

Customer Services Division


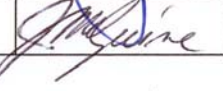
**Albany Effluent Irrigation Treefarm
Triennial Report 2004**

December 2004

**Great Southern Region
Customer Services Division
Water Corporation**

**Albany Effluent Irrigation Treefarm
Triennial Report 2004**



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Executive Summary

The Water Corporation's Effluent Irrigation Treefarm at Gunn Road was established between 1992 and 1994 following extensive public consultation with the people of Albany. Albany's wastewater is treated at the Timewell Road Wastewater Treatment Plant (WWTP) with treated effluent being used to irrigate a woodlot on a site 10km north-west of the town opposite the Albany airport. The treefarm not only manages the disposal of the treated wastewater by means of the woodlot, but also implements a measure of nitrogen reduction through an overland flow system.

This report covers the period 2001 to 2003. It reports on environmental monitoring at the treefarm and provides a Progress and Compliance Report against the Ministerial Conditions that were developed following the public environmental review process.

Incoming flows into the WWTP have increased since 1997 and this has continued to have an impact on treefarm operations. Desludging of the secondary treatment ponds at the WWTP in 2002 reduced the annual average nitrogen concentration. This, combined with improved treatment due to lower winter inflows, resulted in a 20% reduction (from 29.1 to 22.5 mg/L) of the total nitrogen concentration in water irrigated to the blue gum plantation.

The irrigation system in the overland flow system was upgraded during 2002 to allow better distribution and improved nitrogen removal. The new system has substantially reduced the operational maintenance requirements and contributed to a nominal improvement in nitrogen removal through the grass bays.

A number of other measures are planned which will minimise the increase in nitrogen load arriving at the treefarm. Most significantly, Timewell Road WWTP will undergo a major upgrade through an increase in aeration capacity. Concept design is well underway with the upgrade of the WWTP to activated sludge scheduled to commence in 2005.

Outcomes from research at the treefarm by the University of Western Australia (UWA) show the nitrogen removal performance of the treefarm exceeds all design expectations. Use of the canopy material left after harvest to amend the soil additionally allows a substantial increase in the design nitrogen application rate.

Phosphorus retention in the soils at the site continues to be high and is in-line with the design life of in excess of 300 years. Monitoring of groundwater bores and surface runoff has shown nutrient discharges from the site are low and well within the original design assumptions. Groundwater levels on the site have generally decreased in line with changes in the surrounding area.

Harvest operations commenced in 2003 with felling of 49 hectares in 2003 and 65 hectares in 2004. This activity has triggered a number of operational improvements as research findings continue to be translated to operational and performance improvements.

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1 Introduction

The town of Albany is situated some 410km southeast of Perth on the southern coast of Western Australia on Princess Royal Harbour.

Albany's wastewater is treated at the Timewell Road Wastewater Treatment Plant (WWTP) with the treated effluent being used to irrigate gum trees at the Gunn Road treefarm. The Gunn Road treefarm not only manages the disposal of the treated wastewater by means of a woodlot, but also implements a measure of nitrogen reduction through a series of overland flow areas. A further reduction of nitrogen and phosphorus occurs in the woodlot.

The Water Corporation's Effluent Irrigation Treefarm at Gunn Road was developed between 1992 and 1994 following extensive public consultation with the people of Albany. This is the third triennial report on the operation of the treefarm. This report covers the period 2001 to 2003 and reports on the environmental monitoring at the treefarm. A Progress and Compliance Report against the Ministerial Conditions that were developed following the public environmental review process is also incorporated.

1.1 Location

The treefarm is situated off Gunn Road on a 550ha parcel of land approximately 10km North of Albany, directly opposite the city's airport as shown in Figure 1. The site was selected for the high phosphorus retention capacity of the soils and because it is at the head of the Seven-Mile Creek catchment so has limited ground and surface water inputs. This allows for simplified hydrological management as external inputs are minimised and the site out flow is contained to the southern boundary.

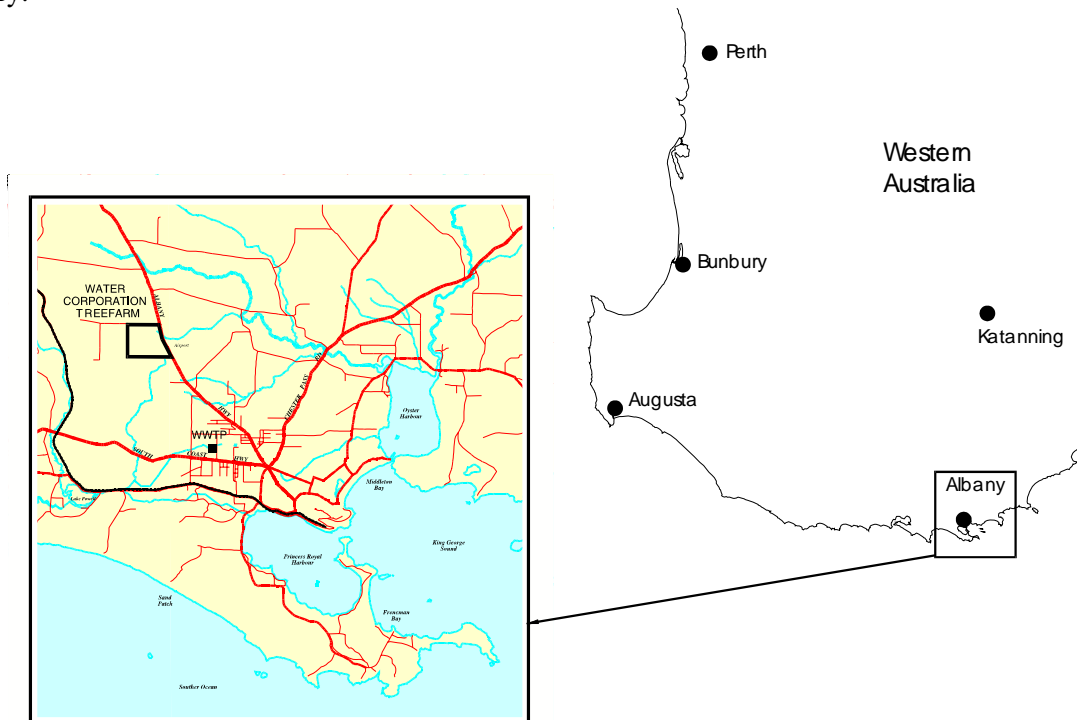


Figure 1 Location of the Water Corporation Treefarm

2 Overview of Operations

2.1 Wastewater Treatment Plant (WWTP) and Land Disposal Site Infrastructure

The Timewell Road WWTP treats all the sewerage from Albany to secondary effluent standard. The design capacity of the Timewell Road WWTP is 6 ML/day. The plant comprises influent screening followed by 2 aerated ponds and 3 facultative ponds.

A schematic of the land treatment process is given in Figure 2 below. Treated wastewater is pumped from Timewell Road directly into two holding ponds at Gunn Road. These ponds supply a distribution pump station that delivers the wastewater to overland flow grass bays. There are 34 individual grass bays that give a total pasture area of 14 hectares. The 34 plots are divided into 2 groups that are flood irrigated each on a 6 hours ON-6 hours OFF cycle. Because the inflow rate to the ponds can exceed the capacity of the grass bays, a bypass is provided that diverts excess flows to additional grass bays and then directly to the wetland area at the inlet to the main irrigation storage dam.

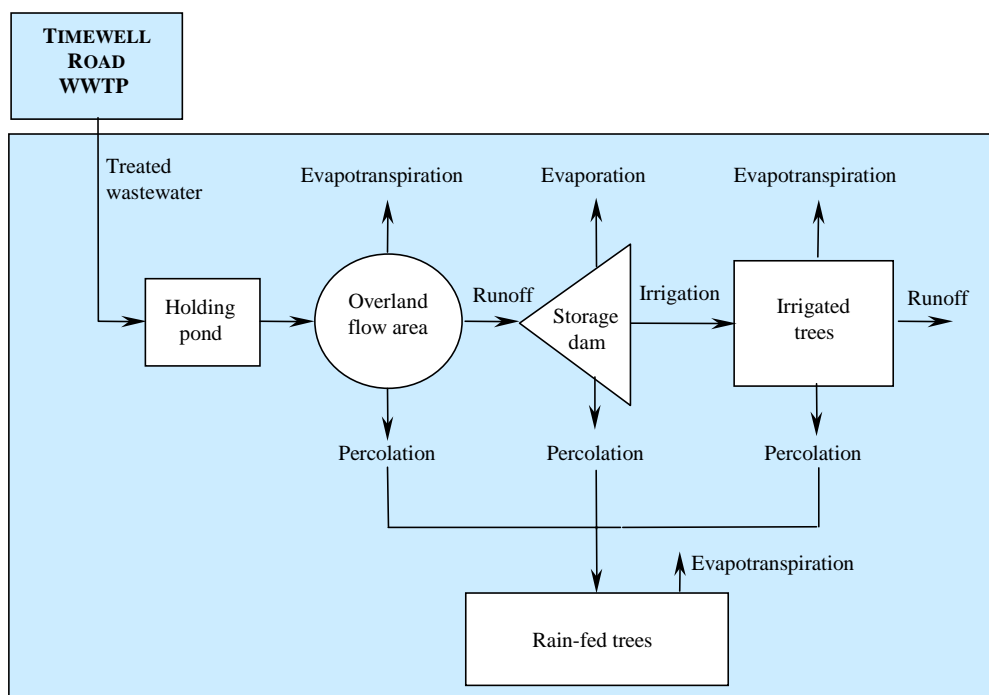


Figure 2 Land Treatment Flow Diagram

The main irrigation storage dam collects all surface runoff from the wetland at the outflow from the overland flow grass bays. The dam supplies the irrigation pump station through a floating off-take for distribution over the 283ha of effluent irrigated blue gums. The pump station has facility for dosing of either sodium hypochlorite or hydrochloric acid for pH control and for chlorination to manage algae growth in the irrigation system. The system measures pH and if greater than 8.5, acid dosing is automatically initiated. Although acid has been dosed intermittently, there has been no use of sodium hypochlorite.

The dam capacity is 365 ML, representing 75 days of storage at the 2003 average daily site inflow rate. During peak winter flow periods the storage is reduced to about 60 days.

2.2 Overview of Wastewater Treatment Operations 2001 to 2003

2.2.1 Timewell Road Wastewater Treatment Plant

Inflows to the treatment plant have continued to increase over the reporting period, primarily in response to natural growth in Albany. The Water Corporation has also continued to actively promote connection to sewer of industries that discharge liquid waste directly to Princess Royal Harbour.

The average annual flow into the treatment plant during the 2003 year was 4.8ML/day. This is higher than the projected average inflow made as part of the treefarm design. To treat this inflow the Timewell Road WWTP will be upgraded to an activated sludge process. Previous reporting indicated only aeration would be increased, however this was discounted at the design stage following a cost-benefit analysis. Consequently the Water Corporation is designing an upgrade to activated sludge technology that will increase both the treatment quality and quantity from 2006.

2.2.1.1 SLUDGE MANAGEMENT

Because of the increased loading on the treatment system, physical aeration requirements have increased and sludge accumulation in the ponds has accelerated to a point where the ponds need to be desludged. Following research into dewatering technology in 1999, full scale desludging was conducted during 2001 and 2002. The desludging used geotextile bags to dewater the sludge. The full geobags are currently stored on-site in a purpose built plastic lined bund. The temperature in the bags is being monitored to enable assessment of pathogen die-off over time. Sludge will continue to be stored on-site in the bags until summer 04/05 when the bags will be cut open for final air-drying of the sludge prior to disposal or reuse.

Biosolids reuse occurred during 2002 and 2003 with approximately 300m³ applied each year to a vineyard at Redmond. These beneficial reuse projects have been highly successful and a third application at the vineyard is proposed for 2004.

2.2.1.2 ODOUR CONTROL

At Albany, the new inlet works incorporates an enzyme dosing system to manage odours produced by the materials collected by the inlet screen. The downstream processes of aerated and facultative lagoons are maintained in an aerobic condition and consequently there have been very few odour problems.

The trial desludging exercise during summer 1999/2000 highlighted the need for odour control measures to be considered during the 2001/2002 desludging of the treatment ponds. However the geobag dewatering process very effectively contained odours and no specific odour control measures were required.

2.3 Overview of Land Treatment Site Operations 2001 to 2003

2.3.1 Overland Flow System

Nitrogen removal from the overland flow treatment system has been excellent. Vegetation in the grass bays has become very dense. The thick grass caused problems during the 1999 harvest as conventional farm machinery had difficulty cutting the material. The wheel tracks left by the machinery also hindered the sheet-flow characteristic of the grass bays. Uniform flow is a key design feature of the overland flow treatment, so a revised harvest strategy was considered.

The harvest strategy now in place has been developed using purpose designed machinery. Half of the grass bays are taken off-line and dried for a period of several weeks. The actual harvest then occurs in one day and is capable of cutting back to a 50 to 150mm thick mat of grass. This equipment will be first used in 2004 over 7 hectares (half) of the grass bays.

The current operational strategy for the overland flow bay irrigation is alternating between each of the two groups of flow bays for 6 hours ON-6 hours OFF. An 18 hours ON-6 hours OFF strategy was implemented during 2001 to improve distribution through the poor performing distribution system prior

to upgrade. This strategy allowed a net 13% increase in the volume passed over the grass bays, yet reduced the instantaneous loading rate.

The grass bay irrigation distributors have required high levels of operator attention to maintain uniform flow distribution. Consequently a revised distribution header was installed in 2002. This header system is more reliable and requires substantially less maintenance through use of more traditionally accepted irrigation methods. This system also allows the 6hr-ON 6hr-OFF irrigation strategy to be used effectively.

2.3.2 Irrigated Blue-gum Plantation

In mid 2000 irrigation to the 1996 and 1998 planted trees was installed and commissioned. This increased the available irrigation area from 230 to 283 hectares. The automatic irrigation control for this area was installed in 2002, including the addition of two more soil moisture sensor sites.

Harvest operations commenced in March 2003 with the felling of 33.4 hectares of irrigated plantation and 16 hectares of rain-fed. This harvest reduced the available irrigation area to 249.6 hectares. Further planned harvest operation commenced in April 2004 with the felling of 60.4 hectares of irrigated and 2.5 hectares of rain-fed trees.

