International Economics (CIE) identified a number of future scenarios for Australian agricultural production and natural resource tradeoffs. These futures were influenced by three major driving variables:

- projections of demand for Australian agricultural production
- physical constraints on agricultural production (availability of land and water) bearing in mind the deterioration in the resource base as well as technical change
- which environmental costs are factored into production decisions

Projections of demand for Australian agricultural products

The CIE report provides a range of views on global economic growth which in turn influence the world demand for agricultural products which can be translated into demand for Australian agricultural products. Some of these Australian demand projections have been made with respect to mathematical model projections for those commodities where these models are held by CIE (eg. grains, meat, wool). Projections of demand for other Australian commodities (sugar, horticulture, rice etc) were made qualitatively.

Long-run aggregate world growth is predicted by CIE in the range of 2.3 to 3.9% per year and will be driven by population growth, the maximum rate of new technological development and its adoption, and the potential of the developing world to 'catch-up ' to the developed countries. This last driver of world economic growth is the most critical.

Availability of land and water

Within the CIE report, it was stated the demand for particular agricultural commodities produced in Australia is expected to increase in the future. CIE reports Australia has sufficient availability of land and water to meet world demand for agricultural products over the next 30 years. However, the forecast demand for commodities such as sugar, cotton and horticulture was predicted to significantly increase in the future, and as these crops are likely to be irrigation crops, there may be increasing tension between irrigators for the limited water resource, and tension between irrigators and the environment as the demand for irrigation water increases. For example, water requirements for crops such as cotton would create tensions with other irrigated production sectors such as grains if the area planted to cotton increases as predicted. Current use of water for irrigation is constrained by both management and the environment.

Environmental cost influence on production decisions

Future decisions regarding agricultural production will depend upon the level of importance placed upon environmental issues by producers. In the future, production decisions will depend upon the cost of the land and the water to the producer and the external environmental cost associated with production (ie. the cost of reduced biodiversity and environmental degradation).

Within the CIE report, three scenarios were considered regarding the importance of environmental issues. The first scenario considered by CIE was 'Economic Growth' which assumed greater importance would be placed upon production objectives in the future by the government as a result of community pressure. The second scenario was 'Conservative Development' which is similar to the current directions being taken to address environmental and production objectives, for example, sustainable development. The third scenario developed by CIE was 'Post Materialism' which envisages massive change in Australian agricultural production systems. The post materialism scenario would involve directing considerable resources to improving the environment at the cost of reduced agricultural production.

