Use of Reclaimed Effluent Water in Australian Horticulture

Final Report

Project Number:
NPSI - VPI4

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Use of reclaimed effluent water in Australian horticulture
Stage 1: A scoping study
Stage 2: Research required to ensure sustainable development of horticultural industries in Australia

Funders and Collaborators:

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Disclaimer:

The National Program for Sustainable Irrigation focuses research on the development and adoption of sustainable irrigation practices in Australian agriculture. The aim is to address critical emerging environmental management issues, while generating long-term economic and social benefits that ensure irrigation has a viable future. The Program has 14 funding partners who are: Land & Water Australia (Managing Partner); Sunwater, Queensland; Horticulture Australia Limited; Goulburn-Murray Water, Victoria; Cotton Research and Development Corporation; Harvey Water, Western Australia; Lower Murray Water Authority, Victoria; Wimmera Mallee Water, Victoria; Ord Irrigation Cooperative, Western Australia; Australian Government Department of Agriculture, Fisheries and Forestry; Department of Natural Resources and Mines, Queensland; Department of Primary Industries and Resources South Australia; Department of Environment Water and Catchment, Western Australia; and Department of Agriculture, Western Australia.

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Project team and steering committee members participate in technical tours on recycled water use in horticulture across Australia

Table of Contents

1. Executive Summary

Being the world's driest inhabited continent with a human population of around 20 million places significant strain on Australia's water resources. Environmental, economic, and social drivers have increased pressure on policy makers to manage this precious resource as efficiently as possible. Significant reform in Australia's water policy has included an emphasis on the need to make better use of recycled water (DPS, 2005)[1] particularly where water of drinking water quality is not required (Radcliffe, 2004)[2]. This reform has aided the development of commercial recycled water schemes (Boland et al., 2005)[3] that provide a reliable and continuous source of water of 'fit-for-purpose' standard.

With the Australian horticultural industry expected to continue expanding, reliable access to water has been identified as one of the major limitations to growth and sustainability. Competition from urban, environmental, industrial, and other agricultural users for water has resulted in the exploration of recycled water options. However, the horticultural industry has generally viewed the use of recycled water with a degree of trepidation. This has mainly been due to concerns about community perceptions relating to food safety and the long-term sustainability of recycled water schemes, as well as the marketability of produce.

This project was established to determine the key drivers, barriers and knowledge gaps to the use of recycled water in Australian horticulture, and address these barriers through targeted research, development and extension activities. It was anticipated that increased knowledge in priority areas would lead to greater confidence in the safety and economic viability of recycled water schemes.

The project was conducted in two stages with the initial stage providing the groundwork for future work. Highlights in Stage 1 were;

- the establishment of a national multidisciplinary project team including expertise in biophysical and social research, training, communication and extension
- formation of a national steering committee representing all major stakeholders including environmental and health regulators, NRM agencies, water authorities, Quality Assurance, Horticulture Australia Limited, and horticulture growers
- development of a close collaboration with the Coordinator for Recycled Water Development in Horticulture (CRWDH) including the establishment of a joint steering committee
- assessment of the potential (availability and practicability) of reclaimed water use for the horticultural industry and subsequent publication as a book chapter
- development of a systems framework to identify the potential benefits and risks of irrigation with reclaimed water for competing users including major stakeholders of government, water suppliers, primary producers, market chain and consumers
- publication in an international journal of a comprehensive literature review identifying the key issues associated with the use of reclaimed water in horticulture
- conduct of 5 scoping studies addressing issues of; sustainability for primary producers; policy drivers; market requirements; consumer perceptions; and impediments for primary producers

Information derived in the initial stage of the project enabled the identification of key gaps in our knowledge and current research. The development of Stage 2 focused on four major areas;

- integrated best management practices and monitoring package based on risk principles
- understanding stakeholder perceptions
- training and education
- guidelines for policy

[1]Department of Parliamentary Services Australia (2005) Issues encountered in advancing Australia's water recycling schemes, cat. no. 2,2005-06, DPS, Parliamentary Library, Canberra, Australia.
[2]Radcliffe, J (2004) Water recycling in Australia, Australian Academy of Technological Sciences and Engineering, Parkville, Australia.
[3]Boland, A-M, Hamilton, AJ, Stevens, D & Ziehrl, A (2006) Opportunities for reclaimed water use in Australian agriculture, in D Stevens (ed*), Growing crops with reclaimed wastewater.* CSIRO Publishing, Collingwood, Victoria, Australia.

Stage 2 of the project responded to an immediate need for information on the safety, economic viability and environmental impact of recycled water schemes. Highlights from this stage were:

- increased understanding of stakeholder perceptions through a social appraisal of the South Australian Virginia Pipeline Scheme
- improved understanding of consumer perceptions to the use of recycled water for horticulture through a survey of 400 consumers in Melbourne
- application of the systems framework to 2 case study sites of Werribee Irrigation District (WID) and Virginia Pipeline Scheme (VPS)
- production of a practical guide for horticulture growers on how to use recycled water based on knowledge and experience of growers in the Virginia Pipeline Scheme (VPS) and Werribee Irrigation District (WID)
- distribution of approximately 200 copies of guide for growers
- development and distribution of more than 300 salinity tools including a salinity unit converter and salt tolerance of vegetable and fruit crops
- development of a training overlay to complement existing irrigation management training with a focus on the differences associated with recycled water
- publication of guidelines for developing recycled water schemes with more than 1000 copies distributed
- publication of an information document on recycling water in Australia for the general community
- effective utilisation of steering committee to guide and inform project outcomes
- high degree of interest from associated industries in the outputs from the project

The National Program for Sustainable Irrigation (NPSI) project also provided a catalyst for additional funding and work which was undertaken in the areas of food safety, risk assessment modelling and longer term sustainability for vegetables.

Many lessons were learnt through the conduct of the project and an analysis of these is provided. They focus on issues related to:

- application of systems-thinking approach
- obtaining the maximum benefit from an effective and knowledgeable steering committee
- collaboration and partnerships
- research, development, extension and policy continuum
- effective communication
- research innovation

This project has been instrumental in providing a firm foundation on the use of recycled water in Australian horticulture. While this baseline information has been provided at the right time there are many questions still unanswered. Areas that require further attention include:

Biophysical systems – understanding groundwater, surface water and irrigation linkages; managing the movement of salt and nutrients in water; environmental risk assessment

Social systems – understanding perspectives and issues of diverse stakeholders; application of systems framework to scheme development; understanding the social systems at a scheme level; undertaking economic analysis and recognising risks and rewards

Knowledge management – education and training including amenity horticulture, agriculture, water sector; extension to growers; perceptions of community, processors and growers; regulation and policy

Systems science – learning through systems science and the application of theory (eg through the Regional Irrigation Business Partnerships of CRC Irrigation Futures)

The project has made significant gains in addressing the issues related to recycled water in horticulture using innovative methodologies. Of greatest significance has been the application of a systems thinking approach, the integration of biophysical and social research with knowledge management, the effective utilisation of a skills based steering committee and the production of information documents to assist decision making for a range of audiences from the policy maker through to the horticulture producer. The outcomes from the project have and will continue to have a major impact on the adoption of recycled water for horticulture.

