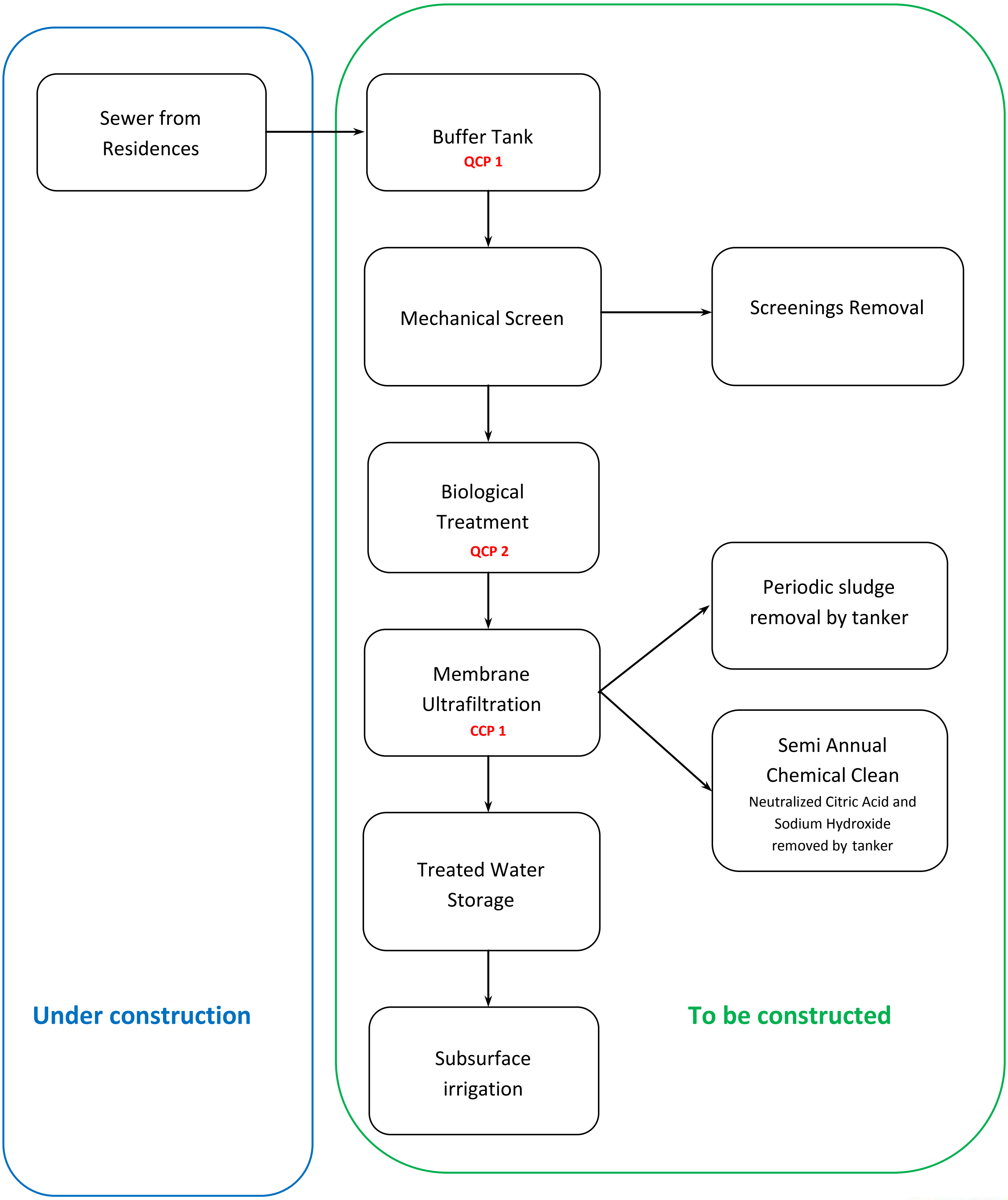
Process Flow Diagram of Kurrajong Hamlet Water Treatment Plant



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EnviroTech PTY LTD

Environmental & Engineering Consultants

Bennett Real Estate

'On-site Wastewater Management Report'

For:

Lot 19 Vincent Rd., KURRAJONG, NSW

Report No.: REP-21408-A

Date: 3RD December 2009

EnviroTech PTY LTD

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LIMITATIONS STATEMENT

EnviroTech Pty. Ltd. has undertaken the following report in accordance with the scope of works set out between EnviroTech Pty. Ltd. and the client.

EnviroTech Pty. Ltd. derived the data in this report primarily from the site and soil assessment conducted on the date of site inspection. The impacts of future events may require future investigation of the site and subsequent data analysis, together with a re-evaluation of the conclusions and recommendations of this report.

In preparing this report, EnviroTech Pty. Ltd has relied upon, and assumed accurate, certain site information provided by the client and other persons. Except as otherwise stated in the report, we have not attempted to verify the accuracy or completeness of any such information.

EnviroTech Pty. Ltd. accepts no liability or responsibility whatsoever for or in respect to any use or reliance upon this report by any third party.

TABLE OF CONTENTS

* Not included with Council Copy report

INTRODUCTION

EnviroTech Pty. Ltd. has been engaged by the client to undertake an 'onsite wastewater management study' at the above mentioned site address. This report presents the results of that study.

Objective

The objective of the 'onsite wastewater management study' is to investigate the relevant site, soil, public health and economic factors that can impact on the selection, location and design of an on-site wastewater management system to determine:

- Whether or not the site is suitable for an on-site wastewater management system
- The best practical on-site wastewater management system for the specific site and proposed development.

This study has been prepared in accordance with:

- Australian Standard AS1547: 2000"On-site Domestic Wastewater Management"
- Dept. Local Government 1998, On-site Sewage Management for Single Households,
- Relevant Council Development Control Policies

Scope of Works

The scope of works undertaken for this site evaluation included:

- *Desktop Study* – An initial investigation to collate relevant information about the site and proposed development prior to the site inspection.

- *Site Assessment* – An on-site inspection by an engineer or scientist to record land surface, site features, identify potential site constraints and define the most appropriate land application area.

- *Soil Assessment* – A subsoil investigation by an engineer or scientist to record the soil profile and relevant soil properties within the land application area to determine potential soil limitations.

- *On-site Wastewater Management System Design* - An evaluation of the expected wastewater flowrate, site and soil limitations to select, size and position a waste treatment unit and land application system that will provide the best practical option.

- *Operation & Maintenance / Construction & Installation Guidelines*

DESKTOP INFORMATION

Proposed Development: New wastewater treatment system for proposed retirement village

Intended Water Supply Source: Town water

Equivalent Population: Up to 54 people (18 dwellings)

Design Wastewater Allowance: 110 L / person / day[1]

1: Households with "full water-reduction facilities"
- Reduced flush 6/3 litre water closets,
- Aerator faucets,
- Front-load washing machines,
- Shower-flow restrictors

Design Wastewater Flowrate 5940 L / day

Climate

Rainfall: Source: Bureau of Meteorology – Richmond RAAF

- Median Annual Precipitation: 835.6mm
- Median Monthly Precipitation (mm):

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
75.6	78.4	74.8	45.3	29.4	32.7	24.4	21.2	30.5	53.0	61.8	56.2

Evaporation: Source: Bureau of Meteorology – Richmond RAAF

- Mean Daily Evaporation (Annual Value): 4.3mm
- Mean Daily Evaporation (Monthly Values):

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
6.3	5.4	4.4	3.3	2.1	1.8	2.0	3.1	4.3	5.4	5.9	7.0

Site Assessment

This following relevant site features were recorded and given a rating in terms of their potential constraints to onsite wastewater management. The three ratings are minor limitation, moderate limitation or major limitation. Only those site features that are rated as being a major limitation to onsite wastewater management are further discussed in the 'Site Assessment Discussion'.

Landform Description

The landform is described by first dividing an area into landform elements of approximately 40-m diameter. A description of the slope, morphological type and relative inclination is then provided for each element. These landform elements define the boundaries of this site assessment.

Landform Element	*Slope (%)*	*Morphological Type*	*Relative inclination*	*Slope Instability*
1	14	Mid hillslope	Linear planar	Low

Vegetation

The vegetation is described by dividing the study area into vegetation elements. Each vegetation element has a unique set of properties.

Vegetation Element	*Growth Form*	*Height*	*Cover / Separation*
A	Closed Grassland	< 300 mm	Dense
B	Open Woodland	< 10-m	Well separated

Vegetation Element	*Exposure*	*Existing Erosion*		*Landform Element (s)*
		State	*Type*	
A	Excellent	Stabilised	-	1
B	Good	Stabilised	-	1

Overland Flow

Run-on and run-off potential is largely determined by slope, surface cover and soil infiltration rate.

Landform element.	*Run-on*	*Run-off*
1	Slow +	Moderately Rapid

+ A run-on diversion drain already exists above the proposed effluent disposal area.

Soil Disturbance

The site assessor noted no areas of soil disturbance within the available land application envelope.

Rocky Outcrops

The site assessor noted no areas of rocky outcrops.

Soil / Water Status

No wet areas observed.

Setbacks

The following buffer distances are available between the proposed land application area and:

Permanent Watercourses:	> 100-m
Intermittent Watercourses / Dams:	> 40-m
Dwellings:	> 15-m
Paths & Walkways:	> 3-m
Property Boundaries:	
- Up-gradient: > 3-m	- Down gradient: > 6-m

Site Assessment Discussion

A range of site features that can commonly place limitations on on-site wastewater management have been assessed and classified. All features, except the following, have been shown to place <u>no major limitations</u> to on-site wastewater management.

Run-off

Run-off from the proposed land application area is classified as moderately rapid due to the landform elements within and surrounding the land application area being moderately inclined.

Treated wastewater run-off beyond the boundaries of the proposed land application area can pollute adjacent areas. In particular, discharge of additional organic matter, suspended solids, nitrogen and phosphorus to the on-site dam may promote the growth of oxygen demanding algae. Algal growth consequentially kills off other organisms in dams, creeks and rivers that rely on sufficient oxygen concentrations to survive.

Sub-surface irrigation removes the problem of treated wastewater run-off. It is therefore recommended that, because of the moderately inclined land application area, that sub-surface irrigation be installed. Lateral and vertical seepage will also provide further biological and physical treatment of the irrigation water

SOIL ASSESSMENT

The location of the borehole excavated during the site inspection is shown on the attached site plan. Physical and chemical soil properties were recorded on a soil profile log (see attached). On each property two boreholes are performed, the first analyses soil features listed below, and the second serves a confirmatory borehole. If soil properties found in the two boreholes on site differ, then both samples are taken for analysis.

The following properties were recorded for each soil horizon:

- Horizon depth and type
- Mottling
- Colour
- Structural stability
- Depth to groundwater
- Depth to bedrock
- Texture
- pH
- Electrical Conductivity
- Coarse Fragments Percentage
- Phosphorus Sorption Capacity

Physical Properties

In summary, the soil profile is described below:

Soil Horizon	Depth	Colour	Mottles	Coarse Fragments %	Texture
A2	400	Brown	-	< 10	Clay loam
B1	1500	Red Brown	-	< 10	Light clay

Excavation terminated at: 1500 mm

Reason: Soil depth is minor limitation

Bedrock Depth: > 1500-mm.

Water Table Depth: > 1500-mm

Topsoil soil-water status: Moderately moist

Surface Condition: Firm

Chemical Properties

Soil samples were collected from each major soil horizon and the relevant chemical properties are presented below:

Borehole 1

Horizon	*PH*	*Electrical Conductivity (μS/cm)*
A2	5.54	45
B1	5.07	67

Phosphorus Adsorption Capacity (kg / ha): 18,270

Erodability / Erosion Hazard

Soil erodability is the susceptibility of the topsoil to detachment and transport of soil particles. It is a characteristic of the soil surface and varies with time, soil / water status and land use. Soil erodability classification is stated as low, moderate or high.

Erosion hazard is the susceptibility of an area of land to the prevailing agents of erosion. It is a function of climate, soil erodability, vegetation cover and topography.

	Borehole 1
Erodability	Moderate
Erosion Hazard	Slight

Salinity

Salinity is the concentration of water-soluble salts contained within a soil. Increases in soil salinity (i.e. salinisation) can occur as a result of irrigation water raising the level of an already saline groundwater. Management of potential salinisation problems involve ensuring that salts introduced to the soil surface are removed (by crop uptake or subsoil leaching) and by ensuring the irrigation area provides adequate subsoil drainage to prevent raising of saline groundwaters into root zones.

Drainage is a statement describing the site and soil drainage that is likely to occur most of the year. It is influenced by soil permeability, water source, landform description, evapotranspiration, slope gradient and slope length.

The drainage of this site should be adequate for the leaching of salts and ensure the groundwater level does not reach the root zone.

A major adverse effect of high soil salinity is the restrictive effects on plant growth. However, for this site the soil salinity levels (as indicated by the electrical conductivity values) are low enough that the adverse effects on plant growth will be minimal.

Soil Assessment Discussion

A range of soil properties that commonly place limitations on on-site wastewater management have been assessed and classified. In accordance with the Environmental and Health Protection Guidelines all soil properties have been shown to present no major limitations to on-site wastewater management.

On-site Wastewater Management System Design

The design process adopted here involves an evaluation of the expected wastewater flow, site limitations and soil limitations, to select, size and position a waste treatment unit and land application system that will provide the best practical option.

A nutrient balance and water balance were modeled to determine the minimum land application area and wet weather storage requirements.

Nutrient Management

Nutrients commonly found in secondary treated wastewater (effluent) such as nitrogen and phosphorus are generally beneficial to plant growth and need not be removed from the effluent <u>if</u> it can be demonstrated that the land application area can sustain the additional nutrient loading in the short term and long term.

A ‘Nutrient Mass Balance’ (NMB) models the movement of nutrients in the land application area. The NMB allows us to predict the maximum nutrient application rate and can therefore limit the effluent application rate to a given area.

In a NMB, the amount of specific nutrient (nitrogen or phosphorus) assumed to be applied in a year is compared with the amount taken up by the biological, chemical and physical processes of the plant-soil system within the land application area.

> *Note: Preventing Nutrient Accumulation*
>
> Nutrients retained in a standing plant, detritus or residual humus must be regarded as potential sources of soluble nitrogen (or phosphorus) that can pollute surface and ground water. Therefore removal of the harvested plants from the site is required to prevent nutrient accumulation.

Nitrogen

The chemical forms of nitrogen typically found in secondary treated wastewater (effluent) are:

• Organic	0% – 25%
• Mineral:	
- Gaseous ammonia and ammonium,	25%
- Nitrate and nitrite.	50% – 75%

Note: The mineral forms of nitrogen are readily transformed into other mineral forms

Nitrate / Nitrite

- Most readily mobile nitrogen form,
- Most readily taken up by plants,
- Readily leached to groundwater,
- Unsuitable for stock and domestic water supplies in high concentrations,
- Can nourish unwanted plants and algae

Ammonia / Ammonium
- Lost to the atmosphere in gaseous form (ammonia)
- Conservative estimate of 20% of liquid ammonium volatilised to ammonia,

Organic Nitrogen
- Much slower interaction with plant growth / environment than mineral forms
- Converted over 5-years to mineral forms through a 'mineralisation' process,
- Remaining organic nitrogen retained as residual humus
- Humus slows decomposes, continuing to release mineral nitrogen forms

Nitrogen Mass Balance

A nitrogen mass balance in a plant-soil system is complex. It includes:

1) Additions to the system via:
   - Effluent
   - Fertiliser
   - Nitrogen fixation by plants

2) Losses from the system via:
   - Removal of harvestable plant matter,
   - Volatilisation of ammonia,
   - De-nitrification of nitrates / nitrites to nitrogen gas,

3) Transformations into other forms of nitrogen (for example 'mineralisation'),

4) Nitrogen storage in the system (for example as humus in the soil).

A simple, yet conservative approach to the nitrogen mass balance is to compare the total nitrogen usage of each harvested plant (calculated as average plant yield x % nitrogen in the plant) with the amount of total nitrogen available from the effluent (estimated as effluent total-nitrogen concentration).

For a given design flowrate and plant type within an effluent irrigation area it is therefore possible to calculate a minimum irrigation area required to ensure nitrogen applied does not exceed the plant nitrogen-removal capacity.

Phosphorus

Phosphorus contained in effluent (usually expressed as just 'Total P') exists in several forms that include:

- Orthophosphates - most readily available for reacting with the soil-plant-water system
- Polyphosphates - Slowly broken down to orthophosphates
- Organic phosphates - More slowly broken down than polyphosphates,

Phosphorus Mass Balance

The three major phosphorus removal mechanisms are;

- Vegetation uptake,
- Chemical precipitation,
- Soil adsorption.

Similar to the nitrogen mass balance described previously, a simple approach to a phosphorus mass balance is to compare the total phosphorus usage of each harvested plant (calculated as average plant yield x % phosphorus in the plant) with the amount of total phosphorus available from the effluent (estimated as effluent total-phosphorus concentration).

P Sorption Capacity

Unlike a nitrogen mass balance, a phosphorus mass balance includes removal by soil adsorption. Soil adsorption of P (P sorption capacity) is an immobilisation reaction that renders phosphorus unavailable for plant uptake. A simple explanation of P sorption capacity is that the soil behaves like a phosphorus 'sink'. The phosphorus sink will in time reach a point when the soil is saturated with phosphorus ('the sink is full'). The recommended lifespan of a land application area is 50 years[1].

The phosphorus saturation point of most soils is probably reached between 0.25 and 0.5 of total sorption capacity (Kruger et al, 1995). We shall use a value of 0.33. Further phosphorus applications to the soil will result in phosphorus leaching to further below.

[1] NSW Dept Local Government, 1998. "On-site Sewage Management for Single Households".

For the soil on this site, the phosphorus sorption capacity was determined using a 90 percentile value from known soil data. The data set used to determine the 90 percentile included only those soils within a similar soil landscape, of same texture (particularly clay %) with similar pH and electrical conductivity values. This data was obtained from several “Soil Landscapes” texts published by the Soil Conservation Service of NSW.

Therefore a phosphorus mass balance compares the total phosphorus usage of each plant plus the phosphorus soil adsorption with the amount of total phosphorus available from the effluent.

For a given design flowrate, plant type and P sorption capacity within an effluent irrigation area it is therefore possible to calculate a minimum irrigation area required to ensure phosphorus applied does not exceed the plant phosphorus-removal capacity and soil P sorption capacity within 50 years.

Note: Plant Yield

Nutrient uptake by vegetation becomes inhibited when the vegetation is not experiencing an active growth period. Therefore to ensure year-round nutrient removal the vegetation grown should contain a species or mix of species such that at any given time of the year, within the land application area, there is vegetation experiencing active growth.

	Mass Balance	**Minimum Irrigation Area (m²)**
	Nitrogen	4752
	Phosphorus	1960
Limiting Nutrient	**Nitrogen**	**4752**

Water Balance

The ‘water balance’ models the interactions between climate, soil, and topography. For a site where wastewater land application is proposed, the ‘natural water balance’ has to be modified to include the applied wastewater. The modified water balance becomes:

$$P + Tw = Et + S_L + S_V + \Delta S$$

Where:

Inputs:

P = Precipitation

Tw = Wastewater applied

Outputs:

Et = Evapotranspiration

S_L = Lateral seepage

S_V = Vertical seepage

ΔS = Changes in the soil-water storage

Note:
Some regulatory authorities take the view that for a land application area to be sustainable it must be designed so that lateral seepage (S_L) and vertical seepage (S_V) of wastewater equal zero, thereby relying wholly on evapotranspiration to remove the applied wastewater plus precipitation.

From an environmental science point of view this is usually incorrect. On land where treated wastewater is stripped of its nutrients and microorganisms to a very high degree by treatment processes, in most cases there can be no objection to ‘clean’ water being removed by vertical seepage and lateral seepage.

OBJECTIVE

The objective of modeling the water balance for a site where wastewater land application is proposed is to calculate the minimum irrigation area size required for a given wastewater loading, or inversely, the maximum wastewater loading that can be applied to a given land application area. In calculating these values we must ensure the following requirement is satisfied:

“Sub-surface saturation shall not be caused by wastewater application.”

COMPONENT DEFINITIONS

Precipitation (P)
Precipitation is the rainfall pattern over a historical period. Precipitation data is obtained from the Bureau of Meteorology (BOM). The weather station chosen as a source of precipitation data shall be relatively close to the site and have a substantial period of available historical data. One set of precipitation data is used in the water balance:

- Median monthly precipitation

Treated Wastewater Applied (Tw)
The amount of treated wastewater applied measured as a depth. This is calculated by dividing the average monthly wastewater flow by a nominated land application area.

Evapotranspiration (Et)
Monthly evapotranspiration is estimated by multiplying pan evaporation by a relevant crop factor. Pan evaporation data is obtained from the Bureau of Meteorology (BOM). The weather station chosen for pan evaporation data shall be relatively close to the site and have a sufficient period of available historical data.

Subsurface Seepage - Vertical (S_V) & Lateral (S_L)
Seepage velocity through a permeable medium is proportional to the permeability of the medium (saturated hydraulic conductivity – K_{sat}) and the hydraulic gradient.

- Lateral Seepage is estimated as the relevant Design Irrigation Rate (DIR) recommended in AS1547: 2000 for the conducting soil layer multiplied by the slope of the soil layer.

- Vertical Seepage is estimated as the relevant Design Irrigation Rate (DIR) recommended in AS1547: 2000 for the least permeable subsoil layer multiplied by a hydraulic gradient of 1.

Changes in Soil-Water Storage (ΔS)
Soil-water storage is the difference between water inputs (P + Tw) and water outputs (Et + S_L + S_V)]. Changes in soil-water storage are the difference in soil-water storage values between different model time steps.

GENERAL WATER BALANCE METHODOLOGY

1 - Nominate a Land Application Area Size

Nominate the minimum irrigation area requirement as from the nutrient balance. This value becomes the initial area value against which we will check that the water balance is satisfied.

2 - Check that:

"Sub-surface saturation shall not be caused by wastewater application."

To check that sub-surface saturation shall not be caused by wastewater application we will use a water balance model using the median precipitation event (refer to attached spreadsheet)

Water Balance Summary
The minimum irrigation area required based on the water balance was found to be 4752m^2

System Selection

Treatment System*:* Aerated Wastewater Treatment System (AWTS)

- Reason:

High quality effluent produced suitable for irrigation purposes

Land Application System: Low-pressure Effluent Irrigation

Irrigation System Options

EnviroTech recommends the following method of irrigation is suitable for installation on this site.

Any irrigation system must be installed within the proposed irrigation shown on the site plan or within the 'available irrigation envelope' (if an envelope is shown on your site plan).

Option4: Subsurface Drip Irrigation

Subsurface drip irrigation includes fixed and buried drip irrigation lines generally laid in parallel at 1-m spacings. These systems require flush valves, vacuum breaker valves and effluent filters. The drippers should be pressure compensating to allow even discharge from all drippers along a drip line. Specialist design advice from irrigation system installers should be sought.

<u>Please refer to Appendix E for further detailed irrigation descriptions and standard drawings.</u>

Site Modifications Recommended

- Fit "full water-reduction facilities" to all water use outlets in the house:
    - o Reduced flush 6/3 litre water closets,
    - - Aerator faucets,
    - o Front-load washing machines,
    - - Shower-flow restrictors

RECOMMENDATIONS

- Installation of a NSW Health accredited Aerated Wastewater Treatment System (AWTS) with capacity to treat the design flowrate (5940 L/d) to a secondary treatment standard with disinfection.

- Installation of 4752 m^2 of a low-pressure effluent irrigation system.

- The proposed land application area is designated for effluent reuse only.

- EnviroTech recommends all of the following irrigation system types (presented as options) are suitable for installation on this site.
  ~~+ Option1: Moveable Surface Irrigation~~
  ~~+ Option2: Fixed / Semi-fixed Surface Spray Irrigation~~
  ~~+ Option3: Surface Drip Irrigation~~
  + Option4: Subsurface Drip Irrigation

- To provide the client with a better understanding of the suitable irrigation options for their property and also guidance on the construction / installation of such irrigation types, this wastewater report includes comprehensive irrigation descriptions and drawings.

- Further site-specific irrigation details (for example, accurate sprinkler and distribution line positioning within the proposed irrigation area), if required, may be determined in consultation with your plumber / irrigation installer.

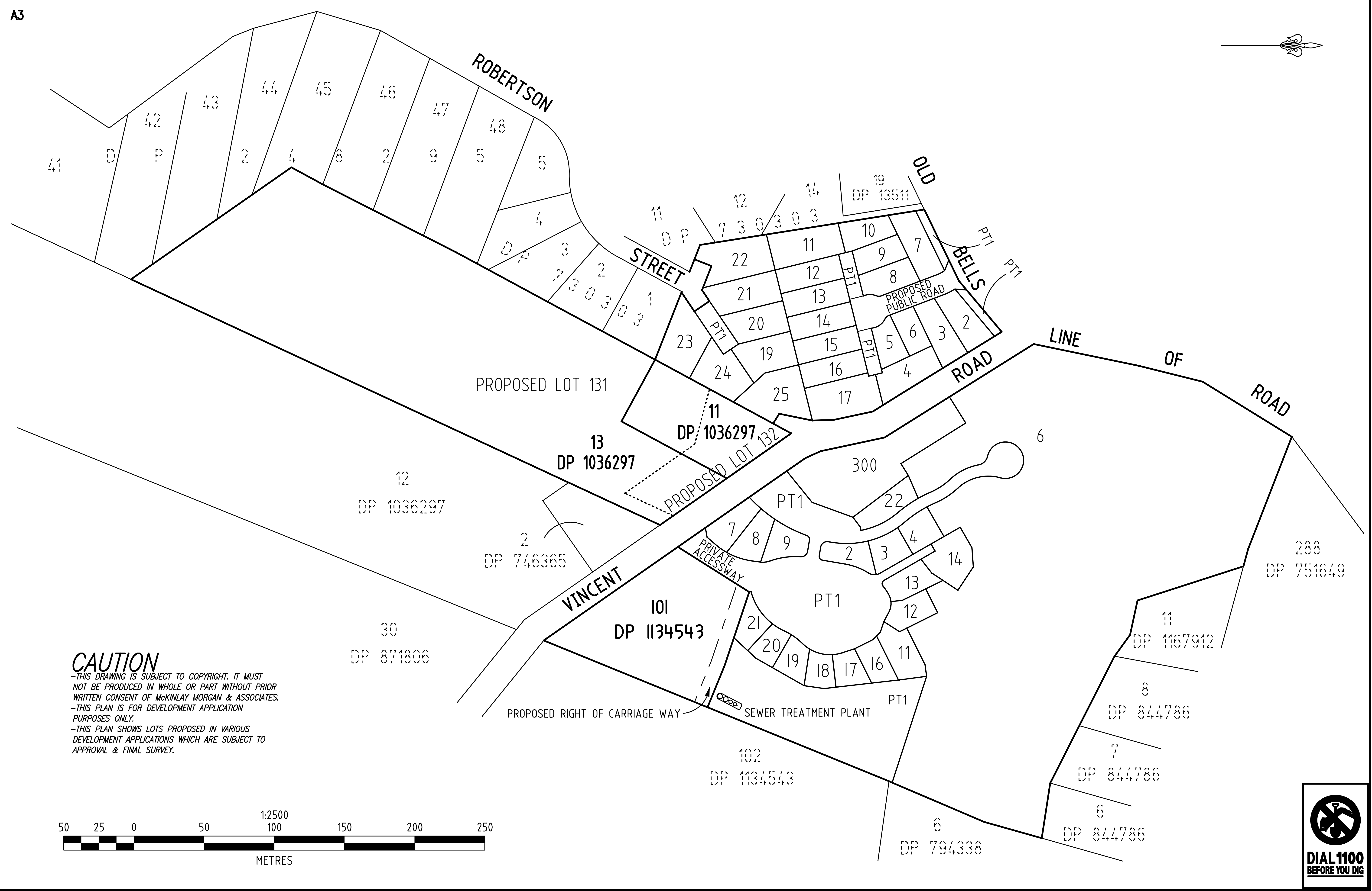
- Each irrigation system must be installed within the proposed land application area shown on the site plan or within the ‘available irrigation envelope’ (if an envelope is shown on your site plan).

- Fit “full water-reduction facilities” to all water use outlets in the house:
  - Reduced flush 6/3 litre water closets,
  - Aerator faucets,
  - Front-load washing machines,
  - Shower-flow restrictors

Regards,
ENVIROTECH PTY. LTD.

Daniel Mathew
Senior Environmental Engineer

A3



CAUTION

- THIS DRAWING IS SUBJECT TO COPYRIGHT. IT MUST NOT BE PRODUCED IN WHOLE OR PART WITHOUT PRIOR WRITTEN CONSENT OF McKINLAY MORGAN & ASSOCIATES.
- THIS PLAN IS FOR DEVELOPMENT APPLICATION PURPOSES ONLY.
- THIS PLAN SHOWS LOTS PROPOSED IN VARIOUS DEVELOPMENT APPLICATIONS WHICH ARE SUBJECT TO APPROVAL & FINAL SURVEY.