Figure 3 to Figure 5 below show the weekly irrigation depth and the level in the main storage dam for each of the reporting years 2001 to 2003. This data provides an overview of growth in wastewater flows and the capacity of the infrastructure at the treefarm. The average inflow during 2001 (Figure 3) was 4559 kL/day. This is about 75% of the design capacity for the site. The inflow and irrigation volumes presented here for 2002 are different to those presented in the annual report previously submitted due to calibration of the meters and subsequent correction of data in 2002. The capacity of the irrigation system and the design hydraulic capacity of the site are still well within the design values of 80mm/month during summer and 50mm/month during winter.

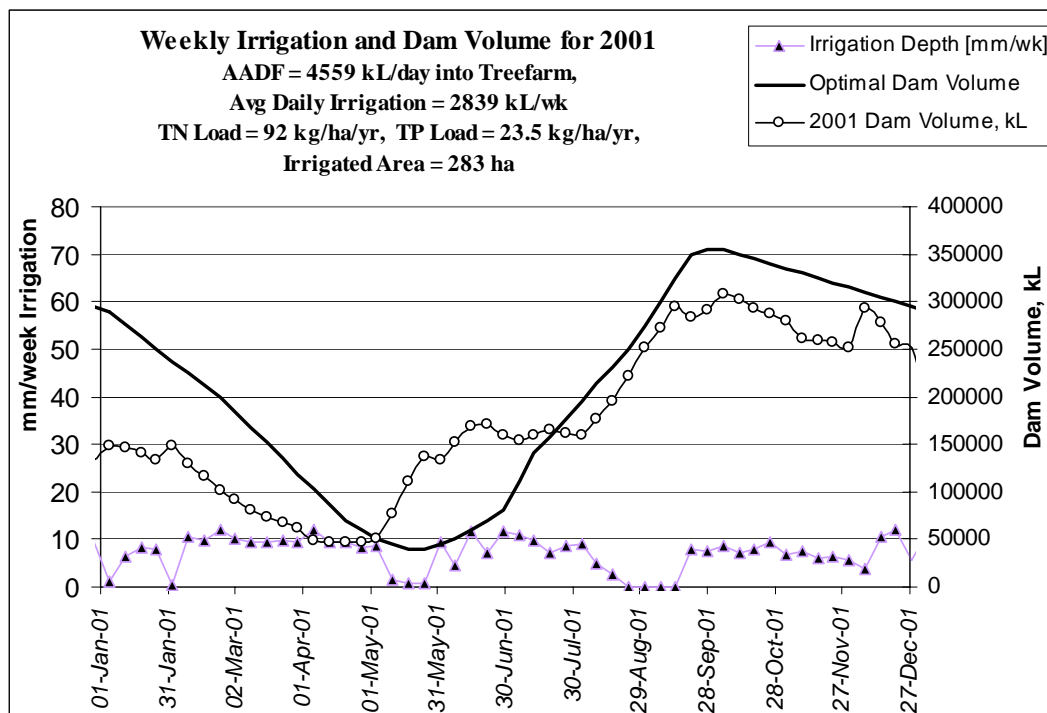


Figure 3 Dam Volume and Weekly Irrigation Summary for 2001

In all years (2001 to 2003) the storage levels maintained in the irrigation dam during have been different to the optimal design level. The optimal dam curve is designed for the treefarm when operating at the design site inflow capacity of 6ML/day. Consequently there has previously been increased scope to deviate from the optimal curve to allow for various operational drivers. For example,

the optimal dam level was altered for the 2002 year (Figure 4). This allowed an increased irrigation rate to be maintained during a period of reduced winter inflow volumes.

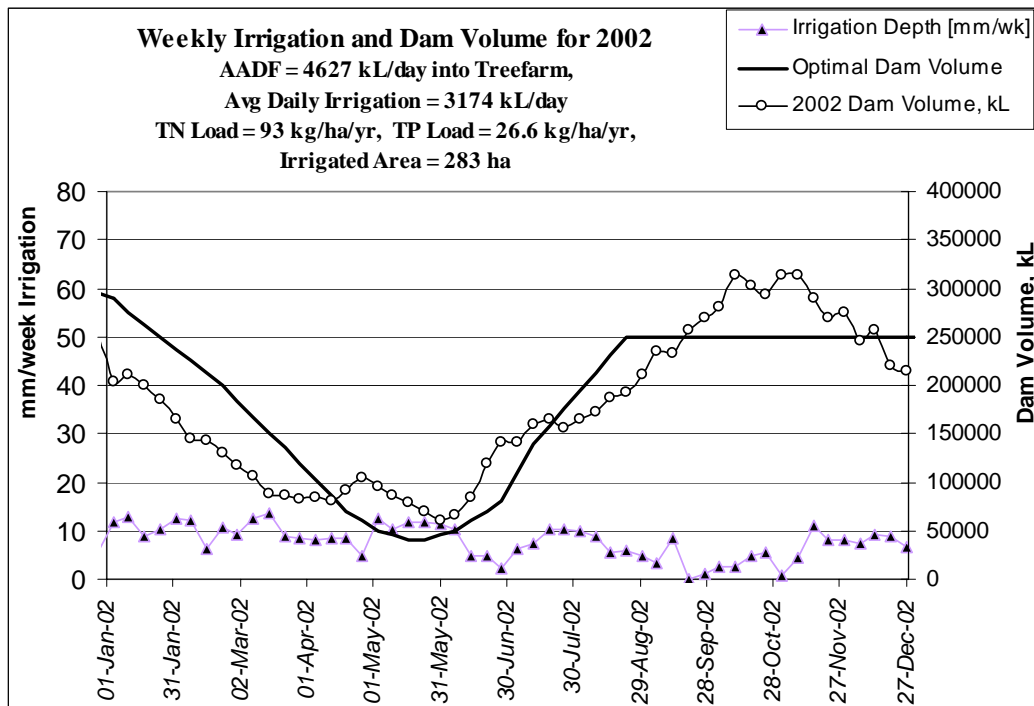


Figure 4 Dam Volume and Weekly Irrigation Summary for 2002

Total irrigation in 2002 was very similar to that in 2003, despite an increase in the flow volumes delivered to the treefarm. However, the nitrogen application rate increased from 93kg/ha/yr in 2002 to 104kg/ha/yr in 2003. This increase is due to the reduced irrigation area (lower by 11%) from March 2003 when the first harvest occurred. The phosphorus application rate was constant over these years at 27kg/ha/yr due to lower phosphorus loads (lower by 10%) received at the Timewell Rd WWTP in 2003. The nitrogen concentration in the treated effluent received at the treefarm also improved, but not to the same degree (lower by 7%) so the improved quality could not fully offset the reduced irrigation area.

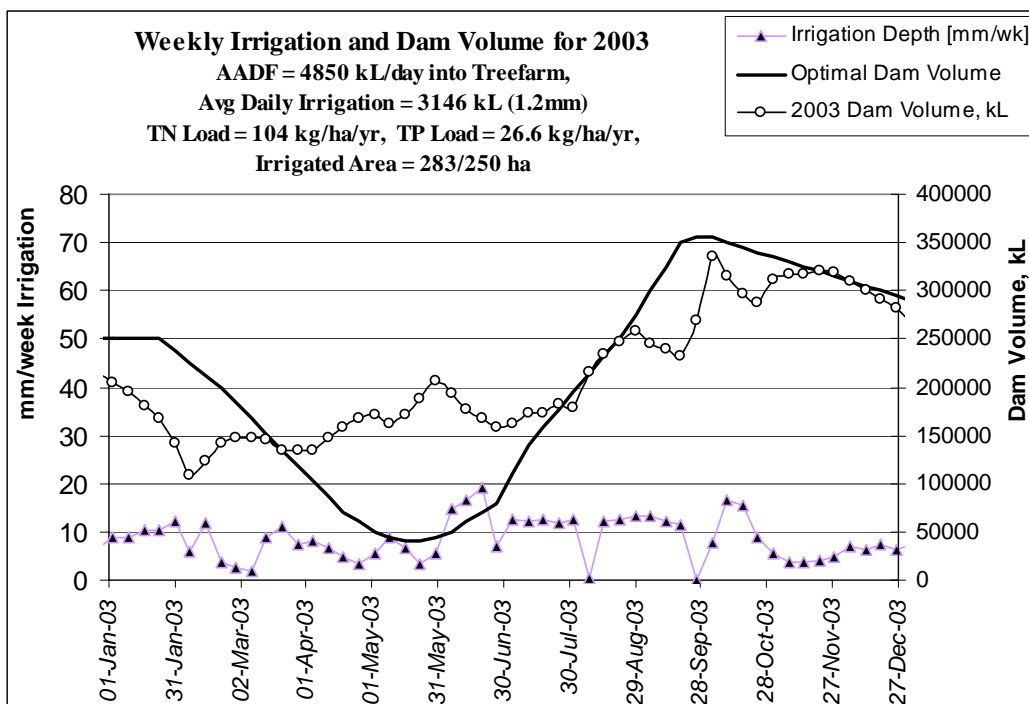


Figure 5 Dam Volume and Weekly Irrigation Summary for 2003

From mid October 2003 an algebraic irrigation model has been used to set the weekly irrigation rate. The impact of this model is shown in Figure 5 as the observed dam level tracks immediately back to the optimal dam level curve. The model was implemented as flows have increased sufficiently to warrant its use and the nitrogen load in the irrigation effluent requires more regular monitoring. Use of the model is expected to reduce variability in weekly irrigation rates as it accounts for rainfall and other variables that require consideration.

2.3.3 Plantation Irrigation Control System

Irrigation control is managed centrally via radio telemetry to 8 field units. Each field unit manages a group of 4 valves and also transmits soil moisture data to the control centre. Irrigation is scheduled according to the soil moisture condition, inflow quantity and prevalent weather to ensure that excess soil saturation does not occur and also so that the trees do not become stressed due to low soil moisture.

Since 1997 there has been increased operational difficulty with the soil moisture system because of radio-telemetry problems. Upgrade work commenced in 2002 and will be completed in 2004. This work has duplicated solar panels, upgraded radio communications and added functionality to the control reporting system. Upgrade works including ensuring reliability of the soil moisture transducers and updating the control software for the soil moisture data management system have been ongoing and are expected to be complete in 2004/05.

2.3.4 Soils

Soil Management Consultants were engaged to early 2004 to undertake soil analysis across the irrigated plantation and also in the irrigated grass bays. The full report is included in Appendix A. The soil sampling was extended to take samples from 0.1-0.3m depth in addition to the minimum requirements of surface soil sampling. This deeper sampling is in response to recommendations from previous independent investigations at the treefarm.

Soil samples were taken at 12 sites (7 irrigated, 3 rainfed and 2 overland flow) and analysis performed for all major plant nutrients, cation exchange capacity, phosphorus retention index (PRI), exchangeable aluminium, conductivity and pH. The report concluded that the soils are stable and maintain "considerable" potential for phosphorus retention.

Previously identified elevated pH in some surface soils have been attributed to cropping before the treefarm was established, and is not related to the plantation activity. The soil analysis has identified some reduced availability of potassium in the soils under rainfed trees; however the plantation has not exhibited any signs of trace element deficiency. Preliminary analysis in 2004 showed a potassium concentration of 18mg/L in the water irrigated to the blue gum plantation, accounting for the difference in potassium availability compared to rainfed trees.

2.3.5 Plantation Management

The Forest Products Commission carries out all plantation management under contract to the Water Corporation. A summary report of their operations is provided in Appendix B.

Chemical insect controls have not been necessary as the irrigated plantation continues to outgrow the impacts of pests, however there is some need for ground spraying for weed control in harvested areas. Wood production continues to be good-excellent owing to the benefits of treated wastewater irrigation of the plantation.

2.3.6 Arboretum

The arboretum was planted in 1994 and includes 12 different species for comparison. An assessment of the relative performance of each of the species was made by the Forest Products Commission and is included in Appendix B. Species identified as not suitable for irrigation will be removed and replaced with either blue gums or other species suitable to be developed for saw log production. This work will be undertaken in the summer/autumn of 2005.

3 Performance Monitoring

3.1 Flow Volumes

Flows to the treefarm are directly related to wastewater inflows at Timewell Road WWTP. The treatment plant allows some attenuation of the flows to the treefarm except during periods of very high storm flow. In these cases the pumping rate is increased to ensure adequate storage capacity is maintained in the ponds.

An extreme rainfall over the period 29 September to 01 October 2003 resulted in overflow to Five-Mile Creek. This is not reflected in the discharge data (Figure 6) due to problems with the pressure main restricting the peak flow rate. The pressure main from the Timewell Road WWTP to the treefarm has since been scoured of accumulated sediment to reduce the head losses and increase the pumping flow rate.

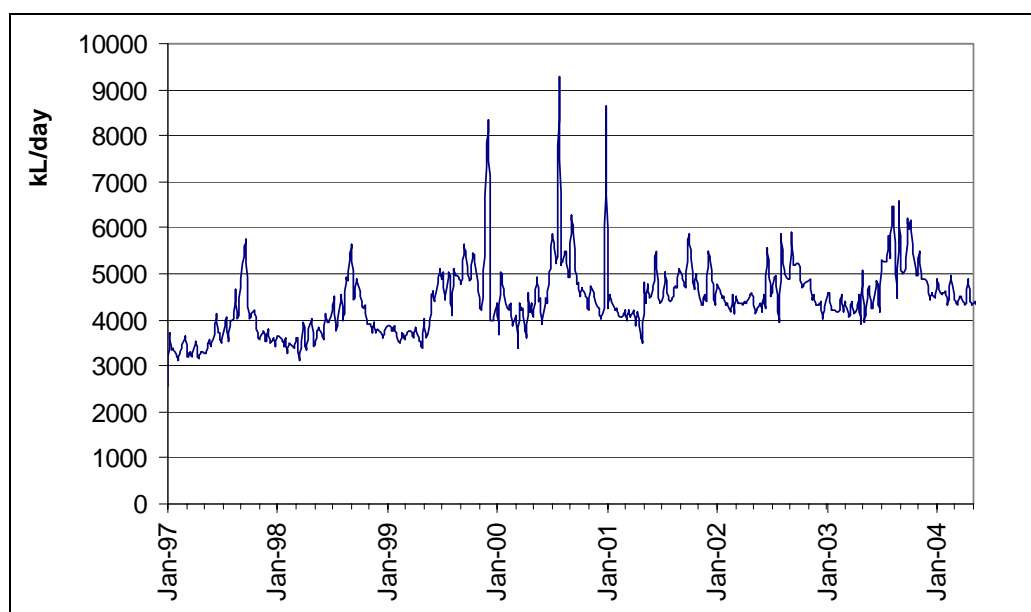


Figure 6 Daily inflow to the Albany tree farm, 1997 to 2003

The average inflow to the tree farm during 2003 was 4.85 ML/day, representing an annual growth of about 3% per annum from 2001. This compares favourably to the licensed hydraulic capacity of 5.5ML/day for the WWTP and 6ML/day for the treefarm.

