AUSTRALIAN GUIDELINES FOR SUSTAINABLE EFFLUENT-IRRIGATED PLANTATIONS

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ABSTRACT

In August 1999 the Commonwealth Scientific and Industrial Research Organisation (CSIRO) will publish Australia's first comprehensive guideline for the sustainable planning, design and management of effluent-irrigated plantations entitled: *Sustainable Effluent-Irrigated Plantations: An Australian Guideline* written by B.J. Myers, R.G. Benyon, W.J. Bond, R.A. Falkiner, P.J. Polglase, C.J. Smith, V.O. Snow, and S. Theiveyanathan. The guideline represents the culmination and final output of a major multi-disciplinary 7-year research effort – the *Wagga Wagga Effluent Plantation Project*.

The purpose of this paper is to present the reason for the guideline, its scientific information base and to summarise the contents of the guideline.

KEY WORDS

Effluent Irrigation, Tree Plantation, Guidelines, Land Treatment

1.0 INTRODUCTION

1.1 The Need for Guidelines

At the beginning of the new millennium, disposal of secondary-treated domestic sewage wastes into rivers and oceans still continues at varying rates in much of Australia. However, in recent years there has been an increasing commitment to recycling of both the liquid phase (effluent) and the solid phase (biosolids) on land. This has arisen from concern about environmental damage caused by sewage disposal into water bodies — in particular, the resultant nutrient pollution caused by the addition of phosphorus and nitrogen which often leads to the growth of algal blooms that are toxic to man and animals.

The frequent occurrence of large algal blooms in river systems in Australia in recent years has become a major environmental hazard. Increasingly, public opinion and regulatory pressures in all States demand alternate methods of waste treatment. Growing tree plantations irrigated with effluent has become a very popular method of land-treatment of effluent, both as a solution to an environmental problem and as a means of producing an additional wood resource. Despite the rapid adoption of this practice and widespread enthusiasm for it, many of these plantations risk causing serious degradation to soil and groundwater because they are based on little or no information about the processes of water use, nutrient cycling and salt management to ensure their sustainability.

1.2 Related Guidelines

A large variety of agricultural and industrial applications have been developed to reuse treated sewage effluent and other wastewater. In particular, utilisation of the water and nutrients in the effluent as resources for growing pasture or tree crops has become a popular use of effluent on land. Until recently, however, inadequate attention has been paid to how to avoid potential environmental problems associated with many of these uses.

Australia and New Zealand (through the Agricultural and Resource Management Council of Australia and New Zealand and the Australian and New Zealand Environment and Conservation Council) have now produced documents setting out guiding principles for sustainable reuse practices

(NWQMS 1997 & 1998), and several Australian State governments have developed guidelines on sustainable effluent irrigation requirements with an emphasis on agricultural crops (EPA NSW 1995; EPA SA 1997; Thomas 1991).

The National Water Quality Management Strategy publication *Australian Guidelines for Sewerage Systems — Effluent Management* (NWQMS 1998) sets the basic principles for land application of effluent as:

- the build-up of any substance in the soil should not preclude sustainable use of the land in the long term
- the effluent is not detrimental to the vegetative cover
- any change to the soil structure should not preclude the use of the land in the long term
- any runoff to surface waters or percolation to groundwater should not compromise the agreed environmental values
- no gaseous emissions to cause nuisance odour.

These publications do not, however, address issues specific to plantations. Determination of acceptable rates of application of effluent, knowledge of what happens to the water, nutrients, salts and other contaminants once applied to the plantation and knowledge of the longer-term effects of effluent-irrigated plantations on soils and groundwater have been seriously lacking. As a result, no authoritative guidelines or other widely applicable and user-friendly tools have been available to assist planners and managers with the design and management of environmentally sound effluent-irrigated plantations. Many existing regulations are based on limited knowledge or adapted from overseas experience.

