NORSKE SKOG ALBURY MILL

Revised Treated Process Water Management Strategies

STATEMENT OF ENVIRONMENTAL EFFECTS

APPENDIX 1,2,3,4,5,6 & 10

APPENDIX 1

DETERMINATION OF A DEVELOPMENT APPLICATION FOR STATE SIGNIFICANT AND INTEGRATED DEVELOPMENT UNDER SECTION 80 OF THE ENVIRONMENTAL PLANNING AND ASSESSMENT ACT, 1979

I, the Minister for Infrastructure and Planning, under Section 80 of the *Environmental Planning and Assessment Act 1979* ("the Act"), determine the development application ("the Application") referred to in Schedule 1 by granting consent subject to the conditions set out in Schedule 2.

The reason for the imposition of conditions is to:
(i) prevent, minimise, and/or offset adverse environmental impacts;
(ii) set standards and performance measures for acceptable environmental performance;
(iii) require regular monitoring and reporting; and
(iv) provide for the on-going environmental management of the development.

Craig Knowles MP
Minister for Infrastructure and Planning
Minister for Natural Resources

Sydney, 7 January 2004 File No. S03/01422

SCHEDULE 1

Development Application:	DA-389-8-2003-i.
Applicant:	Norske Skog Paper Mills (Australia) Ltd.
Consent Authority:	Minister for Infrastructure and Planning.
Land:	Lot 1 DP 258810, Lot 6 DP 264463, Lot 21 DP 604181, and Lot 2 DP 629660, Ettamogah, in the Albury local government area.
Proposed Development:	An upgrade to the existing Albury Paper Mill (approved by the then Minister for Planning on 12 October 1992) to increase the output capacity of the Mill from 215,000 tpa to 265,000 tpa. The proposal consists of: • upgrading the existing paper machine with a new press section and a higher speed drive; • installation of a new winder, and winder building;

- recommissioning of the 4th thermo-mechanical pulping line;
- installation of technology to treat additional wastewater;
- expansion of the existing wastewater re-use scheme, via the planting of an additional 50 ha land with crops;
- receipt of increased supplies of plantation thinnings and/or sawmill woodchips (80,000 tpa increase) and recovered paper (17,000 tpa increase).

BCA Classification: Class 8 – new winder building, constructed as an annex adjoining the existing paper machine building.

State Significant Development: The proposal is classified as State significant development under the provisions of Schedule 1 of *State Environmental Planning Policy No. 34 – Major Employment Generating Industrial Development* and Section 76(A)7 of the *Environmental Planning and Assessment Act 1979*.

Non-Designated Development: The proposal falls within the meaning of 'alterations and additions' as provided under Part 2 of Schedule 3 of the *Environmental Planning and Assessment Regulation 2000*. As such, the proposed development does not constitute designated development.

Integrated Development: The proposal is classified as integrated development, under Section 91 of the *Environmental Planning and Assessment Act 1979*, because it requires additional approvals from the Environment Protection Authority (EPA) under the *Protection of the Environment Operations Act 1997*.

Note:
1) *To find out when this consent becomes effective, see Section 83 of the Act;*
2) *To find out when this consent is liable to lapse, see Section 95 of the Act; and*
3) *To find out about appeal rights, see Section 97 of the Act.*

SCHEDULE 2

In this consent, except in so far as the context or subject-matter otherwise indicates or requires, the following terms have the meanings indicated:

Act	*Environmental Planning and Assessment Act, 1979*
Applicant	Norske Skog Paper Mills (Australia) Ltd
BCA	Building Code of Australia
construction	any activity requiring a Construction Certificate, the laying of a slab or significant excavation work
Council	Albury City Council
Department	NSW Department of Infrastructure, Planning and Natural Resources
Director-General	Director-General of the NSW Department of Infrastructure, Planning and Natural Resources or delegate
dust	any solid material that may become suspended in air or deposited
SEE	The Statement of Environmental Effects entitled *Norske Skog Albury Mill Paper Machine (PM1) Rebuild Statement of Environmental Effects*, dated August 2002
DEC	NSW Department of Environment and Conservation (DEC), incorporating officers of the NSW Environment Protection Authority
EPA	The statutory authority the NSW Environment Protection Authority
EPL	Environment Protection Licence issued under the *Protection of the Environment Operations Act, 1997*
MDBC	Murray Darling Basin Commission
Minister	NSW Minister for Infrastructure and Planning, or delegate
operation	any activity that results in the production, or intended production of paper from the upgraded paper machine
Principal Certifying Authority	the Minister or an accredited certifier, appointed under section 109E of the Act, to issue a Part 4A Certificate as provided under section 109C of the Act
Regulation	*Environmental Planning and Assessment Regulation, 2000*
site	the land to which this consent applies

1. GENERAL

Obligation to Minimise Harm to the Environment

1.1 The Applicant shall implement all practicable measures to prevent and/or minimise any harm to the environment that may result from the construction, operation, or decommissioning of the development.

Terms of Approval

1.2 [1] The Applicant shall carry out the development generally in accordance with the:
- (a) DA 389-8-2003-i;
- (b) Statement of Environmental Effects entitled *Norske Skog Albury Mill Paper Machine (PM1) Rebuild Statement of Environmental Effects*, dated August 2002;
- (c) additional information submitted to the Department in response to information request, dated 3 October 2003, 27 October, and 30 October 2003;
- (d) conditions of this consent.

If there is any inconsistency between the above documents and the conditions of consent, the conditions of this consent shall prevail to the extent of the inconsistency, otherwise. If there is an inconsistency between the documents other than the conditions of consent then the most recent document shall prevail.

Provision of Information

1.3 Where practicable, the Applicant shall provide all documents and reports required to be submitted to the Director-General under this consent in an appropriate electronic format. Provision of documents and reports to other parties, as required under this consent, shall be in a format acceptable to those parties and shall aim to minimise resource consumption.

Note: At the date of this consent, an appropriate electronic format is the “portable document format” (pdf) or another format that may be readily converted to pdf.

Statutory Requirements

1.4 The Applicant shall ensure that all necessary licences, permits and approvals are obtained and kept up-to-date as required throughout the life of the development. No condition of this consent removes the obligation for the Applicant to obtain, renew or comply with such licences, permits or approvals.

Compliance

1.5 The Applicant shall ensure that all employees, contractors and sub-contractors are aware of, and comply with, the conditions of this consent. The Applicant shall be responsible for the environmental impacts resulting from the actions of all persons on the site, including any visitors.

1.6 Prior to the commencement of each of the events listed from (a) to (b) below, or within such period as otherwise agreed by the Director-General, the Applicant shall certify in writing, to the satisfaction of the Director-General, that it has complied with all conditions of this consent applicable prior to the commencement of that event.
- (a) construction of the development; and
- (b) operation of the development.

Where an event is to be undertaken in stages, the Applicant may, subject to the agreement of the Director-General, stage the submission of compliance certification consistent with the staging of activities relating to that event. The events referred to in this condition are as follows:

[1] Incorporates an EPA general term of approval (A.1)

1.7 Notwithstanding condition 1.6 of this consent, the Director-General may require an update on compliance with all, or any part, of the conditions of this consent. Any such update shall meet the reasonable requirements of the Director-General and be submitted within such period as the Director-General may require.

1.8 The Applicant shall comply with any reasonable requirement/s of the Director-General arising from the Department's assessment of:
(a) any reports, plans or correspondence that are submitted in accordance with this consent; and
(b) the implementation of any actions or measures contained in these reports, plans or correspondence.

Protection of Public Infrastructure
1.9 The Applicant shall:
(a) repair, or pay the full costs associated with repairing, any public infrastructure that is damaged by the development;
(b) relocate, or pay the full costs associated with relocating, any public infrastructure that needs to be relocated as a result of the development.

2. CONSTRUCTION AND OCCUPATION CERTIFICATION

2.1 In relation to the construction and occupation of the development, the Applicant shall provide to the Director-General and Council the following:
(a) written notification of the appointment of a Principal Certifying Authority;
(b) copies of all Construction Certificates issued for the development;
(c) written notification of the intention to commence construction work, to be received at least two working days prior to the commencement of construction. In the event that more than one Construction Certificate is issued, notification shall be provided prior to the commencement of construction the subject of each Certificate;
(d) copies of all Occupation Certificates issued for the development; and
(e) written notification of the intention to occupy all relevant components of the development for which an Occupation Certificate has issued, to be received at least two working days prior to occupation. In the event that more than one Occupation Certificate is issued, notification shall be provided prior to the occupation the subject of each Certificate.

Note: Part 4A of the Environmental Planning and Assessment Act 1979 provides specific details of the Applicant's obligations in relation to certification and provides the overarching requirements in this regard. These requirements have been summarised and reproduced under condition 2.1 of this consent to highlight the need for this certification.

2.2 Prior to the commencement of any construction work associated with the development, the Applicant shall erect at least one sign at the site and in a prominent position at the site boundary where the sign can be viewed from the nearest public place. The sign shall indicate:
(a) the name, address and telephone number of the Principal Certifying Authority;
(b) the name of the person in charge of the construction site and telephone number at which that person may be contacted outside working hours; and
(c) a statement that unauthorised entry to the construction site is prohibited.

The sign(s) shall be maintained for the duration of construction works.

3. ENVIRONMENTAL PERFORMANCE

Air Quality Impacts

3.1 The development shall be carried out in a manner that will minimise the generation or emission of wind blown or traffic generated dust from the site at all times.

Noise Impacts

3.2 During construction works for the major rebuild of the paper machine, the Applicant shall ensure that the Wood Mill is not operational unless previously approved by the Director-General.

3.3 During construction works other than those described in condition 3.2, the Applicant shall take all practicable measures to minimise noise emissions, including limiting activities that would cause audible noise at the site boundary to daytime hours (7am – 7pm) Monday to Saturday.

Water Quality Impacts

Construction

3.4 The Applicant shall ensure that contaminated construction stormwater is appropriately treated in the retention basins prior to release to Eight Mile Creek, in accordance with the Construction Stormwater Management Plan, described in condition 6.1.

Effluent Reuse

3.5 [2] In accordance with the SEE the Applicant shall ensure that a minimum of 450 hectares of effective irrigation area is established prior to commencement of operations of the upgraded development. This effective irrigation area must be operated and maintained in a proper and efficient manner.

Note: Effective irrigation area means the net area of land that is under irrigation, and excludes areas not able to be used for irrigation such as clear felled timber areas.

Winter Water Storage Dam Management and effluent release

3.6 The Applicant shall manage the water storage dam in the following manner:

(a) Provided the river disposal criterion of 1:600 dilution is met at the point of discharge in the Murray River:

i. On October 1 of each year, or as otherwise agreed with the EPA, if the water level in the winter storage dam exceeds 213.0 m AHD (or 6.3 m depth) the treated wastewater from the Mill shall be diverted by the return pipeline to the Murray River until the water level in the dam has receded to 212.8 m AHD (or 6.1 m depth).

ii. On 1 March each year, or as otherwise agreed with the EPA, if the water in the winter storage dam exceeds 211.1 m AHD (or 4.4 m depth) the treated wastewater from the Mill shall be diverted by the return pipeline to the Murray River either until 30 April of that year, or until the water level in the dam has receded to 210.7 m AHD (or 4.0 m depth) whichever occurs first.

(b) If the river disposal criterion cannot be met, the winter storage dam water level must be allowed to reach the spillway level. At that stage, treated wastewater must be sent directly to the Murray River by return pipeline regardless of whether the River disposal criterion can be met. The release of treated wastewater must

[2] Incorporates EPA general terms of approval (O4.3.1 and O4.3.2)

be managed with the objective of preventing or minimising flow of water from the dam to Nine Mile Creek.

(c) The Applicant must not discharge dissolved salts into the Murray River except in accordance with any licencing conditions imposed by the EPA.

(d) In the event that the winter storage dam is likely to overtop due to adverse weather conditions the licensee shall consult with the EPA to determine the appropriate course of action, and meet the EPA's requirements.

Note: Condition 3.6(a) changes the primary method for determining appropriate timing of discharges to the Murray River. It supersedes condition 9.2 in the consent issued 19 July 1991, as modified on 12 October 1992. Conditions 3.7(b) and (c) are identical to conditions 9.3 and 9.4 in the consent issued 19 July 1991, as modified on 12 October 1992. They are provided to ensure that the conditions are appropriately considered collectively.

3.7 The Applicant shall provide the MDBC with the following:

(a) notification of likely discharges from the winter storage dam to the Murray River, both flow and salinity, before they are commenced; and

(b) data of any actual discharge made, from the winter storage dam to the Murray River, on completion of that event.

Traffic and Transport Impacts

3.8 Within such time as the RTA may agree, the Applicant shall undertake a **Traffic Impact Statement** for the intersection between RW Henry Drive and the Hume Highway. The Statement shall be undertaken in consultation with the RTA and Albury City Council, and must include, but not necessarily be limited to:

(a) current and future generation of traffic from the Mill in its entirety; and

(b) composition of all traffic generated by the Mill and information relating to the directional split of that traffic.

Note: The RTA has indicated that the Traffic Impact Statement would be required six weeks after consent being granted by the Minister.

Note: The Traffic Impact Statement described in Condition 3.8 and the subsequent Traffic Management Plan, described in Condition 6.4, are intended to identify measures to ensure appropriate safety management of the subject intersection, and to provide an on-going framework for the management of traffic generated by the Mill in it entirety.

Soil and Salinity Impacts

3.9 The Applicant shall submit an **Effluent Re-use Management Report** to the Director-General and the EPA, within 12 months of the commencement of operations of the upgraded development, or within such time as the Director-General may agree. This Report must be prepared in consultation with the Department and the EPA, and must discuss:

(a) the actual monitored impacts associated with the re-use of treated effluent on the effected soils;

(b) an assessment of the potential impacts from the on-going re-use of treated effluent on the soils, including within the context of potential expansion to the scheme in the future; and

(c) investigations into alternative management options for the effluent, including the feasibility of a salinity offset scheme, in which effluent might be returned to the Murray River, and various salt extraction or mitigation measures employed elsewhere in the catchment, within the context of establishing effluent re-use/ disposal options for any future expansion to the Mill beyond this development.

Visual Amenity Impacts

3.10 The Applicant shall construct and design the development in a way that is consistent with visual aspects of the existing development at the site.

4. ENVIRONMENTAL MONITORING AND AUDITING

Monitoring

4.1 Prior to commencement of operations the Applicant shall provide the Department with the results of a formal review of existing monitoring requirements and how the upgraded development may interact with such requirements. This review must demonstrate how the existing monitoring requirements will be expanded to include the upgraded aspects of the development.

4.2 In particular the Applicant shall expand the soil monitoring regime to include the additional area under effluent irrigation, such that the parameters monitored and methods and frequencies of monitoring of this additional effluent re-use area are consistent with the monitoring requirements for the total effluent re-use scheme, as prescribed in the EPL.

Auditing

4.3 Within two years of the commencement of operations of the upgraded development, and thereafter as directed by the Director-General, the Applicant shall commission, and pay the full cost of, an independent person or team to undertake an Independent Environmental Audit of the entire development, including the existing development and the upgrade. The independent person or team shall be approved by the Director-General, in consultation with the EPA, prior to the commencement of the Audit. An **Environmental Audit Report** shall be submitted for comment to the Director-General, the EPA and Council, within one month of the completion of the Audit. The Audit shall:

(a) be carried out in accordance with *ISO 14010 - Guidelines and General Principles for Environmental Auditing* and *ISO 14011 - Procedures for Environmental Auditing*;

(b) assess compliance with the requirements of this consent, and other licences and approvals that apply to the development, including existing development consents;

(c) assess the development against the predictions made and conclusions drawn in the SEE and additional information; and

(d) review the effectiveness of the environmental management of the development, including any environmental impact mitigation works.

The Director-General may, having considered any submission made by the EPA and/or Council in response to the Environmental Audit Report, require the Applicant to undertake works to address the findings or recommendations presented in the Report. Any such works shall be completed within such time as the Director-General may require.

Safety Management System Audit

4.4 Within twelve months after the commencement of operations of the upgraded development, or within such further period as the Director-General may agree, the Applicant shall submit to the Director-General, for approval, a report containing the findings and an implementation program for the current external audit of the Safety Management System. The implementation program shall also include any matters outstanding from previous audits. Every three years thereafter, the Applicant shall submit the most recent external Safety Management System Audit report for the approval of the Director-General.

5. COMMUNITY CONSULTATION AND INVOLVEMENT

5.1 Subject to confidentiality, the Applicant shall make all documents required under this consent available for public inspection upon request. This shall include provision of all documents at the site for inspection by visitors, and in an appropriate electronic format on the Applicant's internet site, should one exist.

Complaints Procedure

5.2 Prior to the commencement of construction for the development, the Applicant shall ensure that the following are available for community complaints for the life of the development (including construction and operation):

(a) a telephone number on which complaints about operations on the site may be registered;
(b) a postal address to which written complaints may be sent; and
(c) an email address to which electronic complaints may be transmitted, should the Applicant have email capabilities.

The Applicant shall ensure that the required details are publicly available including, but not limited to, displaying the information on a sign near the entrance to the site, in a position that is clearly visible to the public. These details shall also be provided on the Applicant's internet site, should one exist.

5.3 The Applicant shall record details of all complaints received through the means listed under condition 5.2 of this consent in an up-to-date Complaints Register. The Register shall record, but not necessarily be limited to:

(a) the date and time, where relevant, of the complaint;
(b) the means by which the complaint was made (telephone, mail or email);
(c) any personal details of the complainant that were provided, or if no details were provided, a note to that effect;
(d) the nature of the complaint;
(e) any action(s) taken by the Applicant in relation to the complaint, including any follow-up contact with the complainant; and
(f) if no action was taken by the Applicant in relation to the complaint, the reason(s) why no action was taken.

The Complaints Register shall be made available for inspection by the EPA or the Director-General upon request.

6. ENVIRONMENTAL MANAGEMENT

Construction

6.1 The Applicant shall prepare and implement a **Construction Stormwater Management Plan** to detail measures to ensure that erosion and water pollutants are not transported off site during the construction period. In particular the Applicant must detail the monitoring regime to ensure that contaminated stormwater is not discharged from the retention basins. The Plan shall be submitted for the approval of the Director-General prior to the commencement of construction of the development.

6.2 Two months prior to the commencement of commissioning of the upgraded development, or within such time as the Director-General may agree, the Applicant shall submit, for the approval of the Director-General, documentation demonstrating that the Safety Management System, including existing and upgraded development components, is consistent with the Department's publication *Hazardous Industry Planning Advisory Paper No. 9 - Safety Management*.

Operation

6.3 The Applicant shall undertake a formal review of the existing **Environmental Management Plan(s)** (EMP(s)) and amend the relevant parts of those Plan(s) to reflect the upgrade. The updated EMP(s) shall be made available to the Director-General, and any other interested authority or person upon request.

6.4 By 30/06/2004, or as otherwise agreed with the RTA, the Applicant shall prepare a **Traffic Management Plan** to address the impact of the additional traffic generated at the site. The Traffic Management Plan shall identify remedial actions and works required to maintain the safety and efficiency of the Hume Highway within the vicinity of the intersection with RW Henry Drive. The Traffic Management Plan shall be undertaken in consultation with the RTA and Albury City Council. A copy of the finalised Plan shall be provided to the Director-General. The Applicant shall implement the recommendations of the Traffic Management Plan prior to the operation of the upgraded development, to the satisfaction of the RTA.

Note: This consent does not remove the requirement for the Applicant to obtain the relevant permits and licences from the relevant roads authorities for any works which may impact on any roads.

7. ENVIRONMENTAL REPORTING

Incident Reporting

7.1 The Applicant shall notify the EPA and the Director-General of any incident with actual or potential significant off-site impacts on people or the biophysical environment as soon as practicable after the occurrence of the incident. The Applicant shall provide written details of the incident to the EPA and the Director-General within seven days of the date on which the incident occurred.

7.2 The Applicant shall meet the requirements of the Director-General to address the cause or impact of any incident, as it relates to this consent, reported in accordance with condition 7.1, within such period as the Director-General may require.

Note: Condition 7.2 of this consent does not limit or preclude the EPA from requiring any action to address the cause or impact of any incident, in the context of the EPA's statutory role in relation to the development.

Annual Performance Reporting

7.3 The **Annual Environmental Management Report** to be submitted directly after operations of the upgraded development have commenced, and all future Reports, must incorporate all relevant aspects of the upgrade to the satisfaction of the Director-General.

APPENDIX 2

Environment Protection Licence

Licence Details	
Number:	1272
Anniversary Date:	01-July
Review Due Date:	16-Feb-2011

Licensee

NORSKE SKOG PAPER MILLS (AUSTRALIA) LIMITED
PRIVATE BAG
LAVINGTON NSW 2641

Licence Type

Premises

Premises

NORSKE SKOG PAPER MILLS, ALBURY
HUME HIGHWAY
TABLE TOP NSW 2640
NORSKE SKOG EFFLUENT REUSE AREAS
-
ETTAMOGAH NSW 2640

Scheduled Activity

Paper or pulp production

Fee Based Activity	Scale
Paper or pulp production	> 150000 - T produced

Region

South - Albury
4th Floor, Albury City Council Chambers, 553 Kiewa Street
ALBURY NSW 2640
Phone: 02 6022 0600
Fax: 02 6022 0610

PO Box 544 ALBURY
NSW 2640

Information about this licence

Dictionary

A definition of terms used in the licence can be found in the dictionary at the end of this licence.

Responsibilities of licensee

Separate to the requirements of this licence, general obligations of licensees are set out in the Protection of the Environment Operations Act 1997 ("the Act") and the Regulations made under the Act. These include obligations to:

- ensure persons associated with you comply with this licence, as set out in section 64 of the Act;
- control the pollution of waters and the pollution of air (see for example sections 120 - 132 of the Act); and
- report incidents causing or threatening material environmental harm to the environment, as set out in Part 5.7 of the Act.

Variation of licence conditions

The licence holder can apply to vary the conditions of this licence. An application form for this purpose is available from the EPA.

The EPA may also vary the conditions of the licence at any time by written notice without an application being made.

Where a licence has been granted in relation to development which was assessed under the Environmental Planning and Assessment Act 1979 in accordance with the procedures applying to integrated development, the EPA may not impose conditions which are inconsistent with the development consent conditions until the licence is first reviewed under Part 3.6 of the Act.

Duration of licence

This licence will remain in force until the licence is surrendered by the licence holder or until it is suspended or revoked by the EPA or the Minister. A licence may only be surrendered with the written approval of the EPA.

Licence review

The Act requires that the EPA review your licence at least every 5 years after the issue of the licence, as set out in Part 3.6 and Schedule 5 of the Act. You will receive advance notice of the licence review.

Fees and annual return to be sent to the EPA

For each licence fee period you must pay:

- an administrative fee; and
- a load-based fee (if applicable).

The EPA publication "A Guide to Licensing" contains information about how to calculate your licence fees.

The licence requires that an Annual Return, comprising a Statement of Compliance and a summary of any monitoring required by the licence (including the recording of complaints), be submitted to the EPA. The Annual Return must be submitted within 60 days after the end of each reporting period. See condition R1 regarding the Annual Return reporting requirements.

Usually the licence fee period is the same as the reporting period.

Transfer of licence

The licence holder can apply to transfer the licence to another person. An application form for this purpose is available from the EPA.

Public register and access to monitoring data

Part 9.5 of the Act requires the EPA to keep a public register of details and decisions of the EPA in relation to, for example:

- licence applications;
- licence conditions and variations;
- statements of compliance;
- load based licensing information; and
- load reduction agreements.

Under s320 of the Act application can be made to the EPA for access to monitoring data which has been submitted to the EPA by licensees.

This licence is issued to:

NORSKE SKOG PAPER MILLS (AUSTRALIA) LIMITED
PRIVATE BAG
LAVINGTON NSW 2641

subject to the conditions which follow.

1 Administrative conditions

A1 What the licence authorises and regulates

A1.1 Not applicable.

A1.2 This licence authorises the carrying out of the scheduled activities listed below at the premises specified in A2. The activities are listed according to their scheduled activity classification, fee-based activity classification and the scale of the operation.

Unless otherwise further restricted by a condition of this licence, the scale at which the activity is carried out must not exceed the maximum scale specified in this condition.

Scheduled Activity
Paper or pulp production

Fee Based Activity	**Scale**
Paper or pulp production	> 150000 - T produced

A1.3 Not applicable.

A2 Premises to which this licence applies

A2.1 The licence applies to the following premises:

Premises Details
NORSKE SKOG PAPER MILLS, ALBURY
HUME HIGHWAY
TABLE TOP
NSW
2640
LOT2 DP 629660, LOT 21 DP604181
NORSKE SKOG EFFLUENT REUSE AREAS
-
ETTAMOGAH
NSW
2640

Premises Details
LOTS 2,7,8 DP10665; LOTS 1,2 DP823347; LOT 1 DP 134756; LOTS 1,2 DP 126224; LOT 15 DP 813569

A3 Other activities

A3.1 Not applicable.

A4 Information supplied to the EPA

A4.1 Works and activities must be carried out in accordance with the proposal contained in the licence application, except as expressly provided by a condition of this licence.

In this condition the reference to "the licence application" includes a reference to:
(a) the applications for any licences (including former pollution control approvals) which this licence replaces under the Protection of the Environment Operations (Savings and Transitional) Regulation 1998; and
(b) the licence information form provided by the licensee to the EPA to assist the EPA in connection with the issuing of this licence.

2 Discharges to air and water and applications to land

P1 Location of monitoring/discharge points and areas

P1.1 The following points referred to in the table below are identified in this licence for the purposes of monitoring and/or the setting of limits for the emission of pollutants to the air from the point.

Air

EPA Identi-fication no.	Type of Monitoring Point	Type of Discharge Point	Description of Location
11	Discharge to air, air emissions monitoring	Discharge to air, air emissions monitoring	Common stack serving the 2 boilers.

P1.2 The following points referred to in the table are identified in this licence for the purposes of the monitoring and/or the setting of limits for discharges of pollutants to water from the point.

P1.3 The following utilisation areas referred to in the table below are identified in this licence for the purposes of the monitoring and/or the setting of limits for any application of solids or liquids to the utilisation area.

Water and land

EPA identi-fication no.	Type of monitoring point	Type of discharge point	Description of location
1	Discharge to waters, Effluent quality and volume monitoring.	Discharge to waters, Effluent quality and volume monitoring.	Effluent discharged under the 'winter' release program: Inlet structure for return water pipeline leading to Murray River
2	Discharge to waters; Effluent volume and qualtity monitoring.	Discharge to waters; Effluent volume and qualtity monitoring.	Cooling Water Discharge: Inlet structure for return water pipeline that discharges to the Murray River
3		Discharge to utilisation area	Maryvale Effluent Reuse Area
4		Discharge to utilisation area	Curly Wood effluent reuse area
5	Effluent quality monitoring		4 day pond outlet
6	Effluent quality monitoring		Maryvale effluent storage dam
7	Volume monitoring		Maryvale effluent reuse system: Flow meter downstream of irrigation punp station.
8	Volume monitoring		Curly wood pump station.
9	Groundwater quality monitoring		Maryvale monitoring bore network, and the monitoring bores in the expanded irrigation area.
10	Soil monitoring		Maryvale: Various soil monitoring sites in the pine plantation, and the expanded irrigation area; and Centre pivot irrigation area on lot 6 DP264463.
12	Discharge to utilisation area; effluent volume monitoring.	Discharge to utilisation area; effluent volume monitoring.	Various locations along the Return Water Pipeline
13	Discharge to utilisation area; Volume monitoring.	Discharge to utilisation area; Volume monitoring.	Offtake point for new pipeline supplying effluent to the Albury Wodonga National Highway Project (Note Clause E3.1)

3 Limit conditions

L1 Pollution of waters

L1.1 Except as may be expressly provided in any other condition of this licence, the licensee must comply with section 120 of the Protection of the Environment Operations Act 1997.

L2 Load limits

L2.1 The actual load of an assessable pollutant discharged from the premises during the reporting period must not exceed the load limit specified for the assessable pollutant in the table below.

Note: An assessable pollutant is a pollutant which affects the licence fee payable for the licence.

L2.2 The actual load of an assessable pollutant must be calculated in accordance with the relevant load calculation protocol.

Assessable Pollutant	Load limit (kg)
BOD (Enclosed Waters)	51000
Coarse Particulates (Air)	8300
Fine Particulates (Air)	57500
Nitrogen (total) (Enclosed Waters)	31000
Nitrogen Oxides (Air)	285000
Phosphorus (total) (Enclosed Waters)	1900
Salt (Enclosed Waters)	7500000
Total suspended solids (Enclosed Waters)	82900
Zinc (Enclosed Waters)	1400

L3 Concentration limits

L3.1 For each monitoring/discharge point or utilisation area specified in the table\s below (by a point number), the concentration of a pollutant discharged at that point, or applied to that area, must not exceed the concentration limits specified for that pollutant in the table.

L3.2 Where a pH quality limit is specified in the table, the specified percentage of samples must be within the specified ranges.

L3.3 To avoid any doubt, this condition does not authorise the pollution of waters by any pollutant other than those specified in the table\s.