2. Background

Australia currently wastes close to 86% (1,376,000 ML) of its treated effluent water (reclaimed water). While use of reclaimed sewage effluent has increased over the past decade it still remains a small proportion of the amount of water running to waste. The potential exists to use this reclaimed water for horticultural production (including viticulture and amenity horticulture) freeing up significant volumes of irrigation water for alternative uses (eg potable).

Stage 1 of this project (national scoping study) determined the resource potential for reclaimed water in horticultural production and developed a systems framework for the assessment of potential benefits and risk associated with reclaimed water. The scoping study established a network of stakeholders representing a diversity of backgrounds and identified key gaps in knowledge. Stage 1 laid the foundation for, and clearly identified the key areas of research and development required in the next stage of the project.

Stage 2 of the project focused on the development and application of collective knowledge to enable the adoption of sustainable and safe practices for growers using reclaimed water for horticultural production.

The issue was tackled using a multidisciplinary approach undertaking strategic analysis, social and biophysical research and knowledge management.

3. Project Objectives

Stage 1: A scoping study

Undertake a national scoping study to assess the pros and cons of irrigation with reclaimed water in Australian horticulture by:

1. Establishing a national coordinated approach and key stakeholder network to a) inform best use policy objectives within catchments and b) integrate national research and development outcomes
2. Determining the potential (availability and practicability) of reclaimed water use for the horticultural industry
3. Developing a systems framework for the potential benefits and risks of irrigation with reclaimed water for competing users, applying a whole of catchment perspective
4. Identifying gaps in current research and undertaking project development for implementation of Stage 2

Stage 2: Research required to ensure sustainable development of horticultural industries in Australia

1. To facilitate the safe, productive, profitable and environmentally sound use of reclaimed water in Australian horticulture
2. To provide the tools and information for growers to identify risks, apply best practice and monitor key indicators
3. To ensure the adoption of these tools/guidelines through a targeted extension strategy
4. To enable growers to meet all stakeholders requirements (eg EPA, DHS, wholesalers, QA schemes, supermarkets) through effective communication and application of integrated management packages
5. Development and publication of guidelines to assist policy makers with regard to future implementation and communication of reclaimed water use in horticulture

4. Methods, Results and Practical Significance against Project Objectives

Stage 1: A scoping study

1. *A national coordinated approach and key stakeholder network were established through:*
   - Development of a national multidisciplinary project team including expertise in biophysical and social research, training, communication and extension **(Appendix 1 – project team)**.
   - The establishment of a national steering committee representing all major stakeholders including environmental and health regulators, NRM agencies, water authorities, Quality Assurance, Horticulture Australia Limited, and horticulture growers **(Appendix 2 – national steering committee)**. The steering committee met every 6 months with the technical meeting followed by a study tour. A newsletter was also established to inform the steering committee members of the project progress **(Appendix 2 – meeting minutes, newsletters)**. The steering committee was highly effective in guiding the progress and directions of the project and was fundamental to the production of highly relevant resources.
   - Collaboration with the Coordinator for Recycled Water Development in Horticulture (CRWDH) including the establishment of a joint steering committee.
   - Organisation and participation in national and international study tours to understand and appreciate issues associated with different stakeholders and available options in a broader water management context.
   - Collaboration with a broad rage of stakeholders including the CRC for Irrigation Futures, Department of Agriculture, Fisheries and Forestry (DAFF) and state agencies (Agriculture, Environment and Health).

2. *The potential (availability and practicability) of reclaimed water use for the horticultural industry was assessed.* This involved a desk-top analysis using available data predominantly provided by the ABS Water Account. The information was further developed and prepared as a chapter for publication **(Appendix 3 – opportunities for reclaimed water use in Australian agriculture)**.

3. *A systems framework was developed to identify the potential benefits and risks of irrigation with reclaimed water for competing users.* The framework applied a whole of catchment perspective including major stakeholders of government, water suppliers, primary producers, market chain and consumers and incorporated the key issues of stakeholder communication and engagement **(Appendix 4 – systems framework)**. The framework was applied to case study sites in Stage 2 and further developed as a process to be used in the establishment of new schemes.

4. *A comprehensive literature review was undertaken to identify the key issues associated with the use of reclaimed water in horticulture.* This review was published in an international journal **(Appendix 5 – literature review)**. The desk-top review and consultation with key stakeholders identified priority areas for further investigation. Five scoping studies were undertaken addressing the following key areas:
   - identification of risks and implementation of sustainable systems for primary producers at a regional level
   - identifying and communicating key policy drivers to key stakeholders (water suppliers, horticultural producers)
   - market analysis and communication – understanding of requirements for business systems (QA, HACCP & EMS)
   - consumer perceptions to the use of reclaimed water for horticulture
   - understanding impediments to the use of reclaimed water for primary producers

These scoping studies informed the development of Stage 2. While the scoping studies are provided **(Appendix 6 – five scoping studies)** the knowledge in the area was further developed in Stage 2 of the project. As a consequence, in some cases the information in the scoping studies has been superseded.

Information derived in Stage 1 of the project enabled the identification of key gaps in our knowledge and current research. The strategic analysis provided a clear process for defining priority areas and developing the project brief for Stage 2. Two key products from the initial analysis were:

- the policy position statement for the use of reclaimed water for Australian horticulture
- analysis of requirements of business systems (QA, HACCP, EMS) using reclaimed water

Both of these papers were important resources in the conduct of Stage 2.

Stage 1 also identified the requirement for additional research in the area of consumer attitudes to irrigation of horticulture produce. The key risks to the implementation of sustainable horticulture systems related to management of salinity, food safety and nutrients. The development of Stage 2 focused on 3 major areas;

- integrated best management practices and monitoring package based on risk principles
- understanding stakeholder perceptions
- training and education

The development of Stage 2 can best be described by Figure 1.