1.3 Objective of the Plantations Guideline

The CSIRO guideline to be published in 1999, *Sustainable Effluent-Irrigated Plantations: An Australian Guideline*, aims to fill that gap. It is consistent with the NWQMS guidelines and reinforces the principles set out there by providing the wherewithal for practitioners to implement them. It brings together, in one place, most of the available information on the issues that must be addressed to ensure that effluent-irrigated plantations are designed and managed so that effects on groundwater, soils and vegetation are maintained within acceptable limits in the Australian context. It provides guidance on all the important parameters for both design and management of a sustainable plantation enterprise, formulae for calculating them and a number of tools to assist planners and operators to adopt best management practices.

It is intended as a starting point for anyone wishing to design an effluent-irrigated plantation, examine the potential environmental consequences and manage the plantation in a sustainable way. In some cases, the information provided will be all, or nearly all, that is required. However, the issues surrounding effluent-irrigated plantations are complex and not all possibilities could be covered; it will therefore generally be necessary to seek additional advice.

Expert advice can be obtained from a range of sources, including officers of State and Territory government departments, CSIRO, and forestry, irrigation and environmental consultants. Contacts for State government regulatory bodies are provided.

1.4 Target Audience

The guideline is designed to be easily read and understood by a wide range of people with quite different needs. Chapters contain different depths of detail depending on the target audience and the intended use for the information.

The guideline provides a discussion of the important environmental issues and analysis of the economics of alternative effluent-irrigated plantation and crop enterprises. These will assist councils, industry managers and their advisers to make informed decisions on the efficacy of plantations as a means of land reuse of effluent in their own particular circumstances and to ensure that all relevant regulatory obligations are met. The guideline provides tools that will assist in the design of effluent-irrigated plantations and scenario analyses generated from a specially developed model. It will help council engineers, environmental engineering consultants and regulatory authorities select suitable sites and species, determine required plantation areas and appropriate effluent loading rates, and ensure adequate monitoring standards are maintained. It will also help managers and operators of plantations — whether council engineers and foremen, private consultants, foresters or farmers — establish plantations and manage their daily operations, including irrigation scheduling and silvicultural practices, in an environmentally sustainable way. For any serious student of the subject, it provides a deep insight into the role of effluent-irrigated plantations and the potential risks as well as a comprehensive list of references to Australian literature on the subject.

2.0 SCIENTIFIC INFORMATION BASE

Sustainable Effluent-Irrigated Plantations: An Australian Guideline is the final outcome from the *Wagga Wagga Effluent Plantation Project*, a major 7-year study by CSIRO of the sustainability of effluent-irrigated plantations.

This guideline, which is national in its scope and application, is based on knowledge generated from many sources including:

- the *Wagga Wagga Effluent Plantation Project*;
- a number of effluent-irrigated plantation research trials and operational plantations conducted over many years by government agencies and private industry in Victoria, New South Wales, South Australia, Queensland and in New Zealand;
- experience of the authors in a wide range of related research.

Although it draws heavily on results from the *Wagga Wagga Effluent Plantation Project* — especially in the development of calibrated models — it is not a report of the scientific results of that research. These have been published extensively elsewhere and the sources are included in the Australian bibliography provided in the guideline. A summary of the research results is contained in the proceedings of the WaterTECH 98 Conference, published by the Australian Water and Wastewater Association (Myers *et al*. 1998).

In 1994, the first publication in the series culminating in the guideline, entitled *Green Rivers or Green Trees,* was published by the Land and Water Resources R & D Corporation (Myers *et al*. 1994) and 20 000 copies were distributed nationally.

The second, a popular easily-read manual that presented the environmental issues in more detail, entitled *Effluent-Irrigated Plantations: Design and Management* (Myers *et al*. 1995), was published in 1995 and 10 000 copies were distributed, including to each member of the New Zealand Land Treatment Collective. Production of *Sustainable Effluent-Irrigated Plantations: An Australian Guideline* was the final stage in this process.