Water and Land

POINT 1

Pollutant	Units of Measure	50 percentile concentration limit	90 percentile concentration limit	3DGM concentration limit	100 percentile Concentration Limit
Cadmium	milligrams per litre				0.006
Chemical oxygen demand	milligrams per litre	120	170		200
Colour	Hazen	80	95		120
Copper	milligrams per litre				0.1
Iron	milligrams per litre				3
Manganese	milligrams per litre				1.5
Oil and Grease	milligrams per litre				10
pH	pH				6.5 - 8.5
Temperature	degrees Celsius				40
Total dissolved solids	milligrams per litre				1500
Nitrogen (total)	milligrams per litre	4	7		10
Phosphorus (total)	milligrams per litre	0.2	0.3		0.5
Zinc	milligrams per litre				0.3
Nitrogen (ammonia)	milligrams per litre	0.8	1		3
Total suspended solids	milligrams per litre	15	25		30
Biochemical oxygen demand	milligrams per litre	14	18		20
ethylene diamine tetraacetic acid	milligrams per litre				Note 1
Diethylene triamine pentaacetic acid	milligrams per litre				Note 1

POINT 2

Pollutant	Units of Measure	50 percentile concentration limit	90 percentile concentration limit	3DGM concentration limit	100 percentile Concentration Limit
Chemical oxygen demand	milligrams per litre				80
Oil and Grease	milligrams per litre		2		10
pH	pH				6.5 - 8.5
Temperature	degrees Celsius				40
Total dissolved solids	milligrams per litre				200

Note 1: The total combined concentration of ethylene diamine tetraacetic acid (EDTA) and Diethylene triamine pentaacetic acid (DTPA) must not exceed 100 mg/L.

L4 Volume and mass limits

L4.1 For each discharge point or utilisation area specified below (by a point number), the volume/mass of:

(a) liquids discharged to water; or;

(b) solids or liquids applied to the area;

must not exceed the volume/mass limit specified for that discharge point or area.

Point	Unit of measure	Volume/Mass Limit
1	kilolitres per day	10000
2	kilolitres per day	10000

L5 Waste

L5.1 The licensee must assess, classify and manage any waste generated at the premises in accordance with the Waste Guidelines prior to dispatching the waste off site.

L6 Noise Limits

L6.1 Not applicable.

4 Operating conditions

O1 Activities must be carried out in a competent manner

O1.1 Licensed activities must be carried out in a competent manner.

This includes:
(a) the processing, handling, movement and storage of materials and substances used to carry out the activity; and
(b) the treatment, storage, processing, reprocessing, transport and disposal of waste generated by the activity.

O2 Maintenance of plant and equipment

O2.1 All plant and equipment installed at the premises or used in connection with the licensed activity:
(a) must be maintained in a proper and efficient condition; and
(b) must be operated in a proper and efficient manner.

O3 Other Operational Requirements

O3.1 The obscuration meter installed on the boiler chimney must be set to give an alarm whenever the shade of the smoke exceeds 20 % opacity.

O3.2 The premises must be maintained in a condition which minimises or prevents the emission of dust from the premises.

O3.3 All effluent discharged to the spill pond from plant operations must be reclaimed to the wastewater treatment plant within 48 hours.

O4 Effluent Reuse

O4.1 The licensee must prepare a staged thinning, logging and replanting program designed to maximise the utilisation of wastewater by the irrigation scheme. This program must be submitted to the Environment Protection Authority prior to the commencement of harvesting and subsequently updated and resubmitted annually.

O4.2 The wastewater re-use scheme shall operate generally in accordance with the EIS (Figure 6.2 and 6.3) and shall utilise establishment, management and irrigation scheduling principles as described in the EIS (pages 6-25, 6-26 and 6-27).

O4.3 A minimum 450 hectares of effective irrigation area must be maintained and used at all times.

O4.4 Adequate notices, warning the public not to drink or otherwise use the treated effluent, must be erected on the site. These notices must be legible English and in any other languages as may be necessary, and must indicate at least that the water in use is "Reclaimed Water - Unfit for Drinking".

5 Monitoring and recording conditions

M1 Monitoring records

M1.1 The results of any monitoring required to be conducted by this licence or a load calculation protocol must be recorded and retained as set out in this condition.

M1.2 All records required to be kept by this licence must be:
(a) in a legible form, or in a form that can readily be reduced to a legible form;
(b) kept for at least 4 years after the monitoring or event to which they relate took place; and
(c) produced in a legible form to any authorised officer of the EPA who asks to see them.

M1.3 The following records must be kept in respect of any samples required to be collected for the purposes of this licence:
(a) the date(s) on which the sample was taken;

(b) the time(s) at which the sample was collected;
(c) the point at which the sample was taken; and
(d) the name of the person who collected the sample.

M2 Requirement to monitor concentration of pollutants discharged

M2.1 For each monitoring/discharge point or utilisation area specified below (by a point number), the licensee must monitor (by sampling and obtaining results by analysis) the concentration of each pollutant specified in Column 1. The licensee must use the sampling method, units of measure, and sample at the frequency, specified opposite in the other columns:

POINT 1

Pollutant	Units of measure	Frequency	Sampling Method
AOX	milligrams per litre	Quarterly	Composite sample
Biochemical oxygen demand	milligrams per litre	Daily	Composite sample
Cadmium	milligrams per litre	Monthly	Composite sample
Chemical oxygen demand	milligrams per litre	Daily	Composite sample
Chloride	milligrams per litre	Monthly	Composite sample
Colour	Hazen	Daily	Composite sample
Copper	milligrams per litre	Monthly	Composite sample
Diethylene triamine pentaacetic acid	milligrams per litre	Monthly	Composite sample
Iron	milligrams per litre	Weekly	Composite sample
Manganese	milligrams per litre	Monthly	Composite sample
Nitrogen (ammonia)	milligrams per litre	Daily	Composite sample
Nitrogen (total)	milligrams per litre	Daily	Composite sample
Oil and Grease	milligrams per litre	Weekly	Composite sample
Phosphorus (total)	milligrams per litre	Daily	Composite sample
Sodium	milligrams per litre	Monthly	Composite sample
Temperature	degrees Celsius	Daily	Composite sample
Total Resin Acids	milligrams per litre	Monthly	Composite sample
Total dissolved solids	milligrams per litre	Daily	Composite sample
Total organic carbon	milligrams per litre	Quarterly	Composite sample
Total suspended solids	milligrams per litre	Weekly	Composite sample
Zinc	milligrams per litre	Weekly	Composite sample
ethylene diamine tetraacetic acid	milligrams per litre	Monthly	Composite sample
pH	pH	Daily	Composite sample

POINT 2

Pollutant	Units of measure	Frequency	Sampling Method
Biochemical oxygen demand	milligrams per litre	Monthly	Composite sample
Chemical oxygen demand	milligrams per litre	Daily	Composite sample
Nitrogen (total)	milligrams per litre	Monthly	Composite sample
Oil and Grease	milligrams per litre	Monthly	Composite sample
Phosphorus (total)	milligrams per litre	Monthly	Composite sample
Temperature	degrees Celsius	Daily	Representative sample
Total dissolved solids	milligrams per litre	Daily	Composite sample
Total suspended solids	milligrams per litre	Monthly	Composite sample
Zinc	milligrams per litre	Monthly	Composite sample
pH	pH	Daily	Composite sample

POINT 5

Pollutant	Units of measure	Frequency	Sampling Method
Biochemical oxygen demand	milligrams per litre	Weekly during any discharge	Grab sample
Nitrogen (total)	milligrams per litre	Weekly during any discharge	Grab sample
Phosphorus (total)	milligrams per litre	Weekly during any discharge	Grab sample
Sulfate	milligrams per litre	Weekly during any discharge	Grab sample
Total dissolved solids	milligrams per litre	Weekly during any discharge	Grab sample
Total suspended solids	milligrams per litre	Weekly during any discharge	Grab sample
Zinc	milligrams per litre	Weekly during any discharge	Grab sample
pH	pH	Weekly during any discharge	Grab sample

POINT 6

Pollutant	Units of measure	Frequency	Sampling Method
AOX	milligrams per litre	6 Times a year	Representative sample
Ammonia	milligrams per litre	6 Times a year	Representative sample
Biochemical oxygen demand	milligrams per litre	6 Times a year	Representative sample
Cadmium	milligrams per litre	6 Times a year	Representative sample
Chemical oxygen demand	milligrams per litre	6 Times a year	Representative sample
Colour	milligrams per litre	6 Times a year	Representative sample
Copper	milligrams per litre	6 Times a year	Representative sample
DTPA	milligrams per litre	6 Times a year	Representative sample
Iron	milligrams per litre	6 Times a year	Representative sample
Manganese	milligrams per litre	6 Times a year	Representative sample
Nitrogen (total)	milligrams per litre	6 Times a year	Representative sample
Phosphorus (total)	milligrams per litre	6 Times a year	Representative sample
Temperature	degrees Celsius	6 Times a year	Representative sample
Total dissolved solids	milligrams per litre	6 Times a year	Representative sample
Total organic carbon	milligrams per litre	6 Times a year	Representative sample
Total suspended solids	milligrams per litre	6 Times a year	Representative sample
Zinc	milligrams per litre	6 Times a year	Representative sample
ethylene diamine tetraacetic acid	milligrams per litre	6 Times a year	Representative sample
pH	pH	6 Times a year	Representative sample

POINT 9

Pollutant	Units of measure	Frequency	Sampling Method
Bicarbonate	milligrams per litre	Yearly	Representative sample
Calcium	milligrams per litre	Yearly	Representative sample
Chemical oxygen demand	milligrams per litre	Yearly	Representative sample
Chloride	milligrams per litre	Yearly	Representative sample
Chromium	milligrams per litre	Yearly	Representative sample
Conductivity	microsiemens per centimetre	Monthly	Representative sample
Iron	milligrams per litre	Yearly	Representative sample
Lead	milligrams per litre	Yearly	Representative sample
Magnesium	milligrams per litre	Yearly	Representative sample
Manganese	milligrams per litre	Yearly	Representative sample
Nitrate	milligrams per litre	Yearly	Representative sample
Nitrogen (ammonia)	milligrams per litre	Yearly	Representative sample
Nitrogen (total)	milligrams per litre	Yearly	Representative sample
Phosphorus (total)	milligrams per litre	Yearly	Representative sample
Potassium	milligrams per litre	Yearly	Representative sample
Sodium	milligrams per litre	Yearly	Representative sample
Standing Water Level	metres	Monthly	No method specified
Sulfate	milligrams per litre	Yearly	Representative sample
Total dissolved solids	milligrams per litre	Quarterly	Representative sample
Zinc	milligrams per litre	Yearly	Representative sample
pH	milligrams per litre	Quarterly	Representative sample

POINT 11

Pollutant	Units of measure	Frequency	Sampling Method
Coarse Particulates	milligrams per cubic metre	2 Times a year	OM-9
Fine Particulates	milligrams per cubic metre	2 Times a year	OM-5
Nitrogen Oxides	milligrams per cubic metre	2 Times a year	TM-11

M2.2 For Discharge Point 1, the first monitoring sample for all pollutants must be collected on the day discharge to the Murray River commences, with further sampling undertaken in accordance with the frequency specified in condition M2.1 for the duration of the discharge.

M2.3 **Point 10 – Soil Monitoring Requirements**

The licensee must implement, in consultation with NSW Agriculture the following soil monitoring program. The monitoring program must focus on the measurement of adverse impacts on soils at an early stage and include the monitoring of the following environmental changes:

I. any increase in soil salinity levels using in-situ techniques as agreed by NSW Agriculture;

II. any decrease in soil pH;

III. an increase in the proportion of halophytes and salt tolerant plant species;

IV. a deterioration in the growth rate of pines, pasture or other plants reasonably attributable to the wastewater. Should deterioration occur, then tissue culture testing shall be carried out in accordance to the requirements of NSW Agriculture.

V. The soil monitoring program includes both physical and chemical testing parameters to be carried out over specified time frames as outlined.

a) Soil Monitoring Program

Soil unit	Unit 1,2,3,4 - (all units)
Soil test and type	Chemical – Annual Physical - every 5 years
Test depths (cm)	0-10 20-30 50-60 80-90

b) Test elements

Chemical (Annual - all depths)	5 yearly (Physical - all depths)
pH (H_2O + $CaCl_2$)	Soil texture
EC (1:5)	Soil structure
Soluble Chloride	Bulk density
Extractable sulphate	Colour
Exchangeable Cations (Ca, Mg, K Na)	Infiltration rate
Exchangeable Aluminium	Dispersion
Extractable Phosphorus (Bray P)	PSA
Total Nitrogen	EAT
Total Carbon (Dumas method)	
Organic carbon (oxidisable C)	
SAR	

c) Soil Amelioration Requirements

The licensee must undertake trials to establish the most appropriate gypsum application rates and frequencies for the effluent reuse site. Whilst these trials are underway, gypsum is to be applied to trafficable areas of irrigated plantation at a minimum rate of 5 t/ha every five years or as required.

M3 Testing methods - concentration limits

M3.1 Monitoring for the concentration of a pollutant emitted to the air required to be conducted by this licence must be done in accordance with:

(a) any methodology which is required by or under the Act to be used for the testing of the concentration of the pollutant; or

(b) if no such requirement is imposed by or under the Act, any methodology which a condition of this licence requires to be used for that testing; or

(c) if no such requirement is imposed by or under the Act or by a condition of this licence, any methodology approved in writing by the EPA for the purposes of that testing prior to the testing taking place.

Note: The Protection of the Environment Operations (Clean Air) Regulation 2002 requires testing for certain purposes to be conducted in accordance with test methods contained in the publication "Approved Methods for the Sampling and Analysis of Air Pollutants in NSW".

M3.2 Subject to any express provision to the contrary in this licence, monitoring for the concentration of a pollutant discharged to waters or applied to a utilisation area must be done in accordance with the Approved Methods Publication unless another method has been approved by the EPA in writing before any tests are conducted.

Note: Testing methods - load limit

Note: Clause 18 (1) and (2) of the Protection of the Environment Operations (General) Regulation 1998 requires that monitoring of actual loads of assessable pollutants listed in L2.1 must be carried out in accordance with the testing method set out in the relevant load calculation protocol for the fee-based activity classification listed in condition A1.2.

M4 Recording of pollution complaints

M4.1 The licensee must keep a legible record of all complaints made to the licensee or any employee or agent of the licensee in relation to pollution arising from any activity to which this licence applies.

M4.2 The record must include details of the following:
(a) the date and time of the complaint;
(b) the method by which the complaint was made;
(c) any personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect;
(d) the nature of the complaint;
(e) the action taken by the licensee in relation to the complaint, including any follow-up contact with the complainant; and
(f) if no action was taken by the licensee, the reasons why no action was taken.

M4.3 The record of a complaint must be kept for at least 4 years after the complaint was made.

M4.4 The record must be produced to any authorised officer of the EPA who asks to see them.

M5 Telephone complaints line

M5.1 The licensee must operate during its operating hours a telephone complaints line for the purpose of receiving any complaints from members of the public in relation to activities conducted at the premises or by the vehicle or mobile plant, unless otherwise specified in the licence.

M5.2 The licensee must notify the public of the complaints line telephone number and the fact that it is a complaints line so that the impacted community knows how to make a complaint.

M5.3 Conditions M5.1 and M5.2 do not apply until 3 months after:
(a) the date of the issue of this licence or

(b) if this licence is a replacement licence within the meaning of the Protection of the Environment Operations (Savings and Transitional) Regulation 1998, the date on which a copy of the licence was served on the licensee under clause 10 of that regulation.

M6 Requirement to monitor volume or mass

M6.1 For each discharge point or utilisation area specified below, the licensee must monitor:

(a) the volume of liquids discharged to water or applied to the area;
(b) the mass of solids applied to the area;
(c) the mass of pollutants emitted to the air;

at the frequency and using the method and units of measure, specified below.

POINT 1

Frequency	Unit Of Measure	Sampling Method
Continuous during discharge	kilolitres per day	Flow meter and continuous logger

POINT 2

Frequency	Unit Of Measure	Sampling Method
Continuous	kilolitres per day	Flow meter and continuous logger

POINT 7

Frequency	Unit Of Measure	Sampling Method
Continuous	kilolitres per day	Flow meter and continuous logger

POINT 8

Frequency	Unit Of Measure	Sampling Method
Continuous	kilolitres per day	Flow meter and continuous logger

POINT 12

Frequency	Unit Of Measure	Sampling Method
Continuous	kilolitres per day	Flow meter and continuous logger

POINT 13

Frequency	Unit Of Measure	Sampling Method
Continuous	kilolitres per day	Flow meter and continuous logger

6 Reporting conditions

R1 Annual return documents

What documents must an Annual Return contain?

R1.1 The licensee must complete and supply to the EPA an Annual Return in the approved form comprising:
(a) a Statement of Compliance; and
(b) a Monitoring and Complaints Summary.
A copy of the form in which the Annual Return must be supplied to the EPA accompanies this licence. Before the end of each reporting period, the EPA will provide to the licensee a copy of the form that must be completed and returned to the EPA.

Period covered by Annual Return

R1.2 An Annual Return must be prepared in respect of each reporting period, except as provided below.

Note: The term "reporting period" is defined in the dictionary at the end of this licence. Do not complete the Annual Return until after the end of the reporting period.

R1.3 Where this licence is transferred from the licensee to a new licensee:
(a) the transferring licensee must prepare an Annual Return for the period commencing on the first day of the reporting period and ending on the date the application for the transfer of the licence to the new licensee is granted; and
(b) the new licensee must prepare an Annual Return for the period commencing on the date the application for the transfer of the licence is granted and ending on the last day of the reporting period.

Note: An application to transfer a licence must be made in the approved form for this purpose.

R1.4 Where this licence is surrendered by the licensee or revoked by the EPA or Minister, the licensee must prepare an Annual Return in respect of the period commencing on the first day of the reporting period and ending on:
(a) in relation to the surrender of a licence - the date when notice in writing of approval of the surrender is given; or
(b) in relation to the revocation of the licence - the date from which notice revoking the licence operates.

Deadline for Annual Return

R1.5 The Annual Return for the reporting period must be supplied to the EPA by registered post not later than 60 days after the end of each reporting period or in the case of a transferring licence not later than 60 days after the date the transfer was granted (the 'due date').

Notification where actual load can not be calculated

R1.6 Where the licensee is unable to complete a part of the Annual Return by the due date because the licensee was unable to calculate the actual load of a pollutant due to circumstances beyond the licensee's control, the licensee must notify the EPA in writing as soon as practicable, and in any event not later than the due date. The notification must specify:

(a) the assessable pollutants for which the actual load could not be calculated; and

(b) the relevant circumstances that were beyond the control of the licensee.

Licensee must retain copy of Annual Return

R1.7 The licensee must retain a copy of the Annual Return supplied to the EPA for a period of at least 4 years after the Annual Return was due to be supplied to the EPA.

Certifying of Statement of Compliance and signing of Monitoring and Complaints Summary

R1.8 Within the Annual Return, the Statement of Compliance must be certified and the Monitoring and Complaints Summary must be signed by:
(a) the licence holder; or
(b) by a person approved in writing by the EPA to sign on behalf of the licence holder.

R1.9 A person who has been given written approval to certify a certificate of compliance under a licence issued under the Pollution Control Act 1970 is taken to be approved for the purpose of this condition until the date of first review of this licence.

R2 Notification of environmental harm

Note: The licensee or its employees must notify the EPA of incidents causing or threatening material harm to the environment as soon as practicable after the person becomes aware of the incident in accordance with the requirements of Part 5.7 of the Act.

R2.1 Notifications must be made by telephoning the EPA's Pollution Line service on 131 555.

R2.2 The licensee must provide written details of the notification to the EPA within 7 days of the date on which the incident occurred.

R3 Written report

R3.1 Where an authorised officer of the EPA suspects on reasonable grounds that:
(a) where this licence applies to premises, an event has occurred at the premises; or
(b) where this licence applies to vehicles or mobile plant, an event has occurred in connection with the carrying out of the activities authorised by this licence,
and the event has caused, is causing or is likely to cause material harm to the environment (whether the harm occurs on or off premises to which the licence applies), the authorised officer may request a written report of the event.

R3.2 The licensee must make all reasonable inquiries in relation to the event and supply the report to the EPA within such time as may be specified in the request.

R3.3 The request may require a report which includes any or all of the following information:
(a) the cause, time and duration of the event;
(b) the type, volume and concentration of every pollutant discharged as a result of the event;

(c) the name, address and business hours telephone number of employees or agents of the licensee, or a specified class of them, who witnessed the event;
(d) the name, address and business hours telephone number of every other person (of whom the licensee is aware) who witnessed the event, unless the licensee has been unable to obtain that information after making reasonable effort;
(e) action taken by the licensee in relation to the event, including any follow-up contact with any complainants;
(f) details of any measure taken or proposed to be taken to prevent or mitigate against a recurrence of such an event; and
(g) any other relevant matters.

R3.4 The EPA may make a written request for further details in relation to any of the above matters if it is not satisfied with the report provided by the licensee. The licensee must provide such further details to the EPA within the time specified in the request.

R4 Annual Report

R4.1 **Pulp and Paper Mill Annual Report Requirements**

The licensee must prepare an annual report which supplements the requirements of the annual return. The report shall be for each reporting period, and shall:

a) detail chemicals usage, both quantitatively and qualitatively, the efficiency of the process, including any investigations into new technology. Any performance indicator relating to the paper making process must include details of chemicals used (kilograms or tonnes) including sulphuric acid, sodium hydroxide, hydrogen peroxide, dyes, slimacides, polyelectrolytes, and DTPA per tonne of paper production. Such information must be summarised on a monthly basis.

b) detail the results of all monitoring required by the conditions of this licence including any exceedences and the reasons for such exceedences, and shall include the following information:

i) The name of the testing laboratory, parameter(s) monitored, date(s) of sampling, location(s) of sampling and result(s) of analysis must be included.
ii) The results must be presented in a graphical or tabular format for each parameter for each authorised point of discharge.
iii) Any data compiled, collected or recorded in compliance with the Monitoring Condition(s) of this licence must show the 50 percentile and 90 percentile limits where these limits are specified in the Limit Conditions of this licence.

The annual report must be supplied to the Environment Protection Authority, PlanningNSW, Department of Land and Water Conservation, NSW Fisheries, NSW Agriculture, the Murray-Darling Basin Commission, the Murray Catchment Management Committee, and the Albury City Council no later than 60 days after the end of each reporting period, or such other time as may be approved.

R4.2 **Effluent Reuse Area Annual Report Requirements.**

a) The licensee must prepare, on an annual basis, a report which analyses the principal findings of the wastewater and solid waste disposal program monitoring, bioassay testing and environmental monitoring program and any independent environmental audit. In addition, the report must include sections dealing with the analysis and interpretation of the monitoring data and make an assessment of the impact of the development on the environment. These sections must be prepared by a person with relevant experience and qualifications on behalf of the licensee.

The report shall include:
(a) control of odour emission;
(b) solid wastes management;
(c) liquid wastes management;
(d) soils and agriforest management;
(e) protection of surface and groundwaters;
(f) Murray River environmental monitoring and bioassay testing programs;
(g) storage dam management;
(h) findings of any audit.

b) The licensee must present the Annual Environmental Management Report no later than 60 days after the end of the reporting period to the PlanningNSW, Environment Protection Authority, NSW Agriculture, NSW Fisheries, Department of Land and Water Conservation, Albury City Council and Hume and Corowa Shire Councils and Murray Darling Basin Commission. The applicant must also provide additional copies of this report to the Councils for public access.

c) The licensee must adjust, if necessary, the monitoring programs and requirements referred to above after consultation with the relevant authorities referred to in these conditions, in accordance with the requirements of the Environment Protection Authority.

General conditions

G1 Copy of licence kept at the premises

G1.1 A copy of this licence must be kept at the premises to which the licence applies.

G1.2 The licence must be produced to any authorised officer of the EPA who asks to see it.

G1.3 The licence must be available for inspection by any employee or agent of the licensee working at the premises.

Pollution studies and reduction programs

U1.1 Not applicable.

Special conditions

E1 **Effluent Discharge Program**

The licensee may only discharge treated wastewater to the Murray River in accordance with the following conditions:

a) Provided the river disposal criterion of 1:600 dilution is met at the point of discharge in the Murray River:
   i. On October 1 of each year, or as otherwise agreed in writing by the EPA, if the water level in the winter storage dam exceeds 213.0 m AHD (or 6.3 m depth) the treated wastewater from the Mill shall be diverted by the return pipeline to the Murray River until the water level in the dam has receded to 212.8 m AHD (or 6.1 m depth).
   ii. On 1 March each year, or as otherwise agreed in writing by the EPA, if the water in the winter storage dam exceeds 211.1 m AHD (or 4.4 m depth) the treated wastewater from the Mill shall be diverted by the return pipeline to the Murray River either until 30 April of that year, or until the water level in the dam has receded to 210.7 m AHD (or 4.0 m depth) whichever occurs first.

b) If the river disposal criterion cannot be met, the winter storage dam water level must be allowed to reach the spillway level. At that stage, treated wastewater must be sent directly to the Murray River by the return pipeline regardless of whether the River disposal criterion can be met. The release of treated wastewater must be managed with the objective of preventing or minimising flow of water from the dam to Nine Mile Creek.

c) The licensee must not discharge dissolved salts into the Murray River except in accordance with any licensing conditions imposed by the Environment Protection Authority.

d) The licensee must not discharge diethylene triamine pentaacetic acid (DTPA) into the Murray River except in accordance with any licensing conditions of the Environment Protection Authority

E2 **Expansion of Effluent Reuse Area**

The effluent reuse area shall be expanded if necessary in accordance with the following requirements:

a) If the water use of the scheme for any rolling two year period after 1 January 1997, is less than that projected by the model used to generate the EIS estimates of water utilisation, the licensee must put in place measures to rectify this inadequacy in the water utilisation, within one month of the end of that two year period. These measures could involve expanding the irrigation plantation area and/or implementing alternative procedures as outlined in the EIS, such as reduction in water usage in the mill, to the requirements of the Environment Protection Authority.

b) If after 1 January 1997, the monitoring program establishes that there are soil structural, nutrient or toxicity problems in the irrigated plantations, the licensee shall within one month of notification by NSW Agriculture, expand the irrigated plantation area and/or implement alternative procedures as outlined in the EIS, to the requirements of NSW Agriculture and the Environment Protection Authority.

c) Should larger irrigated plantation areas be required within Maryvale as a result of Condition a) or b) above, then the larger areas shall be irrigated in accordance with the same principles set out in the EIS (pages 6-25, 6-26, 6-27) prepared by Gutteridge, Haskins & Davey Pty Ltd, dated May 1992.

E3 Effluent reuse -special provisions for small scale short term proposals

E3.1 Effluent may be supplied to a third party for small scale reuse proposals that are either short term, one off proposals, or for occasional periodic reuse, subject to the following conditions:

a) Approval from the EPA must be obtained in writing; and

b) The reuse of the effluent must be undertaken in accordance with any condition attached to the approval in writing.

E4 Construction of the Albury Wodonga National Highway Project

E4.1 Interim Provisions for Discharge Point 13

E4.1.1 As an interim provision until 19th October 2007, or until the effluent distribution work detailed in the licence variation application is completed, the discharge location and volume monitoring method for effluent supplied from licence Discharge Point 13 is amended as follows:

Discharge Location: Standpipes located within the irrigation area.
Volume monitoring: Calculated by recording the number of times each tanker is refilled, and multiplying the number of loads by the known tank capacity.

