# Green forests and clean rivers

## Smart sewage use on trial at Wagga

Bryony Bennett

Local authorities facing strict controls on sewage discharge to rivers are being urged to reassess the commercial value of secondary-treated effluent. Forget costly chemical and biological tertiary treatments. Consider instead a sewage effluent treatment unit that consumes water, recycles nutrients and, given a balanced diet of effluent, grows in value every day.

The units require little maintenance. Before installation, however, expert planning is needed to ensure their presence doesn't disrupt the surrounding environment.

This is why CSIRO has more than 7000 such sewage effluent treatment units under trial at Wagga Wagga, the largest inland town in New South Wales. The 'units' are trees and they are being irrigated with sewage effluent.

Wagga's Effluent Plantation Project, begun in 1991, looks at water and nutrient management in effluent-irrigated plantations. It will produce national guidelines for designing, establishing and managing such plantations. The site, affectionately named 'Flushing Meadows', also functions as a demonstration of a scientifically-managed plantation.

Funding for the project ($8 million over six years) comes from the Land and Water Resources Research and Development Corporation, the Murray Darling Basin Commission and the NSW Public Works Department.

The Wagga trial site 19 months after planting (species trial in foreground).

The trial site at Forest Hill, 15 kilometres east of Wagga, is owned by Tahara Pastoral Pty Ltd. Wagga Wagga City Council treats the sewage and pumps it to the site, and the nearby Royal Australian Air Force base and Forest Hill residents kindly donate their waste.

Division of Forestry scientist Brian Myers is in charge of the Wagga project, which draws on the expertise of nearly 20 scientists and technicians from three CSIRO divisions (Forestry, Soils and Water Resources).

Myers says using treated municipal effluent to irrigate tree plantations can convert an expensive problem into a valuable resource, but whether it can be profitable has yet to be determined.

He says effluent produced in the Murray Darling Basin could support about 18 000 hectares of fast-growing plantations on land that otherwise would be too dry for timber. Such an enterprise could produce up to 360 000 tonnes of wood a year as an added resource for wood product industries or valuable leaf oils, tannins or cut foliage.

### Major pollution source

Australian communities discharge about 4500 megalitres of treated municipal effluent into rivers and oceans a day. That discharge is the largest point source of nutrients (particularly nitrogen and phosphorus) entering these water bodies.

The nutrients promote the growth of algal blooms, some of which are toxic and present serious health risks. The massive blooms that developed over 1000 km of the Darling River and in other waterways during the summer of 1991-92 are stark evidence. (See 'What can be done about algal blooms?', *Ecos* 72).

Myers says chemical, physical or biological treatments to remove nutrients from effluent are expensive or give inconsistent results. Also, they produce only sludge and saline effluent. On the other hand, lack of water and nutrients restricts the areas suitable for woodlots and limits the growth of many plantation forests in Australia. For these reasons, methods of land treatment that can recycle nutrients are being sought, encouraged by public opinion and legislative pressure.

For example, the NSW Environmental Protection Authority has imposed a limit of one part per million as the maximum concentration of phosphorus in effluent disposed into rivers from new

Brian Myers: turning an expensive problem into a valuable resource.

CSIRO scientists and technicians 'dig in' at Wagga. They are (from left) Randall Falkiner, Mark Tunningly, Leroy Stewart, Arthur Eilert, Brian Myers, David Wettenhall (Australian Forest Industries), Wilf Crane and Peter Leppert.

or modified sewage works. The State Government intends that all councils in NSW should achieve total off-river disposal in the foreseeable future.

One option for land-treatment of effluent is irrigation of wood-production plantations (woodlots). They use more water than agricultural crops and require simpler management. Also, toxic components in the effluent do not enter the food chain.

Effluent irrigation of plantations in Australia has lifted the growth rate of *Pinus radiata* and several species of eucalypt and casuarina. But knowledge of the uptake and cycling of nutrients and water in the plantations is scarce. Also, the performance of different tree species and clones when irrigated with effluent is not well understood.

## Planning a plantation

According to Myers, many effluent-irrigation plantations in Australia are poorly managed. Consequently they may not be protecting rivers and water tables from nutrient contamination. Irrigation scheduling is determined by the rate of effluent production, without regard for the plantation's ability to transpire water or absorb nutrients.

Myers has developed a computer-based model to help design effluent-irrigated plantations that do not upset a site's natural hydrological cycle (see box story p17). The model, called WATLOAD, calculates how much effluent can be applied without increasing runoff or deep drainage (the water loading rate). However, even when a plantation is irrigated at the correct water loading rate, nutrients may accumulate in the soil and be leached out by winter rains if the effluent is very concentrated with nutrients such as nitrates.