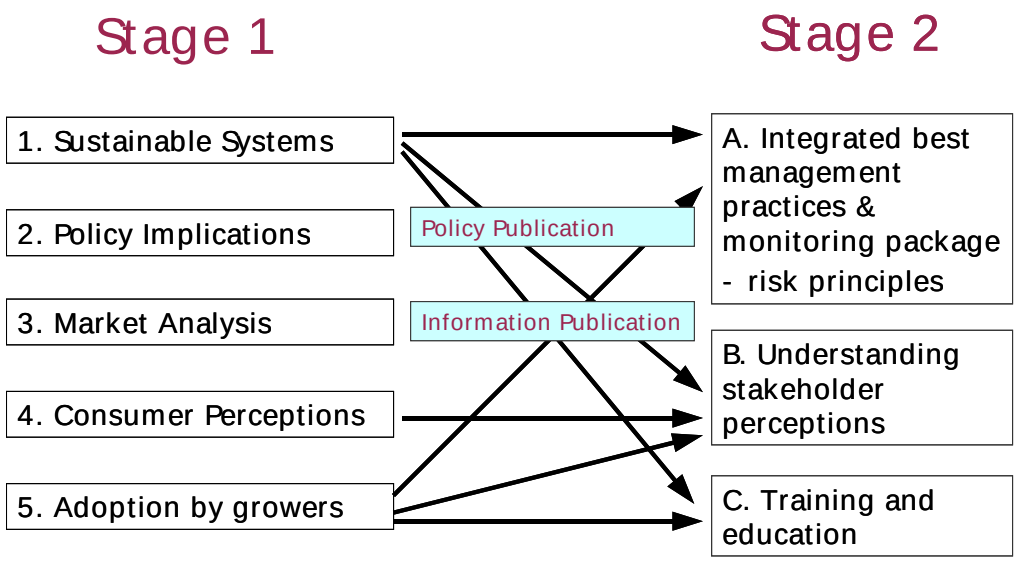

Figure 1: Summary of the key issues identified in Stage 1 and the project plan for Stage 2

Following discussion with external stakeholders, an additional area was identified around the development of policy guidelines for the development of recycled water schemes.

Stage 2: Research required to ensure sustainable development of horticultural industries in Australia

Stage 2 of the project undertook research, development and extension activities, to address key knowledge gaps and disseminate information about using recycled water. The project responded to an immediate need for information on the safety, economic viability and environmental impact of recycled water schemes. The science involved in Stage 2 represents an attempt to understand the

landscape system with an analysis of economic, environmental and social (TBL) aspects of recycled water application for irrigation of horticulture.

1. *To facilitate the safe, productive, profitable and environmentally sound use of reclaimed water in Australian horticulture*

This objective was addressed through increasing our understanding on key issues identified during the strategic analysis phase. Ensuring that this information was packaged into appropriate materials for all stakeholders was a key focus. Information was developed for growers, scheme managers, water industry and government.

It was also identified that social barriers could significantly limit the uptake of recycled water by horticulture. As consumer behaviour can potentially impact on the productive use of reclaimed water two major studies were undertaken to further understand the social dynamics involved.

A social appraisal of the South Australian Virginia Pipeline Scheme was conducted **(Appendix 7 – a social appraisal of the SA VPS)**. The study involved an assessment of stakeholders associated with the VPS five years following its inception. The design involved face-to-face interviews with 75 stakeholders representing growers, QA advisors, retailers, wholesalers, regulators, water advisers, horticulture advisers and researchers and industry associations. The key findings of the study were that Class A water has generally been accepted. An intensive communication strategy in the early stages of the scheme appeared to allay concerns. The water was perceived to provide a viable, alternative water source; enabled security and expansion; and provided wider environmental benefits. Some issues identified by stakeholders included;

- arrangements and conditions of scheme, for example pricing
- on-farm management particularly for salinity
- on-going education, information and training tailored for different ethnic groups and
- confirmation on market and consumer acceptance

Understanding consumer perceptions to the use of recycled water for horticulture is critical for the on-going future of growers. Poor community perceptions and acceptance are consistently identified as the key risks to growers and ultimately scheme viability. A study was undertaken to further explore what drives decisions to accept or reject recycled water **(Appendix 8 – the community and water reuse)**. The study involved a survey of 400 consumers in Melbourne and included questions around the potential consumption of vegetables grown with recycled water in the Werribee region. The Melbourne case study formed part of a larger study conducted for Water for a Healthy Country. The key findings from the study included;

- subjective norms (opinions and influence of others), emotions and trust are key factors
- trust and subjective norms are the main influences on emotions
- risk perceptions have only a weak contribution
- knowledge has minimal influence on decision making however having open communication and readily available information can build trust

These findings have been utilised by agencies in all states in the establishment phase of recycled water schemes.

The systems framework developed in the initial phase of the project provides a comprehensive analysis of the major stakeholders involved in recycled water schemes and the issues that they need to consider. The framework was further developed and applied in 2 case study sites of Werribee Irrigation District (WID) and Virginia Pipeline Scheme (VPS). The key learnings and potential to apply this process have been summarised in a paper **(Appendix 9 – recycled water-scheme development using systems thinking)**.

2. *To provide the tools and information for growers to identify risks, apply best practice and monitor key indicators*

Understanding the requirements for using recycled water can be daunting for an individual grower. However, recycled water is just another irrigation water source with some additional management factors. The project aimed to identify the key risks associated with the use of recycled water and compile them into a guide for horticulture growers **(Appendix 10 – recycled water guide)**. The guide was developed in consultation with growers in the Virginia Pipeline Scheme (VPS) and the Werribee Irrigation District (WID) drawing on their considerable expertise and experience. The guide is a practical information document focusing on:

- quality assurance schemes and guidelines
- planning to use recycled water
- quality of recycled water
- soil salinity and sodicity
- irrigation management
- fertilisation and nutrient management
- further information sources

Salinity was identified as one of the major risks associated with irrigation with recycled water. A salinity tool has been developed which includes a salinity unit converter and salt tolerance of vegetable and fruit crops **(Appendix 11 – salinity converter and salt tolerance)**.

These tools have been widely used by growers and advisers with more than 300 hard copies having been distributed. Significant interest in these resources has also been expressed by other industries.

3. To ensure the adoption of these tools/guidelines through a targeted extension strategy

The project team identified a requirement for development of training materials to complement existing irrigation management training and extension. The training materials focus on the differences associated with recycled water and provide an overlay to established training competencies **(Appendix 12 – training overlay)**. This work has been undertaken in consultation with the Irrigation Association of Australia (IAA). The team have worked with extension personnel primarily from agriculture agencies to ensure that information resources are relevant and practical. An extension network has been established to ensure the effective distribution of resources.

4. To enable growers to meet all stakeholders requirements (eg EPA, DHS, wholesalers, QA schemes, supermarkets) through effective communication and application of integrated management packages

The recycled water guide **(Appendix 10)** was developed in collaboration with key stakeholders and aims to address the specific requirements associated with recycled water. The information has been tested with growers and has been through an extensive review process. Many presentations have been made to diverse stakeholders groups. Discussions have occurred to ensure requirements of stakeholder groups are understood and communicated.

5. Development and publication of guidelines to assist policy makers with regard to future implementation and communication of reclaimed water use in horticulture

The project team identified a gap in the communication of information on reclaimed water in horticulture. A document was developed to assist in the implementation of new schemes **(Appendix 13 – guidelines for developing recycled water schemes)**. The guidelines provide an:

- introduction to recycled water
- guiding principles
- how to engage with stakeholders
- key considerations for stakeholders
- a positive approach
- checklist
- further information

The Department of Agriculture, Fisheries and Forestry (DAFF) has distributed more than 1000 hard copies of the guidelines predominantly to environmental protection authorities and agriculture departments and they are available electronically on the DAFF website.

