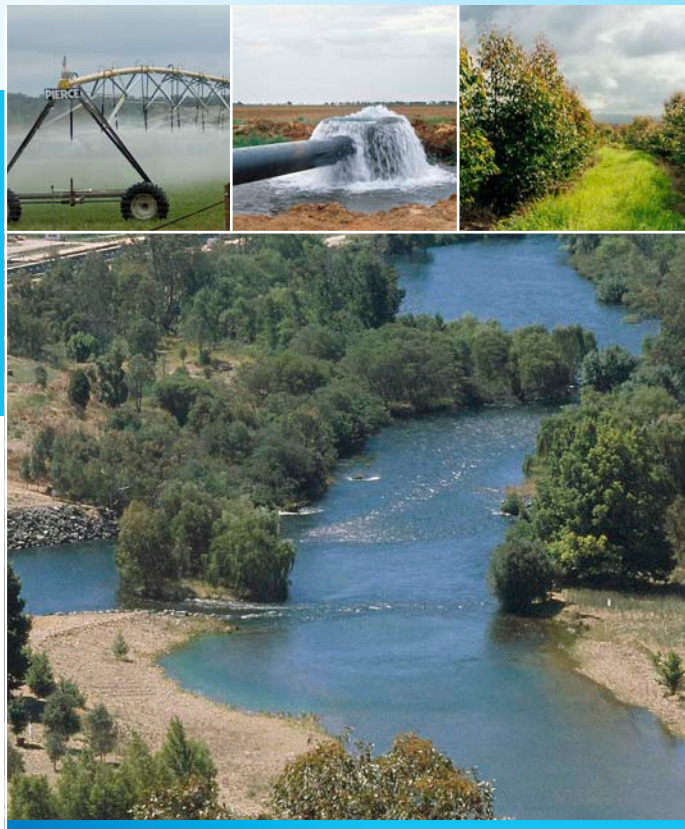
NSW GOVERNMENT | Industry & Investment

# Background Paper
# water



**I&I NSW** – PROFITABLE, ADAPTIVE AND SUSTAINABLE PRIMARY INDUSTRIES IN NSW

Background Paper - water

*This paper was prepared by NSW Department of Primary Industries Science & Research Division to identify water research priorities. Input was received from the divisions of Agriculture, Biosecurity and Mine Safety and Strategy, Policy and Communications.*

*NSW Department of Primary Industries became part of Industry & Investment NSW on 1 July 2009.*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## Issue

Water and how it is managed in an agricultural and natural resource context is the most significant resource management issue in NSW and Australia. At a national level the National Water Initiative and supporting government programs are in both place and still evolving. NSW DPI has capabilities and expertise that can advance the better management of water in this state and nationally. Some reorganisation of NSW DPI's focus and structures may facilitate better water management outcomes.

This document considers the national and state context of the water debate and proposes objectives and research actions to facilitate better targeting of Science and Research's water management research. It has been prepared by the Science & Research Division with input from Agriculture, Bio-security and Mine Safety and Strategy, Policy and Communications Divisions.

## Background

Water and how it is managed in an agricultural and natural resource context is the most significant resource management issue in NSW and Australia. Over recent times water quantity and quality has gained a prominent position in the consciousness of politicians, the media and the general public including land managers and primary producers. It is widely considered that our water resources are not being well managed, that water has been over allocated and is now a scarce resource which is being used inefficiently and that significant changes are needed to the way water is managed.

The level of awareness of the need for change to the way water is managed has been reinforced by drought and climate change. Additionally it is perceived that our rivers and watercourses are seriously degraded because of over extraction of water for consumptive use due to previous over-allocation of water during wetter periods. If current predictions for reduced flows in rivers are in any way accurate, significant changes are needed at every level of water management. This will need to include not only the 'downstream' users that include irrigation, urban and environmental users but the 'upstream' land management practices that control hydrology, including recharge and surface runoff which provide water to streams and groundwater systems.

Water resource research in the NSW/MDB context encompasses an enormous range of issues and "unknowns" in terms of research requirements. The urgency of these research questions has been exacerbated by extended drought in recent years. Given the importance of new information and the need for scientific credibility in future policy decisions, it is vital that considerable effort be given in terms of planning future water research. Water use/allocation has and will become increasingly fertile ground for dispute.

## National and NSW frameworks for improving water management

*At a national level,* the Natural Resource Management Ministerial Council is established under the Coalition of Australian Governments (COAG) and is responsible for delivery of **National Water Initiative (NWI) 2004.** The NWI continues to be the entry point and overarching framework for the national water reform agenda. The National Water Initiative agreement includes objectives, outcomes and agreed actions to be undertaken by governments across eight inter-related elements of water management:

i. water access entitlements and planning framework
ii. water markets and trading
iii. best practice water pricing
iv. integrated management of water for environmental and other public benefit outcomes
v. water resource accounting
vi. urban water reform
vii. knowledge and capacity building
viii. community partnerships and adjustment

It was ratified at the State/Territory level through an intergovernmental agreement and is being actioned through implementation plans in each jurisdiction.

A new iteration of the elements of water management are currently emerging.

COAG met in March 2008 and created a number of core areas of focus with an Australian Government Minister chairing each. Of interest is the **COAG Water and Climate Change Working Group,** chaired by Senator Penny Wong. Beneath this sits individual water and climate sub-groups. The water sub-group is developing a program of works or activities that need to be accelerated. This works program has 13 elements *including the 'old' NWI priorities [for example paras 55-57 relating to interception policy, which has a cross jurisdictional working group]. The 13 elements should be available under COAG website and the MDB agreement.*

The Rudd Government recently announced the **Caring for our Country Program**. This will see $2.25 billion invested nationally over five years and has four areas of priority that are of relevance to NSW DPIs water activities:

- Biodiversity and natural icons
- Coastal environments and critical aquatic habitats
- Sustainable farm practices – building on the success of landcare and improving delivery of ecosystem services
- Community skills, knowledge and engagement.