2.1 Wagga Wagga Effluent Plantation Project

In 1991, CSIRO established a major project at Wagga Wagga in the dry Riverina region of New South Wales (widely known as Flushing Meadows) to determine the effectiveness, environmental limitations and sustainability of plantations as a means of land treatment of effluent. The award-winning research was multi-disciplinary and holistic in its approach to studying the processes in this ecosystem, integrating the disciplines of tree physiology, plant nutrition, soil science, hydrology, silviculture and modelling. It was unique among Australian studies in the diversity of ecosystem

processes studied, the intensity of measurements made and the 7-year duration of the monitoring. The research team included up to nine research scientists, their support staff and a PhD student.

Eight integrated sub-projects examined aspects of eucalypt and pine plantations that were irrigated with effluent at three different rates and with fresh water. Studies included: tree growth and nutrient accumulation, water balance, groundwater impact, N dynamics, P dynamics, changes in soil chemistry, salt dynamics, salinity stress and tree species and clone performance. The processes have been integrated in three models — APSIM for Effluent, WATLOAD2 and WATSKED — to extrapolate the results to a wide range of sites, effluents and climates. A sub-project, conducted by the Australian Bureau of Agricultural and Resource Economics and CSIRO, analysed the economics of effluent-irrigated plantations and led to the development of the WATCOST model.

The ultimate aim of the research was to develop guidelines based on a detailed understanding of the dynamic processes, with the objective of assisting communities in evaluating, designing and managing sustainable plantations for land treatment of effluent under a variety of effluent, soil and climatic conditions.

Specifically, the project aimed to:

- quantify the water balance of effluent-irrigated eucalypt and pine plantations under a range of irrigation rates and develop sustainable irrigation scheduling strategies based on the plantations' ability to use the water and accumulate nutrients;
- determine and model the fate of water, salt, N and P applied to these plantations in the effluent and the effect of irrigation on transformation processes of N and P in the soil and their rate of removal through uptake by the trees, gaseous losses and leaching;
- quantify important changes in soil properties, including salinity, sodicity, acidity and permeability, that will determine the long-term sustainability of effluent irrigation;

- contrast growth, nutrient uptake and partitioning, wood quality, salt sensitivity and water use of radiata pine and eucalypts under a range of water and nutrient application rates and develop appropriate silvicultural strategies; and
- identify genetically superior clones of radiata pine and screen a range of native species for use in effluent-irrigated plantations.

The research team was drawn from three CSIRO Divisions: Forestry and Forest Products, Soils, and Water Resources (now CSIRO Land and Water) plus the Australian Bureau of Agricultural and Resource Economics. It included scientists R.G. Benyon, W.J. Bond, R.A. Falkiner, B.J. Myers, N.D. O'Brien, P.J. Polglase, C.J. Smith, V.O. Snow, and S. Theiveyanathan of CSIRO and economists P. Connell, T. Bull and D. Samaranayaka of ABARE.

One of the strengths of both the research project and the guideline development has been the close involvement from the outset of sponsors and stakeholders at all levels of government including: Land and Water Resources R & D Corporation, Murray Darling Basin Commission, NSW Department of Public Works, NSW Department of Land and Water Conservation, Wagga Wagga City Council, the federal Department of Primary Industries and Energy, Tahara Pastoral Pty Ltd, Laminex Pty Ltd, Agricultural Water Management Pty Ltd, and University of Melbourne. The city of Wagga Wagga was chosen as the research location because of its progressive policy to achieve zero discharge of effluent to rivers by the year 2000.

Independent recognition of the project has included winning the following awards:

- 1995 BHP Landcare Research Award for New South Wales for '*outstanding achievement in land and water conservation research*'.

- 1996 Australian Banksia Environmental Award for Land Management, for '*protecting existing land and water systems from degradation and developing new land management practices that contribute to the sustainable fertility and productivity of that land*'.
- 1997 Theo Charles-Jones Tree Award for '*conservation and sustainable development'* presented by the Murray Darling Association.