diagram 1

Table 2
Summary

Element of the environment/ issue	State	Adequate info	Response	Effectiveness of Response
Water Resources				
Storage and abstraction for human use	Secure supplies but substantial overuse in some regions	✔✔✔✔	Conservation policies; public education in most States; consideration being given to reallocation of water to environment	Good; poor understanding of ecological processes; reallocation could be ineffective
Forest harvesting	An initial increase in water yield is followed by a reduction as regeneration occurs, sometimes dramatically	✔✔✔	Logging restrictions; small-scale and patch logging; fire management	Appropriate, but water issues often not considered in forestry planning
Groundwater	Overuse—use greater than recharge in some areas	✔✔✔	Bore metering and licensing; regulation; capping of bores; water pricing; education; some artificial recharge	Appropriate but limited effect
Farm dams	Proliferation has reduced streamflow particulary during dry conditions	✔✔	No action	Inappropriate—farm dams not considered in water resources planning
Irrigation	Irrigation is the major user of stored water and a large portion is used inefficiently for marginal economic benefit	✔✔✔✔	Water pricing; reform and restructuring of industry; improved irrigation technology	Approprate but not applied nationally; minimal effect yet
Domestic and urban uses	Supplies adequate but increased demand is leading to more dams	✔✔✔✔	Water pricing; demand managemnet; education; some recycling	Good regional effect; stabilisation of per capita demand where responses have been implemented; minimal national effect
Catchment pollutant sources				
Agriculture and land clearing	Most waterbodies in areas of agriculture affected by fine and coarse sediment, elevated nutrient loads, and, in some cases, salt; increased volume and rate of run-off; major stream channel changes	✔✔	Strategic revegetation and farm forestry; clearing bans; drainage; broadacre soil conservation and fertiliser management; tree planting to reduce salinity; streambank stabilisation; catchment management and Landcare	Poor—not targeted at water quality; effectiveness of tree planting unknown; streambank stabilisation costly and only partially successful; Landcare working in some areas
Mining	Localised pollution by metals and acid run-off; many sites of disturbance in past areas of coal, alluvial tin and gold mining, sulfide mining and sand and gravel extraction	✔✔✔	Stricter management of all new mines; recycling of water; stabilisation and rehabilitation of some old mine sites	Good in relation to new mines; poor in relation to old mines
Intensive animal industries	Localised but significant pollution by nutrients, organic matter and bacteria	✔✔✔	Guidelines and regulations for effluent discharges, operation, and management; education; implementation of regulations	Inadequate because responses not widely adopted; some local effectiveness
Irrigated agriculture	Localised but significant pollution by sediments, nutrients, pesticides, salt and waterlogging producing serious environmental and social problems	✔✔✔	Guidelines and regulations for effluent discharge and drainage in some areas; improved irrigation techniques; soil conservation; education; industry restructuring; water industry reform	Locally effective but often problem transferred further downstream; guidelines often based on poor biological knowledge; too early to judge effectiveness of restructuring; insufficient land and water management
Urban and industrial development	Localised but significant pollution by sediment, nutrients, oils, organic chemicals and metals	✔✔✔	Guidelines and regulations for effluent management; monitoring; education	Good for trade wastes; poor for general urban run-off; monitoring adequate for some surface run-off, inadequate for groundwater
Forestry	Localised pollution by sediments, nutrients and pesticides	✔	Guidelines and field practice manuals; buffer strips; patch and selective logging; strategic forest and plantation planning	Inadequate because of poor integrated land and water management
Habitat quality and biota	(Aspects not already listed above)			
Drainage	Destruction of wetlands with effects on waterbirds and other biota	✔✔	Almost no response	Inadequate

Table 2 (continued)
Summary

Element of the environment/ issue	State	Adequate info	Response	Effectiveness of Response
Changed flow regimes	Reduced flows, increased flows, reversal of seasonal flows, reduced medium floods all change habitat quality; reduction and/or extinction of some native species; decline in ecological health	✔✔	Debate, limited trials, and research	In the right direction
Reservoirs and farm dams	1. New habitat and drought refuges 2. Reduced mobility of biota, especially fish 3. Downstream effects, especially erosion, temperature change and changed flow regimes	✔✔ ✔✔✔ ✔✔	1. No active management 2. Fish ladders 3. Little response	1. n.a. 2. inadequate 3. inadequate
Riparian vegetation changes	1. Riparian habitats widely degraded or destroyed 2. Exotic species produce organic inputs to streams different from native species	✔✔	1. Little response; some local fencing and provision of alternative water points; some research and demonstration underway, eg. Landcare, Save the Bush 2. Limited control of exotic species	Needs much greater action to protect and repare riparian zones; research and action needs to be in a whole-catchment context
Water quality changes	Changes in water quality affect habitat quality biodiversity and ecological processes, sometimes dramatically; some extinctions in native species; algal bloom enhancement and encouragement of exotic species	✔✔	Catchment management; flow management and point source control	Point source control adequate and effective with increased emphasis on rural and urban catchment management; urban and rural diffuse source control not widely developed
Exotic species	1. Displaced native species 2. Some waterbodies dominated by exotic plants and animals	✔✔	1. Attempts to control import, translocation and spread of potentially damaging exotic species of plants and animals 2. Biological control; management of new outbreaks	1. Inadequate and ineffective particularly with regard to the control of aquatic plants and fish imports. Education programs required 2. Significant potential effectiveness in some cases
Water Quality (Aspects not already listed above)				
Chlorination	Produces byproducts that are potentially damaging to human health	✔✔✔✔ (cities) ✔✔(rural)	Shift to chloramination, filtration prior to chlorination, use of dissolved air flotation, and activated carbon to reduce byproducts	Appropriate and appears to be successful; little knowledge of rural communities
Recreation	Localised but relatively minor increases of bacterial, nutrient and algal concentrations in heavily used waterbodies; some water quality unsafe for some recreation	✔✔	Recreation banned in most drinking water supply reservoirs; provision of toilets; bans and warning notices on water bodies	Appropriate and successful
Sewage disposal	Increased nutrient and pathogen concentrations locally; sewage flow often maintains river flow in dry times	✔✔✔✔	Treatment and land disposal; integrated land and water management and research; community efforts to reduce inputs to sewage plants; discharge licences	Inadequate—level of treatment needs to be reviewed; land disposal in some areas is successful but elsewhere may by unnecessary and unsustainable
Management				
Short-term thinking	Most governments and organisations focus on the short term	✔✔✔✔	Ecologically sustainable development; national and regional strategies	Appropriate but not widely implemented; too early to judge success
Policy development	Policy development and decision making does not take adequate account of science and does not cope well with scientific uncertainty; reduced skills due to restructuring of major water authorities	✔✔	Appointment of scientific advisory panels; more targeted and integrated science—eg. CRCs; economics often used in place of science rather than complementary to science; no response to reduction of skills in water authorities	Inadequate; maybe improving in some areas but not in privatised or corporatised organisations; use of economics often inappropriate
Data and monitoring	Inadequate data sets; fragmentary in space and time; short term; often of limited value; often not interpreted or archived	✔✔✔✔	Very little; National River Health Program, key site monitoring; EPA review	Too early to tell; agency restructuring and privatisation hinders effectiveness
Big picture management, integrated decision making	Lack of integrated decision making	✔✔✔✔	Catchment management and flow management	Many single issue policies developed without consideration of whole policies