DIAL 1100 BEFORE YOU DIG

Date		REVISION
	F	
	E	
	D	
	C	
	B	
2-10-12	A	STP ADDED

MILLIMETRES AT A3: 0 5 10 15 20 25 ... 50 55 60 65 70 75

DESIGN BY
SURVEY BY
CALCS BY
DRAWN BY GD/AJE
CHECKED BY AJE

REDUCTION RATIO AT A3 1:1500
CONTOUR INTERVAL
ORIGIN OF LEVELS
DATUM

McKINLAY MORGAN & ASSOCIATES Pty Ltd.
ACN 003 750 525 ABN 23 003 750 525
CONSULTING SURVEYORS - PROJECT MANAGERS
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PO Box 217 Windsor NSW 2756
Phone: 4577 6011
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Email: mail@mckinlaymorgan.com.au
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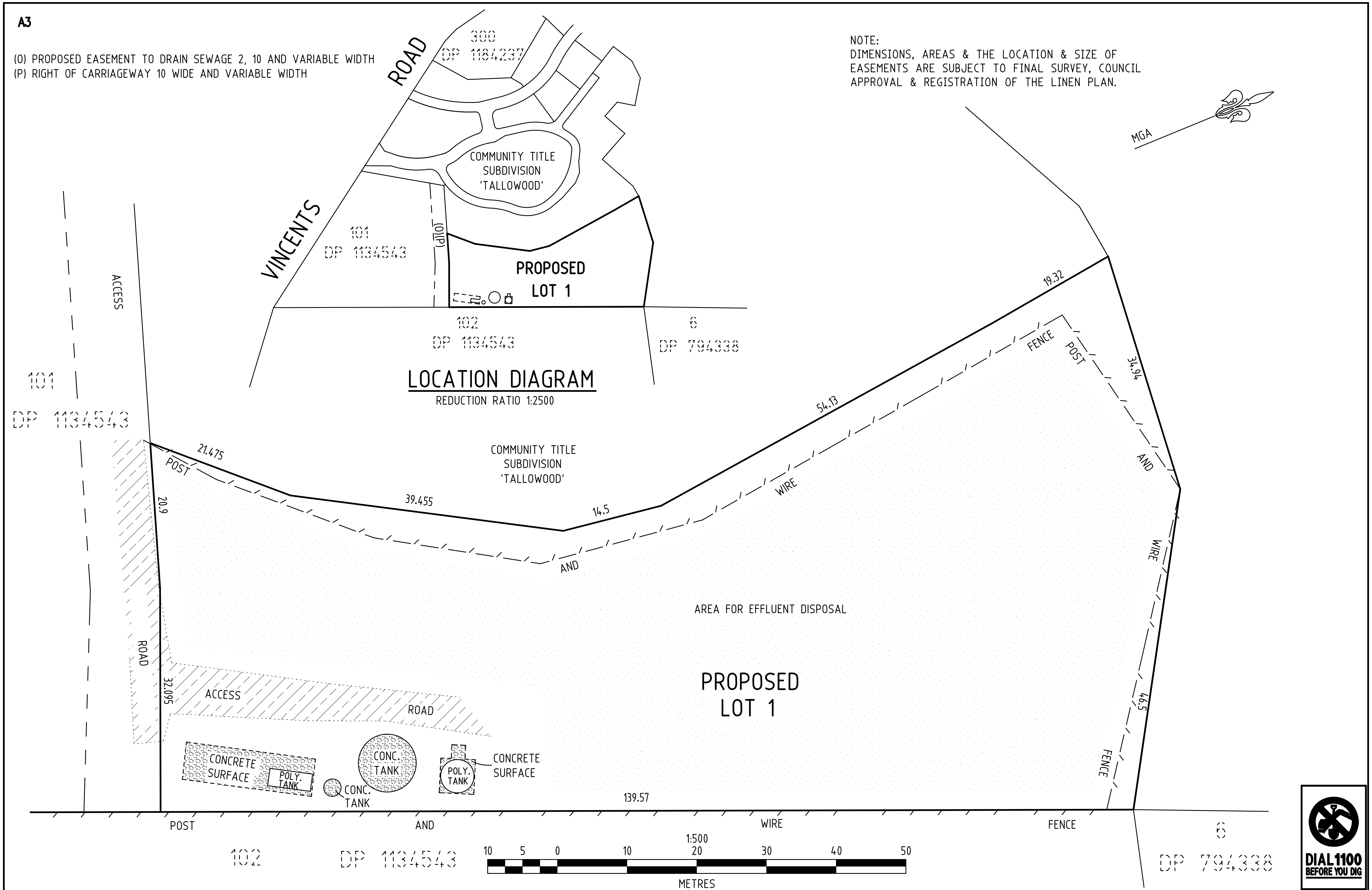
DATE 29 AUGUST 2012
FILE No. 89312/1
COUNCIL REF
CLIENT NAME BENCORP
LOCALITY KURRAJONG
LGA HAWKESBURY
PLAN No. 89312:DA:8
C.FILE: 893121DA8-A.DWG

PLAN OF EXISTING LOTS AND PROPOSED DEVELOPMENTS AT KURRAJONG

SHEET No. 1 OF 1 SHEETS

A0069 Appendix 4.3.3.2 - Location of Treatment Plant_DETAIL



Date		REVISION
	F	
	E	
	D	
	C	
	B	
	A	

0 5 10 15 20 25 MILLIMETRES AT A3 50 55 60 65 70 75

DESIGN BY
SURVEY BY TS
CALCS BY
DRAWN BY TS
CHECKED BY AE

REDUCTION RATIO AT A3 1:500
CONTOUR INTERVAL
ORIGIN OF LEVELS
DATUM

McKINLAY MORGAN & ASSOCIATES Pty Ltd.
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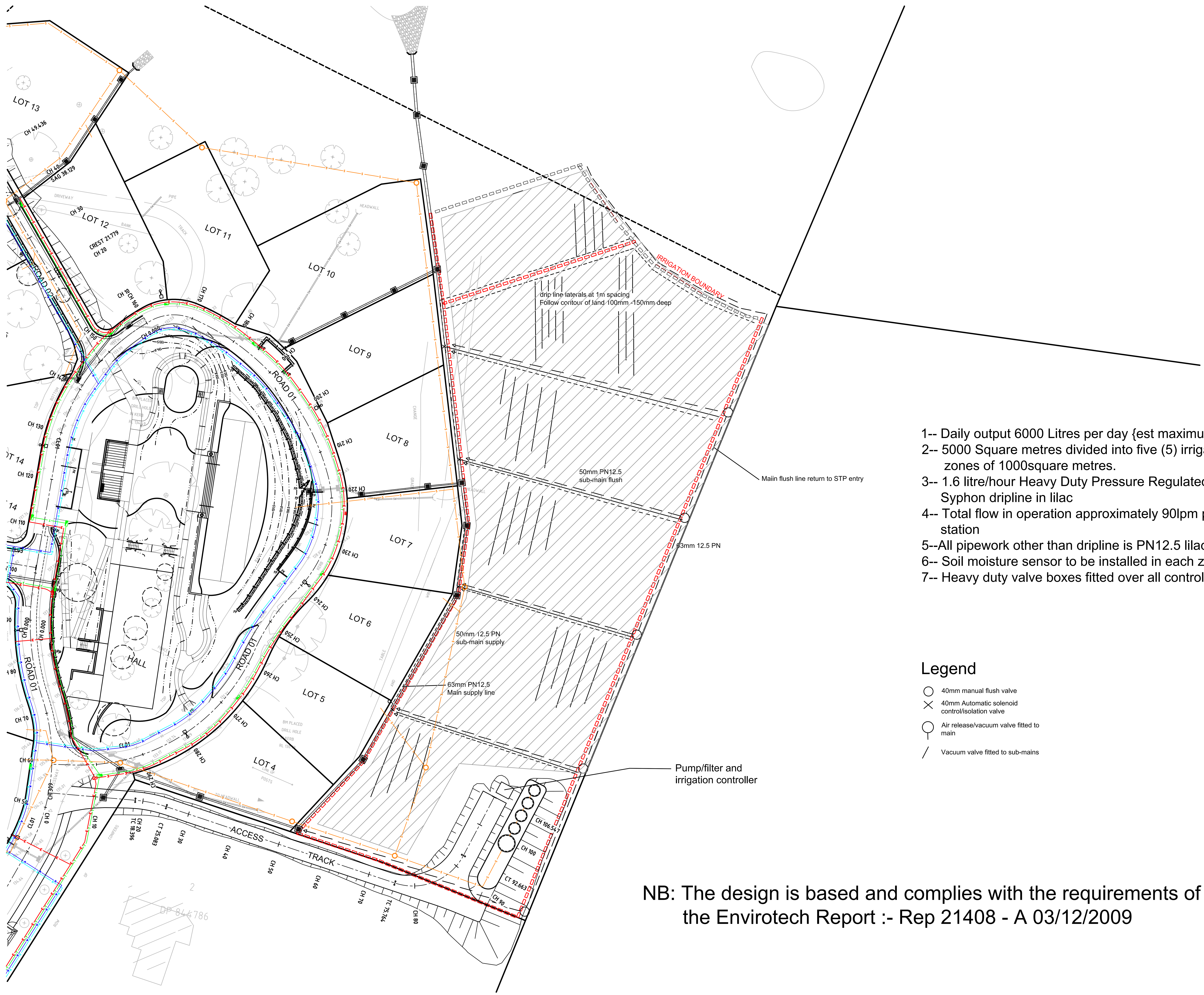
DATE OF SURVEY 29 OCTOBER 2013
FILE No. 88159/3
COUNCIL REF
CLIENT NAME BENCORP DEVELOPMENTS
LOCALITY KURRAJONG
LGA HAWKESBURY
PLAN No. 88159/3:0:4
C.FILE: 88159 3STP.DWG

PLAN OF SEWER TREATMENT PLANT FOR THE COMMUNITY TITLE SUBDIVISION 'TALLOWOOD' VINCENTS ROAD KURRAJONG

SHEET No. 1 OF 1 SHEETS



1-- Daily output 6000 Litres per day {est maximum}
2-- 5000 Square metres divided into five (5) irrigation zones of 1000square metres.
3-- 1.6 litre/hour Heavy Duty Pressure Regulated Anti-Syphon dripline in lilac
4-- Total flow in operation approximately 90lpm per station
5--All pipework other than dripline is PN12.5 lilac
6-- Soil moisture sensor to be installed in each zone
7-- Heavy duty valve boxes fitted over all control valves

Legend

- ○ 40mm manual flush valve
- × 40mm Automatic solenoid control/isolation valve
- Air release/vacuum valve fitted to main
- / Vacuum valve fitted to sub-mains

NB: The design is based and complies with the requirements of the Envirotech Report :- Rep 21408 - A 03/12/2009

Issue	Description	Date
B	Pump/filter station relocated	26/07/12
A	For Approval	7/12/11

Project:

Bennett Hamlet Kurrajong Village

Lang Irrigation Pty Ltd
0419 469 365
P.O. Box
Richmond 2753

Design CI	Drawn IG
Drawing No. 001	Scale 1:400

Effluent Management Investigations

at

Vincent Road, Kurrajong

Prepared for

BENNETT PROPERTY

Woodlots and Wetlands Pty Ltd
220 Purchase Road
Cherrybrook
NSW 2126

Document Registration

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Date Issued	15 November 2012
Document File name	*Kurrajong Hamlet Effluent Management Investigation V2*
Document Title	Effluent Management Investigations at Vincent Road, Kurrajong
Document Registered By	Peter Bacon Principal Consultant

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Acknowledgements

The technical assistance of Aquacell Pty Ltd is gratefully acknowledged.

Glossary

Abbreviation or acronym	Explanation
ADWF	Average Dry Weather Flow (cubic m/day)
BOD	Biological Oxygen Demand
C	Carbon
Ca	Calcium
CANRI	Community Access Natural Resource Information
cfu	Colony Forming Units. A measure of microbial population. It is sometimes referred to as MPN (Most Probable Number)
cm	centimetres
DALY	Disability Adjusted Life Years. A World Health Organisation sponsored system of assessing the impact of accidents or disease on a population. DALYs for a disease or health condition are calculated as the sum of the Years of Life Lost (YLL) due to premature mortality in the population and the Years Lost due to Disability (YLD) for incident cases of the health condition (WHO web site, accessed May, 2012). The minimum tolerable health risk is typically 10^{-6} DALY (NRMMC/ EPHC/ AHMC (2006).
DEC	Department of Environment and Conservation (in 2012 it was part of Office of Environment and Heritage)
DIPNR	Department of Planning Infrastructure and Natural Resources in May 2012, the environmental components had been transferred to the Office of Water (NOW) and OEH)
DIR	Design Irrigation Rate as per AS/NZS 1547
dS/m	decisiemens/metre A measure of electrical conductivity (1 dS/m=1000 microsiemens/cm)
Effective risk management	The identification of all potential hazards, their sources and hazardous events, and an assessment of the level of risk presented by each.
Effluent	Treated wastewater from a sewage treatment plant (STP)
Ensiled	Storage of fodder as silage. Silage is the result of anaerobic fermentation process used to preserve green vegetation such as oaten hay or green pasture. The vegetation is and packed while at about 70-80% moisture and put into sealed holes in the ground.
ESCP	Erosion and Sediment Control Plan
Field capacity (water holding capacity)	The amount of water held in soil once gravitational water has drained from the profile. Typically it is reached approximately 48 hr. after saturation. It can be expressed as a variety of units. In the current report it is in mm of water stored in the plant root zone.

Faecal coliforms	Bacteria that is indicative of faecal contamination.
g	grams
K	Potassium
ha	hectare (1 ha=100m*100m)
HACCP	HACCP is the Hazard Analysis and Critical Control Point system. (That is: What can we do to reduce hazards)
Hazard	HAZARD=probability*consequences A hazard is a biological, chemical, physical or radiological agent that has the potential to cause harm. A hazardous event is an incident or situation that can lead to the presence of a hazard. (What can happen and how)?
HRT	Hydraulic Retention Time – the average travel time for water to pass through a system such as a wetland, maturation pond or reaction chamber.
kg	Kilograms
kL	Kilolitres (1000 L)
km	kilometres
L	litres
m	metres
mg	milligrams (10^{-3}g)
Mg	Magnesium
mL	millilitres (10^{-3}L)
ML	megalitres (10^{6}L)
MSDS	Material Safety Data Sheets
Na	Sodium
N	Nitrogen
EMP	Environmental Management Plan
P	Phosphorus
PET	Potential Evapotranspiration: Rate of loss of water from plants and soil when there is an unlimited supply.
pH	A measure of acidity
Risk	The likelihood of identified hazards (see definition above) causing harm in exposed populations in a specified timeframe, including the severity of the consequences.

	(How likely is it to happen? How serious are the consequences?) Risk is maximum risk in the absence of preventive measures Residual risk is the risk after consideration of existing preventive measures.
SAR	Sodium Adsorption Ratio. A measure of the ratio of sodium to calcium plus magnesium. It is used in conjunction with salinity data to determine the stability of irrigation water.
Stormwater	Rainfall derived water arising from roof or ground surfaces.
STP	Sewage Treatment Plant
TWL	Top water level (m)

Executive summary

This investigation is concerned with providing a proposed development at Vincent Road Kurrajong with a sustainable system for managing its tertiary treated sewage.

According to the Australian Bureau of Statistics, the average number of residents per dwelling in the Kurrajong urban area is 2.7. Many of the 41 dwellings to be connected to a centralised sewerage treatment plant (STP) are within a retirement complex and the majority of these are occupied by single people. The dwellings have full water reduction features in them including twin flush toilets and flow reducers on the shower heads. According to AS 1547 the design sewage flow allowance per person is 110 L. Therefore the design sewage flow/day is

41*2.7*110= 12,177 L/day.

Effluent strength is classified as 'low' according to the EPA's criteria (DEC, 2004). Sub surface irrigation will minimise risk of contact.

A landform assessment showed that the site was suitable for effluent irrigation. The main concern was the slope which ranged from 5 to 20%, with an average grade of 11%. Subsurface irrigation is recommended to minimise the risk of effluent runoff.

A back hoe was used to excavate 4 soil inspection and sampling pits. The soils were sampled to a layer of rotted shale. The depth to this layer varied from 1.5 to 1.9m. The soils were sampled at 0-20, 20-40, 40-70, 70-100 and on top of the rotted shale layer. The soils all had moderate structure throughout the profile. The surface 40 cm was typically a clay loam while the 40 to 100 cm layer was a light-medium clay. Heavy clay occurred on top of the shale. This suggests imperfect drainage at depth.

The moderate pedality in the topsoil is not ideal for effluent irrigation. Organic matter is a key agent for soil structure. Increasing organic matter will increase surface soil stability. Permanent pasture is strongly recommended.

The chemistry of the soils varies across the site and within individual profiles. However some generalisations can be made:

- The soils are non-saline and non-sodic. They have good supplies of potassium, calcium and magnesium.
- Applying 1800 kg agricultural lime per ha prior to commencement of effluent irrigation will ensure that productivity is not limited by aluminium toxicity.
- The P sorption capacity of the soil is sufficient for approximately 375 years at moderate rates of effluent irrigation.
- Phosphorus availability is marginal. Addition of 120 kg/ha/year of single superphosphate is recommended for pastures.

All of these features make the soils suitable for effluent irrigation provided the application rate is light.

The irrigation area size needed was based on AS 1547 and the daily weather since 1970. A maximum of 10,150 msq is available. Sensitivity analysis was used to identify sustainability of the irrigation system at a range of rates. A 1 ha field was sufficient for up to 22 cubic m/day of tertiary treated effluent. This is over 80% higher than the anticipated flow of 12.2 cubic m/day.

The environmental risks from the proposed system are small and considered acceptable.

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1 BACKGROUND

This investigation is concerned with providing a sustainable effluent management for tertiary treated effluent from 41 dwellings on Vincent Road Kurrajong.

The development comprises a mix of 23 retirement villas and 18 'normal' suburban type allotments. Figure 1.1 shows the locality of the development.

Lands to the immediate east of the retirement villas are available for irrigation. Figure 1.2 shows the irrigation area in detail.

This current report assesses the suitability of these lands. It also determines suitable size and configuration of the irrigation area.

1.1 Objectives of the effluent management activities

The aims of the scheme include:

1. Minimising risks to human and environmental health
2. Maximising effluent reuse opportunities

Bennett Property is committed to ensuring that the effluent management scheme is consistent with the principles of ESD. Additionally it aims to ensure there are no adverse impacts on human and environmental health due to implementation of the effluent management scheme.

1.2 Environmental objectives of the effluent management project

The environmental objectives of the project can be summarised as:

- To ensure environmental and public health safeguards are implemented correctly;
- To comply with the requirements of all relevant Local regulations and NSW and Australian legislation;
- To ensure that the establishment and operational phases of the project are managed to minimise adverse impacts on the environment and on human health.

Figure 1.1. Regional context of the development area and the proposed irrigation site. (Image: Google Earth 11.2012)

Figure 1.2. Detail of irrigation area (Source :Envirotech, 2012).

NOTES:

1 The proposed irrigation area is 10,150 msq

2. The irrigation area is 40m upslope from an existing farm dam

3. The irrigation area does not drain to the dam to the immediate south of the site.

1.3 Relationships between Bennett Property's commitment to ESD[1] National and State Government Policies

'*The EPA's wastewater management policy is to encourage the utilisation of effluent where it is safe and practicable to do so and where it provides the best environmental outcome. The EPA especially encourages the substitution of treated effluent for fresh/potable water wherever potable water is being used for non-potable purposes e.g. irrigation of crops and pastures.'* (EPA, 1995).

The key objectives of the *EPA's wastewater management policy* are listed in the draft document *'The utilisation of treated effluent by irrigation'* (EPA, 1995). Each objective is discussed below.

Resource Utilisation

Effluent and its constituents such as water, and nutrients should be evaluated for their usefulness. The agronomic systems for effective utilisation of these constituents should be implemented.

Protection of Lands

The management of the system must be in accordance with ESD principles. In particular it should maintain the productive capacity of the land. No deterioration of land quality through soil structural degradation, salinisation, waterlogging, chemical contamination or erosion should occur.

Protection of Surface Waters

Irrigation areas should be sited, designed, constructed and operated so that surface water does not become contaminated by either the effluent or any effluent contaminated runoff from the irrigation scheme.

Protection of Ground Waters

Irrigation areas should be sited, designed, constructed and operated so that useable subsurface water does not become contaminated by either the effluent or effluent runoff from the irrigation scheme.

Community Amenity

The scheme should be sited, designed, constructed and operated so that it does not cause unreasonable interference with any commercial activity or comfortable enjoyment of life and property off site. Where possible it should add to the amenity.

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[1] Ecological Sustainable Development principle involves
'Using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future can be increased.' (Commonwealth of Australia, 1992).

In NSW the principles of ESD as stated in the Protection of the Environment (Administration) Act 1991 are:
'The precautionary principle-if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
Intergenerational equity – the present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations;
Conservation of biological diversity and ecological integrity, and;
Improved valuation and pricing of environmental resources.

1.4 Investigation requirements

The investigation brief requires a series of tasks to be undertaken in order to provide evidence that the development will be consistent with ESD principles. These requirements are listed below:

⇒ Site inspection
⇒ Review of available information
⇒ Review of regulatory requirements
⇒ Risk assessment
⇒ Reclaimed water quality
⇒ Reclaimed water volumes
⇒ Identification of potential reuse areas
⇒ Soil and topographical assessment
⇒ Water and groundwater investigations
⇒ Soil chemical analysis
⇒ Identification of potential reuse options
⇒ Identification of preferred irrigation system
⇒ Water, salt and nutrient budgets
⇒ Recommendations

The current report addresses each of these requirements.

1.5 Reference documents

There are a variety of technical documents, guidelines and policy statements that provide instruction on sewage and stormwater management. The list below has been consulted during this investigation.

Asano, T. (1998). Wastewater Reclamation and Reuse. Technomic Publ. Co. Lancaster PA.

DEC (2004). Environmental Guidelines: Use of Effluent by Irrigation. Dept. Env. and Con. Sydney, NSW.

NRMMC/ EPHC/ AHMC (2006). Australian Guidelines for Water Recycling: Managing health and Environmental Risk (Phase 1). NWQMS No. 21. Natural Resource Management Ministerial Council/ Environment Protection and Heritage Council/ Australian Health Ministers Conference. Canberra ACT.

NCST (2009). Australian Soil and Land Survey Field Handbook. The National Committee on Soil and Terrain. Third Edition. CSIRO, Collingwood. Vic.

NSW Agriculture (1997). The NSW Feedlot Manual. NSW Agriculture, Orange, NSW.

QDNR (1998). MEDLI Technical Manual. T. Gardner and R. Davis Eds. Indooroopilly, Qld.

Standards Australia (2000). AS/NZS 1547:2000. On-site domestic wastewater management. Sydney, NSW.

Water Services Australia (2002). Sewerage Code of Australia WSA 03- Version 2.3.

2 SITE ASSESSMENT

The site was inspected by Dr Peter Bacon of Woodlots and Wetlands in October 2012. The inspection activities included the soil and landscape assessment reported below.

The location and issues associated with irrigating the lands to the east were assessed.

The approach has been to identify the likely sewage volume generated from the STP, assess the site to determine the design irrigation rate (DIR) as per AS/NZS 1547, and then determine the irrigation area requirements for sustainable irrigation of this volume. Because the exact sewage flows and number of occupants are unknown a range of possible flows were assessed.

The study also provides an assessment of the risks to human and environmental health from the scheme, and then identifies options to minimise these risks.

3 AVAILABLE INFORMATION

3.1 Sewage flows

Sewage flows are based on AS1547 APPENDIX 4.2D. According to the Australian Bureau of Statistics 2011 census data, the average number of presidents per dwelling in the Kurrajong Urban Area is 2.7. Many of the 41 dwellings to be connected to the sewerage treatment plant (STP) are within a retirement villa complex, and the majority of these are occupied by single people, so the 2.7 persons/ dwelling is likely to be an overestimate. The dwellings have full water reduction features in them including twin flush toilets and flow reducers on the shower heads. According to AS/NZS 1547 the design sewage flow allowance per person in dwellings with full flow reduction devices is 110 L/day. Therefore the design sewage flow/day is

41*2.7*110= 12,177 L/day.

Sensitivity analysis was undertaken to assess the effect of a range of flow rates. The following variables were tested:

- 2.7 persons/dwelling
- 3.7 persons/dwelling
- 4.7 persons/dwelling <u>and</u>
- 110 L/person/day (the anticipated sewage flow assuming full flow reduction fixtures)
- 145 L/person/day (the sewage flow if there are limited flow reduction fixtures in the dwellings (from AS/NZS 1547)

Table 3.1. Effect of varying number of resident/dwelling and average flow/ resident on total effluent volume/day

Assumed 41 dwellings	Persons/ dwelling	2.7	3.7	4.7
Flow/person	110	**12.2**	**16.7**	**21.2**
Flow/person	145	**16.1**	**22.0**	**27.9**

The sensitivity analysis in table 3.1 shows that increasing the flow rate per person and increasing the average number of people in residence more than doubles the anticipated flow rate.

3.2 Effluent attributes

The proposed STP is an Aquacell membrane bioreactor. The anticipated effluent characteristics are shown below.

Table 3.2. Anticipated characteristics of the effluent and criteria for determining low strength effluent (Source: DEC, 2004).

Constituent	Anticipated effluent characteristics	Low strength effluent characteristics
Total Nitrogen (mg/L)	<15	<50
Total Phosphorus (mg/L)	<10	<10
Biochemical Oxygen Demand (mg/L)	<15	<40
Total Suspended Solids (mg/L)	<5	Not given
E coli (CFU/100mL)	<10	Not given

4 LANDFORM ASSESSMENT

4.1 Site configuration

Figure 1.2 shows the site. The proposed irrigation area is on an eastern facing slope, below the development area. Figure 1.2 also shows that the subject site is currently surrounded by grazing lands. The nearest downslope waterbody is over 40m south of the subsurface irrigation area.

The soil landscape map (Bannerman and Hazelton, 1989) shows that the site is on the Luddenham Soil Landscape. Gymea Soil Landscape occurs downslope of the site. Typical attributes are summarised in table 5.1.

Table 5.1 typical attributes of the Luddenham and Gymea Soil Landscapes (Source: Bannerman and Hazelton, 1998).

Attribute	Luddenham Soil Landscape	Gymea Soil Landscape
Geology	Wianamatta Shales	Hawkesbury Sandstone
Topography	Low rolling to steep hills	Undulating to rolling low hills
Slopes	5-20%	10-25%
Erosion hazard	High	High
Soils classification b	Red (upper slope) to yellow (lower slope) podsolics	Yellow earths, earthy sands yellow podsolics
Fertility	Moderate fertility	Very low fertility

4.2 Landform assessment procedures

A total of four localities within the proposed irrigation area were assessed for landform and soil characteristics.

Table 4.2 summarises the results of the landform assessment.

Table 4.2. Site attributes and their likely impact on site suitability of effluent irrigation at the site.

Attribute	Rationale	Comment
Grid ref	Permanent record of assessment position	
Aspect	Influences solar radiation intensity on lands with more than 10% slope	Slopes towards the east. It will get full morning sun, but little late afternoon sun. There will be reduced exposure to dry westerly winds.
Exposure	Exposed areas have higher evapotranspiration demand	The trees shown in figure 1.1 and 1.2 have been removed. All areas are now exposed, with no tree cover. Therefore OK.
Slope %,	Impacts on the erosion and runoff potential	Ranges from 5 to 20%. Therefore use subsurface irrigation
Slope length	Impacts on the erosion and runoff potential	Maximum of 120m
Landscape position	Impacts on the extent on run-on from upper slopes. Impacts on local drainage.	Mid slope. Drainage to the north and east of the development site. A minimum of 40m between the proposed irrigation area and the farm dam line.
Local Relief	Indicates the extent of steep slopes	Undulating low hills. Subsurface irrigation will minimise risk of effluent runoff.
Landform element	Identifies drainage issues, e.g. floodplains	Convex, divergent slope, so ideal
Drainage line distance (m)	Indicates risk of stream contamination via runoff. Used in DEC (2004) as a buffer distance guide.	Minimum of 40m to a farm dam This is in excess of the 40m distance where Office of Water involvement occurs under the Water Management Act (2000).
Flow patterns	Indicates stream networks and the risk of contamination	No apparent drainage network within the site. There is an opportunity to capture and convey stormwater runoff around the topside of the irrigation area. This will minimise run-on
Run-on/ runoff potential	Identify management needed to minimise excess inflow or losses from the site.	A contour bank will intercept flow above the irrigation area.
Surface water bodies- dams, ponds, springs DS or US of site	Used in DEC (2004) table 4.9 as a buffer distance guide.	No springs or other surface water bodies were evident within the irrigation area. Use of tertiary treatment of the effluent and subsurface irrigation at the AS/NZS 1547 design irrigation rate(DIR) will minimise risk
Storm water	Risk of external flooding, especially with contaminated water.	A contour bank will intercept flow above the irrigation area.
Salt	Salinisation can limit plants' ability to utilise the effluent. It can indicate poor	The profiles seem reasonably well drained. There is no evidence of

Attribute	Rationale	Comment
	drainage and the need salt tolerant plants. Salinisation can destroy soil structure leading to increased risk of effluent runoff.	salinisation.
Erosion potential+/- cult	Erosion potential is used to adjust the cropping/ pasture regime to minimise risk	Low erosion potential once permanent grass cover is established and maintained.
Rock out crops %	Rocky soil can reduce plant growth, make cultivation difficult and increase runoff.	None
Depth to hard rock	Soil less than 1m deep can have poor root development and inadequate ability to retain nutrients. They can also become waterlogged.	All except location 4 have over 1.5m of soil. Location 3 has decomposed rock at 1.5m
Water table, depth	Depth to water table is critical in determining the most suitable vegetation. A shallow water table will preclude irrigation in parts of the year.	None evident.
Groundwater	Distance between the irrigation area and groundwater bores used for domestic purposes is a critical issue in risk assessment	The site itself has a bore on it. However it is not used anymore as town water is now available.
Flood risk	Frequent flooding can destroy infrastructure, prevent irrigation and damage crops.	Not an issue
Land use	The most suitable land uses should be the ones that result in acceptable minimum risks to human and environmental health. At the same time the landuse must be suitable for the site and not be too expensive to establish or operate. A range of permanent pastures and cropping will be considered.	Improved pasture. Therefore OK. The lack of trees makes it simpler to install subsurface irrigation.
Land use history	Past land use activities such as sheep dips and landfills can result in contaminated lands. These lands are normally unsuited for effluent irrigation because the irrigation will increase the risk of off-site contamination.	Long term, low intensity woodlot and pastures. Therefore OK.
Landuse zoning	The proposed landuse must be consistent with current / proposed land zoning.	A new LEP has been placed on public display. It is assumed that the STP and associated irrigation area will be consistent with this LEP.
Distance to public roads houses, etc.	Buffer distances will be a function of the likely contaminant load and the likely level of exposure to the effluent.	A minimum of 80m to the nearest public road. This is well beyond the 25 to 30m recommended in the National Guidelines.
Fire hazard	Fire hazard can be significant for landuses such as woodlots. Fire can destroy both vegetation and equipment.	Not considered an issue

4.3 Conclusions from site assessment

The land slopes relatively steeply to the east. Run-on and run-off are likely to be moderate because of the relatively steep slope. Therefore subsurface irrigation is proposed. Additionally a contour bank immediately upslope of the irrigation area will divert run-on. Permanent pasture cover is also essential to reduce erosion rate.

There is a farm dam near the eastern boundary of the site but this is over 40m from the likely irrigation area.

Other site attributes create minimal risk. On this basis the site appears suitable for application of effluent, especially in view of the relatively low level of contamination in the effluent as shown in table 3.2.

5 SOILS ASSESSMENT

5.1 Insitu soil assessment

A back hoe was used to excavate 4 pits. The sampling depths used to assess the profiles were based on DEC (2004). DEC (2004) suggest 4 sampling depths in the surface 100 cm. A total of 5 depths were used. Four of these were in the top metre and a fifth sample at least 2m or at refusal. The surface depth aimed to define soil surface conditions such as structural stability. The deepest sample was used to assess phosphorus sorption capacity of the entire profile.

The results of the field assessment are shown in table 5.1.

Field texture

Field texture typically changed gradually from clay loams to medium to heavy clay at approximately 1m depth.

The presence of clay loam on the soil surface means that the irrigation application rate needs to be relatively light.

The clay dominant subsoil means that the soil can store adequate supplies of water. However the profile can also become saturated and poorly drained. Overwatering must be avoided.

Soil strength

Soil strength varied from very strong at the surface of sites 1, to very weak at depth in profile 4. The very strong conditions in the surface soil reflect dry conditions and compaction.

A combination of long term pasture and cropping using reduced tillage is recommended.

Pedality

The pedality is moderate in almost all samples. Organic matter accumulation under pasture will assist in maintaining soil structural stability.

Moderate pedality is preferred in the subsoil as weak pedality can indicate structural degradation. Strong pedality can mean that the effluent passes through the soil too quickly.

Fabric

Earthy or rough pedal fabric is preferred. All the samples had earthy fabric.

Colour

Soil colour is derived from organic matter, clay mineralogy, and drainage conditions. Pale greys, yellow and whites indicate poor drainage. Dark browns are indicative of organic matter accumulation, while bright reds and oranges are indicative of good drainage. The topsoils are typically brown or reddish brown, indicating organic matter accumulation and moderate drainage. The increasing grey colour with increasing depth indicated imperfect drainage.

Table 5.1. Insitu soil conditions.

Few soil fauna evident, no water repellency or hard setting evident but no obvious hard pan or bleaching. The fabric was earthy at all depths. There was no hard pan or bleaching at depth.

Site No.	Depth (cm)	Field texture	Consistency	Moisture	Pedality	Colour	Boundaries	Mottles %	Nodules %	Root No.	Biological activity	Texture change	Hard setting	% rock
KH1	0 to 20	clay loam	very strong	dry	weak	dark reddish brown	diffuse	none	none	common	none	gradual	hard setting	none
	20 to 40	clay loam	firm	moderately moist	moderate	dark reddish brown	diffuse	none	none	common	none	gradual		none
	40 to 70	light medium clay	weak	moderately moist	moderate	very dark gray	diffuse	none	none	common	none	gradual		15%
	70 to 100	medium clay	weak	moderately moist	moderate	dark grayish brown	diffuse	20% yellow	none	common	none	gradual		10%
	160 to 180	heavy clay	weak	moist	moderate	grayish brown	diffuse	10% yellow	none	common	none	gradual		60% (shale)
KH2	0 to 20	clay loam	firm	moderately moist	moderate	very dark gray	diffuse	none	none	common	common	gradual	hard setting	none
	20 to 40	clay loam	firm	moderately moist	moderate	dark brown	diffuse	none	none	abundant	none	gradual		none

Site No.	Depth (cm)	Field texture	Consistency	Moisture	Pedality	Colour	Boundaries	Mottles %	Nodules %	Root No.	Biological activity	Texture change	Hard setting	% rock
	40 to 70	clay loam	weak	moderately moist	moderate	reddish gray	diffuse	10% red	none	common	none	gradual		20%
	70 to 100	medium clay	weak	moderately moist	moderate	reddish brown	diffuse	25% red	none	common	none	gradual		40%
	165 to 175	heavy clay	weak	moist	moderate	gray	diffuse	20% orange	none	rare	none	gradual		80%
KH3	0 to 20	clay loam	firm	moderately moist	moderate	dark brown	diffuse	none	none	common	rare	gradual	compacted	none
	20 to 40	clay loam	firm	moderately moist	moderate	dark brown	diffuse	none	none	common	none	gradual		none
	40 to 70	clay loam	weak	moderately moist	moderate	dark grayish red	diffuse	none	none	rare	none	gradual		none
	70 to 100	medium clay	weak	moderately moist	moderate	reddish gray	diffuse	20% red	none	rare	none	gradual		none
	180 to 190	heavy clay	firm	moist	moderate	light gray	diffuse	30% red	none	none	none	gradual		none

Site No.	Depth (cm)	Field texture	Consistency	Moisture	Pedality	Colour	Boundaries	Mottles %	Nodules %	Root No.	Biological activity	Texture change	Hard setting	% rock
KH4	0 to 20	clay loam	firm	moderately moist	moderate	reddish brown	diffuse	none	none	common	common	gradual	compacted	none
	20 to 40	clay loam	weak	moderately moist	moderate	brown	diffuse	10% orange	none	abundant	none	gradual		none
	40 to 70	light medium clay	weak	moderately moist	moderate	grayish brown	diffuse	20% orange	none	common	none	gradual		10%
	70 to 100	medium clay	very weak	moderately moist	moderate	olive yellow	diffuse	30% orange	none	common	none	gradual		15%
	135 to 145	heavy clay	very weak	moist	moderate	olive	diffuse	20% orange	none	rare	none	gradual		5%

Boundaries

The sharpness of the boundaries between the soil layers generally indicates the extent of soil development (Isbell, 1996). There is a gradual increase in clay content with depth: clay loam topsoils grade into medium then to heavy clay subsoils.