Dictionary

General Dictionary

In this licence, unless the contrary is indicated, the terms below have the following meanings:

3DGM [in relation to a concentration limit]	Means the three day geometric mean, which is calculated by multiplying the results of the analysis of three samples collected on consecutive days and then taking the cubed root of that amount. Where one or more of the samples is zero or below the detection limit for the analysis, then 1 or the detection limit respectively should be used in place of those samples
Act	Means the Protection of the Environment Operations Act 1997
activity	Means a scheduled or non-scheduled activity within the meaning of the Protection of the Environment Operations Act 1997
actual load	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 1998
AM	Together with a number, means an ambient air monitoring method of that number prescribed by the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*.
AMG	Australian Map Grid

anniversary date	The anniversary date is the anniversary each year of the date of issue of the licence. In the case of a licence continued in force by the Protection of the Environment Operations Act 1997, the date of issue of the licence is the first anniversary of the date of issue or last renewal of the licence following the commencement of the Act.
annual return	Is defined in R1.1
Approved Methods Publication	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 1998
assessable pollutants	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 1998
BOD	Means biochemical oxygen demand
CEM	Together with a number, means a continuous emission monitoring method of that number prescribed by the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*.
COD	Means chemical oxygen demand
composite sample	Unless otherwise specifically approved in writing by the EPA, a sample consisting of 24 individual samples collected at hourly intervals and each having an equivalent volume.
cond.	Means conductivity
environment	Has the same meaning as in the Protection of the Environment Operations Act 1997
environment protection legislation	Has the same meaning as in the Protection of the Environment Administration Act 1991
EPA	Means Environment Protection Authority of New South Wales.
fee-based activity classification	Means the numbered short descriptions in Schedule 1 of the Protection of the Environment Operations (General) Regulation 1998.
flow weighted composite sample	Means a sample whose composites are sized in proportion to the flow at each composites time of collection.
grab sample	Means a single sample taken at a point at a single time
hazardous waste	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
industrial waste	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
inert waste	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
licensee	Means the licence holder described at the front of this licence
load calculation protocol	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 1998
local authority	Has the same meaning as in the Protection of the Environment Operations Act 1997
material harm	Has the same meaning as in section 147 Protection of the Environment Operations Act 1997
MBAS	Means methylene blue active substances
Minister	Means the Minister administering the Protection of the Environment Operations Act 1997
mobile plant	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997

	1997
motor vehicle	Has the same meaning as in the Protection of the Environment Operations Act 1997
O&G	Means oil and grease
percentile [in relation to a concentration limit of a sample]	Means that percentage [eg.50%] of the number of samples taken that must meet the concentration limit specified in the licence for that pollutant over a specified period of time. In this licence, the specified period of time is the Reporting Period unless otherwise stated in this licence.
plant	Includes all plant within the meaning of the Protection of the Environment Operations Act 1997 as well as motor vehicles.
pollution of waters [or water pollution]	Has the same meaning as in the Protection of the Environment Operations Act 1997
premises	Means the premises described in condition A2.1
public authority	Has the same meaning as in the Protection of the Environment Operations Act 1997
regional office	Means the relevant EPA office referred to in the Contacting the EPA document accompanying this licence
reporting period	For the purposes of this licence, the reporting period means the period of 12 months after the issue of the licence, and each subsequent period of 12 months. In the case of a licence continued in force by the Protection of the Environment Operations Act 1997, the date of issue of the licence is the first anniversary of the date of issue or last renewal of the licence following the commencement of the Act.
reprocessing of waste	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
scheduled activity	Means an activity listed in Schedule 1 of the Protection of the Environment Operations Act 1997
solid waste	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
TM	Together with a number, means a test method of that number prescribed by the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*.
treatment of waste	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
TSP	Means total suspended particles
TSS	Means total suspended solids
Type 1 substance	Means the elements antimony, arsenic, cadmium, lead or mercury or any compound containing one or more of those elements
Type 2 substance	Means the elements beryllium, chromium, cobalt, manganese, nickel, selenium, tin or vanadium or any compound containing one or more of those elements
utilisation area	Means any area shown as a utilisation area on a map submitted with the application for this licence
waste	Has the same meaning as in the Protection of the Environment Operations Act 1997
waste code	Means the waste codes listed in Appendix 5 of the EPA document A Guide to Licensing Part B.
waste type	Means Group A, Group B, Group C, inert, solid, industrial or hazardous waste

Mr Bernie Weir

Environment Protection Authority

(By Delegation)

Date of this edition - 11-May-2008

End Notes

1	Licence varied by notice 1016666, issued on 19-Feb-2003, which came into effect on 16-Mar-2003.
2	Licence varied by notice 1035196, issued on 22-Mar-2004, which came into effect on 16-Apr-2004.
3	Licence varied by change to LGA boundary, issued on 07-Mar-2005, which came into effect on 07-Mar-2005.
4	Licence fee period changed by notice 1046182 on 04-Apr-2005.
5	Licence varied by notice 1052361, issued on 30-Sep-2005, which came into effect on 30-Sep-2005.
6	Licence varied by notice 1052771, issued on 16-Nov-2005, which came into effect on 11-Dec-2005.
7	Licence varied by notice 1055880, issued on 10-Feb-2006, which came into effect on 07-Mar-2006.
8	Licence varied by notice 1060839, issued on 30-Jun-2006, which came into effect on 30-Jun-2006.
9	Licence varied by notice 1073858, issued on 20-Sep-2007, which came into effect on 20-Sep-2007.
10	Licence varied by notice 1085799, issued on 11-May-2008, which came into effect on 11-May-2008.

APPENDIX 3

Multi Port Diffuser

APPENDIX 3 - THEORY OF MULTIPLE PORT DIFFUSER (SUMMARISED FROM GHD TECHNICAL BULLETIN NO. M.C.71)

This section covers the general theory behind the design process and the methodology used to obtain design solutions.

Design Process

The design process consists of analysing three basic problems whose sum represents the elements of the outfall system and effluent field behaviour:

(a) initial dilution

(b) subsequent dilution

(c) diffuser hydraulics

Analysis of these three systems is essentially carried out independently with the connecting link being as follows:

(i) Assume a 'perfect' diffuser, that is, the creation of an effluent field with the following dilution:

$$S_{perf} = \frac{Ubh}{Q}$$

where U = velocity of the effluent field

b = width of effluent field perpendicular to the current direction

h = vertical height of effluent field

Q = effluent discharge rate

(ii) Estimate the optimum diffuser and outfall lengths to obtain specified minimum effluent standards.

(iii) Assume certain diffuser port distribution, number and size and calculate average port flow and initial average dilution (S_{av}). Check this dilution to ensure it is greater than $S_{perf,}$ if not, redesign the diffuser.

(iv) Carry out detailed analysis of the diffuser hydraulics. The major objectives being to minimise port flow variation and ensure that all ports flow full.

Initial Dilution

Initial dilution is defined as the dilution of effluent discharged from the multiport diffuser into the ambient fluid at the end of the buoyant jet mixing process. The mixing process is largely one of turbulent entrainment of one fluid moving past another (i.e. it is mainly mixing by dispersion). A number of influences which affect this jet mixing process are discussed in detail below.

(a) Momentum Effect

The momentum of effluent as it is discharged from the diffuser port is initially the major influence on the turbulent mixing. The exact zone of influence of momentum is difficult to estimate, but for the theoretical analysis it is assumed to be the prime influence for a distance of about six port diameters from the outlet.

(b) Buoyancy Effect

Because the temperature of the return water will be higher than the river water its density will be lower than that of the ambient fluid. The density difference has an effect on the jet or plume mixing. An effluent jet discharging horizontally into heavier water will be deflected upwards. Such a jet, which has a combined momentum and buoyancy flux, is called a buoyant jet (or forced plume). If flow is only influenced by the buoyancy flux (which is effectively the case towards the end of its path), it is called a simple plume.

(c) Density Stratification

Oceans and lakes can develop a variable density profile due to non-uniform temperature profiles developing as a result of heating of the surface layers and a lack of adequate circulation through the water column. However, this would not apply in the riverine situation.

(d) Current Effect

The river currents will affect jet mixing characteristics. The effect will serve to increase dilution over that which would occur for a stagnant water situation.

(e) Jet Interference

If the jets are spaced sufficiently close together, they will gradually merge as they spread. The merged plumes are considered as being produced from a two dimensional slot. It is normal practice to select a port spacing sufficient to prevent merging of the individual plumes before they reach the surface field. However, for certain conditions, a closer port spacing and the resulting slot jet may produce greater dilutions than those occurring for the individual plume situation.

Schematic diagrams demonstrating the five major influences on the tubulent mixing process are shown in Figure A.

Subsequent Dilution in a Current

On reaching the surface the diluted effluent cloud, effectively a line source resulting from the merging of all the individual plumes, loses its momentum and buoyant turbulent mixing capacities. Subsequent dilution of this surface field, as it is carried away by a current, is controlled by molecular diffusion, settling of solids, bacteria die-off and general biochemical oxidation.

The following assumptions are made of subsequent dilution of the effluent field:

1. Ficks law for molecular diffusion applies
   i.e. Effluent flux $= \frac{\varepsilon \partial c}{\partial x}$
   in the x direction
2. Effluent concentration distribution is Gaussian
3. Vertical mixing is negligible
4. Longitudinal mixing in the current direction is negligible.
5. Steady flow conditions apply
6. Coliform die-off is proportional to concentration.

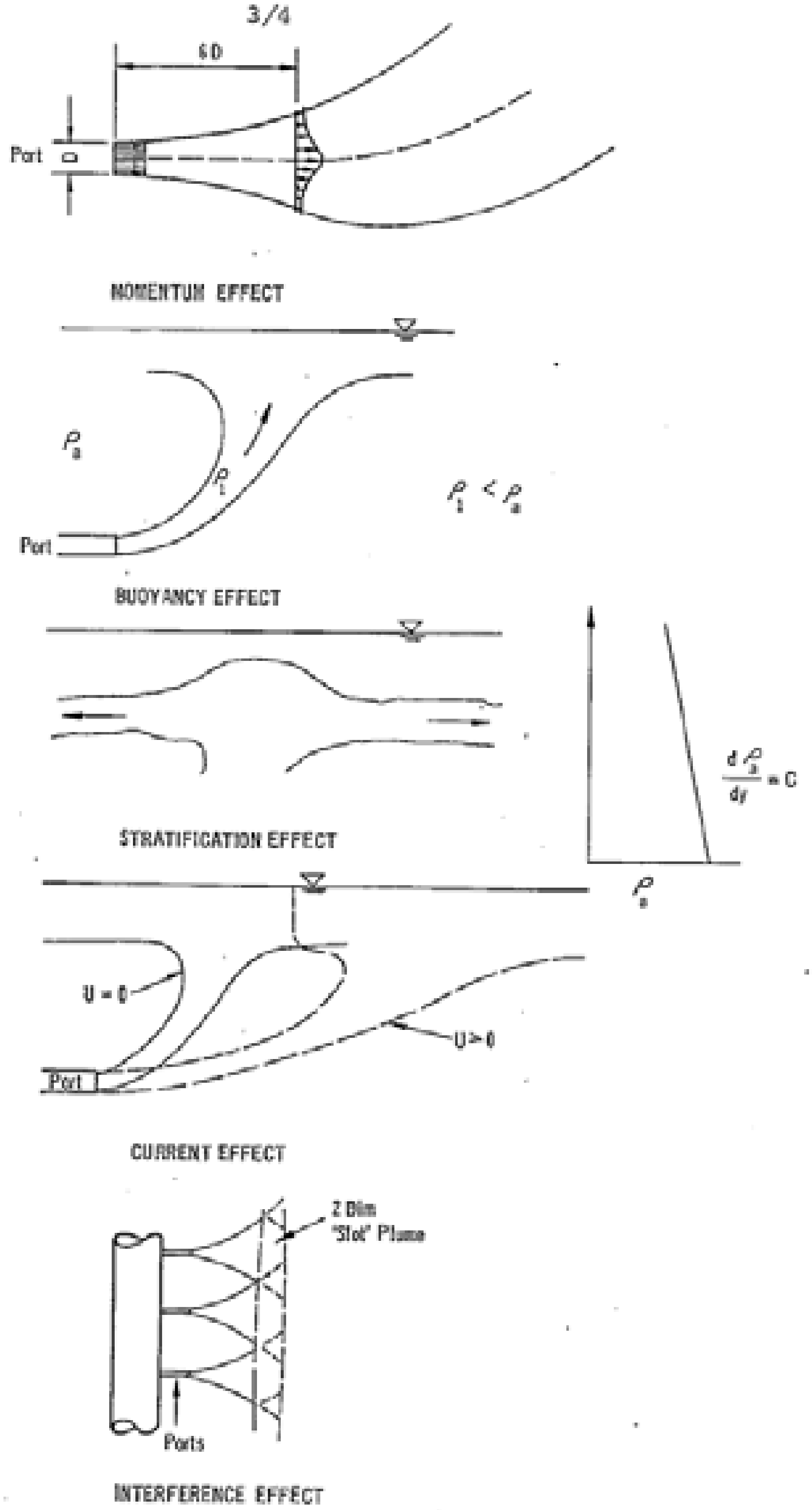

Figure A
Influences on
Turbulent Jet Mixing

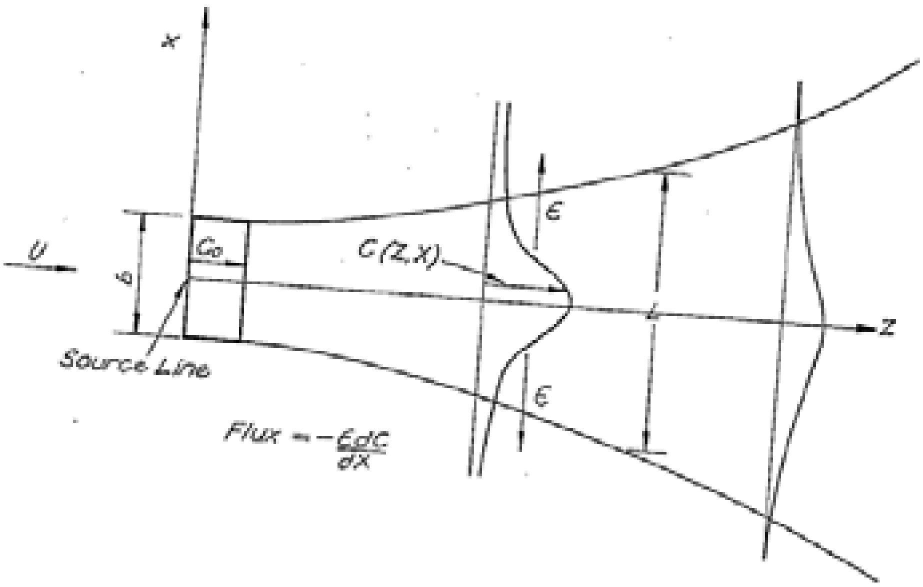

Figure B
Lateral Diffusion of an Effluent Field
Ficks Law

Diffuser Hydraulics

A multi-port diffuser is basically a problem of manifold flow. The main objectives of the hydraulic design of the multi-port diffuser are the following:

- (i) minimum variation in port discharge
- (ii) maintenance of full port flow
- (iii) minimum energy losses at discharge
- (iv) maintenance of adequate velocities in diffuser pipe

The effluent flow range and the degree of solids present in the effluent will affect the amount of consideration given to each of these objectives.

In order to maintain a reasonable diffuser velocity, it may be necessary to reduce the diffuser pipe diameter in stages towards the outer end of the diffuser. The number of reductions and their degree will be dependent on the order of flow magnitude and the range of flows. The exact format necessary to achieve the four objectives set out earlier will require a certain amount of trial and error. A number of general rules can be applied to the hydraulic design to assist in the selection of an optimum configuration. These rules, which are set out below, are based on past experimentation and observation of actual diffusers.

Design Rules

(i) $\frac{\Sigma \text{ Port Areas, a}}{\text{Diffuser area, A}} > \frac{1}{2}$: to minimise head loss and maintain adequate velocities at the lower end of the diffuser

(ii) $\frac{\Sigma \text{ Port areas, a}}{\text{Diffuser area, A}} < \frac{2}{3}$: to obtain a minimum variation in port discharges

(iii) where the diffuser is expected to operate over a large range of flows, the following are criteria for ensuring that all ports flow full at low flow:

(a) low flow $\frac{q\ max}{q\ min} < 3$

(b) average flow $\frac{q\ max}{q\ min} < 1.25$

(iv) for high rates of flow, allow deeper ports to discharge more than average port discharge.

APPENDIX 4

NSW Government
Department of Water & Energy

The Billabong Creek Salt Interception Scheme: A summary of investigations, modelling and recommended operational/monitoring parameters.

Version 6
August 2007

Authors
Chris Ribbons & Michael Williams

Acknowledgments
Richard Beecham and Ilan Salbe plus the Water Resource Management Modelling Team

Name of publication The Billabong Creek Salt Interception Scheme: A summary of investigations, modelling and recommended operation/monitoring parameters

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Contents

1. Billabong Creek and Salinity Issues

The following text outlines the salinity issues in the Billabong Creek catchment (NSW) and was taken from SIS (2004).

The Billabong Creek catchment was identified as having a high salt load in the upper catchment (Williamson et al, 1997). The Murray Darling Basin Salinity Audit MDBC (1999) also defined it as likely to have a large salt load increase over the next 50 years. The salt loads were estimated to increase the salinity at Morgan by 1.93 EC by 2010 and around 3.9 EC by 2020.

As part of the NSW State Salinity Strategy preliminary river salinity targets have been set for the creek system to the confluence of the Murray and Wakool Rivers as discussed in DLWC (2001). In light of the predicted salt load increases these targets will be difficult to attain unless intervention measures are developed. Alamgir (1999) defined a 2.4 km reach of the Billabong Creek north of Walla Walla as having a groundwater inflow of 2.47 ML/day with a stream salinity that increased from 2120 to 3130 μS/cm. The average groundwater salinity required to develop this change is 4750 μS/cm. The saline seepage at this reach is believed to be contributing to the increased salt load to a certain extent, measured at Morgan, SA.

The Billabong Creek catchment consists of granite and metasediments such as slate and volcanic rocks. There is an alluvial cover up to 100 metres thick associated with the creek system. The alluvium has been subdivided into a basal sand unit that is confined to a palaeochannel about one kilometre wide at depths greater than 55 metres (Lachlan Formation). This is overlain by a predominantly clay unit through which shoestring sands are interbedded (Cowra Formation). The shallow unit has groundwater with salinities between 400 and greater than 10,000 μS/cm while the deeper unit ranges from 400 to 1,600 μS/cm (Williams & Kulatunga, 2002).

The conceptual model for groundwater inflow at Morgan's Lookout on Billabong Creek builds on the previous regional hydrogeology and occurrence of saline groundwater by Alamgir (1999).

The groundwater inflow to the Billabong Creek is primarily caused by the constriction of the Cowra Formation at Morgan's Lookout. The secondary influence is the more permeable sand units deposited in the Cowra Formation that allow preferential upward leakage from the Lachlan Formation. The upward leakage is enhanced by the narrowing down of the palaeochannel of the Lachlan Formation from east to west.

Murray Darling Basin Commission funded a study to examine the feasibility for a salt interception scheme at Morgan's Lookout under the MDBC salinity strategy. A detailed study commenced with field investigations to test the above saline inflow hypothesis which included re-interpretation of existing information, installation of stream gauges, fully penetrating multi-level piezometer nests and a production bore. Regular monitoring of surface water, groundwater and sub-surface geophysical characteristics have been a major part of ongoing field investigations. Initially a seven-day constant discharge test was carried out on the production bore to gather more accurate data on aquifer geometry and aquifer parameters to develop a groundwater flow model. This was followed up by a six-month constant discharge test in 2003 (April to October) to assess aquifer responses to groundwater pumping as well as to assess the groundwater seepage to the creek from the shallow aquifer.

2. Summary of Investigations into Groundwater System and Pumping Trials

Surface and groundwater investigations have shown that a significant salt load is generated from groundwater sources within the Billabong Creek catchment. The preliminary investigations were conducted by the installation and monitoring of 11 shallow and 5 deep nested piezometers and 2 stream gauges. Locations of initial shallow piezometers, nested piezometers and the production bore are shown in Figure 2.1 (Williams & Kulatunga et al, 2002).

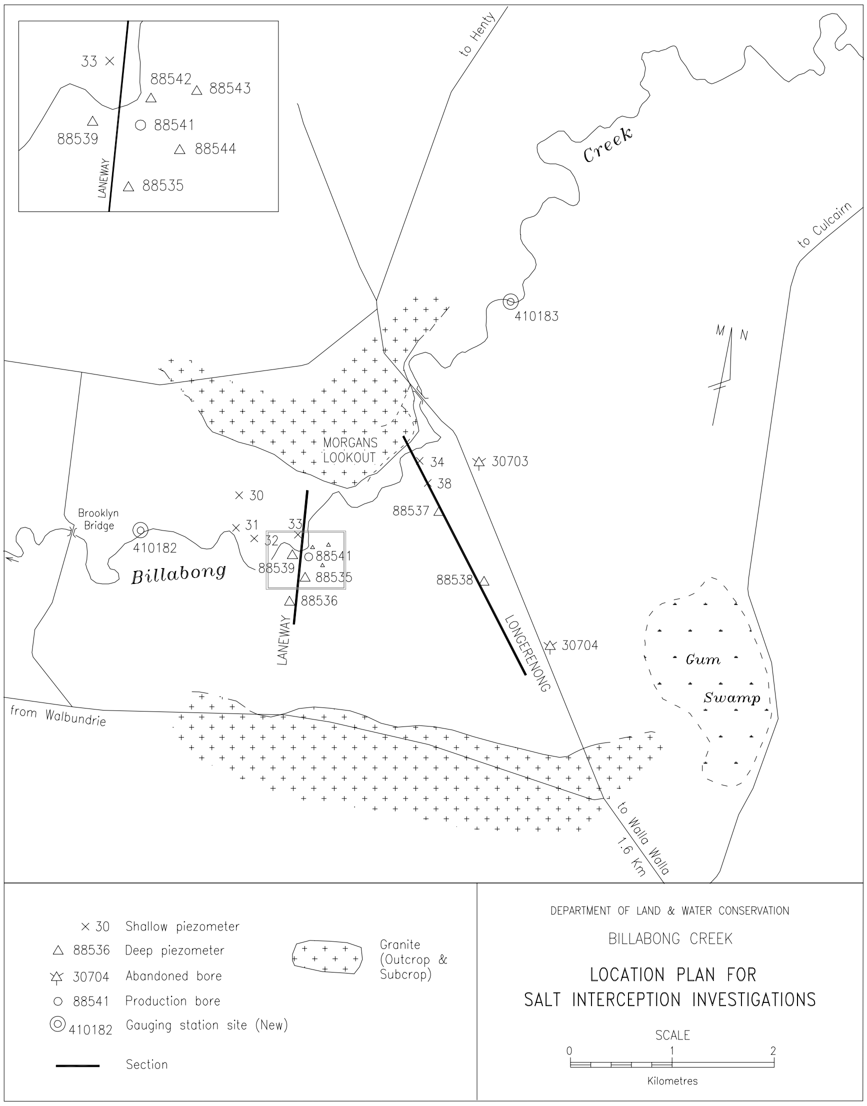

Figure 2.1 Location of Piezometer network for proposed Salt Interception Scheme

The investigation and groundwater pumping trials indicated that:

- There are two aquifer systems: the shallow aquifer (Cowra Formation) consists of thin shoestring sands interbedded with clay and has a thickness up to about 60 metres and clayey sands and clay that overlie a basal aquifer (Lachlan Formation) which is up to 35 metres thick. Total alluvial thickness is generally less than 90m. The basement is granite that is effectively impermeable.
- At Morgans Lookout the two-aquifer systems appear to be in reasonable hydraulic connection.
- The Cowra Formation provides only small bore yield generally less than 2 L/sec. The deeper Lachlan Formation is highly permeable with yields of up to 80 L /sec available to suitably constructed bores.
- Immediately south of Morgan's Lookout is a constriction of the alluvial width from 5 km to less than 1.6 km. The constriction causes groundwater in the shallow zone to be forced into Billabong Creek with a complementary upward driving head from the basal Lachlan Formation aquifer.
- The Cowra Formation has salinity that ranges from 400 to 10,000 uS/cm. An average groundwater salinity of 4,750 μS/cm for this aquifer was derived to allow for the observed salinity increase in stream flow. The Lachlan Formation has salinity up to 1,200 μS/cm although the salinity in the permeable zones is generally about 400 μS/cm. Due to the connection between the aquifers and Billabong Creek, pumping from the Lachlan Formation causes lower water heads which induces downward leakage from the overlying saline Cowra Formation. This causes the saline groundwater flow to the Creek to cease in this reach.

A 6 month trial pumping test using a single production bore at an average rate of 4.06 ML/day was carried out between April and October 2003. The test showed that the salinity of the discharge water (from pumping) increased from 680 uS/cm to 800 uS/cm and indicated a plateau at that level. On cessation of pumping the salinity of the discharge water declined to 680 uS/cm within 4 weeks.

Monitoring during the pumping tests and to the present has demonstrated that the increase in salinity is only a local effect in the vicinity of the production bore. There is a very large store of low salinity groundwater available to dilute the minute addition of salt due to interception pumping. Salinity impact of discharge in pumped water is significantly less than the salinity impact of the groundwater seepage.

During the trial pumping tests the salinity levels in Billabong Creek were monitored at stream gauging station upstream and downstream of the pump site.

Figure **2.2** shows the observed salinity levels on the creek before and during the pump trial. As can be seen the salinity levels at Hillview (410182) (downstream) are generally higher than salinity levels at Parkside (410183) (upstream) up until April 2003 when the pump test started. After that date salinity levels upstream and downstream are about the same.

The pump was again operated between November 2006 and May 2007 discharging 4.3 ML/day into Billabong Creek with salinity levels ranging from 700 to 800 uS/cm. On cessation of pumping the groundwater system quickly recovered with the salinity falling to 590 uS/cm. Unfortunately data problems occurred during the test with the upstream stream gauge not recording salinity and the downstream gauge having several unexplained ‘spikes’ in the flow recorded from December 2006 to February 2007. However the salinity of the downstream gauge was clearly suppressed to about 2000 uS/cm during the test from the 4000 and 6000 uS/cm before and after the test respectively. However as the salinity of the flow above the interception reach is unknown the relative impact of interception of the saline groundwater and dilution by pumped groundwater is unclear.

Town water supply bores for Culcairn and Holbrook townships tap aquifers of similar configuration and quality to this site. They have pumped from the same aquifer for the last 25 – 30 years and experienced similar groundwater salinity cycling. They have not shown any long term increase in salinity.

In addition for the NSW Water Sharing Plan process the sustainable yield for this aquifer system was developed on the basis of the low salinity groundwater not changing beneficial use class.

The aquifer parameter information derived from the pump test was used in a two layer groundwater model to predict the long term impact of pumping. Results indicated that pumping from a single production bore at 5 ML /day has the potential to stop water table leakage into Billabong Creek. Modelling also supports the prediction that a second production bore about 1400 metres to the east of the existing bore would improve interception design. This configuration would allow control of discharge to a longer stream reach for a similar pumping rate as the single bore, while reducing the potential for over pumping to induce stream water movement into the aquifer.

Due to variations in the vertical connectivity between the aquifer, the long term pumping rate required to control the saline groundwater inflow to Billabong Creek is uncertain. However on the basis of the pumping test end numbers and modelling it is likely to be between 4 and 5 ML /day regardless whether 1 or 2 production bores are employed.

Because higher stream stages naturally suppress the saline groundwater inflow pumping should only occur when Billabong Creek flow is less than 320 ML/day. This is about 80% of the time, 300 days/year based on historic stream flows records from Walbundrie. It is further recommended that operating conditions be set for pumped water salinities up to a maximum of 930 μS/cm.

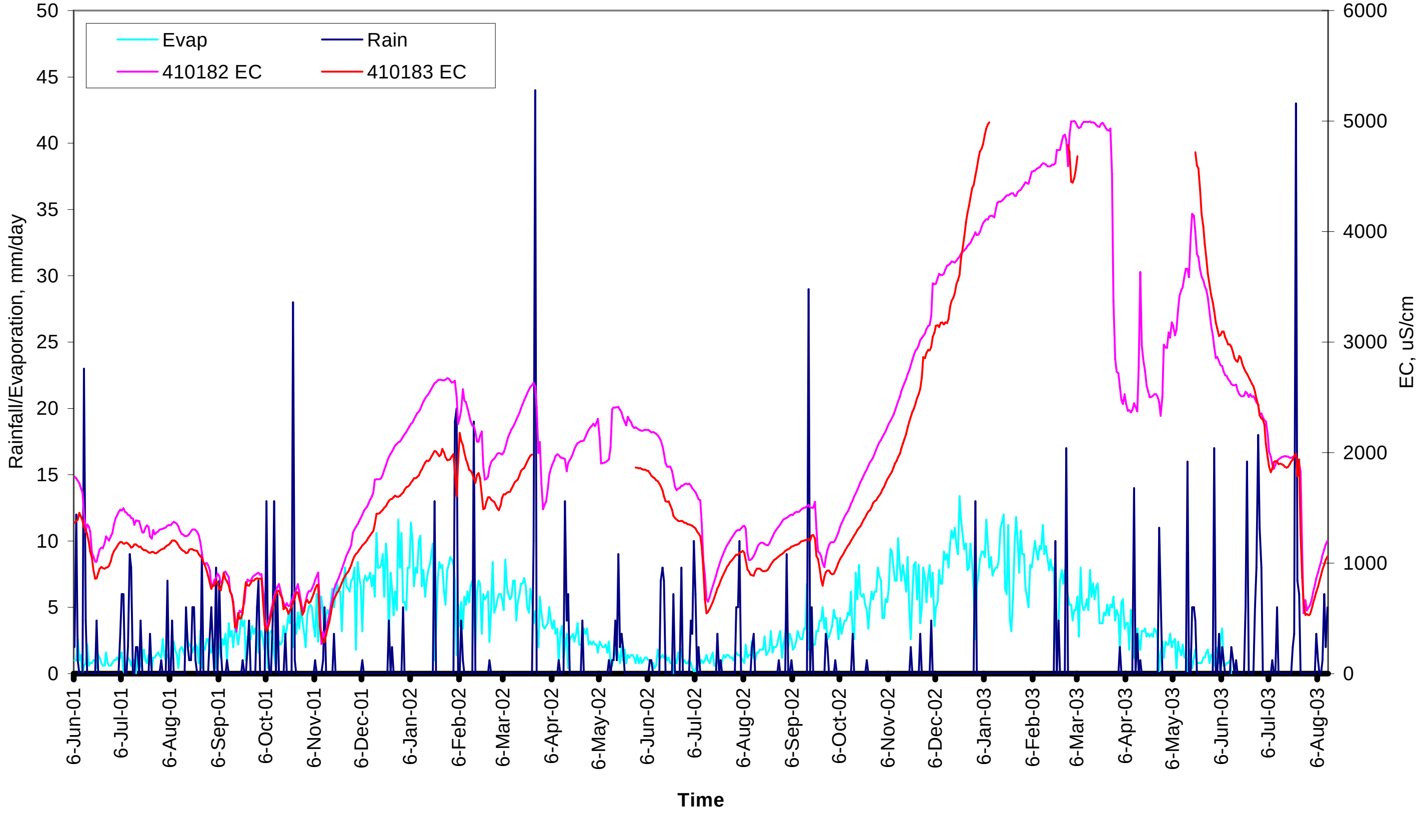

Figure 2.2 Salinity, rain and evaporation data at BCSIS– 2001 to 2003

3. Summary of Surface Water and Salinity Modelling

In order to assess the potential impact of a Billabong Creek Salt Interception Scheme on Billabong Creek salinity levels and the salinity levels in the Murray River at Morgan, two salt interception pumping options were assessed using the calibrated Murrumbidgee Salinity Integrated Quality Quantity Model (IQQM). The Murrumbidgee IQQM has been accredited by the MDBC for assessment of Basin Salinity Management Strategy.