The annual volumes of flow through the overland flow distribution system and the irrigated plantation are summarised below in Table 1.

Table 1 Summary of flows at the Albany treefarm site

	Inflow to Gunn Rd		Pumped to overland	Irrigated to blue-gum
	ML/year	Avg kL/day	flow bays	plantation
	ML/year	Avg kL/day	ML/yr (% of inflow)	ML/yr (% of inflow)
1997	1354	3720	1118 (83%)	896 (66%)
1998	1426	3920	876 (61%)	958 (67%)
1999	1595	4380	947 (59%)	950 (60%)
2000	1732	4760	1254 (72%)	1249 (72%)
2001	1660	4560	1443 (87%)	1033 (62%)
2002	1689	4640	1700 (100%) ¹	1155 (68%)
2003	1765	4850	1607 (91%)	1145 (65%)

1. Unreliable data due to a calibration error with the magflow meter.

The average increase in inflow received at the site for the 2001 to 2003 period is lower than the annual increase reported in the previous triennial reporting period due to the reduced peak winter inflow rates. The volume delivered to the grass bays has increased as a percentage of inflows. This is primarily as a

result of the improved irrigation distribution system installed in 2002 as well as reduced seasonal bypass of the grass bays due to lower peak winter inflows.

Annual irrigation volume has consistently been about 65% of the site inflow. The design irrigation capacity of the site is for 1826 ML/year over 233 ha (effective) giving 784mm/yr irrigation depth. Total annual irrigation depths were 365, 408 and 449mm/year for 2001 to 2003 respectively, representing 45% to 60% of the design irrigation capacity.

3.1.1 Raw Wastewater and Effluent Quality at Treefarm Inlet

Influent quality at the Timewell Road has been very consistent as would be expected for a predominantly domestic wastewater and is summarised in Table 2.

Table 2 Average influent quality at inlet to Timewell Road WWTP.

<i>Raw Wastewater Inlet to Works</i>	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorus (mg/L)	pH	BOD₅ (mg/L)	Total Dissolved Solids (mg/L)
1997	50.8 (8)	8.9 (8)	7.4 (8)	220 (8)	890 (8)
1998	62.9 (12)	10.1 (12)	7.4 (11)	235 (12)	940 (11)
1999	61.1 (13)	9.9 (13)	7.5 (12)	200 (13)	1000 (12)
2000	57.9 (11)	11.4 (11)	7.6 (10)	225 (10)	880 (10)
2001	52.2 (13)	8.3 (13)	7.4 (14)	180 (13)	860 (13)
2002	58.9 (11)	9.9 (11)	7.4 (11)	205 (11)	910 (11)
2003	54.4 (11)	8.8 (12)	7.4 (12)	145 (12)	970 (10)

(n) is number of samples used to calculate the average value and is all NATA certified analysis

The effluent quality from Timewell Road is measured at the holding ponds at Gunn Road and data is summarised in Table 3 below. This data is the combined averages from operational analysis conducted on-site and compliance analysis performed at a NATA certified laboratory. The total nitrogen concentration of the treated wastewater pumped from the Timewell Road treatment plant (the treefarm inflow) increased steadily from 1997 to 2002. A decrease in TN concentration in 2003 is attributed to desludging of the wastewater treatment ponds at Timewell Road.

Table 3 Average effluent quality at inflow to treefarm (sampled in the holding ponds)

<i>Holding Ponds</i>	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	pH	BOD₅ (mg/L)	Hardness mg/L as CaCO₃
1997	32.2 (41)	9.0 (38)	7.6 (12)	21 (12)	<i>No data</i>
1998	40.3 (24)	8.6 (26)	7.6 (21)	30 (19)	229 (13)
1999	45.9 (51)	7.6 (49)	7.5 (49)	31 (16)	222 (47)
2000	48.4 (48)	8.1 (48)	7.3 (47)	26 (14)	225 (46)
2001	47.2 (45)	7.8 (48)	7.3 (47)	28 (16)	221 (34)
2002	50.7 (41)	8.9 (41)	7.6 (41)	27 (16)	238 (37)
2003	46.0 (48)	7.7 (48)	7.7 (48)	27 (15)	221 (44)

(n) is number of samples used to calculate the average value from on-site and NATA certified analysis

The biological oxygen demand (BOD₅) of the treated wastewater has increased from 20 mg/L to 30 mg/L since 1997. This, and the increasing nitrogen concentration to 2003, is demonstrative of the increased loading due to higher flow rates associated with growth in annual wastewater volumes received at the WWTP. This level of BOD in the treated wastewater is typical for a pond type treatment system.

3.1.2 Overland Grass Bays

The overland flow bays operate at reduced performance during winter due to the colder temperatures and higher flows. Data presented in Table 4 is however limited to the annual average values to allow comparison with other site data. Improvements to the distribution system and scheduling of the grass bay irrigation, has led to some improvement in the nitrogen removal. Combined with the positive

effects of pond desludging, this has achieved the lowest nitrogen concentrations in the grass bay discharge since 1998, despite the increased volumes being treated at the WWTP and through the overland flow system. These process and performance improvements are despite ongoing difficulty in the harvesting of the overland flow grass bays as discussed in section 2.3.1. Following implementation of the new equipment, it is anticipated there will be at least some seasonal improvement in the nitrogen removal efficiency.

Table 4 Average effluent quality at outflow from overland flow bays

<i>Grass bay out-flow</i>	Total Nitrogen mg/L	Total Phosphorus mg/L	pH	Hardness, mg /L as CaCO₃
1997	20.6 (38)	7.2 (32)	7.6 (6)	<i>No data</i>
1998	24.2 (16)	6.3 (13)	7.5 (13)	235 (12)
1999	31.7 (47) ¹	6.0 (46) ¹	7.4 (47)	226 (46)
2000	33.0 (44) ¹	6.4 (45) ¹	7.3 (46)	228 (44)
2001	32.0 (42)	6.5 (45)	7.3 (45)	222 (34)
2002	33.0 (38)	6.7 (38)	7.6 (38)	237 (36)
2003	27.7 (46)	5.8 (46)	7.5 (46)	216 (44)

(n) is number of samples used to calculate the average value

1. Adjustment to 99-00 data compared to previously reported following 2001 review of onsite and NATA analysis results

3.1.3 Tree Irrigation

Nutrient concentrations in the irrigation dam are lower than in the outflow from the overland flow bays due to continuing biological processes and nitrogen volatilisation in the dam. The annual average water quality in the dam is given in Table 5 below. As presented in Section 2.3.2, the nitrogen loading to the irrigated plantation was less than the Ministerial Condition limit of 106kg/ha/year.

Table 5 Average effluent quality irrigated to blue-gum plantation

Main irrigation dam	Total Nitrogen mg/L	NH₃-N mg/L	NO_x-N Mg/L	Total Phosphorus mg/L	BOD₅ mg/L	pH	Hardness, mg/L as CaCO₃
1997	15.7 (41)	<i>No data</i>	<i>No data</i>	5.9 (39)	<i>No data</i>	<i>No data</i>	<i>No data</i>
1998	22.2 (24)	<i>No data</i>	<i>No data</i>	5.5 (25)	<i>No data</i>	7.8 (14)	227 (13)
1999	27.2 (49)	<i>No data</i>	<i>No data</i>	6.7 (48)	<i>No data</i>	7.6 (48)	224 (47)
2000	29.1 (48)	20.7 (8)	2.3 (8)	6.3 (48)	6 (2)	7.5 (46)	220 (46)
2001	24.6 (44)	18.2 (13)	2.6 (13)	6.6 (48)	4 (2)	7.5 (43)	223 (37)
2002	23.5 (48)	17.5 (20)	2.2 (12)	6.8 (42)	<i>No data</i>	7.9 (38)	231 (38)
2003	22.5 (49)	18.0 (14)	1.9 (14)	6.1 (49)	4 (4)	7.9 (46)	220 (44)

(n) is number of samples used to calculate the average value

The steady increase in nitrogen loading at the treefarm inflow is reflected in the dam average ammonia-nitrogen concentration while more recently the dam total nitrogen has improved. Total nitrogen concentrations have reduced due to the successful desludging of the Timewell Road treatment plant and the improvements to the grass bay operation. The nominal increase in total phosphorus in the dam is due to the larger inflows and reduced relative impact of direct rainfall and runoff inputs to the dam causing less dilution of the phosphorus discharged from the grass bays.

3.1.4 Gunn Rd Discharge

Surface discharge from the land treatment site is gauged at the Gunn Road gauging station at the head of the Seven-Mile Creek. There is automatic flow logging and water quality sampling at this point. The daily discharge for the period 1997 to 2003 is shown in Figure 7 below.

Data for the first 6 months of 2003 was lost due to repeat failure of the logging instrumentation. These failures led to a full upgrade of the logging equipment and the data is now additionally sent via the district telemetry system to a central computer at the Albany operations centre.

Some very high storm peaks in the 2003 discharge can be attributed to high and extreme rainfall events. Weekly rainfall in excess of 45mm was recorded on five occasions during August, September and October 2003. The largest recorded weekly rainfall of 73mm occurred during October 2003.

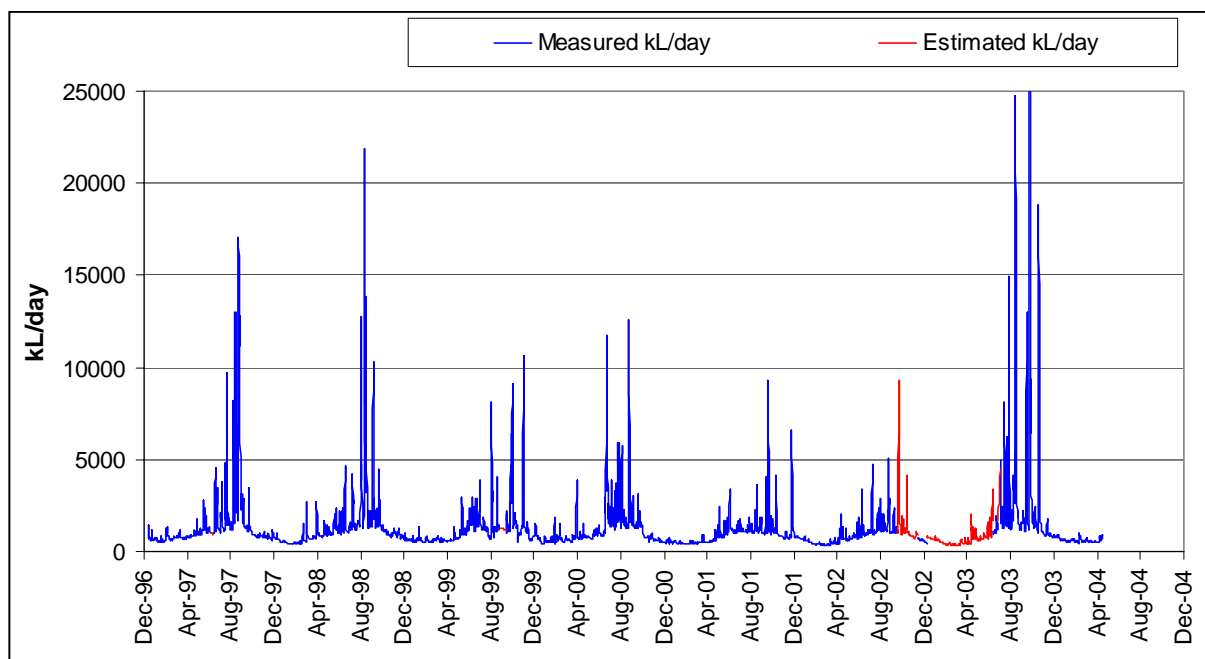


Figure 7 Streamflow at Gunn Road gauging station, 1997 to 2003

Nutrient discharge through the Gunn Road gauging station was calculated using HYDSYS hydrological software to give the nitrogen and phosphorus loads in Seven-Mile Creek. Results of daily flow logging and HYDSYS nutrient load calculations are summarised in Table 6 below. This table includes summary data for all years since the inception of the treefarm, the commencement of planting in 1993 and the start of irrigation in March 1995. The discharge volume in Seven-Mile Creek is strongly driven by annual rainfall ($R^2=0.68$) rather than irrigation ($R^2<0.01$). The annual nutrient loads in the discharge from the site have fallen substantially since the establishment of the plantation due to the combined influences of reduced rainfall and improved runoff interception of the plantation compared to pasture.

Table 6 Summary of HYDSYS calculation of nutrient loads in Seven-Mile Creek

Year	Rainfall mm/year	Irrigation ¹ mm/yr	Average Irrigation Area, ha	Discharge ML/year	Total Nitrogen Load kg/year	Total phosphorus Load kg/year
1992 ⁴	930	0	-	950	1399	262
1993 ⁴	821	0	-	734	916	207
1994 ⁴	675	0	-	576	1054	169
1995 ⁴	720	146	230	466	514	67
1996 ⁴	831	264	230	593	733	95
1997	724	389	230	525	466	40
1998	783	417	230	486	456	36
1999	719	398	240	419	162 ²	21 ¹
2000	768	455	275	450	459	37
2001	879	365	283	370	225	10.9
2002	684	408	283	347 ³	146 ²	8.3 ²
2003	847	449	255	648 ³	386 ³	35.9 ³

1. Irrigation depth calculated over weekly irrigated area.
2. Load underestimated due to insufficient nutrient data for HYDSYS
3. Includes estimated data
4. Sourced from Albany Land Treatment System Review (Kinhill Pty Ltd, 1997)

To improve the measure of nutrient export from the site, an independent consultant (CYMOD Systems Pty Ltd) is now using groundwater data to calculate the groundwater discharge component. The modelling system used for these calculations has additionally been developed to estimate the surface (Seven-Mile Creek) discharge and nutrient export. HYDSYS data is used in total nutrient export calibrations due to the higher frequency of in-stream water quality analysis than groundwater bore analysis. Table 7 below summarises calculated nutrient discharges using both HYDSYS and CYMOD results.