Source: Australia: State of the Environment, 1996

Smarter irrigation: an Israeli perspective

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Abstract

Three stages during the growth of Israel's irrigated agriculture in the last 50 years are distinguished and the varying inputs of water, energy and information examined. During the last ten years changes in the country's economic, water and environmental policies have seriously eroded irrigated agriculture's hitherto major role in the national economy.

Although the export of expensive irrigation water—in the form of exports of high value fruit, vegetable and flower crops—still pays for the import of low-cost, rainfed staple foods used by the human and farm livestock populations, it is no longer able to subsidise the cost of irrigation water, still less to rehabilitate the country's now over-exploited and polluted water resources.

The future of irrigation in Israel is dependent on a number of unpredictable factors outside the industry's control. Externally these include the overseas demand for high value crops and the cost of fossil fuel needed for energy intensive, smart irrigation; local factors include the non-agricultural competition for water supply and land; also the possibility of climate changes that could alter water supply and demand.

The wise and possibly only response to present and future challenges appears to be a substantial increase in the information input to irrigated agriculture that would reduce the need for water and energy intensive inputs. Scientific advances to substantially increase the water use efficiency of irrigated crops could ensure a sustainable future for wise irrigation in the same way that advances in water application efficiency in the past provided the basis for the success of Israel's smart irrigation.