The Billabong Creek sub-catchment of the Murrumbidgee Valley is presented in Figure **3.**. The parameters used for the simulation of the salt interception scheme options were based on the results from the pumping tests and groundwater modelling outlined above in Section 2. The salt interception operational strategies assessed in the Murrumbidgee Salinity IQQM were:

Scenario 1 – Pump from Lachlan Formation, stop Cowra Formation recharge of Billabong Creek with none of the pumped water returning to Billabong Creek.

For flows less than 320 ML in the Billabong Creek at Walbundrie intercepted groundwater is pumped away from Billabong Creek reducing flow in the creek by 4 ML/day and salt load by 12 tonnes per day (5000 μS/cm) entering from the groundwater.

Scenario 2 – Pump from Lachlan Formation, stop Cowra Formation recharge of Billabong Creek and return pumped water to Billabong Creek at reduced salinity.

For flows less than 320 ML in the Billabong Creek at Walbundrie, all intercepted groundwater returned to the creek at reduced salinity (4 ML/day at 700 μS/cm) thus reducing salt load by about 10.3 tonnes per day.

Three different hydrologic models were linked to evaluate these two scenarios. The aim of the modelling was to determine reductions in salinity at the Wakool/Murray Junction and Morgan as a result of changed flow and salinity conditions caused by the scenario "actions". The three models were:

- A simple Billabong Creek IQQM to route flows and salinity impacts (from the operation of this trial SIS scheme on the Billabong Creek), between Walbundrie and the Billabong Creek's confluence with the regulated Colombo Creek
- Murrumbidgee IQQM that routed flow and salt loads from the Colombo Creek – Billabong Creek junction to Darlot (Figure 3.2 shows the two combined IQQM models).
- The contributing flow and salinity at Darlot (from Murrumbidgee IQQM) was then input into the Murray Darling Basin Commission (MDBC) daily model BIGMOD to determine EC & load changes at Murray Catchment Blueprint End-of-Valley Target site (EOV) at Wakool Junction and finally at Morgan.

These models were run for the MDBC Basin Salinity Management Strategy standard benchmark period of May 1975 to April 2000. The baseline run represents the conditions that existed in 2000 in terms of operating rules, procedures, level of development and management practices. The use of this benchmark period is the standard assessment method used in the Basin for assessment of all salinity proposals.

The model results shows a small reduction in average EC under both scenarios as compared to baseline run as shown in Table 3.1 below.

Table 3.1 Change in Salinity at Target Sites

	Baseline Salinity EC	Change in salinity (EC)	
		Scenario 1- Baseline	Scenario 2- Baseline
MDBC Model run number	5878000	5878001	5878002
Average Morgan Salinity	578.08	-0.06	-0.14
Average Wakool Junction Salinity	282.41	-0.13	-0.20

Scenario 2 (the return of the pumped groundwater to Billabong Creek) resulted in the greatest modelled salinity reduction benefits at Morgan and Wakool Junction.

Considering the accuracy of the modelling process it would be reasonable to say that the operation of the salt interception scheme at Billabong Creek would reduce EC levels at the EOV site at Wakool Junction by around 0.1 to 0.2 EC and at Morgan by about 0.1 EC.

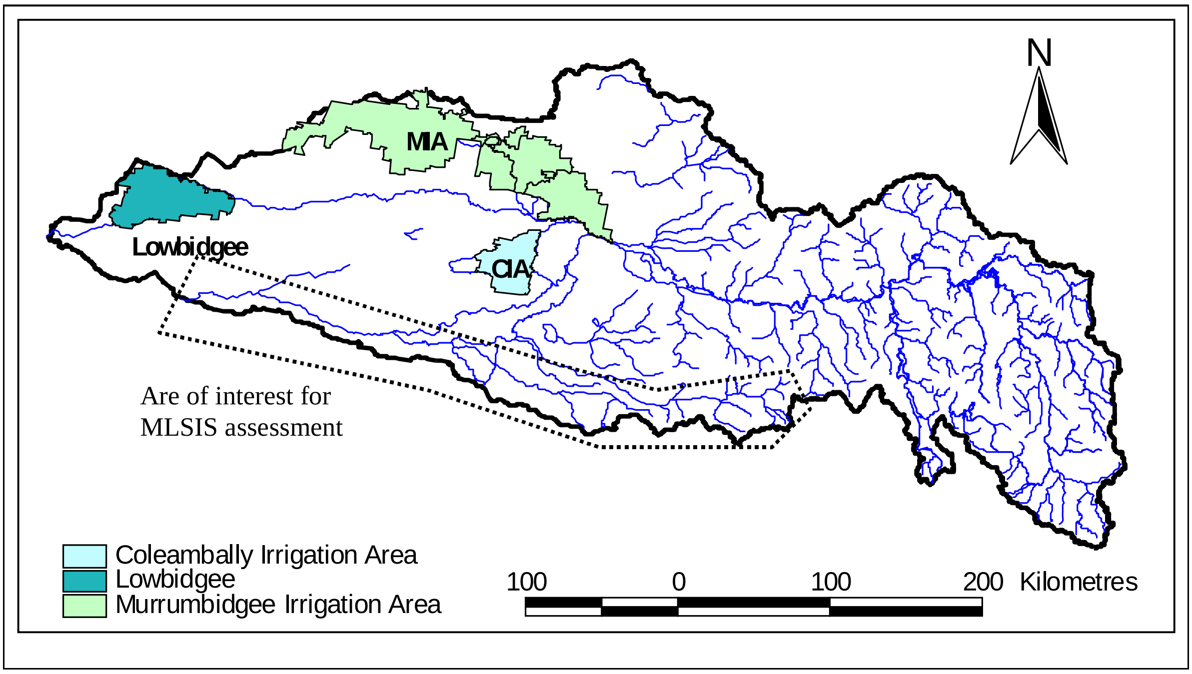

Figure 3.1. Area of interest for BCSIS in Murrumbidgee catchment

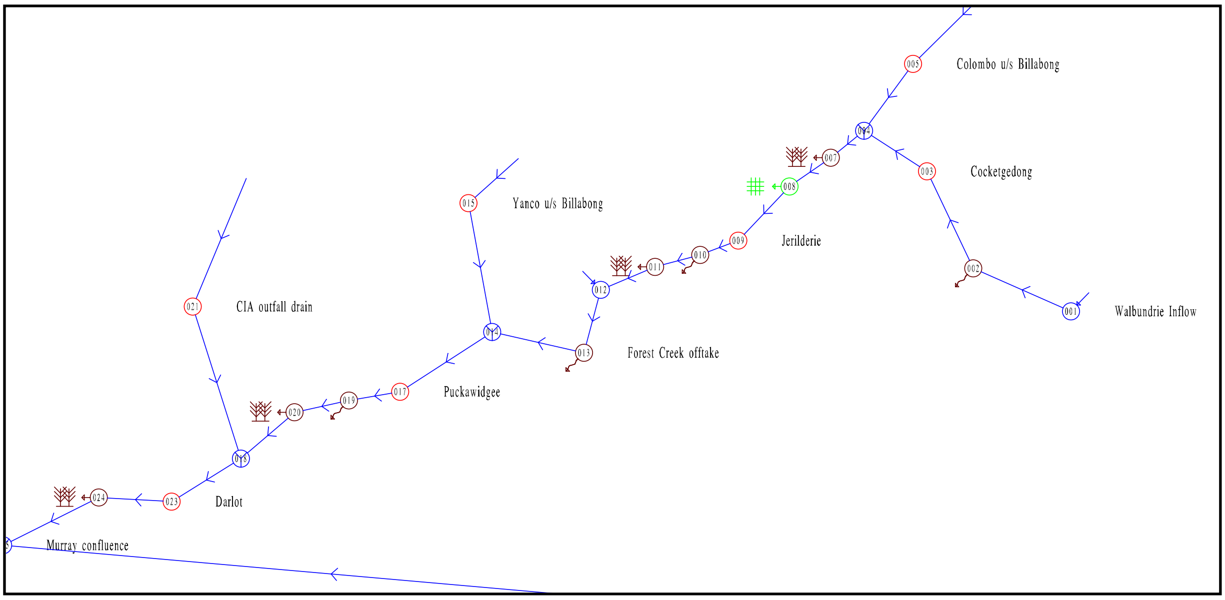

Figure 3.2. Schematic for BCSIS salinity modelling in Murrumbidgee catchment

4. Recommended operational parameters and monitoring

An operational and monitoring program should be put in place to efficiently operate the scheme, monitor the operation of the scheme and report on performance. There are a number of components to the Billabong Creek Salt Interception Scheme including:

- Gauging stations to monitor salinity and stream flow
- Creek flow information (ML/day)
- Quality and quantity of water pumped into creek
- Groundwater depths as measured by the monitoring bores
- Pump hours run
- A lot of this information can be logged and telemetered.

Operation and Monitoring of the Scheme

As outlined in Section 2 and 3, when operated on the basis of a single production bore pumping 4 to 5 ML/day and a flow measured at the Walbundrie stream gauge of less than 320 ML/day, the scheme can be successful in preventing the intrusion of saline groundwater into the Billabong Creek. It is recommended that operating conditions be set for pumped water salinities up to a maximum of 930 µS/cm. Based on historic stream flow records from Walbundrie the pump would operate about 80% of the time or 300 days/year on average. On the basis of the suggested design the following operation and license monitoring is recommended.

The monitoring program has been developed to demonstrate the effectiveness of the salt interception scheme.

Measuring In stream Salinity

Stream gauges that straddle the SIS interception reach could be used to measure whether there is a change in the salt inflow over this reach. Given the water travel times this could be monitored continuously and reported daily.

Stream gauging stations Parkside (410183) and Hillview (410182) developed for the investigation could be used for this purpose. The stream conductivity only should used as there are no suitable controls from which to derive an accurate flow. For salt load estimates the flow at Walbundrie (410091) should be used.

Given instrumentation sensitivity it is not clear if any change in stream conductivity can be estimated under operational conditions.

Measuring Groundwater Levels

In other SIS schemes the groundwater levels in key observation bores have been set as a surrogate for stream conductivity measurement. This is on the basis that if the water table is at the same level as the stream no flow groundwater will flow into the river. Groundwater levels should be monitored continuously and reported weekly.

Comparison of data with Long Term Records.

There appears to be sufficient historical stream flow and conductivity data at Walbundrie to compare the impact of the operation SIS against. This assumes that the system is at steady state and that no changes occur between the SIS site and the Walbundrie gauge.

Annual Review and Reporting

Reporting should be on an annual basis using the daily and monthly data collected as outlined in the below tables. The reporting should cover the following general detail:

- Flow and salinity characteristics of the stream at the site
- Volumes, salinity and timing of the water being pumped
- Quantity (tonnes) of salt being intercepted by the scheme
- Performance of the groundwater system

Operational Monitoring

It is assumed that the SIS would be telemetered so that the production bore pump could be stopped and started remotely. The infrastructure required would allow the monitoring to be gathered on a real time basis. On the basis of existing SIS schemes the monitoring regime should be as tabled below.

Table 4.1 Recommended Monitoring Program

Item	Production Bore Sites Information to be monitored and reported on	Site Visits Frequency	Comments
1	Pump hours run	Monthly	This information is provided by SCADA as well
2	Pump down time	Monthly	This information is provided by SCADA as well
3	Power consumption	Monthly	Manually read monthly
4	Supply Voltage and Amps	Monthly	Manually read monthly
5	Pump Frequency	Monthly	This information is provided by SCADA as well
6	Motor Amps	Monthly	Manually read monthly
7	Standing Water level	Monthly	This information is provided by SCADA as well
8	Discharge from pump	Monthly	This information is provided by SCADA as well
9	Mains pressure at bore site	Monthly	This information is provided by SCADA as well
10	Salt load pumped	Monthly	Manual Calculation
11	Pumped Water Conductivity	Monthly	Manual sampling
Item	**Monitoring Bores Information to be monitored and reported on**	**Site Visits Frequency**	**Comments**
1	Standing Water Level	Monthly	Continuous. This information is provided by SCADA as well
2	Groundwater Conductivity	Monthly	Manual sampling
Item	**Stream Gauges (410182 & 410183) Information to be monitored and reported on**	**Site Visits Frequency**	**Comments**
1	Water Level	Monthly	Continuous. This information is provided by SCADA as well
2	Water Conductivity	Monthly	Continuous. This information is provided by SCADA as well
3	Walbundrie (410091)	No operational change	SCADA already

5. References

Alamgir M (1999) – Scoping study on the saline groundwater inflows into Billabong Creek. Resource Assessment and Planning. Murray Region DLWC.

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SIS Report No 4 (August 2004) - unpublished

APPENDIX 5

Background and summary of Murray River salinity modelling for a potential Norske Skog Albury Mill 'salinity offset' project.

V4 – 18/04/07

Report compiled by DNR and Norske Skog

Background

Norske Skog operates a newsprint manufacturing facility at Albury, NSW. As part of the conditions of consent associated with a recent upgrade of the site, Norske Skog is required (amongst other things) to investigate and report on “the feasibility of a salinity offset scheme, in which effluent might be returned to the Murray River, and various salt extraction or mitigation measures [be] employed elsewhere in the catchment”.

Norske Skog has explored the possibility of a ‘salinity offset’ with the NSW Department of Environment and Conservation (Environment Protection Authority) (DEC) and NSW Department of Natural Resources (DNR). The objective of a salinity offset is to achieve a net environmental benefit by removing a greater quantity of salt from the catchment than the quantity introduced. The applicability of the concept to the Albury Mill is related to the offsetting of potential salt loads in treated effluent discharged to the Murray River through the removal of salt loads via a salt interception scheme (or schemes) elsewhere in the catchment.

A water and salt balance model of the mill site was developed to understand the potential salinity impacts of different effluent discharge scenarios. A series of effluent management scenarios, (including some not currently possible), were modelled to establish the impact ‘space’. The modelled outputs can then be used to assist with the options evaluation, design and establishment of performance criteria for any salinity offset proposal.

Method

Norske Skog Water balance model

A spreadsheet water and salt balance model was jointly developed between Norske Skog and DNR. The model was designed to produce a time series of daily flows and salt loads discharged to the Murray River for the MDBMC Basin Salinity Management Strategy (BSMS) benchmark modelling period (1/5/1975-30/4/2000). The model is shown schematically in Figure 1.

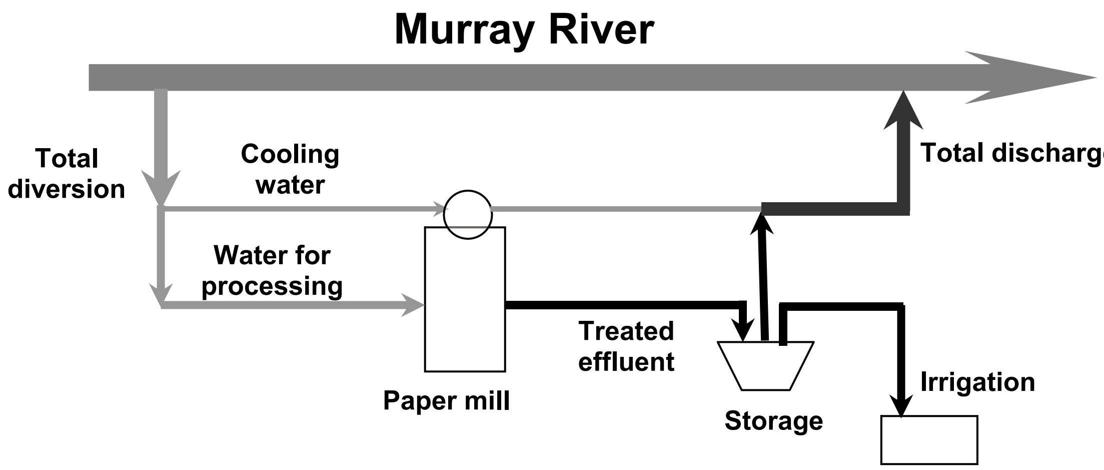

Figure 3. Water and salt balance model for Norske Skog paper mill effluent

The total volume diverted from the Murray River (DivTot ML/d) is estimated as having a salinity of 50 mg/L, corresponding with mean salinity estimates of the water in Hume Dam. A fixed volume of 5 ML/d is used for cooling water, and its quantity and quality is unchanged by its usage.

The rest of the water diverted (DivTot -5 ML/d) is used for processing in the paper mill. The volume of this water is unchanged in the waste-stream, but after usage and treatment, the salinity increases to 2000 mg/L (conservatively high). This treated effluent is stored, and is either used for irrigation, or combined with the cooling water and discharged into the Murray River.

A volume of 12 ML/d is applied as irrigation to plantation and pasture between 1 October and 30 April, if there had been not more than 10 mm of rainfall in total in the previous 3 days. Water is discharged to the Murray River based on in-stream dilution constraints, or by a pipeline discharge capacity. This volume with salinity 2000 mg/L then combines with the 5 ML/d cooling water at 50 mg/L, and flows into the Murray River.

Time series data for the Benchmark Climate Period (1/5/1975-30/4/2000) for flow upstream of the paper mill (Murray River @ Doctors Point) and rainfall at Albury was used as inputs to a daily time step spreadsheet model of the water and salt balance.

Water and salt balances were then calculated for a total of fifteen possible scenarios, with each scenario combinations of:

1. in-river dilution ratio (nil, 1:600, 1:1000, 1:1500)
2. maximum effluent discharge (4 ML/d, 8 ML/d, 12 ML/d, unconstrained)
3. maximum discharge to Murray River (10 ML/d, unconstrained).

These are summarised in Table 1.

Table 1. Summary of parameters for modelled scenarios

Scenario No.	River water extraction rate (ML/d)	In-river dilution ratio (1:X)	Maximum effluent discharge (ML/d)	Maximum pipeline discharge (ML/d)
1	14	No constraint	4	10
2	14	No constraint	8	10
3	14	No constraint	9	10
3a	17	No constraint	12	10
4	14	600	4	10
5	14	600	8	10
6	14	600	9	10
6a	17	600	12	10
7	14	1000	4	10
8	14	1000	8	10
9	14	1000	9	10
9a	17	1000	12	10
10	22	600	No constraint	No constraint
11	20	1000	No constraint	No constraint
12	18	1500	No constraint	No constraint

The spreadsheet salt balance model was run with these parameters and summary statistics calculated. For each of the fifteen scenarios, the calculated time series of Total Discharge to the Murray River (Figure 1) salinity was saved to a spreadsheet, and forwarded to MDBC. These were then used as inputs to MSM-BigMod, the MDBC water and salt balance model, to calculate EC impacts according to the BSMS Protocols.

Results

Summary results of mean daily total discharge, salinity, and salt load are presented in Table 2.

Table 2. Summary of spreadsheet results

Scenario No.	Mean daily irrigation (ML/d)	Mean treated effluent discharge (ML/d)	Mean daily salinity (mg/L)	Mean daily salt load (t/d)
1	5.0	4.0	917	8
2	1.0	8.0	1,250	16
3	0.0	9.0	1,304	18
3a	0.0	12.0	1,426	24
4	5.1	3.9	897	8
5	1.9	7.1	1,165	14
6	0.6	8.4	1,228	17
6a	2.1	9.9	1,288	20
7	5.3	3.7	858	7
8	2.5	6.5	1,094	13
9	1.2	7.8	1,156	16
9a	3.1	8.9	1,203	18
10	1.64	15.3	1,402	24
11	2.75	12.2	1,278	20
12	3.74	9.7	1,147	18

The full output from the MSM-BigMod modelling is presented in Appendix 1. The EC impacts are summarised in Table 3.

Table 3. Summary EC impacts

Scenario No.	Change in mean EC at Morgan (µS/cm)	Economic EC effect
1	-0.01	-0.35
2	-0.24	-1.07
3	-0.31	-1.36
3a	-0.60	-2.09
4	0.01	-0.28
5	-0.17	-0.79
6	-0.24	-1.02
6a	-0.41	-1.36
7	0.03	-0.21
8	-0.11	-0.64
9	-0.19	-0.86
9a	-0.33	-1.14
10	-0.87	-2.57
11	-0.61	-1.86
12	-0.37	-1.23

The relationship between mean daily discharge and EC impacts is presented in Figure 2 and the corresponding relationship between mean daily salt load and EC impacts is presented in Figure 3. These figures show the impact at Morgan reduces with increasing rates of in-stream dilution. The predicted EC impact at Morgan of small discharge volumes (eg the 4 ML/day scenarios) is negligible (either positive or negative) due to the relatively small loads and flows involved.

The in-stream dilution constraint also influences the volume of treated effluent that can be discharged. During the winter, flow in the river falls below the volume needed for in-stream dilution, eg. for maximum effluent discharge of 4 ML/day @ 1:1000 dilution, the river flows need to exceed 4000 ML/day. For river flows below this, less than the maximum 4 ML/d can be discharged. This impact can be seen when comparing Scenario 1, 4, and 7; the mean daily discharge decreases as the dilution constraint increases.

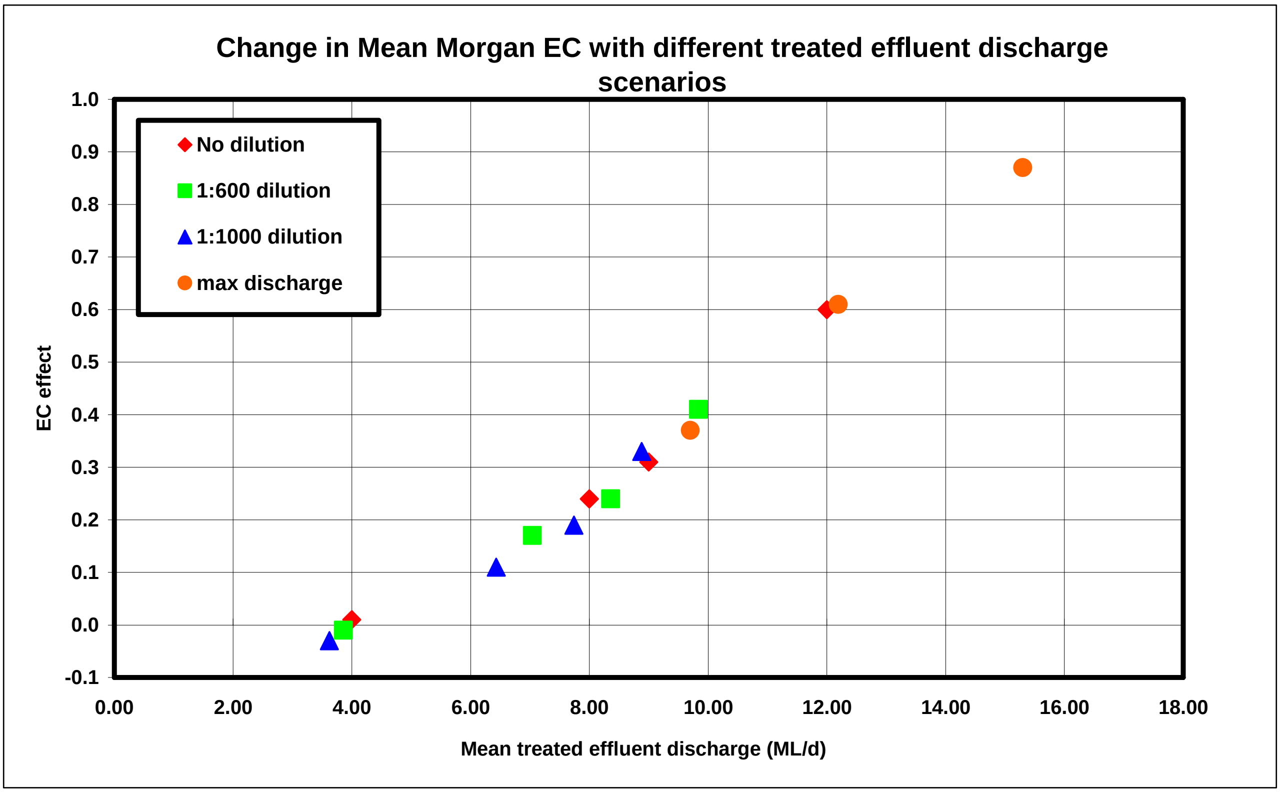

Figure 2. Modelled EC impact at Morgan for different treated effluent discharge scenarios.

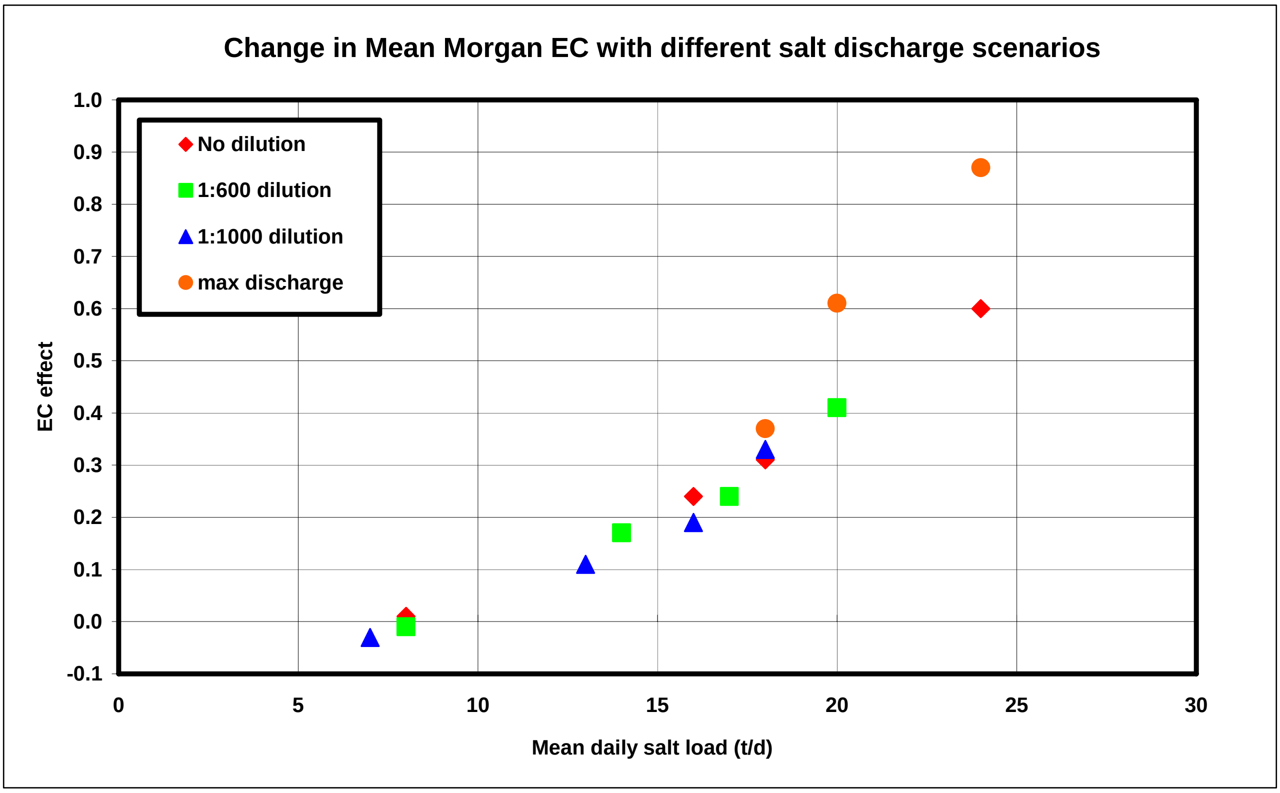

Figure 3. Modelled EC impact at Morgan for different treated effluent discharge scenarios.

Conclusions

The modelling approach undertaken by Norske Skog and DNR overlays a series of constraints (in-stream dilution, mill effluent flow, discharge pipeline capacity) to estimate the volume of treated effluent which could be discharged to the Murray River, with a corresponding salt load. These volumes are then used by the MDBC models to estimate the in-stream salinity impact.

The modelled scenarios provide guidance on the predicted EC impact of potential treated effluent discharges at numerous locations on the Murray River including the Morgan reference point. In this respect the modelling process provides useful information for the development of a 'salinity offset' project.