The CYMOD estimates for phosphorus are less accurate than nitrogen owing to the complexities in soil processes that govern phosphorus immobilisation processes, however the calibrations for nitrogen are good (Refer to Appendix C). These estimates show the groundwater nitrogen export to be comparable to previous years.

Table 7 Annual TN and TP loads in groundwater and surface runoff

Year	Estimated TN in groundwater (kg/year)	Estimated TN in surface runoff (kg/year)	Overall TN load (kg/year)	Estimated TP in groundwater (kg/year)	Estimated TP in surface runoff (kg/year)	Overall TP load (kg/year)
1997 ¹	191	339	530	13	30	43
1998 ¹	221	312	533	16	26	42
1999 ¹	205	368	573	15	26	41
2000 ¹	305	318	623	34	14	48
2001 ²	148 ²	225 ³	373	18 ²	10.9 ³	28.9
2002 ²	156 ²	146 ³	302	18 ²	8.3 ³	26.3
2003 ²	162 ²	482 ³	644	18 ²	45.5 ³	63.5

1. data from Brown & Root (2001) independent review
2. data from CYMOD (2004) independent review, TP groundwater data is estimated average over three year period.
3. Calculated from HYDSYS hydrological analysis of actual flows and weekly analysis results.

The surface runoff loads calculated by HYDSYS for 1997 to 2000 (Table 6) are higher than those made by the Kinhill independent review for 1997 to 2000 (Table 7). This provides some confidence that the nutrient loads calculated here for 2001 to 2003 are conservative/high as these were determined using the more conservative HYDSYS methodology.

Nutrient discharges of both nitrogen and phosphorus increased in 2003 compared to decreases in 2001 and 2002. The lower discharge loads in 2001 and 2002 are due to lower incidence of storm events and lower total discharge volume (refer Table 6). The higher discharge in 2003 is attributed to the number of storm events and higher peak stream flows recorded in Seven-Mile Creek than in previous years. In particular, two storms in late September and early October contributed about 15% of the annual nutrient discharge down Seven-Mile Creek.

The total nutrient loads are well within the design estimates of 3 tonnes total nitrogen and 1 tonne total phosphorus per annum, and continue to be stable at about 500kg nitrogen and 50kg phosphorus.

3.2 Groundwater Monitoring

Environmental and operational monitoring at the Albany Treefarm incorporates monthly groundwater level and quarterly analysis of 34 bores across the treefarm site. The location of the individual bores is given in Figure 8 below.

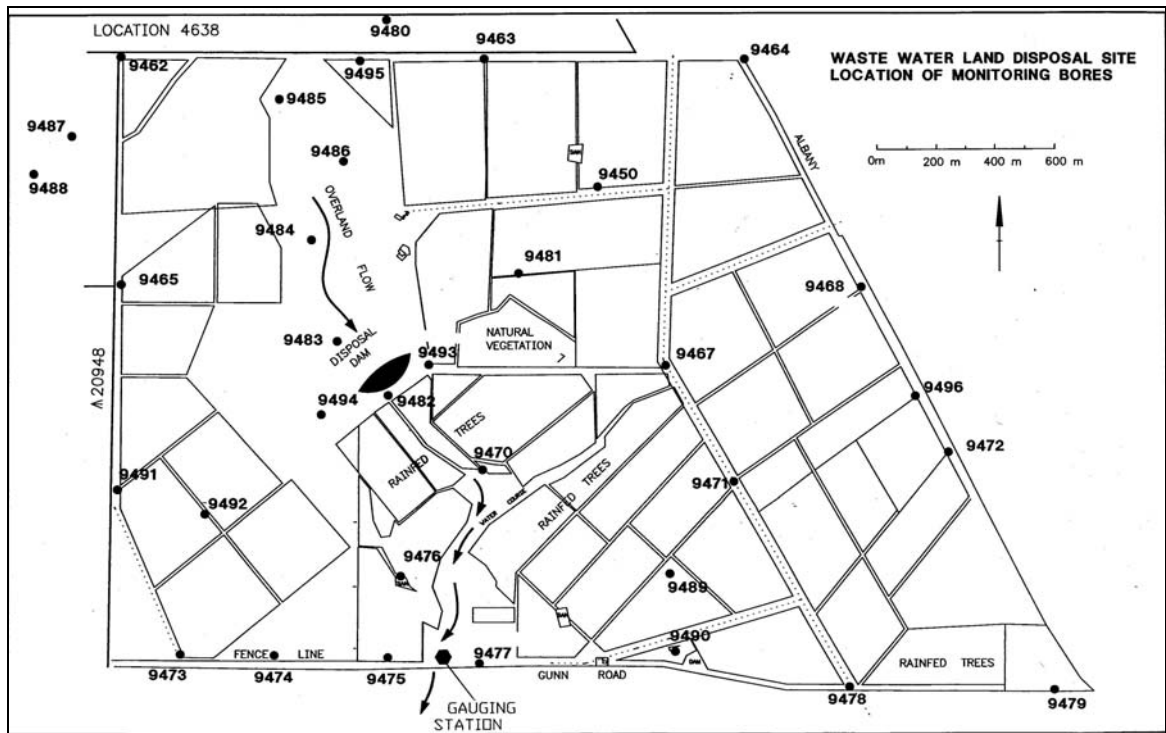


Figure 8 Treefarm layout showing location of monitoring bores

CYMOD Systems Pty Ltd has undertaken an independent analysis of the groundwater levels at the treefarm and produced groundwater contour plots for each triennial reporting period. Contours from March 1996 and March 2003 are given in Figure 9 and Figure 10 below. Note that each of these contours is superimposed over a 2003 aerial photo of the treefarm site. These plots show that the summer 2003 groundwater levels were very similar to those in 1996, when the treefarm was very lightly irrigated.



Figure 9 Groundwater Contours in March 1996

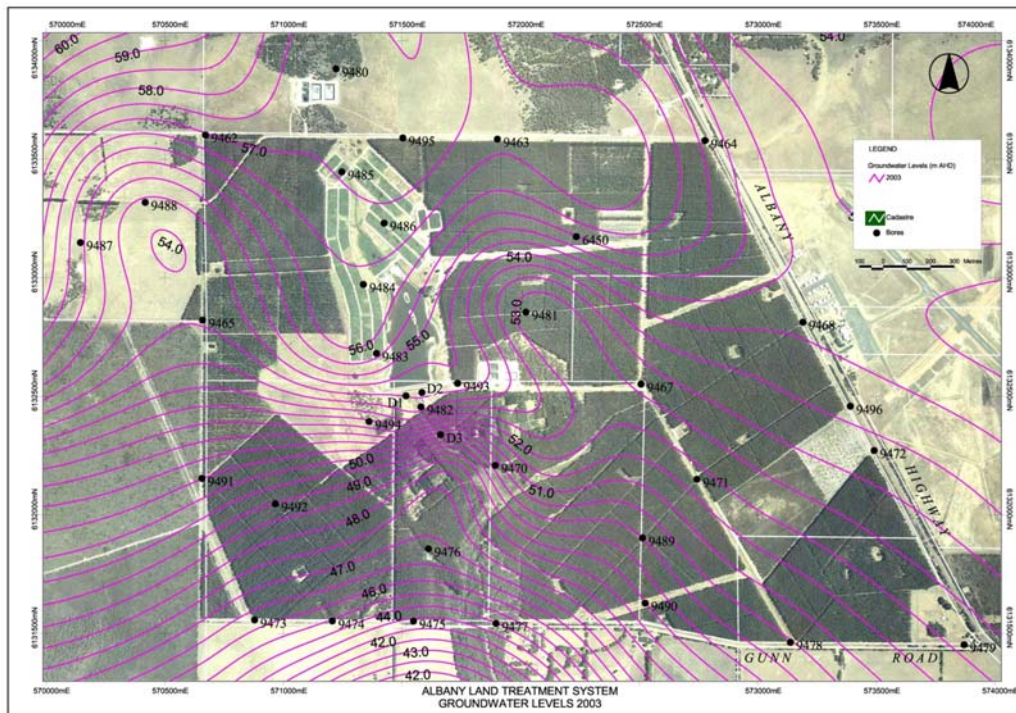


Figure 10 Groundwater Contours in March 2003

Some elevation of groundwater has been evident in the past due to the high irrigation rates over the overland flow bays. This is a localised effect around the overland flow bays and main irrigation dam, and has stabilised at nominally higher than historical levels. The most significant change to groundwater levels in the overland flow area is the seasonal variability in level due to the winter irrigation loading. Groundwater levels below the dam in both irrigated and rainfed areas exhibit similar large seasonal variations associated with rainfall and the storage level in the main irrigation dam.

The majority of other bores across the site, in both rainfed and irrigated plantation, and also in non-irrigated pasture and neighbouring farm land, show a steady decline in the groundwater level. Average rest levels in 2003/04 are now about 0.3 to 0.6 metres below the average levels in 1995. This uniform trend across the treefarm and in neighbouring areas suggests the groundwater decline is a response to local groundwater change and not plantation water demands, and is consistent with the drying climate being experienced. Groundwater levels are also influenced by the spatial and temporal variability in seasonal rainfall, as more regular lower rainfall amounts lead to greater interception by the plantation canopy.

3.2.1 Groundwater Quality and Levels

Data for the monitoring bores has been summarised in the following sections to describe particular areas of the treefarm and groundwater features. Groundwater level, conductivity and nutrient concentration data is presented graphically for all bores in Appendix D and graphs are grouped by location to correspond with the following discussion.

Note that a number of bores (9489 to 9496 inclusive) have shown a lowering of the water table below the effective sampling depth from the bores, especially during summer. These sites therefore will only show analysis results from when sample collection was possible.

3.2.1.1 NORTHERN, WESTERN & EASTERN BOUNDARIES

Groundwater flow onto the site occurs to a limited extent on the northern and western boundaries. Monitoring bores along the site boundary and control bores on neighbouring properties to the north and west show groundwater variations as large as those within the irrigated areas of the treefarm. Total nitrogen and conductivity show moderate to large variations at most points, although 2 bores (9463 and 9480) on the northern boundary have very low total nitrogen.

Bore 9491 (boundary) shown in Figure 11 below shows a seasonal variation in nitrogen due to irrigation and rain wetting of the soil profile. The total nitrogen peaks, in the absence of nitrate, suggest this may be due to short-circuiting of irrigated water down the bore casing. This is supported by the steady decline in the conductivity in this bore to levels around the 100mS/m typically recorded in the main irrigation dam. It is most likely that the response in this bore is a combination of the impacts of the seasonal leaching beneath the plantation to manage salinity, and other external groundwater effects.

Large and seasonal nitrogen spikes are also observed on the eastern boundary, but only to a limited extent along the northern boundary. Whilst on the eastern boundary the nitrogen spikes are related to irrigation and seasonal groundwater levels, the variations on the northern and western boundaries do not exhibit such seasonal trends. As there is some groundwater flow onto the site on the northern and western boundaries, but not the eastern, bores 9462, 9480, 9487 and 9488 are presenting the natural variations in groundwater quality without irrigation. These bores show low-moderate (1-8mg/L) nitrogen concentrations, and generally stable conductivity. High nitrogen results for bore 9487 in 2001 have been attributed to the failure of bore sampling equipment preventing the correct sampling technique being used, rather than irrigation effects.

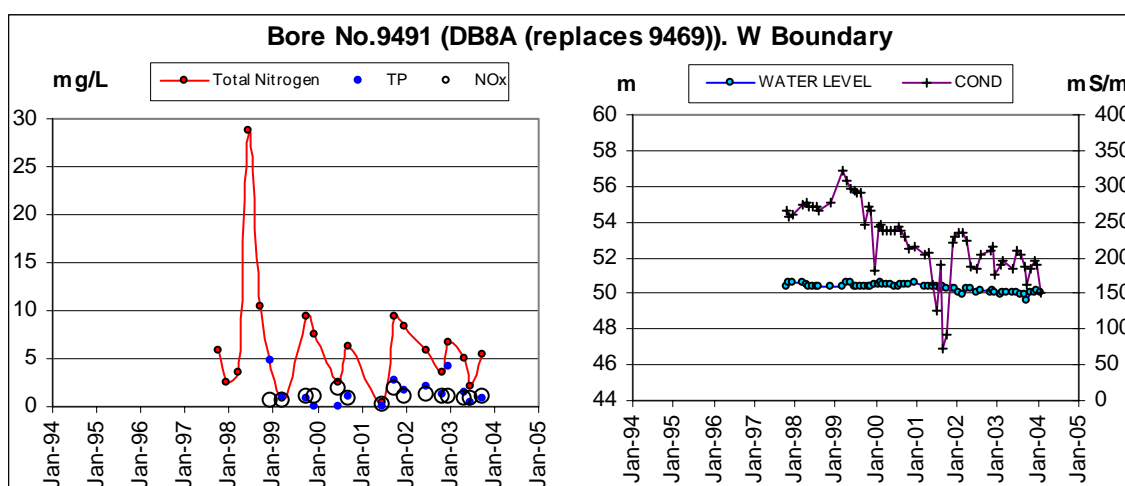


Figure 11 Bore 9491 western boundary - nutrients, conductivity and water level.

Most bores along the northern and western boundaries show an initial increase in groundwater elevation of between 0.5 and 1 metre since irrigation commenced in 1995. However, since the lower rainfall years of 2001 and 2002, there has been an overall decline in groundwater levels which are now very similar to pre-irrigation levels. The groundwater level along this eastern boundary has fallen by up to 1.0 metre since 1995. In the absence of inflow to the site along this boundary, this fall in level shows the combined impacts of lower recent rainfall and managed irrigation and uptake by the blue gum plantation.

The three bores along the central eastern boundary show very different profiles of total nitrogen and electrical conductivity. Total nitrogen concentration is low along this boundary except for seasonal irrigation spikes at bore 9468 and 9496 within the irrigated plantation. Recently there have been problems with sampling in these bores due to very low (or empty) water depth preventing adequate flushing prior to sampling. These bores are also adjacent large areas where the laterite layer is very shallow, and preferential drainage pathways are suggested to have resulted from the site ripping during establishment. This could account for the high phosphorus in bore 9496, but not the elevated nitrate concentration in bore 9468. This area would benefit from the installation of lysimeters so that the free draining pore water can be studied to determine the likelihood of nutrient leaching.