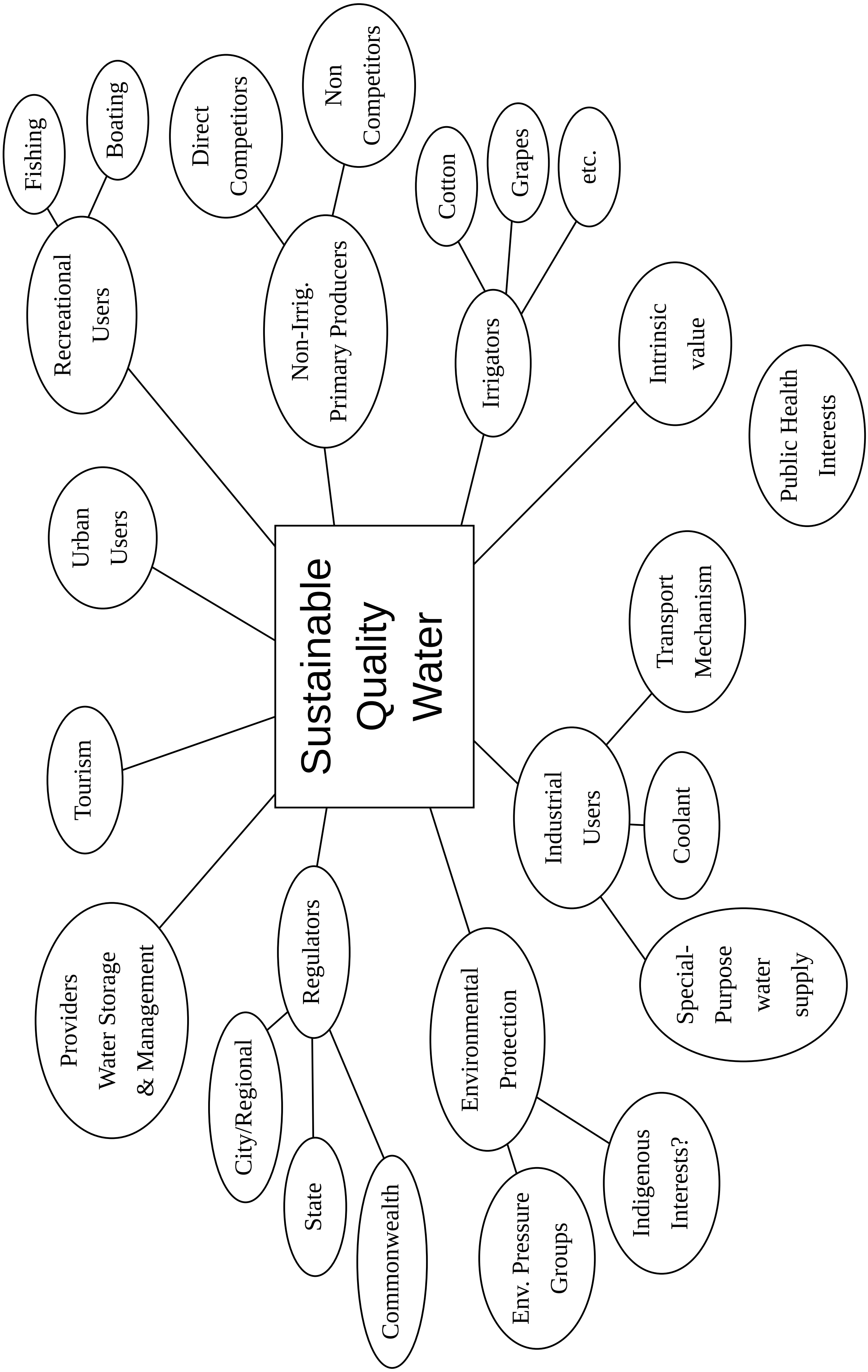
The changing attitude to irrigated agriculture can be illustrated by the reflooding in 1994 of a portion of the intensively cash-cropped Huleh valley. Until the mid 1950s this area consisted of swamp surrounded lake rich in wildlife, and its drainage and conversion to irrigated agriculture was then hailed as a major national achievement. Forty years later, its reflooding is widely seen as important for wildlife, water and soil conservation and as a potential tourist attraction.

ANNEX C

Interest maps

map 1

map 2


Sustainable Quality Water
Recreational Users
Fishing
Boating
Non-Irrig. Primary Producers
Direct Competitors
Non Competitors
Irrigators
Cotton
Grapes
etc.
Intrinsic value
Public Health Interests
Urban Users
Tourism
Providers Water Storage & Management
Regulators
City/Regional
State
Commonwealth
Environmental Protection
Env. Pressure Groups
Indigenous Interests?
Industrial Users
Transport Mechanism
Coolant
Special-Purpose water supply