To plan and evaluate the feasibility of irrigating plantations with effluent in a particular environment, information is needed about: physical and chemical soil properties; effluent characteristics; climatic data; the expected growth and water use rate of trees and the depth and location of a potable water table.

A soil survey can determine the suitability of soils for irrigation with a particular effluent, and permit later evaluation of soil changes. Not all soils are suitable. The research team is studying ways to predict which ones are.

Warren Bond of the CSIRO Division of Soils is testing the division's SWIM computer model to predict the hydraulic suitability of soils for effluent irrigation. SWIM is used to predict the infiltration and movement of water through soils. Randall Falkiner is conducting repeated soil surveys to monitor changes in chemical properties as a result of effluent application. He is also exploring simpler methods than those currently used to determine a soil's ability to adsorb phosphorus.

Biological features of the crop, and the climate in which it is grown, combine to determine a plantation's expected water balance. These factors are used to determine effluent loading rates and the land area required to safely treat a given volume of effluent.

## How good are they?

Having identified the basic information needed to design plantations, scientists now want to determine how sustainable and effective they are as land-based method of using effluent.

At 'Flushing Meadows', in the winter and spring of 1991, Myers and his team planted 7600 native and exotic trees in an area covering seven hectares. The irrigation system is controlled by a computer that can be accessed by a modem from the Division of Forestry in Canberra.

Four trials were established: a pine rates trial, a eucalypt rates trial, a pine clone trial and a species trial. The rates trials are monitoring water use and nutrient cycling in *Pinus radiata* (radiata pine) and *Eucalyptus grandis* (flooded gum) plantations irrigated with different amounts of effluent and bore water.

Under investigation by Philip Polglase and Chris Smith is the path of nitrogen and phosphorus applied in the effluent, their

The pine plantation after two months. Milk cartons were used to protect the young trees from cockatoos.

'Speed wobbles' in *Pinus radiata* caused by high growth rates and wind bending.

rate of uptake by the trees and their immobilisation in the soil. Myers says important changes in soil permeability, salinity and acidity, and the fate of heavy metals and other toxins, will determine the long-term viability of effluent irrigation. Peter Crapper (whose ancestor, Sir Thomas Crapper invented the flush toilet) is monitoring the soil for the development of temporary water tables that could be a means of losing nutrients from the site.

In the clone and species trials, the growth and wood quality of radiata pine and a range of native species under effluent irrigation are being assessed. This information will aid the selection of superior radiata pine clones and suitable native species and seed sources (or provenances).

Provenance refers to a tree's natural geographic origin. Trees of the same species that have evolved in different environments display varied characteristics. For example, a community of river red gums (*E. camaldulensis*) at Leonora in Western Australia will have adapted to a drier climate than those growing at Echuca on the banks of the Murray. Scientists can make use of this natural variation by selecting provenances best suited to specific uses, such as wood production, in sewage effluent plantations.

Undesirable characteristics have shown up in some trial species already. For example, some radiata pine clones have developed 'speed wobbles'(kinks in the trunk caused by a combination of high growth rates and wind bending) and several rainforest species from Queensland failed to survive winter frosts.

### Watch them grow!

Nick O'Brien is doing a PhD study on the growth rate and nutrient uptake of the trees under different irrigation levels. He says trees irrigated with effluent grow about twice as fast as in their natural environment and those with the

## Project a boon for Wagga

A $20 million waste-management plan implemented by Wagga Wagga City Council aims to halt sewage effluent flow to the Murrumbidgee River by the year 2000 and reduce nutrient discharge by 10% each year.

Council facilities engineer, Colin Earnshaw, says approximately $500,000 of this total has been invested in CSIRO's Wagga Effluent Plantation Project. The council probably would have outlayed a similar sum had it chosen to establish its own effluent-irrigated plantation, Earnshaw says.

Joining forces with CSIRO, however, offers more than just a sewage disposal solution. The symbiotic parnership boosts the local economy, gives access to the latest research findings and wins the council recognition.

Earnshaw says the council decided five years ago to move toward total land disposal of liquid waste. The 10-year plan involves a range of strategies designed to reduce nutrient discharge to the Murrumbidgee.

The council has used secondary-treated sewage effluent to irrigate parks, gardens and sports grounds for the past 25 years. A recent review of future sewage treatment options recommended extending the existing reuse program, rather than investing in chemical treatments.

Wagga's proximity to the Murrumbidgee makes it attractive to industries requiring high volumes of water to operate. The council's trade-waste policy encourages such industries to recycle their own waste on site.