Mottle %

Mottles can indicate imperfect drainage. Mottles become evident from 40 to 70 cm. The mottles are typically red, suggesting reasonable drainage. Yellow mottles at depth in site KH 1 suggest poorer drainage at this site.

Nodule %

There were few if any nodules evident.

Root number

Root number is typically common to abundant in the surface 40cm and common in the 40-70 cm layers. They were common to rare in the 70-100cm layer and common to absent in the lowest horizon.

There was no evidence of impedance. It is expected that the root frequency will be maintained under permanent pasture. The widespread presence of roots at 70cm suggests adequate physical conditions throughout the normal rooting depth.

Biological activity

Biological activity indicators include the presence of ants, earthworms, millipedes and insect holes in the ground. The activity was rare to absent. The acidic conditions can reduce soil biota numbers.

Liming and planting of long term pasture will increase soil biodiversity, thereby ensuring longevity of the effluent irrigation system.

Rock %

More than 10% rock in the surface horizon can increase risk of machinery damage. None of the soils have rock in the surface 40cm.

Profile HK 2 has a significant volume of rocks below 70cm. This can interfere with water movement through the profile in this area.

Conclusions and management recommendations

The ideal soil for effluent irrigation has sand dominant topsoil overlying moderately structured clay subsoil. The subject site has relatively little sand in it. Therefore the irrigation application rate needs to be relatively light to minimise the risk of runoff.

The moderate pedality in the topsoil is not ideal for effluent irrigation. Organic matter is a key agent for soil structure. Increasing organic matter will increase surface soil stability. Consequently, the establishment of long term is strongly recommended for the area.

Soil colour indicates that the subsoils have imperfect internal drainage. The irrigation rate needs to be relatively light in order to avoid effluent accumulation in the subsoil.

The soils have good root penetration into the subsoil. This suggests that the soils are suitable for effluent irrigation.

Rocks are not an issue.

It is concluded that the soils appear suited to effluent irrigation, however the application rate should be low to avoid waterlogging at depth.

A good cover of vegetation, either as crops or long term pasture, is critical.

The proposed use of subsoil irrigation is ideal for this site as there is clay loam extending 40 to 70cm below the surface.

5.2 Soil chemistry

The soil analysis aims to quantify the soil attributes that influence the ability of the site to sustainably utilise the effluent. Two soil profiles were analysed in detail. Table 5.2 sets out the major soil attributes.

pH (5_{water}:1_{soil})

The pH in the surface 20 cm is ideally between 5.8 and 7 (Slattery, et al, 1999). Profile 1 is too acidic, while profile 4 is in the 'ideal' range. However table 5.2 shows that profile 4 becomes more acidic with depth.

Both profiles would have improved fertility if the pH were higher.

Liming is considered essential.

Salinity

Salinity is expressed as electrical conductivity (EC) in saturated paste equivalent. The units are dS/m. Soils with $EC_{sat\ paste}$ less than 4 are non-saline (Richards, 1954). Table 5.2 shows that none of the soils are saline. This is an important result as it means that salinity will not limit the site's usefulness for effluent irrigation.

Cation exchange capacity

Cation exchange capacity (CEC) is a measure of the soil's ability to retain nutrients. Ideally the CEC should be at least 5, and preferably greater than 12 cmol(+)/kg (Metson, 1961). Table 5.2 shows that both sites have slightly low CEC.

Table 5.2. Results of laboratory analysis.

Attribute	KH1 0-20 cm	KH1 20-40 cm	KH1 40-70 cm	KH4 0-20 cm	KH4 20-40 cm	KH4 40-70 cm
pH (5:1) water: soil	5.37	5.18	5.27	6.05	5.3	5.07
pH (CaCl2)	4.38	4.17	4.35	5.06	4.20	4.01
Salinity (dS/m sat paste)	0.70	0.39	0.32	0.49	0.39	0.41
Exch Ca (cmol+/kg)	2.65	2.66	2.12	5.08	2.42	1.19
Exch Ca as % of CEC	27	22	27	58	23	9
Exch Mg (cmol+/kg)	2.74	2.67	1.34	2.33	2.31	2.15
Exch Mg as % of CEC	28	22	17	27	21	16
Exch K (cmol+/kg)	0.45	0.45	0.61	0.72	0.49	0.43
Exch K as % of CEC	5	4	8	8	5	3
Exch Na (cmol+/kg)	0.43	0.24	0.09	0.30	0.24	0.26
Exch Na as % of CEC	4	2	1	3	2	2
Exch Al (cmol+/kg)	2.13	3.98	2.31	0.13	3.55	6.61
Exch Al as % of CEC	22	33	29	2	33	49
Organic carbon (%)	2.73	2.09	2.86	2.44	0.57	0.45
Total nitrogen (%)	0.17	0.15	0.17	0.14	0.09	0.08
C:N ratio	16.0	14.1	17.0	17.7	6.2	5.7
Available phosphorus (Bray No 1, mg/kg)	5.2	6.5	4.2	3.9	9.0	9.5

Exchangeable calcium (Ca)

Ideally soils should contain over 10 cmol(+) /kg of exchangeable Ca (Metson, 1961). However soils with 5 to 10 cmol(+) /kg of exchangeable Ca are considered to have moderate concentrations. Thus both soil profiles have low exchangeable Ca as table 5.2 shows.

Adding good quality agricultural lime will remove Ca deficiency and increase production of acid sensitive plants such as clover.

According to Abbott (1989) Ca should make up 65 to 80 % of the sum of cations. Both profiles are deficient in Exch Ca as a % of the CEC. This can result in structural instability.

Addition of lime prior to commencement of irrigation is essential to correct this. The soil should be retested after 3 years.

Exchangeable magnesium (Mg)

Soils should contain at least 1, and up to 3 cmol(+) of exchangeable Mg (Metson, 1961). The data in table 5.2 show that the soils have sufficient Mg.

Dolomite is not required.

According to Abbott (1989) Mg should make up 10 to 15 % of the sum of cations. Both profiles have excessive Exch Mg as a % of the CEC. The ratio of Exch Ca : Exch Mg should be at least 2:1. The Kurrajong soils are typically 1:1. This can result in structural instability. Liming is essential.

Exchangeable potassium (K)

Potassium is an essential nutrient and topsoils should have at least 0.3 cmol(+)/kg. Table 5.2 shows that all soils have an abundant supply of potassium.

Exchangeable sodium (Na)

Exchangeable Na in soil is important because excessive Na can cause structural instability. This is especially critical in the topsoil, where cultivation or heavy rainfall can make the soil susceptible to structural degradation. Generally the potential impact is expressed as Exch Na as a percentage of the sum of cations:

$$\frac{\text{Exch Na*100}}{\text{Exchangeable (Na+K+Ca+Mg+Al)}}$$

Less than 5% exchangeable Na is preferred.

All surface soils have less than 5% Exchangeable Na. The surface soils are therefore non-sodic. Sodicity is also low at depth. Sodicity is not an issue in these soils.

Any soil structural problems, such as crusting on the soil surface, are likely to be due to excessive Mg, over-cultivation and the consequent loss of organic matter. Strategies to increase and maintain organic matter near the soil surface are important for this site.

Exchangeable aluminium (Al)

Exchangeable Al is a potentially toxic ion. Ideally its concentration is below detection. It can stunt growth of susceptible plants such as clovers when more than 5% of the total exchangeable cations are Al. Some of the soil samples have over 4 times more than this percentage.

Agricultural lime addition will reduce this percentage to nontoxic values.

Assuming that the typical Exchangeable Al concentration in the surface 20 cm is 2 cmol+/kg, and the bulk density is 1.2 MT/cubic m, then 1800 kg/ha of lime is needed to minimise exchangeable Al.

It is essential that the lime be incorporated into the soil.

Organic carbon

Soils with less than 1% organic carbon (OC) are likely to have poor structure and low structural stability (Charman and Roper, 2000). Clay loams similar to the Kurrajong topsoils typically should have around 2.5% OC. Table 5.2 shows that on the subject site the soils are near or slightly above this concentration. Ideally the effluent irrigation will be used to produce permanent pasture as this will result in a gradual increase in soil organic carbon concentration.

Total Nitrogen

Soil total nitrogen concentrations less than 0.15% are considered low (Bruce and Rayment (1982). The nitrogen concentrations of the soils are close to this value. Nitrogen addition via effluent irrigation should increase site nutritional status.

C : N ratio

The C : N ratio in typical soils is 10 to 12. The higher values in the current soils suggest that there is accumulation of carbon rich residues. This may be due to the acidic conditions inhibiting bacterial activity. Liming will assist in normalising carbon transformations.

Bray No.1 Available phosphorus

Available phosphorus concentration is a measure of the current adequacy of supply of this nutrient. According to Moody and Bolland (1999), a concentration of 10 to 12 mg/kg in the surface 7.5 cm is sufficient for 90% potential yield of pastures. Table 5.2 shows that the soils have less than 1/2 of this concentration.

The soils would benefit from the phosphorus in the effluent. So effluent irrigation will increase pasture yield, partly at least by increasing phosphorus supply.

P sorption capacity

Table 5.3 shows the P sorption capacity expressed in kg/ha for each horizon. The P sorption capacity is a measure of the soils' ability to retain phosphorus. It is a function of the P sorption capacity expressed as mg/kg of soil and the mass of soil.

The storage capacity in the surface 20 cm is relatively small and the bulk of the storage occurs at depth.

Table 5.3. Phosphorus sorption capacity (kg/ha).

Profile/ depth	P sorption (mg/kg)	P sorption (kg/ha)
KH1 0-20 cm	815	1939
KH1 20-40 cm	824	2059
KH1 40-70 cm	801	3125
KH1 70-100 cm	737	2983
KH1 1.6-1.8 m	624	6552
Total P sorption		16658
KH4 0-20 cm	702	1671
KH4 20-40 cm	809	2023
KH4 40-70 cm	834	3251
KH4 70-100 cm	710	2876
KH4 1.4 m	602	3612
Total P sorption		13432

The average capacity over the two profiles is 15 t/ha. Assuming the effluent has 10 mg/L of P and 4 ML/year were applied, it would take approximately 375 years before the profiles would become saturated with phosphorus, even if there was no removal of phosphorus in cut or grazed pasture. It is reasonable to conclude that addition of P via effluent will not reduce site sustainability.

Conclusions and recommendations

The soils varied across the site and within individual profiles. However some generalisations can be made:

- The soils are non-saline and non-sodic. They have good supplies of potassium and magnesium.
- The soils are deficient in calcium. Applying and incorporating 1800 kg agricultural lime per ha prior to commencement of effluent irrigation will ensure that productivity is not limited by aluminium toxicity.
- The P sorption capacity of the soil is sufficient for approximately 375 to 500 years at moderate rates of effluent irrigation.
- Phosphorus availability is marginal. Addition of 120 kg/ha of single superphosphate is recommended for pastures at establishment. After this the effluent will supply sufficient phosphorus.

All of these features would make the soils suitable for effluent irrigation.

The key recommendations:

- Install runoff diversion banks upslope of the irrigation area
- Apply and incorporate 1.8 t/ha of agricultural lime
- Install subsurface irrigation
- Apply 120 kg/ha of single superphosphate at pasture establishment
- Plant pasture as soon as possible after the irrigation system is installed and operational.
- The pasture should include a mix of perennial temperate grasses such as perennial ryegrass.
- Facilitate accumulation of soil organic carbon by combinations of long term pasture and reduced tillage cropping.
- Retest the soil for nutrients, pH, organic carbon and stability after 3 years of effluent irrigation.

6 SIZING OF IRRIGATION AREA.

6.1 Net effluent production

Net effluent production was based on AS/NZS 1547 (2000). According to this standard, wastewater flow allowance for dual flush toilets, front loading washing machines, shower flow restrictors and aerated faucets is 110L/EP/day[2]. According to the 2011 census data (Australian Bureau of Statistics for the 2011 census), the average dwelling in the Kurrajong area has 2.7 persons in residence. There will be 41 dwellings at the full development stage. So the design sewage flow is 110*2.7*41= 12.2 cubic m/day.

In practice the flow is likely to be less as many of the dwellings are within a retirement section and the majority of dwellings will have 1 person in them.

Table 3.1, reproduced below as table 6.1, shows the range of design effluent flow rate depending on number of people/dwelling and flow per person.

Table 6.1. Effect of varying number of resident/dwelling and average flow/ resident on total effluent volume in cubic m/day.

Assume 41 dwellings	Persons/dwelling	2.7	3.7	4.7
Flow/person (L/day)	110	**12.2**	**16.7**	**21.2**
Flow/person (L/day)	145	**16.1**	**22.0**	**27.9**

The flow ranged from 12.2 cubic to 27.9 cubic m/day.

6.2 Irrigation area requirement

AS/NZS 1547 table 4.2A4 shows the recommended design irrigation rate (DIR) for irrigation systems over a range of soil textures. This information is combined with the range of estimated flow rates to assess the irrigation area requirement.

Table 6.2. Effect of varying the design flow rate and design irrigation rate (DIR) for different soil textures on irrigation land requirement.

Design flow rate (cubic m/day)	DIR for clay loams: (25mm/week)	DIR for light clay: (20mm/week)	DIR for medium to heavy clay: (15mm/week)
12.2	3416	4270	5693
16.7	4676	5845	7793
21.2	5936	7420	9893
16.1	4508	5635	7513
22	6160	7700	10267
27.9	7812	9765	13020

[2] EP = equivalent person

Table 6.2 shows that even with the higher flow rate/person and over 4 people per retirement unit, less than 1 ha of irrigation would be needed for clay loam and light clay soils.

Table 5.1 shows that the typical soil profile has clay loam to between 40 and 70 cm and light to medium clay to at least 1 metre. This observation indicates that a 1 ha subsurface irrigation, as shown in figure 1.2, would be sufficient even for conservatively estimated design flows.

6.3 Irrigation area available.

The proposed irrigation area lies to the immediate north of the STP. The maximum proposed irrigation area is 10150 msq.

Based on AS/NZS 1547 this area is sufficient.

7 PROPOSED IRRIGATION STRATEGY AND OPTIMISATION OF THE IRRIGATION AREA

7.1 Model inputs

Table 7.1 itemises the inputs used to model the site water balance.

Table 7.1. Components used to model irrigation demand. Daily data over the 42 years between Jan 1970 and October 2012 was used. (Climate data from BoM).

Component	units	Average/y
Effluent production (12.2 cubic m/day)	cubic m	4448
Rainfall	mm	1040
Pan evaporation	mm	1387
Potential evapotranspiration (PET)	mm	1186
Runoff	mm	129
Run-on to irrigation area	mm	zero
Effective root zone	500 mm	
Plant available water in root zone at field capacity	92 mm	

Table 7.2. Effect of effluent irrigation onto 1 ha of land at 1.2 mm/day since 1970.

Water balance component (all mm/y)	No irrigation	With irrigation	Comment
Rainfall infiltration	911	911	
Irrigation	0	438	Daily at 1.2 mm.
Total water available	911	1349	
Actual evapotranspiration[1]	737	1004	
Percolation	175	345	An additional 14mm/month of percolation.

[1] *Plant evapotranspiration is assumed to occur at Potential Evapotranspiration (PET) until 46 mm moisture deficit, then a linear fall to zero at permanent wilting point.*

7.2 Model output

In the period 1970-2012, the average annual rainfall was 1040 mm. Of this 911 mm infiltrated the soil while 129 mm ran off the site. Some 175 mm of the infiltrated rainfall moved below the 500 mm deep root zone.

Pan evaporation averaged 1387 mm while potential evapotranspiration (PET) averages 1186 mm. The PET has a strong annual cycle varying from over 6 mm/day in summer to 1 mm/day in winter. Figure 7.1 shows that the rainfall pattern is more varied and can occur throughout the year.

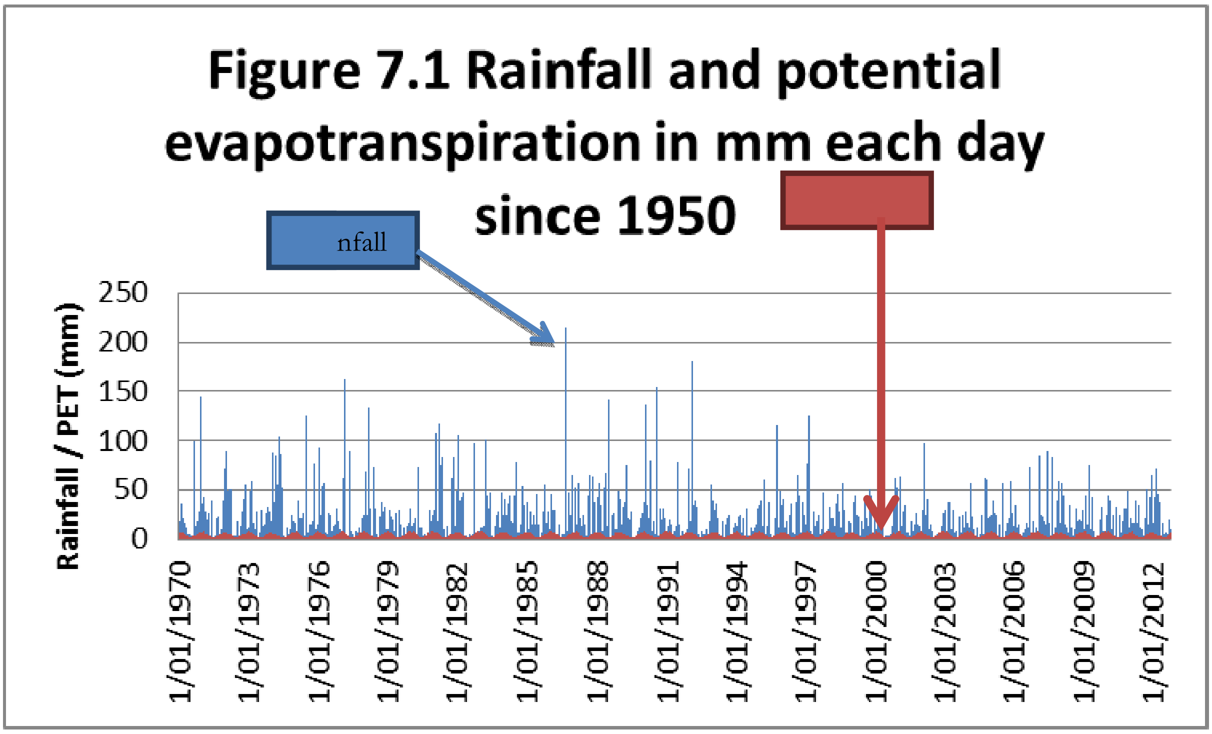
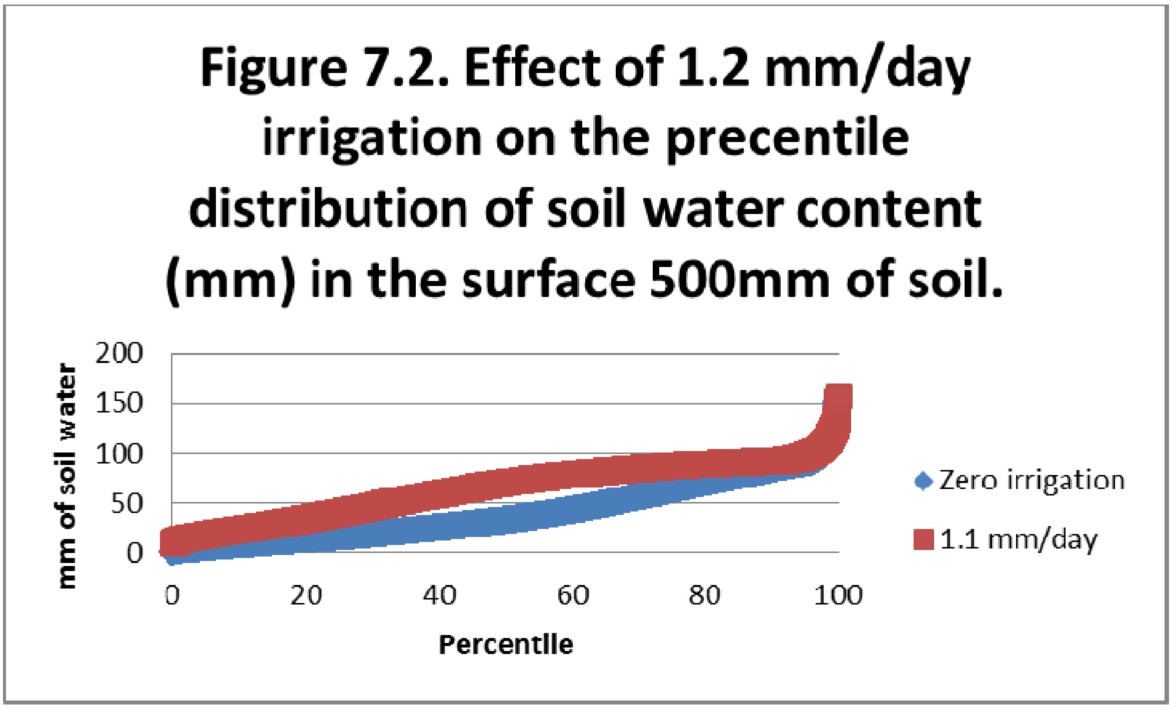


Figure 7.2 shows the effect of applying 1.2mm/day irrigation on the soil water balance.

The main effect of the irrigation is to increase the mid-range soil water content. During prolonged dry periods the irrigation impact is relatively minor. During periods of heavy rainfall, the 1.2 mm/day is small compared with the more than 20mm of rainfall during the same day.

The non-irrigated soil has moisture content in excess of field capacity (92mm in the top 500 mm) in 3% of days whilst the soil receiving 1.2 mm/day irrigation has moisture content exceeding field capacity in 8% of days. The result is increased percolation on the irrigated soil, but this only occurs during heavy rainfall.



It is concluded at the proposed irrigation rate will not increase runoff from the subsurface irrigation area. There will be increased deep percolation, but this will only occur during heavy rainfall events.

8 MANAGEMENT OF CONTAMINANT LOADS

8.1 Nitrogen

The indicative nitrogen concentration in the effluent is <15 mg/L.

Table 8.1 shows the nitrogen loading rate for a range of irrigation areas and nitrogen concentrations.

Table 8.1. Effect of varying irrigation area on the nitrogen and phosphorus loading rates (kg/ha/y). The assumed flow was 12.2 cubic m/day

Irrigation area	**0.8 ha**	**1 ha**	**1.2 ha**
mm of irrigation/year	454	406	365
Assumed nitrogen concentration in irrigated effluent (mg/L)	15	15	15
Nitrogen application rate (kg N/ha/y)	68	61	55
Assumed phosphorus concentration in irrigated effluent (mg/L)	10	10	10
Phosphorus application rate (kg P/ha/y)	45	41	37

According to NSW Agriculture (1997), a typical 12 dry t/ha crop of perennial pasture will have a nitrogen concentration of 2.4 to 3.5% nitrogen. That is, the crop will accumulate 290 to 420 kg/ha/year of nitrogen, provided the crop is harvested. This is more than 4 times the nitrogen application rate in the effluent as shown in table 8.1.

If the pasture is not forage harvested then the nutrient removal rate is dependent on grazing intensity. Plant growth and nutrient uptake are similar, but a proportion of the ingested nutrients is returned in urine and faeces. As an example, a 500 kg cow grazing low quality pasture will excrete approximately 35 kg/year of nitrogen and 14 kg/year of phosphorus (QDNR, 1998). Depending on its initial weight and calf management it will 'accumulate' over 100 kg of N /year. That is, provided the site is either cut and baled or grazed the potential nitrogen export could exceed the nitrogen being supplied in the effluent.

8.2 Phosphorus

Raw sewage contains 10 to 25 mg/L of phosphorus (DLG, 1998). Precipitation and other processes within the STP results in the effluent usually having less than 10 mg/L of phosphorus.

Assuming 10 mg/L of phosphorus, the phosphorus application rate will range from 37 to 45 kg P/ha/y depending on the irrigation rate. Phosphorus concentration in the pasture will be approximately 0.3%, so 12 dry t /ha of pasture will contain 36 kg of phosphorus. This is virtually the anticipated phosphorus application rate.

Section 5.2 shows that the soil profile contains some 15 t/ha of P sorption capacity. That is, even if there was an excess of phosphorus being applied with the effluent, it will take centuries for the soil's sorption capacity to become saturated. (If there were zero net uptake the site would last 369 years prior to saturation).

8.3 Salinity

Salinity increases by some 0.3 dS/m as water passes through a domestic sewerage system.

The current proposal is to subsurface irrigate the water over 1.0 ha on lands that are over 40m from any drainage line. The soils are not saline. Finally the proposed irrigation rate of 400 mm/year is adequate but not excessive, so there will be minimal risk of waterlogging or salinisation.

Salinity is not an issue at this site.

8.4 Conclusions

The anticipated nitrogen application rate via effluent irrigation is 2 to 4 times less than the potential uptake by the pasture. Consequently nitrogen leaching to below the root zone is unlikely to be significant.

Phosphorus application rate is similar to the anticipated accumulation rate by plants. This, plus a large sorption capacity in the soil profile, means that the system can be considered sustainable: Profile saturation with P is unlikely for at least 3.5 centuries.

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Responses to questions and comments from IPART.

Prepared by Dr Peter Bacon who prepared the original site evaluation and effluent management scheme.

Potential for elevating groundwater levels within and near the effluent irrigation areas.

Groundwater accumulation will occur when the rainfall + effluent irrigation exceeds Evapotranspiration + runoff + infiltration capacity.

The proposed system was designed using AS/NZS1547 (2012). The calculated volume of effluent produced per day was used in conjunction with the soil evaluation to determine the design irrigation (mm/day) as per AS/NZS 1547(2012) table M1 (page 160).

The soil evaluation indicated that the soil was a clay loam for the surface 40 to 70 cm, overlying a light to medium clay subsoil. The subsurface irrigation will be some 10 to 15 cm below the surface and installed into the clay loam horizon.

According to AS 1547/NS (2012) the Design Irrigation Rate (DIR) for clay loams is 3.5mm/day while the DIR for light clays is 3mm/day, and that for medium to heavy clays is 2mm/day.

The soils had moderate pedality, so the permeability range for the clay loams, light clays and medium to heavy clays is 500 to 1500mm/day for clay loams, 60 to 120mm/day for light clays and 60 to 500mm/day for medium to heavy clays (AS/NZS1547: 2012). That is, the DIR is maximum of 1/30 of the permeability of the soil.

Put simply the design irrigation rate is a small fraction of the soil's ability to transmit the effluent. Elevation of groundwater due to application of 2 to 3.5 mm/day of effluent is highly unlikely.

Bores in the vicinity of the effluent irrigation

The only bore within the 250m recommended separation distance for domestic use water supplies (DEC, 2004) is a disused one some 120m uphill to the NW of the irrigation area. Apparently the bore was used before the Sydney Water Corporation installed reticulated water in the area. The bore number is GW104396. The main water zone is between 156 and 160 m.

There are no other bores within 250m of the irrigation area. This reflects the local preference for farm dams rather than trying to tap into the deep and potentially poor quality groundwater resources in the area.

It is concluded that the bore data suggests that the regional water table is extremely deep. It is highly unlikely that the proposed irrigation in an area of less than a hectare in an area without other irrigation is likely to have any impact on the water table.

During the site investigation holes up to 3m or to rock if less than this depth were excavated. There was no evidence of a shallow water table.

It is highly unlikely that the relatively low design application rate would create a shallow water table.

There is a farm dam downslope of the irrigation area. The application rate is so low that runoff is highly unlikely, however if there was downslope flow of water through the soil then it should become evident in the existing dam.

It is RECOMMENDED that the dam be tested before the irrigation commences and then annually to detect and 'leakage'.

This approach is preferred to testing groundwater because there is no evidence of a shallow water table, so the monitoring well would be dry. Conversely, the dam is expected to contain a permanent body of water and the quality of this water should reflect any impacts of the effluent irrigation.

Thus, there is no need for a groundwater monitoring program.   A surface water monitoring program is recommended.

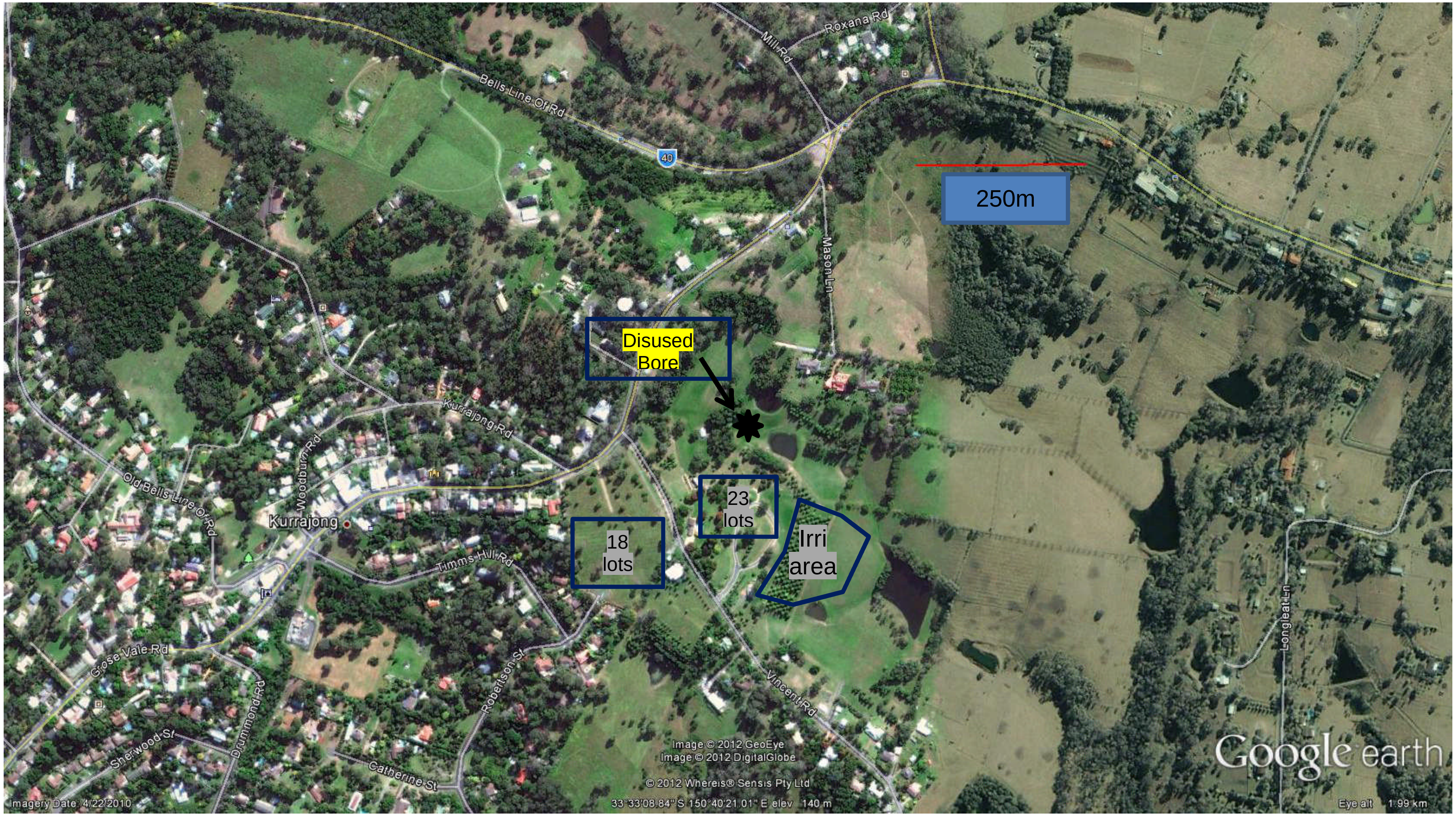

Figure 1. Regional context of the development area and the proposed irrigation site. The location of the bore is also shown (Image: Google Earth 11.2012)

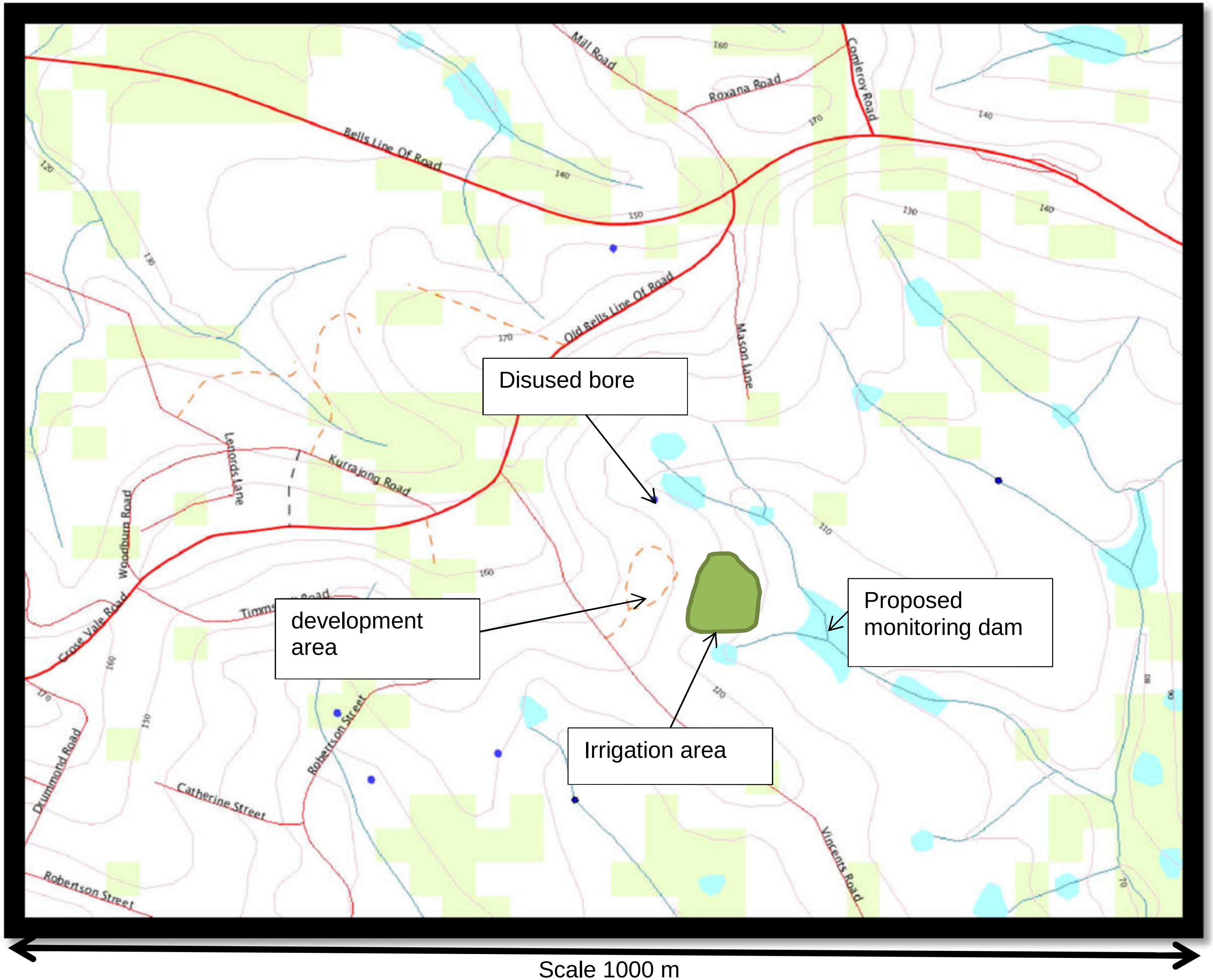

Figure 2. Location of bore and proposed monitoring dam in relation to subsurface irrigation area.