3.2.1.2 SOUTHERN BOUNDARY

Groundwater from the treefarm exits the site along the southern boundary. Figure 12 below shows variations in groundwater level, total nitrogen concentration and conductivity across the southern boundary from 1995 to 2003. There was an immediate reduction in the total nitrogen concentration

along the western end of the southern boundary at the commencement of the treefarm operations, and a more recent reduction observed at the eastern end. Groundwater levels have also reflected the establishment of plantation and also differences in annual rainfall, though groundwater level changes have been small.

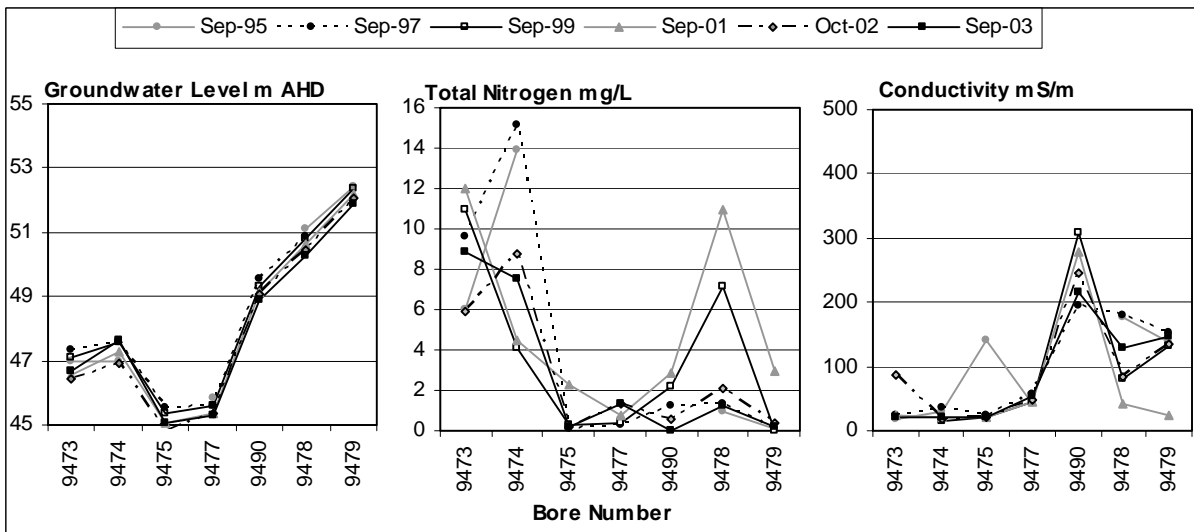


Figure 12 Cross-section of bore data along the southern boundary

Individual bores along the southern boundary continue to show strong seasonal fluctuations in groundwater level, particularly in the valley area where groundwater and surface water interactions are the strongest. Total nitrogen concentration varies with groundwater and season owing to the increased flows and dam level during winter. Bore 9477 (Figure 13 below) shows consistently low nutrient concentrations at the boundary adjacent to the Seven-Mile Creek gauging station. There has been a slight increase in total nitrogen (nitrate) in this bore, and this will be monitored with conductivity (which to date has been stable) to detect the presence of treated wastewater.

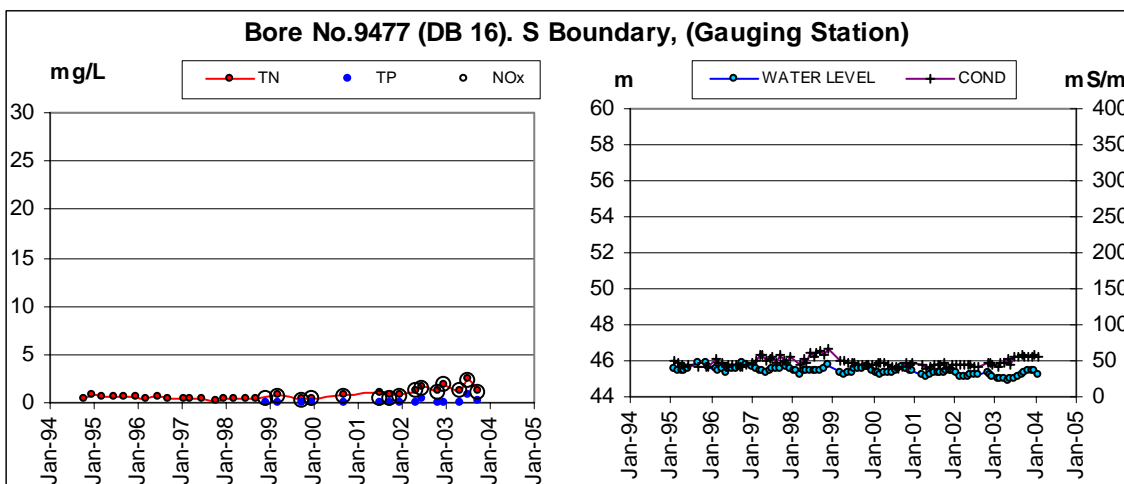


Figure 13 Bore 9474 southern boundary - nutrients, conductivity and water level.

Comparison of rainfed (bores 9474, 9475 and 9479) and irrigated (9473, 9478, 9490) bore data shows nitrate levels below the rainfed areas to be consistently lower than the irrigated areas. This is consistent with the irrigation of treated wastewater and the nutrient management purposes of the rainfed trees, particularly in the valley area. Bore 9479 located at the south-eastern border of the site on farmland shows background groundwater conditions, and irrigated areas on the southern boundary are comparable to this site.

3.2.1.3 RAIN-FED CENTRAL VALLEY BELOW DAM

Bores 9470 and 9476 are both below the dam wall and located in the valley area where the design expectation was that runoff from irrigated areas would be intercepted. Bore 9470 has exhibited a

progressive increase in conductivity since commencement of irrigation, reflecting the presence of treated wastewater. The nutrient concentrations in this bore have however remained stable, and even decreased recently, indicating the nutrient management process at the treefarm are effective. The high seasonality of level in bore 9476 in particular is due to the seasonal variations in the dam storage level increasing the head on groundwater movement in that area.

3.2.1.4 OVERLAND FLOW BAYS

The four bores in the over land flow area show high seasonal change in level due to the high irrigation rates and seasonal rainfall. In the last Triennial report published in 2001, it was reported that the groundwater level in this area had stabilised at one metre above the historic levels as a result of the irrigation. The more recent data shows that the groundwater level has fallen back to levels comparable to when the treefarm was established. This has been attributed to the drier winters experienced in 2001 and 2002.

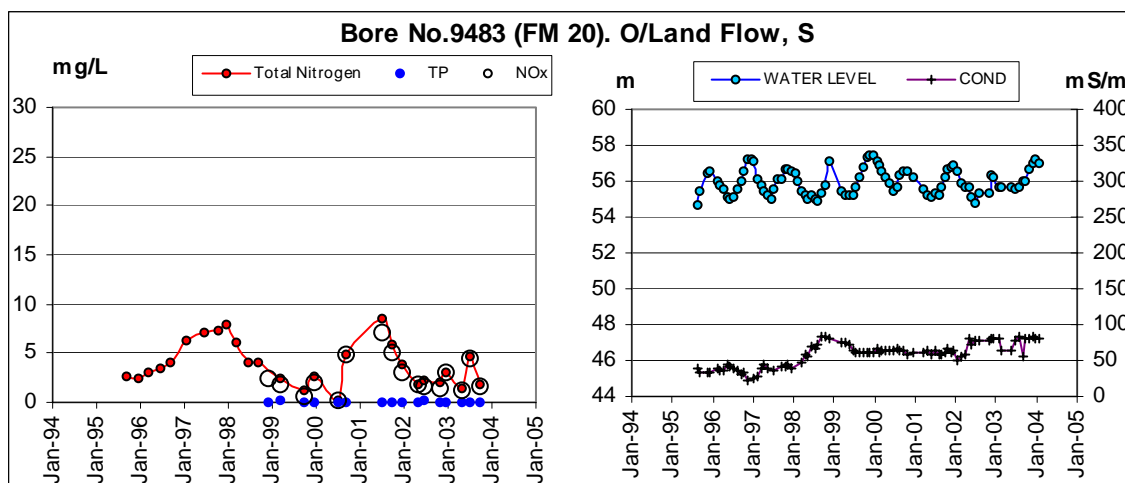


Figure 14 Bore 9483 overland flow area - nutrients, conductivity and water level.

Bores 9483 (Figure 14) and 9484 are at the lower edge of the overland flow bays and show seasonal changes in level as well as typical variations in nitrogen. The increases in nitrate concentration below the grass bays was expected at design, and is a function of the higher nitrogen loading that has occurred in recent years.

Consistently low total phosphorus concentrations have been measured at all bores in the overland flow area despite the very high loading rates. This is evidence that the soils are effectively retaining phosphorus in the surface layers and not allowing leaching.

3.2.1.5 STORAGE DAM AREA

Bores below and adjacent to the storage dam typically show a seasonal variation in level due to the changes in the dam storage. Bore 9482 (Figure 15 below) in rain-fed trees immediately below the dam wall, shows the largest response to the hydraulic pressures at the dam wall. The conductivity of 20-70 mS/m is representative of the groundwater at the site before the treefarm was established. The total nitrogen concentration has fallen since 1998 as a direct result of repair to the dam lining in March 1998. The total nitrogen concentration has fallen because there is less transient flow through the bore site and this additionally allows greater transformation of nitrogen in the soil.

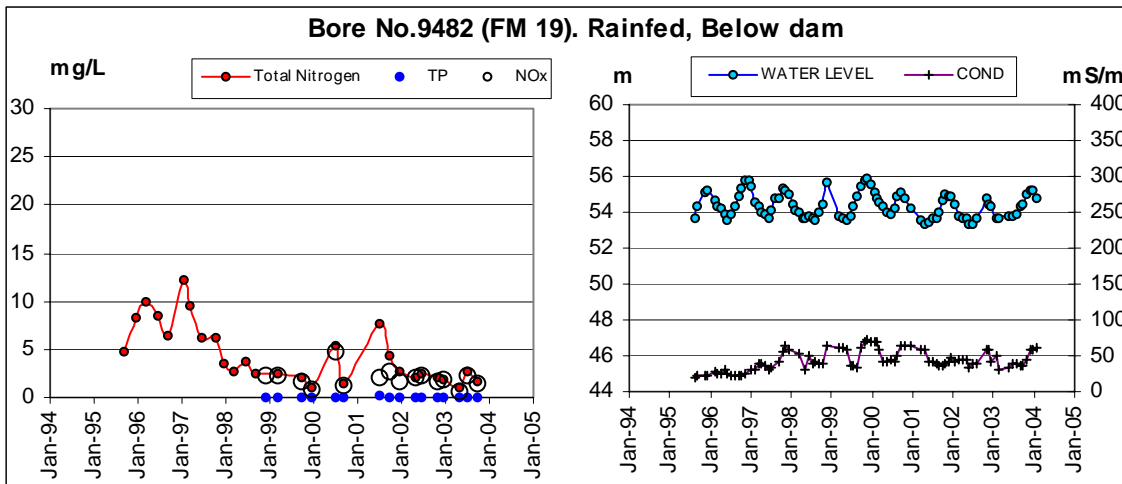


Figure 15 Bore 9482 rainfed below dam - nutrients, conductivity and water level.

Bore 9493 located to the east of the dam wall and within an irrigated area also shows a large response to the dam level. Since repair of the dam lining the conductivity in bore 9493 has steadily returned to background levels of 50 mS/m. This also represents a decline in the transient flow through the bore site.

3.2.1.6 IRRIGATED - CENTRAL PLATEAU

Bores 9450, 9467, 9471 and 9481 are all located at the centre area of the treefarm and above the valley. Total nitrogen in these bores is consistently low except for bore 9467 (Figure 16 below). This bore is located at the junction of three access roads and is in a depression in the surface topography. There has been no significant increase in conductivity, and groundwater has declined steadily since the commencement of irrigation activity at the site. Given that the conductivity has remained constant in this bore, it is unclear why the nitrogen concentration should be increasing. This area becomes very wet during winter and especially following storm rainfall events, so it is possible the nitrate concentrations of greater than 10mg/L may be attributed to excessive flushing of the irrigated soils. This would have to be through the drainage accumulation of rainfall as the conductivity results suggest the flushing is not caused by irrigation of treated wastewater.

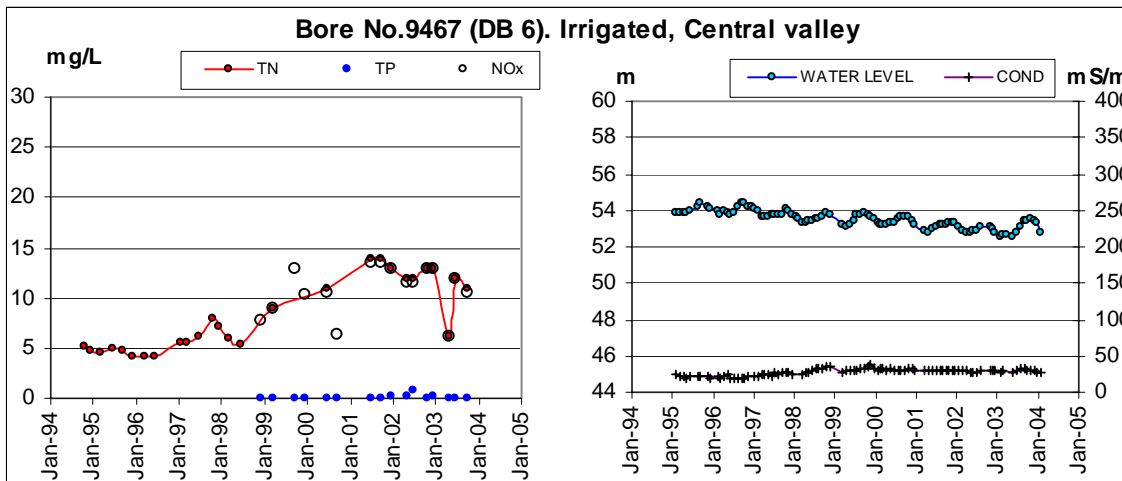


Figure 16 Bore 9467 irrigated, central valley - nutrients, conductivity and water level.