Following on from this document it was concluded that the general community required additional information on recycled water. A general information document was developed **(Appendix 14 – general information on recycling water in Australia)**. The document includes the following:

- Why recycle our water?
- What is recycled water?
- Australia's water resources
- Australia's recycled water resources
- What can recycled water be used for?
- Recycled water for agriculture and amenity horticulture
- The reclamation or treatment process
- Guidelines and risk management
- How do I know where recycled water is used?
- What are the potential risks associated with recycled water
- How safe is recycled water?
- Is recycled water safe for use in agriculture?
- Is recycled water safe for use around the home?
- Is the person using recycled water safe?
- Environmental allocation
- Acceptance of recycled water use in agriculture and amenity horticulture
- Some important issues for the future
- Summary
- Examples of recycled water schemes in Australia
- Glossary
- Further information
- Websites

The document has been well received with distribution of more than 200 hard copies to date.

Recycled water in Australian horticulture (RWAH) program

The initial work undertaken in the project resulted in the establishment of additional studies relevant to recycled water in horticulture. Over a 2-year period the program evolved with the attraction of additional funds from Horticulture Australia Limited (HAL), the Natural Heritage Trust (NHT), the Our Rural Landscape (ORL) initiative of the Victorian Department of Primary Industries (DPI), and the Australian Research Council (ARC). This additional work has added considerable value to the initial investment from the NPSI. The combined projects have been referred to collectively in this report as the Recycled Water in Australian Horticulture (RWAH) program.

The major components of the program are outlined below (Figure 2) and include (1) strategic analysis of the potential for use of recycled water in the horticultural industry and the current policy position; (2) understanding consumer and stakeholder perceptions to irrigation of horticultural crops with recycled water; (3) sustainability and safety of recycled water schemes through empirical research and risk assessment modelling; and (4) extension, training and links with communication activities.

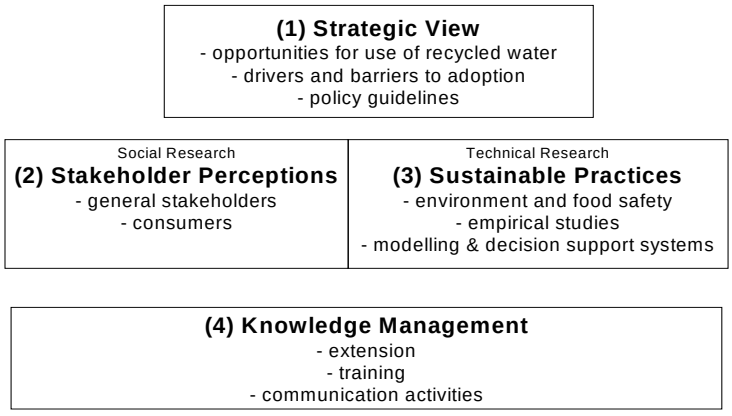

Figure 2: Summary of major components of the Recycled Water in Australian Horticulture Program

5. Adoption activities

Effective communication was identified as one of the key barriers to the adoption of reclaimed water in horticulture. As a result the project focused on the development of scientifically based information to target a range of audiences including policy makers, quality assurance managers, growers, scientific community, water suppliers, agricultural advisers and the general community. These information packages have been designed to address barriers and have successfully facilitated the appropriate adoption of recycled water (refer to appendices and publications).

Project activities have largely been targeted to the stakeholders that were associated with the establishment, and on-going success of, recycled water schemes. However, the project has also worked closely with extension providers and growers. During the developmental and implementation phases, extension providers are frequently the major source of information. The project developed products to assist in the transfer of accurate information **(Appendix 10 and 11)**. The grower tools that have been developed have proved extremely popular.

To ensure ongoing adoption of tools and practices the project team have developed a training overlay to complement existing irrigation training courses and workshops **(Appendix 12)**. The overlay will comply with national competency based materials enabling generic delivery by training providers.

6. Key learnings

The project has delivered on all its objectives. In the process of implementation innovative methodologies were tested. An analysis of key learnings from these approaches is provided.

Systems-thinking approach

The design of the project ensured that the entire system associated with the use of recycled water was considered. A systems-thinking approach was essential given the complexity and scale of the problem and the diversity of stakeholders involved.

To ensure that a systems approach was utilised a multi-disciplinary project team was established. This team represented expertise in biophysical and social research, extension and communication. The project team enabled all aspects of the system to be considered.

Rather than focusing on particular research issues, a strategic analysis of the system as a whole was initially undertaken. This analysis resulted in the development of a systems framework considering all stakeholders' issues and views. The strategic analysis provided an accurate means to identify the drivers of and impediments to the use of recycled water in a range of scenarios and for all stakeholders. It also highlighted the importance of considering social, economic and environmental aspects and addressing issues at all levels (growers, consumers, scheme operators, policy makers, etc).

The systems approach enabled the key research and development issues to be clearly identified. Establishment of a strategic plan ensured clarity on the priority areas and also facilitated the process of attracting additional funding for these work areas. The NPSI project in effect acted as a catalyst for further investment in the area of recycled water.

Steering Committee (SC)

One of the keys to the success of the project was its national, interdisciplinary Steering Committee (SC). The SC was developed through close collaboration with industry, researchers and other relevant stakeholders, and was shared with the Co-ordinator For Recycled Water Development in Horticulture (CRWDH) initiative – funded through Horticulture Australia Limited (HAL). Members of the SC represented a diverse range of stakeholders (eg water authorities, natural resource

managers, growers and regulators) **(Appendix 2)**. The role of the SC was to provide an insight into the perspectives of different stakeholders, guide the research and activities of both projects through regular meetings, and provide a critical forum for peer review. The SC meetings were held at a different location every six months and included a tour of local recycled water facilities and associated horticultural enterprises. The SC was a great asset for the project and was instrumental in guiding its progress. The discussions between the SC members and the project team ensured a mutual appreciation of stakeholder perspectives and a deeper understanding of the issues faced by each group. While not all SC members agreed on certain topics there was always interesting debate.

On completion of the project a survey of SC members was conducted. All respondents were positive about their involvement in the SC and the systems approach that was taken. SC members also stated that that they had gained an appreciation for other stakeholders' views and a better understanding of issues associated with recycled water use.

Overall the SC was a highly effective method for guiding progress of the project and ensuring quality outputs.

