WATER MANAGEMENT ON THE THURGOONA CAMPUS OF CHARLES STURT UNIVERSITY

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Abstract

The new campus (87 ha) on the "green fields" site in Thurgoona, Albury, presented Charles Sturt University with the opportunity to develop learning environment in accordance with principles of environmental sustainability, including efficient on-site management of natural resources. This campus provides its students with experiences of life style choices, which emphasise sensitivity to the Australian environment.

Water and wastewater management principles were laid down at the outset and consistently applied. Meandering swales and contour banks collect run-off water and deposit it in three interconnected reservoirs at the base of the site. Two "turkey-nest" dams at the highest part of the site receive water from the lowest reservoir via a solar energy pump and windmill and used for watering plants when required. Rainwater is used in the laundry.

Potable water purchased from Albury City Council is used for drinking, cooking, laundry and personal hygiene. Greywater from these uses is treated in intermittent-flow, constructed wetlands and recycled via the storage reservoirs. Installation of composting toilets obviates blackwater generation. Initial facilities were commissioned in January 1999 and have generally operated very satisfactorily.

The Thurgoona Campus is an exciting educational environment that continues to develop facilities for tertiary education within the context of sustainable management of Australian natural resources. The on-site management of water resources described in this paper has already won four statewide awards.

Keywords

environmental sustainability; greywater treatment; water management; wetlands.

1 Introduction

The development of a new Thurgoona Campus for Charles Sturt University presented a marvellous opportunity for principled planning of environmentally efficient, on-site management of water resources (and other natural resources) in an undeveloped, "green field" site. The development also provided the University with the opportunity to develop a holistic learning environment extending beyond normal academic curricula by providing experiences of living in sympathy with the natural environment (Howard *et al.* 2000). This enrichment of Australian tertiary education is particularly appropriate at this time, as the nation seeks to come to terms with essential, but uncomfortable, changes to its management of the country's natural resources. Such learning experiences outside the formal curriculum can be expected to have profound, nation-wide flow-on effects now and into the future.

This paper presents an account of the way these opportunities were grasped with respect to the design and development of facilities and procedures for the management of water resources on the new campus of Charles Sturt University at Thurgoona on the northern outskirts of Albury, NSW.

2 The Site

The site was purchased in 1994. It slopes to the north from a high point in the southern third. Consisting mostly of poor quality pasture, the land had been previously used, over the past 150 years or so, for various forms of agriculture, including mixed cropping, viticulture and horticulture,. Most of the original woodland had been cleared and replaced by grassland, which was dominated by introduced species and infested with woody weeds. The northern slopes of the site were fenced into of paddocks and were traversed by a series of cattle and sheep paths and a few farm roads. Some 10 ha had been replanted, in about 1970, with a range of Australian native trees, mostly not indigenous to the area. Seven house sites dating from the 1800s were located (Spennemann 1995), only one having a standing house. Eight farm dams had been constructed. Seven were still functional.

3 Overall Site Plans

The University's Director of Design, Marci Webster-Mannison, initially formulated an overall plan for the progressive development of the site, which focussed on the undeveloped northern slopes (Webster-Mannison and McInerney, 1998). There were already three relatively new buildings of conventional design and construction on the southern slopes. A fourth building was constructed in 1996 as a prototype for the design of future buildings on the northern slopes of the campus and to serve as a temporary home for the Students Union. All these buildings were connected to sewers already supplied to this southern part of the site.

The undeveloped nature of the northern slopes meant that it was possible to adopt an environmentally sensitive philosophy for the design of the campus and its facilities from the outset. The resultant conceptual plan envisaged a range of buildings either side of a contour encircling the hill. Eventually, this would form a pedestrian mall connecting the different University precincts on the northern and southern slopes. An arboretum consisting of trees from different countries, representing the ancient continents of Gondwanaland and Eurasia and grouped accordingly, would be planted along the pedestrian mall. As far as possible, trees requiring no additional watering would be selected for the arboretum.