Caring for our Country is intended to complement the Water for the Future program (see below). It follows on from the NAP for Salinity and Water Quality, maintaining a focus on water quality. However, it will not invest in activities more appropriately the focus of Water for the Future including projects designed to deliver water efficiencies and water savings.

The **$10 billion National Plan for Water Security** (NPWS) was announced by the Howard Government in 2007, focusing on reducing water losses, improved efficiency and addressing over allocation in the Murray Darling Basin. Relevant points of this plan for primary industries include:

- Nationwide investment in irrigation infrastructure to line and pipe major delivery channels
- An nationwide program to improve on-farm irrigation technology and metering
- Establishing new institutional arrangements including the MDB Authority
- Expanding the role of the Bureau of Meteorology to provide the water data necessary for good decision making by governments and industry.

The Rudd Government is committed to implementation of the NPWS and Penny Wong recently re-labelled it **Water for the Future** and identified four key priorities:

- Taking action on climate change
- Using water wisely
- Securing water supplies
- Supporting healthy rivers.

*NSW level*

At a NSW/state level changes to the way water is managed are supported by the **State Plan** under the Environment for Living theme and goals of Supporting our supply of water and energy and Practical environmental solutions. Priority E1 – A secure and sustainable water supply for all users will be primarily measured against the target of *Across NSW, meet commitments under the NWI to restore water extraction from rivers to sustainable levels.*

Priority E4 of Better environmental outcomes for native vegetation, biodiversity, land, rivers and coastal waterways makes a strong connection with the Standard and Targets established by the Natural Resources Commission which all Catchment Management Authorities are focused on meeting.

NSW Government has recently supported processes to more effectively monitor and report change in resource condition. This is led by DECC and the development of a state wide **Monitoring Evaluation and Reporting (MER) Strategy**. This strategy supports implementation of the 13 targets proposed by the Natural Resources Commission and included in the State plan under Priority E4. NSW DPI leads the development of MER protocols against three targets – T4 for invasive species, T7 for marine ecosystems and T12 for socio-economic well being.

The NSW Government has recently submitted a $3 billion package of activities under the Water for the Future program, titled Sustaining the Basin. The package is designed to deliver in the order of 1000 gigalitres of recovered water per annum for the benefit of both the environment and the communities that rely on the Murray Darling for their livelihood. The activities are focused on infrastructure projects. NSW DPI will lead a project on socio-economic assessment valued at approximately $1.3 million and a large project titled Irrigation Farm Modernisation, valued at $300 million over eight years.

*Within NSW DPI*

The Science and Research Division Board of Management have identified the following **priority research areas for 2008 to 2011:**

- Climate change
- Water management (irrigation and dryland)
- Bio-security including food health and pesticides
- Food security
- Ecology and biodiversity

A Water Network has been established and operating across divisions for some months. This has terms of reference relating to policy development as well as promoting NSW DPI's capacity to lead strategic water issues. The Water Network is in the process of finalising a NSW DPI Water Priority Statement 2008 – 2010 that sets the direction for priority water actions by NSW DPI for 2008 – 2011. The Water Action Plan is an internal, NSW DPI wide document, designed to articulate actions requiring cross divisional, coordinated activity and generally does not include actions that are single division accountabilities. The actions that the S&R Division has carriage of are included in Appendix 2.

NSW DPI is registered with the Bureau of Meteorology under the Survey for Water Regulations Online as a Category B provider – *agencies who collect water information but whose primary function is not water resource planning, management or policy*. Three components of NSW DPI have a legislative responsibility to provide data to the BoM – the weather stations and Key Sites research under S&R and forest hydrology monitoring of Forests NSW.

## NSW DPI's capabilities in water research

NSW DPI undertakes research to encourage the sustainable and appropriate use of water by the State's primary industries. Research into efficient use of water, better management of water losses, maximising returns from available water and water quality issues are addressed. NSW DPI also leads research to ensure the movement of water and salt in catchments and into waterways is understood, and that recommendations and policy to support new land management systems are based on this knowledge.

Specific projects include research into the use of water for irrigation and in irrigated farming systems, hydrology of farming systems in salt affected catchments, impact of planted and native forestry, and the discharge of acid water from acid sulfate soils in coastal catchments. This research deals with water at a range of scales from soil/plant interface to whole of catchment. Research is also undertaken into the socio-economic impact of water reform policies.

NSW DPI's core research strength stems from a combination of scientific excellence and a strong extension focus. The department is ranked internationally in the top 1% of world scientific institutions in the fields of agriculture, and plant and animal sciences. It is also actively engaged with and has a high level of credibility with the largest single group of water managers in NSW – farmers, foresters, fishers and miners.

Strengths specific to water research include leading the economic and socio-economic evaluation of water/NRM issues and a demonstrated knowledge of the interaction of surface and groundwater systems with land use at a paddock, farm and catchment scale. NSW DPI researchers manage high quality data sets in regolith mapping, soil classification, land use etc as base GIS layers for planning NRM/water research and modelling. The department has a demonstrated capability in the management of large research projects and has partnerships with key industry and research players, including numerous CRCs, Research and Development Corporations and Universities

NSW DPI water research is often farm, paddock scale and here our expertise is obvious. However to ensure continued relevance into the future, this research needs to be prioritised in the context of broader water accounting being attempted by the

Bureau of Meteorology and involved state agencies (DECC, DWE etc). Agriculture is both a major user of water and in many cases agricultural land exports significant quantities of water. It is also known that agriculture/land use has significant effects on water storage/ export.