One weakness of the modelling process undertaken is that it assumes effluent discharge occurs every day of the year (subject to various constraints). It may be possible to discharge greater volumes of treated effluent on a daily basis during periods of high river flow (summer irrigation flow or flood conditions) and achieve superior in-river dilution rates and reduced impacts at Morgan.

APPENDIX 1

Albury Paper Mill salt inflow assessment
Model Run Request

Request

On 31 October 2005, Richard Beecham, NSW DNR, supplied input data files for Albury Paper Mill, Scenarios 1 to 12, and requested the Murray-Darling Basin Commission to assess their salinity impacts in the River Murray. On the 18 November 2005 another three scenarios were sent and assessed.

The following table shows the average flows, salinities and salt loads of the data sent.

Scenario	Diversion			Discharge			
	Diversion (ML/d)	Average salinity (mg/L)	Average salinity (EC)	Average discharge (ML/day)	Average salinity (mg/L)	Average salinity (EC)	Salt load (t/d)
1	14	50	83	9	917	1528	8
2	14	50	83	13	1250	2083	16
3	14	50	83	14	1304	2173	18
4	14	50	83	8.86	897	1495	8
5	14	50	83	12.04	1165	1941	14
6	14	50	83	13.36	1228	2046	17
7	14	50	83	8.62	858	1430	7
8	14	50	83	11.43	1094	1823	13
9	14	50	83	12.74	1156	1926	16
10	22	50	83	20.3	1402	2337	31
11	20	50	83	17.19	1277	2129	25
12	18	50	83	14.17	1147	1912	19
3a	17	50	83	17	1426	2377	24
6a	17	50	83	14.84	1288	2147	20
9a	17	50	83	13.9	1203	2004	18

Method

Modelling Paper Mill salinity impacts:

- Run no. 7358 000 – base run
- Run no. 7307 000 – Scenario 1
- Run no. 7314 000 – Scenario 2
- Run no. 7319 000 – Scenario 3
- Run no. 7320 000 – Scenario 4
- Run no. 7329 000 – Scenario 5
- Run no. 7331 000 – Scenario 6
- Run no. 7333 000 – Scenario 7
- Run no. 7334 000 – Scenario 8
- Run no. 7336 000 – Scenario 9
- Run no. 7338 000 – Scenario 10
- Run no. 7340 000 – Scenario 11
- Run no. 7342 000 – Scenario 12
- Run no. 7342 000 – Scenario 3a
- Run no. 7342 000 – Scenario 6a
- Run no. 7342 000 – Scenario 9a

Used flow and salt loads time series received 0from NSW for 1975-2000 and added this data to Biginflow5 and Bigsalinity1 files.

Salinity Impacts

- The results are shown in Attachments 1 (Scenarios 1 to 12) and 2 (Scenarios 3a to 9a). All model runs, Scenarios 1 to 12 and 3a to 9a, were compared with model run 7358000 the baseline run.
- The discharge value used for Albury paper mill baseline run is 14 ML/d with a salinity of 309 EC and diversion figure is 14 ML/d.
- The equivalent EC effect is shown on both attachments and for each scenario.

File Created by Cris Diaconu
On 18/11/200

Attachment 1: Model runs summary for Albury Paper Mill – Scenarios 1 to 12

	7358000	7307000	7314000	7319000	7320000	7329000	7331000	7333000	7334000	7336000	7338000	7340000	7342000
TITLE	Base run for Albury Paper Mill assessment	Run for Albury Paper Mill - Scenario 1	Run for Albury Paper Mill - Scenario 2	Run for Albury Paper Mill - Scenario 3	Run for Albury Paper Mill - Scenario 4	Run for Albury Paper Mill - Scenario 5	Run for Albury Paper Mill - Scenario 6	Run for Albury Paper Mill - Scenario 7	Run for Albury Paper Mill - Scenario 8	Run for Albury Paper Mill - Scenario 9	Run for Albury Paper Mill - Scenario 10	Run for Albury Paper Mill - Scenario 11	Run for Albury Paper Mill - Scenario 12
RUN BY	BSMSANM-1	BSMSANM-2	BSMSANM-3	BSMSANM-4	BSMSANM-5	BSMSANM-6	BSMSANM-7	BSMSANM-8	BSMSANM-9	BSMSANM-10	BSMSANM-11	BSMSANM-12	BSMSANM-13
DATE	16/11/05	9/11/05	9/11/05	9/11/05	9/11/05	9/11/05	9/11/05	9/11/05	9/11/05	9/11/05	9/11/05	9/11/05	9/11/05
Average Morgan Salinity	581.94	0.01	0.24	0.31	-0.01	0.17	0.24	-0.03	0.11	0.19	0.87	0.61	0.37
Morgan 95%ile Salinity	90	-4	-4	-4	-4	-4	-4	-4	-4	-4	-3	-3	-4

	2												
Mean Annual Flow (GL/year)													
Euston	6786.1	-1.6	-0.3	0.0	-1.7	-0.7	-0.2	-1.8	-0.8	-0.4	-0.6	-0.9	-1.2
Flow to South Australia	6986.6	-0.8	0.4	0.7	-0.9	0.1	0.5	-1.0	-0.1	0.3	0.1	-0.2	-0.5
Barrages	5227.6	-0.8	0.4	0.7	-0.9	0.1	0.4	-1.0	-0.1	0.3	0.1	-0.2	-0.5
Average Salinities (EC)													
Yarrawonga	62.96	0.71	1.67	1.91	0.67	1.35	1.59	0.59	1.14	1.37	2.82	2.06	1.44
Torrumbarry	124.42	0.55	1.20	1.37	0.52	1.02	1.20	0.48	0.91	1.08	2.24	1.69	1.22
Swan Hill	287.99	0.56	1.07	1.19	0.54	0.94	1.08	0.51	0.86	0.99	2.07	1.61	1.20
Stevens Weir	106.93	0.63	1.42	1.62	0.60	1.20	1.42	0.54	1.06	1.27	2.63	2.00	1.43
Kyalite	307.47	0.45	0.88	0.99	0.43	0.75	0.88	0.40	0.68	0.81	1.68	1.33	1.00
Wakool Junction	292.40	0.54	1.02	1.14	0.52	0.89	1.03	0.48	0.81	0.95	1.96	1.54	1.15
Red Cliffs	319.41	0.78	1.17	1.27	0.77	1.08	1.19	0.74	1.02	1.14	2.02	1.66	1.31
Merbein	342.26	1.26	1.64	1.73	1.25	1.55	1.66	1.23	1.49	1.60	2.49	2.12	1.78
Lock 9	366.78	-0.10	0.03	0.25	0.01	0.00	0.08	-0.01	-0.06	0.03	0.69	0.44	0.19
Renmark	415.89	-0.08	0.14	0.23	-0.10	0.05	0.13	-0.12	-0.01	0.07	0.71	0.45	0.22
Berri	461.46	-0.02	0.17	0.25	-0.04	0.09	0.17	-0.06	0.04	0.11	0.76	0.50	0.26
Morgan	581.94	0.01	0.24	0.31	-0.00	0.17	0.24	-0.00	0.11	0.19	0.87	0.61	0.37

					1			3					
Murray Bridge	618.20	0.00	0.24	0.34	-0.02	0.16	0.23	-0.04	0.10	0.18	0.87	0.60	0.37
Milang	724.54	-0.18	0.03	0.08	-0.19	-0.06	0.01	-0.21	-0.12	-0.06	0.60	0.38	0.18
Weir 32	402.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Burtundy	408.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Anabranch Outflow	953.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salinity Cost ($m/year)	99.28	0.036	0.111	0.140	0.029	0.081	0.105	0.022	0.065	0.088	0.265	0.192	0.127
Average diversion (ML/d)	14	14	14	14	14	14	14	14	14	14	22	20	18
Average discharge (ML/d)	14	9.0	13.0	14.0	8.9	12.0	13.4	8.6	11.4	12.7	20.3	17.2	14.2
Salt load (t/d)	2.6	8.3	16.3	18.3	8.0	14.3	17.0	7.5	13.1	15.7	30.8	24.6	18.6
Equivalent EC effect		-0.35	-1.07	-1.36	-0.28	-0.79	-1.02	-0.21	-0.64	-0.86	-2.57	-1.86	-1.23

Attachment 2: Model runs summary for Albury Paper Mill – Scenarios 3a, 6a and 9a

	7358000	7398000	7399000	7400000
TITLE	Base run for Albury Paper Mill assessment	Run for Albury Paper Mill - Scenario 3a	Run for Albury Paper Mill - Scenario 6a	Run for Albury Paper Mill - Scenario 9a
RUN BY	BSMSANM-1	BSMSANM-14	BSMSANM-15	BSMSANM-16
DATE	16/11/05	18/11/05	18/11/05	18/11/05
Average Morgan Salinity	581.94	0.60	0.41	0.33
Morgan 95%ile Salinity	902	-4	-4	-4
Mean Annual Flow (GL/year)				

Euston	6786.1	0.0	-0.7	-1.0
Flow to South Australia	6986.6	0.7	0.0	-0.3
Barrages	5227.6	0.7	0.0	-0.3
Average Salinities (EC)				
Yarrawonga	62.96	2.63	1.91	1.59
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Stevens Weir	106.93	2.24	1.74	1.51
Kyalite	307.47	1.37	1.09	0.98
Wakool Junction	292.40	1.57	1.28	1.15
Red Cliffs	319.41	1.64	1.42	1.31
Merbein	342.26	2.09	1.88	1.78
Lock 9	366.78	0.53	0.26	0.19
Renmark	415.89	0.51	0.30	0.20
Berri	461.46	0.54	0.33	0.24
Morgan	581.94	0.60	0.41	0.33
Murray Bridge	618.20	0.63	0.39	0.32
Milang	724.54	0.37	0.16	0.08
Weir 32	402.06	0.00	0.00	0.00
Burtundy	408.39	0.00	0.00	0.00
Anabranch Outflow	953.25	0.00	0.00	0.00
Salinity Cost ($m/year)	99.28	0.215	0.140	0.117
Average diversion (ML/d)	14	17	17	17
Average discharge (ML/d)	14	17.0	14.84	13.9
Salt load (t/d)	2.6	24	20	18
Equivalent EC effect		-2.09	-1.36	-1.14

Report compile

APPENDIX 6

Soil Properties and Nutrition of Radiata Pine Irrigated with Paper Mill Effluent at Albury in 2006

Peter Hopmans

Report 2007/07

June 2007

A 'commercial in confidence' report prepared by Timberlands Research Pty Ltd
for Norske Skog Paper Mills (Australia) Ltd

Timberlands Research Pty Ltd
1 Rodney Place Carlton (3053) | Victoria Australia
Tel: 9662 1554 | peterhopmans@tresearch.com.au
ABN: 73 109 531 517

Table of Contents

1. SUMMARY

Since 1995 effluent from the Norske Skog paper mill has been used to irrigate a plantation of Radiata pine (260 ha). More recently the area under irrigation has been expanded to include crops and pastures (210 ha). Annual monitoring of tree nutrition, irrigation water, and soil properties has been conducted as part of the EPA license agreement for the reuse of effluent at Ettamogah. Results for the monitoring program conducted in 2006 are summarized as follows:

Radiata Pine Plantation

- Tree health and condition has decreased as indicated by increasing numbers of trees showing a decline in crown condition including loss of foliage, yellowing of needles, and dead topping. Furthermore tree mortality has become widespread in the plantation consistent with abiotic environmental stresses rather than inadequate nutrient supply.
- The nutrient status of Radiata pine has remained satisfactory except for a decline in nitrogen to sub-optimal or marginal levels.
- Nutrient balances for nitrogen and phosphorus indicated that loads of these nutrients in effluent were significantly less than the average annual requirement of fast-growing Radiata pine over a 12 year rotation. However, nutrient demand of trees is likely to have decreased due to a decline in tree condition in recent years.
- A decline in crown condition and foliage biomass affects both nutrient uptake as well as water use by trees and therefore evapotranspiration will be much lower in the poorer sections of the plantation.

It is recommended that a systematic survey of the plantation be conducted to determine the present growth and condition of trees within each irrigation block to identify areas in poor condition and with low water use. Irrigation and harvesting schedules should be reviewed to take into account changes in plantation conditions.

Soils

Irrigation of the tree plantation commenced in 1995 and resulted in significant increases in pH, salinity, sodicity and sulphate in soil profiles. Steady state conditions were reached after 6 to 7 years of irrigation at rates of approximately 6 Ml/ha/yr. Irrigation of crops and pastures commenced in 2002 and the area has been expanded annually to 210 ha in 2006. Results for the soil monitoring program of Radiata pine after 11 years and crops and pastures after 3 and 4 years of irrigation can be summarized as follows:

- Soil pH_{Ca} in root zones ranged from 6.7 to 7.1 under Radiata pine and from 5.9 to 7.4 under irrigated crops and pastures.
- Exchangeable sodium percentage (ESP) ranged from 14% in the surface soil to 23% in the sub-soil under Radiata pine and from 12% to 28% under irrigated crops and pastures.
- Average salinity in root zones was estimated at 2.4 dS/m under Radiata pine and 1.8 dS/m under crops and pastures. Root zone salinity in 2006 was below the threshold value of 4.0 dS/m required by the EPA Load Based Licensing Protocol.

Average salinity in root zones of Radiata pine (2.4 dS/m) and crops and pastures (1.8 dS/m) in 2006 remain below the Load Base Licensing threshold level of 4.0 dS/m for the re-use scheme.

2. INTRODUCTION

Since 1995 effluent from the Norske Skog paper mill has been re-used at a Radiata pine plantation adjacent to the mill. Effluent from the mill is discharged to a large storage dam and the water is then used to irrigate the plantation (~260 ha) using a drip irrigation system and more recently to irrigate agricultural crops and pastures (~210 ha) using centre-pivot sprinkler systems. Since the project commenced, annual monitoring of tree nutrition, irrigation water, and soil properties has been conducted as part of the EPA license agreement for the reuse of effluent to the plantation and pastures at Ettamogah. In 2005 after one decade of reuse of effluent the monitoring program was reviewed to develop site-specific protocols (Hopmans 2006).

In 2006, the nutrient status of trees was assessed and soil monitoring was undertaken in the irrigated pine plantation at Ettamogah as well as irrigated and non-irrigated crops and pastures at Maryvale, Rosevale, Davey Rd, and Spring Park. This report presents the results of the soil testing and the assessment of tree nutrition conducted during 2006.

3. METHODS

Nutrition of Irrigated Radiata Pine

The condition of Radiata pine is monitored at a number of sites and foliage samples are collected for chemical analysis to determine the nutrient status of trees, the fate of nutrients applied through effluent and the requirement for fertilizer treatment. This includes chemical analysis of all essential plant nutrients as well as soluble chloride in foliage as an indicator of salt stress in trees.

Foliage samples for diagnostic testing were collected within each age class of Radiata pine in three blocks irrigated with effluent (ten samples) and one compartment not irrigated (one sample). These included several samples collected from irrigated plantation areas treated with gypsum at a rate of 5 t/ha in recent years.

At each sampling location, foliage (0-1 year old needles) was collected from the upper crowns of six trees and needle samples from individual trees were combined on an equal weight basis to provide a composite sample for chemical analysis. These composite samples were analyzed for essential plant nutrients including total N by the Dumas combustion method using a LECO-CN analyzer and S, P, K, Ca, Mg, Na, Al, Fe, Mn, Zn, Cu, and B on a nitric acid digest by ICP-AES and ICP-MS. Soluble chloride in foliage was determined by potentiometric titration on an acidified aqueous extract. Preparation and chemical analysis of Radiata pine foliage and soils was carried out at the inorganic chemistry laboratory of Primary Industries Research Victoria at Werribee.

Diagnostic criteria indicating low and adequate or satisfactory nutrient status of Radiata pine are shown in Table 1. Concentrations of nutrients at or below the ‘low’ levels correspond to the development of visual symptoms of deficiency (nutrient disorder) and under these conditions tree growth is limited by nutrient supply (Boardman *et al*. 1997). Adequate concentrations are the minimum desirable levels for satisfactory growth of Radiata pine. Concentrations between these two levels are classed as marginal or sub-optimal indicating some constraint on growth due to nutrient availability. The levels of Na and Cl are typical of Radiata pine growing on saline or sodic soils and concentrations in foliage in excess of these values are generally associated with salt stress and Cl toxicity in pine.

Table 1. Interpretation of concentrations of nutrients in foliage of Radiata pine for the diagnosis of nutrient disorders and fertilizer requirements.

Level	N	S	P	K	Ca	Mg	Na	Cl	Fe	Mn	Zn	Cu	B
	(g/kg)								(mg/kg)				
Low	10	-	1.0	3	1.0	0.7	-	-	20	10	10	2	8
Adequate	15	-	1.5	5	1.2	1.0	2	4	30	30	20	4	12

Soils

Collection

In August 2006 soil profile samples (0 - 10, 20 - 30, 50 – 60, and 80 - 90 cm) were collected at six monitoring plots in the irrigated pine plantation at Ettamogah. Samples could not be collected at plot 3.15 because of water logged conditions.

In addition soil profile samples (0 - 10, 20 - 30, and 50 - 60 cm) were collected at Maryvale from monitoring plots (10 plots) established in 2003 in pastures irrigated by centre pivot systems and from adjacent areas under pasture but not irrigated with effluent (4 plots).

Profile samples were also collected at Rosevale from soil monitoring plots established in irrigated (3 plots) and non-irrigated pasture (3 plots) in 2004.

Likewise profile samples were collected from newly established plots in irrigated (6 plots) and adjacent non-irrigated areas (5 plots) at Davey Rd and Spring Park where application of effluent commenced in April 2006.

Soil Chemical Tests

Soil testing was carried out by the inorganic chemistry laboratory of the Department of Primary Industries at Werribee in Victoria using standard methods (Rayment and Higginson 1992). Soil tests included the following:

- pH in water and in 0.01 M $CaCl_2$ both at a ratio of 1:5
- Electrical conductivity (EC) at soil/water ratio of 1:5
- Extractable chloride at soil/water ratio of 1:5
- Acidified fluoride extractable phosphorus (Bray-2 P)
- Extractable sulphur in 0.01M calcium phosphate
- Total carbon and nitrogen by Dumas combustion (LECO CN Analyzer)
- Exchangeable cations using a compulsive exchange method (0.1M $BaCl_2$ – 0.1 M NH_4Cl) after removal of soluble salts with aqueous ethanol (2 washes)

Soil Salinity

Salinity was measured as $EC_{1:5}$ (dS/m) on 1:5 soil-water extracts and EC_{se} was estimated using the site-specific relationship developed for soils at Ettamogah (Hopmans 2006):

$EC_{se} = 7.0 \times EC_{1:5}$ (n = 148, F = 2162, $R^2 = 0.94$)

Average salinity in root zones under Radiata pine and crops and pastures was calculated as a water-use-weighted (WUW) average EC_{se} based on weighting factors reflecting the gradient in plant water use with depth published by Shaw (1999) and adapted for the soil monitoring protocol used at Ettamogah (Hopmans 2006).

4. RESULTS AND DISCUSSION

4.1. Radiata pine

Health and Condition

As part of the monitoring program the general condition of Radiata pine was noted at each of the soil monitoring plots in the plantation. The condition of trees was variable ranging from healthy crowns to trees with low needle retention, upper-crown yellowing and dead tops. The proportion of trees showing dead topping and the incidence of tree mortality was generally higher in compartments on lower slopes and areas with poor drainage.

There was a gradient of wet to dry soil conditions along sampling transects in plots 1.03 (soil unit 3) and 1.09 (soil unit 1). However soil profiles were generally dry at other locations except at plot 3.15 where profiles were saturated.

Tree Nutrient Status

Results for the chemical analysis of Radiata pine foliage collected in July 2006 are tabulated in Appendix 1 and average concentrations of nutrients are shown in Table 2 together with results for previous collections since age 2 (1995). Annual monitoring of the nutrient status of Radiata pine showed that the concentrations of essential nutrients in foliage remain satisfactory in general, however average levels of N were sub-optimal in 2006 (see Tables 1 and 2).

Table 2. Average concentrations of nutrients in foliage Radiata pine planted in 1993 and irrigated with effluent since 1995.

Treatment	Age	N g/kg	S	P	K	Ca	Mg	Na	Cl	Al mg/kg	Fe	Mn	Zn	Cu	B
Irrigated	2	19	1.7	1.3	7.3	3.3	1.4	0.2	2.6	240	91	250	33	5	18
Irrigated	4	15	1.4	1.3	5.7	3.5	1.5	0.1	1.9	200	55	400	29	4	24
Irrigated	5	18	2.0	1.4	6.3	3.5	1.7	0.5	2.5	153	65	444	31	4	32
Irrigated	6	18	1.5	1.4	6.5	2.6	1.4	0.5	2.2	162	72	265	26	4	29
Irrigated	7	19	1.9	2.2	10.6	1.8	1.1	0.8	2.4	268	69	195	31	4	32
Irrigated	8	17	1.8	1.3	7.2	2.9	1.5	0.4	1.5	189	67	295	30	3	24
Irrigated	9	18	1.7	1.3	6.5	2.7	1.5	0.5	1.2	188	73	207	24	3	26
Irrigated	10	16	2.2	1.3	5.9	3.3	1.9	0.7	1.1	511	222	318	34	3	29
Irrigated	11	17	2.8	1.5	6.9	2.9	1.3	1.8	1.1	173	64	298	24	3	25
Irrigated	12	15	2.7	1.1	7.4	3.4	1.1	2.0	1.1	219	86	328	17	3	21
Irrigated	13	14	3.1	1.4	7.8	4.1	1.3	2.3	1.1	232	77	442	29	3	40

Results for the annual monitoring of the nutrient status of Radiata pine irrigated with effluent since 1995 can be summarized as follows:

- Levels of N in foliage have declined in recent years and N status of trees was sub-optimal at some sampling locations including block 1.02 and 1.08 (see Appendix 1).
- Average concentrations of S are high and results indicate variation in S levels across the plantation (Appendix 1 and Figure 1). Irrigation with effluent has gradually increased the uptake of S by trees as indicated by the level of S in foliage of irrigated trees (2.8 g/kg) compared with non-irrigated trees (1.2 g/kg) in 2006.
- Concentrations of micronutrients in foliage were generally satisfactory (Appendix 1, Table 2) and there is no evidence of accumulation of metals such as Fe and Zn applied in effluent (Figure 1).
- Levels of soluble salts (Na and Cl) in foliage are considered to be reliable indicators of salt stress and the accumulation of salt in trees growing on saline soils. In 2006, levels of soluble Cl in foliage remained low (Figure 1) and were well below the critical value of 4 g/kg associated with the onset of salt stress in Radiata pine (Table 1). This reflects the low level of Cl in paper mill effluent dominated by sodium, sulphate and bicarbonate salts. Therefore levels of Na and S in foliage can be expected to provide a better indication of salt stress in trees irrigated with effluent. Annual monitoring has shown a gradual increase in the uptake of Na and S (Table 2 and Figure 1). However there has been little change in average levels of S in foliage in recent years.

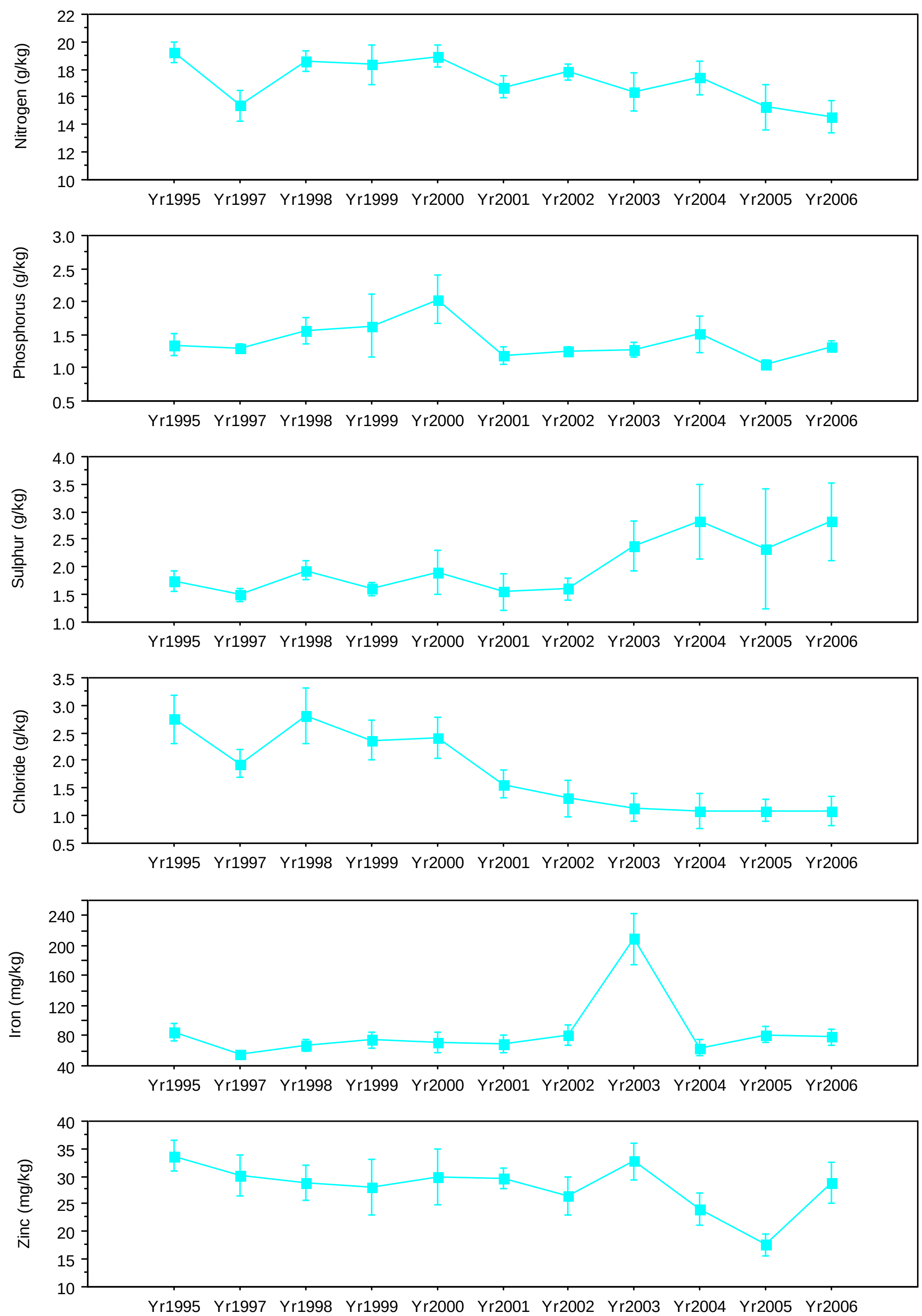

Figure 1. Concentrations of N, P, S, Cl, Fe, and Zn in foliage of Radiata pine irrigated with effluent since 1995. Bars indicate standard deviations.

4.2. Soils under Radiata Pine

Chemical Properties

Results of the chemical analysis of soil profiles collected in 2006 are shown in Appendix 2 and average values for soil profile layers in 2006 are shown in Table 4. Soil profile data for 2006 was analyzed together with previous data to examine changes in soil properties since irrigation commenced in 1995. This showed significant increases in soil pH, salinity (EC_{se}), exchangeable cations and exchangeable sodium percentage (ESP), as well as extractable S in soil profiles since 1995 (Figure 2). Results of soil testing in 2006 are summarized below:

- Average soil pH_{Ca} in profiles has increased from 4.7 in 1993 to 7.0 in 2006 (Figure 3). Soil pH_{Ca} in profiles has remained steady since 2002 and ranged from 6.7 in the surface soil (0 – 10 cm) to 7.1 in sub-soil (80 – 90 cm) in 2006.

- Average salinity (EC_{se}) in soil profiles declined in 2006 (Figure 3). There was a general gradient of increasing salinity with depth from 2.1 dS/m in the surface soil to 3.7 dS/m at the lowest sampling depth (80 – 90 cm).

- Exchangeable Ca in the surface soil (6.8 cmolc/kg) is similar to the initial value of 6.3 cmolc/kg in 1993 (Figure 3). Levels of exchangeable Ca in the sub-soil (50 – 60 cm and 80 – 90 cm) have increased in recent years to 6.8 and 6.2 cmolc/kg and are similar to original level (7 cmolc/kg) prior to irrigation (Figure 3).

- Exchangeable Mg has remained steady throughout the soil profile (0 – 10 cm, 20 - 30 cm, and 80 - 90 cm) but present levels of 0.9, 0.9, and 3.8 cmolc/kg are still lower compared with original values of 1.5, 2.8, and 5.6 cmolc/kg in 1993 (Figure 3).

- Exchangeable K has decreased throughout the soil profile (0 – 10 cm, 20 - 30 cm, and 80 - 90 cm) from original values of 1.1, 0.9, and 0.8 cmolc/kg in 1993 to 0.6, 0.5, and 0.5 cmolc/kg in 2006.