Impact of rainfall on irrigation
The irrigation can be turned off and then back on by a 'Mini Clik' system. This is shown below. It is marketed by Hunter Irrigation.

Figure 3. The Mini Clik system is used to ensure that irrigation will not occur during rain events greater than 10mm. This is during rain events that could cause runoff.

Hunter's Mini Clik rain sensor provides the simplest, most effective way to prevent surface or subsurface irrigation from running during or after any level of rainfall. It easily installs on any automatic irrigation system. The Mini-Clik stops scheduled irrigation when it detects a pre-set level of rain has fallen. This automatic process ensures landscapes aren't watered during a storm. Once the storm passes, the Mini-Clik allows the controller to resume normal irrigation. This occurs once the water container in the Mini-clik dries out. Thus there is a delay of 1 to 2 days before the irrigation commences.

Wet weather storage
Large scale wet weather storage is not needed. The reason for this is that the system relies on subsurface irrigation so mixing with rainfall runoff and moving off site in combined flow does not occur. Secondly, the Mini-clik system ensures that irrigation does not occur once a predetermined rain event happens. In these circumstances a 5 day storage is sufficient to allow for the Mini-clik system to dry out sufficiently to allow irrigation to resume. A 5 day rather than a 2 day storage is recommended because it provides for longer periods of intense rainfall.

Health and Environmental Risk and Impact assessment
This assessment is discussed in relation to the quality of the effluent being reliably produced by the Aquacell STP.

The system produces effluent with less than 1 cfu/100mL of E.Coli. This means that the effluent is virtually sterile. The extremely low microbial load, plus the subsurface application system means that the NRMMC/ EPHC/ AHMC (2006). Australian Guidelines for Water Recycling: Managing Health and Environmental Risk requirements are met.

The minimum of 40m distance to the farm dam is not an issue because the water is virtually sterile and is applied via subsurface irrigation (DEC, 2004). .

References

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Appendix 4.3.9 - HACCP and HAZOP for Tallowood Development

Risk

Likelihood		Consequences 1	2	3	4	5
	1	Low	Low	Low	Moderate	High
	2	Low	Low	Moderate	High	Very High
	3	Low	Moderate	High	Very High	Very High
	4	Low	Moderate	High	Very High	Very High
	5	Low	Moderate	High	Very High	Very High

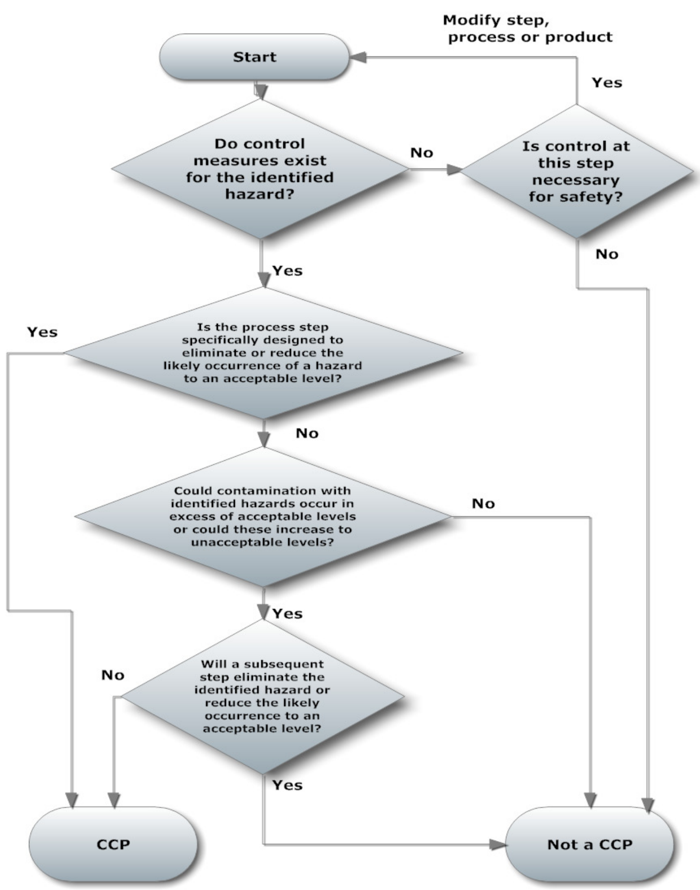
Qualitative measures of likelihood

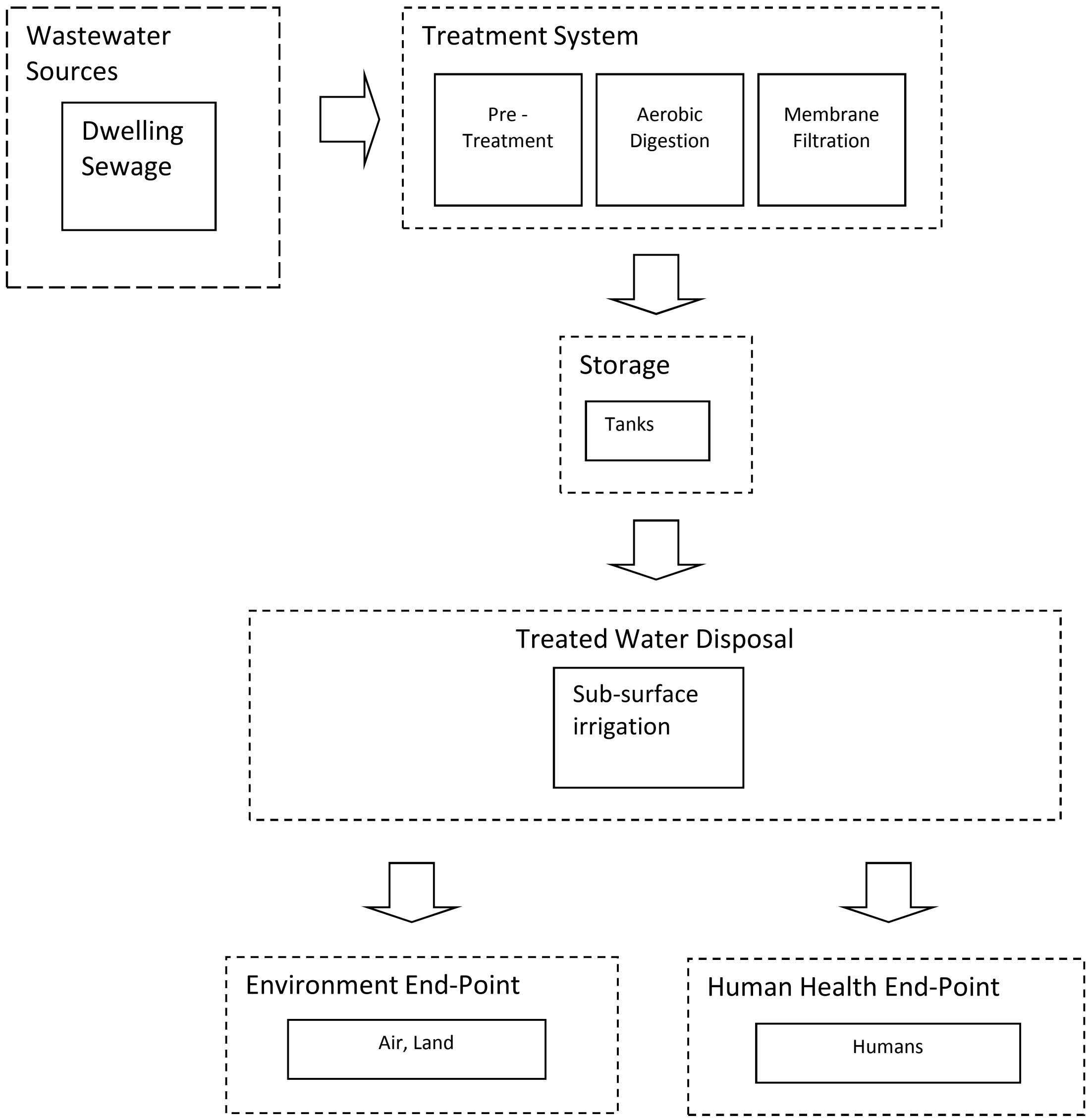
Level	*Descriptor*	*Example of Description*	
1	Rare	May occur only in exceptional circumstances	very rarely > annual
2	Unlikely	Could occur in unusual circumstances	chance of annual occurence
3	Possible	Might occur or should be expected to occur under certain circumstances	chance of monthly occurence
4	Likely	Will probably occur	chance of weekly occurence
5	Almost Certain	Is expected to occur	chance of daily occurrence

Qualitative measures of consequence

Level	*Descriptor*	*Example of Description*
1	Insignificant	Insignificant impact or not detectable
2	Minor	Health - Minor impact on contact population, first aid treatment Environment - Minimal and short term harm to the environment
3	Moderate	Health - Moderate impact on contact population, medical treatment required Environment - Significant harm to the local environment for a short period
4	Major	Health - Major impact on contact population, extensive injuries Environment - significant harm to the environment
5	Catastrophic	Health - Potentially lethal on on contact population, death Environment - significant, widespread harm outside local area

Decision Tree




Wastewater Sources
Dwelling Sewage
Treatment System
Pre - Treatment
Aerobic Digestion
Membrane Filtration
Storage
Tanks
Treated Water Disposal
Sub-surface irrigation
Environment End-Point
Air, Land
Human Health End-Point
Humans

HACCP Checklist

Project Name:	Kurrajong
Project Engineer:	Technical Manager
Date of Assessment:	14-Jan-16
Revision:	Revision 1
Approved By and Date:	W. Johnson

To be approved by the Technical Manager

HACCP Workshop Attendees	Revision 1 Attendees	Revision 2 Attendees (December 19th 2011)	Revision 3	Revisions
	W. Johnson			
	J. Taylor			
see RWQMP section 4 for company affiliations				

DESIGN /			Before Mitigation			After Mitigation															
Step	**Potential Hazard**	**Preventative Measure**	**Likelihood**	**Consequence**	**Resid. Risk**	**Likelihood**	**Consequence**	**Resid. Risk**	**Uncertainty**	**Decision Tree**				**CCP**	**Critical Levels**		**Monitoring**	**Corrective Action**		**Records**	
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*	*1 to 5*	*1 to 5*	*D + E*		*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*	
1. Source water (sewage influent, collection lines, pump stations)	Physical contact with wastewater	Covers on tanks, locks where appropriate, trained operators to access site, signage, difficult to access. Training of services personnel.	1	2	3	1	2	3	± 1	N	N			No							
	Biological Hazard. Faecal matter in influent above specification. Additional pathogen load to treatment plant resulting in out of spec treated water	Membrane UF treatment. On-line monitoring. Verification monitoring. Actual pathogen removal likely to be higher than operational target. Ongoing monitoring program includes biological parameters. Turbidity meter indicates membrane breach.	1	2	3	1	2	3	± 1	N	N			No							
	Physical hazard.	Exclude the public from the plant and irrigation area. Use correct PPE.	2	2	4	1	1	2	± 1	Y	N	N		No							
	Chemical Hazard	Buffer tank pH is monitored	3	2	5	3	1	4	± 1	Y	N	N		No							
	Blockage or break in sewerage network.	Properly designed sewer. Graviy flow system (no pump stations). Network is comparatively small.	2	1	3	2	1	3	± 1	Y	N	N		No							
2. Screen	Chemical hazard. Non-compliant trade waste discharge up stream.	Buffer tank pH is monitored. Buffer tank pumps don't transfer if pH is out of range.	2	2	4	2	2	4	± 1	N	N			No							
	Residnets disposing of chemicals down the drain	Education of resident . pH monitoring of the influent, any out of range feed not accepted. Dilution of feed by other residents	2	2	4	2	1	3	± 1	Y	N	N		No							
	Screen may block or fail.	Routine maintenance inspections. Level alarms.	2	1	3	2	1	3	± 1	Y	N	N		No							
	Screenings and grit need to be removed from site and accidental discharge to environment may result with potential public contact to pathogens. Contractor may contact the contaminants via the skin or inhalation	Ensure appropriately experienced and licensed contractors are used for maintenance of systems. Contractors use adequate PPE to mitigate against ingestion, skin contact and inhalation. Remediate spills immediately and exclude public from the spill point until rectified.	2	2	4	1	2	3	± 1	Y	N	N		No							
3. MBR (Aerators, Mixed Liquor, Membranes)	Chemical hazard - pH sensitive Shock loads	High MLSS will reduce effects of shock loads. pH exclusion in pre-treatment prevents delivery of non-compliant water to MBR.	2	2	4	2	1	3	± 1	N	N			No							
	Chemical hazard - pH neutral	DO indicator of biomass health. High MLSS - shock resistance.	3	1	4	3	1	4	± 1					No							
	Chemical hazard - Chemical cleaning process destroys biomass	Appropriate procedures. Operator training. Slow down production to allow biomass to rebuild. Last resort, shutdown and re-seed.	3	1	4	2	1	3	± 1	N	N			No							
	Chemical cleaning damages membranes.	Appropriate procedures. Operator training. Membranes selected for broad compatability range. In the event membranes are damaged, breach would be detected by turbidity probe.	3	3	5	1	3	4	± 1	Y	Y			CCP	Turbidity < 2 NTU	Turbidity > 2 NTU	Online turbidity				
	Biological hazard Over aeration - nitrification reduces pH in tank	Operator training. DO monitoring. pH probe in filtrate pit is indicator of bioreactor pH.	3	2	5	3	2	5	± 1	N	N										

Step	Potential Hazard	Preventative Measure	Likelihood	Consequence	Resid. Risk	Likelihood	Consequence	Resid. Risk	Uncertainty	Decision Tree				CCP	Critical Levels		Monitoring	Corrective Action		Records
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*	*1 to 5*	*1 to 5*	*D + E*		*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*
	Biological hazard Under aeration failure. 1) electrical 2) diffuser	Blowers are alarmed for electrical failure. Pressure transducers on aeration system detect diffuser blockages. Separate blowers supply biology and membrane. Routine Maintenance Program DO probe alarmed for aeration failure.	2	2	4	2	1	3	± 1	Y	N	N		No						
	Biological hazard Loss of biomass due to lack of feed.	Residential estate is likely populated at all times. Experience shows biomass can sustain health over several days.	1	2	3	1	2	3	± 1	Y	N	N		No						
	Biological hazard Membrane failure allowing pathogens through, either by gross rupturing or pinholing	Upstream screen to protect membranes from foreign matter. Membrane selection with a broad compatibility range. Level and overflow alarms (membranes dry out) Online turbidity measurement of filtrate. Turbidity shutdown alarm.	2	3	5	2	3	5	± 2	Y	N	Y	N	CCP1	NTU < 2	NTU > 2	Online turbidity			
	Physical hazard Leave drain valve open, emptying membrane tank	Operator training. Remove valve handles. Low level alarm on membrane tank.	1	2	3	1	2	3	± 1	Y	N	N		No						
	Physical hazard Faulty connections to/from membrane filter.	Good pipe work design and flexible connections used. Use stainless steel clamps and screws. Online turbidity to maintain spec.	2	3	5	1	3	4	± 1	Y	N	Y	N	CCP1	Turbidity < 2 NTU	Turbidity > 2 NTU	Online turbidity			
	Physical hazard Loss of air scour due to large bubble size (broken diffuser).	Appropriate design.Inspection. Pressure transducers with low pressure alarm	2	1	3	2	1	3	± 1	Y	N	N		No						
	Physical hazard Faulty membrane installed	Quality checks at manufacturing, construction, commissioning. Manufacturers approval Verification during commissioning . Water Quality Testing. Turbidity monitoring	2	3	5	1	3	4	± 1	Y	N	Y	N	CCP1	Turbidity < 2 NTU	Turbidity > 2 NTU	Online turbidity			
	Sludge needs to be removed from site and accidental discharge to environment may result with potential public contact to pathogens. Operator handling also implies human exposure risk	Ensure contractors are adequately trained and licensed. Exclude public access and immediately rectify spills. Use appropriate PPE to avoid inhalation and skin contact. Supervision by Aquacell staff.	1	3	4	1	3	4	± 1	Y	N	N		No						
	Sludge wasting may fail leading to disruption of plant function	Sluge is manually wasted. Ensure wasted sludge flows to sludge tank and is not contacted by humans	3	1	4	3	1	4	± 1	Y	N	N		No						
4. Irrigation System and Storage Tanks	Exposurel hazard, improper use of treated water.	Education program for occupants. Lilac coloured pipes and fittings. Signage indicating recycled water usage. No taps on irrigation network. Treatment plant operating correctly	1	3	4	1	3	4	± 2	N	N			No						
	Degredation in water quality and delivery due to biofilm growth	Correct sizing of irrigaton field and storage tanks. Flushing point on irrigation system installed. Tank level alarms if irrigation system blocks.	2	3	5	1	3	4	± 2	N	N			No						
	Irrigation pump may fail	Small pump which is readily available. Adequate storage volume in buffer and irrigation tank to allow time for pump to be replaced. Irrigation tank and buffer tank can be pump out if necessary.	2	3	5	1	3	4	± 1	N	N			No						
	Irrigation pipes or fittings may fail	Five seperately operable irrigation zones so problem zones can be isolated. Routine checks to look for pooling or leaking. Adequate storage volume in buffer and irrigation tank to allow time for pump to be replaced. Irrigation tank and buffer tank can be pump out if necessary.	2	3	5	1	3	4	± 1	N	N			No						
11. General	Prolonged power outages	Buffer tank can hold 8 times daily demand. Buffer tank can be pumped out.	1	2	3	1	2	3	± 1	N	N			No						

Step	Potential Hazard	Preventative Measure	Likelihood	Consequence	Resid. Risk	Likelihood	Consequence	Resid. Risk	Uncertainty	Decision Tree				CCP	Critical Levels		Monitoring	Corrective Action		Records
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*	*1 to 5*	*1 to 5*	*D + E*		*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*
	Extreme weather (flooding/heat)	Critical equipment under cover. Plant is above flood level on the side of a hill. Pump out can be used if plant is disabled.	1	4	5	1	4	5	± 1	N	N			No						
	Earth quake	Pump out can be used if plant is disabled.	1	4	5	1	4	5	± 1	N	N			No						
	Fire	Pump out can be used if plant is disabled. Vegetation is maintained around plant.	1	4	5	1	4	5	± 1	N	N			No						
	Human actions (sabotage)	Pump out can be used if plant is disabled. Plant is in gated estate to prevent any access from general public.	1	3	4	1	3	4	± 1	N	N			No						

HAZOP
Checklist

Project Name:	Kurrajong	
Project Engineer:	Technical Manager	
Date of Assessment:	14-Jan-16	
Revision:	Revision 1	
Approved By and Date:	W. Johnson 14/1/16	*To be approved by the Technical Manager*

HAZOP Workshop Attendees		**Revision 1 Attendees**	**Revision 2 Attendees**
		W. Johnson	
		J. Taylor	

HAZOP

Item	**Deviation**	**Consequence**	**Causes**	**Safeguards**	**Actions**	**Who**	**Due Date**	**Status**
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*			
1. Source water (sewage input, collection lines)	No influent	Low levels, not providing enough flow to biology	Low influent production Blockage or linebreak upstream of buffer tank	Low level switch to protect downstream equipment if no feed is available.				
	Out of spec influent quality	Upsets biological process and possibly membranes	Long storage time turns septic, contaminated waste, other upsets	pH probe which turns influent pump off if pH low. Pump out tank if required				
	Influent feed not used	Septicity develops, buffer tank overflows	Treatement plant offline, treated water tank full	Buffer tank and treated water tank can be pumped out if required				
	High influent flow	Buffer tank fills up	Flooding of sewer pit, stormwater ingress, high demand due to community activities	Additional capcity built into plant, buffer tank volume 8 times daily flow, buffer tank can be pumped out if				
	Reverse Flow	Back-up in inlet pipe	Cannot hapen in ths configuration (gravity flow system)	Gravity flow system				
	Low level	as for 'no influent'						
	High level	Buffer tank fills up. Overflow to sump	Treatement plant offline, treated water tank full	Buffer tank and treated water tank can be pumped out if required				
	High pressure	Not possible in gravity flow system	N/A	N/A				
	Low pressure	Not possible in gravity flow system	N/A	N/A				
	Tank rupture	Spill of influent to environment	Earthquake, subsidence, flood, flotation	Good design. Fit for purpose tank. Located above flood level cut into side of hill				
	pH outside expected range	Biological process upset	Influent pH	pH meter in buffer tank				
	Start up/ shutdown	No- issue						
	Isolation	No requirement for isolation						
	Cleaning	no requirement for cleaning						

HAZOP

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*			
2. Screen	No Flow	No feed into biology tanks	Screen blockage, motor trip	Level switches, motor overload, screen overflow to buffer tank				
	High flow	Overflow	Screen blockage	High level alarms and control logic, screen overflows to buffer tank				
	Reverse flow from sewer overflow	Not possible						
	Level	As for 'flow'						
	High pressure in pumped line	Damage pipe and pump	Blockage	Trip and alarm on pump				
	Composition	Foaming and possible overflow	Detergents and/or microbiology	Sealing lids. Overflow to buffer tank				
	Start up/ shutdown	No Issues						
3.MBR	No Flow into MBR	Biomass dies	No flow from upstream	Low level alarm				
	No flow out of MBR	No effluent produced	Membrane fouling, jammed actuated valve, pipe blockage, turbidity alarms, filtrate pump failure	Turbidity alarm, actuated valve alarm, regular membrane cleaning, flux rate monitoring, air scour of membranes				
	Sludge build up in base of tank	No flux through membranes. Blocked diffusers preventing air scour	Poor influent screening. Blocked diffusers preventing air scour	Inspections. Monitoring scour air pressure				
	High flow	High level and overflows	Over-pumping in from previous tank. Blocked recirculation lines.	Level alarms				
	High flux through membrane	More rapid membrane fouling	High trans-membrane pressure. Chemical membrane clean	Turbidity meter. Flux monitoring.				
	High air pressure	Damage pipe and blower. Damage membranes	Diffuser blockage	Thermal overloads on blowers. Sour air pressure monitoring				

HAZOP

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*			
	pH drops	Biomass dies. Corrosion. Out of spec water quality pH	Nitrification in aeration tanks does not have sufficient alkalinity therefore dropping pH	Filtrate pH meter. DO control. Can consider alkalinity dosing.				
	Low air flow	Biomass negatively impacted. Membrane fouling from lack of scouring.	Aeration fails. High MLSS	DO probe, blower alarms Monitoring of MLSS/DO. Monitoring biology air pressure.				
	Low levels	No flux through membrane Membrane dries out and/or fouls Biomass dies	Faulty actuated valve	Low level alarm				
	High level	Overflows	Over-pumping in from previous tank. Recirculation pumps blocked or damaged.	Level alarms. Adjustment of recirculation valves lines from bio to MBR.				
	Low pressure on air lines	Low air supply. Membranes do not scour properly. Anaerobic conditions	Broken diffuser or air pipe	DO monitoring for Bio (not MBR). Pressure monitoring of membrane and biology air				
	High air pressure	Damage pipes and pumps	Blockage in pipes or diffusers	thermal overloads on blowers				
	High permeate pressure	Not possible						
	Composition	Biomass impacted and biological treatment lost. Membranes damaged.	Toxins in waste water	DO probe. Influent pH probe.				
4. Filtrate pit	High level	Overflow	Pump failure, level switch failure, filtrate valve failure	Fault pump detection, overflow pipe				
	Inaccurate turbidity reading	false alarms, instrument failure	Failure of turbidity probe. Biofilm in filtrate pit or lines	Routine servicing and calibration				
	Low level	Dry running pump, turbidity probe function	Failure float switch	Low level alarm				
	No flow or overflow	Same as low and high level						
5 Irrigation system and storage tanks	Low level	Dry running of pumps	irrigatino pump fails to stop	Level switch				

HAZOP

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*			
	High level	Overflows to environment	Failure of irrigation controller or solenoid valves.	Level alarms. Treatement plant stops processing				
	Low pressure	not disposing of water uniformally	irrigation pump stops	Routine inspections of irrigation field				
	high pressure	irrigation pump stops prematurely	blocked lines	high level alarm in irrigation tank				
	Reverse flow in mains supply	not possible - no cross conneciton potential						
6. Manual Work	Maintenance	Damage to equipment	Poor workmanship	Following Work Instructions				
	Maintenance	Chemical spills	Chemical handling	Following Work Instructions				

Appendix 4.3.9 Retail Risk Assessment - Tallowood

Risk Matrix

Likelihood	Consequence 1	2	3	4	5
1	Low	Low	Low	Moderate	High
2	Low	Low	Moderate	High	Very High
3	Low	Moderate	High	Very High	Very High
4	Low	Moderate	High	Very High	Very High
5	Low	Moderate	High	Very High	Very High

Qualitative measures of likelihood

Level	*Descriptor*	*Example of Description*	
1	Rare	May occur only in exceptional circumstances	very rarely > annual
2	Unlikely	Could occur in unusual circumstances	chance of annual occurence
3	Possible	Might occur or should be expected to occur under certain circumstances	chance of monthly occurence
4	Likely	Will probably occur	chance of weekly occurence
5	Almost Certain	Is expected to occur	chance of daily occurrence

Qualitative measures of consequence

Level	*Descriptor*	*Example of Description*
1	Insignificant	Insignificant impact or not detectable
2	Minor	Health - Minor impact on contact population, first aid treatment Environment - Minimal and short term harm to the environment
3	Moderate	Health - Moderate impact on contact population, medical treatment required Environment - Significant harm to the local environment for a short period
4	Major	Health - Major impact on contact population, extensive injuries Environment - significant harm to the environment
5	Catastrophic	Health - Potentially lethal on on contact population, death Environment - significant, widespread harm outside local area

Construction and Business Operations Risk Assessment

Project Name:	Kurrajong
Date of Assessment:	27th April 2015
Revision:	Original
Created	Justin Taylor
Approved	Colin Fisher
Personnel Consulted	Justin Taylor, Colin Fisher Simon Grimwood

Activity	Risk	Impact	Unmitigated Risk					Control Strategy	Mitigated Risk				
			Likelihood		Consequence		Risk		Likelihood		Consequence		Risk
Construction	Insufficient information available to construct the infrastructure	Infrastructure incomplete or not correctly installed	3	Possible	3	Moderate	High	-Detailed process flow diagram, P&ID, electrical drawings, civil drawings, mechanical fabrication drawings - Detailed GA and installation drawings - Detailed valve, equipment and instrument schedules - Project Manager with waste water treatment experience overseeing the project to ensure design is complete prior to construction commencing - Project Manager relates detailed information to construction team and oversees construction	1	Rare	3	Moderate	Low
	Issued for construction drawings not followed accurately	Infrastructure does not operate correctly. Effluent quality may be outside specification. Plant may not achieve design capacity.	3	Possible	3	Moderate	High	- Installation to be supervised by competent Aquacell staff member - Construction by employees or contractors with prior experience installation Aquacell plants - Detailed commissioning check sheets to ensure plant is systematically checked against design prior to start up	1	Rare	2	Minor	Low
	Wrong equipment delivered by supplier and subsequently installed during construction	Infrastructure does not operate correctly. Effluent quality may be outside specification. Plant may not achieve design capacity.	4	Likely	2	Minor	Medium	- Detailed purchase orders including supplier part number - all goods checked in against goods inwards note, purchase order and supplier delivery docket to ensure ordered part has been correctly supplied - Incoming goods labelled and stored in dedicate project bay	1	Rare	2	Minor	Low
	Correct equipment supplied but mixed up and installed in the wrong position on site	Treatment plant does not produce required effluent quality	2	Unlikely	2	Minor	Low	- Detailed P&ID with tag numbers that match valve, instrument and equipment schedules - detailed commissioning check sheets used by Commissioning Engineer to verify installed equipment against the P&ID	1	Rare	1	Insignificant	Low
	Treated plant cannot be constructed as designed and drawn	Treatment plant cannot be completed with design change	4	Likely	3	Moderate	High	- Treatment plant modelled with 3D software so entire assembly can reviewed prior to 2D fabrication drawings being developed - design review prior to issue for construction drawings being developed which considers constructability of the plant	2	Unlikely	1	Insignificant	Low
	Treatment plant contains design omission or oversight	Non-compliant treated water produced, spill or other adverse environmental condition occurs	2	Unlikely	4	Major	High	- HACCP and HAZOP undertaken prior to issued for construction drawings - HACCP and HAZOP conducted by multidisciplinary team to consider all aspects of the plant design - Peer review of design calculations to check their validity	1	Rare	2	M	Low
	Reticulation pipe work not correctly installed	Non-compliant and possibly non-operational reticulation system	3	Possible	3	Moderate	High	- reticulation system designed by suitably qualified person - licensed plumber used to supervise and install the reticulation system - system installed compliant with relevant Australian Standards	2	Unlikely	1	Insignificant	Low
	Plant, irrigation field or reticulation network installed in incorrect place	Location contrary to approvals which have been granted	3	Possible	4	Major	Very High	- Surveyors used where necessary to mark boundaries and ensure infrastructure installed in DA approved area	1	Rare	1	Insignificant	Low
	Pipe across Vincent Road installed in the incorrect place	Pipe not within designated easement	3	Possible	4	Major	Very High	- Surveyor used to mark location of pipe and ensure it is within designated easement	1	Rare	1	Insignificant	Low
	Working on public road to install pipe across Vincent Road	Injury to installer or public	3	Possible	4	Major	Very High	- Traffic Management Plan implemented to ensure safe work - All approvals sought from local council prior to closing road and undertaking work	1	Rare	2	Minor	Low