## S&R framework for investment

The Primary Industries Science and Research Strategy 2005 – 2008 (page 3) proposes a framework to ensure that investment results in maximum benefit to stakeholders and that future allocation decisions for research will be based on the following criteria:

- Appropriateness of the issue
    - Existence of market failure
    - Alignment with corporate goals and state needs and priorities
    - Significance of the problem
    - Appropriateness and capacity of agency (skills, competence, critical mass, infrastructure and competitive advantage)
- Efficiency of investment strategies
    - Likely return on investment (economic, environmental and social)
    - Achievement of a targeted outcome at least cost
- Effectiveness of research and development approaches
    - Likelihood of success
    - Identification of beneficiaries
    - Capacity to extend new knowledge
    - Probability of various (desirable and undesirable) outcomes
    - Performance against agreed indicators.

This investment framework has been considered and supported by the NSW DPI Board of Management and the Minister. It provides a valid tool on which to base decisions relating to allocation of research resources.

## NSW DPI S&R water research projects currently underway

NSW DPI's recently commissioned Clarity database contains over 2200 NSW DPI projects including all projects led by the S&R Division. Clarity has been interrogated to identify what water research activities are under way in S&R. This interrogation involved the preparation of a list of S&R staff who have a role with water research. An estimate was made of each individuals time allocated to water research, after a brief discussion with the relevant Research Leader. This revealed 58 staff members contributing approximately 19 FTE to water research.

All projects led by the 58 staff members were reviewed and cut down to provide a list of 93 research projects with a water component.

As a starting point, the water research FTE identified with RLs was applied to each project to indicate a proportion of the project funds that may be relevant to water research. For example, if a research officer had 20% of their time nominated to water research by their RL, 20% of individual project budgets were assumed to be relevant to water research. After this coarse means of analysis was applied, each of the projects had the water component reviewed and later altered if it appeared warranted.

This has provided an estimate of the proportion of the S&R external funds budget that is being applied to water research. While it is rough, it is transparent.

The analysis has revealed that a total of approximately $6.427 million of external funds for research projects that have some water components is utilised by S&R each year. When the FTE multipliers are used on individual projects, the annual total external funds for water research activities led by S&R is $2.349 million.
If S&R receive total external funds of $50 million per year, the proportion of external funds applied to water research activities is 4.7%.

If S&R has 400 permanent research and technical FTE, the 19 FTE identified as contributing to water research is approximately 4.8%.

Observations in regard the analysis include:

- There are a large number of 'small' water projects – 93 projects at a total value of $2.5 million gives an average of $27K per project per annum
- The largest single project is Key Sites that received about $700 K per annum for 5 years. It is nominated as 100% water focused.
- The nominated water component of 7 rice breeding projects [50%] totals about $515K per annum.
- Take out Key Sites and rice and we halve our water research activities.
- Key Sites will not gain access to anywhere near the same amount of funds as it has in the past.
- Funds for rice breeding are sourced from industry and the industry has had very little income for a number of years.
- 50% of our water research is at risk of ceasing very soon.

**Table 1: Audit of S&R Water projects**

| Grouping | # Projects | $ Value (annual external) | % of total |
|---|---|---|---|
| Water focused – measuring and monitoring [A] | 5 | $830,709 | 35 |
| Breeding in irrigated farming systems [D] | 12 | $657,007 | 28 |
| Grazing systems [E] | 12 | $198,685 | 8 |
| Irrigation focused, including irrigated farming systems [B] | 14 | $191,561 | 8 |
| Horticulture – broadacre including citrus [G] | 6 | $155,936 | 7 |
| Breeding in dryland farming systems | 9 | $112,659 | 5 |
| Broadacre cropping systems | 8 | $45,336 | 2 |
| Horticulture – greenhouse and hydroponic [J] | 2 | $43,347 | 2 |
| Forestry [K] | 3 | $33,418 | 1 |
| Horticulture – vegies [H] | 2 | $27,907 | 1 |
| Water quality / nutrition / acidity [L] | 7 | $23,419 | 1 |
| Overseas aid projects [M] | 3 | $14,468 | 1 |
| Viticulture [I] | 10 | $14,321 | 1 |
| | **93** | **$2,348,852** | |

Summary points from Table 1.

- Total of 93 projects with a water focus
- Total average annual value of water projects $6.427 million
- Average annual investment into water component of the projects - $2.349 million
- Average proportion of projects targeted at water – 37%

## Water research structures within NSW DPI

Within NSW DPI water research in an agricultural context is largely dispersed across many Units. It could be argued that most if not all of NSW DPI's research activities at least intersect with water issues. Much of the farm systems, plant breeding and livestock health units are involved with research that is intended to improve the efficiency or productivity of water systems, especially regarding their capacity to optimise benefits of water utilisation by industry groupings.

The dispersed nature of water research is likely to be a result of NSW DPI having operated for many years with a primary focus on industry groupings, rather than a focus on management of specific resources such as water or soil. Such an industry focus has been an effective way to support the development of specific primary industries. However, issues that are common across all industries – water and probably soil – are not always addressed effectively by an industry focus approach.

There are two (agricultural) Units with a specific water research focus – Salinity & Catchment Hydrology with research principally focused on dryland systems and the impact of land use at a paddock, farm and 1$^{st}$ or low order sub-catchments and the Climate Science & Irrigation Unit which includes a water focus on the development of sustainable production systems for irrigated agriculture, as well research to mitigate and develop strategies to adapt to climate change.