An independent evaluation of the project estimated that it *"has a high probability (85%) of achieving a benefit/cost ratio exceeding 14, with the most likely outcome yielding a benefit/cost ratio of approximately 44. It is important to note that this outcome does not take directly into account the additional important environmental benefit of maintenance of groundwater quality"*. (Sullivan 1999).

2.3 Other Effluent-Irrigated Plantation Projects

Effective communication between scientists and practitioners involved with effluent-irrigated plantations in Australia and New Zealand has been conducted over the years through a variety of media such as: published papers and reports, conferences, specialist workshops, field visits and personal networking. Information and experience from numerous demonstration trials, sites where detailed research has been carried out and operational plantations has contributed to the recommendations contained in this guideline.

Most of the Australian pioneering research in this field was conducted in Victoria. Early trials in the 1970s, by the then Forests Commission of Victoria, provided useful insights into appropriate plantation establishment techniques, selection of suitable native species and potential growth rates (Stewart and Flinn 1984). Subsequent research at Wodonga, Victoria, by the same workers examined the biomass accumulation of seven native and exotic tree species, the accumulation of nutrients in that biomass and the effects of 4 years of effluent irrigation on soil chemistry (Stewart *et al*. 1988 & 1990). Other work in Victoria by CSIRO reported on the growth response of radiata pine plantations when irrigated for 3 years with combined municipal and pulp-mill effluent and the effects on soil and groundwater chemistry (Cromer *et al*. 1983 & 1984).

Several major studies over the past 10 years have provided quite detailed additional understanding of the environmental sustainability of effluent-irrigated plantations, of their biomass production potential and of water and nutrient dynamics under a range of plantation, site, climate and effluent conditions. These include:

- the *Hardwood Irrigated Afforestation Trial* at Bolivar Sewage Treatment Works in Adelaide, conducted by Primary Industries South Australia – Forestry on a coastal site over a shallow saline watertable (Boardman *et al*. 1996);
- the *Short Rotation Coppice Trial* at the Shepparton Wastewater Treatment Complex in Victoria, conducted by the Centre for Forest Tree Technology and the Goulburn Valley Region Water Authority using mixed municipal and industrial effluent and flood irrigation on a site with a shallow water table (Duncan *et al*. 1998);
- the *WC Fields Experiment* at Cleveland Water Pollution Control Works near Brisbane, conducted by the Queensland Department of Natural Resources and the University of Queensland, comparing effluent-irrigated pastures and plantations on poorly drained soil in a sub-tropical coastal climate (Moss *et al*. 1998);
- the *Curly's Wood* and *Ettamogah Forest Trials* at Albury, New South Wales, conducted by Australian Newsprint Mills using thermomechanical pulp mill effluent on radiata pine plantations (Dahl 1997); and
- the *Rotorua Land Treatment System* at Rotorua, New Zealand, conducted by the New Zealand Forest Research Institute and Rotorua District Council using high rates of effluent irrigation in a wet climate on radiata pine growing on volcanic soils (Tomer *et al*. 1997).

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4.0 CONCLUSION

The purpose of the Guidelines is to ensure that treating sewage effluent by irrigating forest plantations will be done sustainably – protecting rivers, soil and groundwater while producing valuable forest products. It is the final output of a major multi-million dollar, award winning research effort by CSIRO. The Guidelines are a 300 page reference book for planners, designers and operators of effluent-irrigated plantations including a CD with 3 computer modelling tools plus extensive look-up graphs and tables and a national bibliography.

The guideline is priced at $195, plus postage ($15). As signatures are needed on licence agreements for the software included, order forms must be filled in to obtain copies. These are available from CSIRO Forestry and Forest Products:

- phone (02) 6281 8300,
- e-mail Effluent.Guideline@ffp.csiro.au, or visit the
- web site http://www.ffp.csiro.au/pff/effluent_guideline/.

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