3.2.1.7 GROUNDWATER MONITORING SUMMARY

Seasonal variations in rainfall and storage depth in the main irrigation dam drive a regular fluctuation of up to 2 metres in the groundwater level over much of the treefarm site. This fluctuation is superimposed over a longer term reduction in the groundwater levels beneath the site by about 1 metre. The changes in groundwater level in bush and farm areas adjacent to the treefarm do not show the seasonal variation, but do show a reduction in level over the past 10 or so years. So while the irrigation activity has

changed seasonal levels, the mean groundwater level beneath the treefarm is similar that beneath other land activity in the immediate area.

Groundwater quality is variable over the treefarm, depending in part to the proximity to the over land flow bays where irrigation rates are very high. Some areas exhibit high and variable nitrogen concentrations in the groundwater that cannot be adequately explained. The installation of lysimeters to replace a number of bores is suggested as this will provide more direct data of what nutrients are leaching below the root zone and into the groundwater.

The phosphorus retention by the duplex soils at the site is clearly effective, as all areas of the treefarm show consistently low total phosphorus concentrations in the groundwater. Nitrogen transformations and the cycling of nutrients from sources other than the treated wastewater irrigation, such as the decay of litter-fall, make the nitrogen data more difficult to interpret. However, the nitrogen concentration in groundwater at the southern boundary has remained stable or decreased in recent years. The groundwater beneath irrigated plantation also typically shows stable total nitrogen and low nitrate concentrations. The overland flow area consistently shows higher total nitrogen and nitrate concentrations in response to the very high (~11metre) annual irrigation depth.

3.3 Hydraulic conductivity/Soil moisture monitoring

The continuous monitoring of soil moisture at several points around the treefarm allows for direct management of the irrigation scheduling. Consequently, measurement of soil infiltration rates is not required. The soil moisture measurements would show any changes in soil hydraulic conductivity that could potentially impact on irrigation operations. For example a decrease in hydraulic conductivity would be indicated by rapid surface saturation and limited soil moisture increase at depth. An increase in conductivity would result in rapid increases in soil moisture at depth and possibly deep drainage below the effective root zone.

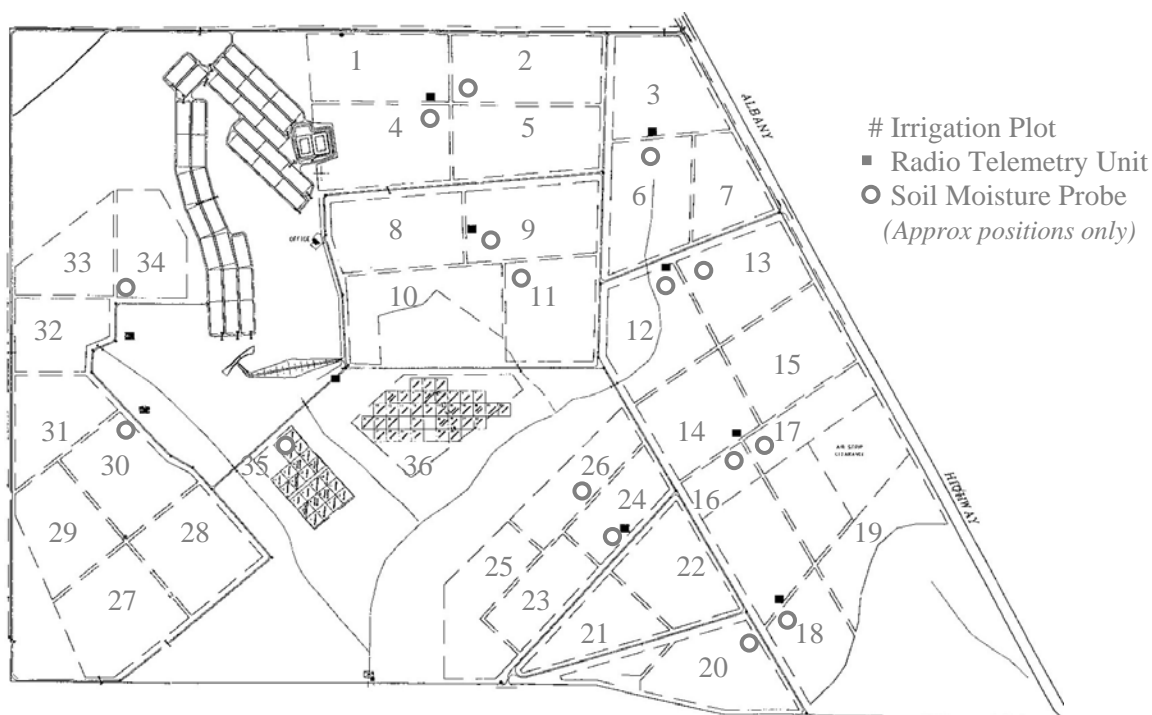


Figure 17 Treefarm layout map showing location of irrigation plots and soil moisture probes

The soil moisture records for the 14 monitoring points are given in Appendix E. This data is used for operational management of the irrigation, and as such is at very high resolution. This makes presentation of the historical data trends difficult due to the noise of seasonal rainfall and irrigation events. However, the general soil moisture condition can be assessed, and by focussing on the 10cm and 200cm deep probes the impacts of rainfall and irrigation can be assessed.

As the soil moisture probes are indicative of soil moisture and not a direct measurement (such as would be obtained gravimetrically), when reviewing this data it is important to look at relative changes rather than absolute values. All sites show spikes associated with rain events and to a lesser extent irrigation events at the surface (10cm) and typically at 20cm and 50cm probe depths. Plot 17 clearly shows the daily and seasonal fluctuations of soil moisture at depth. Other sites are less clear owing to a number of variables including soil conditions, position of probe installation relative to irrigation drippers, calibration differences and also the local topography and position on the site.

The most useful purpose of the soil moisture measuring system is as an operation tool used to regularly assess if irrigation needs to be limited to particular areas of the treefarm. This occurs if the soil moisture increases to a level where excess deep drainage is likely, and results in the operator reducing scheduled irrigation to that irrigation group. Because of reducing groundwater levels and the comparatively low irrigation rates (relative to design capacity and rainfall), there has been only limited need to vary irrigation rate across the site. This however will progressively become more common as loading increases and the effects of harvest operation and variable age structure of the plantation occur.

3.4 Metals analysis

Annual metals analysis is summarised in Table 8 below that gives the average of annual analysis from samples taken at the inlet to the treefarm. Calcium and magnesium data is also provided for the main irrigation dam as this represents water irrigated to the blue-gum plantation.

Table 8 Average concentration of metals in treefarm influent

		1998	1999	2000	2001	2002	2003	Guideline Limit ¹
Holding ponds	Cadmium - CD	0.01	0.01	0.01	0.0001	0.005	0.01	0.01
	Calcium - CA			51	66	58	54	0.4 - 1
	Chromium - CR	0.01	0.01	0.01	0.006	0.006	0.01	0.10
	Copper - CU	0.01	0.01	0.01		0.02	0.03	0.20
	Lead - PB	0.03	0.05	0.05	0.001	0.0055	0.01	5.0
	Iron – FE <i>unfiltered</i>			0.28			0.26	5.0
	Magnesium - MG			11	13	12	13	0.1 – 0.3
	Mercury - HG	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.05 ²
	Sodium - NA			130		125	125	
Zinc - ZN	0.015	0.01	0.03		0.025	0.04	2.0	
Main dam	Calcium - CA			48	47	57	56	0.4 - 1
	Magnesium - MG			11	11	12	13	0.1 – 0.3

1. CSIRO (1999) *Sustainable Effluent-Irrigated Plantations An Australian Guideline*

2. NWQMS (1992) *Guidelines for Sewerage Systems Acceptance of Trade Waste (Industrial Waste)* (Appendix 1)

All metals analysed are within the guideline limits for sustainable irrigation. Typically, concentrations are one or two orders of magnitude smaller than the guideline limits. The only exception is cadmium which has some variability in analysis results, though never exceeding the recommended irrigation limit. The guideline limits for calcium and magnesium are recommended minimum foliar concentrations required for good plantation health. The concentrations are all not only low, but are also stable, and consequently the management of metals in the irrigation water is not seen as an issue.

3.5 Actual and Design Performance

The treefarm was designed using average and wet year rainfall, and for the irrigation rate expected at a site inflow of 6 ML/day. Recent years have had lower than average rainfall, and the inflow to the site is less than the design figure. This has meant that loading at the treefarm has been lower than the design capacity, but is increasing. The continuing stable nutrient discharge from the site and the overall stability in the groundwater under the plantation are strong indicators that the performance of the treefarm conforms well to the design.

4 Nutrient and Water Balance Modelling

A total nitrogen balance and water balance through the wastewater treatment scheme for 2001 to 2003 inclusive is shown below. While these balances are primarily based on measured flows and nitrogen concentrations, it is not possible to directly measure many aspect of the treatment process such as denitrification and volatilisation losses, or total loss due to seepage. Consequently, the balances are completed using a combination of research measurements from previous years, estimated data, modelled data and engineering design values.

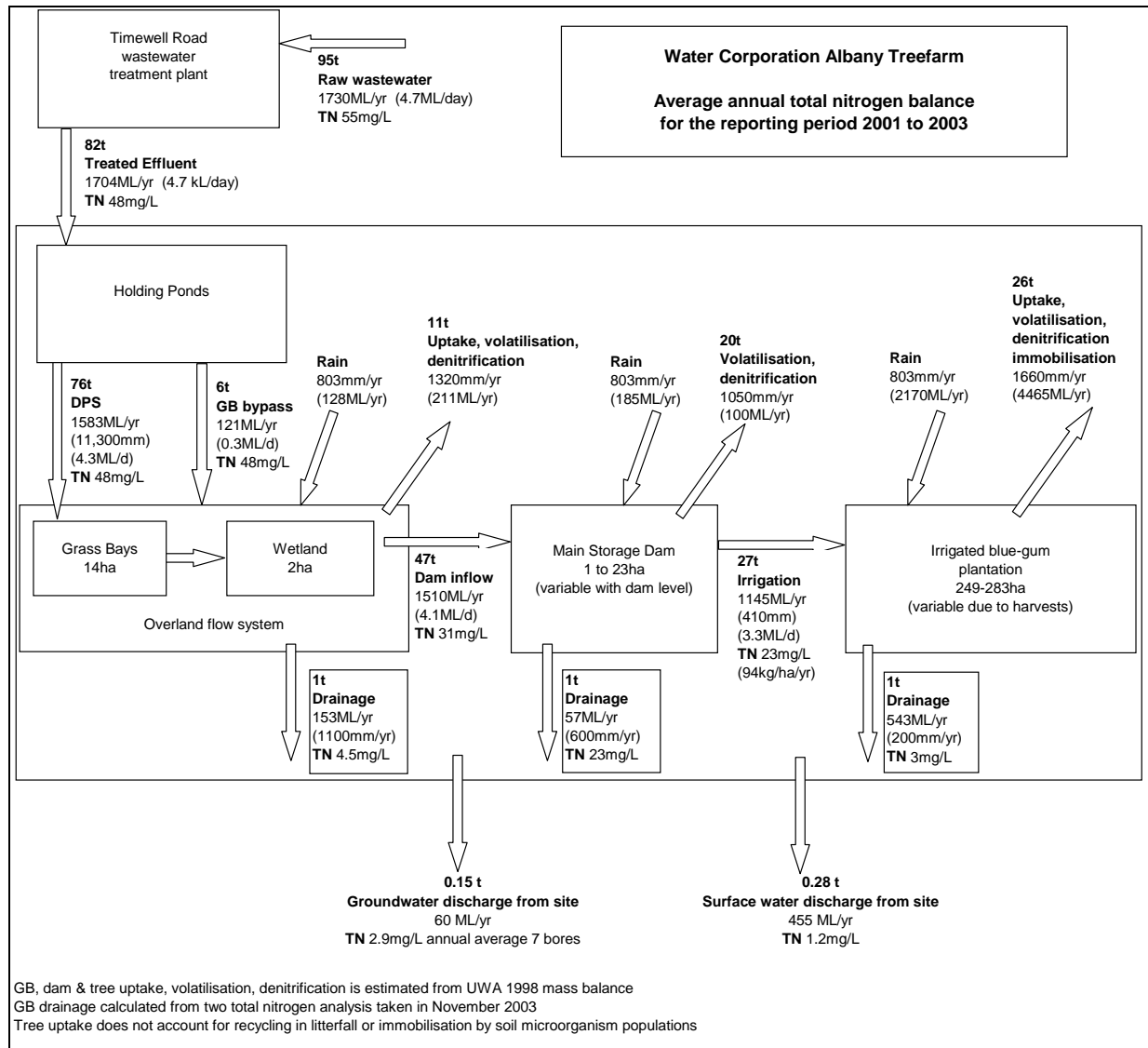


Figure 18 Nitrogen balance through the Albany wastewater scheme

The water balance is accurate for directly measured flows between primary process compartments (WWTP, grass bays/irrigation dam and plantation). Evaporation and infiltration/seepage losses are estimated from a combination of weather data, design expectation, research data and modelling. Surface water discharge is measured at the Gunn Road gauging station to Seven-Mile Creek, and groundwater flows determined by analysis of groundwater contours. These data combine to give an overall account for water movement through the system.

The average irrigation depth to the plantation was approximately 50% of the average annual rainfall of 800mm for the period and approximately 55% of the design irrigation capacity of 770mm per annum.

Applying actual monitoring results to the water balance data gives a measure of nitrogen loads through the system. Balances for the WWTP, holding ponds, main irrigation dam and the irrigated plantation are good, but there is some unquantified error in the balance for the overland flow system. Here the total nitrogen inputs amount to 82t TN/yr. Environmental (uptake, volatilisation, denitrification, drainage) losses are estimated from research data from previous years and the outflow to the dam is from detailed water balance modelling of the main dam. To improve the TN balance over the grass bays requires that an additional 23t TN/yr be accounted for. It is possible that uptake in the grass bays and the surrounding wetland area is higher than previously estimated, however UWA results and modelling suggests that higher rates of volatilisation are likely.

Overall the nitrogen budget shows that greater than 95% of the influent total nitrogen load received at the Timewell Road wastewater treatment plant is removed through the biological processes of uptake, volatilisation, denitrification and immobilisation.