	Unsafe work practices during construction	Injury to construction team or equipment damage	4	Likely	4	Major	Very High	- Work undertaken under the jurisdiction of Aquacell's WHS System including, but not limited to procedures for risk assessment, working at heights, confined space, manual handling etc. - Safe Work Method Statements developed to cover the activities undertaken during construction - Licensed persons used to undertake work where necessary - Construction WHS considered at design phase so the plant can be constructed safely, e.g., lifting hooks added to heavy equipment - Correct equipment used to undertake the tasks, e.g., crane for lifting plant in to place	2	Unlikely	2	Minor	Low
	Interruption to residents during construction	Resident complaints	3	Possible	2	Minor	Medium	- Keep noise to a minimum - Work only during normal hours - Workers to keep clear of traffic ways and not park cars or leave materials such that they interrupt the peaceful enjoyment of the residents - Rubbish to be removed from site as soon as practically possible	2	Unlikely	1	Insignificant	Low
	Waste generated on site during construction	Environmental contamination	3	Possible	2	Minor	Medium	- all waste to be removed from site as soon as practical, preferably daily - where waste cannot be immediately removed from site it is stored such that it cannot be blown or washed into the local environment - recyclable material returned to Aquacell for recycling	1	Rare	1	Insignificant	Low
	Chemical spill during construction	Environmental contamination	3	Possible	2	Minor	Medium	- minimise number of chemicals used during construction - bring chemicals onto site only when required - do not store chemicals on site when they are not needed - ensure MSD and appropriate clean up materials are available on site	1	Rare	1	Insignificant	Low
	Plant produces effluent which is out of specification during start up phase	Environmental contamination	4	Likely	4	Major	Very High	- online instrumentation measure critical parameters and causes plant to alarm if effluent is not suitable for discharge - water quality can be verified with hand held instrumentation which the Commissioning Engineer carries - out of specification water can be held in the treated water tank and be tankered off site if required	1	Rare	1	Insignificant	Low
	Construction of infrastructure not completed on time	Residents cannot get occupancy	3	Possible	3	Moderate	High	- install balance tank as first stage of project. Sewage can be collected in the balance tank and tankered out if there are any delays constructing the treatment plant or irrigation field	2	Unlikely	1	Insignificant	Low
	Long lead time items are no longer available in quoted lead time	Residents cannot get occupancy	2	Unlikely	3	Moderate	Medium	- Long lead time items ordered as soon as issued for construction design approved - Long lead time items generally have an alternate which could be used if required	1	Rare	1	Insignificant	Low
Business Operations	Business Interruption, e.g. fire, flood, natural disaster	Aquacell unable to complete construction	1	Rare	5	Catastrophic	High	- Business interruption insurance in place - Procedures in place to minimise disruption, e.g., digital files archived off site - Construction works could be undertaken on site if Aquacell workshop was unavailable	1	Rare	3	Moderate	Low
	Financial Risk - Aquacell Cash Flow	Aquacell unable to complete construction	2	Unlikely	4	Major	High	- Project Manager manages against agreed budget - Project Manager aims to run the project cash flow positive if practical - Project has milestone payments to ensure Aquacell has a revenue stream through the duration of the project - Aquacell has other income streams from servicing and operations to smooth business cash flows - Ongoing management reviews of business wide cash flow to forecast and manage periods of low cash flow	1	Rare	2	Minor	Low

Financial Risk - Supplier Insolvency	Aquacell not able to receive parts which have been ordered. Loss of deposits or payments already made	2	Unlikely	3	Moderate	High	- Aquacell's standard terms are to pay for the goods once received - Aquacell's standard terms are 60 days - Where deposits are required, they are negotiated to minimum amounts to mitigate risk - Where goods are not provided due to supplier insolvency, an equivalent alternate could be sourced	1	Rare	2	Minor	Low
Financial Risk - Customer Insolvency	Aquacell does not get paid for the costs they have incurred	1	Rare	3	Moderate	Low	- Milestone payments negotiated into the contract to minimise financial exposure - Active debtor management to ensure overdue amounts are collected	1	Rare	2	Minor	Low
Technical	Plant doesn't operate as designed due to oversight, omission or error	2	Unlikely	4	Major	High	- Aquacell recruit suitably qualified design personnel who are competent to design to required infrastructure - Where skills are required outside Aquacell's core competency, appropriately qualified persons are contracted to undertake the work - Aquacell maintains Professional Indemnity insurance to mitigate costs associated with technical failures	1	Rare	2	Minor	Low
Contract Labour	Contractor does, or omits to do something that causes harm or damage	3	Possible	3	Moderate	High	- Contractor's management to ensure contractors are reviewed prior to commencing work - Each contractors relevant insurances, licenses and safe work method statements are reviewed prior to engagement - Contractor insurance	2	Unlikely	2	Minor	Low
Personnel - key persons leave the company	Plant cannot be constructed and built with staff available	3	Possible	3	Moderate	High	- disciplined design procedures and storage of documentation to allow others to continue should a staff member become unavailable - Standard design blocks which can be reused on each project rather than requiring bespoke designs for each project - other employees within Aquacell have similar skills and could continue the work to completion	1	Rare	2	Minor	Low
Contractual - Aquacell and client disagree on scope	Delays	3	Possible	3	Moderate	High	- a detailed contract between the customer and Aquacell is put in place prior to commencement of works. This document is the reference document and both parties are bound by it	2	Unlikely	2	Minor	Low
Contractual - Aquacell and supplier/contractor disagree on scope	Delays	3	Possible	3	Moderate	High	- Aquacell only order items with a formal purchase order backed by a set of standard terms and conditions. Scope, price and payment terms are clearly defined prior to purchase	2	Unlikely	2	Minor	Low
Resource - insufficient resources available	Delays	3	Possible	3	Moderate	High	- Aquacell staff have multiple skill sets and can be redeployed within the business to satisfy short term resource deficiencies - Aquacell have established relationships with a number of external contractors who could be called upon if the incumbent was unable to complete the job in a timely manner	2	Unlikely	1	Insignificant	Low
Safety - Employees	Injury, Lost time, costs to business	4	Likely	4	Major	Very High	- WHS system developed and in place - Staff training in WHS procedures - SWMS developed for tasks work which is carried out - Correct methods of work identified and appropriate equipment used to ensure risks associated with work are as low as practically possible - Workers Compensation insurance in place to minimise business costs should an injury occur	1	Rare	2	Minor	Low
Safety - Contractors	Injury, Lost time, costs to business	4	Likely	4	Major	Very High	- WHS system developed and in place - Contractors to supply SWMS prior to commencing work - Contractor selection to ensure appropriate persons selected to undertake work, and licensed where necessary - Contractor management to ensure selected contractors have workers compensation policy and other appropriate insurances in place prior to providing them with a purchase order	1	Rare	2	Minor	Low

	Organisational - restructure, sale of business etc.	Project delivery compromised	1	Rare	3	Moderate	Low	- Aquacell is 100% privately owned with no third parties or holding companies and therefore are unlikely to be sold or restructured at short notice. Any organisational change will be negotiated with the current project and work load in mind	1	Rare	1	Insignificant	Low

Tallowood Residential Community Development - Kurrajong NSW

Sewage Management Plan

7 January 2016

A0069 Sewage Management Plan

Prepared by: **Warren Johnson - phone 02 4721 0545**

Email: warrenj@aquacell.com.au

Revision	Date	By	Checked	Document Status	Amendments
1	10/12/13	S. Valenzisi	W. Johnson	Draft for internal review	First draft
2	12/12/2013	S. Valenzisi	W. Johnson	Final Document for IPART to review	Minor editing changes
3	7/1/16	W.Johnson	J. Taylor	Issued	Minor editing changes and updated verification testing on monitoring requirements

Table of Contents

1. Introduction

The Tallowood Residential Community Development is a 41 dwelling residential estate, being developed by the Bennet Property Group. It is located at the intersection of Bells Line of Road and Vincents Road Kurrajong. Kurrajong is located 75 kilometres north-west of Sydney, in the local government area of the City of Hawkesbury. There are two stages to the development. The first stage (stage 1), east of Vincents Road, will contain 22 dwellings, community facility, as well as the blackwater treatment plant and designated area for the sub-surface irrigation. This stage was developed under an existing Section 68 approval. The second stage (stage 2), west of Vincents Road, is currently under development following IPART's granting of a Network Operator License and Retail Supplier Licence to Aquacell.

Potable water is being supplied by Hawkesbury Council's existing potable water reticulation, however Council do not intend to provide sewer reticulation for this area.

An Aquacell S20 blackwater treatment plant is to be installed in Stage 1 of the development, which intends to service all 41 dwellings. The client will provide gravity sewer reticulation from each dwelling, as well as sub-irrigation reticulation adjacent to the treatment plant. There is no effluent reuse/recycling proposed for this site, only wastewater disposal. The treated effluent is to be discharged to the environment via sub-surface irrigation, in compliance with WICA / Council Section 68 approval.

Blackwater treatment system, including the sewer and irrigation reticulation, is to provide an efficient, reliable and complete effluent wastewater disposal system for the entire 41 dwelling of the Tallowood Residential Community development, Kurrajong. The proposed Aquacell blacwater system is self contained and does not place any demand on council's sewerage network. The treated effluent is disposed of via sub-surface irrigation of an allotted area within the boundaries of the development.

The proposed blackwater treatment plant will utilise wastewater discharged from the facility and irrigate via subsurface irrigation at a rate of 12.2kL/day (0.508 kL/hr).

Effective management of domestic sewage and wastewater is an important consideration for human health and the environment. Effective management of this facility requires the active involvement of the residential community representatives, the Tallowood Community Association, as well as the system maintenance and operator contractor, Aquacell.

This Sewage Management Plan (SMP) is prepared in accordance with the requirements of the Local Government Regulations and WICA Network Operator and Retail Supplier Licence requirements.

The SMP is to regulate and manage the selection, design, installation, operation and maintenance of on-site sewage management systems.

The benefits of an on-site sewage management plan are:

- Better catchment management;
- A consistent message to householders and on-site sewage operators;
- A coordinated approach to liaise with industry, including developers, professional consultants, private certifiers, service agents and plumbers.

2. Purpose and Scope of the Sewage Management Plan

The purpose of the on-site Sewage Management Plan is to:

- Guide landholders towards sustainable on-site management of domestic sewage and effluent water.
- Protect and enhance the quality of public health and the environment within the Kurrajong and Hawkesbury Shire Council Local Government Area (LGA).
- Assist landowner to prioritise resources for the efficient regulation and monitoring of On-site Sewage Management Systems.
- Coordinate monitoring, environmental assessment and data collection related to On-site Sewage Management.
- Allow for site assessment on risk management basis and consideration of alternate solutions on environmentally sensitive sites.

3. Objectives

The objectives of the On-Site Sewage Management Plan are to provide for the safe collection, treatment and disposal of wastewater generated by the Tallowood community.

Sewage contains bacteria, viruses, parasites and other disease-causing organisms. Contact with effluent should be minimised or eliminated, particularly for children. Insects can also act as a vector for disease where they have access to effluent. Residuals, such as composted material, should be handled carefully. Treated sewage should not be used on edible plants that are consumed without cooking.

On-site Sewage Management systems should be selected, sited, designed, constructed, operated and maintained to ensure:

- **Protection of surface water -** surface waters are not contaminated by any flow from treated systems and land application areas (including effluent, rainfall run-off and contaminated groundwater flow).
- **Protection of groundwater -** groundwater will not be contaminated by any flow from either the treatment systems or land application areas.
- **Protection of land and vegetation -** land is not contaminated by any flow from treatment systems, effluent, rainfall run-off or removed tank solids.
- **Protection of community amenity -** quality of life shall not be unreasonably interfered with. Where possible, systems should enhance the local amenity - special consideration should be given to aesthetics, odour, dust, disease vectors and excessive noise.
- **Conservation and reuse of resources -** the resources in domestic wastewater (including nutrients, organic matter and water) should be identified and utilised as much as possible within the bounds posed by the other performance objectives; water conservation should be practiced and wastewater production should be minimised.

4. Goals

The goals of the On-site Sewage Management Plan are to:

- Ensure sustainable on-site sewage management for the Tallowood Community development.
- Identify roles and responsibilities for the sewage management system.
- To identify communication channels for emergency response and complaints.

5. Roles and Responsibilities

The Tallowood Residential Community blackwater system is located on Stage 1 of the two stage development (Stage 1 is East of Vincents Road Kurrajong NSW). This development is owned by the Bennett Property Group and Tallowood Community Association will manage the community facilities. The system consists of an effluent treatment plant, sewage collection reticulation network and a sub-surface irrigation reticulation network for the disposal of the treated effluent. There is no effluent recycling or reuse on this site.

The following table defines roles and responsibilities of Tallwood Community Association (TCA) and Aquacell, given the ownership and contract status.

Table 1: Roles and Responsibilities of Tallowood Residential Community Development Blackwater Treatment System

Role/Responsibility		Sewage Collection Network		Blackwater Treatment Plant		Irrigation Disposal Scheme	
		TCA	**Aquacell**	TCA	**Aquacell**	TCA	**Aquacell**
Blackwater Treatment System - Owner		X		X		X	
Treated Effluent - Supplier					X		X
SMP	Preparation and Approval		X		X		X
	Statutory reporting		X		X		X
	System audit		X		X		X
Operation and Maintenance	Operation		X		X		X
	Maintenance		X		X		X
	Logs: incident, maint., complaint, calibration, audit, non-compliance		X		X		X
	Water sample collection and forwarding				X		
	Management of water testing contract				X		
Manage Environmental Risk	Initial risk assessment and LCA per SMP		X		X		X

Role/Responsibility		Sewage Collection Network		Blackwater Treatment Plant		Irrigation Disposal Scheme	
		TCA	Aquacell	TCA	Aquacell	TCA	Aquacell
	Resident/neighbour education	X	X	X	X	X	X
Communication Strategy	Development	X	X	X	X	X	X
	Implementation	X	X	X	X	X	X
	Maintenance	X	X	X	X	X	X
	Feedback	X	X	X	X	X	X
	Evaluation	X	X	X	X	X	X
	Review	X	X	X	X	X	X
Incidents and Emergencies	Identification of potential incidents and emergencies	X	X	X	X	X	X
	Development of protocols, response actions, responsibilities and communications		X		X		X
Training of employees and contractors			X		X		X
Documentation and Reporting	Notification of non-compliances and incidents to DHS/EPA		X		X		X
Reviews	SMP		X		X		X

6. Overview of the Sewage Management System

The purpose of the overview is to outline factors that will affect the efficient and appropriate functioning of on-site Sewage Management Systems within the Tallowood Residential Development.

6.1 Sewage collection

Sewage collected from the homes on the site flows by gravity through the sewerage network to the buffer collection tank.

6.2 Treatment Process

6.2.1 Overview

The treatment process has been selected based on application of the *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)* (2006).

A risk minimisation approach has been adopted which involves the use of sub-surface irrigation and an irrigation area blocked to public access. In addition, as this is a waste disposal project, there is no reuse of treated water allowed. The risk of human contact with pathogens from the plant is therefore limited to workers on the plant and addressed in the use of safe work practises.

The treatment process will be MBR technology which is capable of achieving significant pathogen reduction and very high treated water quality. This, combined with an extremely low risk of human contact during normal operations, ensure that the risk to human health is eliminated.

The process selected to achieve the required water quality as discussed above, and described in further detail in the following sections, is shown below.

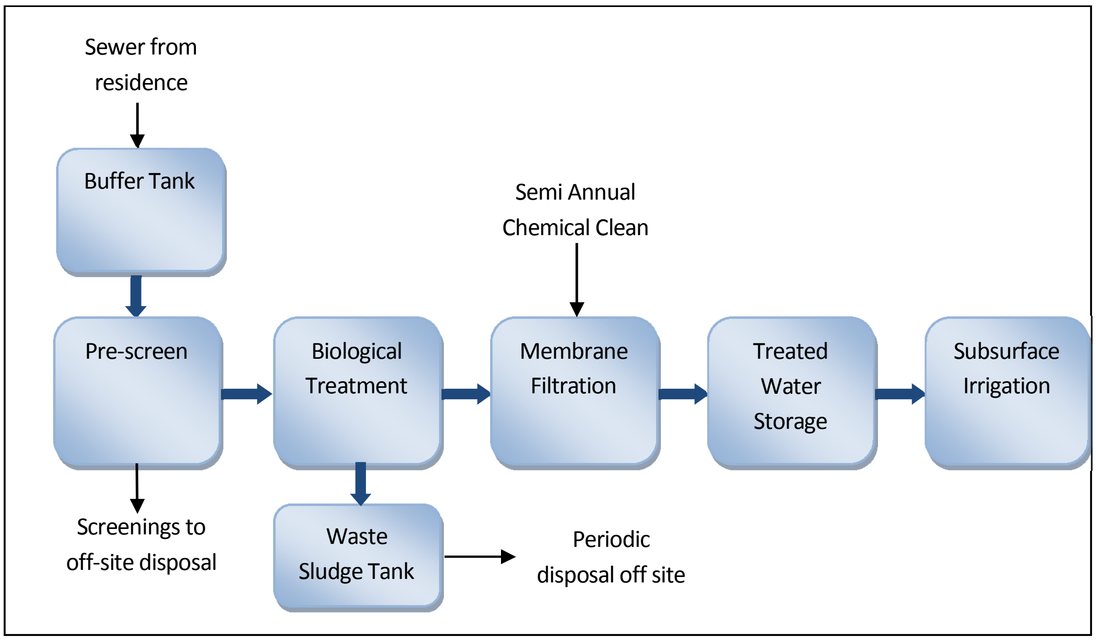


Figure 6.1 – Treatment process to achieve treated effluent fit for subsurface irrigation.

The expected wastewater quality and typical treated water quality is shown in table 6.2.

Table 6.2 Expected raw wastewater quality and typical treated water quality

Parameter	Expected Wastewater	Typical Treated Water
Biochemical Oxygen demand (BOD)	300-600 mg/L	< 10 mg/L
Suspended solids	200-400 mg/L	< 5 mg/L
pH	6.5-8.5	5 - 9
Oil and grease	< 50 mg/L	< 5 mg/L
Total Nitrogen	85mg/L	< 20 mg/L
Total phosphorous	20 mg/L	< 15 mg/L
E. *coli*	10^6-10^8 cfu/100mL	< 10 cfu/100mL
Turbidity		< 2 NTU

6.2.2 Buffer Tank

Wastewater collected from the community residence is directed to a 100 kL concrete buffer tank. When the residential community is fully populated (i.e. 41 lots in total), 12.2 kL/day of wastewater will be produced. This buffer tank will provide up to 8 days storage capacity. Should the tank need to be emptied due to the treatment plant being off line, a tanker will be called in to empty the buffer tank and remove it for disposal off site.

6.2.3 Pre-screen

Wastewater is pumped from the buffer tank to the pre-screen on demand. The pre-screen is a 2mm spiral sieve screen. Screenings are captured, washed and dewatered, then discharged into a wheelie bin via a continuous bagging system. Screenings are sent off site to land fill.

Odours from screenings has been minimised by enclosing the pre-screen and ensuring that screenings are captured in a sealed bag.

The pre-screen is designed to remove fibrous material and large foreign objects, while retaining as little solid organic matter as practical. The screen wastewater is then sent to biological treatment.

6.2.4 Biological Treatment

The biological process uses aerobic treatment to break down and digest the organic matter that contributes to biological oxygen demand (BOD). The aerobic zone uses air blowers and diffusers to distribute air within the reactor to supply the necessary oxygen for biological digestion to take place.

6.2.5 Membrane Filtration

Ultrafiltration membranes (flat sheet 2x BC100 with nominal pore size 0.04 μm) are used to separate the biomass from the treated water. In addition to removing essentially all the suspended solids, a substantial amount of the pathogens present in the wastewater are also removed in this process step.

The membrane is an integral part of the biological process and the combination is usually referred to as a membrane bioreactor (MBR).

Periodic chemical cleaning of the membranes is required to maintain performance. This will be carried out using sodium hypochlorite and citric acid, and occur approximately once every 3-6 months. Spent chemicals will be neutralised and discharged to the sludge tank for periodic disposal.

6.2.6 Treated Water Storage

The final treated water will be sent to treated water storage tank, 46 kL in volume. The treated water is to be discharge to the environment via sub-surface irrigation.

6.3 Irrigation System

Treated water from the storage tank is automatically distributed to subsurface irrigation via an irrigation control system. The irrigation system is controlled independently from the treatment plant, and is based on level in the treated water storage tank. When water is available, a pump sends water to one of five irrigation zones. Solenoid valves switch the irrigation zones in sequence and timers in the control panel control the duration of irrigation to each zone. This ensures no single area is over irrigated and minimises the risk of surface pooling.

7. Description of End Use

7.1 Overview

The treated water produced by the treatment process is intended for sub-surface irrigation disposal within the lower section of the Tallowood Community development, and not for distribution beyond the boundaries of the irrigation area.

7.2 Acceptable Uses

The treated water is intended only for disposal by subsurface irrigation in the designated area within the Tallowood development. The treatment process and associated risk has been assessed on that basis, and although the water quality may exceed the requirements, it is not intended for reuse or disposal by any other means.

8. Managing Human Health Risks

8.1 Overview

The report prepared by Woodlots and Wetlands Pty Ltd, Effluent Management Investigations. The document is attached as appendix A.

This SMP focuses on the assessment and management of risks relating to the end uses of sub-surface irrigation.

A summary of the key human health risks and mitigation measures is provided in table 8.1, and detailed further in the following sections.

A HAZOP and HCCP analysis has been carried out to assist in determining the risks and associated mitigation measures. A copy of the risk assessment is provided in appendix A.

Table 8.1 – Summary of health risk and mitigation measures

Risk	Management Measures	Risk after mitigation
Workers exposed to recycled water	Exposure in minimised by: • No above ground uses. • Irrigation is subsurface, so no exposure to humans. • Signage will be provided to warn people of the use of treated water in allotted irrigation area. • Site inductions of workers and visitors to include reference to the presence of treated effluent and the necessary precautions to take.	Low
Connection to irrigation reticulation	• Plumbing check for connection before delivering treated water to irrigation network. • Site inductions for any plumbing staff to include details on treated effluent water use. • Any plumbing mods to have management approval and qualified certification and inspection. • Signage where treated effluent is being used to warn and advise precautions. • Sub-surface irrigation network does not cross connect with any other water (potable or otherwise) network.	Low
Inappropriate use	• No above ground treated effluent water taps. • All treated effluent reticulation is sub-surface and the reticulation network is isolated and not connected to any other network. The chance for human contact is minimal. • Signage will be displayed, where sub-surface irrigation is being carried out, to warn and advise precautions.	Low
Spray drift and runoff	• All irrigation is sub-surface. • No above ground irrigation, hence no spray drift possible. • No wet weather storage is required (refer to Effluent Management Investigations by Woodlots and Wetlands Pty Ltd), hence sub-surface irrigation possible all year round.	Low
Contaminants in water that are detrimental to health	• Chemical contaminant levels in the treated effluent are expected to be very low. No special management practises are required.	Low

8.2 Workers Exposed to Treated Effluent

The water quality of the treated effluent is such that health risks are minimal. However, it is important that on-site workers and people that may come into contact with treated effluent are educated about the presence of treated effluent on site. This includes washing hands before eating, drinking, or smoking.

Signage will be provided to warn people of the potential presence of treated effluent in the allotted irrigation zone.

Site inductions of workers and visitors should also include reference to the presence of treated effluent and the necessary precautions to take.

The above measures make this a low level risk.

8.3 Cross Connections

There is no dual pipe system or recycled water taps located anywhere in the development. Reuse is not permitted and the disposal network will be largely inaccessible, underground, and sign posted.

The above measures are considered sufficient to eliminate cross connection risk.

8.4 Treated Effluent Outlets

There will be no above ground tap bibs that are fed with treated effluent. These will only be rainwater or potable water.

8.5 Spray Drift and Runoff

Treated effluent will solely be used for sub-surface irrigation of the allotted irrigation zone/area on site

Wet weather storage is not required on site. Refer to Effluent Management Investigations report prepared by Woodlots and Wetlands Pty Ltd. This report states that sub-surface irrigation is possible all year round (even during wet weather) as the soil characteristics and the area allocated enable irrigation all year round. The chance for runoff due to soil saturation is minimal.

These measures are sufficient to consider no spray drift will occur and determine runoff to be a low risk.

8.6 Contaminants

Chemical contaminant levels in the treated effluent are expected to be very low. No special management practises are required.

9. Managing Environmental Risks

9.1 Overview

A risk assessment approach will be undertaken to establish controls for environmental risks associated with the treated effluent treatment and use.

Various control and monitoring measures will be implemented to manage and mitigate environmental risks. Risks to be assessed include soil capability and irrigation risks, noise and odour. A summary of these is provided in table 9.1, and detailed further in the following sections.

Table 9.1 – Summary of environmental risks and mitigation measures

Risk	Management Measures	Risk after mitigation
Nutrients and salinity in irrigation water	• LCA conducted and confirms nutrient load is not an issue.	Low
Spray drift and runoff to the environment	• Spray drift prevented by using subsurface drip irrigation. • Runoff low level risk refer to LCA report	Low
Chemical contaminants in the water	• Chemical concentration in treated effluent is expected to be low. • Chemical usage on site is minimal and spent chemicals are neutralised and discharged to the sludge tank for periodic disposal off site.	Low
Noise	• Treatment plant is situated on site in a cut-away section in the hill side, which helps to reduce operational noise. Equipment that produces noise, such as blowers, are enclosed in noise reduction acoustic enclosures to minimise noise pollution.	Low
Odour	• Covered tanks and enclosed equipment used • Aerobic process, so septic smells are not expected	Low

9.2 Nutrients and Salinity

A Land Capability Assessment has been carried out for the Tallowood Residential Community site and is attached as appendix B. This assessment indicated that the irrigation area within this site do not contain saline soils. This is an important result as it means that salinity will not limit the site's usefulness for treated effluent irrigation.

The report concludes that there is minimal risk of any runoff occurring to the local water ways.

The report further concludes that the expected concentration of nitrogen and phosphorus in the effluent do not represent a significant environmental risk.

10. Communication

The Tallowood Community Association are to liaise with Aquacell to ensure existing and new residents are informed of the wastewater disposal system and how to ensure that it is protected from inappropriate disposal of wastes to the sewer.

This will include addition of community specific information to the Aquacell website, and attendance at community meetings as required.

11. Monitoring and Reporting

11.1 Monitoring

11.1.1 Monitoring of Treatment Plant Operation

Operational monitoring of the treatment plant is carried out by a combination of site visits for routine servicing and remote monitoring.

Routine service visits are carried out monthly for the purpose of checking and calibrating instruments, checking plant operation and performing chemical cleans on the membrane when needed. Periodic inspection of the irrigation field is also carried out to check for signs of water surface pooling or uneven irrigation.

Remote monitoring is used to allow daily checks on plant operation. Operating data are logged every 5-minutes to the Aquacell server to assist with trouble shooting and for reporting purposes.

System failures or operational issues are dealt with as they arise by Aquacell service personnel.

11.1.2 Validation Monitoring

In order to ensure the installed system is performing as intended, a series of 8 samples will be collected over 8 weeks and analysed as per table 11.1. A validation report will be prepared summarising these results.

The target water quality is based on the low risk of subsurface irrigation in an area with controlled and restricted access, as outlined in section 8.

Table 3.8 of the *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)* (NHMRC 2006) is used as a guide to an appropriate water quality. This table provides guidance on the water quality objectives for various uses. As a conservative target the figures for “Landscape irrigation – trees, shrubs, public gardens, etc.” can be used. This site has the additional mitigating measure of no public access and subsurface irrigation. The additional monitoring parameter of membrane turbidity is added to ensure membrane integrity is maintained, as this provides the bulk of the required pathogen reduction.

Table 11.1: Verification Monitoring and target water quality

Parameter	Feed	Treated Water	Target Quality
E. *coli*	Weekly	Weekly	< 1,000 cfu/100mL
BOD	Weekly	Weekly	< 20 mg/L
Suspended Solids	Weekly	Weekly	< 30 mg/L
Turbidity	N/A	continuous	< 5 NTU

11.1.3 Ongoing Monitoring of Treated Water Quality

Treated water quality is monitored by reference to critical control point operating values. The turbidity of the treated water effluent is the critical control point for the plant and will be maintained at or below 5 NTU. An alert level will be maintained at > 2 NTU to give advance warning of a potential problem and trigger an investigation into the cause. If the turbidity exceeds 5 NTU the plant will shutdown and stop delivering water to the storage tank.

The treated water turbidity will logged every 5 minutes and stored on Aquacell's server.

The buffer capacity is sufficient to ensure the plant can be down for periods for service or breakdown, with offsite disposal of waste by pump out a fall-back option for extended periods.

As an added water quality monitor, treated water E. *coli* levels will be tested at least quarterly to ensure the water meets the requirement shown in table 11.1.

11.2 Complaints and Faults Procedure

A record of any complaints received shall be kept by Aquacell, as well as responses and any corrective actions taken. Aquacell will follow the complaints procedure as documented in IMS CS030-3 Complaints Handling and Dispute Resolution Policy. A copy is available on request.

12. Management of incidents and emergencies

Aquacell maintains a community contact and FAQ section of its website with procedures relating to the management of emergencies. This will be updated to include Tallowood Community.

The specific responses to potential incidents and emergencies have been compiled with reference to IPART Incident Notification by private sector water licensees, WICA 2006, Water – Incident Notification August 2009, Section 2, Incident Notification Process.

Table 12.1: Incidents and emergencies

Hazards and events that may lead to emergencies	Immediate Response		Corrective Action		Authorities	
	What	**Who**	**What**	**Who**	**What**	**Who**
Non-conformance of water with critical limits	If detected by online instrument, plant automatically shuts off supply	Aquacell	If fault persists, Aquacell to disable effluent disposal and notify Tallowood Community while they continue to troubleshoot and resolve.	Aquacell	Has non-compliant water been discharged? If yes, notify authorities in accordance with WICA licence conditions.	Aquacell
Response to exceedances of water quality targets	If detected by water testing, evaluate severity to determine whether plant should be shutdown. Order immediate reset.	Aquacell	If fault persists, Aquacell to disable effluent disposal and notify Tallowood Community while they continue to troubleshoot and resolve.	Aquacell	Has non-compliant water been discharged? If yes, notify authorities in accordance with WICA licence conditions.	Aquacell
Accidents that increase level of contamination in source water	Collection tank continuously monitored for pH. Feed pump disabled when pH outside limits.	Aquacell	Aquacell to review cause and treat if possible. If not possible to treat safely, arrange pumpout.	Aquacell		
Equipment breakdown and mechanical failure	Blowers and pumps are alarmed for malfunction. Alarm received by operator. Operator to log in and inspect operation of plant. Disable plant if required.	Aquacell	Repair	Aquacell		
Cross-connections	Not applicable – no reuse in place.					
Gas build-up	As this an outdoors plant, the risk of harmful concentrations of hazardous gases such as methane and ammonia is extremely low.	Aquacell	Investigate any odour complaints or unusual odour occurrences.	Aquacell		
Prolonged power outages	Power failures cause delivery pumps and filtrate solenoid valves to shut. There is sufficient buffer capacity to hold water for at least several days. Power outages beyond this are unlikely.		If buffer tanks fills during a prolonged power outage, arrange pump out.	Tallowood		

Aquacell, as the contracted operator and licence holder will immediately notify the appropriate authorities of any incident that potentially places public health at risk in accordance with the WICA general regulation 2008, Schedule 1, Part 1, cl. 1(2)(a,b) and Schedule 2, Part 1, cl. 1(2)(a,b)

IPART and NSW Health will be notified immediately by Aquacell if any of the following incidents occur:

- An emergency or incident that potentially places public health at risk.
- Any changes to the SMP or operation of the treatment process that may potentially impact achieving the required water quality objectives.

NSW Health information is:

C/- Nepean Hospital
Derby Street
PENRITH NSW 2750
Phone: 02 47342022

EPA NSW

Phone: 131 555

Tallowood Community Association primary contact person is:

C/O Raine and Horne, St Mary's
210 Queen St, St Mary's NSW 2760
Phone: 02 96235666

Aquacell Primary contact for notifications is:

Justin Taylor – General Manager, Aquacell

Address:	1 / 10B Production Place, Jamisontown, NSW, 2750
Phone:	02 4721 0545
Mobile:	0417 652 079
Email:	justint@aquacell.com.au

If an incident occurs, Aquacell are responsible for completing an incident report using a form provided in appendix C.

13. Operator, contractor and end user awareness and training

All employees, including contractors, that are working on the blackwater treatment system must be appropriately trained, and qualified, and records kept by their employer to document training. It is the responsibility of the Aquacell to ensure that their staff and subcontractors are suitably qualified and trained to carry out work on the recycled water system.

Aquacell operators are made aware of approval conditions and instructed on occupational health and safety requirements as part of their training. An induction program helps ensure new employees understand what is required and operate accordingly.

Training needs for individual Aquacell employees are identified and adequate resources made available during the induction phase. Annual performance reviews help identify additional training requirements and set performance targets. Training records are kept at the Aquacell head office.

The Tallowood Community Association is provided with a copy of the SMP and additional awareness information is available in the Aquacell website.

14. Community involvement and awareness

All residents and potential residents are made aware of the existence of the on-site wastewater treatment system on disposal areas during the early stages of their move or planned move to the community. The area where the treatment plant is located and the disposal field are clearly marked.

The association is provided with a copy of the SMP which is available to all members of the community. Additional general and site specific information is provided on the Aquacell website.

15. Research and development

The design and operation of the backwater plant is the responsibility of Aquacell. The technology used is state of the art, and is continually being improved through experience and active research. Any improvements that are identified will be presented to TRC for assessment of potential savings or improvements in efficiency.

Aquacell continuously monitor the regulatory environment. Any changes to regulations that potentially alter the operating requirements of the plant will be assessed. Where appropriate these changes can be made to ensure the required water quality is met in the most efficient and economical way.