The buildings are designed to take advantage of Albury's climate and have high thermal mass and efficient insulation against heat exchange with the exterior. The walls are composed of rammed earth, interposed with rainwater tanks filled with run-off from the roofs. The buildings are heated in the winter by cycling water, which is heated in solar collectors on the north facing roofs, through the concrete slabs forming the floors and ceilings. Cooling in the summer is by natural ventilation of cool air, which is generated by spray misting of external areas during the day and naturally cooled air during the night, replacing warm air leaving the building through upper vents in thermal chimneys. This is assisted by water cycled through the building, being cooled in the solar panels, which act as heat exchangers in summer nights.

Throughout the design and construction of these buildings, careful consideration is given to the choice of materials and to the process of construction to minimise adverse impacts on environmental conditions and resources. For example, recycled timber or plantation timber is used throughout the buildings, paints are non-toxic and working surfaces do not release "off-vapours".

4 Conceptual Plans for Water and Wastewater Management

Plans for the management of water and wastewater were formulated in the context of the overall plans to avoid adverse long-term impacts on natural resources. During initial preparation of the site and the construction of roads and buildings, consideration has to be given to potential risks of environmental damage to vegetation, animal habitats, soil integrity and water quality. Subsequent management of the campus also has to address the impact of changed land-use on rainfall/run-off ratios, depth and quality of ground waters, quality and flows of surface waters, nutrient cycling and soil erosion.

4.1 Principles

The following principles and guidelines for action with respect to the management of water and wastewater were prepared for the technical report compiled for the Albury City Council (Mitchell and Webster-Mannison 1998), where they appear in a slightly modified layout. This report formed part of the development approval process for the Thurgoona Campus. They have been consistently applied to planning and development of the site.

- Pollution of water is to be minimised.
- Water is to be re-cycled wherever possible, provided that the water to be re-used meets the criteria required for that form of re-use.
- Water that is used for widely different purposes will not be allowed to mix before it has been treated to a level that will not cause cross contamination. If necessary, wastewater derived from different uses will be disposed of separately.
- Water on the campus will be circulated and stored in ways that are aesthetically pleasing and that promote maintenance of good water quality.
- Development of ecologically sustainable, natural, aquatic ecosystems will be encouraged.
- Water resources will be used economically and not wastefully.
- Water resources on the campus will be monitored with regard to quantity and quality and the information used to enable sustainable management of water on the campus.
- Water storage facilities on the campus must be sized so that the natural supply of rainfall will exceed requirements at least once every five years, to reduce build-up of salts in storages. Access to additional supplies of water must be maintained so that essential requirements can be met during periods when natural precipitation is insufficient.
- Maximum use should be made of opportunities for research. This could include, for example, studies to establish causative links between water quality and catchment management with respect to different intensities and forms of water use; the development and sustainable management of natural aquatic ecosystems in close proximity to human populations, and the effectiveness of the different components of the water treatment, storage, and supply systems.

The application of these principles and actions to the collection, treatment, storage and use of stormwater, and the generation, treatment and reuse of wastewaters, for example, are presented in this paper.

5 The Identification of Water Supplies for the Campus

Three potential forms of water for use on the campus were identified: rainwater collected from the roofs of buildings; stormwater run-off; and potable water purchased from the Albury City Council (no supplies of groundwater appear to be present). The first two forms of water are unreliable in terms of both quality and quantity, but can be used for low security uses such as landscape watering. Rainwater can also be used for some domestic uses such as in a laundry.

High security water for human consumption, personal hygiene and some other domestic uses requires potable water from an authorised supplier such as the City Council. The possibility of decreasing the University's requirement for this water by using rainwater for human consumption, common practice in rural Australia, was investigated but considered by the University to pose unacceptable risks to personnel, for which it was responsible.

Some savings in water use were obtained by installing aerobic composting toilets in all the buildings in the unsewered northern part of the campus. This also saved the cost of providing reticulated sewerage to this part of the campus, and avoided the gross pollution of water by the addition to it of human sewage.

Further savings in the consumption of water comes by treating grey water in artificial wetland systems to the level where it was safe to recycle it with stormwater run-off, as described later in this paper.