There are Units with fisheries pedigrees that are focused on water – the Aquatic Ecosystems and Wild Fisheries Units. In addition, much of the horticulture research is focused on water management because of the reliance of horticulture on supplementary or full irrigation.

## Objectives of NSW DPIs involvement in water R&D

A group of Level 4 Leaders/Managers from three Divisions led by Rob Young is making progress to finalise the water theme paper. The group met in January and identified a comprehensive list of water research actions for the S&R Division to ensure we are placing appropriate focus on the water management issue.

These actions have been grouped into seven broad themes or objectives that are intended to meet the following outcomes:

| Outcome | Objectives |
|---|---|
| Returns from the use of water are maximised | • Develop an understanding of the economic incentives facing users of water in primary industries and the community with respect to water use technologies and water management policies *(Note: This bio-economic analysis objective meets all three Outcomes).*<br>• Improve current and develop new agricultural, horticultural and forestry systems to improve water use and productivity at the farm, catchment and NSW scale.<br>• Improve the water productivity of irrigation systems.<br>• Identify plant varieties and adjust traits that enable them to capture more of the available water. |
| Functional and productive ecosystems are maintained or improved | • Develop management systems for primary industries that minimise adverse impacts on water quality and ecosystem functions. |
| Water resource planning and policy addresses primary industries' needs | • Improve capacity to respond to the water that is available<br>• Provide information and knowledge to develop policy that results in sound water management. |

The Outcomes included above have been established by the NSW DPI Water Network which operates across divisions. The network has terms of reference relating to policy development as well as promoting NSW DPI's capacity to lead strategic water issues. The outcomes have been included in the NSW DPI Water Priority Statement 2008 – 2010 which sets the direction for priority water actions by NSW DPI over the next three years. The Water Priority Statement is an internal, NSW DPI wide document, designed to articulate actions requiring cross divisional, coordinated activity and generally does not include actions that are single division accountabilities.

## Water research actions to address the Water Management Theme in S&R

**Table 2:**

| **Outcome** | **Objective** *(led by)* | **Actions** *(across all agricultural and forestry industry sectors)* |
|---|---|---|
| Returns from the use of water are maximised | Improve current and develop new agricultural, horticultural and forestry systems to improve water use and productivity at the farm, catchment and state scale.<br>*(Peter Regan)* | Research areas – increase knowledge and understanding of:<br>• Farming systems, livestock systems and rotations that utilise water more efficiently<br>• Management strategies to increase the tolerance of plants and systems to periods of water stress<br>• The role of precision agriculture in improving water productivity<br>• Integration of cropping and grazing systems for better water use outcomes<br>• The critical water management needs for intensive livestock and livestock on irrigated pastures<br>• The critical water management needs for protected cropping industries (eg greenhouse, hydroponics)<br>• The issues and locations where significant adaptation or adjustment is required to respond to new water use needs |
| | Identify plant varieties and adjust traits that enable them to capture more of the available water.<br>*(John Sykes)* | Research areas – increase knowledge and understanding of:<br>• New crop and pasture varieties that maximise yield when fully or partially irrigated.<br>• Accurate identification (phenotype) of plant growth traits that can be adjusted to improve yield when water is limited.<br>• The role of genetic variation to improve yield when crops and pastures are stressed at critical growth stages. |

| **Outcome** | **Objective** *(led by)* | **Actions** *(across all agricultural and forestry industry sectors)* |
|---|---|---|
| | Improve the water productivity of irrigation systems<br>*(Geoff Beecher)* | Research areas - increase knowledge and understanding of:<br>• Irrigation systems (on and off farm) that are flexible and better aligned to soil, crop and irrigation supply (quantity and quality) constraints in field situations including financial viability<br>• Role of hydroponics in covered cropping and field crop situations<br>• Continued improvement of irrigation technology to quantify and manage water in irrigation systems |
| Functional and productive ecosystems are maintained or improved | Develop management systems for agricultural industries that minimise adverse impacts on water quality and ecosystem functions.<br>(soils, ASS, water quality, habitat (links with biodiversity and fish) *(Peter Slavich)* | Research areas – increase knowledge and understanding of<br>• Interactions between management of agriculture and forestry systems on sediment loads to waterways<br>• Interactions between nutrient management practices on nutrient loads to waterways and groundwater.<br>• Interactions between land management systems, drainage systems and water quality.<br>• Interactions between on-farm water retention systems and hydrological processes (groundwater recharge, runoff, and stream flow), water quality and aquatic ecology in small catchments<br>• Interactions between land uses (vegetation type) and hydrological processes affecting stream flow and quality |
| Water resources planning and policy address primary industries needs | Improve capacity to respond to the water that is available<br>*(Rob Young)* | Research areas – increase knowledge and understanding of:<br>• What is required to make sound, defendable decisions regarding the use of water that is available<br>• Planning decisions regarding the season variability in water availability<br>• Planning decisions around longer term climate change forecasts on water availability |