Collaboration and partnerships

Central to the methodology is a strong emphasis on stakeholder involvement and collaboration. The project team has collaborated extensively across national and state organisations through involvement in the development of recycled water guidelines (National) and implementation of recycled water schemes (eg Werribee). The multi-disciplinary nature of the program and the issues of concern have necessitated the establishment of multi-disciplinary teams with expertise in systems science, biophysical science (agronomy, food safety, irrigation), social science, extension, communication and training. The program has involved scientists from state based scientific agencies, regulatory agencies, Universities, CSIRO and the private sector. Essential to the success of the project has been an understanding and appreciation of the perspectives of different stakeholders. NPSI invested in the establishment of networks with a diverse range of stakeholders and has demonstrated leadership in resourcing these partnerships ie 'funding the arrows not just the boxes'.

Research, development, extension and policy continuum

The project has provided a model for delivery of strategic research through to on-ground extension of findings and communications to influence policy development. The timely nature and quality of the science has resulted in the immediate application of knowledge produced. Examples include:

- national guidelines for developing recycled water schemes in horticulture (NHT) prepared by the project team
- social research findings that describe consumer decision making being utilised by state water authorities (eg Perth, Melbourne and Brisbane Water) in their communication strategies
- market analysis review informing Quality Assurance auditors
- key findings informing national and state policy (eg DAFF and Vic DSE)

This continuum of information has been critical in an area that is rapidly changing and the information requirements are immediate.

Communication

Effective communication is critical to increase the acceptance of the use of recycled water and to the dissemination of research results in general. The project has focused extensively on communication with a diversity of stakeholders. The partnership with the industry supported Co-ordinator for Recycled Water Development in Horticulture (CRWDH) has worked exceptionally well resulting in a highly effective and targeted science program with clear definitions of end-user requirements. There has been a seamless transition of research findings to end-user with communication activities that are appropriate for the target audience.

Information products

Information gaps were identified during the strategic analysis phase. These gaps related to different stakeholder groups including policy makers, growers and consumers. The project in conjunction with the CRWDH therefore developed a number of information resources including the policy guidelines, the best practice guide and salinity tools and the general information document. The positive manner in which the information resources have been viewed would suggest that information dissemination and knowledge management has been a strength of the project. Now that this information base has been established, activities should be more targeted engaging such groups as growers in newly developed schemes and consumers.

Research innovation

The exploration of the issues associated with the use of recycled water is a new and exciting area. The basic research of particular interest includes the assessment of food safety through risk assessment modelling - critical for the review of current health guidelines. The establishment of an experimental site in the Werribee region to analyse the impacts from recycled water (food safety, agronomic & environmental) is a significant achievement providing enormous potential for quantitative analysis and stakeholder engagement. The social research on decision-making models has taken the current industry thinking far beyond market research and persuasion paradigms focusing on issues such as trust and subjective norms.

7. Future Priorities

Recycled water for horticulture use has been a high priority issue over the past 5 years. Numerous schemes have been proposed and developed across Australia. As the community became a part of the decision making process it was often found that clear, concise and scientifically sound information was lacking. This project has been instrumental in providing a firm foundation on the use of recycled water in Australian horticulture. Critical elements have been the strategic analysis, collaboration, engagement with stakeholders and rigorous research. While this baseline information has been provided at the right time there are many questions still unanswered.

The project team working in conjunction with the steering committee have identified key areas of research and development that require further attention. Key gaps in knowledge have also been identified from feedback at a CRC Irrigation Futures forum and responses from the SC to a survey distributed in April 2006. The recommendations are based on the current (May 2006) knowledge of the project team and will be further refined with input from the SC during a strategic planning workshop proposed for July 2006.

Biophysical systems

Understanding groundwater, surface water and irrigation linkages

When assessing the feasibility of a recycled water scheme it is critical that there is a sound understanding of the hydrology of the region and the impact of all irrigation water sources on surface and groundwater sources. Frequently we treat these sources in isolation not recognising the links and potential impacts that irrigation will have on yields and quantity. For example if increased water is provided into a system through recycled sources what effect will it have on the water table. Or should the recycled water only be used to replace other stressed water sources eg groundwater or river?

Recommendation: Development of new recycled water schemes should rely on an assessment using a systems-thinking approach integrating all water sources. NPSI should invest in the application of this approach for a specific pilot site with the expectation of applying the findings more broadly. This approach would aim to link the on-farm activity to the catchment scale.

Managing movement of salt and nutrients in water

The quality of water can be impacted by the quantity of water. How do we best manage the solutes (particularly salts, nitrogen and phosphorus) to minimise environmental impacts but at the same utilising the resources in from an agronomic perspective? Linking the agronomic requirements, with the hydrology and end point impacts is critical. This may require careful management of nutrients

that may be different from the management practices used for salinity. For example if the aquifer drains to the sea it may make good sense to irrigate at a high leaching rate to move salts through the rootzone. However, we would need to ensure that N and P were not leached out of the rootzone as they could have negative impacts on marine life.

Recommendation: As described above, the development of recycled water schemes should rely on an assessment using a systems-thinking approach not only for quantity of water but also quality of water quality. NPSI should invest in the application of the systems-thinking approach that integrates water quantity and quality for a specific pilot site with the expectation of applying the findings more broadly. This would include an understanding of the flow of solutes from the farm to the catchment.

Environmental risk assessment

Environmental risk assessment is a sound method of assessing the key endpoints and the potential impacts of inputs of the recycled waste. A risk assessment approach will ensure that the scheme focuses on key risk areas. The risk assessment should be undertaken from both an environmental and agronomic impact perspective. Schemes should focus on an optimisation of risk, as it should be recognised that profitable intensive horticulture would have some environmental impacts. How do we minimise risks and what level of impact is acceptable. What are the trade-offs that society is willing to accept?

Recommendation: Risk assessment has been used extensively in the application of quality and environmental assurance and in the development of food safety and recycled water guidelines. NPSI should support the application of risk assessment and management principles in their research program. This should include the recognition of risk optimisation and trade-offs.

Social systems

Understanding perspectives and issues of diverse stakeholders

The research has highlighted that the perspectives and issues of stakeholders involved in recycled water are extremely varied. It will therefore take time to develop mutual respect and understanding. All stakeholders need to be involved in the discussion as they have a stake in the outcomes and must develop trust in the players.

Recommendation: The findings from the project have identified some key strategies to facilitate the uptake of recycled water in horticulture. NPSI should support the further dissemination of knowledge on the elements associated with successful stakeholder engagement.

Understanding social systems at a scheme level

Knowledge on stakeholder and consumer perceptions has been developed in this project and the learnings can be applied to other situations. However, this does not substitute the critical requirement for understanding the social fabric of associated players for each scheme under development. Engagement with stakeholders will take considerable effort, and time will be required to understand, come to terms with and address their issues.

Recommendation: The application of the knowledge described above will be the responsibility of each scheme developer. NPSI has a role in ensuring that this knowledge reaches the target audience.