6 The Management of Stormwater

The site can be divided into 7 sub-catchments. Ultimately each of these will be developed to harness, store and recycle stormwater run-off. Run-off from each sub-catchment will be directed by contour banks into drainage swales. These will meander over the landscape in order to control erosion and to provide natural-looking aesthetic features before discharging into storage reservoirs. In-stream treatment wetlands (described in the next section) will be constructed in each swale to improve water quality and contribute to aesthetic appeal. The swales, the in-stream wetlands and the storage reservoirs combine to form a range of aquatic habitats for colonisation by native flora and fauna.

Three of the sub-catchments have initially been developed; one in the SW corner and two on the NW side of the campus. The first has an estimated average annual yield of 7.5 ML and a 1 in 10 year yield of 11 ML. A small reservoir with an estimated capacity of 1.5 ML has been constructed in this sub-catchment. The other two sub-catchments have a combined estimated average yield of 42.7 ML and a 1 in 10 year yield of 61 ML. Three interconnected reservoirs have been constructed at the bottom of the campus along its northern boundary to store the run-off from these two sub-catchments. These reservoirs have a total estimated capacity of 55 ML. Direct precipitation onto the reservoirs is estimated to contribute an annual average of 32 ML compared to evaporation of 66 ML.

The small SW reservoir will overflow every year into roadside drains and sewers that had already been constructed in this area by the civic authorities. The three northern reservoirs are expected to discharge water in years of high rainfall into Six Mile Creek, and thence into Twelve Mile Creek, which ultimately flows into the Murray River above Albury. This will ensure that there is no build up of salinity on the campus. Since these overflows will occur when creek flows are high, there should not be any perceptible adverse impact on water quality of the creek.

Water from the lowest storage reservoir is pumped to two turkey nest dams at the top of the hill via a windmill and a solar energy powered pump. From here, it can be directed to any part of the campus requiring water.

7 Constructed In-Stream Wetlands for the Treatment of Stormwater

7.1 Design Objectives

1. Sedimentation of particulate matter.
2. Retention of plant nutrients.
3. Aeration of inflowing water.
4. Self-sustaining and self-optimising aquatic ecosystems.

7.2 Construction Guidelines

A suitable position on a swale meander is chosen with due regard to effectiveness of treatment functions and to eventual aesthetic appeal on the landscape. The number of wetlands to be constructed depends on the length of the swale and the likely quality of the stormwater run-off. Aeration is achieved by constructing a rock-based waterfall/water cascade at the point of inflow. The water then falls into a sedimentation pool, which should be at least 4 m deep with steep sides. The side of the pool closest to the eventual out-flow should be shaped to become progressively more shallow from a depth of about 0.5 m over a distance of 5-10 m, as determined by the natural slope of the land at that point. This shallow area is then planted with a succession of emergent aquatic plants with decreasing tolerance to water depth to form a marsh area in which nutrient uptake is maximised and further sedimentation occurs.

7.3 Management and Maintenance

If properly constructed, these are low maintenance systems. The invasion of unwanted species, such as *Typha spp.*, which can progressively dominate the plant community, and the alien grass, *Paspalum dilatatum*, which can dominate the moist margins of the marsh area, may need to be controlled. This is best achieved by hand-weeding invading plants before they flower and establish a seed bank.

If the sedimentation pool is operating well, it will be necessary to remove accumulated sediment with a mechanical shovel at some stage. The removed sediment is best recycled by incorporation into soil at a suitable site.

8 Constructed Wetlands for the Treatment of Greywater

8.1 Design Objectives

1. To treat greywater from wash hand basins, showers, laundries and kitchen sinks to the level that it would be safe to re-use for landscape watering.
2. To ensure wetland systems provide aesthetic as well as functional treatment of wastewater on the campus.

8.2 Conceptual Design and Operation

A major shortcoming of most artificial wetlands for the treatment of wastewaters is that water, which enters and leaves as a more or less constant flow, will take a preferential path through the wetland. This results in a marked reduction in residence time for the bulk of the water passing through the wetland and consequent reduction in level of treatment (Mitchell *et al.*1995). The intermittent nature of the production of grey water on the campus raised the possibility of designing an artificial wetland that would operate as an intermittent inflow and retention system rather than a constant through-flow system.