- Exchangeable Na has increased throughout the soil profile (0 – 10 cm, 20 - 30 cm, and 80 - 90 cm) from original values of 0.2, 0.3, and 0.6 cmolc/kg in 1993 to 1.3, 1.3, and 3.1 cmolc/kg in 2006. There has been little change in exchangeable Na in recent years (Figure 3).

- Sodicity or ESP (exchangeable sodium percentage) has increased in all soil profile layers (0 – 10 cm, 20 - 30 cm, and 80 - 90 cm) from values of 2.3, 4.2, and 4.0 % prior to irrigation in 1993 to 14.0, 17.4, and 22.9 % in 2006. After an initial rapid increase to around 30% in the sub-soil, ESP has remained within the range of 20% to 30% since 1999 (Figure 3).

- Extractable S has increased throughout the soil profile (0 – 10 cm, 20 - 30 cm, and 80 - 90 cm) from original concentrations of 14, 27, and 18 mg/kg in 1993 to 120, 118, and 298 mg/kg in 2006. Levels of S in the upper layers of the soil profile have remained steady since 2003 (Figure 3) while there has been a gradual decline in the sub-soil (80 – 90 cm).

- Levels of total N in soil profiles have decreased gradually since 2001 (Figure 3). Nitrogen in the surface soil (0 -10 cm) has decreased from 1.7 g/kg in 1993 to 0.80 g/kg in 2006. Gradual decreases in total N were observed throughout the profile to 2005 but there was no further decline in 2006 (Figure 3).

- Extractable P in the upper parts of the soil profile (0 – 10 cm and 20 – 30 cm layers) increased from 11 and 5 mg/kg in 1993 to maximum values of 26 and 12 mg/kg in 2002 and then declined to 22 and 8 mg/kg in 2006 (Figure 3).

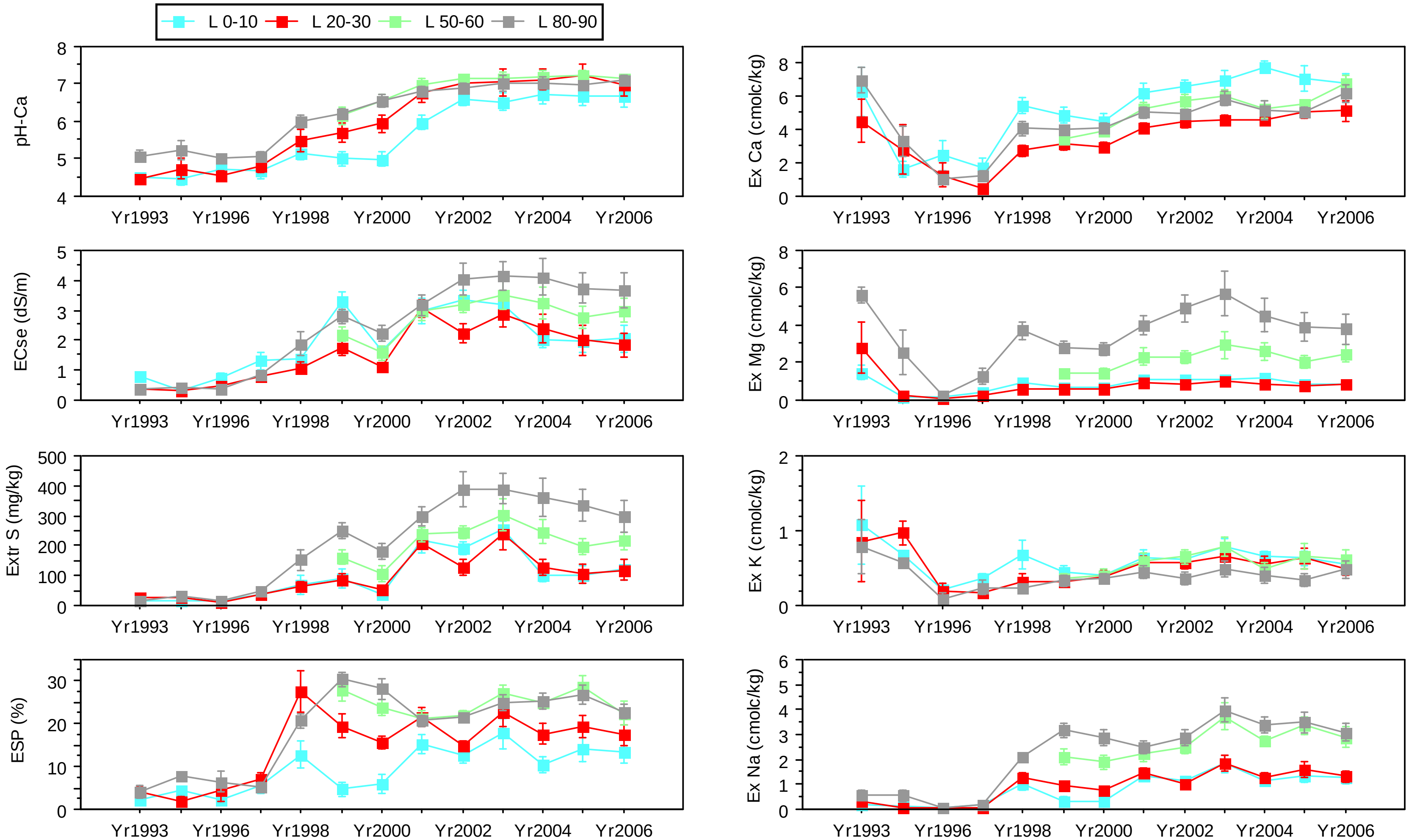

Figure 2. Average pH_{Ca}, EC_{se} (dS/m), extractable S (mg/kg), ESP%, and exchangeable cations (cmolc/kg) in plantation soil profiles irrigated with effluent at Ettamogah since 1995 (bars indicate standard deviations). Monitoring of an additional soil profile layer (50 – 60 cm) commenced in 1999.

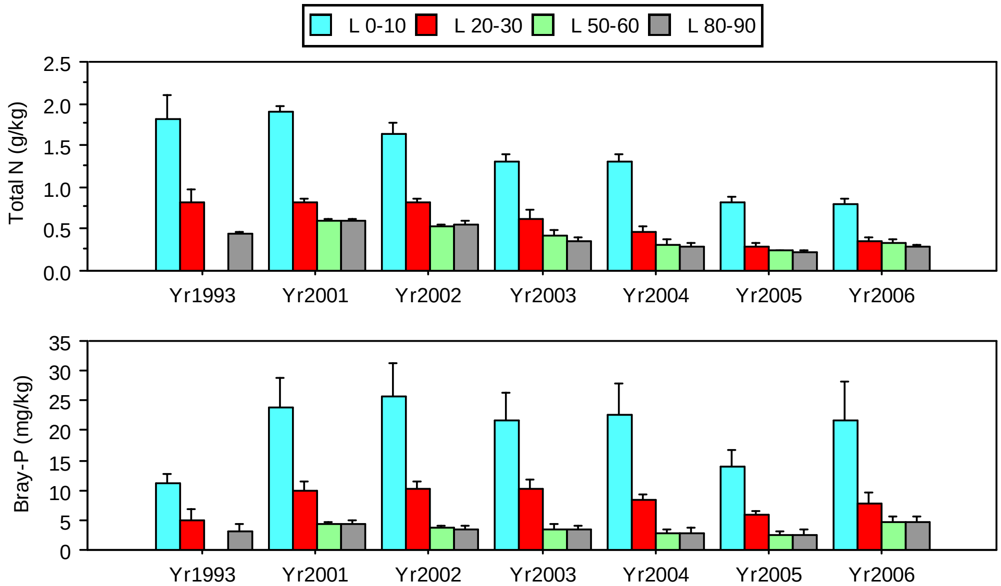

Figure 3. Average concentrations of total N and extractable P at four depths in soil profiles of the Radiata pine plantation irrigated with effluent since 1995. Bars indicate standard deviations.

4.3. Nutrient Balance

Annual rainfall, irrigation volume, and the load of nitrogen, phosphorus, zinc and total dissolved solids (TDS) in mill effluent applied from 1 July 2005 to 30 June 2006 were estimated for both the Radiata pine plantation and the pastures at Ettamogah (Appendix 4). The loads of N, P, and Zn in effluent were compared with the average annual requirement of these nutrients for fast-growing Radiata pine at Ettamogah.

Growth of Radiata pine is assessed annually and these data were used to estimate above-ground biomass and nutrients in trees from biomass models for Radiata pine and average nutrient concentrations in biomass components *i.e.*, stem wood, bark, foliage, and branches. Accumulation of nitrogen, phosphorus and zinc in above-ground tree biomass was estimated on the basis of projected growth for a 12-year rotation without thinning.

Total accumulation of N, P, and Zn in above-ground tree biomass over a 12-year rotation was estimated at 488, 55 and 1.3 kg/ha respectively (Table 3). This is equivalent to annual rates of accumulation for N, P, and Zn of 41, 4.6 and 0.11 kg/ha and compares with loads in effluent applied during the irrigation season from 1 July 2005 to 30 June 2006 of 20, 1.1, and 0.39 kg/ha respectively (Appendix 4 and Table 3).

Table 3. Accumulation of nitrogen, phosphorus and zinc in above-ground biomass of Radiata pine grown over a 12-year rotation without thinning and amounts applied in effluent in 2006.

Source	Stocking (stems/ha)	Wood Volume (m^3/ha)	Total Biomass (t/ha)	N (kg/ha)	P (kg/ha)	Zn (kg/ha)
Biomass# at 12 yrs	1050	380	181	488	55	1.3
Accumulation (units/ha/yr)		32	15	41	4.6	0.11
Irrigation Load				20	1.1	0.39

Biomass components estimated using allometric equations for Radiata pine (Madgwick 1994)

The impact of irrigation with effluent on the nutrient balance in the Radiata pine plantation can be summarized as follows:

- The load of N and P in effluent was less than the annual requirement of fast-growing Radiata pine. In contrast, the load of Zn exceeded the annual requirement of trees indicating potential accumulation of this metal in soil (Table 3).

- Annual monitoring of the nutrient status of Radiata pine showed a gradual decline in N to sub-optimal levels (Figure 1) consistent with the decrease in total N in soil (Figure 3).

- Levels of P in foliage have increased (Figure 1) consistent with the increase in load of P in effluent in 2006 (0.4 to 1.1 kg/ha). Likewise levels of Zn in foliage have increased but the load of Zn in 2006 was similar to the previous year (0.4 kg/ha).

4.4. Soils under Crops and Pastures

Chemical Properties

Results of the chemical analysis of soil profiles under crops and pastures collected in 2006 are shown in Appendix 2 and average values for soil tests in 2006 are shown for profile layers at each site in Table 4. Soil profile data was analyzed together with previous data to examine changes in soil properties since irrigation commenced at Maryvale (2003), Rosevale (2004) and at Davey Rd and Spring Park (2006). Results of soil testing in 2006 are summarized below:

Maryvale

Irrigation with effluent since 2003 has increased pH, salinity (EC_{se}), exchangeable Na, and extractable S in soil profiles (Table 4 and Figure 4). After four years of irrigation the main impacts on soil properties can be summarized as follows:

- Soil pH_{Ca} in profiles has increased from 6.0 to 7.4 (0 – 10 cm), from 5.3 to 6.6 (20 – 30 cm), and from 5.8 to 6.3 (50 – 60 cm).

- Salinity (EC_{se}) has increased from 0.7 to 1.6 dS/m (0 – 10 cm), from 0.6 to 1.9 dS/m (20 – 30 cm), and from 0.7 to 2.0 dS/m (50 – 60 cm).

- Sodicity (ESP) in soil profiles has increased from 0.7 to 17% (0 – 10 cm), from 2 to 28% (20 – 30 cm), and from 6 to 19% (50 – 60 cm).

- Extractable S has increased throughout the profile from 19 to 71 mg/kg (0 – 10 cm), from 24 to 134 mg/kg (20 – 30 cm), and 33 to 155 mg/kg (50 – 60 cm).

Rosevale

Three years after irrigation with effluent commenced soil pH, salinity (EC_{se}), exchangeable Na, and extractable S have increased (Table 4 and Figure 5). The impacts of irrigation on soil properties can be summarized as follows:

- Soil pH_{Ca} in profiles has increased from 5.5 to 7.2 (0 – 10 cm), from 4.9 to 6.0 (20 – 30 cm), and from 5.3 to 5.9 (50 – 60 cm).

- Salinity (EC_{se}) has increased from 1.0 to 1.6 dS/m (0 – 10 cm), from 0.7 to 1.8 dS/m (20 – 30 cm), and from 0.8 to 1.6 dS/m (50 – 60 cm).

- Sodicity (ESP) in soil profiles has increased from 5 to 17% (0 – 10 cm), from 4 to 26% (20 – 30 cm), and from 6 to 12% (50 – 60 cm).

- Extractable S has increased from 37 to 56 mg/kg (0 – 10 cm), from 37 to 135 mg/kg (20 – 30 cm), and from 40 to 129 mg/kg (50 – 60 cm).

Table 4. Average pH, EC, total C and N, extractable Cl, P and S, and exchangeable cations in soil profiles under Radiata pine, pastures, and crops in 2006.

Site	Treatment	Layer	pH-w	pH-Ca	EC1:5 dS/m	ECse dS/m	Extr Cl mg/kg	Total C g/kg	Total N g/kg	Bray-P mg/kg	Extr S mg/kg	Ex Ca cmolc/kg	Ex Mg cmolc/kg	Ex K cmolc/kg	Ex Na cmolc/kg	Ex Cats cmolc/kg	ESP %	Ex Ca/Mg
Ettamogah Pine	Effluent	L 0-10	7.5	6.7	0.29	2.06	34.9	13.7	0.80	21.7	120	6.8	0.9	0.55	1.26	9.5	13.6	8.1
Ettamogah Pine	Effluent	L 20-30	7.9	7.0	0.26	1.84	27.0	6.2	0.35	7.9	118	5.1	0.9	0.50	1.32	7.8	17.4	6.6
Ettamogah Pine	Effluent	L 50-60	8.0	7.1	0.43	3.00	37.8	5.2	0.33	4.5	217	6.8	2.5	0.62	2.89	12.8	22.5	3.2
Ettamogah Pine	Effluent	L 80-90	7.9	7.1	0.52	3.68	50.6	4.4	0.29	4.8	298	6.2	3.8	0.48	3.09	13.6	22.9	2.1
Maryvale	Nil	L 0-10	6.5	6.0	0.10	0.70	14.4	9.7	0.63	14.7	19	5.9	0.4	0.17	0.05	6.5	0.7	19.3
Maryvale	Nil	L 20-30	6.0	5.3	0.09	0.60	14.7	4.0	0.27	3.4	24	3.8	1.8	0.11	0.13	5.8	2.0	2.3
Maryvale	Nil	L 50-60	6.8	5.8	0.11	0.74	28.7	5.1	0.37	5.7	33	5.7	4.1	0.15	0.68	10.7	6.1	1.4
Maryvale	Effluent	L 0-10	8.4	7.4	0.23	1.63	22.6	8.2	0.46	13.5	71	5.5	0.6	0.21	1.21	7.5	16.6	10.0
Maryvale	Effluent	L 20-30	7.5	6.6	0.27	1.87	29.6	3.9	0.24	4.1	134	3.3	1.3	0.17	1.63	6.4	27.6	2.9
Maryvale	Effluent	L 50-60	7.1	6.3	0.29	2.04	31.7	5.0	0.32	6.9	155	4.4	2.5	0.21	1.57	8.7	18.7	3.9
Rosevale	Nil	L 0-10	6.3	5.5	0.14	0.95	18.7	13.4	0.97	22.7	37	6.4	0.6	0.23	0.33	7.6	4.7	11.6
Rosevale	Nil	L 20-30	5.7	4.9	0.10	0.71	17.3	4.6	0.29	5.3	37	3.8	2.2	0.13	0.29	6.4	4.4	1.9
Rosevale	Nil	L 50-60	6.2	5.3	0.11	0.75	18.9	8.6	0.63	12.7	40	6.9	4.3	0.23	0.71	12.1	5.5	1.7
Rosevale	Effluent	L 0-10	8.3	7.2	0.22	1.56	20.4	12.8	0.87	20.2	56	6.8	0.5	0.12	1.52	8.9	16.8	13.2
Rosevale	Effluent	L 20-30	7.1	6.0	0.25	1.78	28.7	3.8	0.21	5.4	135	2.1	0.7	0.04	1.06	4.0	25.5	2.9
Rosevale	Effluent	L 50-60	6.7	5.9	0.23	1.61	32.0	6.6	0.43	8.0	129	5.3	4.2	0.12	1.22	10.9	11.6	1.6
Davey Rd	Nil	L 0-10	4.8	4.2	0.10	0.67	8.6	9.6	0.69	14.1	36	2.6	0.5	0.10	0.02	3.2	0.6	5.5
Davey Rd	Nil	L 20-30	5.5	4.5	0.04	0.29	2.2	5.2	0.35	3.3	16	3.4	2.3	0.10	0.14	5.9	2.0	1.8
Davey Rd	Nil	L 50-60	5.6	4.5	0.05	0.33	0.4	5.1	0.43	3.0	21	4.0	2.7	0.11	0.22	7.0	2.9	1.5
Davey Rd	Effluent	L 0-10	5.2	4.5	0.14	0.97	10.0	10.0	0.73	13.5	69	3.2	0.9	0.13	0.08	4.3	1.9	4.5
Davey Rd	Effluent	L 20-30	5.6	4.7	0.06	0.42	7.4	3.9	0.26	3.3	18	3.0	1.7	0.08	0.16	4.9	2.7	2.0
Davey Rd	Effluent	L 50-60	6.3	5.2	0.07	0.50	14.9	4.3	0.32	2.1	25	4.7	4.7	0.14	0.79	10.3	7.9	1.0
Spring Park	Nil	L 0-10	5.6	4.7	0.06	0.41	7.8	7.3	0.56	16.3	11	3.7	1.2	0.08	0.06	5.0	1.0	5.0
Spring Park	Nil	L 20-30	5.1	4.5	0.06	0.39	6.9	7.3	0.53	17.7	13	2.7	0.4	0.08	0.01	3.2	0.3	12.6
Spring Park	Nil	L 50-60	5.4	4.5	0.03	0.24	6.1	3.1	0.24	3.6	11	3.3	1.6	0.08	0.07	5.0	1.1	3.0
Spring Park	Effluent	L 0-10	5.2	4.5	0.09	0.60	11.9	12.5	0.90	24.9	22	3.5	0.2	0.15	0.03	3.9	0.9	16.7
Spring Park	Effluent	L 20-30	5.7	4.8	0.05	0.34	5.2	3.6	0.25	3.5	16	3.4	1.4	0.09	0.11	5.0	1.6	3.9
Spring Park	Effluent	L 50-60	5.7	4.7	0.04	0.32	5.5	3.8	0.23	3.3	18	4.2	2.0	0.07	0.13	6.4	1.5	4.6

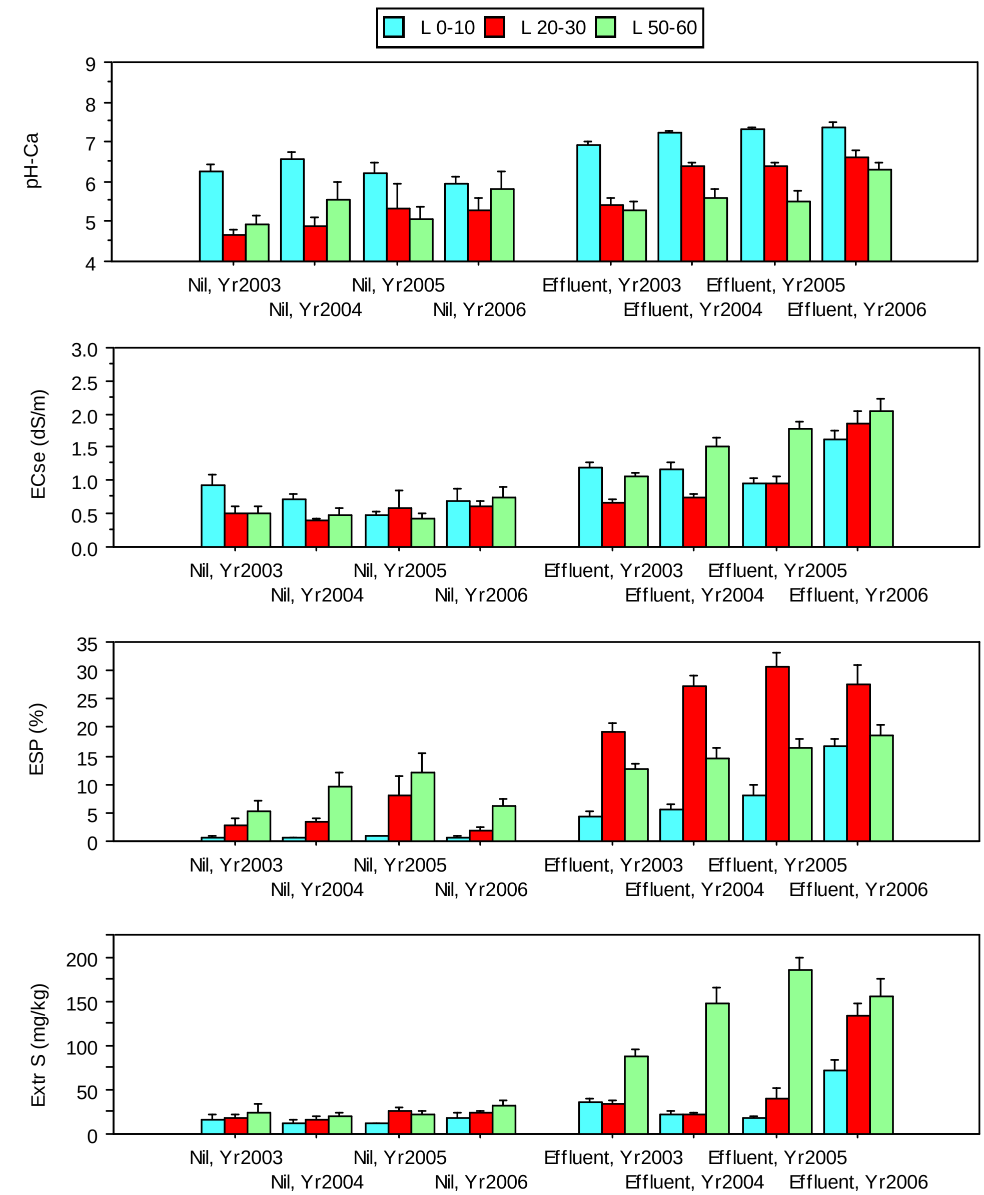

Figure 4. Average soil pH (calcium chloride), ECse (dS/m), ESP (%), and extractable sulphur (mg/kg) at three depths in soil profiles of control (nil irrigation) and effluent irrigated soils under pasture at Maryvale. Bars indicate standard deviations.

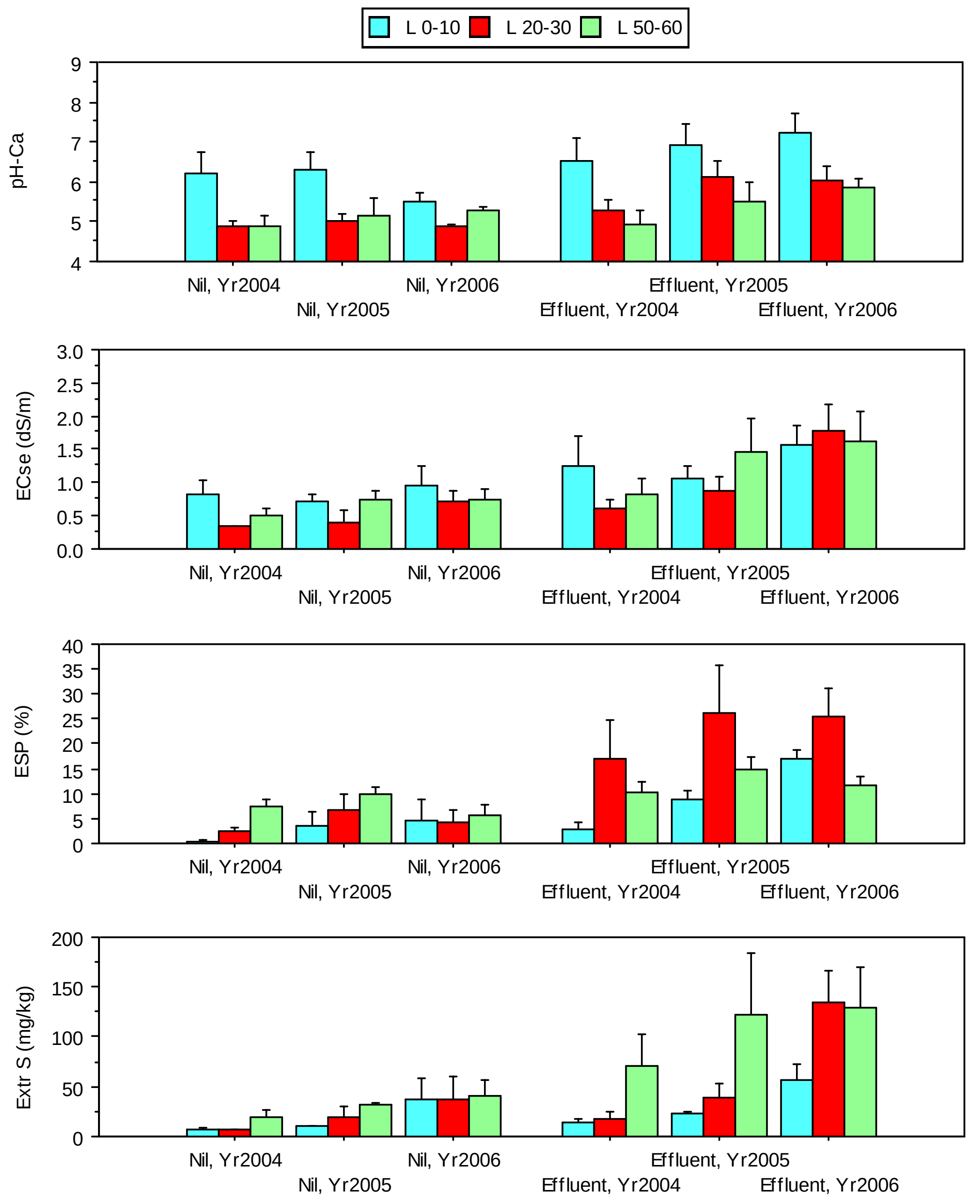

Figure 5. Average soil pH (calcium chloride), EC_{se} (dS/m), ESP (%), and extractable sulphur (mg/kg) at three depths in soil profiles of control (nil irrigation) and effluent irrigated soils under pasture at Rosevale. Bars indicate standard deviations.

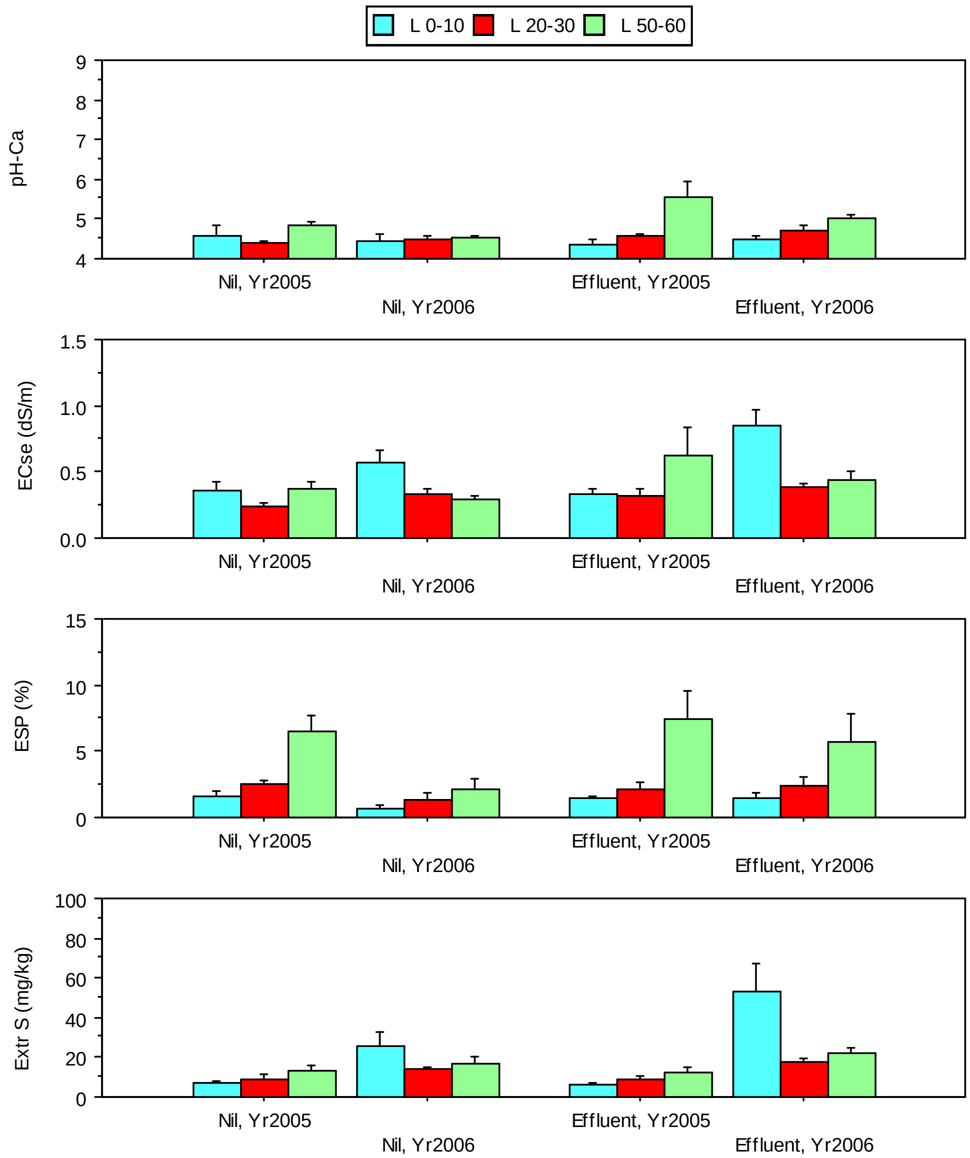

Figure 6. Average soil pH (calcium chloride), EC_{se} (dS/m), ESP (%), and extractable sulphur (mg/kg) at three depths in soil profiles of control (nil irrigation) and effluent irrigated soils under wheat at Davey Rd and Spring Park. Bars indicate standard deviations.