Perceptions and behavioural decisions of stakeholders

Perceptions and attitudes held by individuals strongly influence their behavioural decisions and hence the success of schemes. How people make their decisions to use recycled water or the products grown from recycled water is extremely complex and this project identified the influence of trust in authorities, emotions and what “significant others” are doing. Potential schemes should focus on these areas. The project also identified the insignificant effect of risk and the lack of influence of knowledge on people’s decision making. While the effect of risk may be tempered by the existence of trust, further research is required to better understand this aspect. Also, more knowledge is required on the role of information on influencing the key decision making variables to ensure the effective targeting of communication strategies.

Recommendation: Additional work is required to better understand the role of risk on behavioural decision-making, and how information can influence the major attitudinal predictors of decisions. NPSI should support this innovative research.

Application of systems framework

It has been highlighted that a process that facilitates the identification and understanding of key issues of stakeholders will be extremely useful. The systems framework attempts to undertake this task. The framework has been refined through Werribee and Virginia case studies and will hopefully be applied in the Regional Irrigation Business Partnership for the CRCIF.

Recommendation: NPSI should continue to support the application and utilisation of the systems framework through an awareness program. This may also involve investment to ensure that the framework is more user-friendly and appropriate for different end user needs.

Identifying the economic risks and rewards

Horticulture is one user of recycled water. Understanding the economic gains of recycled water in horticulture compared with alternative uses (eg industry, urban) will assist in the pricing of recycled water. A broader issue for horticulture is maintaining access to a secure water source. What will be the position of horticulture if water moves to those with the ability to pay most?

Recommendation: NPSI should invest in research that identifies the economic benefits and risks associated with recycled water in horticulture. NPSI would have a role in informing policy of the major considerations.

Knowledge management

Education and training – including amenity horticulture, agriculture, water sector

A significant gap in competency based training information has been identified relating to the use of recycled water. A training program has been proposed which would meet national training requirements. The training would be extended to also include amenity horticulture (golf course, turf, ornamentals), other agriculture industries (eg dairy) and the water sector.

Recommendation: NPSI should promote awareness of the recycled water training overlay to appropriate organizations (IAA, CRC-IF) who will likely ensure its ongoing application. NPSI has a role in facilitating the development of a recycled water competency across industries.

Extension to growers

While information has been developed on recycled water it is critical that this be extended out to growers. It is likely that extension of information will be reliant upon existing service provider and irrigation/industry advisor networks. As recycled water is just one water source the extension activities should focus on coordinating and facilitating linkages with current programs.

Recommendation: NPSI should continue to promote the awareness of the tools and resources for growers. NPSI should develop a strategy to target the adoption of resources through private and public extension and training programs to ensure effective uptake.

Perceptions of community, processors and growers

Knowledge on stakeholder perceptions and decision-making has highlighted the need for addressing trust in authorities and what “significant others” think. Emotive feelings also play a large role in behavioural decisions. Obtaining stakeholder agreements for using recycled water or accepting the products of horticultural recycling schemes will take considerable time and resources. This requires a systematic focus on engagement, consultation, partnerships and communication strategies that meet the needs of the stakeholders and build trust in the authorities.

Recommendation: NPSI should continue to promote awareness of the social research findings to targeted groups. Responsibility for engagement and communication will be with the scheme developers.

Regulation and policy

Regulation and policy have at times lagged behind what is actually occurring on the ground. In addition state and department differences have made interpretation quite challenging. This and other projects have worked to address the issue but continued efforts are required. Providing scientifically based information has been a critical component of this project and informing policy has also been a focus. Moving the debate to fit-for-purpose water use rather than considering the source of the water will be critical. However, current regulation would find it difficult to deal with

this fit-for-purpose water concept (eg winery waste water is managed differently from reclaimed effluent).
Recommendation: NPSI should continue to play a key role of science informing policy and *vice versa.*

Systems science

Learning through systems science

The project has significantly benefited from the application of the systems approach. The traditional reductionist approach has shortcomings when we consider an issue such as recycled water with significant environmental, economic and social impacts. Systems-thinking provides a method for understanding the triple bottom line outcomes and enables us to optimise these outcomes.
Recommendation: NPSI should promote a systems-thinking approach facilitated by 'big picture' thinking, strategic analysis, multi-disciplinary project teams and broadly skilled steering committees.

Fit-for-purpose water use

The project has identified that recycled water is water derived from a specific source. Water management should not focus on the source of the water but on the requirements for its end use.
Recommendation: NPSI should continue to promote the fit-for-purpose approach through its research program.

Example application - Regional Irrigation Business Partnership Sydney (CRC Irrigation Futures)

This project has applied the systems science approach to a specific issue being recycled water in horticulture. Similarly the CRC IF has developed a process referred to as System Harmonisation that considers the whole irrigation system. This process is being used in the Regional Irrigation Business Partnerships of which one is the Sydney catchment. We hope to apply our foundation knowledge to this partnership project.
Recommendation: NPSI should facilitate the application of findings to the RIBP.

8. Commercial potential

The project team has developed a number of information products. These have been produced at no charge to the end-user and represent the integration of knowledge from a range of sources. In addition a training overlay has been developed which will be available for Registered Training Organizations (RTO) to deliver. It is expected that the systems framework will be freely available to scheme developers. In particular, it is likely to be applied in the Regional Irrigation Business Partnership managed by the CRCIF.

Given the public good focus of the project, commercial potential of these or any additional products is unlikely.

9. Publications

Peer Reviewed Scientific Papers and Book Chapters

Boland, A-M, Hamilton, AJ, Stevens, D & Ziehrl, A (2006). Opportunities for reclaimed water use in Australian agriculture, in D Stevens (ed*), Growing crops with reclaimed wastewater.* CSIRO Publishing, Collingwood, Victoria, Australia.

Boland, A-M, Bewsell, D and Kaine G. (2005) Adoption of sustainable irrigation management practices by stone and pome fruit growers in the Goulburn/Murray Valleys, Australia. *Irrigation Science* on-line.

Hamilton, A.J., Boland, A.M., Stevens, D., Kelly, J., Radcliffe, J., Ziehrl, A., Dillon, P.J. & Paulin, R. (2005). Position of the Australian horticultural industry with respect to the use of reclaimed water. *Agricultural Water Management* 71, 181–209.

Hamilton, A.J., Mebalds, M.I., Aldaoud, R. & Heath, M. (2005). A survey of physical, agrochemical and microbial characteristics of waste-water from the carrot washing process: implications for re-use and environmental discharge. *Journal of Vegetable Science* **11,** 57–72.

Hamilton, A.J. & Stagnitti, F. (submitted). Deterministic versus stochastic quantitative microbial risk assessment models for wastewater irrigation of food crops. *Acta Horticulturae.*

Hamilton, A.J., Stagnitti, F., Boland, A-M. & Premier, R. (2005). Quantitative microbial risk assessment modelling for the use of reclaimed water in irrigated horticulture. In *Environmental Health Risk III*, C.A. Brebbia, V. Popov, & D. Fayzieva (eds.). *Transactions on Biomedicine and Health series, Vol. 9. Wessex Institute of Technology*. pp. 71–81.