16. Auditing, review and improvement programs

This SMP will be reviewed on an annual basis or when a major change or addition to the blackwater treatment system is implemented. The review will take into consideration changes to:

- Customer base
- Water quality
- WICA guidelines

Appendix A – HAZOP and HCCP

Risk

		Consequences				
		1	2	3	4	5
Likelihood	1	Low	Low	Low	Moderate	High
	2	Low	Low	Moderate	High	Very High
	3	Low	Moderate	High	Very High	Very High
	4	Low	Moderate	High	Very High	Very High
	5	Low	Moderate	High	Very High	Very High

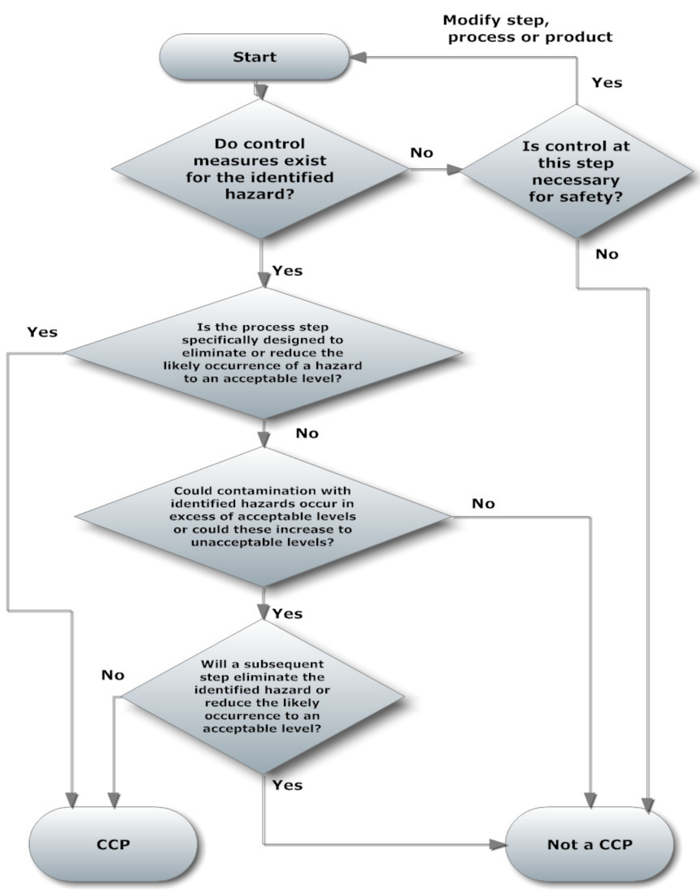
Qualitative measures of likelihood

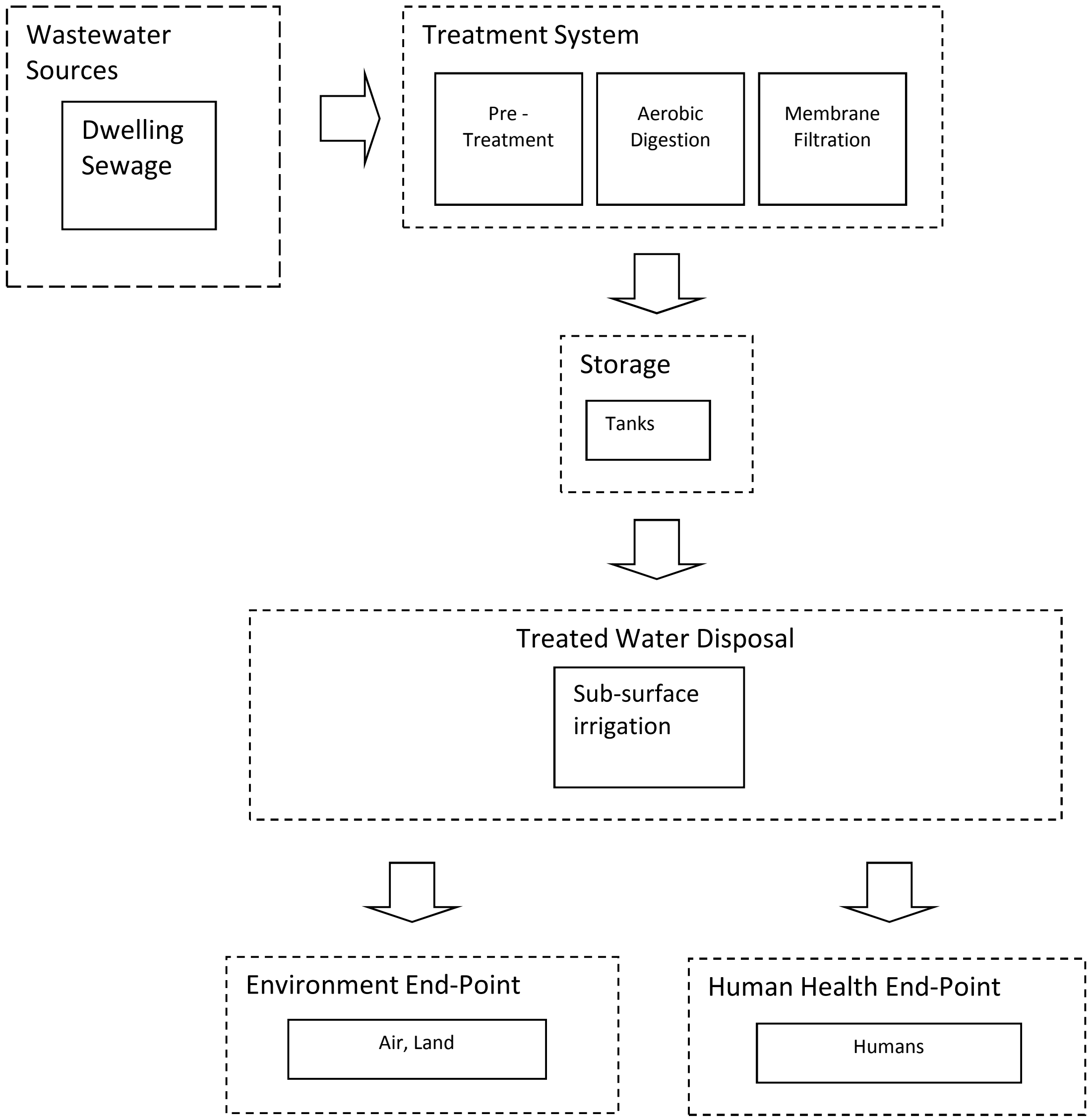
Level	*Descriptor*	*Example of Description*	
1	Rare	May occur only in exceptional circumstances	very rarely > annual
2	Unlikely	Could occur in unusual circumstances	chance of annual occurence
3	Possible	Might occur or should be expected to occur under certain circumstances	chance of monthly occurence
4	Likely	Will probably occur	chance of weekly occurence
5	Almost Certain	Is expected to occur	chance of daily occurrence

Qualitative measures of consequence

Level	*Descriptor*	*Example of Description*
1	Insignificant	Insignificant impact or not detectable
2	Minor	Health - Minor impact on contact population, first aid treatment
		Environment - Minimal and short term harm to the environment
3	Moderate	Health - Moderate impact on contact population, medical treatment required
		Environment - Significant harm to the local environment for a short period
4	Major	Health - Major impact on contact population, extensive injuries
		Environment - significant harm to the environment
5	Catastrophic	Health - Potentially lethal on on contact population, death
		Environment - significant, widespread harm outside local area

Decision Tree




Wastewater Sources
Dwelling Sewage
Treatment System
Pre - Treatment
Aerobic Digestion
Membrane Filtration
Storage
Tanks
Treated Water Disposal
Sub-surface irrigation
Environment End-Point
Air, Land
Human Health End-Point
Humans

HACCP Checklist

Project Name:	Kurrajong
Project Engineer:	Technical Manager
Date of Assessment:	14-Jan-16
Revision:	Revision 1
Approved By and Date:	W. Johnson

To be approved by the Technical Manager

HACCP Workshop Attendees			Revision 1 Attendees	Revision 2 Attendees (December 19th 2011)				Revision 3	Revisions
			W. Johnson						
			J. Taylor						
	see RWQMP section 4 for company affiliations								

DESIGN / — **Before Mitigation** / **After Mitigation**

Step	Potential Hazard	Preventative Measure	Likelihood (Before Mitigation)	Consequence (Before Mitigation)	Resid. Risk (Before Mitigation)	Likelihood (After Mitigation)	Consequence (After Mitigation)	Resid. Risk (After Mitigation)	Uncertainty	Decision Tree				CCP	Critical Levels		Monitoring	Corrective Action		Records
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*	*1 to 5*	*1 to 5*	*D + E*		*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*
1. Source water (sewage influent, collection lines, pump stations)	Physical contact with wastewater	Covers on tanks, locks where appropriate, trained operators to access site, signage, difficult to access. Training of services personnel.	1	2	3	1	2	3	± 1	N	N			No						
	Biological Hazard. Faecal matter in influent above specification. Additional pathogen load to treatment plant resulting in out of spec treated water	Membrane UF treatment. On-line monitoring. Verification monitoring. Actual pathogen removal likely to be higher than operational target. Ongoing monitoring program includes biological parameters. Turbidity meter indicates membrane breach.	1	2	3	1	2	3	± 1	N	N			No						
	Physical hazard.	Exclude the public from the plant and irrigation area. Use correct PPE.	2	2	4	1	1	2	± 1	Y	N	N		No						
	Chemical Hazard	Buffer tank pH is monitored	3	2	5	3	1	4	± 1	Y	N	N		No						
	Blockage or break in sewerage network.	Properly designed sewer. Graviy flow system (no pump stations). Network is comparatively small.	2	1	3	2	1	3	± 1	Y	N	N		No						
2. Screen	Chemical hazard. Non-compliant trade waste discharge up stream.	Buffer tank pH is monitored. Buffer tank pumps don't transfer if pH is out of range.	2	2	4	2	2	4	± 1	N	N			No						
	Residnets disposing of chemicals down the drain	Education of resident . pH monitoring of the influent, any out of range feed not accepted. Dilution of feed by other residents	2	2	4	2	1	3	± 1	Y	N	N		No						
	Screen may block or fail.	Routine maintenance inspections. Level alarms.	2	1	3	2	1	3	± 1	Y	N	N		No						
	Screenings and grit need to be removed from site and accidental discharge to environment may result with potential public contact to pathogens. Contractor may contact the contaminants via the skin or inhalation	Ensure appropriately experienced and licensed contractors are used for maintenance of systems. Contractors use adequate PPE to mitigate against ingestion, skin contact and inhalation. Remediate spills immediately and exclude public from the spill point until rectified.	2	2	4	1	2	3	± 1	Y	N	N		No						
3. MBR (Aerators, Mixed Liquor, Membranes)	Chemical hazard - pH sensitive Shock loads	High MLSS will reduce effects of shock loads. pH exclusion in pre-treatment prevents delivery of non-compliant water to MBR.	2	2	4	2	1	3	± 1	N	N			No						
	Chemical hazard - pH neutral	DO indicator of biomass health. High MLSS - shock resistance.	3	1	4	3	1	4	± 1					No						
	Chemical hazard - Chemical cleaning process destroys biomass	Appropriate procedures. Operator training. Slow down production to allow biomass to rebuild. Last resort, shutdown and re-seed.	3	1	4	2	1	3	± 1	N	N			No						
	Chemical cleaning damages membranes.	Appropriate procedures. Operator training. Membranes selected for broad compatability range. In the event membranes are damaged, breach would be detected by turbidity probe.	3	3	5	1	3	4	± 1	Y	Y			CCP	Turbidity < 2 NTU	Turbidity > 2 NTU	Online turbidity			
	Biological hazard Over aeration - nitrification reduces pH in tank	Operator training. DO monitoring. pH probe in filtrate pit is indicator of bioreactor pH.	3	2	5	3	2	5	± 1	N	N									

Step	Potential Hazard	Preventative Measure	Likelihood	Consequence	Resid. Risk	Likelihood	Consequence	Resid. Risk	Uncertainty	Decision Tree				CCP	Critical Levels		Monitoring	Corrective Action		Records
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*	*1 to 5*	*1 to 5*	*D + E*		*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*
	Biological hazard Under aeration failure. 1) electrical 2) diffuser	Blowers are alarmed for electrical failure. Pressure transducers on aeration system detect diffuser blockages. Separate blowers supply biology and membrane. Routine Maintenance Program DO probe alarmed for aeration failure.	2	2	4	2	1	3	± 1	Y	N	N		No						
	Biological hazard Loss of biomass due to lack of feed.	Residential estate is likely populated at all times. Experience shows biomass can sustain health over several days.	1	2	3	1	2	3	± 1	Y	N	N		No						
	Biological hazard Membrane failure allowing pathogens through, either by gross rupturing or pinholing	Upstream screen to protect membranes from foreign matter. Membrane selection with a broad compatibility range. Level and overflow alarms (membranes dry out) Online turbidity measurement of filtrate. Turbidity shutdown alarm.	2	3	5	2	3	5	± 2	Y	N	Y	N	CCP1	NTU < 2	NTU > 2	Online turbidity			
	Physical hazard Leave drain valve open, emptying membrane tank	Operator training. Remove valve handles. Low level alarm on membrane tank.	1	2	3	1	2	3	± 1	Y	N	N		No						
	Physical hazard Faulty connections to/from membrane filter.	Good pipe work design and flexible connections used. Use stainless steel clamps and screws. Online turbidity to maintain spec.	2	3	5	1	3	4	± 1	Y	N	Y	N	CCP1	Turbidity < 2 NTU	Turbidity > 2 NTU	Online turbidity			
	Physical hazard Loss of air scour due to large bubble size (broken diffuser).	Appropriate design.Inspection. Pressure transducers with low pressure alarm	2	1	3	2	1	3	± 1	Y	N	N		No						
	Physical hazard Faulty membrane installed	Quality checks at manufacturing, construction, commissioning. Manufacturers approval Verification during commissioning . Water Quality Testing. Turbidity monitoring	2	3	5	1	3	4	± 1	Y	N	Y	N	CCP1	Turbidity < 2 NTU	Turbidity > 2 NTU	Online turbidity			
	Sludge needs to be removed from site and accidental discharge to environment may result with potential public contact to pathogens. Operator handling also implies human exposure risk	Ensure contractors are adequately trained and licensed. Exclude public access and immediately rectify spills. Use appropriate PPE to avoid inhalation and skin contact. Supervision by Aquacell staff.	1	3	4	1	3	4	± 1	Y	N	N		No						
	Sludge wasting may fail leading to disruption of plant function	Sluge is manually wasted. Ensure wasted sludge flows to sludge tank and is not contacted by humans	3	1	4	3	1	4	± 1	Y	N	N		No						
4. Irrigation System and Storage Tanks	Exposurel hazard, improper use of treated water.	Education program for occupants. Lilac coloured pipes and fittings. Signage indicating recycled water usage. No taps on irrigation network. Treatment plant operating correctly	1	3	4	1	3	4	± 2	N	N			No						
	Degredation in water quality and delivery due to biofilm growth	Correct sizing of irrigaton field and storage tanks. Flushing point on irrigation system installed. Tank level alarms if irrigation system blocks.	2	3	5	1	3	4	± 2	N	N			No						
	Irrigation pump may fail	Small pump which is readily available. Adequate storage volume in buffer and irrigation tank to allow time for pump to be replaced. Irrigation tank and buffer tank can be pump out if necessary.	2	3	5	1	3	4	± 1	N	N			No						
	Irrigation pipes or fittings may fail	Five seperately operable irrigation zones so problem zones can be isolated. Routine checks to look for pooling or leaking. Adequate storage volume in buffer and irrigation tank to allow time for pump to be replaced. Irrigation tank and buffer tank can be pump out if necessary.	2	3	5	1	3	4	± 1	N	N			No						
11. General	Prolonged power outages	Buffer tank can hold 8 times daily demand. Buffer tank can be pumped out.	1	2	3	1	2	3	± 1	N	N			No						

Step	Potential Hazard	Preventative Measure	Likelihood	Consequence	Resid. Risk	Likelihood	Consequence	Resid. Risk	Uncertainty	Decision Tree				CCP	Critical Levels		Monitoring	Corrective Action		Records
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*	*1 to 5*	*1 to 5*	*D + E*		*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*
	Extreme weather (flooding/heat)	Critical equipment under cover. Plant is above flood level on the side of a hill. Pump out can be used if plant is disabled.	1	4	5	1	4	5	± 1	N	N			No						
	Earth quake	Pump out can be used if plant is disabled.	1	4	5	1	4	5	± 1	N	N			No						
	Fire	Pump out can be used if plant is disabled. Vegetation is maintained around plant.	1	4	5	1	4	5	± 1	N	N			No						
	Human actions (sabotage)	Pump out can be used if plant is disabled. Plant is in gated estate to prevent any access from general public.	1	3	4	1	3	4	± 1	N	N			No						

HAZOP
Checklist

Project Name:	Kurrajong	
Project Engineer:	Technical Manager	
Date of Assessment:	14-Jan-16	
Revision:	Revision 1	
Approved By and Date:	W. Johnson 14/1/16	*To be approved by the Technical Manager*

HAZOP Workshop Attendees		**Revision 1 Attendees**	**Revision 2 Attendees**
		W. Johnson	
		J. Taylor	

HAZOP

Item	**Deviation**	**Consequence**	**Causes**	**Safeguards**	**Actions**	**Who**	**Due Date**	**Status**
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*			
1. Source water (sewage input, collection lines)	No influent	Low levels, not providing enough flow to biology	Low influent production Blockage or linebreak upstream of buffer tank	Low level switch to protect downstream equipment if no feed is available.				
	Out of spec influent quality	Upsets biological process and possibly membranes	Long storage time turns septic, contaminated waste, other upsets	pH probe which turns influent pump off if pH low. Pump out tank if required				
	Influent feed not used	Septicity develops, buffer tank overflows	Treatement plant offline, treated water tank full	Buffer tank and treated water tank can be pumped out if required				
	High influent flow	Buffer tank fills up	Flooding of sewer pit, stormwater ingress, high demand due to community activities	Additional capcity built into plant, buffer tank volume 8 times daily flow, buffer tank can be pumped out if				
	Reverse Flow	Back-up in inlet pipe	Cannot hapen in ths configuration (gravity flow system)	Gravity flow system				
	Low level	as for 'no influent'						
	High level	Buffer tank fills up. Overflow to sump	Treatement plant offline, treated water tank full	Buffer tank and treated water tank can be pumped out if required				
	High pressure	Not possible in gravity flow system	N/A	N/A				
	Low pressure	Not possible in gravity flow system	N/A	N/A				
	Tank rupture	Spill of influent to environment	Earthquake, subsidence, flood, flotation	Good design. Fit for purpose tank. Located above flood level cut into side of hill				
	pH outside expected range	Biological process upset	Influent pH	pH meter in buffer tank				
	Start up/ shutdown	No- issue						
	Isolation	No requirement for isolation						
	Cleaning	no requirement for cleaning						

HAZOP

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*			
2. Screen	No Flow	No feed into biology tanks	Screen blockage, motor trip	Level switches, motor overload, screen overflow to buffer tank				
	High flow	Overflow	Screen blockage	High level alarms and control logic, screen overflows to buffer tank				
	Reverse flow from sewer overflow	Not possible						
	Level	As for 'flow'						
	High pressure in pumped line	Damage pipe and pump	Blockage	Trip and alarm on pump				
	Composition	Foaming and possible overflow	Detergents and/or microbiology	Sealing lids. Overflow to buffer tank				
	Start up/ shutdown	No Issues						
3.MBR	No Flow into MBR	Biomass dies	No flow from upstream	Low level alarm				
	No flow out of MBR	No effluent produced	Membrane fouling, jammed actuated valve, pipe blockage, turbidity alarms, filtrate pump failure	Turbidity alarm, actuated valve alarm, regular membrane cleaning, flux rate monitoring, air scour of membranes				
	Sludge build up in base of tank	No flux through membranes. Blocked diffusers preventing air scour	Poor influent screening. Blocked diffusers preventing air scour	Inspections. Monitoring scour air pressure				
	High flow	High level and overflows	Over-pumping in from previous tank. Blocked recirculation lines.	Level alarms				
	High flux through membrane	More rapid membrane fouling	High trans-membrane pressure. Chemical membrane clean	Turbidity meter. Flux monitoring.				
	High air pressure	Damage pipe and blower. Damage membranes	Diffuser blockage	Thermal overloads on blowers. Sour air pressure monitoring				

HAZOP

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*			
	pH drops	Biomass dies. Corrosion. Out of spec water quality pH	Nitrification in aeration tanks does not have sufficient alkalinity therefore dropping pH	Filtrate pH meter. DO control. Can consider alkalinity dosing.				
	Low air flow	Biomass negatively impacted. Membrane fouling from lack of scouring.	Aeration fails. High MLSS	DO probe, blower alarms Monitoring of MLSS/DO. Monitoring biology air pressure.				
	Low levels	No flux through membrane Membrane dries out and/or fouls Biomass dies	Faulty actuated valve	Low level alarm				
	High level	Overflows	Over-pumping in from previous tank. Recirculation pumps blocked or damaged.	Level alarms. Adjustment of recirculation valves lines from bio to MBR.				
	Low pressure on air lines	Low air supply. Membranes do not scour properly. Anaerobic conditions	Broken diffuser or air pipe	DO monitoring for Bio (not MBR). Pressure monitoring of membrane and biology air				
	High air pressure	Damage pipes and pumps	Blockage in pipes or diffusers	thermal overloads on blowers				
	High permeate pressure	Not possible						
	Composition	Biomass impacted and biological treatment lost. Membranes damaged.	Toxins in waste water	DO probe. Influent pH probe.				
4. Filtrate pit	High level	Overflow	Pump failure, level switch failure, filtrate valve failure	Fault pump detection, overflow pipe				
	Inaccurate turbidity reading	false alarms, instrument failure	Failure of turbidity probe. Biofilm in filtrate pit or lines	Routine servicing and calibration				
	Low level	Dry running pump, turbidity probe function	Failure float switch	Low level alarm				
	No flow or overflow	Same as low and high level						
5 Irrigation system and storage tanks	Low level	Dry running of pumps	irrigatino pump fails to stop	Level switch				

HAZOP								
Item	**Deviation**	**Consequence**	**Causes**	**Safeguards**	**Actions**	**Who**	**Due Date**	**Status**
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*			
	High level	Overflows to environment	Failure of irrigation controller or solenoid valves.	Level alarms. Treatement plant stops processing				
	Low pressure	not disposing of water uniformally	irrigation pump stops	Routine inspections of irrigation field				
	high pressure	irrigation pump stops prematurely	blocked lines	high level alarm in irrigation tank				
	Reverse flow in mains supply	not possible - no cross conneciton potential						
6. Manual Work	Maintenance	Damage to equipment	Poor workmanship	Following Work Instructions				
	Maintenance	Chemical spills	Chemical handling	Following Work Instructions				

Appendix B – Land Capability Assessment

Effluent Management Investigations

at

Vincent Road, Kurrajong

Prepared for

BENNETT PROPERTY

Woodlots and Wetlands Pty Ltd
220 Purchase Road
Cherrybrook
NSW 2126

Document Registration

Client	**BENNETT PROPERTY**
Prepared By	Woodlots & Wetlands Pty Ltd 220 Purchase Road Cherrybrook NSW 2126 Telephone (02) 94842700 Mobile 0427905440 E mail woodlots3@bigpond.com
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Glossary

Abbreviation or acronym	Explanation
ADWF	Average Dry Weather Flow (cubic m/day)
BOD	Biological Oxygen Demand
C	Carbon
Ca	Calcium
CANRI	Community Access Natural Resource Information
cfu	Colony Forming Units. A measure of microbial population. It is sometimes referred to as MPN (Most Probable Number)
cm	centimetres
DALY	Disability Adjusted Life Years. A World Health Organisation sponsored system of assessing the impact of accidents or disease on a population. DALYs for a disease or health condition are calculated as the sum of the Years of Life Lost (YLL) due to premature mortality in the population and the Years Lost due to Disability (YLD) for incident cases of the health condition (WHO web site, accessed May, 2012). The minimum tolerable health risk is typically 10^{-6} DALY (NRMMC/ EPHC/ AHMC (2006).
DEC	Department of Environment and Conservation (in 2012 it was part of Office of Environment and Heritage)
DIPNR	Department of Planning Infrastructure and Natural Resources in May 2012, the environmental components had been transferred to the Office of Water (NOW) and OEH)
DIR	Design Irrigation Rate as per AS/NZS 1547
dS/m	decisiemens/metre A measure of electrical conductivity (1 dS/m=1000 microsiemens/cm)
Effective risk management	The identification of all potential hazards, their sources and hazardous events, and an assessment of the level of risk presented by each.
Effluent	Treated wastewater from a sewage treatment plant (STP)
Ensiled	Storage of fodder as silage. Silage is the result of anaerobic fermentation process used to preserve green vegetation such as oaten hay or green pasture. The vegetation is and packed while at about 70-80% moisture and put into sealed holes in the ground.
ESCP	Erosion and Sediment Control Plan
Field capacity (water holding capacity)	The amount of water held in soil once gravitational water has drained from the profile. Typically it is reached approximately 48 hr. after saturation. It can be expressed as a variety of units. In the current report it is in mm of water stored in the plant root zone.

Faecal coliforms	Bacteria that is indicative of faecal contamination.
g	grams
K	Potassium
ha	hectare (1 ha=100m*100m)
HACCP	HACCP is the Hazard Analysis and Critical Control Point system. (That is: What can we do to reduce hazards)
Hazard	HAZARD=probability*consequences A hazard is a biological, chemical, physical or radiological agent that has the potential to cause harm. A hazardous event is an incident or situation that can lead to the presence of a hazard. (What can happen and how)?
HRT	Hydraulic Retention Time – the average travel time for water to pass through a system such as a wetland, maturation pond or reaction chamber.
kg	Kilograms
kL	Kilolitres (1000 L)
km	kilometres
L	litres
m	metres
mg	milligrams (10^{-3}g)
Mg	Magnesium
mL	millilitres (10^{-3}L)
ML	megalitres (10^{6}L)
MSDS	Material Safety Data Sheets
Na	Sodium
N	Nitrogen
EMP	Environmental Management Plan
P	Phosphorus
PET	Potential Evapotranspiration: Rate of loss of water from plants and soil when there is an unlimited supply.
pH	A measure of acidity
Risk	The likelihood of identified hazards (see definition above) causing harm in exposed populations in a specified timeframe, including the severity of the consequences.

	(How likely is it to happen? How serious are the consequences?) Risk is maximum risk in the absence of preventive measures Residual risk is the risk after consideration of existing preventive measures.
SAR	Sodium Adsorption Ratio. A measure of the ratio of sodium to calcium plus magnesium. It is used in conjunction with salinity data to determine the stability of irrigation water.
Stormwater	Rainfall derived water arising from roof or ground surfaces.
STP	Sewage Treatment Plant
TWL	Top water level (m)

Executive summary

This investigation is concerned with providing a proposed development at Vincent Road Kurrajong with a sustainable system for managing its tertiary treated sewage.

According to the Australian Bureau of Statistics, the average number of residents per dwelling in the Kurrajong urban area is 2.7. Many of the 41 dwellings to be connected to a centralised sewerage treatment plant (STP) are within a retirement complex and the majority of these are occupied by single people. The dwellings have full water reduction features in them including twin flush toilets and flow reducers on the shower heads. According to AS 1547 the design sewage flow allowance per person is 110 L. Therefore the design sewage flow/day is

41*2.7*110= 12,177 L/day.

Effluent strength is classified as ‘low’ according to the EPA’s criteria (DEC, 2004). Sub surface irrigation will minimise risk of contact.

A landform assessment showed that the site was suitable for effluent irrigation. The main concern was the slope which ranged from 5 to 20%, with an average grade of 11%. Subsurface irrigation is recommended to minimise the risk of effluent runoff.

A back hoe was used to excavate 4 soil inspection and sampling pits. The soils were sampled to a layer of rotted shale. The depth to this layer varied from 1.5 to 1.9m. The soils were sampled at 0-20, 20-40, 40-70, 70-100 and on top of the rotted shale layer. The soils all had moderate structure throughout the profile. The surface 40 cm was typically a clay loam while the 40 to 100 cm layer was a light-medium clay. Heavy clay occurred on top of the shale. This suggests imperfect drainage at depth.

The moderate pedality in the topsoil is not ideal for effluent irrigation. Organic matter is a key agent for soil structure. Increasing organic matter will increase surface soil stability. Permanent pasture is strongly recommended.

The chemistry of the soils varies across the site and within individual profiles. However some generalisations can be made:

- The soils are non-saline and non-sodic. They have good supplies of potassium, calcium and magnesium.
- Applying 1800 kg agricultural lime per ha prior to commencement of effluent irrigation will ensure that productivity is not limited by aluminium toxicity.
- The P sorption capacity of the soil is sufficient for approximately 375 years at moderate rates of effluent irrigation.
- Phosphorus availability is marginal. Addition of 120 kg/ha/year of single superphosphate is recommended for pastures.

All of these features make the soils suitable for effluent irrigation provided the application rate is light.

The irrigation area size needed was based on AS 1547 and the daily weather since 1970. A maximum of 10,150 msq is available. Sensitivity analysis was used to identify sustainability of the irrigation system at a range of rates. A 1 ha field was sufficient for up to 22 cubic m/day of tertiary treated effluent. This is over 80% higher than the anticipated flow of 12.2 cubic m/day.

The environmental risks from the proposed system are small and considered acceptable.

Table of Contents

1 BACKGROUND

This investigation is concerned with providing a sustainable effluent management for tertiary treated effluent from 41 dwellings on Vincent Road Kurrajong.

The development comprises a mix of 23 retirement villas and 18 'normal' suburban type allotments. Figure 1.1 shows the locality of the development.

Lands to the immediate east of the retirement villas are available for irrigation. Figure 1.2 shows the irrigation area in detail.

This current report assesses the suitability of these lands. It also determines suitable size and configuration of the irrigation area.

1.1 Objectives of the effluent management activities

The aims of the scheme include:

1. Minimising risks to human and environmental health
2. Maximising effluent reuse opportunities

Bennett Property is committed to ensuring that the effluent management scheme is consistent with the principles of ESD. Additionally it aims to ensure there are no adverse impacts on human and environmental health due to implementation of the effluent management scheme.

1.2 Environmental objectives of the effluent management project

The environmental objectives of the project can be summarised as:

- To ensure environmental and public health safeguards are implemented correctly;
- To comply with the requirements of all relevant Local regulations and NSW and Australian legislation;
- To ensure that the establishment and operational phases of the project are managed to minimise adverse impacts on the environment and on human health.

Figure 1.1. Regional context of the development area and the proposed irrigation site. (Image: Google Earth 11.2012)

Figure 1.2. Detail of irrigation area (Source :Envirotech, 2012).

NOTES:

1 The proposed irrigation area is 10,150 msq

2. The irrigation area is 40m upslope from an existing farm dam

3. The irrigation area does not drain to the dam to the immediate south of the site.

1.3 Relationships between Bennett Property's commitment to ESD[1] National and State Government Policies

'*The EPA's wastewater management policy is to encourage the utilisation of effluent where it is safe and practicable to do so and where it provides the best environmental outcome. The EPA especially encourages the substitution of treated effluent for fresh/potable water wherever potable water is being used for non-potable purposes e.g. irrigation of crops and pastures.'* (EPA, 1995).

The key objectives of the *EPA's wastewater management policy* are listed in the draft document *'The utilisation of treated effluent by irrigation'* (EPA, 1995). Each objective is discussed below.

Resource Utilisation

Effluent and its constituents such as water, and nutrients should be evaluated for their usefulness. The agronomic systems for effective utilisation of these constituents should be implemented.

Protection of Lands

The management of the system must be in accordance with ESD principles. In particular it should maintain the productive capacity of the land. No deterioration of land quality through soil structural degradation, salinisation, waterlogging, chemical contamination or erosion should occur.

Protection of Surface Waters

Irrigation areas should be sited, designed, constructed and operated so that surface water does not become contaminated by either the effluent or any effluent contaminated runoff from the irrigation scheme.

Protection of Ground Waters

Irrigation areas should be sited, designed, constructed and operated so that useable subsurface water does not become contaminated by either the effluent or effluent runoff from the irrigation scheme.

Community Amenity

The scheme should be sited, designed, constructed and operated so that it does not cause unreasonable interference with any commercial activity or comfortable enjoyment of life and property off site. Where possible it should add to the amenity.

---

[1] Ecological Sustainable Development principle involves
'Using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future can be increased.' (Commonwealth of Australia, 1992).

In NSW the principles of ESD as stated in the Protection of the Environment (Administration) Act 1991 are:
'The precautionary principle-if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
Intergenerational equity – the present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations;
Conservation of biological diversity and ecological integrity, and;
Improved valuation and pricing of environmental resources.

1.4 Investigation requirements

The investigation brief requires a series of tasks to be undertaken in order to provide evidence that the development will be consistent with ESD principles. These requirements are listed below:

⇒ Site inspection
⇒ Review of available information
⇒ Review of regulatory requirements
⇒ Risk assessment
⇒ Reclaimed water quality
⇒ Reclaimed water volumes
⇒ Identification of potential reuse areas
⇒ Soil and topographical assessment
⇒ Water and groundwater investigations
⇒ Soil chemical analysis
⇒ Identification of potential reuse options
⇒ Identification of preferred irrigation system
⇒ Water, salt and nutrient budgets
⇒ Recommendations

The current report addresses each of these requirements.