| Outcome | Objective *(led by)* | Actions *(across all agricultural and forestry industry sectors)* |
|---|---|---|
| | Provide information and knowledge to develop policy that results in sound water management<br>*(Rebekah Gomez-Fort)* | Research areas – increase knowledge and understanding of:<br>• The implications of government climate change policy on water availability (for example, policy relating to land use and interception)<br>• Which industries in which locations will require adjustment<br>• Production systems and technologies that will assist with adjustment<br>• The impact of farm rationalisation (eg increase property size) on capacity of new production systems to improve PI water productivity?<br>• The research required to influence water sharing decisions for the benefit of primary industries |
| | Develop an understanding of the economic incentives facing users of water in primary industries and the community with respect to new water use technologies and water management policies.<br>*(John Mullen)*<br><br>***Note**: This objective is common across all three outcomes.* | Bio-economic modelling will lead to profitable decisions by primary producers about their use of water and inform the development of water use policy reflecting the interests of the community. (*why we do it)*<br><br>Conduct bio-economic analysis of the TBL impacts of new technologies and changes in land use and water availability in agricultural and forestry systems by evaluating on farm and downstream impacts of new irrigation technologies,<br>o Evaluating on farm and downstream impacts changes in the amount and timing of water entitlements and emerging water markets,<br>o Evaluating the on farm and downstream impacts of all land uses which deliver different water quality and quantity outcomes<br>o Evaluating the implications of changes to water availability to structural adjustment<br><br>Economic analysis tools to be implemented include:<br>o Enterprise budgeting<br>o Crop sequence budgeting<br>o Whole farm budgeting<br>o Bio-economic programming models<br>o Benefit cost and real options analysis<br>o Experimental economics<br>o Valuation of natural resource flows<br>o Assessing distribution of winners and losers to better understand social impacts |

## SWOT of NSW DPI water research

**Table 3: SWOT of NSW DPI Water Research**

| Strengths | Weaknesses |
|---|---|
| • Capacity for integrated RD&E<br>• Good connections with primary industries [commodity based]<br>• Good range of disciplines – multi disciplinary teams<br>• Good staff reputations and skill recognition<br>• Competitive advantage at 'farm scale'<br>• Socio-economic / bio-economic analysis skills and capability<br>• Pre-breeding capability<br>• Local scientific knowledge of climate, soils etc<br>• Strong science base<br>• Good plat stress physiology knowledge base across all commodities [plant response to water stress]<br>• Lots of resources [field equipment etc] to do water research | • Staff losses: do not know medium future, reliance on short term, loss of experience & leadership<br>• Small 'water industry' so poor funding for research<br>• Limited engineering capacity for system design<br>• Undeveloped linkages to other agencies and universities<br>• Industry focused and challenged by a 'non industry' issue<br>• Increase %age of staff on external funds for NRM – despite the obvious public good<br>• Short term funding cycles for long term issues [NRM]<br>• Loosing connection with extension and policy due to divisional structure<br>• Lack of numbers or critical mass in the water area<br>• People working on water are spread across a number of different programs / branches<br>• Loss of science experience<br>• Reduced opportunity for training<br>• No CR recruitment |
| **Opportunities** | **Threats** |
| • Water is a big issue / priority issue politically<br>• Opportunity to liaise with clients and parallel providers<br>• Great amount of water funding<br>• NSW DPI can meet many water needs for many partners [industry, investors etc]<br>• Re-focus on water as the main game<br>• Growing global demand for food means that agriculture/food security has an important future – an essential service<br>• Partnerships with other research agencies / universities<br>• Opportunity to build capacity in areas of skill shortage<br>• Refocus to high priority areas | • International response to GHG reduction – how bad might CC become?<br>• CC impacts and recommendations<br>• Treasury, budgets [in NSW DPI],<br>• PWC review<br>• Competitive advantage not articulated and recognised<br>• Other agencies<br>• Too much noise / too much going on in the area of water / NRM, climate etc<br>• Lack of economic incentive for adoption of practice change<br>• Lack of water<br>• Outputs may be overshadowed by other agendas eg CC<br>• Competition for external funds<br>• Feds bypassing state agencies |

This SWOT analysis can be used as the basis of the preparation of a prospectus on NSW DPI's water research capabilities (based on the identified strengths and opportunities) and a risk management strategy (based on the identified weaknesses and threats).

## Appendices

**i) Water research actions to address the Water Management Theme in S&R** – Note this table contains the same actions and research areas as the table in the body of the report and also includes specific research questions.

| **Outcome** | **Objective** *(led by)* | **Actions – research questions?** *(across all agricultural and forestry industry sectors)* |
|---|---|---|
| Returns from the use of water are maximised | Improve current and develop new agricultural, horticultural and forestry systems to improve water use and productivity at the farm, catchment and state scale.<br><br>Primary industries systems (rotations, livestock, productions, pathogens, animal welfare) *(Peter Regan)* | Research areas – increase knowledge and understanding of:<br>• Farming systems, livestock systems and rotations that utilise water more efficiently<br>• Management strategies to increase the tolerance of plants and systems to periods of water stress<br>• The role of precision agriculture in improving water productivity<br>• Integration of cropping and grazing systems for better water use outcomes<br>• The critical water management needs for intensive livestock and livestock on irrigated pastures<br>• The critical water management needs for protected cropping industries (eg greenhouse, hydroponics)<br>• The issues and locations where significant adaptation or adjustment is required to respond to new water use needs<br><br>Research will be conducted to answer the following questions (in irrigated and rainfed systems):<br>• What new and improved rotations and systems will maximise WUE and better manage water resources (and associated resource issues including soils, water quality, acidity, nutrients etc)<br>• What new and innovative systems will be more flexible, adaptive and opportunistic?<br>• How do we improve the flexibility of our irrigation systems – agronomy, rotation ?<br>• Which annual cropping systems will be more water efficient?<br>• How can we better integrate cropping and grazing systems (ie integration of crops and perennial spp to improve resilience to drought)?<br>• What management strategies will increase tolerance of plants and systems to periods of water stress?<br>• What are the specific needs and solutions for low RF zones (eg water efficient varieties)<br>• What adaptive management strategies will increase tolerance to water stress?<br>• How can precision agriculture be applied to water use efficiency needs?<br>• What are the critical water management needs for livestock in irrigated pasture systems?<br>• What are the critical water management needs for intensive livestock systems?<br>• What are the water research needs of the protected cropping industries? (pathology, water quality, water re-use, use of non potable and reclaimed water)<br>• What are the issues and locations where significant adaptation or adjustment is required and new areas suitable for sustainable and profitable primary industries' water use?<br>• What are the effects of forestry activities (afforestation, pine plantation, native forests and their management/silviculture, access roads) on catchment water yields and water quality?<br>• What are the impacts of forestry activities on groundwater recharge to streams and groundwater nutrients? |
| | Identify plant varieties and adjust traits that enable them to capture more of the available water. *(John Sykes)* | Research areas – increase knowledge and understanding of:<br>• New crop and pasture varieties that maximise yield when fully or partially irrigated.<br>• Accurate identification (phenotype) of plant growth traits that can be adjusted to improve yield when water is limited.<br>• The role of genetic variation to improve yield when crops and pastures are stressed at critical growth stages. |