ANNEX D

Preparation material for expert workshop

A summary of key future drivers

(i) Water supply
  — including rainfall (El Nino) and water catchments

(ii) Water demand
  — agricultural, domestic, industrial

(iii) Demand for commodities produced using irrigation

(iv) Water/river sustainability

(v) General environmental concerns

(vi) Globalisation/economics competition

Some key uncertainties

(i) New technology
  — for infrastructure replacement
  — for reducing water requirements of commodity production

(ii) World commodity supply

(iii) Climate change

(iv) Major water carried health threat/scares

(v) Introduction of policies for full resource accounting

Some potential scenarios

The market rules

- the water sector is fully privatised and largely owned by multinational companies
- in the deregulated market, a range of new water products and services are on offer
- water futures are traded on stock market
- there is a considerable export market in water management services
- some companies have sold water catchment's surplus to requirements
- water prices have soared, largely due to the need to measuredly upgrade infrastructure
- this has led to major investment in improved treatment and delivery technology
- new legally enforceable national water quality standards are the basis of regulation
- environmental concerns are addressed through market based mechanisms

The environment rules

- emergence of a range of ecological crises has led to legislation that requires all infrastructure projects to meet ESD criteria
- strict regulation has led to a significant diminution of supply to agriculture and industrial users who cannot meet effluent quality requirements
- environmental costs are now fully internalised

- there has been significant advances in genetic technologies to halve the water requirements of crop production
- green parties dominate the international political scene
- green criteria have become crucial in access to capital
- the price of water has remained roughly constant through increased environmental costs being balanced by improved demand management
- water management is conducted through integrated local water management plans

Steady as she goes

- water provision and management is still conducted largely by public sector agencies
- the infrastructure is undergoing gradual, long-term decline patched up from time to time
- Rising groundwater tables and salinity continue to reduce the arable land available providing a de facto demand management mechanism
- the water industry operates in an environment of low status and morale and is largely defensive in posture
- over-extraction of water has to increasing pollution of surface waters, and a dramatic decline in the recreational use of rivers
- the partial privatisation has led to only a limited flow of private capital to the industry
- environmental concerns are regarded as long-term, and clearing of wetlands for development continues
- there is a major investment in R&D directed to treating and destroying algal blooms
- a combination of price-based and mandatory rationing measures are used to manage water access

ANNEX E

Preparation material for stakeholder workshop

Future R&D requirements for managing Australia's natural resources—Sustainable irrigation and river health

STAKEHOLDER WORKSHOP, MELBOURNE AIRPORT TRAVELODGE, 13–14 NOVEMBER 1997
CONDUCTED BY PROFESSOR RON JOHNSTON, ACIIC AND DR PETER CHUDLEIGH, AGTRANS RESEARCH
FOR LAND AND WATER RESOURCES RESEARCH AND DEVELOPMENT CORPORATION

Evaluation form 1

Before arriving at the workshop, please complete this form.

Identify the three most important areas of R&D for Irrigation and River Health for Australia over the next 20 years.

1.
2.
3.

Identify the three key elements of a strategy to promote appropriate R&D to support Irrigation and River Health in Australia over the next 20 years.

1.
2.
3.

Program

Thursday, 13 November 1997—Day One

1.30pm	Registration and Coffee
2.00pm	The LWRRDC project—Future R&D Requirements for Managing Australia's Natural Resources—Irrigation and River Health
2.15pm	Issues for Irrigation and River Health
2.45pm	Introduction to Scenario-based Foresight
3.15pm	The Scenarios for the Future of Irrigation and River Health
3.30pm	Afternoon Tea
3.45pm	Exploring the Scenarios (small group exercise) • living the scenario • refining the scenario
5.00pm	Report back on the Scenarios
5.45pm	Refining the Scenarios
6.00pm	Close
7.30pm	Dinner

Friday, 14 November 1997—Day Two

9.00am	Refreshing the Scenarios
9.15am	Implication of Scenarios for the Future of Irrigation and River Health (small group exercise)
10.15am	Report back
10.45am	Coffee
11.00am	Implications of Scenarios for the Future of Irrigation and River Health R&D (small group exercise)
12.00	Report back and discussion
1.00pm	Lunch
2.00pm	Formulating an appropriate R&D Strategy (small group exercise)
2.45pm	Report Back
3.30pm	Evaluation
3.45pm	Summary and Conclusions
4.00pm	Close

Background to this project

The Land and Water Resources R&D Corporation has determined that it intends to apply the process of foresighting across a range of its programs. It intends to do this will the overall aim of improving the framework within which management, policy and investment decisions are made in dealing with Australia's natural resources.