1.5 Reference documents

There are a variety of technical documents, guidelines and policy statements that provide instruction on sewage and stormwater management. The list below has been consulted during this investigation.

Asano, T. (1998). Wastewater Reclamation and Reuse. Technomic Publ. Co. Lancaster PA.

DEC (2004). Environmental Guidelines: Use of Effluent by Irrigation. Dept. Env. and Con. Sydney, NSW.

NRMMC/ EPHC/ AHMC (2006). Australian Guidelines for Water Recycling: Managing health and Environmental Risk (Phase 1). NWQMS No. 21. Natural Resource Management Ministerial Council/ Environment Protection and Heritage Council/ Australian Health Ministers Conference. Canberra ACT.

NCST (2009). Australian Soil and Land Survey Field Handbook. The National Committee on Soil and Terrain. Third Edition. CSIRO, Collingwood. Vic.

NSW Agriculture (1997). The NSW Feedlot Manual. NSW Agriculture, Orange, NSW.

QDNR (1998). MEDLI Technical Manual. T. Gardner and R. Davis Eds. Indooroopilly, Qld.

Standards Australia (2000). AS/NZS 1547:2000. On-site domestic wastewater management. Sydney, NSW.

Water Services Australia (2002). Sewerage Code of Australia WSA 03- Version 2.3.

2 SITE ASSESSMENT

The site was inspected by Dr Peter Bacon of Woodlots and Wetlands in October 2012. The inspection activities included the soil and landscape assessment reported below.

The location and issues associated with irrigating the lands to the east were assessed.

The approach has been to identify the likely sewage volume generated from the STP, assess the site to determine the design irrigation rate (DIR) as per AS/NZS 1547, and then determine the irrigation area requirements for sustainable irrigation of this volume. Because the exact sewage flows and number of occupants are unknown a range of possible flows were assessed.

The study also provides an assessment of the risks to human and environmental health from the scheme, and then identifies options to minimise these risks.

3 AVAILABLE INFORMATION

3.1 Sewage flows

Sewage flows are based on AS1547 APPENDIX 4.2D. According to the Australian Bureau of Statistics 2011 census data, the average number of presidents per dwelling in the Kurrajong Urban Area is 2.7. Many of the 41 dwellings to be connected to the sewerage treatment plant (STP) are within a retirement villa complex, and the majority of these are occupied by single people, so the 2.7 persons/ dwelling is likely to be an overestimate. The dwellings have full water reduction features in them including twin flush toilets and flow reducers on the shower heads. According to AS/NZS 1547 the design sewage flow allowance per person in dwellings with full flow reduction devices is 110 L/day. Therefore the design sewage flow/day is

41*2.7*110= 12,177 L/day.

Sensitivity analysis was undertaken to assess the effect of a range of flow rates. The following variables were tested:

- 2.7 persons/dwelling
- 3.7 persons/dwelling
- 4.7 persons/dwelling <u>and</u>
- 110 L/person/day (the anticipated sewage flow assuming full flow reduction fixtures)
- 145 L/person/day (the sewage flow if there are limited flow reduction fixtures in the dwellings (from AS/NZS 1547)

Table 3.1. Effect of varying number of resident/dwelling and average flow/ resident on total effluent volume/day

Assumed 41 dwellings	Persons/ dwelling	2.7	3.7	4.7
Flow/person	110	**12.2**	**16.7**	**21.2**
Flow/person	145	**16.1**	**22.0**	**27.9**

The sensitivity analysis in table 3.1 shows that increasing the flow rate per person and increasing the average number of people in residence more than doubles the anticipated flow rate.

3.2 Effluent attributes

The proposed STP is an Aquacell membrane bioreactor. The anticipated effluent characteristics are shown below.

Table 3.2. Anticipated characteristics of the effluent and criteria for determining low strength effluent (Source: DEC, 2004).

Constituent	Anticipated effluent characteristics	Low strength effluent characteristics
Total Nitrogen (mg/L)	<15	<50
Total Phosphorus (mg/L)	<10	<10
Biochemical Oxygen Demand (mg/L)	<15	<40
Total Suspended Solids (mg/L)	<5	Not given
E coli (CFU/100mL)	<10	Not given

4 LANDFORM ASSESSMENT

4.1 Site configuration

Figure 1.2 shows the site. The proposed irrigation area is on an eastern facing slope, below the development area. Figure 1.2 also shows that the subject site is currently surrounded by grazing lands. The nearest downslope waterbody is over 40m south of the subsurface irrigation area.

The soil landscape map (Bannerman and Hazelton, 1989) shows that the site is on the Luddenham Soil Landscape. Gymea Soil Landscape occurs downslope of the site. Typical attributes are summarised in table 5.1.

Table 5.1 typical attributes of the Luddenham and Gymea Soil Landscapes (Source: Bannerman and Hazelton, 1998).

Attribute	Luddenham Soil Landscape	Gymea Soil Landscape
Geology	Wianamatta Shales	Hawkesbury Sandstone
Topography	Low rolling to steep hills	Undulating to rolling low hills
Slopes	5-20%	10-25%
Erosion hazard	High	High
Soils classification b	Red (upper slope) to yellow (lower slope) podsolics	Yellow earths, earthy sands yellow podsolics
Fertility	Moderate fertility	Very low fertility

4.2 Landform assessment procedures

A total of four localities within the proposed irrigation area were assessed for landform and soil characteristics.

Table 4.2 summarises the results of the landform assessment.

Table 4.2. Site attributes and their likely impact on site suitability of effluent irrigation at the site.

Attribute	Rationale	Comment
Grid ref	Permanent record of assessment position	
Aspect	Influences solar radiation intensity on lands with more than 10% slope	Slopes towards the east. It will get full morning sun, but little late afternoon sun. There will be reduced exposure to dry westerly winds.
Exposure	Exposed areas have higher evapotranspiration demand	The trees shown in figure 1.1 and 1.2 have been removed. All areas are now exposed, with no tree cover. Therefore OK.
Slope %,	Impacts on the erosion and runoff potential	Ranges from 5 to 20%. Therefore use subsurface irrigation
Slope length	Impacts on the erosion and runoff potential	Maximum of 120m
Landscape position	Impacts on the extent on run-on from upper slopes. Impacts on local drainage.	Mid slope. Drainage to the north and east of the development site. A minimum of 40m between the proposed irrigation area and the farm dam line.
Local Relief	Indicates the extent of steep slopes	Undulating low hills. Subsurface irrigation will minimise risk of effluent runoff.
Landform element	Identifies drainage issues, e.g. floodplains	Convex, divergent slope, so ideal
Drainage line distance (m)	Indicates risk of stream contamination via runoff. Used in DEC (2004) as a buffer distance guide.	Minimum of 40m to a farm dam This is in excess of the 40m distance where Office of Water involvement occurs under the Water Management Act (2000).
Flow patterns	Indicates stream networks and the risk of contamination	No apparent drainage network within the site. There is an opportunity to capture and convey stormwater runoff around the topside of the irrigation area. This will minimise run-on
Run-on/ runoff potential	Identify management needed to minimise excess inflow or losses from the site.	A contour bank will intercept flow above the irrigation area.
Surface water bodies- dams, ponds, springs DS or US of site	Used in DEC (2004) table 4.9 as a buffer distance guide.	No springs or other surface water bodies were evident within the irrigation area. Use of tertiary treatment of the effluent and subsurface irrigation at the AS/NZS 1547 design irrigation rate(DIR) will minimise risk
Storm water	Risk of external flooding, especially with contaminated water.	A contour bank will intercept flow above the irrigation area.
Salt	Salinisation can limit plants' ability to utilise the effluent. It can indicate poor	The profiles seem reasonably well drained. There is no evidence of

Attribute	Rationale	Comment
	drainage and the need salt tolerant plants. Salinisation can destroy soil structure leading to increased risk of effluent runoff.	salinisation.
Erosion potential+/- cult	Erosion potential is used to adjust the cropping/ pasture regime to minimise risk	Low erosion potential once permanent grass cover is established and maintained.
Rock out crops %	Rocky soil can reduce plant growth, make cultivation difficult and increase runoff.	None
Depth to hard rock	Soil less than 1m deep can have poor root development and inadequate ability to retain nutrients. They can also become waterlogged.	All except location 4 have over 1.5m of soil. Location 3 has decomposed rock at 1.5m
Water table, depth	Depth to water table is critical in determining the most suitable vegetation. A shallow water table will preclude irrigation in parts of the year.	None evident.
Groundwater	Distance between the irrigation area and groundwater bores used for domestic purposes is a critical issue in risk assessment	The site itself has a bore on it. However it is not used anymore as town water is now available.
Flood risk	Frequent flooding can destroy infrastructure, prevent irrigation and damage crops.	Not an issue
Land use	The most suitable land uses should be the ones that result in acceptable minimum risks to human and environmental health. At the same time the landuse must be suitable for the site and not be too expensive to establish or operate. A range of permanent pastures and cropping will be considered.	Improved pasture. Therefore OK. The lack of trees makes it simpler to install subsurface irrigation.
Land use history	Past land use activities such as sheep dips and landfills can result in contaminated lands. These lands are normally unsuited for effluent irrigation because the irrigation will increase the risk of off-site contamination.	Long term, low intensity woodlot and pastures. Therefore OK.
Landuse zoning	The proposed landuse must be consistent with current / proposed land zoning.	A new LEP has been placed on public display. It is assumed that the STP and associated irrigation area will be consistent with this LEP.
Distance to public roads houses, etc.	Buffer distances will be a function of the likely contaminant load and the likely level of exposure to the effluent.	A minimum of 80m to the nearest public road. This is well beyond the 25 to 30m recommended in the National Guidelines.
Fire hazard	Fire hazard can be significant for landuses such as woodlots. Fire can destroy both vegetation and equipment.	Not considered an issue

4.3 Conclusions from site assessment

The land slopes relatively steeply to the east. Run-on and run-off are likely to be moderate because of the relatively steep slope. Therefore subsurface irrigation is proposed. Additionally a contour bank immediately upslope of the irrigation area will divert run-on. Permanent pasture cover is also essential to reduce erosion rate.

There is a farm dam near the eastern boundary of the site but this is over 40m from the likely irrigation area.

Other site attributes create minimal risk. On this basis the site appears suitable for application of effluent, especially in view of the relatively low level of contamination in the effluent as shown in table 3.2.

5 SOILS ASSESSMENT

5.1 Insitu soil assessment

A back hoe was used to excavate 4 pits. The sampling depths used to assess the profiles were based on DEC (2004). DEC (2004) suggest 4 sampling depths in the surface 100 cm. A total of 5 depths were used. Four of these were in the top metre and a fifth sample at least 2m or at refusal. The surface depth aimed to define soil surface conditions such as structural stability. The deepest sample was used to assess phosphorus sorption capacity of the entire profile.

The results of the field assessment are shown in table 5.1.

Field texture

Field texture typically changed gradually from clay loams to medium to heavy clay at approximately 1m depth.

The presence of clay loam on the soil surface means that the irrigation application rate needs to be relatively light.

The clay dominant subsoil means that the soil can store adequate supplies of water. However the profile can also become saturated and poorly drained. Overwatering must be avoided.

Soil strength

Soil strength varied from very strong at the surface of sites 1, to very weak at depth in profile 4. The very strong conditions in the surface soil reflect dry conditions and compaction.

A combination of long term pasture and cropping using reduced tillage is recommended.

Pedality

The pedality is moderate in almost all samples. Organic matter accumulation under pasture will assist in maintaining soil structural stability.

Moderate pedality is preferred in the subsoil as weak pedality can indicate structural degradation. Strong pedality can mean that the effluent passes through the soil too quickly.

Fabric

Earthy or rough pedal fabric is preferred. All the samples had earthy fabric.

Colour

Soil colour is derived from organic matter, clay mineralogy, and drainage conditions. Pale greys, yellow and whites indicate poor drainage. Dark browns are indicative of organic matter accumulation, while bright reds and oranges are indicative of good drainage. The topsoils are typically brown or reddish brown, indicating organic matter accumulation and moderate drainage. The increasing grey colour with increasing depth indicated imperfect drainage.

Table 5.1. Insitu soil conditions.

Few soil fauna evident, no water repellency or hard setting evident but no obvious hard pan or bleaching. The fabric was earthy at all depths. There was no hard pan or bleaching at depth.

Site No.	Depth (cm)	Field texture	Consistency	Moisture	Pedality	Colour	Boundaries	Mottles %	Nodules %	Root No.	Biological activity	Texture change	Hard setting	% rock
KH1	0 to 20	clay loam	very strong	dry	weak	dark reddish brown	diffuse	none	none	common	none	gradual	hard setting	none
	20 to 40	clay loam	firm	moderately moist	moderate	dark reddish brown	diffuse	none	none	common	none	gradual		none
	40 to 70	light medium clay	weak	moderately moist	moderate	very dark gray	diffuse	none	none	common	none	gradual		15%
	70 to 100	medium clay	weak	moderately moist	moderate	dark grayish brown	diffuse	20% yellow	none	common	none	gradual		10%
	160 to 180	heavy clay	weak	moist	moderate	grayish brown	diffuse	10% yellow	none	common	none	gradual		60% (shale)
KH2	0 to 20	clay loam	firm	moderately moist	moderate	very dark gray	diffuse	none	none	common	common	gradual	hard setting	none
	20 to 40	clay loam	firm	moderately moist	moderate	dark brown	diffuse	none	none	abundant	none	gradual		none

Site No.	Depth (cm)	Field texture	Consistency	Moisture	Pedality	Colour	Boundaries	Mottles %	Nodules %	Root No.	Biological activity	Texture change	Hard setting	% rock
	40 to 70	clay loam	weak	moderately moist	moderate	reddish gray	diffuse	10% red	none	common	none	gradual		20%
	70 to 100	medium clay	weak	moderately moist	moderate	reddish brown	diffuse	25% red	none	common	none	gradual		40%
	165 to 175	heavy clay	weak	moist	moderate	gray	diffuse	20% orange	none	rare	none	gradual		80%
KH3	0 to 20	clay loam	firm	moderately moist	moderate	dark brown	diffuse	none	none	common	rare	gradual	compacted	none
	20 to 40	clay loam	firm	moderately moist	moderate	dark brown	diffuse	none	none	common	none	gradual		none
	40 to 70	clay loam	weak	moderately moist	moderate	dark grayish red	diffuse	none	none	rare	none	gradual		none
	70 to 100	medium clay	weak	moderately moist	moderate	reddish gray	diffuse	20% red	none	rare	none	gradual		none
	180 to 190	heavy clay	firm	moist	moderate	light gray	diffuse	30% red	none	none	none	gradual		none

Site No.	Depth (cm)	Field texture	Consistency	Moisture	Pedality	Colour	Boundaries	Mottles %	Nodules %	Root No.	Biological activity	Texture change	Hard setting	% rock
KH4	0 to 20	clay loam	firm	moderately moist	moderate	reddish brown	diffuse	none	none	common	common	gradual	compacted	none
	20 to 40	clay loam	weak	moderately moist	moderate	brown	diffuse	10% orange	none	abundant	none	gradual		none
	40 to 70	light medium clay	weak	moderately moist	moderate	grayish brown	diffuse	20% orange	none	common	none	gradual		10%
	70 to 100	medium clay	very weak	moderately moist	moderate	olive yellow	diffuse	30% orange	none	common	none	gradual		15%
	135 to 145	heavy clay	very weak	moist	moderate	olive	diffuse	20% orange	none	rare	none	gradual		5%

Boundaries

The sharpness of the boundaries between the soil layers generally indicates the extent of soil development (Isbell, 1996). There is a gradual increase in clay content with depth: clay loam topsoils grade into medium then to heavy clay subsoils.

Mottle %

Mottles can indicate imperfect drainage. Mottles become evident from 40 to 70 cm. The mottles are typically red, suggesting reasonable drainage. Yellow mottles at depth in site KH 1 suggest poorer drainage at this site.

Nodule %

There were few if any nodules evident.

Root number

Root number is typically common to abundant in the surface 40cm and common in the 40-70 cm layers. They were common to rare in the 70-100cm layer and common to absent in the lowest horizon.

There was no evidence of impedance. It is expected that the root frequency will be maintained under permanent pasture. The widespread presence of roots at 70cm suggests adequate physical conditions throughout the normal rooting depth.

Biological activity

Biological activity indicators include the presence of ants, earthworms, millipedes and insect holes in the ground. The activity was rare to absent. The acidic conditions can reduce soil biota numbers.

Liming and planting of long term pasture will increase soil biodiversity, thereby ensuring longevity of the effluent irrigation system.

Rock %

More than 10% rock in the surface horizon can increase risk of machinery damage. None of the soils have rock in the surface 40cm.

Profile HK 2 has a significant volume of rocks below 70cm. This can interfere with water movement through the profile in this area.

Conclusions and management recommendations

The ideal soil for effluent irrigation has sand dominant topsoil overlying moderately structured clay subsoil. The subject site has relatively little sand in it. Therefore the irrigation application rate needs to be relatively light to minimise the risk of runoff.

The moderate pedality in the topsoil is not ideal for effluent irrigation. Organic matter is a key agent for soil structure. Increasing organic matter will increase surface soil stability. Consequently, the establishment of long term is strongly recommended for the area.

Soil colour indicates that the subsoils have imperfect internal drainage. The irrigation rate needs to be relatively light in order to avoid effluent accumulation in the subsoil.

The soils have good root penetration into the subsoil. This suggests that the soils are suitable for effluent irrigation.

Rocks are not an issue.

It is concluded that the soils appear suited to effluent irrigation, however the application rate should be low to avoid waterlogging at depth.

A good cover of vegetation, either as crops or long term pasture, is critical.

The proposed use of subsoil irrigation is ideal for this site as there is clay loam extending 40 to 70cm below the surface.

5.2 Soil chemistry

The soil analysis aims to quantify the soil attributes that influence the ability of the site to sustainably utilise the effluent. Two soil profiles were analysed in detail. Table 5.2 sets out the major soil attributes.

pH (5_{water}:1_{soil})

The pH in the surface 20 cm is ideally between 5.8 and 7 (Slattery, et al, 1999). Profile 1 is too acidic, while profile 4 is in the 'ideal' range. However table 5.2 shows that profile 4 becomes more acidic with depth.

Both profiles would have improved fertility if the pH were higher.

Liming is considered essential.

Salinity

Salinity is expressed as electrical conductivity (EC) in saturated paste equivalent. The units are dS/m. Soils with $EC_{sat\ paste}$ less than 4 are non-saline (Richards, 1954). Table 5.2 shows that none of the soils are saline. This is an important result as it means that salinity will not limit the site's usefulness for effluent irrigation.

Cation exchange capacity

Cation exchange capacity (CEC) is a measure of the soil's ability to retain nutrients. Ideally the CEC should be at least 5, and preferably greater than 12 cmol(+)/kg (Metson, 1961). Table 5.2 shows that both sites have slightly low CEC.

Table 5.2. Results of laboratory analysis.

Attribute	KH1 0-20 cm	KH1 20-40 cm	KH1 40-70 cm	KH4 0-20 cm	KH4 20-40 cm	KH4 40-70 cm
pH (5:1) water: soil	5.37	5.18	5.27	6.05	5.3	5.07
pH (CaCl2)	4.38	4.17	4.35	5.06	4.20	4.01
Salinity (dS/m sat paste)	0.70	0.39	0.32	0.49	0.39	0.41
Exch Ca (cmol+/kg)	2.65	2.66	2.12	5.08	2.42	1.19
Exch Ca as % of CEC	27	22	27	58	23	9
Exch Mg (cmol+/kg)	2.74	2.67	1.34	2.33	2.31	2.15
Exch Mg as % of CEC	28	22	17	27	21	16
Exch K (cmol+/kg)	0.45	0.45	0.61	0.72	0.49	0.43
Exch K as % of CEC	5	4	8	8	5	3
Exch Na (cmol+/kg)	0.43	0.24	0.09	0.30	0.24	0.26
Exch Na as % of CEC	4	2	1	3	2	2
Exch Al (cmol+/kg)	2.13	3.98	2.31	0.13	3.55	6.61
Exch Al as % of CEC	22	33	29	2	33	49
Organic carbon (%)	2.73	2.09	2.86	2.44	0.57	0.45
Total nitrogen (%)	0.17	0.15	0.17	0.14	0.09	0.08
C:N ratio	16.0	14.1	17.0	17.7	6.2	5.7
Available phosphorus (Bray No 1, mg/kg)	5.2	6.5	4.2	3.9	9.0	9.5

Exchangeable calcium (Ca)

Ideally soils should contain over 10 cmol(+) /kg of exchangeable Ca (Metson, 1961). However soils with 5 to 10 cmol(+) /kg of exchangeable Ca are considered to have moderate concentrations. Thus both soil profiles have low exchangeable Ca as table 5.2 shows.

Adding good quality agricultural lime will remove Ca deficiency and increase production of acid sensitive plants such as clover.

According to Abbott (1989) Ca should make up 65 to 80 % of the sum of cations. Both profiles are deficient in Exch Ca as a % of the CEC. This can result in structural instability.

Addition of lime prior to commencement of irrigation is essential to correct this. The soil should be retested after 3 years.

Exchangeable magnesium (Mg)

Soils should contain at least 1, and up to 3 cmol(+) of exchangeable Mg (Metson, 1961). The data in table 5.2 show that the soils have sufficient Mg.

Dolomite is not required.

According to Abbott (1989) Mg should make up 10 to 15 % of the sum of cations. Both profiles have excessive Exch Mg as a % of the CEC. The ratio of Exch Ca : Exch Mg should be at least 2:1. The Kurrajong soils are typically 1:1. This can result in structural instability. Liming is essential.

Exchangeable potassium (K)

Potassium is an essential nutrient and topsoils should have at least 0.3 cmol(+)/kg. Table 5.2 shows that all soils have an abundant supply of potassium.

Exchangeable sodium (Na)

Exchangeable Na in soil is important because excessive Na can cause structural instability. This is especially critical in the topsoil, where cultivation or heavy rainfall can make the soil susceptible to structural degradation. Generally the potential impact is expressed as Exch Na as a percentage of the sum of cations:

$$\frac{\text{Exch Na*100}}{\text{Exchangeable (Na+K+Ca+Mg+Al)}}$$

Less than 5% exchangeable Na is preferred.

All surface soils have less than 5% Exchangeable Na. The surface soils are therefore non-sodic. Sodicity is also low at depth. Sodicity is not an issue in these soils.

Any soil structural problems, such as crusting on the soil surface, are likely to be due to excessive Mg, over-cultivation and the consequent loss of organic matter. Strategies to increase and maintain organic matter near the soil surface are important for this site.

Exchangeable aluminium (Al)

Exchangeable Al is a potentially toxic ion. Ideally its concentration is below detection. It can stunt growth of susceptible plants such as clovers when more than 5% of the total exchangeable cations are Al. Some of the soil samples have over 4 times more than this percentage.

Agricultural lime addition will reduce this percentage to nontoxic values.

Assuming that the typical Exchangeable Al concentration in the surface 20 cm is 2 cmol+/kg, and the bulk density is 1.2 MT/cubic m, then 1800 kg/ha of lime is needed to minimise exchangeable Al.

It is essential that the lime be incorporated into the soil.

Organic carbon

Soils with less than 1% organic carbon (OC) are likely to have poor structure and low structural stability (Charman and Roper, 2000). Clay loams similar to the Kurrajong topsoils typically should have around 2.5% OC. Table 5.2 shows that on the subject site the soils are near or slightly above this concentration. Ideally the effluent irrigation will be used to produce permanent pasture as this will result in a gradual increase in soil organic carbon concentration.

Total Nitrogen

Soil total nitrogen concentrations less than 0.15% are considered low (Bruce and Rayment (1982). The nitrogen concentrations of the soils are close to this value. Nitrogen addition via effluent irrigation should increase site nutritional status.

C : N ratio

The C : N ratio in typical soils is 10 to 12. The higher values in the current soils suggest that there is accumulation of carbon rich residues. This may be due to the acidic conditions inhibiting bacterial activity. Liming will assist in normalising carbon transformations.

Bray No.1 Available phosphorus

Available phosphorus concentration is a measure of the current adequacy of supply of this nutrient. According to Moody and Bolland (1999), a concentration of 10 to 12 mg/kg in the surface 7.5 cm is sufficient for 90% potential yield of pastures. Table 5.2 shows that the soils have less than 1/2 of this concentration.

The soils would benefit from the phosphorus in the effluent. So effluent irrigation will increase pasture yield, partly at least by increasing phosphorus supply.

P sorption capacity

Table 5.3 shows the P sorption capacity expressed in kg/ha for each horizon. The P sorption capacity is a measure of the soils' ability to retain phosphorus. It is a function of the P sorption capacity expressed as mg/kg of soil and the mass of soil.

The storage capacity in the surface 20 cm is relatively small and the bulk of the storage occurs at depth.

Table 5.3. Phosphorus sorption capacity (kg/ha).

Profile/ depth	P sorption (mg/kg)	P sorption (kg/ha)
KH1 0-20 cm	815	1939
KH1 20-40 cm	824	2059
KH1 40-70 cm	801	3125
KH1 70-100 cm	737	2983
KH1 1.6-1.8 m	624	6552
Total P sorption		16658
KH4 0-20 cm	702	1671
KH4 20-40 cm	809	2023
KH4 40-70 cm	834	3251
KH4 70-100 cm	710	2876
KH4 1.4 m	602	3612
Total P sorption		13432

The average capacity over the two profiles is 15 t/ha. Assuming the effluent has 10 mg/L of P and 4 ML/year were applied, it would take approximately 375 years before the profiles would become saturated with phosphorus, even if there was no removal of phosphorus in cut or grazed pasture. It is reasonable to conclude that addition of P via effluent will not reduce site sustainability.

Conclusions and recommendations

The soils varied across the site and within individual profiles. However some generalisations can be made:

- The soils are non-saline and non-sodic. They have good supplies of potassium and magnesium.
- The soils are deficient in calcium. Applying and incorporating 1800 kg agricultural lime per ha prior to commencement of effluent irrigation will ensure that productivity is not limited by aluminium toxicity.
- The P sorption capacity of the soil is sufficient for approximately 375 to 500 years at moderate rates of effluent irrigation.
- Phosphorus availability is marginal. Addition of 120 kg/ha of single superphosphate is recommended for pastures at establishment. After this the effluent will supply sufficient phosphorus.

All of these features would make the soils suitable for effluent irrigation.

The key recommendations:

- Install runoff diversion banks upslope of the irrigation area
- Apply and incorporate 1.8 t/ha of agricultural lime
- Install subsurface irrigation
- Apply 120 kg/ha of single superphosphate at pasture establishment
- Plant pasture as soon as possible after the irrigation system is installed and operational.
- The pasture should include a mix of perennial temperate grasses such as perennial ryegrass.
- Facilitate accumulation of soil organic carbon by combinations of long term pasture and reduced tillage cropping.
- Retest the soil for nutrients, pH, organic carbon and stability after 3 years of effluent irrigation.

6 SIZING OF IRRIGATION AREA.

6.1 Net effluent production

Net effluent production was based on AS/NZS 1547 (2000). According to this standard, wastewater flow allowance for dual flush toilets, front loading washing machines, shower flow restrictors and aerated faucets is 110L/EP/day[2]. According to the 2011 census data (Australian Bureau of Statistics for the 2011 census), the average dwelling in the Kurrajong area has 2.7 persons in residence. There will be 41 dwellings at the full development stage. So the design sewage flow is 110*2.7*41= 12.2 cubic m/day.

In practice the flow is likely to be less as many of the dwellings are within a retirement section and the majority of dwellings will have 1 person in them.

Table 3.1, reproduced below as table 6.1, shows the range of design effluent flow rate depending on number of people/dwelling and flow per person.

Table 6.1. Effect of varying number of resident/dwelling and average flow/ resident on total effluent volume in cubic m/day.

Assume 41 dwellings	Persons/dwelling	2.7	3.7	4.7
Flow/person (L/day)	110	**12.2**	**16.7**	**21.2**
Flow/person (L/day)	145	**16.1**	**22.0**	**27.9**

The flow ranged from 12.2 cubic to 27.9 cubic m/day.

6.2 Irrigation area requirement

AS/NZS 1547 table 4.2A4 shows the recommended design irrigation rate (DIR) for irrigation systems over a range of soil textures. This information is combined with the range of estimated flow rates to assess the irrigation area requirement.

Table 6.2. Effect of varying the design flow rate and design irrigation rate (DIR) for different soil textures on irrigation land requirement.

Design flow rate (cubic m/day)	DIR for clay loams: (25mm/week)	DIR for light clay: (20mm/week)	DIR for medium to heavy clay: (15mm/week)
12.2	3416	4270	5693
16.7	4676	5845	7793
21.2	5936	7420	9893
16.1	4508	5635	7513
22	6160	7700	10267
27.9	7812	9765	13020

[2] EP = equivalent person

Table 6.2 shows that even with the higher flow rate/person and over 4 people per retirement unit, less than 1 ha of irrigation would be needed for clay loam and light clay soils.

Table 5.1 shows that the typical soil profile has clay loam to between 40 and 70 cm and light to medium clay to at least 1 metre. This observation indicates that a 1 ha subsurface irrigation, as shown in figure 1.2, would be sufficient even for conservatively estimated design flows.

6.3 Irrigation area available.

The proposed irrigation area lies to the immediate north of the STP. The maximum proposed irrigation area is 10150 msq.

Based on AS/NZS 1547 this area is sufficient.

7 PROPOSED IRRIGATION STRATEGY AND OPTIMISATION OF THE IRRIGATION AREA

7.1 Model inputs

Table 7.1 itemises the inputs used to model the site water balance.

Table 7.1. Components used to model irrigation demand. Daily data over the 42 years between Jan 1970 and October 2012 was used. (Climate data from BoM).

Component	units	Average/y
Effluent production (12.2 cubic m/day)	cubic m	4448
Rainfall	mm	1040
Pan evaporation	mm	1387
Potential evapotranspiration (PET)	mm	1186
Runoff	mm	129
Run-on to irrigation area	mm	zero
Effective root zone	500 mm	
Plant available water in root zone at field capacity	92 mm	

Table 7.2. Effect of effluent irrigation onto 1 ha of land at 1.2 mm/day since 1970.

Water balance component (all mm/y)	No irrigation	With irrigation	Comment
Rainfall infiltration	911	911	
Irrigation	0	438	Daily at 1.2 mm.
Total water available	911	1349	
Actual evapotranspiration[1]	737	1004	
Percolation	175	345	An additional 14mm/month of percolation.

[1] *Plant evapotranspiration is assumed to occur at Potential Evapotranspiration (PET) until 46 mm moisture deficit, then a linear fall to zero at permanent wilting point.*

7.2 Model output

In the period 1970-2012, the average annual rainfall was 1040 mm. Of this 911 mm infiltrated the soil while 129 mm ran off the site. Some 175 mm of the infiltrated rainfall moved below the 500 mm deep root zone.

Pan evaporation averaged 1387 mm while potential evapotranspiration (PET) averages 1186 mm. The PET has a strong annual cycle varying from over 6 mm/day in summer to 1 mm/day in winter. Figure 7.1 shows that the rainfall pattern is more varied and can occur throughout the year.