| **Outcome** | **Objective** *(led by)* | **Actions – research questions?** *(across all agricultural and forestry industry sectors)* |
|---|---|---|
| | Improve the water productivity of irrigation systems *(Geoff Beecher)* | Research areas - increase knowledge and understanding of:<br>• Irrigation systems (on and off farm) that are flexible and better aligned to soil, crop and irrigation supply (quantity and quality) constraints in field situations including financial viability<br>• Role of hydroponics in covered cropping and field crop situations<br>• Continued improvement of irrigation technology to quantify and manage water in irrigation systems<br><br>Specific research questions would focus around the following questions<br>• How should the irrigation system paradigm be changed to achieve both WU and energy efficient systems (ie bank-less channels, tradeoffs when converting from gravity to pressurised systems)?<br>• How to design systems that are flexible enough to cope with increasing variability of supply and still meet sustainability and productivity outcomes?<br>• Does improved precision of irrigation lead to a more sustainable system at a regional scale (ie the impact of improved irrigation efficiency at the root, field, farm and regional scale)?<br>• How do hydroponic systems compare to field irrigation systems for vegetable and other crops?<br>• What are the opportunities for the use of waste water (eg in greenhouse systems)?<br>• What are the opportunities to better use water in greenhouse systems?<br>• How do various hydroponic systems compare – WUE, disease control, food safety etc?<br>• Where are the opportunities to integrate aquaculture and horticulture with regard to hydroponics?<br>• How can irrigation technology including scheduling, root-zone management improve water use?<br>• What are the opportunities for better timing and placement of irrigation water to improve WUE in perennial crops?<br>• How can water delivery systems be better managed to improve WUE?<br>• How can on farm infrastructure be improved to take advantage of opportunistic flows?<br>• How can improved irrigation technology (lasering, layouts, pressurised, subsurface drip etc) and better irrigation system design improve WUE?<br>• What are the critical water management needs for intensive livestock systems?<br>• What ongoing research is required to support the Tools developed by CRC IF (eg IRRImate, IRRIgate, SMS scheduling etc)<br>• How can we better align our irrigation systems to soil and resource capacity needs? |

| **Outcome** | **Objective** *(led by)* | **Actions – research questions?** *(across all agricultural and forestry industry sectors)* |
|---|---|---|
| Functional and productive ecosystems are maintained or improved | Resource capacity and health<br><br>Objective<br>To develop management systems for agricultural industries that minimise adverse impacts on water quality and ecosystem functions.<br>(soils, ASS, water quality, habitat (links with biodiversity and fish)<br>*(Peter Slavich)* | Research areas – increase knowledge and understanding of<br>• Interactions between management of agriculture and forestry systems on sediment loads to waterways<br>• Interactions between nutrient management practices on nutrient loads to waterways and groundwater.<br>• Interactions between land management systems, drainage systems and water quality.<br>• Interactions between on-farm water retention systems and hydrological processes (groundwater recharge, runoff, and stream flow), water quality and aquatic ecology in small catchments<br>• Interactions between land uses (vegetation type) and hydrological processes affecting stream flow and quality<br><br>Specific research questions would focus around the following questions<br>• Where are the major runoff and recharge areas of NSW that provide most of the water resources?<br>• What are the dominant hydrological processes and what are the threats / risks / opportunities?<br>• What are the critical bio-physical processes that influence the flow of water and to what extent can they be influenced or changed?<br>• How will changes to landuses (including perennial pastures, afforestation, conservation farming) affect water supply, security, quality? And how will this knowledge improve BMPs for fertiliser, grazing, cultivation etc?<br>• What are the optimum combinations of landuse that provide optimum balance between water inputs and outputs (RF, ET, runoff and recharge)<br>• Where are the sources of sediment and what BMPs will better manage sediment delivery to streams and protect the aquatic environment?<br>• What agricultural and forestry practices will best improve carbon/soil health to improve soil water holding capacity?<br>• What management practices will best manage water quality (nutrient export, nutrient balances)<br>• What are the most appropriate land management strategies for floodplains – eg black water, acid water?<br>• What is the impact of land use at the paddock to farm scale [low order sub-catchment, includes all areas of NSW] on water quality and quantity?<br>• What are the impacts of irrigation on native fish and what management can minimise this?<br>• What is the impact of mining industry on agricultural land [eg subsidence and aluminium oxide pollution effect on viticulture in the Hunter] |