Davey Rd and Spring Park

Soil profile samples were collected at six plots where irrigation with effluent commenced in April 2006 and at five non-irrigated 'control' plots located outside the centre pivot irrigated areas. It was necessary to relocate irrigated plot DRP6b and control plot DRC2 by short distances (20 to 30 m) to ensure plots were truly representative of 'control' and irrigation treatments. Comparison of results for irrigated and non-irrigated plots indicated slight changes in soil pH, salinity (EC_{se}), sodicity (ESP) and extractable S after a relatively short period of irrigation (Table 4 and Figure 6). It should be noted that these changes were not significant statistically at the 5% level of probability (P<0.05).

4.5. Salinity in Root Zones

Salinity in soil profiles under Radiata pine and crops and pastures together with water-use weighted salinity (WUW EC_{se}) in the appropriate root zones were calculated according to the site-specific soil monitoring protocol for the effluent re-use scheme (see Appendix 3). Average WUW salinity in root zones together with standard deviations and coefficients of variation for each site were used to calculate the average root zone salinity for each type of land use viz. irrigated plantation and irrigated and non-irrigated agricultural crops & pastures (Table 5).

- Average salinity in root zones under Radiata pine was estimated at 2.3 ± 1.1 dS/m and is below the threshold level of root zone salinity of 4.0 dS/m as required by the EPA Load Based Licensing Protocol. Average root zone salinity (WUW EC_{se}) under Radiata pine showed a downward trend in recent years but variability in soil salinity was greater in 2006 (Figure 7).
- Average salinity in root zones under crops and pastures irrigated with effluent in 2006 was estimated at 1.4 ± 0.7 dS/m and therefore well below the threshold value of 4.0 dS/m. Salinity was low at Davey Rd and Spring Park (0.6 ± 0.2 dS/m) where irrigation commenced only in April 2006; when these areas were excluded from the calculations the average salinity under irrigated crops and pastures increased to 1.8 ± 0.5 dS/m.
- Average salinity in root zones under non-irrigated crops and pastures at Maryvale, Rosevale, Davey Rd and Spring Park was 0.5 ± 0.2 dS/m.

Table 5. Average water-use weighted salinity (WUW EC_{se}) in root zones under Radiata pine and crops and pastures irrigated with paper mill effluent in 2006.

Site	Irrigated (yrs)	WUW EC_{se} (dS/m) Average	Std Dev[#]	Plots (n)	CoVar[†] (%)
Plantation					
Ettamogah - Radiata pine	11	**2.3**	**1.1**	6	42
Crops & Pastures					
Maryvale - lucerne	3	1.8	0.4	10	24
Rosevale - lucerne	2	1.6	0.6	3	38
Davey Rd & Spring Park - wheat	1	0.6	0.2	6	30
Average Crops & Pastures		**1.4**	**0.7**	19	47
Non-irrigated					
Crops & Pastures		**0.5**	**0.2**	12	37

[#] Std Dev: standard deviation
[†] CoVar: coefficient of variation

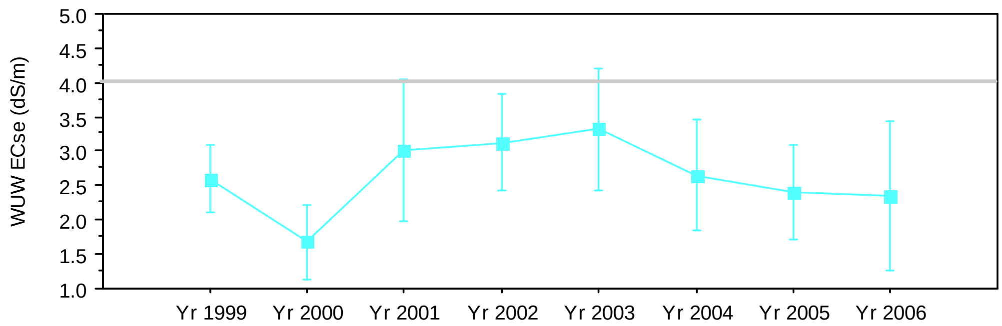

Figure 7. Average salinity (WUW EC_{se}) in the root zone (0 – 90 cm) of irrigated Radiata pine since sampling of an additional layer (50 – 60 cm) in the soil profile commenced. Bars indicate standard deviations.

5. CONCLUSIONS & MANAGEMENT RECOMMENDATIONS

Radiata Pine Plantation

Annual monitoring of Radiata pine has shown that the nutrition of trees irrigated with effluent has remained satisfactory, however tree health and condition has declined in recent years. Results can be summarized as follows:

- Tree health and condition has decreased as indicated by increasing numbers of trees showing a decline in crown condition including loss of foliage, yellowing of needles, and dead topping. Furthermore tree mortality has become widespread in the plantation consistent with abiotic environmental stresses rather than inadequate nutrient supply.
- The nutrient status of Radiata pine has remained satisfactory except for a decline in nitrogen to sub-optimal or marginal levels.
- Levels of sulphur in foliage remain high in response to sulphate applied in effluent together with broadcast applications of gypsum in some sections of the plantation and therefore spatial variation in foliar concentrations of sulphur is high.
- Nutrient balances for nitrogen and phosphorus indicated that loads of these nutrients in effluent were significantly less than the average annual requirement of fast-growing Radiata pine over a 12 year rotation. However, nutrient demand of trees is likely to have decreased due to a decline in tree condition in recent years.
- A decline in crown condition and foliage biomass affects both nutrient uptake as well as water use by trees and therefore evapotranspiration will be much lower in the poorer sections of the plantation.

It is recommended that annual monitoring of the health and nutrient status of trees be continued. It is also recommended that a systematic survey of the plantation be conducted to determine the present growth and condition of trees within each irrigation block to identify areas in poor condition and with low water use. Irrigation and harvesting schedules should be reviewed to take into account changes in plantation conditions.

Soils

Annual monitoring of soil profiles is conducted to determine long-term impacts of irrigation with effluent on soil properties in the root zones of trees as well as crops and pastures. Irrigation of the tree plantation commenced in 1995 and results showed significant increases in pH, salinity, sodicity and sulphate in soil profiles. Steady state conditions were reached after 6 to 7 years of irrigation at rates of approximately 6 Ml/ha/yr. By comparison the impact on other soil properties has been relatively minor. Results for the soil monitoring program of Radiata pine after 11 years and crops and pastures after 3 and 4 years of irrigation can be summarized as follows:

- Soil pH_{Ca} in root zones ranged from 6.7 to 7.1 under Radiata pine and from 5.9 to 7.4 under irrigated crops and pastures at Maryvale and Rosevale.
- Exchangeable sodium percentage (ESP) ranged from 14% in the surface soil to 23% in the sub-soil under Radiata pine and from 12% to 28% under irrigated crops and pastures.
- Average salinity in root zones was estimated at 2.4 dS/m under Radiata pine and 1.8 dS/m under crops and pastures. Root zone salinity in 2006 was below the threshold value of 4.0 dS/m required by the EPA Load Based Licensing Protocol.
- Levels of extractable sulphur have increased mainly in the sub-soil and have reached a 'steady state' with average levels of sulphur at 300 mg/kg under Radiata pine in 2006. Sulphur in sub-soils ranged from 130 to 160 mg/kg under crops and pastures at Rosevale and Maryvale respectively. This compares with levels of 30 to 40 mg/kg in sub-soils of non-irrigated crops and pastures.

Average salinity in root zones of Radiata pine (2.4 dS/m) and crops and pastures (1.8 dS/m) in 2006 remain below the Load Base Licensing threshold level of 4.0 dS/m for the re-use scheme.

6. REFERENCES

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Appendix 1. Results of chemical analysis of foliage of Radiata pine at Ettamogah irrigated with effluent from the Norske Skog paper mill at Albury.

MATERIAL: Radiata pine foliage							COMMENTS:														
SOURCE: Norske Skog																					
LOCATION: Albury																					
SAMPLE							N	S	P	K	Ca	Mg	Na	Cl	Al	Fe	Mn	Zn	Cu	B	N/S
Plantation	Block	Comp	Age	Type	Treatment	Sample	(g/kg)								(mg/kg)						ratio
Ettamogah	1	1-20	1993	Irrigated	Nil	1	14.9	4.2	1.4	9.1	4.5	1.5	3.0	1.0	253	61	490	33	2.9	34	4
Ettamogah	1	1-20	1993	Irrigated	Nil	2	15.0	2.6	1.5	7.8	2.8	1.2	2.0	1.1	232	81	388	31	3.1	43	6
Ettamogah	3	1-23	1994	Irrigated	Gypsum	1	13.6	3.1	1.3	8.2	3.5	1.1	2.3	1.4	274	81	671	30	2.7	28	4
Ettamogah	3	1-23	1994	Irrigated	Gypsum	2	14.8	3.0	1.3	7.6	3.2	1.5	2.0	1.1	252	85	412	31	2.9	28	5
Ettamogah	2	1-36	1995	Irrigated	Nil	1	15.2	2.1	1.3	6.8	3.9	1.5	1.4	0.8	358	86	857	24	3.1	24	7
Ettamogah	2	1-36	1995	Irrigated	Nil	2	15.1	1.7	1.2	6.5	3.0	1.7	1.0	0.7	351	70	880	28	3.2	26	9
Ettamogah	1	1.02	1993	Irrigated	Nil	2	12.7	3.4	1.3	10.5	5.1	1.0	1.2	1.5	259	72	745	25	2.3	43	4
Ettamogah	1	1.08	1993	Irrigated	Gypsum	3	12.5	2.7	1.3	7.8	3.3	0.9	2.4	0.8	288	96	589	23	3.2	50	5
Ettamogah	1	1.11	1993	Irrigated	Nil	4	15.4	2.3	1.4	6.0	4.5	1.5	1.7	1.0	212	86	207	32	3.1	34	7
Ettamogah	1	1.11.02	1993	Unirrigated	Nil	5	14.7	1.2	1.2	3.6	6.0	2.4	0.1	0.9	315	88	390	22	2.6	32	12
Ettamogah	1	1.12	1993	Irrigated	Nil	1	15.9	3.2	1.3	5.3	4.6	1.5	3.1	1.4	150	66	232	32	2.8	34	5

Appendix 2. Results of chemical analysis of soil profiles under Radiata pine at Ettamogah and under crops and pastures at Maryvale, Rosevale, Davey Rd and Spring Park in 2006.

Radiata pine at Ettamogah

Plot	Treatment	Depth	pH-Ca	pH-W	EC1:5 (dS/m)	Extr Cl (mg/kg)	Total C (g/kg)	Total N (g/kg)	Bray-P (mg/kg)	Extr S (mg/kg)	Ex Ca (cmolc/kg)	Ex Mg (cmolc/kg)	Ex K (cmolc/kg)	Ex Na (cmolc/kg)
1.02	irrigated	0-10	5.9	6.7	0.11	12.7	18.6	1.06	62.8	18	5.7	0.7	0.2	0.6
1.02	irrigated	20-30	6.4	7.7	0.09	9.7	7.8	0.41	19.2	15	3.1	0.4	0.2	0.9
1.02	irrigated	50-60	6.7	7.6	0.35	32.3	4.7	0.30	8.8	226	4.7	1.6	0.4	2.5
1.02	irrigated	80-90	6.5	7.1	0.50	41.3	4.2	0.29	9.2	317	3.3	3.1	0.2	2.5
1.03	irrigated	0-10	7.5	8.5	0.20	18.9	10.4	0.59	20.5	60	8.3	0.8	0.5	1.1
1.03	irrigated	20-30	7.5	8.5	0.16	17.7	3.9	0.18	7.1	64	3.7	0.4	0.2	0.7
1.03	irrigated	50-60	7.4	8.5	0.22	19.1	3.7	0.20	2.9	84	6.9	1.8	0.4	1.8
1.03	irrigated	80-90	7.2	8.3	0.24	24.3	4.6	0.27	5.0	115	6.5	2.5	0.3	2.4
1.09	irrigated	0-10	5.0	5.6	0.31	29.5	14.0	0.92	21.9	178	5.2	1.0	0.9	0.9
1.09	irrigated	20-30	5.8	6.3	0.58	38.8	8.0	0.51	7.2	320	5.9	1.3	0.9	1.8
1.09	irrigated	50-60	6.9	7.5	0.74	59.0	9.3	0.59	8.8	344	8.9	1.7	1.3	3.1
1.09	irrigated	80-90	7.1	7.7	0.66	66.4	6.3	0.40	7.8	365	8.4	1.8	1.1	3.4
1.26	irrigated	0-10	6.8	7.6	0.68	86.5	15.4	0.95	12.5	314	6.4	1.0	0.5	2.6
1.26	irrigated	20-30	7.7	8.9	0.27	37.6	5.5	0.31	6.8	100	3.9	0.6	0.3	1.7
1.26	irrigated	50-60	7.3	8.2	0.48	45.5	5.0	0.30	2.3	229	5.0	2.1	0.4	4.4
1.26	irrigated	80-90	7.1	7.8	0.67	58.5	4.2	0.27	3.1	386	5.2	3.5	0.3	4.1
3.02	irrigated	0-10	6.2	7.1	0.18	25.6	14.5	0.89	10.2	68	8.9	0.8	0.9	0.8
3.02	irrigated	20-30	6.1	6.9	0.20	22.6	8.6	0.55	5.9	100	8.3	1.0	0.9	0.8
3.02	irrigated	50-60	6.8	7.5	0.34	32.6	6.6	0.41	5.2	176	7.5	1.6	0.9	1.4
3.02	irrigated	80-90	7.0	7.9	0.29	37.0	4.3	0.31	4.7	157	6.9	2.6	0.8	1.9
3.11	irrigated	0-10	7.0	7.8	0.32	44.1	14.4	0.69	7.4	116	7.3	0.8	0.3	1.0
3.11	irrigated	20-30	7.2	8.2	0.23	25.9	6.1	0.28	3.7	96	5.2	0.7	0.3	0.9
3.11	irrigated	50-60	7.3	8.3	0.31	30.0	4.5	0.28	3.0	146	7.2	2.0	0.4	1.8
3.11	irrigated	80-90	7.2	8.2	0.26	24.1	3.2	0.22	2.7	127	6.1	2.2	0.4	2.2

Lucerne at Maryvale

Plot	Treatment	Depth	pH-Ca	pH-W	EC1:5 (dS/m)	Extr Cl (mg/kg)	Total C (g/kg)	Total N (g/kg)	Bray-P (mg/kg)	Extr S (mg/kg)	Ex Ca (cmolc/kg)	Ex Mg (cmolc/kg)	Ex K (cmolc/kg)	Ex Na (cmolc/kg)
MVP2a.1	Irrigated	0 - 10	7.4	8.5	0.17	10.7	9.2	0.62	14.4	39	6.8	0.6	0.4	0.9
MVP2a.1	Irrigated	20 - 30	6.6	7.7	0.23	21.4	4.9	0.36	4.0	94	4.4	1.4	0.4	1.8
MVP2a.1	Irrigated	50 - 60	6.6	7.4	0.26	16.8	5.9	0.45	8.1	142	6.7	0.6	0.4	1.3
MVP2a.2	Irrigated	0 - 10	7.6	8.7	0.22	15.0	7.9	0.45	12.8	70	7.0	0.4	0.2	1.2
MVP2a.2	Irrigated	20 - 30	6.7	8.0	0.18	16.8	2.9	0.17	4.1	79	2.0	0.4	0.1	1.1
MVP2a.2	Irrigated	50 - 60	6.4	7.3	0.24	19.9	2.3	0.15	2.7	141	3.0	2.4	0.2	0.9
MVP2b.1	Irrigated	0 - 10	7.2	8.4	0.21	18.0	9.0	0.58	13.6	54	6.6	0.6	0.4	1.2
MVP2b.1	Irrigated	20 - 30	6.3	7.1	0.29	17.1	5.5	0.39	3.8	181	7.2	2.3	0.3	1.4
MVP2b.1	Irrigated	50 - 60	6.4	7.5	0.26	29.7	5.6	0.37	5.4	108	5.2	0.8	0.3	1.4
MVP2b.2	Irrigated	0 - 10	8.0	9.1	0.35	37.3	8.8	0.48	17.3	128	5.4	0.6	0.1	1.4
MVP2b.2	Irrigated	20 - 30	7.7	8.8	0.41	51.4	3.1	0.15	4.1	199	2.4	0.6	0.1	2.5
MVP2b.2	Irrigated	50 - 60	7.3	8.1	0.46	54.5	6.7	0.43	10.3	236	6.6	4.8	0.2	2.6
MVP2c.1	Irrigated	0 - 10	7.2	8.3	0.28	29.5	9.3	0.51	10.9	110	6.0	1.4	0.1	1.9
MVP2c.1	Irrigated	20 - 30	6.2	7.2	0.28	29.7	3.5	0.21	2.2	141	2.5	2.2	0.1	2.0
MVP2c.1	Irrigated	50 - 60	5.6	6.2	0.37	41.9	4.5	0.27	3.2	233	4.4	7.0	0.2	2.1
MVP2c.2	Irrigated	0 - 10	7.5	8.5	0.29	33.5	6.4	0.38	6.8	124	5.3	0.6	0.1	1.3
MVP2c.2	Irrigated	20 - 30	6.7	7.8	0.31	34.7	2.8	0.18	2.4	159	2.6	0.8	0.1	2.3
MVP2c.2	Irrigated	50 - 60	5.6	6.4	0.30	31.9	3.6	0.24	4.4	202	3.3	2.2	0.1	1.6
MVP3a.1	Irrigated	0 - 10	7.8	8.8	0.20	15.8	7.4	0.40	23.3	32	4.2	0.4	0.4	0.9
MVP3a.1	Irrigated	20 - 30	6.2	6.9	0.26	20.9	3.6	0.26	5.6	154	3.2	2.1	0.2	1.3
MVP3a.1	Irrigated	50 - 60	6.6	7.5	0.37	58.3	3.1	0.19	4.8	191	2.4	1.2	0.3	1.7
MVP3a.2	Irrigated	0 - 10	7.1	8.2	0.19	20.2	10.7	0.48	11.5	34	5.1	0.4	0.3	1.1
MVP3a.2	Irrigated	20 - 30	6.1	7.0	0.34	59.9	5.3	0.23	4.4	152	2.7	0.9	0.2	1.9
MVP3a.2	Irrigated	50 - 60	5.7	6.4	0.26	27.2	3.7	0.26	5.0	147	3.8	2.1	0.2	1.4
MVP3b.1	Irrigated	0 - 10	7.2	8.3	0.22	22.2	9.9	0.54	18.0	38	6.6	0.6	0.2	1.4
MVP3b.1	Irrigated	20 - 30	6.1	7.2	0.22	32.8	3.5	0.20	4.4	106	1.9	0.6	0.1	1.3
MVP3b.1	Irrigated	50 - 60	5.4	6.1	0.25	23.6	4.4	0.29	6.3	127	2.9	3.0	0.1	1.7
MVP3b.2	Irrigated	0 - 10	6.6	7.7	0.18	23.7	3.4	0.17	6.2	85	1.9	0.4	0.1	0.8
MVP3b.2	Irrigated	20 - 30	7.6	7.5	0.15	11.0	3.7	0.23	5.5	76	4.3	1.9	0.1	0.9
MVP3b.2	Irrigated	50 - 60	7.2	8.3	0.16	12.9	10.1	0.59	19.1	23	5.9	0.5	0.2	1.0
MVC2a	Unirrigated	0 - 10	6.4	7.0	0.07	5.0	8.9	0.52	15.7	11	5.9	0.2	0.2	<0.1
MVC2a	Unirrigated	20 - 30	5.9	6.9	0.09	0.3	3.4	0.26	3.1	24	5.2	3.2	0.1	0.3
MVC2a	Unirrigated	50 - 60	6.9	7.9	0.17	68.0	5.5	0.42	4.7	34	9.6	7.1	0.1	1.5
MVC2b	Unirrigated	0 - 10	6.0	6.6	0.05	3.8	8.3	0.51	14.6	10	5.2	0.2	0.1	<0.1
MVC2b	Unirrigated	20 - 30	5.6	6.3	0.06	-1.3	3.1	0.20	3.1	19	2.8	1.1	0.1	0.1
MVC2b	Unirrigated	50 - 60	5.9	6.9	0.08	9.2	3.4	0.24	3.1	35	3.3	3.1	0.1	0.5
MVC3a	Unirrigated	0 - 10	5.6	6.2	0.16	21.9	10.4	0.74	15.1	36	5.9	0.5	0.3	0.1
MVC3a	Unirrigated	20 - 30	4.9	5.6	0.11	26.7	5.2	0.36	4.0	32	4.5	1.6	0.2	0.1
MVC3a	Unirrigated	50 - 60	5.8	6.5	0.11	16.1	6.5	0.50	9.5	46	6.3	3.1	0.2	0.2
MVC3b	Unirrigated	0 - 10	5.8	6.4	0.12	26.8	11.3	0.73	13.2	17	6.7	0.4	0.1	0.1
MVC3b	Unirrigated	20 - 30	4.7	5.4	0.08	33.1	4.3	0.26	3.2	20	2.9	1.2	0.1	0.1
MVC3b	Unirrigated	50 - 60	4.7	5.8	0.07	21.5	4.9	0.33	5.5	16	3.7	3.1	0.1	0.5

Lucerne at Rosevale

Plot	Treatment	Depth	pH-Ca	pH-W	EC1:5 (dS/m)	Extr Cl (mg/kg)	Total C (g/kg)	Total N (g/kg)	Bray-P (mg/kg)	Extr S (mg/kg)	Ex Ca (cmolc/kg)	Ex Mg (cmolc/kg)	Ex K (cmolc/kg)	Ex Na (cmolc/kg)
RVP1.1.1	Irrigated	0 - 10	7.8	9.0	0.24	20.9	10.7	0.70	19.4	62	6.8	0.5	0.1	1.9
RVP1.1.1	Irrigated	20 - 30	6.6	7.6	0.29	31.3	3.6	0.20	4.9	157	2.5	0.9	0.1	1.5
RVP1.1.1	Irrigated	50 - 60	6.3	6.9	0.30	41.3	7.7	0.51	8.0	169	7.5	6.0	0.1	1.6
RVP1.1.2	Unirrigated	0 - 10	5.4	6.1	0.06	4.5	12.1	0.84	13.6	11	7.1	0.7	0.1	0.1
RVP1.1.2	Unirrigated	20 - 30	4.9	5.9	0.06	7.8	4.1	0.25	2.6	19	5.5	3.6	0.1	0.3
RVP1.1.2	Unirrigated	50 - 60	5.1	6.2	0.07	4.8	9.3	0.67	9.9	25	7.6	3.8	0.2	0.5
RVP1.2.1	Irrigated	0 - 10	7.5	8.6	0.28	28.8	16.2	1.14	21.6	81	8.7	0.7	0.1	1.7
RVP1.2.1	Irrigated	20 - 30	6.1	7.1	0.32	30.1	4.6	0.26	4.9	175	2.1	0.6	0.1	1.2
RVP1.2.1	Irrigated	50 - 60	5.7	6.4	0.29	30.6	7.0	0.43	11.6	171	4.8	1.8	0.1	1.2
RVP1.2.2	Unirrigated	0 - 10	5.9	6.4	0.15	31.6	14.8	1.08	32.9	22	7.2	0.4	0.3	<0.1
RVP1.2.2	Unirrigated	20 - 30	4.9	5.6	0.09	23.6	4.3	0.28	8.3	10	2.6	1.2	0.1	<0.1
RVP1.2.2	Unirrigated	50 - 60	5.3	6.0	0.10	20.7	8.8	0.66	21.3	24	6.2	3.6	0.4	0.3
RVP2.1.1	Irrigated	0 - 10	6.3	7.5	0.14	11.6	11.4	0.76	19.6	24	4.9	0.4	0.1	0.9
RVP2.1.1	Irrigated	20 - 30	5.4	6.5	0.14	24.8	3.3	0.18	6.3	74	1.8	0.7	<0.1	0.4
RVP2.1.1	Irrigated	50 - 60	5.6	6.7	0.10	24.0	5.0	0.35	4.3	47	3.6	4.8	0.1	0.9
RVP2.1.2	Unirrigated	0 - 10	5.2	6.3	0.20	20.1	13.4	0.99	21.6	79	4.8	0.9	0.3	0.9
RVP2.1.2	Unirrigated	20 - 30	4.7	5.7	0.15	20.6	5.3	0.34	4.9	83	3.3	1.6	0.1	0.5
RVP2.1.2	Unirrigated	50 - 60	5.4	6.5	0.15	31.2	7.7	0.57	7.0	72	6.9	5.5	0.2	1.4

Wheat at Spring Park

Plot	Treatment	Depth	pH-Ca	pH-W	EC1:5 (dS/m)	Extr Cl (mg/kg)	Total C (g/kg)	Total N (g/kg)	Bray-P (mg/kg)	Extr S (mg/kg)	Ex Ca (cmolc/kg)	Ex Mg (cmolc/kg)	Ex K (cmolc/kg)	Ex Na (cmolc/kg)
SPP10a	Irrigated	0 - 10	4.5	5.3	0.11	16.8	12.7	0.90	24.4	34	3.7	0.2	0.1	0.1
SPP10a	Irrigated	20 - 30	4.3	5.1	0.05	7.0	3.2	0.21	4.3	19	1.8	0.3	0.1	<0.1
SPP10a	Irrigated	50 - 60	4.8	5.9	0.05	5.7	3.2	0.23	1.8	25	5.3	3.6	0.1	0.2
SPC10a	Unirrigated	0 - 10	4.3	4.9	0.08	9.8	10.8	0.82	27.8	11	3.0	0.4	0.1	<0.1
SPC10a	Unirrigated	20 - 30	4.2	4.8	0.05	6.9	3.8	0.26	5.2	14	1.7	0.7	0.1	0.0
SPC10a	Unirrigated	50 - 60	4.6	5.8	0.03	6.7	3.5	0.30	2.9	12	4.9	2.9	0.1	0.1
SPP10c	Irrigated	0 - 10	4.4	5.2	0.06	6.9	12.2	0.89	25.3	10	3.2	0.2	0.2	<0.1
SPP10c	Irrigated	20 - 30	5.2	6.3	0.04	3.3	3.9	0.28	2.7	13	5.0	2.4	0.1	0.2
SPP10c	Irrigated	50 - 60	4.7	5.5	0.04	5.3	4.3	0.24	4.7	11	3.1	0.4	0.1	<0.1
SPC10c	Unirrigated	0 - 10	5.2	6.2	0.03	5.7	3.9	0.29	4.7	11	4.3	2.0	0.1	0.1
SPC10c	Unirrigated	20 - 30	4.8	5.5	0.07	6.8	10.9	0.80	30.2	11	3.6	0.2	0.1	<0.1
SPC10c	Unirrigated	50 - 60	4.3	5.1	0.04	5.4	2.7	0.18	4.2	9	1.6	0.4	0.1	<0.1

Wheat at Davey Rd

Plot	Treatment	Depth	pH-Ca	pH-W	EC1:5 (dS/m)	Extr Cl (mg/kg)	Total C (g/kg)	Total N (g/kg)	Bray-P (mg/kg)	Extr S (mg/kg)	Ex Ca (cmolc/kg)	Ex Mg (cmolc/kg)	Ex K (cmolc/kg)	Ex Na (cmolc/kg)
DRP2.1	Irrigated	0 - 10	4.7	5.4	0.18	10.6	13.0	0.98	16.8	104	3.5	0.9	0.1	0.1
DRP2.1	Irrigated	20 - 30	4.7	5.7	0.06	10.6	4.6	0.29	2.3	19	3.2	1.7	0.1	0.2
DRP2.1	Irrigated	50 - 60	5.1	6.3	0.06	5.5	4.7	0.37	1.6	28	3.3	4.2	0.1	0.7
DRP2.2	Irrigated	0 - 10	4.5	5.1	0.14	9.8	9.7	0.70	11.5	74	2.8	0.4	0.2	0.1
DRP2.2	Irrigated	20 - 30	4.7	5.5	0.05	7.1	3.5	0.25	2.3	13	2.3	0.8	0.1	0.0
DRP2.2	Irrigated	50 - 60	5.3	6.3	0.05	2.6	4.6	0.36	2.2	22	4.8	3.1	0.2	0.3
DRC2	Unirrigated	0 - 10	4.3	4.8	0.11	9.9	11.9	0.87	12.4	49	3.9	0.8	0.2	<0.1
DRC2	Unirrigated	20 - 30	4.4	5.4	0.05	3.6	5.2	0.39	4.1	18	3.0	1.5	0.1	0.1
DRC2	Unirrigated	50 - 60	4.6	5.7	0.05	-0.1	5.7	0.46	3.1	31	4.5	3.3	0.1	0.3
DRP5a	Irrigated	0 - 10	4.3	5.1	0.08	8.0	7.7	0.59	10.0	36	3.4	1.9	0.1	0.1
DRP5a	Irrigated	20 - 30	4.3	5.2	0.06	2.3	4.5	0.32	7.1	22	2.4	1.3	0.1	0.1
DRP5a	Irrigated	50 - 60	5.0	6.1	0.08	11.6	4.8	0.40	2.2	28	7.0	7.1	0.2	0.8
DRC5a	Unirrigated	0 - 10	4.2	4.8	0.10	6.0	8.7	0.61	20.0	30	1.7	0.2	0.1	<0.1
DRC5a	Unirrigated	20 - 30	4.5	5.5	0.03	-3.9	5.1	0.27	2.3	14	3.0	1.3	0.1	<0.1
DRC5a	Unirrigated	50 - 60	4.6	5.8	0.05	1.0	4.8	0.50	3.2	20	3.8	2.8	0.1	0.3
DRP6b	Irrigated	0 - 10	4.4	5.0	0.15	11.4	9.6	0.67	15.6	61	2.8	0.5	0.1	0.1
DRP6b	Irrigated	20 - 30	5.0	6.1	0.06	9.5	2.9	0.19	1.6	19	4.2	2.8	0.1	0.4
DRP6b	Irrigated	50 - 60	5.3	6.5	0.10	39.8	3.1	0.15	2.2	21	3.6	4.6	0.1	1.4
DRC6b	Unirrigated	0 - 10	4.2	4.8	0.08	10.0	8.3	0.59	9.8	28	2.1	0.5	0.1	<0.1
DRC6b	Unirrigated	20 - 30	4.5	5.7	0.04	6.8	5.2	0.40	3.4	15	4.1	4.0	0.1	0.3
DRC6b	Unirrigated	50 - 60	4.3	5.3	0.04	0.4	4.9	0.34	2.7	10	3.5	2.0	0.1	0.1

Appendix 3. Salinity in root zones in 2006.