4.1 Improved operational modelling of the Albany treefarm

The computer software 'Medli' was previously used by the Water Corporation to model the operation of the treefarm. This model was originally developed for crop irrigation and does not have the flexibility to be an accurate replication of actual irrigation events, and is no longer considered suitable as a management tool. Consequently, over the past 3 years a spreadsheet based management model was developed to track volume and nutrient data as well as providing a predictive irrigation tool.

This new management model operates on a weekly time-step, is based around design parameters for the treefarm, and is calibrated against measured water losses over the site from 1997 to 2000. Since August 2003 the model has been used to determine the future irrigation settings and this has helped to maintain good control of the storage level in the main dam.

More detailed nutrient and water balance modelling is possible through application of the CSIRO model 'SWUF' calibrated to the Albany Treefarm by UWA in the course of their research at the site. This model uses detailed daily climate data to predict water stored in the canopy, litter layers, 3 surface soil layers and the deeper root zone. This allows prediction of evaporation, surface runoff, plant uptake and drainage flows for a given set of soil and plantation parameters.

The high detail of inputs required to operate this model has precluded it as being a useful operational tool to date. Due to variability inherent across the treefarm site, such as soil depth and tree age, it would also be necessary to run several configurations of the model and to then develop a means to integrate these into an operational management tool. This level of detailed water balance modelling may be considered in the future as irrigation loading increases nearer to the design capacity. However at this stage the level of complexity in its full implementation cannot be warranted.

The SWUF model has however recently been applied to the treefarm as a whole, without consideration for the age structure of the plantation or spatial variability in soil parameters, to provide a summary measure of the leaching losses beneath the irrigated plantation. The results are given below in Table 9 below. Note that irrigation depths vary slightly to data given in Table 6 due to the different method used to account for annual average irrigation area.

The drainage depth is of interest as this is the critical water loss fraction that is being managed for environmental sustainability of the site. Drainage losses must occur to ensure the surface soils do not suffer increased salinity, yet these drainage losses must be controlled to ensure nutrient losses from the site are managed. The design allowed for drainage of 186mm/yr in an average rainfall year with capacity loading.

Table 9 Summary of SWUF Water Balance Modelling Output

Year	Rainfall mm/year	Irrigation mm/yr	Evaporation mm/yr	Plant water Uptake mm/yr	Surface runoff mm/yr	Drainage mm/yr	Change in Storage mm/yr	Discharge ML/year
1996	831	266	449	478	0	173	3	593
1997	724	350	378	572	0	183	60	525
1998	783	419	336	498	0	340	-17	486
1999	719	396	420	576	0	159	29	419
2000	768	436	418	638	0	131	3	450
2001	879	353	421	547	0	124	-74	370
2002	684	390	414	694	0	17	68	347
2003	847	431	459	601	0	276	5	648

Typically the drainage depth is estimated to be similar to the design figure. The very low estimate in 2002 and the high estimate for 2003 are caused by the modified dam storage profile (and hence irrigation) in 2002. The average drainage for these years is 146mm, which is highly comparable to previous years and expected with the current below capacity irrigation rates.

While the general trend is for increasing plant water uptake, this varies year to year due to the different effects of rainfall, temperature and age of the trees etc. The discharge figure is measured at the Gunn Road gauging station, and there is good correlation ($R^2=0.67$) between this flow and the annual balance for surface waters in the model (rainfall + irrigation – evaporation – plant uptake). The SWUF model accounts for irrigated plantation only and the Gunn Road discharge is the summation of flows from surface and groundwater runoff from pasture, native vegetation and other areas on the treefarm site, so this is a good result and gives some confidence in the model outputs for drainage.

The SWUF model will continue to be used on an annual or triennial basis to supplement the operational monitoring and confirm the hydraulic performance of the treefarm.

5 Progress and Compliance Report

5.1 Review against Ministerial Conditions (Condition 287:M10:1)

Table 10 Statement of progress and compliance against Ministerial Conditions

Element	Requirement	Progress & Compliance
287:M1 The Proposal	Fulfill the commitments	Proposal adhered to - See detailed clauses below.
287:M2:1 Implementation	Adhere to the proposal	Proposal adhered to - See detailed clauses below.
287:M2:2 Implementation	Seek approval for modifications to the proposal	Approval sought to increase the allowable nitrogen application rate from 106 to 150kg/ha/yr (Element 287:P15, (9.3.2) Overland flow area).
287:M3:1 Land-based wastewater disposal trial planting	Commence trial planting on the land disposal site	Arboretum established at project initiation. University and CALM involved in arboretum studies. Additional research trial for Agonis species commenced 2000.
287:M3:2 Visual buffer	Maintain an unharvested 50 metre visual buffer consisting of plantation and ornamental native species along the southern (Gunn Rd) periphery	Buffer established and maintained intact. 2004 harvest operations will not reduce buffer. Harvest of buffer will be necessary in future for safety reasons (risk of trees falling across boundary fence).
287:M3:3 Irrigation	Ensure that remnant vegetation on the land disposal site is not irrigated with wastewater	19/12/1996 - Cleared
287:M3:5 Soil infiltration	Measure soil infiltration rates	Not required at this stage as soil moisture content is continuously monitored across the site
287:M3:6 Soil infiltration	Implement approved contingency measures if the values measured according to the requirements of M3:5 are sufficiently low as to threaten the retention of contaminants on the site	No contingency measures required as soil moisture content shows acceptable performance
287:M3.4:1 Rising main	Design the rising main leading into the holding ponds so that outlet is submerged at all times	19/12/1996 - Cleared
287:M3.4:2 Rising main	Manage the rising main leading into the holding ponds so that the outlet is submerged at all times	Rising main remains submerged. Incorporation of septage facility discharge at treefarm in 2002/2003 also has submerged rising main outlet.
287:M4:1 Remnant vegetation	Retain remnant native vegetation at the Timewell Road (No 2) treatment plant site where practicable	19/12/1996 - Cleared
287:M5:1 Reserve 20948	Ensure that reserve 20948 (vested in the National Parks and Nature Conservation Authority) is not irrigated with wastewater	Reserve not irrigated or exposed to site runoff
287:M5:2 Alternative irrigation plan	Prepare an alternative plan for the temporary irrigation of treated wastewater in the event that insect attack, fire or a decline in soil infiltration threatens to cause either; nutrient losses from the site to exceed 3 tonne of nitrogen and 1 tonne of phosphorus per year; or surface runoff from the site to occur more frequently than 1 year in 10 (based on long term rainfall probabilities)	Nutrient discharges from the site are well within the 1t TP and 3t TN limits. Alternative plan to irrigate rainfed trees and establishment of tree-lots within Timewell Rd buffer has been considered. Plan not yet formally documented. Various other reuse or disposal options are being considered for future growth in wastewater flows.
287:M5:3 Alternative irrigation plan	Implement the plan prepared under M5:2 when required by the EPA	Contingency plan not yet required to be implemented

Element	Requirement	Progress & Compliance
287:M6:1 Reports	Prepare brief annual and comprehensive triennial reports addressing but not limited to the following; 1. A water balance for the land disposal site including a comparison between measured and estimated (modelled) evapotranspiration for both rainfed and irrigated woodlots 2. results of environmental monitoring 3. results of infiltration rate measurements, trends and implications for the onsite retention of water and contaminants 4. results of trial planting of alternative species 5. compliance with the commitments, and 6. any proposed changes to management of monitoring of aspects of the system	1997 Triennial Report ISBN 0-73098-286-6 2001 Triennial Report ISBN 1-74043-073-5 2002 & 2003 Annual reports to DEP 2004 Triennial Report ISBN 1-74043-199-5 Annual reports for Timewell Rd WWTP under DEP licence 6786/3
287:M6:3 Breach of environmental commitments	Report any breach or anticipated breach of the environmental commitments immediately	Discharge of treated wastewater from Timewell Road WWTP to Five-Mile Creek due to extreme storm event (>60mm rain in 24 hours at peak of storm). DoE notified during event and reported to post event.
287:M6:4 Impacts	Modify and remedy the operations of the treatment plants and/or the land disposal site if impacts are detected which are considered to be unacceptable by the Environmental Protection Authority	No requirement to modify operations
287:M6.2:1 Reporting	Submit the reports required by M6:1	Triennial and annual reports submitted 1997-2004.
287:M6.2:2 Reporting	Ensure that annual and triennial reports are publicly available	Triennial reports formally published
287:M7:1 Decommissioning	Prepare a decommissioning and rehabilitation plan for the land disposal site or for any of the treatment plants	4/4/1997 - Cleared
287:M7:2 Decommissioning and rehabilitation plan	Implement the decommissioning and rehabilitation plan	No decommissioning activity from 1997 to 2000.
287:M8:1 Transfer of proponent	Seek approval for transfer of ownership, control or management of the project	No transfer of proponent
287:M9:1 Time limit on approval	Seek approval to extend approval to implement the proposal	Proposal implemented on time
287:M10:1 Compliance auditing	Prepare periodic "Progress and Compliance Reports" to help verify the environmental performance of this project	Progress & compliance reports incorporated into Triennial reports (this table)
287:P1 Pt King WWTP	Cease discharge from the No. 1 treatment plant	19/12/1996 - Cleared
287:P2 Timewell Rd WWTP	Cease discharge from the No. 2 treatment plant into Five Mile Creek	19/12/1996 - Cleared
287:P3 Land Treatment site (9.1.3) nutrient discharge	Ensure that the nutrient discharge from the land treatment site in groundwater or surface water would not exceed 1t of phosphorus and 3t of total nitrogen per annum	Nutrient discharge at Gunn Rd is less than specified by the Ministerial limits.
287:P4 No. 2 WWTP (9.2) plant upgrade	Upgrade capacity of No. 2 aerated treatment pond treatment plant to a capacity of 3,500 kL/day	19/12/1996 - Cleared
287:P5 (9.2) Further modifications of treatment facilities	Carry out further upgrade, enlargement or replacement as necessary to meet further demand depending on performance of the treatment facilities and the land treatment facility	Extensive and detailed monitoring of the treefarm performance continues
287:P6:1 (9.2) Wastewater pumping	Ensure that the volume of wastewater pumped daily to the land treatment site is not less than the volume of water diverted from the No. 1 treatment plant	All treated effluent is diverted to the treefarm after treatment at No. 2 WWTP

Element	Requirement	Progress & Compliance
287:P6:2 (9.2) Wastewater pumping	Increase the volume of wastewater pumped daily to the land treatment site as the trees grow on the site until discharge into 5-Mile creek ceases	Discharge to 5 Mile Creek ceased in 1996
287:P7:1 (9.2) Noise levels	Ensure that noise levels from the aerated pond plant and any subsequent upgraded or new plant comply with the noise limits set by the EPA	Comply
287:P7:2 (9.2) Odours	Ensure that offensive odours from the aerated pond plant and any subsequent upgraded or new plant are only detectable at the nearest odour-sensitive premises on rare occasions	Comply
287:P7:3 (9.2) Odours	Ensure that wastewater from the aerated pond plant and any subsequent upgraded or new plant does not create odour problems on the land treatment site	Comply
287:P7:4 (9.2) Remedial treatment for noise & odour problems	Undertake appropriate remedial action if noise or odour reach unacceptable levels	No unacceptable noise or odour
287:P8 (9.2) Sludge	Dispose of sludge from the plant in accordance with the proposed 'Australian Water Council Draft Guidelines for Sewerage Systems-Sludge Management' or by a method approved by the Health Department of Western Australia	Non-aerated ponds at the Timewell Road WWTP were desludged in 2002/2003 using online dredge technology and geotube dewatering. Some of the biosolids produced were beneficially reused through land application for soil amendment.
287:P9 (9.2) Earthworks	Carry out earthworks for the new aerated pond and storage pond in a manner that minimises increased sediment flow into Five Mile Creek	20/12/1996 - Cleared
287:P10 (9.3.1) Woodlot	Carry out the establishment of the woodlot in an environmentally responsible manner	Woodlot fully established by 1996
287:P11:1 (9.3.1) Shatter ploughing and mounding	Avoid water courses in shatter ploughing and mounding and ensure these activities are managed to minimise increased sediment flow into Seven Mile Creek	19/12/1996 - Cleared
287:P11:2 (9.3.1) Seven Mile creek	Maintain a fifteen metre wide buffer zone on each side of Seven Mile Creek when shatter ploughing and mounding	19/12/1996 - Cleared
287:P12 (9.3.1) Herbicide	Manage herbicide for pre-emergent and post-emergent weed control	Specialist plantation managers CALM (Forest Products Commission) engaged for tree management and responsible for herbicide management
287:P13:1 (9.3.1) Earthworks	Carry out earthworks for construction of the storage dam, tracks and roads during summer	19/12/1996 - Cleared
287:P13:2 (9.3.1) Earthworks drainage discharge	Ensure that drainage discharges from areas disturbed by earthworks for the construction of the storage dam and tracks and roads on the property is diverted on to areas of established pasture	19/12/1996 - Cleared
287:P13:3 (9.3.2) Earthworks dust generation	Suppress generation of dust during earthworks by the use of water tankers	19/12/1996 - Cleared
287:P14 (9.3.2) Land treatment system	Manage and operate the land treatment system in accordance with the National Health and Medical Research Council and Australian Water Resources Council guidelines (1987) for land treatment of wastewater, or as otherwise approved by the Health department of Western Australia	Sheep grazing now occurs very occasionally and is restricted to areas not exposed to treated wastewater.
287:P15 (9.3.2) Overland flow area	Operate the overland flow area so as to remove the nitrogen content in the incoming wastewater to a level that results in not more than 106 kg/ha of total nitrogen per annum being applied to the area of trees irrigated	Overland flow irrigation system upgraded to improve performance. 106kg/ha/yr limit not exceeded in reporting period
287:P16 (9.3.2) Storage dam	Manage storage of wastewater in the dam so that no overflow of the dam occurs in 90 percent of years	No overflow from storage dam
287:P17:1 (9.3.2) Irrigation system	Manage irrigation system so that no runoff is achieved in 90% of years	No runoff offsite