The detailed design of the artificial wetland constructed to give effect to this concept will be described in a paper being prepared by Mitchell, Wicks and Croft. Additional information derived during construction of the systems will be provided in a paper being prepared by Mitchell, Croft, Bootsma and Tonkin.

In summary, three root-zone treatment, gravel-based wetland systems of appropriate volume to treat the estimated flow of grey water were constructed. Two of these are primary systems that are planted with the emergent aquatic plant, *Schoenoplectus validus* and the third is a secondary system planted with *Phragmites australis*. Grey water is allowed to flow into one of the primary systems until the level rises to within about 5 cm below the surface of the gravel. Conceptually this may take about a week. The water is then retained in this primary wetland while the other fills to the same level, presumably over about the same period. The water from the first primary wetland is then emptied into the secondary wetland system where it is retained while the first primary wetland fills and water is retained in the second primary wetland. This alternating sequence of operations then continues indefinitely. The aquatic species planted in these systems grow vigorously and it appears that it will be necessary to harvest the standing crop at the end of every winter, though this still has to be determined.

There was no firm evidence at the time of construction that this wetland design would produce an effluent of acceptable quality. The authorities therefore requested that the design be augmented to include an evaporating mound. This was planted out with the sedge, *Carex appressa*. An ephemeral wetland system was constructed adjacent to the evaporating mound to retain water that is not lost by evaporation during periods of wet weather.

Permission to construct and operate artificial wetlands of this design as a pilot scheme was granted by the City Council after obtaining advice from the relevant NSW Government authorities (Department of Land and Water Conservation, Department of Health and the Environmental Protection Authority). Three separate systems were constructed in 1998 to treat grey water effluent emanating from the School of Environmental and Information Science (SEIS) Precinct, the Core Lecture Theatre, Library and Students Union Precinct (the Library and Students Union are to be constructed this year) and the Residential Precinct. The first of these systems has been operating since February 1999, with the others beginning to be operated as effluent began to flow from the respective precincts.

8.3 Monitoring

Permission to proceed was conditional on the installation of two piezometers and the collection of monitoring data to determine the quality of the effluent of the systems. Monitoring was carried out at three monthly intervals and based on analyses for coliform bacteria, biochemical oxygen demand, total nitrogen and total phosphorus. Additional data on temperature, pH, dissolved oxygen, specific conductivity and turbidity are obtained at the same time using a Horiba Water Checker.

Data collected during regular monitoring assessments of the SEIS system are summarised in Table 1. These data provide the best examples for assessing the effectiveness of the treatment during early maturation of the system. The wetland system for treating effluent from the Residential Precinct is clearly overloaded at present. Additional wetland ponds are required and have been requested. By contrast, the wetlands treating the effluent from the Core Precinct are seriously under-loaded at the present level of building development and need to be supplemented with potable water to maintain essential water levels.

TABLE 1. Averages of Data Collected from the Different Components of the SEIS Treatment Wetland over the Period, June 1999-May 2001.

	Faecal Coliform Org/100ml	BOD mg/L	COD mg/L	Total N mgN/L	Total P mgP/L	D O mgL^{-1}	Cond mS/cm	Temp °C	Turb NTU	pH
Inflow	70000	6	39.5	29	5.25	1.15	0.883	15.7	26	7.3
Primary Ponds	17.5	2	11	6.3	0.04	2.85	0.402	15	5	6.2
Secondary Pond	0	1.5	9	2.63	0.026	1.83	0.290	16.9	7	6.1
Ephemeral Wetland	6	3	16	1.48	0.067	9.56	0.125	12	15	6.7

9 Discussion and Conclusions

Most of the principles underlying the development of the Thurgoona Campus are well known. However there are very few examples of their holistic application to one site. The development has also created a fertile environment for the generation and application of new ideas, such as the artificial, intermittent-flow wetlands.