Radiata Pine Irrigated Plots

Site	Soil Unit	Plot	Treatment	Layer	EC1:5 (dS/m)	ECse (dS/m)	WU Factor	WUW ECse (dS/m) Layer	Profile
Ettamogah	Unit 3	1.02	Effluent	L 0-10	0.11	0.8	0.41	0.32	
Ettamogah	Unit 3	1.02	Effluent	L 20-30	0.09	0.6	0.21	0.13	
Ettamogah	Unit 3	1.02	Effluent	L 50-60	0.35	2.5	0.25	0.61	
Ettamogah	Unit 3	1.02	Effluent	L 80-90	0.50	3.5	0.13	0.46	1.52
Ettamogah	Unit 3	1.03	Effluent	L 0-10	0.20	1.4	0.41	0.57	
Ettamogah	Unit 3	1.03	Effluent	L 20-30	0.16	1.1	0.21	0.24	
Ettamogah	Unit 3	1.03	Effluent	L 50-60	0.22	1.5	0.25	0.39	
Ettamogah	Unit 3	1.03	Effluent	L 80-90	0.24	1.7	0.13	0.22	1.41
Ettamogah	Unit 1	1.09	Effluent	L 0-10	0.31	2.2	0.41	0.89	
Ettamogah	Unit 1	1.09	Effluent	L 20-30	0.58	4.1	0.21	0.85	
Ettamogah	Unit 1	1.09	Effluent	L 50-60	0.73	5.1	0.25	1.28	
Ettamogah	Unit 1	1.09	Effluent	L 80-90	0.66	4.6	0.13	0.60	3.62
Ettamogah	Unit 4	1.26	Effluent	L 0-10	0.68	4.8	0.41	1.95	
Ettamogah	Unit 4	1.26	Effluent	L 20-30	0.27	1.9	0.21	0.40	
Ettamogah	Unit 4	1.26	Effluent	L 50-60	0.48	3.4	0.25	0.84	
Ettamogah	Unit 4	1.26	Effluent	L 80-90	0.67	4.7	0.13	0.61	3.80
Ettamogah	Unit 1	3.02	Effluent	L 0-10	0.18	1.3	0.41	0.52	
Ettamogah	Unit 1	3.02	Effluent	L 20-30	0.20	1.4	0.21	0.29	
Ettamogah	Unit 1	3.02	Effluent	L 50-60	0.34	2.4	0.25	0.60	
Ettamogah	Unit 1	3.02	Effluent	L 80-90	0.29	2.0	0.13	0.26	1.67
Ettamogah	Unit 2	3.11	Effluent	L 0-10	0.32	2.2	0.41	0.92	
Ettamogah	Unit 2	3.11	Effluent	L 20-30	0.24	1.7	0.21	0.35	
Ettamogah	Unit 2	3.11	Effluent	L 50-60	0.31	2.2	0.25	0.54	
Ettamogah	Unit 2	3.11	Effluent	L 80-90	0.26	1.8	0.13	0.24	2.05
								Average	**2.34**
								Std Dev	**1.08**
								Covar%	**46.1**

Maryvale Irrigated Plots

Site	Soil Unit	Plot	Treatment	Layer	EC1:5 (dS/m)	ECse (dS/m)	WU Factor	WUW ECse (dS/m) Layer	Profile
Maryvale Pivot	Unit 2	MVP2a.1	Effluent	L 0-10	0.17	1.19	0.53	0.63	
Maryvale Pivot	Unit 2	MVP2a.1	Effluent	L 20-30	0.23	1.61	0.28	0.45	
Maryvale Pivot	Unit 2	MVP2a.1	Effluent	L 50-60	0.26	1.82	0.19	0.35	1.43
Maryvale Pivot	Unit 3	MVP2a.2	Effluent	L 0-10	0.22	1.54	0.53	0.82	
Maryvale Pivot	Unit 3	MVP2a.2	Effluent	L 20-30	0.18	1.26	0.28	0.35	
Maryvale Pivot	Unit 3	MVP2a.2	Effluent	L 50-60	0.24	1.68	0.19	0.32	1.49
Maryvale Pivot	Unit 2	MVP2b.1	Effluent	L 0-10	0.21	1.47	0.53	0.78	
Maryvale Pivot	Unit 2	MVP2b.1	Effluent	L 20-30	0.29	2.03	0.28	0.57	
Maryvale Pivot	Unit 2	MVP2b.1	Effluent	L 50-60	0.26	1.82	0.19	0.35	1.69
Maryvale Pivot	Unit 3	MVP2b.2	Effluent	L 0-10	0.35	2.45	0.53	1.30	
Maryvale Pivot	Unit 3	MVP2b.2	Effluent	L 20-30	0.41	2.87	0.28	0.80	
Maryvale Pivot	Unit 3	MVP2b.2	Effluent	L 50-60	0.46	3.22	0.19	0.61	2.71
Maryvale Pivot	Unit 4	MVP2c.1	Effluent	L 0-10	0.28	1.96	0.53	1.04	
Maryvale Pivot	Unit 4	MVP2c.1	Effluent	L 20-30	0.28	1.96	0.28	0.55	
Maryvale Pivot	Unit 4	MVP2c.1	Effluent	L 50-60	0.37	2.59	0.19	0.49	2.08
Maryvale Pivot	Unit 4	MVP2c.2	Effluent	L 0-10	0.29	2.03	0.53	1.08	
Maryvale Pivot	Unit 4	MVP2c.2	Effluent	L 20-30	0.31	2.17	0.28	0.61	
Maryvale Pivot	Unit 4	MVP2c.2	Effluent	L 50-60	0.30	2.10	0.19	0.40	2.08
Maryvale Pivot	Unit 4	MVP3a.1	Effluent	L 0-10	0.20	1.40	0.53	0.74	
Maryvale Pivot	Unit 4	MVP3a.1	Effluent	L 20-30	0.26	1.82	0.28	0.51	
Maryvale Pivot	Unit 4	MVP3a.1	Effluent	L 50-60	0.37	2.59	0.19	0.49	1.74
Maryvale Pivot	Unit 4	MVP3a.2	Effluent	L 0-10	0.19	1.33	0.53	0.70	
Maryvale Pivot	Unit 4	MVP3a.2	Effluent	L 20-30	0.34	2.38	0.28	0.67	
Maryvale Pivot	Unit 4	MVP3a.2	Effluent	L 50-60	0.26	1.82	0.19	0.35	1.72
Maryvale Pivot	Unit 4	MVP3b.1	Effluent	L 0-10	0.22	1.54	0.53	0.82	
Maryvale Pivot	Unit 4	MVP3b.1	Effluent	L 20-30	0.22	1.54	0.28	0.43	
Maryvale Pivot	Unit 4	MVP3b.1	Effluent	L 50-60	0.25	1.75	0.19	0.33	1.58
Maryvale Pivot	Unit 4	MVP3b.2	Effluent	L 0-10	0.18	1.26	0.53	0.67	
Maryvale Pivot	Unit 4	MVP3b.2	Effluent	L 20-30	0.15	1.05	0.28	0.29	
Maryvale Pivot	Unit 4	MVP3b.2	Effluent	L 50-60	0.16	1.12	0.19	0.21	1.17
								Average	**1.77**
								Std Dev	**0.43**
								Covar%	**24**

Maryvale Unirrigated Plots

Site	Soil Unit	Plot	Treatment	Layer	EC1:5 (dS/m)	ECse (dS/m)	WU Factor	WUW ECse (dS/m) Layer	Profile
Maryvale Pivot	Unit 2	MVC2a	Nil	L 0-10	0.07	0.49	0.53	0.26	
Maryvale Pivot	Unit 2	MVC2a	Nil	L 20-30	0.10	0.70	0.28	0.20	
Maryvale Pivot	Unit 2	MVC2a	Nil	L 50-60	0.17	1.19	0.19	0.23	0.68
Maryvale Pivot	Unit 2	MVC2b	Nil	L 0-10	0.05	0.35	0.53	0.19	
Maryvale Pivot	Unit 2	MVC2b	Nil	L 20-30	0.06	0.42	0.28	0.12	
Maryvale Pivot	Unit 2	MVC2b	Nil	L 50-60	0.08	0.56	0.19	0.11	0.41
Maryvale Pivot	Unit 4	MVC3a	Nil	L 0-10	0.16	1.12	0.53	0.59	
Maryvale Pivot	Unit 4	MVC3a	Nil	L 20-30	0.11	0.77	0.28	0.22	
Maryvale Pivot	Unit 4	MVC3a	Nil	L 50-60	0.11	0.77	0.19	0.15	0.96
Maryvale Pivot	Unit 4	MVC3b	Nil	L 0-10	0.12	0.84	0.53	0.45	
Maryvale Pivot	Unit 4	MVC3b	Nil	L 20-30	0.08	0.56	0.28	0.16	
Maryvale Pivot	Unit 4	MVC3b	Nil	L 50-60	0.07	0.49	0.19	0.09	0.70
								Average	**0.69**
								Std Dev	**0.22**
								Covar%	**33**

Rosevale Irrigated Plots

Site	Soil Unit	Plot	Treatment	Layer	EC1:5 (dS/m)	ECse (dS/m)	WU Factor	WUW ECse (dS/m) Layer	Profile
Rosevale Pivot	Unit 3	RVP1.1.1	Effluent	L 0-10	0.24	1.68	0.53	0.89	
Rosevale Pivot	Unit 3	RVP1.1.1	Effluent	L 20-30	0.29	2.03	0.28	0.57	
Rosevale Pivot	Unit 3	RVP1.1.1	Effluent	L 50-60	0.30	2.10	0.19	0.40	1.86
Rosevale Pivot	Unit 3	RVP1.2.1	Effluent	L 0-10	0.29	2.03	0.53	1.08	
Rosevale Pivot	Unit 3	RVP1.2.1	Effluent	L 20-30	0.33	2.31	0.28	0.65	
Rosevale Pivot	Unit 3	RVP1.2.1	Effluent	L 50-60	0.29	2.03	0.19	0.39	2.11
Rosevale Pivot	Unit 4	RVP2.1.1	Effluent	L 0-10	0.14	0.98	0.53	0.52	
Rosevale Pivot	Unit 4	RVP2.1.1	Effluent	L 20-30	0.14	0.98	0.28	0.27	
Rosevale Pivot	Unit 4	RVP2.1.1	Effluent	L 50-60	0.10	0.70	0.19	0.13	0.93
								Average	**1.63**
								Std Dev	**0.62**
								Covar%	**38**

Rosevale Unirrigated Plots

Site	Soil Unit	Plot	Treatment	Layer	EC1:5 (dS/m)	ECse (dS/m)	WU Factor	WUW ECse (dS/m) Layer	Profile
Rosevale Pivot	Unit 3	RVP1.1.2	Nil	L 0-10	0.06	0.42	0.53	0.22	
Rosevale Pivot	Unit 3	RVP1.1.2	Nil	L 20-30	0.06	0.42	0.28	0.12	
Rosevale Pivot	Unit 3	RVP1.1.2	Nil	L 50-60	0.07	0.49	0.19	0.09	0.43
Rosevale Pivot	Unit 3	RVP1.2.2	Nil	L 0-10	0.15	1.05	0.53	0.56	
Rosevale Pivot	Unit 3	RVP1.2.2	Nil	L 20-30	0.10	0.70	0.28	0.20	
Rosevale Pivot	Unit 3	RVP1.2.2	Nil	L 50-60	0.10	0.70	0.19	0.13	0.89
Rosevale Pivot	Unit 4	RVP2.1.2	Nil	L 0-10	0.20	1.40	0.53	0.74	
Rosevale Pivot	Unit 4	RVP2.1.2	Nil	L 20-30	0.15	1.05	0.28	0.29	
Rosevale Pivot	Unit 4	RVP2.1.2	Nil	L 50-60	0.15	1.05	0.19	0.20	1.24
								Average	**0.85**
								Std Dev	**0.40**
								Covar%	**47**

Davey Rd and Spring Park Irrigated Plots

Site	Soil Unit	Plot	Treatment	Layer	EC1:5 (dS/m)	ECse (dS/m)	WU Factor	WUW ECse (dS/m) Layer	WUW ECse (dS/m) Profile
Davey Rd Pivot	Unit 2	DRP2.1	Effluent	L 0-10	0.18	1.26	0.53	0.67	
Davey Rd Pivot	Unit 2	DRP2.1	Effluent	L 20-30	0.06	0.42	0.28	0.12	
Davey Rd Pivot	Unit 2	DRP2.1	Effluent	L 50-60	0.06	0.42	0.19	0.08	0.87
Davey Rd Pivot	Unit 2	DRP2.2	Effluent	L 0-10	0.14	0.98	0.53	0.52	
Davey Rd Pivot	Unit 2	DRP2.2	Effluent	L 20-30	0.05	0.35	0.28	0.10	
Davey Rd Pivot	Unit 2	DRP2.2	Effluent	L 50-60	0.05	0.35	0.19	0.07	0.68
Davey Rd Pivot	Unit 3	DRP5a	Effluent	L 0-10	0.08	0.56	0.53	0.30	
Davey Rd Pivot	Unit 3	DRP5a	Effluent	L 20-30	0.06	0.42	0.28	0.12	
Davey Rd Pivot	Unit 3	DRP5a	Effluent	L 50-60	0.08	0.56	0.19	0.11	0.52
Davey Rd Pivot	Unit 3	DRP6b	Effluent	L 0-10	0.15	1.05	0.53	0.56	
Davey Rd Pivot	Unit 3	DRP6b	Effluent	L 20-30	0.07	0.49	0.28	0.14	
Davey Rd Pivot	Unit 3	DRP6b	Effluent	L 50-60	0.10	0.70	0.19	0.13	0.83
Spring Park Pivot	Unit 4	SPP10a	Effluent	L 0-10	0.11	0.77	0.53	0.41	
Spring Park Pivot	Unit 4	SPP10a	Effluent	L 20-30	0.05	0.35	0.28	0.10	
Spring Park Pivot	Unit 4	SPP10a	Effluent	L 50-60	0.05	0.35	0.19	0.07	0.57
Spring Park Pivot	Unit 3	SPP10c	Effluent	L 0-10	0.06	0.42	0.53	0.22	
Spring Park Pivot	Unit 3	SPP10c	Effluent	L 20-30	0.04	0.28	0.28	0.08	
Spring Park Pivot	Unit 3	SPP10c	Effluent	L 50-60	0.04	0.28	0.19	0.05	0.35
								Average	**0.64**
								Std Dev	**0.19**
								Covar%	**30**

Davey Rd and Spring Park Unirrigated Plots

Site	Soil Unit	Plot	Treatment	Layer	EC1:5 (dS/m)	ECse (dS/m)	WU Factor	WUW ECse (dS/m) Layer	WUW ECse (dS/m) Profile
Davey Pivot	Unit 2	DRC2	Nil	L 0-10	0.11	0.77	0.53	0.41	
Davey Pivot	Unit 2	DRC2	Nil	L 20-30	0.04	0.28	0.28	0.08	
Davey Pivot	Unit 2	DRC2	Nil	L 50-60	0.05	0.35	0.19	0.07	0.55
Davey Pivot	Unit 3	DRC5a	Nil	L 0-10	0.10	0.70	0.53	0.37	
Davey Pivot	Unit 3	DRC5a	Nil	L 20-30	0.03	0.21	0.28	0.06	
Davey Pivot	Unit 3	DRC5a	Nil	L 50-60	0.05	0.35	0.19	0.07	0.50
Davey Pivot	Unit 3	DRC6b	Nil	L 0-10	0.08	0.56	0.53	0.30	
Davey Pivot	Unit 3	DRC6b	Nil	L 20-30	0.04	0.28	0.28	0.08	
Davey Pivot	Unit 3	DRC6b	Nil	L 50-60	0.04	0.28	0.19	0.05	0.43
Spring Park Pivot	Unit 4	SPC10a	Nil	L 0-10	0.08	0.56	0.53	0.30	
Spring Park Pivot	Unit 4	SPC10a	Nil	L 20-30	0.04	0.28	0.28	0.08	
Spring Park Pivot	Unit 4	SPC10a	Nil	L 50-60	0.03	0.21	0.19	0.04	0.42
Spring Park Pivot	Unit 3	SPC10c	Nil	L 0-10	0.04	0.28	0.53	0.15	
Spring Park Pivot	Unit 3	SPC10c	Nil	L 20-30	0.07	0.49	0.28	0.14	
Spring Park Pivot	Unit 3	SPC10c	Nil	L 50-60	0.04	0.28	0.19	0.05	0.34
								Average	**0.45**
								Std Dev	**0.08**
								Covar%	**18**

Appendix 4. Annual rainfall, pan evaporation, irrigation and loads of nitrogen, phosphorus, zinc and total dissolved solids (TDS) in effluent applied from 1st July 2004 to 30th June 2006 to Radiata pine and crops and pastures.

Irrigation year 1 Jul - 30 Jun	Rainfall (mm)	Evaporation (mm)	Rainfall (ML/ha)	Irrigation: pine (ML/ha)	Total hydraulic load: pine (ML/ha)	Irrigation: pasture (ML/ha)	Total hydraulic load: pasture (ML/ha)	N pine (kg/ha)	N pasture	P pine (kg/ha)	P pasture	Zn pine (kg/ha)	Zn pasture	TDS pine (kg/ha)	TDS pasture
2005-2006	661	1379	6.6	3.7	10.3	5.2	11.8	19.6	28.2	1.1	1.6	0.39	0.54	6166	8614

APPENDIX 10

Proposal for an Assessment of River Health and River Environment Monitoring Surveys of the Murray River at Albury for Norske Skog
Revised Draft following review by DECC
June 2008

Proposed River Environment Monitoring Surveys

River monitoring surveys will be conducted to assess the effect of Norske Skog's effluent on the receiving environment of the Murray River at Albury. The frequency and timing of these surveys is yet to be determined. This proposal outlines the methods and costs of a single sampling event.

The monitoring program should be implemented as a BACI (Before, After, Control, Impact) design to assess the impact of the effluent. Therefore sampling should commence prior to the discharge of the effluent at upstream and downstream sites to establish the baseline condition, then again after the discharges have commenced to establish any effect or impact of the discharge.

Surveys sediment quality as well as macroinvertebrate community composition will be conducted using the same methods and a subset of the sites that were employed during the surveys conducted by MDFRC for Norske Skog (formerly, Australian Newsprint Mills) from 1992 to 1998 where possible (King and Baldwin 1993, 1994, 1995, 1996 & 1997). Since the original work was completed the Spirit of Progress Bridge (Hume Freeway) over the Murray was built on a section of the river between the railway bridge and the effluent outfall (see Appendix 1). This area was identified as the mixing zone and contained two of the sites used for macroinvertebrate sampling from 1992 to 1997. The area may have been altered by the construction and the presence of the freeway and will need to be assessed for its suitability for this monitoring program. An alternative site may need to be selected. Sediment samples were collected from the deposition zone immediately downstream of the railway bridge and this area may also have been altered by the construction works.

In an effort to reduce cost the number of sites has been reduced (detailed in the following sections). This proposal is based on two sampling sites in the Murray River near Albury

1) Control - upstream of the effluent outfall;
2) Impact – downstream of the effluent outfall (sites to be determined)

Sediment Chemistry

In the first 4 years of the previous monitoring program (1992 to 1995) sediment samples were collected from two deposition zones approximately equidistant (~ 500 m upstream and ~ 500 m downstream respectively) of the mill's effluent outfall. In 1996 & 1997 an additional site 2 km upstream was also sampled, however the elemental composition of sediment from this site was quite different, usually containing higher concentrations of many of the analytes compared with the other two sites (King & Baldwin 1997 & 1996). In an effort to reduce costs it has been necessary to exclude this site from the current proposal.

Sediment sampling should be conducted at the two sites in winter when water levels are low as for previous surveys, usually May or June (King and Baldwin 1993, 1994, 1995, 1996 & 1997). Samples will be collected at 10 metre intervals along the 60 cm depth contour (approximately 2 meters from, and parallel to, the river bank). A total of 20 samples will be taken from each of the deposition zones (40 samples) as for previous surveys. However, to reduce analysis costs without losing too much information on the variability of the analytes at each of the sites, these samples will be combined in the lab, in groups of 4 based on their transect position (i.e. 1 - 4, 5 - 8, 9 - 12, 13 – 16, 17 – 20). A sub-sample of the mixed composite sample will be assayed for cadmium, copper, iron, manganese, zinc, total nitrogen and total phosphorus (10 samples).

Macroinvertebrates

This component has been severely reduced compared with the earlier work. Six sites were used in the previous monitoring program (control (2 sites x 3 samples ~ 500 m upstream); mixing zone (2 sites x 3 samples ~ 500 m downstream); downstream (2 sites x 3 samples ~ 2 km downstream)). Analysis of macroinvertebrates from these 6 sites (18 samples) consistently showed no difference in macroinvertebrates communities compared by site despite monthly sampling over a range of flows and years (King and Baldwin 1993, 1994, 1995, 1996 & 1997). Based this and the budget available, the number of sites has been reduced in this proposed monitoring program. This proposal is based on two paired sites and allows for three samples from each, however it should be noted that five samples are usually recommended for all of the monitoring work conducted using these samplers (Hawking pers. comm.) due to the patchiness of habitats within rivers and high degree of variability in macroinvertebrates communities.

The only way to determine the appropriate number of samples required for this monitoring program is to run power analysis on the extensive data set generated by the previous monitoring program. The cost of this analysis is not included in this proposal.

Aquatic macroinvertebrates will be collected using artificial substrate samplers. Substrates will be deployed a colonizing period of at least one month and not more than 6 weeks. Five artificial substrate samplers will be deployed at each of the 2 paired sites (2 sites upstream and two sites downstream mixing zone). Three substrates from each site will be randomly selected for processing (12 samples) and returned to the lab. If all five substrates are retrievable the other two that are not required will be rinsed in-situ so that the animals are returned to the river.

Macroinvertebrates will be identified at the same taxonomic resolution used in the previous surveys (i.e. genus or species for most groups where appropriate, including chironomids) and counted so that taxonomic diversity and relative abundance can be calculated for each site (King and Baldwin 1993, 1994, 1995, 1996 & 1997).

To comply with current best practice data analyses should include a range of bioassessment metrics. The SIGNAL-2 (Stream Invertebrate Grade Number Average Level) biotic index (Chessman 2003a & b) assesses the relative sensitivity of different taxa to water quality parameters and should be calculated and used to compare the macroinvertebrate communities from the different sites. Other bioassessment metrics may also be used (e.g. EPT index Plafkin *et al.* 1989 and Key Families (Metzeling *et al.* 2006)).

Multivariate statistics (Clarke and Warwick 2001) should also be used to compare the sites based on community data for each substrate (e.g. non-metric Multi Dimensional Scaling (nMDS) to display patterns in community composition; Analysis of Similarity (ANOSIM) to determine significant differences in community composition between sites; Similarity Percentages (SIMPER) to indicate the key taxa contributing to differences in community composition and BIOENV to determine any correlations between differences in community composition and environmental data collected at the same time. However, a one off sampling event data set will have only 6 data points. Multivariate statistical analysis will be of most value when looking at data collected from the sites before and at intervals after the discharge of effluent has commenced.

Subsequent sampling of macroinvertebrates will need to be sensitive to the seasonal variation inherent in macroinvertebrate communities, and reported in the previous work (King and Baldwin 1993, 1994, 1995, 1996 & 1997).

Cost for a Single Sampling Event – Baseline Condition

TASK	**$**
Sediment chemistry (2 sites x 5 composite samples x 7 analytes) data analysis & report	8,745
Macroinvertebrate community structure using artificial substrates (4 sites x 3 samples) data analysis and report	21, 246
TOTAL	**29,991**

References

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King, H. and Baldwin, D. (1997, 1996, 1995, 1994, 1993 and 1992). “Annual Report of Chemical and Biological Monitoring for Australian Newsprint Mills Ltd.” In, “Annual Report of Compliance with EPA Licence Requirements and Development Consent Conditions”, (1997, 1996, 1995, 1994, 1993 and 1992), Australian Newsprint Mills Ltd, Albury Mill, Technical Services Division.

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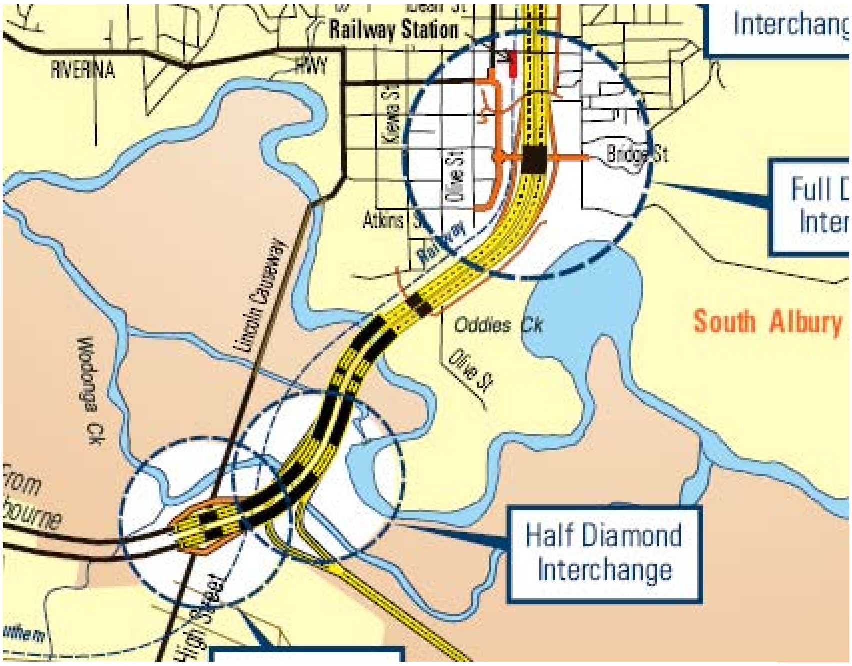
H. Gigney & J. Pengelly

Appendix 1: Location of sites and the Hume Freeway

Figure 1. Approximate location of the mill's effluent outfall and monitoring sites (1992 to 1997) for macroinvertebrates (yellow pins); and deposition zones for sediment sampling. (Satellite image taken prior to the construction of the freeway.)



ALBURY WODONGA HUME FREEWAY PROJECT

Figure 2. Location of Hume Freeway crossing on the Murray River

(www.rta.nsw.gov.au/constructionmaintenance/downloads/awhfp_route_map.pdf)