Hamilton, A.J., Stagnitti, F. & Premier, R. (submitted). RIRA: a tool for conducting health risk assessments for wastewater-irrigation of edible crops. *Computers and Electronics in Agriculture.*

Hamilton, A.J., Stagnitti, F., Premier, R., Boland, A-M., & Hale, G. (2006). Quantitative microbial risk assessment models for consumption of vegetables irrigated with reclaimed water. *Applied and Environmental Microbiology* **72**. 3284–3290

Hamilton, A.J., Stagnitti, F., Premier, R., Boland, A-M. (in press). Are some groups of people more at risk than others to illness through eating vegetables irrigated with reclaimed wastewater? *Water Science and Technology.*

Hamilton, A.J., Stagnitti, F., Versace, V., Li, P., Yin, W., Maher, P., Hermon, K., Premier, R.R. & Ierodiaconou, D. (in press). Balancing environmental impacts and benefits of wastewater reuse. *WSEAS Transactions on Environment & Development*.

Kaine G, Bewsell D, Boland A, Linehan C (2005) Using market research to understand the adoption of irrigation management strategies in the stone and pome fruit industry. *Australian Journal of Experimental Agriculture* 45, 1181–1187.

Conference Papers and Invited Presentations

Barker-Reid, S.F., Engleitner, S., Wos, M.L., Boland, A-M., & Faggian R. (accepted for presentation). Reclaimed water for irrigation of vegetables: a field trial in south-eastern Australia. 21st Annual WateReuse Symposium, USA. Water Reuse & Desalinisation: Hollywood Stars of Water Management, California, September, 2006.

Boland, A-M. The potential for use of recycled water and saline water in horticulture. 5th International Symposium on Irrigation of Horticultural Crops, Mildura August 2006. **Keynote Address**

Boland A, Hamilton AJ, Wos M, Faggian R, Jarwal S, Stevens DP, Kelly J, Marks JS, Nancarrow BE, Po M, Engleiter S, Stagnitti F, Use of recycled water in Australia Horticulture. *AWA OzWater Conference,* Brisbane, 8-12 May, 2005.

Boland A-M, Faggian R, Jarwal S, Stevens D, Kelly J, Nancarrow B, Marks J, Po M, Hamilton A, Wos M. Recycled water – fit-for-purpose use in Australian horticulture*. CRC-IF Annual Forum*, Mildura, September 2005.

Boland, A-M. and Hamilton, A. J. Sustainable use of recycled water in Australian horticulture. Australian National Committee on Irrigation and Drainage *ANCID Conference*, Barossa Valley, South Australia, 10-13 October, 2004.

Boland, A-M. Use of recycled water in Australian horticulture. Irrigation Association of Australia's *Irrigation 2005 Conference,* Townsville, Queensland, 5-7 May, 2005. **Key Note Address**

Boland, A-M Use of Reclaimed Effluent (Recycled) Water in Australian Horticulture (VPI4) *CRC-IF Annual Forum*, Sydney, September 2004.

Engleitner, S., Barker-Reid, S.F., Faggian, R., Wos, M. Boland, A-M. (accepted for presentation). Reclaimed Water for Irrigation of Vegetables in the Werribee Irrigation District. 5th International Symposium on Irrigation of Horticultural Crops, Mildura August 2006

Hamilton, A.J. Stagnitti, F., Versace, V., Li, P., Yin, W., Maher, P., Hermon, K., Premier, R.R. & Ierodiaconou, D. (in press). Wastewater reuse and the environment: reaping the benefits by minimising the impacts. In *Proceedings: Water Resources, Hydraulics & Hydrology*, WSEAS Conference, Chalkida, Evia Island, Greece, May 11–13, 2006. **Keynote address.**

Hamilton, A.J., Stagnitti, F., Premier, R., & Boland, A-M. (accepted for presentation) Is the risk of illness by consuming vegetables irrigated with reclaimed wastewater different for different population groups? IWA World Water Congress and Exhibition, Beijing. September, 2006.

Nancarrow, B. E. The community and water reuse: what drives decisions to accept or reject? *Water Reuse and Recycling Conference,* Sydney, Australia, April 19 - 21, 2005. **Invited presentation**

Stagnitti, F., Hamilton, A.J., Versace, V., & Ierodiaconou, D. (submitted). Sustainable wastewater reuse. *International Conference Biohydrology 2006, Impact of Biological Factors on Soil Hydrology.* Prague, Czech Republic, 20–22 September 2006. **Plenary address.**

Stevens, D., Boland, A-M and Kelly, J. Agricultural use of recycled water in Australia. *Water Reuse and Recycling Conference,* Sydney, Australia, April 19 - 21, 2005. **Invited presentation**

Wos, M.L, Faggian, R, Boland, A-M. & Hamilton, A.J. (accepted for short presentation and poster). Using recycled water to irrigate vegetable crops: The Werribee Irrigation District (Victoria, Australia) case study. IWA World Water Congress and Exhibition, Beijing. September, 2006.

Wos, M and P. Pollard (2005) Understanding bacterial metabolic activity in engineered and natural environments*. Australian Society for Microbiology (ASM) 2005 Annual Scientific Meeting,* Canberra, Australian Capital Territory.

Project Reports

Bewsell, D. and Kaine, G. (2004) Adoption of Reclaimed Water amongst Australian Horticulturalists: results of a qualitative study. *Report to Land and Water Australia as part of VP14 Milestone 2b.*

Hamilton, A.J., Boland, A-M., Stevens, D., Paulin, R., Kelly, J., Radcliffe, J. and Dillon, P. (2003). Use of reclaimed water by the Australian horticultural industry—the state of play and challenges for the future. *Report to Land and Water Australia as part of VP14 Milestone 1.*

Lovell, J. and Galloway, A. (2004) Use of Reclaimed water in horticulture Market analysis and communication – understanding of requirements for business systems (QA, HACCP & EMS). *Report to Land and Water Australia as part of VP14 Milestone 2b.*

Marks, J. and Boon, K. (2005) A social appraisal of the South Australian Virginia Pipeline Scheme: Five years' experience. *Report to Land and Water Australia as part of VP14 Milestone 5.*

Po, M. and Nancarrow, B. E. (2004) Consumer perceptions of the use of reclaimed water for horticultural irrigation. *Report to Land and Water Australia as part of VP14 Milestone 2b.*

Po, M., Nancarrow, B. E., Leviston, Z., Porter, N. B., Syme, G. J. and Kaercher, J. D. Predicting Community Behaviour in Relation to Wastewater Reuse: What Drives Decisions to Accept or Reject? *Report to Land and Water Australia as part of VP14 Milestone 5.*