The objectives of the project are:

1. identify future scenarios for the use and management of Australia's natural resources (land, water and vegetation)
2. consider the implications of these scenarios for changes in the value, condition, and frameworks (political, legal, organisational and socio-economic) for sustainable management of these resources
3. identify strategies for the future management of LWRRDC's R&D programs to accommodate likely future needs
4. identify and prioritise possible future scenarios from which strategic research and development priorities can be identified

The particular focus of this project is on the future of Irrigation and River Health.

Applying foresighting to sustainable irrigation

The extent and seriousness of current problems in irrigation are well known and there are many actions underway to implement programs and practices to improve both sustainability and productivity. Despite this it is clear that many of these practices may not lead to truly sustainable resource use. In addition pressures on water and land resources will increase and this also will demand new approaches to irrigation management. Changes will also present new opportunities to irrigators and the early recognition of these changes will allow time to develop new systems to benefit from these opportunities.

Responses to technology change in irrigation have traditionally been slow often because it was the researchers who identify the need for change and the researchers who developed the new management systems. The marketers of products, the farmers, industry water managers and the community were often operating separately often without any shared vision of how to address issues or take advantage of opportunities.

Foresighting should help to develop such a shared vision and enable action plans to be developed which involve all the players in the achievement of such a vision. It will be useful for identifying the priority research needs, techniques to further develop existing research and future research into practices. It should also define the communication needs and the social and economic changes that will be required to achieve such a vision.

Applying foresighting to sustainable river health

The extent and seriousness of the current state of river health are poorly known. There are many poorly integrated actions underway to implement programs and practices to improve is sustainability. Many of these practices may not lead to truly sustainable resource use. In addition pressures on water and land resources will increase.

A vision in which anthropogenic and environmental goals are integrated in water management is needed. Foresighting should help to develop such a vision and enable action plans to be developed which involve all the players in achievement of such a vision. It will be useful for identifying the priority research needs, techniques to further develop existing research and future research. It should also define the communication and resource management needs and the social and economic changes that will be required to achieve such a vision.

Foresighting is required to project a range of scenarios for potential future changes in human pressures on surface waters. These should be used to forecast trends, in both space and time, in river health.

Objectives of the stakeholder workshop

1. To engage a wide range of stakeholders in Irrigation and River Health in collective consideration of strategies for the future management of LWRRDC's R&D programs in this area.
2. To develop and refine scenarios about the future of Irrigation and River Health.
3. To identify potential priorities for R&D in support of the future of Irrigation and River Health.

Key drivers of the future of irrigation and river health

1. **Global demand for food and materials—**population, deomographics, income, prices, etc.
2. **Demand for water—**urban, industrial, agricultural, recreational.
3. **Limits to available water resource**
4. **Water/river sustainability and environmental tolerance**
5. **Demand for environmental goods—**clean water, clean air, low energy requiring foods, healthy rivers.
6. **Water markets and water ownership**
7. **New knowledge on water-assisted production and environmental effects**
8. **Community attitudes towards environment, agriculture and rural Australia**

Key uncertainties influencing the future of irrigation and river health

1. **New technologies** eg. smart irrigation, low water-dependent crops
2. **Climate change—**direct and indirect effects eg. carbon tax, international targets for greenhouse gas emission
3. **World commodity supply**
4. **Waterborne health threats—**pests, human diseases
5. **Introduction of policies for full resource accounting**
6. **Objectives and influence of environmental lobby groups**
7. **Future of integrated catchment management**

Scenarios for the future of irrigation and river health

Scenario One—The market rules

The date is 13 November 2015.