| **Outcome** | **Objective** *(led by)* | **Actions – research questions?** *(across all agricultural and forestry industry sectors)* |
|---|---|---|
| Water resources planning and policy address primary industries needs | Improve capacity to respond to the water that is available *(Rob Young)* | Research areas – increase knowledge and understanding of:<br>• What is required to make sound, defendable decisions regarding the use of water that is available<br>• Planning decisions regarding the season variability in water availability<br>• Planning decisions around longer term climate change forecasts on water availability<br><br>Specific research questions would focus around the following questions<br>• What advantages can more accurate seasonal and long term RF prediction offer to primary industries?<br>• What are the areas most impacted by CC?<br>• How will reduced and changing patterns of rainfall affect hydrology at the production scale and?<br>• What are the critical moisture contents that influence GHG emissions from primary production systems including soils, pastures, ruminants?<br>• How can weather, seasonal climate and climate change forecasts be incorporated into water resource decision making at all geographic scales?<br>• Can within season DSTs be of benefit regarding probability analysis of water stress, adaptive response options? |
| | Provide information and knowledge to develop policy that results in sound water management *(Peter Regan)* | Research areas – increase knowledge and understanding of:<br>• The implications of government climate change policy on water availability (for example, policy relating to land use and interception)<br>• Which industries in which locations will require adjustment<br>• Production systems and technologies that will assist with adjustment<br>• The impact of farm rationalisation (eg increase property size) on capacity of new production systems to improve PI water productivity?<br>• The research required to influence water sharing decisions for the benefit of primary industries<br><br>Specific research questions would focus around the following questions<br>• Are there any other viable alternatives to traditional water storage (eg managed aquifer recharge?)<br>• What is the contribution of primary industries to diffuse source water pollution?<br>• Is the science done by other agencies reliable / sound / true? (eg Snowy Hydro, SCA, etc) |

| Outcome | Objective *(led by)* | Actions – research questions? *(across all agricultural and forestry industry sectors)* |
|---|---|---|
| | Bio-economic analysis *(John Mullen)*<br><br>*Develop an understanding of the economic incentives facing users of water in primary industries and the community with respect to new water use technologies and water management policies.*<br><br>***Note**: This objective is common across all three outcomes.* | Bio-economic modelling will lead to profitable decisions by primary producers about their use of water and inform the development of water use policy reflecting the interests of the community. (*why we do it)*<br><br>Conduct bio-economic analysis of the TBL impacts of new technologies and changes in land use and water availability in agricultural and forestry systems by evaluating on farm and downstream impacts of new irrigation technologies,<br>o Evaluating on farm and downstream impacts changes in the amount and timing of water entitlements and emerging water markets,<br>o Evaluating the on farm and downstream impacts of all land uses which deliver different water quality and quantity outcomes<br>o Evaluating the implications of changes to water availability to structural adjustment<br><br>Economic analysis tools to be implemented include:<br>o Enterprise budgeting<br>o Crop sequence budgeting<br>o Whole farm budgeting<br>o Bio-economic programming models<br>o Benefit cost and real options analysis<br>o Experimental economics<br>o Valuation of natural resource flows<br>o Assessing distribution of winners and losers to better understand social impacts<br><br>Actions/questions originally posed under bio-economic analysis:<br>• Conduct bio-economic analysis of agricultural and forestry systems and new technology under changing water resource circumstances:<br>• Evaluating on farm and downstream impacts of new irrigation technologies, changes in the amount and timing of water entitlements,<br>• Evaluating on farm impacts of land use options with different water requirements<br>• What is the economic impact of changes to the production systems where significant adaptation or adjustment is required?<br>• What is the economic impact of not fully utilising available resources (water, nutrients etc)<br>• What are the environmental, social and economic consequences of land use in the upper catchments on downstream water users?<br>• What systems or tools can better inform decision making on water sales? 1.2.16, ???<br>• What are the impacts of changes in water technology and availability at the whole farm scale?<br>• What is the economic impact of changes to agricultural and forestry water use at scales beyond the farm?<br>• How do we best apply our bio-economic knowledge to socio-economic analysis?<br>• How do we best utilise NSW DPIs economic analysis capabilities to inform the water trading market?<br>• How do we best apply the Real Options Valuations tool of Anthea McClintock? |

## Appendix ii) S&R Staff with a proportion of time nominated as water research (permanent staff only)

| Name | FTE | Name | FTE |
|---|---|---|---|
| **Salinity & Catchment Hydrology** | | **Viticulture** | |
| Bernardi | 0.9 | Hutton | 0.1 |
| Daniells | 0.6 | Holzapfel | 0.4 |
| Hean | 0.6 | Rogiers | 0.4 |
| Hume | 0.6 | **Pastures & Rangelands** | |
| McLeod | 0.6 | Badgery | 0.1 |
| Mitchell | 0.9 | Boschma | 0.1 |
| Murphy | 0.6 | Lodge | 0.1 |
| Regan | 0.8 | Millar | 0.1 |
| **Climate Science& Irrigation** | | **Systems Research** | |
| Akbar | 1.0 | Fettell | 0.1 |
| Beecher | 0.7 | Fisher | 0.1 |
| Dunn B | 0.7 | Haig | 0.1 |
| Dunn T | 0.4 | Hayes R | 0.1 |
| Gill | 1.0 | Jenkins | 0.1 |
| North | 1.0 | Li | 0.1 |
| **SRORT** | | Martin | 0.1 |
| Dougherty | 0.15 | McMullen | 0.1 |
| Hulugalle | 0.2 | Newell | 0.1 |
| Eldridge | 0.15 | Singh | 0.1 |
| Hirst | 0.7 | Verrell | 0.1 |
| Kimber | 0.1 | **CG&I** | |
| Slavich | 0.3 | Martin | 0.15 |
| Weaver | 0.2 | Nordblom | 0.2 |
| **Forest Resources** | | Reinke | 0.5 |
| Barton | 0.1 | Snell | 0.5 |
| **Horticulture** | | **POG&I** | |
| Parks | 0.35 | Gaynor | 0.15 |
| Sanderson | 0.4 | Luckett | 0.15 |
| Irving | 0.4 | Moore | 0.15 |
| Lidbetter | 0.1 | Rose | 0.1 |
| Golding | 0.1 | **Plant Health Sciences** | |
| McFadyen | 0.1 | Forysth | 0.1 |
| Satyan | 0.1 | Milgate | 0.5 |
| Treeby | 0.3 | | |
| | | **TOTAL** | **19.05** |
| | | **% of 400 FTE in S&R** | **4.76%** |