Earnshaw says this is one area where expertise learned from the effluent plantation project will be applied. The council wants to help its industries establish on-site woodlots that can be maintained and harvested by local contractors.

Other council initiatives include extending effluent irrigation to the local turf club and establishing a dual pipeline and tapping system that carries recycled water to one of its residential localities. The demonstration system, developed under guidelines set down by the NSW Recycled Water Co-ordination Committee, will supply effluent for outdoor use and for toilet flushing.

**Wagga council aims to halt sewage-effluent flow to the Murrumbidgee River by the year 2000.**

Consultancy fees usually account for 10% of the budget for major developments, Earnshaw says. But if the council is involved in relevant areas of research, it can acquire the expertise to do the design work itself.

Wagga council also supports research by the local Charles Sturt University, the University of New South Wales and La Trobe University at Bendigo, Victoria. Earnshaw says the areas in urgent need of research are urban runoff, river quality and sewer systems.

Project leader for the Wagga Effluent Plantation Project, Brian Myers, says nearly 1000 people have visited the site since its establishment two years ago. Members of the research team patronise local businesses, and most materials for the project were bought at Wagga too.

Myers says although the project is based on funding from state and federal bodies, the resources and expertise of Wagga's City Council and the use of Tahara Pastoral's land have combined to make it a collaborative success.

greatest leaf mass use the most water and grow fastest. In July, nearly two years after planting, the tallest *Eucalyptus grandis* (flooded gum) in the trial had reached nine metres. 'Tivi' Theiveyanathan is comparing the water use rates of the pines and understorey weeds as the plantations grow.

Timber from very fast growing trees, however, may not be as high in quality as from more slowly grown ones. Also, to remove nutrients from the site, it will be necessary to harvest the trees at regular, short intervals when they are still small. For these reasons the pines at Wagga will either be used for pulp or reconstituted as products such as fibre board and the eucalypts will be used for firewood, pulp or fence posts.

Other suitable commercial tree crops suggested by Myers are conifers for Christmas trees and native species for leaf oils and cut foliage. But he says the main reason for growing trees is to use the effluent. The cost of alternative effluent treatments should therefore be considered when determining a tree crop's economic value.

The time of harvest in effluent-irrigated plantations is related to the development of the trees' canopies. By the time canopies close over, the rate of nutrient uptake by the trees will about equal the rate of leaf fall and decomposition.

If irrigation continues when closed canopy is reached, the system will become unbalanced. This is because there will be more nutrients entering the soil than can be used by the trees. To avoid this, the trees can be pruned, thinned, burned or harvested. Techniques such as these will be assessed during the Wagga trial. Other silvicultural practices, such as watering to encourage deep root growth, and insect control procedures, are also being looked at.

Using the WATLOAD model, Myers estimates that the combined effluent from the Forest Hill and RAAF sewage treatments works (approximately one megalitre a day) could support 23 ha of fast-growing plantations. On this basis, the total urban population of Wagga (35 000) could support more than 250 ha of forest. As the Wagga Effluent Plantation Project progresses, more local authorities will no doubt be inspired to install their own 'sewage effluent treatment units'.

## Keeping the water balance

During the Wagga trial, project leader, Brian Myers, will validate and expand WATLOAD, a water balance model that aids the design of effluent plantations.

Myers says the aim of effluent irrigation is to stop polluting rivers and water tables with run-off or deep drainage of nutrient-rich effluent. To achieve this, the total effective water (irrigation plus precipitation) added to the plantation must not exceed the total water used.

This is where WATLOAD can help. Town and city planners can use the model to determine how much effluent may be applied to a plantation in their climate without overloading the site's natural water balance.

WATLOAD calculates the size of plantation required to treat the effluent produced by the town and the amount that can be applied each month, from planting to maturity. It also shows the storage capacity needed to retain effluent in winter when the plantation won't use all that is produced.

The model estimates the amount of water transpired by the vegetation and the amount of rainfall intercepted by and evaporated from the foliage. It takes into account the small size of tree canopies in their first few years.

If the effluent contains a high concentration of nutrients, however, irrigation at WATLOAD's predicted water-balance rate may exceed the plantation's capacity to absorb nutrients. To help assess this factor, the CSIRO research team at Wagga will expand the WATLOAD model to account for the variance in effluent nutrient levels.

Myers developed WATLOAD from data collected during CSIRO's Biology of Forest Growth Study (see *Ecos* 74). This eight-year project, which began in 1983, looked at how water and nutrients controlled tree growth in a Pinus radiata plantation near Canberra.

WATLOAD has been used by CSIRO to calculate effluent loading rates and to plan effluent plantation requirements for a number of municipal councils, industries and consultants in eastern Australia.

**More about effluent irrigation**


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