The water industry in Australia has been fully privatised for ten years (increasingly, few remember it was ever in public ownership) and is now dominated by two Multinational Cos—GlobalWater (a consortium led by British firms) and TPQ Ltd (a US/Israeli conglomerate). Water futures are traded on the stock market, and the water companies stood up well during the global stockmarket crash of 2007.

Access to the water system is comprehensively managed, monitored and charged for. Price is the sole mechanism for allocation, apart from requirements to maintain a minimum level of domestic service. While competition initially led to marginal reduction in some water service prices, and a considerable expansion and differentiation in the range of services available, the shake-out in the industry in the five years to 2010, and the need to invest heavily in upgrading infrastructure, has led to dramatically increased prices.

These financial costs, together with an emerging awareness of the energy costs of traditional irrigation, have led to a steady reduction in the acreage under irrigation, but dramatically increased yields, and value of products, from the remaining irrigated food production units. Major advances have been in 'smart' irrigation, with precisely appropriate amounts of water being applied at the various stages of plant life, and by genetic development of crops with much lower water requirements.

There is minimal government regulation, beyond the national water quality standards. The lessons of over-exploitation of groundwaters ten years ago have been learnt, and self-regulation through codes of practice has been firmly established. Land and water users operate under a broad regime of 'duty of care', whereby their responsibility is to manage their operations under a 'no regrets, no damage' model, but have the freedom to determine how best to meet these requirements. Monitoring is largely carried out through landsat analysis, and there have been a few spectacular prosecutions of major pastoralist and fedlot corporations.

Recreational use of rivers has largely been abandoned, with the water, entertainment and fast food companies' huge investment in water recreation centres. These go far beyond the primitive water parks of the 1990s, and provide a huge range of real and simulated forms of water recreation eg. virtual fishing is extremely popular.

R&D is now financed almost exclusively by the private sector, with the exception of that required to assist the government in its broad monitoring role. TPQ has invested in a major R&D centre in water research has developed in Australia, partly to take advantage of the collapse of many university's ability to support first class research, and the internationally recognised strength of a number of research teams.

Scenario Two—The environment rules

The date is 13 November 2015.

A combination of a devastating ‘El Nino’ effect for five years from 1997 to 2002, and marked rise in ambient temperature and variability and intensity of weather patterns (particularly the disastrous cyclone season of 2003, when more than 3 million people were killed in Asia and the Pacific Islands), have led to a dominance of environmental concerns over narrow economic ones.

A regime of strict regulation has emerged, in which all infrastructure projects are required to meet a broad range of ‘sustainability’ criteria. Much water is now regulated to be retained in rivers for flow regime reasons. Environmental costs are fully accounted for and internalised. Substantial acreage has been removed from agricultural production, and polluting industrial production has largely been closed down. Environmental criteria are widely applied in gaining access to capital.

This led to a dramatic rise in price, and consequent reduction in use of water in the mid-2000s. Together with strict regulation, this led to a dramatic reduction in water supply to those agricultural and industrial users who could not meet the ‘cleaner out than in’ effluent standards.

As a consequence, irrigation-based agriculture largely collapsed in the mid-2000s, the products being replaced by natural rain-based products, though at a significantly higher price to consumers. However, a number of producers were able to hang on, and by now have recovered strongly. This was largely due to a major R&D and technology transfer agreement established by the Government between CSIRO and Israeli organisations, which provided the basis for programs of demand management and intelligent water application systems.

The viability of the Australian river systems has improved remarkably, and is now comparable to that of the 1950s (the good old days), largely due to the reduced use for economic activities, and the almost zero pollution requirements. Water sports are booming and there has been a remarkable growth in international tourist trade seeking the natural experience of clean beaches, inland waterways and wetlands.

There is a high level of R&D on environmentally related issues, funded via a government levy on all ’environment consuming’ goods.

Scenario Three—The disease scare

The date is 13 November 2015.

We can all remember that fateful day in July 2007, when an outbreak of bilharzia was confirmed in Australian tropical streams. Two centuries of vigilant quarantine procedures were penetrated, not by the oft-quoted salami, but an eco-tourist. At first government officials attempted to play down the incident as a unique accident, but confirmation within weeks of a number of cases of infection forced a strong reaction.