Element	Requirement	Progress & Compliance
287:P17:2 (9.3.2) Irrigation system	Manage irrigation system so that moisture levels in the effective root zone of the trees are achieved which are sufficient to limit downward percolation to the amount required to ensure root-zone salinity is maintained at a sustainable level	Irrigation scheduled according to soil moisture condition with annual flushing to manage soil salinity
287:P17:3 (9.3.2) Irrigation system	Manage irrigation system so as to achieve optimised evapotranspiration by the trees	Continual development of irrigation strategies in response to ongoing research and plantation management report outcomes
287:P18 (9.3.2) Monitoring performance	Monitor performance of the system in accordance with the program set out in appendix D of the Public Environmental Review	Monitoring program met and exceeded in areas
287:P19 (9.3.2) Insect attack	Join with CALM and other landholders with tree plantations in the Albany area to monitor insect activity	Close working relationship with CALM (now Forest Products Commission)
287:P20 (9.3.2) Insect attack	Develop and implement a plan to control insect attack in conjunction with CALM	Specialist plantation managers CALM (Forest Products Commission) engaged for tree management and responsible for insect control with close liaison with the Water Corporation
287:P21:1 (9.3.2) Firebreaks	Maintain firebreaks on the site to the satisfaction of the bush fires board	Firebreaks managed according to Bush Fire Service Guidelines (1998)
287:P21:2 (9.3.2) Fire dams	Keep all fire dams on the site full of water during summer	Dams that are accessible are maintained full during summer
287:P21:3 (9.3.2) Fire control	Provide and maintain fire control vehicles on the site to the satisfaction of the bush fires board	Fire tender sponsored and established
287:P21:4 (9.3.2) Fire incidents	Ensure that Water Authority employees are trained to handle fire incidents	Employees are trained in fire control
287:P21:5 (9.3.2) Bush Fires Act	Ensure that staff comply with the provisions of the Bush Fires Act 1954	Staff comply with the provisions of the Bush Fires Act.
287:P21:6 (9.3.2) Smoking	Prohibit smoking in the areas planted with trees	Smoking prohibited on site
287:P22:1 (9.3.3) Contingency planning	Expand the overland flow and irrigated tree areas if the land treatment system fails to perform to design	Planning review underway to determine if expansion is required. Upstream wastewater treatment planned to be upgraded to reduce nutrient loading at treefarm
287:P22:2 (9.3.3) Contingency planning	Construct an additional storage dam if the land treatment system fails to perform to design	Treefarm meets and exceeds design expectations and not additional dam is required

5.2 Comparison of performance against commitments (Condition 287:M6:1, 5)

5.2.1 Condition 287:M3:5 Measure Infiltration rates

Measure soil infiltration rates to determine if appropriate soil water storage capacities are being achieved.

The mass balance for 2001 to 2003 and the soil moisture monitoring data shows infiltration rates are maintained at the design expectation of around 200mm/year.

Over the period 1997 to 2000, groundwater levels in the monitoring bores on the site showed some increase in level around the overland flow grass bays and the irrigation dam. More recent data has shown that this level has stabilised. Data from 2001 to 2003 shows that there has been a decline in groundwater levels beneath the treefarm by about 0.5 metres. This fall is in line with the general drying climate and a lowering water table generally in the area. Soil moisture results show that the seasonal infiltration rates are maintained in accordance with the treefarm design.

5.2.2 Condition 287:M5:2 Prepare Contingency Plan

Prepare an alternative plan for the temporary irrigation of treated wastewater in the event that insect attack, fire or a decline in soil infiltration threatens to cause either; nutrient losses from the site to exceed 3 tonne of nitrogen and 1 tonne of phosphorus per year; or surface runoff from the site to occur more frequently than 1 year in 10 (based on long term rainfall probabilities).

On-site monitoring, research results and numerical modelling has described the water discharges from the site. The runoff depth is insignificant relative to the annual rainfall on the rain-fed plantation and would be readily intercepted. Additionally, the irrigated plantation has demonstrated the ability to outgrow insect attack. Blue-gum plantations at Mount Barker have shown fire is unlikely to become established. It is considered unnecessary at this point in time to develop a formal alternative irrigation plan. Alternative irrigation strategies at the Albany treefarm site are available but would be subject to the extent of any impact.

5.2.3 Condition 287:P3 Operation of Land Disposal Site

Ensure that the nutrient discharge from the land treatment site in groundwater or surface water does not exceed one tonne of phosphorus and three tonnes of nitrogen per annum.

Total nitrogen discharge in the Seven-Mile creek prior to the commencement of treated wastewater irrigation was approximately 980 kg. The average loads in the creek for 2001 to 2003 are 285kg TN/year for nitrogen and 22kg TP/year for phosphorus. (refer to Table 7, Section 3.1.4 for summary data).

The total nutrient discharges from the site including the surface load in Seven-Mile Creek and in groundwater have been calculated using groundwater modelling and surface water monitoring. Average total nitrogen discharge is less than 500kg TN/year for nitrogen and less than 50 kg TP/year for phosphorus for both surface and groundwater (refer to Section 3.1.4 for summary data). This is well within the quantities estimated for the land treatment site when operating at capacity.

5.2.4 Condition 287:P14 Manage Land Treatment System

Manage and operate the land treatment site in accordance with National Health and Medical Research Council and Australian Water Resources Guidelines (1987) or as otherwise approved by the Health Department of WA.

The thermotolerant coliforms in the main storage dam have been consistently maintained below the limits set by the health department for the grazing of sheep within drip irrigated areas. Sheep are now only occasionally grazed at the site, and only in clear pasture areas not exposed to treated wastewater.

5.2.5 Condition 287:P15 Operation of Overland Flow Area

Operate the overland flow area so as to remove the nitrogen content in the incoming wastewater to a level that results in not more than 106 kg/ha of total nitrogen per annum being applied to the area of trees irrigated.

Both the hydraulic loading and the nitrogen loading received at the treefarm have increased significantly in the last 4 years. The overland flow bays have been operated in a manner that has maintained or improved their efficiency in nitrogen removal. Other operational works undertaken in the past three years to manage the nitrogen application limits have included;

- Desludging of the treatment ponds at Timewell Rd
- Upgrade of Timewell Road wastewater treatment plant (to commence 2004/05)
- Alternative flow strategy for overland flow irrigation
- Upgraded distribution system for the overland flow irrigation

Future possible strategies to manage the treefarm performance may also include;

- Expansion of overland flow and irrigated plantation area
- Aeration within the main storage dam
- Alternative reuse opportunities

5.2.6 Condition 287:P16 Manage of Storage of Wastewater in the Dam

Manage storage of wastewater in the dam so that no overflow occurs in 90% of years.

There has been no overflow from the storage dam since operations commenced. The hydraulic loading to the site has not yet reached capacity but there is nominally higher than anticipated winter inflow rates to the treefarm. It is considered that overflow is unlikely in the short term unless a large storm event is experienced when the dam level is at or near capacity, or if there is a significant period of equipment failure.

5.2.7 Condition 287:P17.1 and P17.2 Manage the Irrigation System

*Manage irrigation system so that no runoff is achieved in 90% of years, and
Manage irrigation system so that moisture levels in the effective root zone of the trees are achieved which are sufficient to limit downward percolation to the amount required to ensure root-zone salinity is maintained at a sustainable level*

The hydraulic capacity of the site is yet to be reached. This has meant there is reserve capacity in the dam for storage. No overflow has occurred from the main irrigation dam since the project commenced.

The irrigation strategy ensures the soil moisture content is maintained between upper and lower limits. These limits ensure the trees do not become stressed due to low soil moisture availability during summer and that no surface runoff occurs under irrigated conditions during winter. The water soil moisture content is in accordance with the original design parameters to ensure sufficient soil flushing for salinity management.

5.2.8 Condition 287:P17.3 Manage the Irrigation System

Manage irrigation system so as to achieve optimised evapotranspiration by the trees

Irrigation is scheduled to provide wetting-drying cycles in the irrigated plantation. This maximises evapotranspiration and nitrogen volatilisation. Outcomes from research by the University of Western Australia at the Albany treefarm have given improved insight into the mechanisms behind the soil nutrient transformations. This potentially allows for improved optimisation of the wetting-drying cycles to increase nutrient immobilisation and volatilisation. Implementation of these research findings has led to revised management of trash residues following harvest and to some changes in the scheduling of irrigation post harvest.

5.2.9 Condition 287:P18 Monitor Performance of the System

Monitor performance of the system in accordance with the program set out in appendix D of the Public Environmental Review

Sampling and analysis by NATA certified laboratories meets the commitments made in the proposal. Additional on-site analysis is conducted and validated against the NATA certified results. This ensures the minimum monitoring requirements for the site are being consistently exceeded.

The frequency and extent of monitoring at the Albany treefarm can be described as very detailed. It is not possible to fully measure any environmental system, especially one as complex as the Albany treefarm. However, there have been significant improvements in the understanding of nutrient dynamics under irrigated plantations following the detailed research conducted at Albany by the UWA Ecosystems Research Group and the extensive monitoring to date. The improved scientific understanding has given confidence in the design and nutrient assimilation capacity of the treefarm. This is allowing the optimisation of the treefarm as the research findings are progressively translated into operational strategies. Additionally, these advancements in the understanding and management of the treefarm now place the Corporation in a position to scale back aspects of the monitoring program and research to a more appropriate and cost effective level.

6 Management

6.1 Wastewater Flows and Hydrological Management

Weekly inflows to the treatment plant show stormwater infiltration and/or inflow are significant during winter. While this was especially prevalent during 1999 and 2000 (see Figure 6), such extreme flow events were not recorded at the treefarm inflow during 2001 to 2003. This was in part due to problems with the transfer pump and delivery pressure-main to the treefarm that slightly restricted the peak pumping rate to the treefarm.

An infiltration study for the Albany reticulation was conducted in winter 2001 to assess the relative contributions of direct stormwater inflow and infiltration from elevated groundwater tables. The data obtained suggested direct storm inflow due to infiltration to the system and illegal plumbing (stormwater) connections are responsible for the higher winter flows. Otherwise the data was highly variable and inconclusive. Alternative means of assessing the cause of peak flow rates are being utilised including visual inspection of the sewer pipes using remote camera technology.

6.2 Nutrient Loading and Irrigation Management

Nitrogen loading to the irrigated plantation has increased significantly. Primary factors in this increase are the increased inflow volumes and higher nitrogen concentration effluent received from Timewell Road WWTP. A strategy for upgrade of the treatment plant is in place and construction is expected to commence during the summer of 2004/2005. Desludging of the facultative ponds was completed in 2002 and 2003 and this improved the treated wastewater quality received at the treefarm.

The treefarm site has not yet reached the design hydraulic capacity although this is projected to be much earlier than the design estimate of year 2020. This is attributable to growth in influent wastewater flows that has averaged over 5% since 1997. Outcomes from research at the treefarm will contribute to ensuring the maximum sustainable nutrient and hydrological capacity of the site is realised. The research outcomes will involve scheduling of irrigation to maximise nitrogen losses and evaporation and transpiration under irrigated pasture and plantation. For example, improvements to the rates of nutrient cycling and immobilisation under the plantation have been achieved through specific management of the trash material immediately following harvest.

6.3 Licence and Compliance Management

License and compliance management is a means of ensuring the treefarm site is operated to an acceptable level. The Water Corporation actively embraces environmental management and has undertaken a number of measures that exceed the minimum requirements for license compliance. These measures, including those listed below, are in response to proactive environmental management by the Corporation and are to ensure our commitments to the community and the environment are maintained.

Measures that have been or are currently being implemented to improve the efficiency of the Albany wastewater treatment and reuse scheme include;

- Extensive and detailed research by independent and leading experts
- Staged harvest of overland flow bays and revised irrigation strategies
- Revised distribution system for overland flow bays
- Review of data management and higher level data review
- Implementation of improved irrigation scheduling and operational strategies determined from research findings
- Development of the numerical model as a working operational tool
- Consideration of the catchment scale management of nutrients

Practical implementation of the UWA research findings allows the treefarm to be operated in accordance with the latest developments in scientific understanding of irrigated plantations. Combined with the further operational improvements implemented by the Water Corporation in recent years, the Albany treefarm continues to be a world class environmental solution to wastewater management.

7 Conclusions

This report has reviewed operational and environmental data for the Water Corporation treefarm covering the period 2001 to 2003.

The treefarm has been operated in compliance with the Ministerial Conditions despite large increases in the volume of treated wastewater received at the site each year. However, the latest UWA research has shown the actual sustainable nitrogen application rate to be considerably higher than the original conservative design estimates. Additionally, monitoring of nutrient fluxes from the site confirms the low rate of nutrient export from the treefarm.

The past 3 years performance of the treefarm is summarised below.

- Annual inflow to the site has increased at the average annual rate of 5%. This is higher than the design projections of about 3% per annum and is in spite lower than average rainfall in recent years.
- Nitrogen removal in the overland flow bays has been and continues to be excellent.
- The main irrigation dam has not yet reached full capacity and the hydraulic loading on the site is within the design value of 6 ML/day.
- Groundwater levels at the treefarm have generally decreased by between 0.3 and 0.5 metres since the treefarm was established. This reduction is not limited to the treefarm and is representative of groundwater changes in the area.
- Nitrogen and phosphorus concentrations in the discharge from the site continue to be low.

There are a number of measures that have been planned or have been implemented to ensure the continued performance of the treefarm. These include:

- Upgrade of the treatment capacity and quality at Timewell Road WWTP.
- Desludging of the aerobic ponds at the Timewell Road WWTP.
- Enhancements to the overland flow distribution system and operation to further improve nitrogen removal and ease of operation.
- Expansion of the control system to provide increased automation of irrigation and improved flexibility in irrigation scheduling.
- Development of numerical model for integration into the treefarm management to assist in meeting environmental and regulatory requirements.

In 2003 the treefarm entered a new phase of operation with the commencement of the annual harvest of the irrigated and rainfed plantation. The sale of the timber for woodchip production has allowed the operational costs for the scheme to be offset. The Water Corporation is proud of the Albany wastewater treatment scheme and the Timewell Road WWTP and the Albany Treefarm demonstrate the Water Corporations commitment to sustainable and environmentally sound solutions for wastewater management.

8 Appendices

Appendix A

Soils analysis report (Soil Management Consultants, May 2004)

Appendix B

Plantation management report (Neil Worrel, Forest Products Commission, May 2004)
Arboretum report (Neil Worrel, Forest Products Commission, May 2004)

Appendix C

Nutrient discharge calculation (CYMOD, May 2004)

Appendix D

Groundwater bore monitoring data

Appendix E

Soil moisture data

Appendix F

Site photographs