The principal criterion for judging the suitability of treated greywater for re-use is the count of thermo-tolerant coliform bacteria, as this is an indication of faecal contamination and therefore the hygienic quality of the effluent. Nutrient content could also be important, as high nutrient levels would promote blooms of blue-green algae in the storage reservoirs. However, nutrient content would not be an issue if the effluent were used immediately for landscape watering.

The wetland system for treating greywater from the SEIS precinct has performed well with respect to these criteria. For example, no *E. coli* organisms were recorded on 6 of the 10 occasions this parameter was measured at the outlet of one or other of the primary ponds. There was one relatively high reading of 140 organisms per 100 ml following a pollution leak into the inflow. At this time, the inflow to the system contained 2000 organisms per 100 ml, but this shock load was soon dissipated. No *E. coli* were detected at the outlet of the secondary pond on three sampling occasions and only 10/100 ml twice. Nutrient concentrations are progressively reduced as the greywater moves through the system (Table 1). On all occasions water from the outlets of both primary and secondary ponds in this system appears crystal clear and odourless.

A potential shortcoming of an intermittent flow system is the lack of mixing conditions within the pea gravel matrix during the no-flow period. This would mean that some of the processes in the system leading to amelioration of water quality would be inhibited by the slow diffusion of substances through the water from "treatment sites". There are several ways of dealing with this. For example, mixing could be induced by suppling heat into the bottom of the gravel through pipes carrying water heated by solar panels. Alternatively, compressed air could be injected into the base of the trenches through slotted agricultural pipe. Mixing could also be achieved by pumping water from the outlet into the inlet during the no-flow period.

The most noticeable impact of poor mixing would be low dissolved oxygen levels in the water. Under these conditions, the main source of oxygen during the period of no flow would be leakage from the roots of the wetland plants. This is unlikely to provide sufficient oxygen for organically rich waters but may be enough for greywater from the SEIS Precinct.

To establish the reality and significance of this shortcoming, slotted agricultural piping was laid at the base of the wetlands and buried in the gravel. This makes it possible to inject air into the system from an air compressor and it is proposed to investigate the extent of anaerobiosis and to measure the possible benefits of additional aeration. Preliminary studies of flow patterns in the wetland ponds under contrived through-flow conditions are being conducted this year and it is proposed to investigate mixing under no flow conditions when further funds are available.

In the meanwhile, dissolved oxygen levels in the primary ponds of the SEIS system have fluctuated between 0.11 mg L^{-1} and 9.7 mg L^{-1} with an average of 2.85 mg L^{-1}. Dissolved oxygen in the secondary pond has fluctuated between 0.09 mg L^{-1} and 5.3 mg L^{-1} with an average of 1.83 mg L^{-1}. The lower levels in the secondary pond are likely to be an indication of the sparsity of *Phragmites australis* plants in this pond at present. Notwithstanding, these foreseeable low levels, dissolved oxygen levels soon return to normal (between 9 mg L^{-1} and 10.71 mg L^{-1}) in the ephemeral wetland where the water is exposed to air and fully mixed.

The overall approach to water management on the Thurgoona Campus and progress made to date has won several accolades including:

- Certificate of Accreditation to River Care 2000 in 1996,
- River Care 2000 Silver Award: Education-Tertiary in 1996,
- River Care 2000 Gold Award: Education-Tertiary in 1999,
- River Care 2000 Award for Excellence: Education-Tertiary in Stormwater Management and Landscaping in 2000,
- The New South Wales Branch of the Australian Waters and Wastewaters Association Best Practice Water Cycle Management Award in 1999.

Opportunities for research are being grasped, particularly by honour students, as they become known. Other more long-term post-graduate studies have also started, including investigations of the thermal conditions within the rammed earth buildings. An Environmental Management Plan for the Campus is close to finalisation. The campus is also being used as a field laboratory for teaching students in a range of subjects including Ecotourism, Recreational Planning, Cultural Resource Management and Ecological Studies. Current expenditure is understandably focussed in the construction of new buildings, so that research into the effectiveness of existing facilities and further extension of landscaping and other on-site facilities is being constrained.

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