### iii). NSW DPI Water Priority Statement

The Water Priority Statement is under preparation by the NSW DPI Water Network, with a summary table of draft strategies below. S&R has carriage of the strategies highlighted in blue.

| CORPORATE PLAN KRAs | WATER OUTCOMES | KEY OBJECTIVES | STRATEGIES |
|---|---|---|---|
| Strong economic performance of primary industries | Maximise returns from the use of water | Efficient water use | 1. Define new production systems to improve primary industries' water productivity and associated energy efficiency<br>2. Increase adoption of water efficient practices through planning, water efficient technologies and improved management |
| | | Efficient infrastructure | 3. Identify potential improvements in water access and river function that can result in changes to river operations<br>4. Develop models to improve water management practices and understanding of socioeconomic impacts<br>5. Identify scenarios for improving water supply operations to meet industries water needs for sustainable irrigation supply schemes |
| | | Primary industries adapting to changing environments | 6. Identify priority issues and locations where significant adaptation or adjustment is required and identify new areas suitable for sustainable and profitable primary industries' water use<br>7. Equip stakeholders to adjust to changing water availability |
| Appropriate access to and wise management of natural resources | Maintain or improve functional and productive ecosystems | Sustainable technologies & practices for NRM | 8. Develop rural land use systems that deliver priority water quality outcomes<br>9. Address land based causes of decline in water quality and quantity<br>10. Reduce impacts of irrigation practices on native fish<br>11. Identify flow regimes required to enhance key native fish populations<br>12. Facilitate the adoption of energy efficient water technologies |
| | | Key risks to ecosystems are managed | 13. Reduce the impacts of mining on aquatic ecosystems<br>14. Identify the key risks to aquatic biodiversity<br>15. Develop and implement management options to mitigate biodiversity risks that relate to water management<br>16. Inform environmental water planning and releases to enhance both ecosystems and ecosystems services |
| A strong voice for primary industries | Water resources policy and planning address primary industries needs | Water policies & plans provide certainty & rights are clearly defined | 17. Collect and analyse data on water resource availability and reliability assessments and forecasts<br>18. Prepare regional primary industry profiles that include water requirements and key socioeconomic indicators<br>19. Prepare socioeconomic data to inform the water sharing decision making process<br>20. Negotiate primary industry water requirements for informing water sharing decisions<br>21. Contribute to the development of National and State water policies |
| | | A business approach is applied to primary industries water access and management | 22. Contribute to the development of accounting and reporting standards and assess impact of pricing on primary industries' viability and rates of adjustment<br>23. Monitor and evaluate the effectiveness of water trading markets<br>24. Develop flexible water products for primary industries needs<br>25. Equip sector to participate in water trading markets |

**iv) Technical detail**

It is proper to define water in NSW and Australia as a scarce resource, however this concept needs to be appropriately defined and there has been considerable expertise in developing various concepts of water scarcity. Broadly there are two types of water scarcity;

- physical water scarcity - not having sufficient water resources to meet minimum domestic, agricultural, and environmental needs, even with full development and most productive utilisation of their water resources, and
- economic water scarcity - have sufficient water resources to meet their minimum needs, but will have to embark on extremely expensive and possibly environmentally harmful water development projects, such as dams and canals, to actually utilise these resources.

Employing these concepts we can see that very few areas in NSW and Australia would be classified as physically water scarce, as even some of the areas prone to water shortages still have scope to increase efficiency or access additional water resources but possibly at great economic cost.

It is therefore convenient to form criteria about developing water availability on the themes of either increasing water use efficiency or increasing water availability. Part of this is also the ability to predict current or seasonal water availability for a basis to plan seasonal farming and primary production activities.

Water availability can be defined by the following three components;

(1) Local runoff; runoff that is available within a defined boundary in this case farm or small sub catchment. This component is important for local water supplies such as stock and domestic supplies and local environmental uses. This water fraction also includes return flows from irrigation (tail water) which can be recaptured and used within the farm scale.

(2) Exogenous runoff (routed runoff from upstream); this is water sourced from outside the farm or sub catchment and is generated by excess water needs further upstream. Factors that effect exogenous runoff include increased extraction, increased interception and decreased rainfall.

(3) Virtual water flow: the term Virtual Water is defined as the amount of water needed to produce a commodity or service of any kind, although it is most commonly used in relation to the water required to produce agricultural commodities. This concept is important to consider when discussing how water can be substituted. For instance it has been estimated that Australia exports in excess of 2000 $m^3$/capita/yr of virtual water.

Water efficiency can be broadly defined as the ratio of the amount of water extracted or applied to the amount of yield obtained. Increasing the yield or decreasing the amount of applied water per area are both ways of increasing water use efficiency.

Considerable research has been completed on increasing water efficiency at the field and farm scale particularly by NSW DPI and NSW Agriculture. Additionally there has been a considerable research effort to increase efficiency at the irrigation scheme scale particularly with determining and minimising conveyance losses. However so far little research has been completed on measuring water availability particularly in terms of the three components outlined above. As discussed above water availability is affected by increased extraction, increased interception and deceased rainfall. In inland NSW the cap on extractions from the MDB limits further consumptive use therefore changes to availability depends on changes to interception and rainfall. Accordingly rainfall is outside the scope of management which leaves interception of exogenous runoff as the only component to manage to change water availability.