Radcliffe, J., Boland, A-M. and Hamilton, A. (2004) Implications of policy on use of reclaimed water for Australian horticulture. *Report to Land and Water Australia as part of VP14 Milestone 2b.*

Stevens, D. and Boland, A-M. (2004) Identification of risks and implementation of sustainable systems for primary producers at a regional level. *Report to Land and Water Australia as part of VP14 Milestone 2b.*

Ziehrl, A., Boland, A. -M. and Hamilton, A. J. (2003) Australian horticulture and water re-use options – analysis of resource potential. *Report to Land and Water Australia as part of VP14 Milestone 1.*

Milestone Reports

VP14 Milestone Report 1 to Land and Water Australia (1/10/03)

VP14 Milestone Report 2 to Land and Water Australia (31/12/03)

VP14 Milestone Report 2b to Land and Water Australia (16/03/04)
VP14 Milestone Report 3 to Land and Water Australia (30/04/04)
VP14 Milestone Report 4 to Land and Water Australia (30/10/04)
VP14 Milestone Report 5 to Land and Water Australia (31/05/05)
VP14 Milestone Report 6 to Land and Water Australia (31/10/05)

Newsletters

VP14 project newsletter Edition 1
VP14 project newsletter Edition 2
VP14 project newsletter Edition 3
VP14 project newsletter Edition 4

Jarwal, S. Salinity conversion and plant suitability made easier. ReWater. February, 2006. http://www.recycledwater.com.au/news/rewater_feb_06.pdf

Jarwal, S. Salinity conversion made easier. DPI News. 20 February, 2006.

Jarwal, S. Salinity Converter. Swan Hill Regional Premium Pickings. March 2006

Posters

NPSI Investor Forum (2003, 2004 and 2005)

Hamilton, A.J., Stagnitti, F. & Premier, R.R. (2006). .Microbial risk assessment models for irrigation of vegetable crops with reclaimed water. *Australian Vegetable Industry Conference, 2006,* Brisbane, Queensland, 10–12 May 2006.

Wos, M. Recycled water for horticultural irrigation: decision support systems for management of food safety. National Vegetable Expo. Werribee, May 2005. Event sponsored by the Vegetable Growers Association and The University of Melbourne.

General Publications and Extension Materials

Jarwal, S.D. and Boland, A-M. (2005). Salt Tolerance of Vegetable Crops (includes salinity unit converter). (2005). Published by the Victorian Government, Department of Primary Industries, Victoria, Australia

Jarwal, S.D. and Boland, A-M. (2005). Salt Tolerance of Fruit Crops (includes salinity unit converter). (2005). Published by the Victorian Government, Department of Primary Industries, Victoria, Australia

Jarwal, S.D., Boland, A-M., Stevens, D.P. and Faggian, R.F. (2006). Using Recycled Water in Horticulture – A Growers Guide. Published by the Victorian Government, Department of Primary Industries, Victoria, Australia

NHT, NPSI, HAL (2005) Guidelines for developing recycled water schemes in horticulture.

NPSI, HAL (2006) Water recycling in Australia – for those seeking information on recycled water use in Australia, particularly for agricultural and amenity uses.

Training Materials

Overlay to RTE4603A: Implement an irrigation-related environment protection program specifically for using recycled water.

10. Additional Information (Provided in Appendices on CD)

Appendix 1 – project team

Appendix 2 – national steering committee, meeting minutes and newsletters

Appendix 3 – opportunities for reclaimed water use in Australian horticulture

Boland, A-M, Hamilton, AJ, Stevens, D & Ziehrl, A (2006). Opportunities for reclaimed water use in Australian agriculture, in D Stevens (ed), Growing crops with reclaimed wastewater, CSIRO Publishing, Collingwood, Victoria, Australia.

Appendix 4 – systems framework

Appendix 5 – literature review

Hamilton, A.J., Boland, A.M., Stevens, D., Kelly, J., Radcliffe, J., Ziehrl, A., Dillon, P.J. & Paulin, R. (2005). Position of the Australian horticultural industry with respect to the use of reclaimed water. Agricultural Water Management 71, 181–209.

Appendix 6 – five scoping studies

Bewsell, D. and Kaine, G. (2004) Adoption of Reclaimed Water amongst Australian Horticulturalists: results of a qualitative study. Report to Land and Water Australia as part of VP14 Milestone 2b.

Lovell, J. and Galloway, A. (2004) Use of Reclaimed water in horticulture Market analysis and communication – understanding of requirements for business systems (QA, HACCP & EMS). Report to Land and Water Australia as part of VP14 Milestone 2b.

Po, M. and Nancarrow, B. E. (2004) Consumer perceptions of the use of reclaimed water for horticultural irrigation. Report to Land and Water Australia as part of VP14 Milestone 2b.

Radcliffe, J., Boland, A-M. and Hamilton, A. (2004) Implications of policy on use of reclaimed water for Australian horticulture. Report to Land and Water Australia as part of VP14 Milestone 2b.

Stevens, D. and Boland, A-M. (2004) Identification of risks and implementation of sustainable systems for primary producers at a regional level. Report to Land and Water Australia as part of VP14 Milestone 2b.

Appendix 7 – a social appraisal of the South Australian Virginia Pipeline Scheme

Marks, J. and Boon, K. (2005) A social appraisal of the South Australian Virginia Pipeline Scheme: Five years' experience. *Report to Land and Water Australia as part of VP14 Milestone 5.*

Appendix 8 – predicting community behaviour

Po, M., Nancarrow, B. E., Leviston, Z., Porter, N. B., Syme, G. J. and Kaercher, J. D. (2005) Predicting Community Behaviour in Relation to Wastewater Reuse: What Drives Decisions to Accept or Reject? *Report to Land and Water Australia as part of VP14 Milestone 5.*

Appendix 9 – recycled water-scheme development using systems thinking (draft)

Faggian, R., Boland, A.M., and Stevens D. (2006) Identifying the drivers and barriers to recycled water-scheme development using systems thinking.

Appendix 10 – recycled water guide

Jarwal, S. Boland, A.M., Stevens D., and Faggian, R. (2006) Using recycled water in horticulture – a growers guide.

Appendix 11 – salinity converter and salt tolerance

Jarwal, S. and Boland, A.M. (2005). Salinity unit converter; Salt Tolerance of Vegetable Crops; Salt Tolerance of Fruit Crops.

Appendix 12 – training overlay

Overlay to RTE4603A: Implement an irrigation-related environment protection program specifically for using recycled water.

Appendix 13 – guidelines for developing recycled water schemes

NHT, NPSI, HAL (2005) Guidelines for developing recycled water schemes in horticulture.

Appendix 14 – general information on water recycling in Australia

NPSI, HAL (2006) Water recycling in Australia – for those seeking information on recycled water use in Australia, particularly for agricultural and amenity uses.

Appendix 15 - Annexure A – Project Schedule