Water catchment areas north of the Brisbane line were compulsorily quarantined, rivers and lakes were closed to human contact, with enormous penalties for transgression. Employees of companies using water in this region all went on strike until it could be demonstrated that there was no health hazard. Sales of bottled water soared. And there was a mass movement of families, particularly mothers and children, to the South. Australians were refugees in their own land. As if this was not bad enough, the already jittery stock and currency markets went into freefall.

Under these circumstances, it was not surprising that all water-based activities suffered a serious decline. Irrigated foodstuffs produced in the north were unsellable, as were all drinks, even beer! Companies that were able relocated their production to the south. And rivers, once regarded as the family’s natural playground on a summer’s day, were regarded with fear and hostility.

There was an immediate call for an urgent R&D effort to eradicate the disease, to prevent its repeated entry, and to establish the conditions under which water could be safely used. The Minister for Primary Industries was critical of the scientific community, asking them why they had not foreseen such a possibility, and provided advice on appropriate measures to take. There was also an immediate re-ordering of health research priorities, previously dominated by the health problems, and perceptions of the scientists, in the south.

'Safe water use' was emphasised in a huge education campaign. Practices about the use of water, which had remained unexamined for years, were now scrutinised to limit exposure to water, or to have contact only under safe conditions.

Now that the disease has been eradicated, we can look back at some of the positive outcomes. A totally new attitude to water has been established in the community, where clean pure water is regarded as a resource of the highest value, and never to be wasted. Water usage in industry, agriculture and the urban environment was dramatically reduced. A major export industry was established in low water usage systems, and a number of spectacular biological breakthroughs achieved. The multi-disciplinary Centre for Tropical Water Research, with its branches in Cairns and Darwin, is recognised as one of the best in the world. And bottled water from Australia is highly sought after in the capitals of Europe.

Exploring the scenarios—some guiding questions

1. What is your job? Who do you work for and what are your main responsibilities? Describe a typical work day.
2. Where do you live? What is your house like?
3. How did you get to this meeting?
4. What were the headlines in today's paper? (was there a newspaper?)
5. What is the state of Australian agriculture? What proportion of GDP does it contribute? What are the main crops? How are they grown? (are they grown?)
6. What is the public attitude towards irrigation?
7. What is the state of the rural environment?—land, water, air, etc.
8. What is the state of Australian rivers?

Three scenarios for the future of agriculture in Australia

The three scenarios are economic growth, conservative development and post-materialism. The characteristics are described below.

Evaluation form 2

1. What is your view of the scenario-based foresight process you have been engaged in today?
2. In your view what were the process outcomes and content outcomes from the exercise?
3. Do you believe it could be a useful tool in setting R&D priorities for the future? How?
4. Did the process produce R&D priorities different from those you identified prior to the exercise (evaluation form 1)
5. Did the process identify a different strategy (or components of it) from that you identified prior to the exercise?
6. How might the application of scenario-based foresight to setting R&D priorities be made more effective?

ANNEX F

List of participants at stakeholder workshop

Peter Alexander
Jason Alexandra
David Anthony
Angela Arthington
Sally Berridge
Gary Brierley
Jeremy Cape
Phil Cole
Peter Davies
Noel Dawson
Mark Eigenraam
Tom Fisher
Christine Forster
Robert Hutchinson
Jennie Ludlow
Richard Marchant
Jim McColl
Wayne Meyer
Stephen Mills
David Mittelheuser
Monica Muschal
Mark Neeson
Clive Noble
Derek Poulton
Tim Rigden
Nicholas Schofield
Roger Shaw
Henry Tankard
Anne Tarran
Eoin Wallis
Warwick Watkins
Richard Wells
Geoff Wright

ANNEX G

The Delphi Survey Instrument

delphi survey 1

delphi survey 2

delphi survey 3

ANNEX H

Results from the Delphi Instrument

(See page 16 for an interpretation of these results)

delphi results 1

delphi results 2