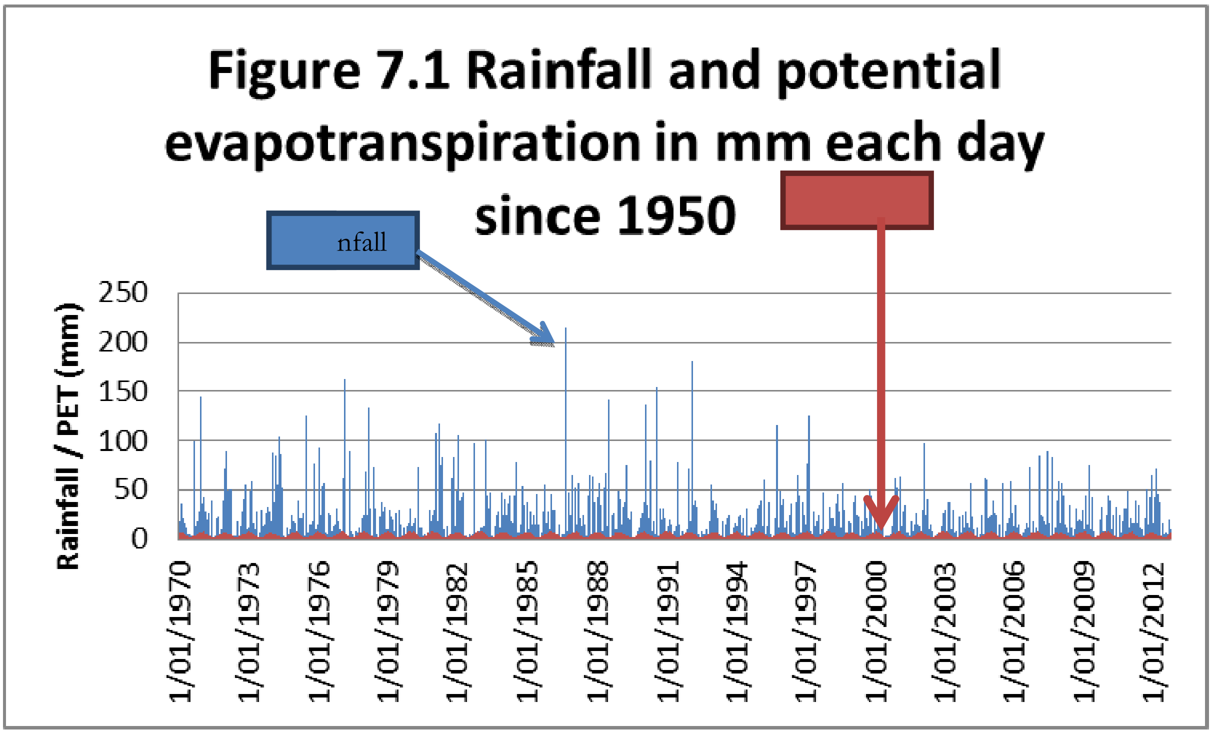
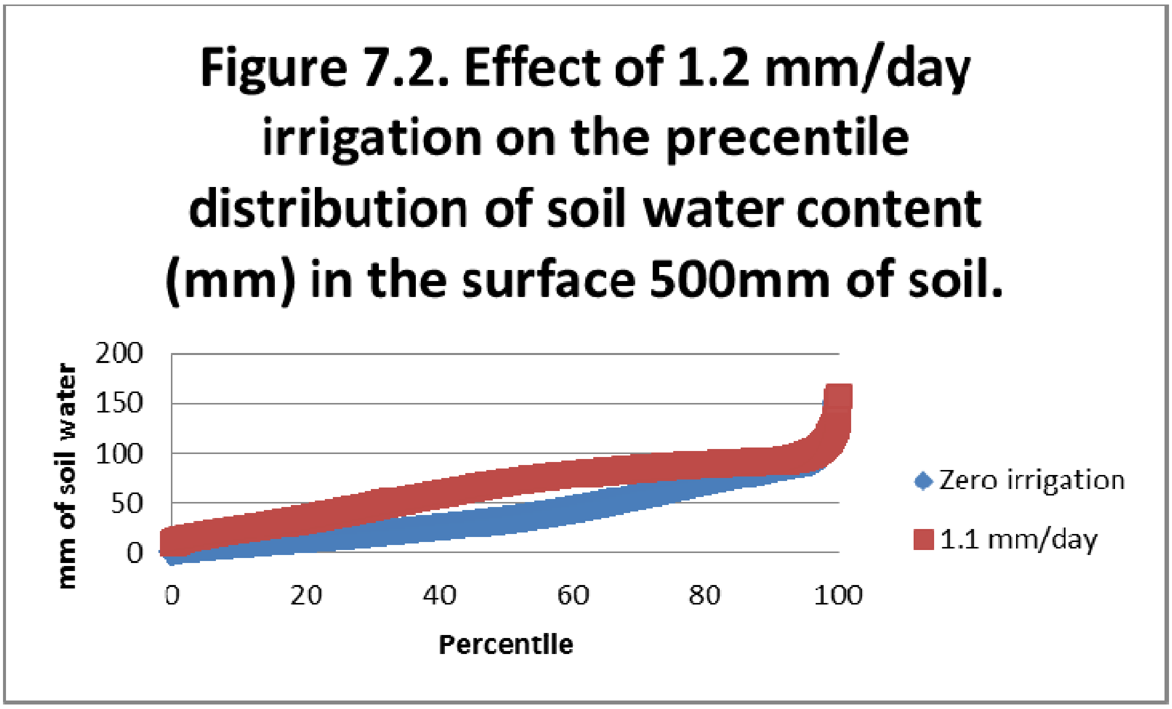


Figure 7.2 shows the effect of applying 1.2mm/day irrigation on the soil water balance.

The main effect of the irrigation is to increase the mid-range soil water content. During prolonged dry periods the irrigation impact is relatively minor. During periods of heavy rainfall, the 1.2 mm/day is small compared with the more than 20mm of rainfall during the same day.

The non-irrigated soil has moisture content in excess of field capacity (92mm in the top 500 mm) in 3% of days whilst the soil receiving 1.2 mm/day irrigation has moisture content exceeding field capacity in 8% of days. The result is increased percolation on the irrigated soil, but this only occurs during heavy rainfall.



It is concluded at the proposed irrigation rate will not increase runoff from the subsurface irrigation area. There will be increased deep percolation, but this will only occur during heavy rainfall events.

8 MANAGEMENT OF CONTAMINANT LOADS

8.1 Nitrogen

The indicative nitrogen concentration in the effluent is <15 mg/L.

Table 8.1 shows the nitrogen loading rate for a range of irrigation areas and nitrogen concentrations.

Table 8.1. Effect of varying irrigation area on the nitrogen and phosphorus loading rates (kg/ha/y). The assumed flow was 12.2 cubic m/day

Irrigation area	**0.8 ha**	**1 ha**	**1.2 ha**
mm of irrigation/year	454	406	365
Assumed nitrogen concentration in irrigated effluent (mg/L)	15	15	15
Nitrogen application rate (kg N/ha/y)	68	61	55
Assumed phosphorus concentration in irrigated effluent (mg/L)	10	10	10
Phosphorus application rate (kg P/ha/y)	45	41	37

According to NSW Agriculture (1997), a typical 12 dry t/ha crop of perennial pasture will have a nitrogen concentration of 2.4 to 3.5% nitrogen. That is, the crop will accumulate 290 to 420 kg/ha/year of nitrogen, provided the crop is harvested. This is more than 4 times the nitrogen application rate in the effluent as shown in table 8.1.

If the pasture is not forage harvested then the nutrient removal rate is dependent on grazing intensity. Plant growth and nutrient uptake are similar, but a proportion of the ingested nutrients is returned in urine and faeces. As an example, a 500 kg cow grazing low quality pasture will excrete approximately 35 kg/year of nitrogen and 14 kg/year of phosphorus (QDNR, 1998). Depending on its initial weight and calf management it will 'accumulate' over 100 kg of N /year. That is, provided the site is either cut and baled or grazed the potential nitrogen export could exceed the nitrogen being supplied in the effluent.

8.2 Phosphorus

Raw sewage contains 10 to 25 mg/L of phosphorus (DLG, 1998). Precipitation and other processes within the STP results in the effluent usually having less than 10 mg/L of phosphorus.

Assuming 10 mg/L of phosphorus, the phosphorus application rate will range from 37 to 45 kg P/ha/y depending on the irrigation rate. Phosphorus concentration in the pasture will be approximately 0.3%, so 12 dry t /ha of pasture will contain 36 kg of phosphorus. This is virtually the anticipated phosphorus application rate.

Section 5.2 shows that the soil profile contains some 15 t/ha of P sorption capacity. That is, even if there was an excess of phosphorus being applied with the effluent, it will take centuries for the soil's sorption capacity to become saturated. (If there were zero net uptake the site would last 369 years prior to saturation).

8.3 Salinity

Salinity increases by some 0.3 dS/m as water passes through a domestic sewerage system.

The current proposal is to subsurface irrigate the water over 1.0 ha on lands that are over 40m from any drainage line. The soils are not saline. Finally the proposed irrigation rate of 400 mm/year is adequate but not excessive, so there will be minimal risk of waterlogging or salinisation.

Salinity is not an issue at this site.

8.4 Conclusions

The anticipated nitrogen application rate via effluent irrigation is 2 to 4 times less than the potential uptake by the pasture. Consequently nitrogen leaching to below the root zone is unlikely to be significant.

Phosphorus application rate is similar to the anticipated accumulation rate by plants. This, plus a large sorption capacity in the soil profile, means that the system can be considered sustainable: Profile saturation with P is unlikely for at least 3.5 centuries.

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Appendix C – Incident report

Reported by: Aquacell Pty Ltd.
1/10b Production Place
Jamisontown NSW 2750
Network Operators Licence Number:
Retail Suppliers Licence Number:

Date of Incident: ____________________

Time of Incident: ____________________

Reported By: ____________________ Position: ____________________ Date: ____________

Reported To: ____________________ Position: ____________________ Date: ____________

Plant location ____________________

Affected Area ____________________

WICA Licence Breached? yes, no, undetermined at this time (circle appropriate)

Description of Incident:

Description of the Impact of the Incident: (have customers been affected? How many?)

Details of the threat or potential threat to water quality, public health or public safety:

Name of Person/Persons Involved in Incident:

Aquacell Pty Ltd
Unit 1/10b Production Place, Penrith NSW 2750, Australia
PO Box 7091, Leura NSW 2780, Australia
P: +61 2 4721 0545 F: +61 2 4721 2761
www.aquacell.com.au
ABN 79 072 487 015

Contact information and name(s) of Person(s) notified of the Incident by Aquacell:

Sequence of Events Immediately Prior to Incident:

Actions Taken Immediately After Incident:

Reason(s) for the Incident occurring / possible cause(s) of the Incident:

Status of the Treatment Plant:

Actions Taken to rectify the incident and prevent reoccurrence:

Anticipated date of return to normal services:

INCIDENT REPORT for RECYCLED WATER TREATMENT PLANTS

For Water Infrastructure related Incidents:

Were water samples taken for analysis? Yes ☐ No ☐

If yes, give the details of the contact person and address of the NATA laboratory tasked with the analysis:

____
____
____
____

Expected date of results:______________________

Sampling Protocol:

Date and time of sampling: ______________________
Water quality characteristics: ______________________
____
Sample location(s): ______________________
____
Water source: ______________________
Intended use / purpose of water: ______________________
Disinfection regime: ______________________
Residual free chlorine (if known): ______________________
Turbidity (if known): ______________________

Compliance Values

Paramter	Units	Compliance Value
E. Coli	Cfu/100mL	
Turbidity	NTU (95%ile)	
pH	units	
Free Chlorine	mg/L	
Coliphages	pfu/100mL	
Clostridia	pfu/100mL	

Additional Sampling required?
Yes ☐ No ☐

Office Use Only

Reported to insurance broker? Yes ☐ No ☐ Date: ______________________

Reported by Office Manager/HR Manager: ______________________ ______________________
Name *Signature*

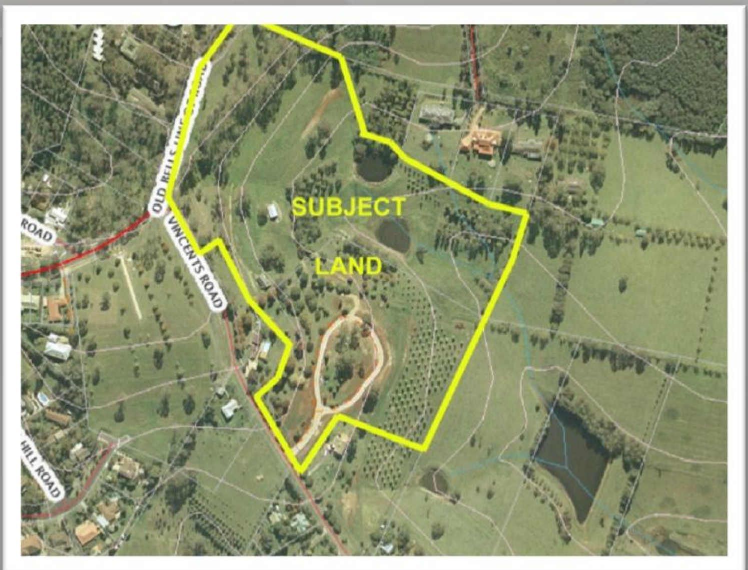
Attach sketch/photograph of scene (if relevant)

Statement of Environmental Effects

Montgomery Planning Solutions

Community Title Subdivision of Seniors Living Housing – 20 lots

No. 19 Old Bells Line of Road Kurrajong
Lots 9 & 10 DP1167912
(Proposed Lot 301)



Submitted to
Hawkesbury City
Council

January 2012

CPP
CERTIFIED PRACTISING PLANNER
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CONTENTS

This Statement of Environmental Effects was prepared by Robert Montgomery, Principal, Montgomery Planning Solutions.

Robert Montgomery BApSc (Environmental Planning) MPIA CPP

Date: January 2012
Reference: 11/38

Montgomery Planning Solutions
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Kurmond NSW 2757

Tel: 4572 2042
Fax: 4572 2044
Mobile: 0407 717 612

Email: robert@montgomeryplanning.com.au

1. Introduction

Montgomery Planning Solutions has been engaged by the owner of the subject land to prepare this statement of environmental effects for a community title subdivision of the approved seniors living development located on the north-east corner of Old Bells Line of Road Vincents Road Kurrajong.

The land is 8.19 hectares in area and is zoned Mixed Agriculture under the provisions of Hawkesbury Local Environmental Plan 1989 (HLEP 1989). The proposal is to create 20 allotments including 18 dwellings lots, one community title lot and a large vacant lot.

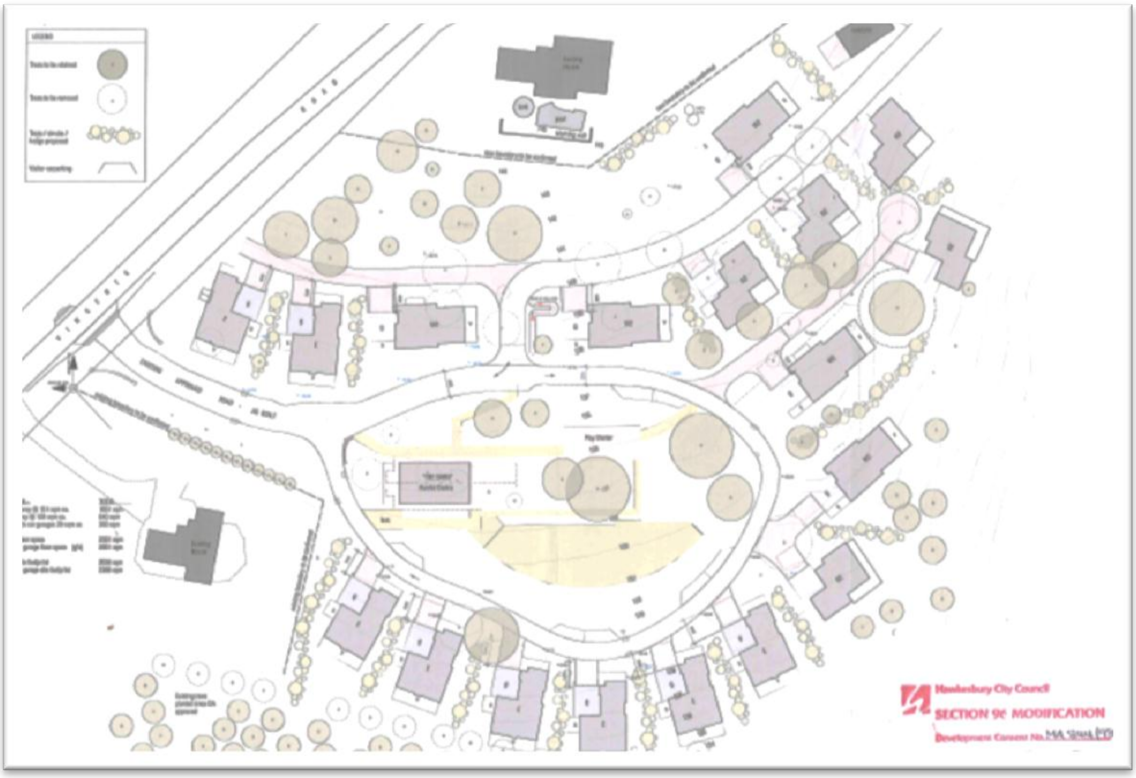
This statement of environmental effects concludes that the proposed subdivision is compliant with all relevant statutory provisions and is recommended for approval.

2. Background

Consent was issued on 15 June 199 (M844/98) for the "construction of aged/disability housing" on the land. The consent approved 18 self-care dwellings and a community building.

The consent was subsequently modified by Council on three occasions, with the last modification being issued on 7 September 2010. The modifications have been in relation to design and layout of buildings within the development. Figure 1 below is the current approved site plan (except for caretaker's residence, which is not approved as per condition 1(b)).

Figure 1: Approved Plan 7 September 2010



3. Site and Surroundings

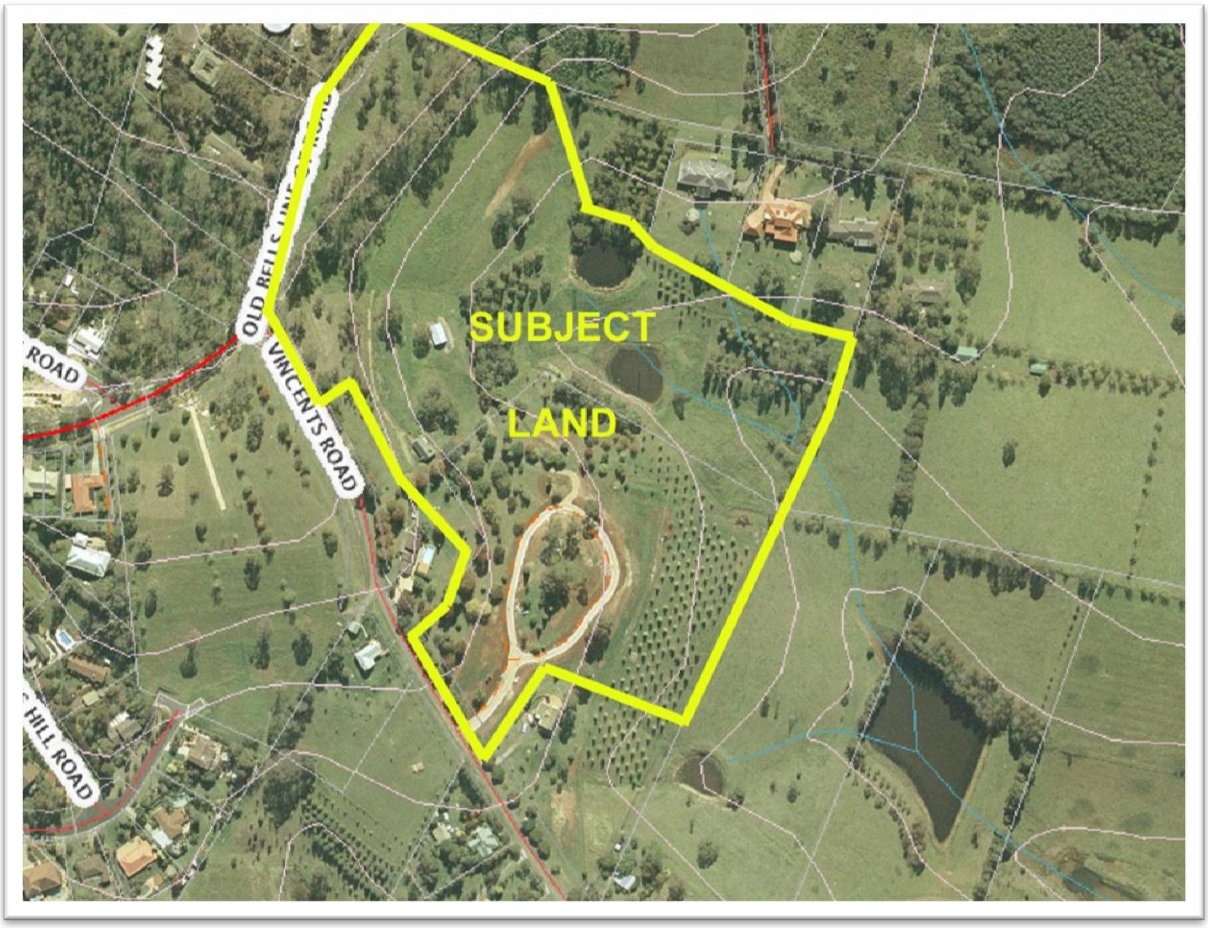
The land is described as proposed Lot 301 in a re-subdivision of Lots 9 and 10 DP1167912 (No. 19) Old Bells Line of Road Kurrajong.

The land is 8.19 hectares in area, with a frontage to Vincents Road of some 110 metres and a frontage to Old Bells Line of Road of some 195 metres. The land currently comprises a farm shed, two dams and scattered trees and is currently used for animal grazing. The proposed dwelling allotments are located generally around the outside of the circular road which has been constructed in accordance with development consent No. M844/98.

Land adjoining to the north comprises four rural lifestyle allotments and a church and cemetery. Land adjoining to the east and south comprises rural living allotments. Land on the southern side of Vincents Road consists of a number of rural living allotments, a larger rural property and an undeveloped parcel of residential land. Land on the western side of Old Bells Line of Road comprises a Sydney Water reservoir, a retirement village and residential allotments.

Figure 1 below is a satellite image showing the land and surrounds.

Figure 2: Locality. Source LPMA SIX Viewer



4. Proposed Development

4.1 Design Objectives

The objectives of the proposed subdivision are:

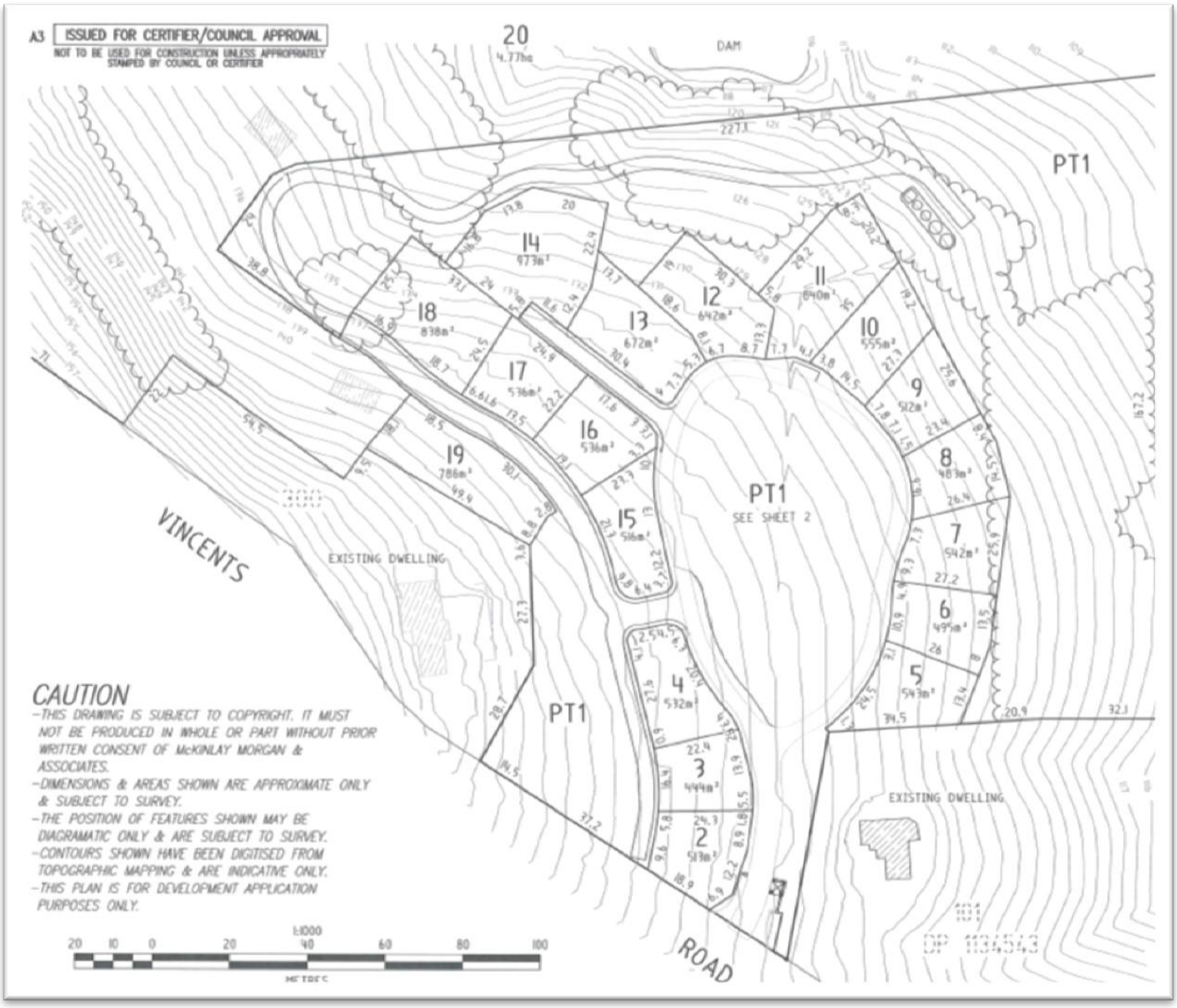
1. To define individual allotments for each of the 18 approved seniors living dwellings with sufficient space for dwelling construction and private space;
2. To create an allotment containing the proposed community building and effluent disposal areas; and
3. To create a large vacant allotment for rural or other land use.

4.2 Development Detail

Development consent is sought for a community title subdivision as follows:

Lot No.	Area	Proposed Use
1	2.3 Ha	Community Building & Effluent Disposal
2	513m2	Dwelling Lot
3	444m2	Dwelling Lot
4	532m2	Dwelling Lot
5	543m2	Dwelling Lot
6	495m2	Dwelling Lot
7	542m2	Dwelling Lot
8	483m2	Dwelling Lot
9	512m2	Dwelling Lot
10	555m2	Dwelling Lot
11	840m2	Dwelling Lot
12	642m2	Dwelling Lot
13	672m2	Dwelling Lot
14	973m2	Dwelling Lot
15	516m2	Dwelling Lot
16	536m2	Dwelling Lot
17	536m2	Dwelling Lot
18	838m2	Dwelling Lot
19	786m2	Dwelling Lot
20	4.77ha	Vacant except for existing shed

Figure 3: Extract from Subdivision Plan



5. Section 79C Matters for Consideration

5.1 Environmental Planning Instruments

5.1.1 State Environmental Planning Policy (Housing for Seniors or People with a Disability 2004

The Policy applies to the subject land in that the land adjoins land zoned primarily for urban purposes as defined and permits dwelling houses and hospitals with consent.

The development was approved under the previous State Environmental Planning Policy No. 5 – Housing for Older People or People with a Disability. Therefore in accordance with the transitional provisions of Clause 6 (1)(c), SEPP 5 continues to apply to the development.

5.1.2 State Environmental Planning Policy No. 5 – Housing for Older People or People with a Disability

Clause 18 is relevant to the proposal. Clause 18 of SEPP 5 states:

> ***18 Subdivision***
>
> *Land on which development has been carried out under this Policy may be subdivided with the consent of the consent authority.*

Although no dwellings have been constructed to date, the internal road has been constructed in accordance with the consent. Therefore, in my submission, the development has technically been “carried out” on the land. In any case, construction is about to commence on Stage 1, comprising community centre and a number of dwellings.

It is submitted that Council can issue development consent for the subdivision with a suitable condition to ensure that the construction of Stage 1 has commenced prior to registration of final plan of subdivision.

5.1.3 Sydney Regional Environmental Plan No. 20 – Hawkesbury Nepean River (No. 2 – 1997***)***

In accordance with clause 120 of Schedule 6 to the Environmental Planning and Assessment Act 1979, this REP is deemed to be a State Environmental Planning Policy.

The aim of SREP 20 is to protect the environment of the Hawkesbury – Nepean River system by ensuring that the impacts of future land uses are considered in a regional context.

The subject land is within the area covered by SREP 20. There are a number of matters for consideration and statutory controls which apply to development within various scenic corridors and defined areas.

There are no specific development controls applying to the proposed development.

5.1.2 Hawkesbury Local Environmental Plan 1989

The land is zoned Mixed Agriculture under the provisions of Hawkesbury Local Environmental Plan 1989 (HLEP 1989). The proposed subdivision relies on the provisions of Clause 18 of State Environmental Planning Policy No. 5 for permissibility.

HLEP 1989 contains a number of general and specific objectives, which are examined in respect of the proposed development as follows.

Aims & Objectives of HLEP 1989

The aims and objectives are listed below, with comments relevant to the proposed development.

(a) to provide the mechanism for the management, orderly and economic development and conservation of land within the City of Hawkesbury;

The proposal does represent the orderly and economic development of land.

(b) to provide appropriate land in area, location and quality for living, working and recreational activities and agricultural production;

The proposal satisfies this objective.

(c) to protect attractive landscapes and preserve places of natural beauty, including wetlands and waterways;

The proposal satisfies this objective.

(d) to conserve and enhance buildings, structures and sites of recognised significance which are part of the heritage of the City of Hawkesbury for future generations; and

There are no listed heritage items on the land.

(e) to provide opportunities for the provision of secure, appropriate and affordable housing in a variety of types and tenures for all income groups within the City.

The proposed development satisfies this objective. In particular, the subdivision of the development will add to the variety of tenure and availability of seniors living housing.

Specific Clauses

The following clauses of HLEP 1989 are relevant and applicable.

Clause 9A – Zone Objectives

Clause 9A provides that Council must be of the opinion that the proposed development is consistent with the relevant objectives of the zone, before granting consent.

Specific Objectives of the Mixed Agriculture zone

The objectives are listed below, with comments relevant to the proposed development.

(a) to encourage existing sustainable agricultural activities,

This objective is not relevant to the proposal.

(b) to ensure that development does not create or contribute to rural land use conflicts,

It is considered that the proposed development will not create or contribute to land use conflict. The land is surrounded by rural residential development.

(c) to encourage agricultural activities that do not rely on highly fertile land,

No agriculture is proposed.

(d) to prevent fragmentation of agricultural land,

The seniors living dwellings have been approved by Council. The subdivision will not create any additional fragmentation.

(e) to ensure that agricultural activities occur in a manner:

(i) that does not have a significant adverse effect on water catchments, including surface and groundwater quality and flows, land surface conditions and important ecosystems such as streams and wetlands, and

(ii) that satisfies best practice guidelines and best management practices.

No agriculture is proposed.

(f) to promote the conservation and enhancement of local native vegetation, including the habitat of threatened species, populations and ecological communities by encouraging development to occur in areas already cleared of vegetation,

The proposal will have no impact in this regard.

(g) to ensure that development retains or enhances existing landscape values that include a distinctive agricultural component,

The existing landscape values will be retained. There is no perceptible change.

(h) to prevent the establishment of traffic generating development along main and arterial roads,

Pursuant to State Environmental Planning policy (Infrastructure) 2007, the development is not traffic generating.

(i) to control outdoor advertising so that it does not disfigure the rural landscape,

No advertising is proposed.

(j) to ensure that development does not create unreasonable economic demands for the provision or extension of public amenities or services.

The proposal will not create any additional demands for the provision or extension of public amenities or public services. The dwellings are already approved, and the proposed subdivision does not change the demand for services.

Clause 18 – Provision of water, sewerage etc. services

Clause 18 requires Council to be satisfied that arrangements have been made for the provision of water, sewerage, drainage and electricity services.

Reticulated water is connected to the land. Effluent will be treated and disposed of on-site as approved in consent No. MA0844/98. Electricity and phone services are available and will be reticulated to each lot.

Clause 37A – Development on land identified on the Acid Sulfate Soils Planning Map

The land is shown as Class 5 on the Acid Sulfate Soils Planning Map. There are no specific requirements for the proposed subdivision.

5.2 Draft Environmental Planning Instruments

Draft Hawkesbury Local Environmental Plan 2011applies. The subject land is proposed to be zoned *“RU1” Primary Production*.

The objectives of the RU1 zone are similar to those of the Mixed Agriculture zone under Hawkesbury LEP 1989.

The draft plan has no bearing on the permissibility of the proposed subdivision as Clause 18 of SEPP 5 provides statutory permissibility.

5.3 Planning Agreements

No planning agreement has been entered into or is offered under section 93F of the Environmentally Planning and Assessment Act, 1979 in respect of the land.

5.4 Development Control Plans

The Hawkesbury Development Control Plan applies to the subject land. The following chapters are relevant to the proposed development.

Part A: 3 – Notification

In accordance with the notification table in Clause 3.10, the proposed development is required to be notified to adjoining landowners/occupiers.

Part C: 7 – Effluent disposal

An on-site wastewater management plant will be installed in accordance with condition 7(b) of development consent No M844/98.

Part D: 3 – Subdivision

It is submitted that this section is not relevant to the proposal as the subdivision is simply applying cadastral boundaries to the development which has already been approved by Council.

5.5 Matters prescribed by the Regulations

There are no prescribed matters relevant to the proposed development.

5.6 Likely Impacts of the Proposed Development

5.6.1 Context and Setting

The site is located within a transition area between residential and rural land uses. The existing lot configuration sits in context with both the surrounding rural-residential allotments and nearby residential area.

5.6.2 Access, Transport & Traffic

There is no change proposed to the access arrangements to the site as approved by development consent M844/98. The access, transport and traffic arrangements were considered as part of the approved development application and found to be acceptable.

It is submitted that no further analysis is required.

5.6.3 Public Domain

The proposed subdivision has no impact in terms of the public domain.

5.6.4 Other Land Resources

This development has no impact in terms of other land resources.

5.6.5 Water

There will be no impacts on water.

5.6.6 Soils

It is considered that there is no impact on soils.

5.6.7 Flora and Fauna

There is no impact on flora and fauna. The proposal simply creates cadastral boundaries around the dwellings and facilities already approved by Council.

5.6.8 Waste

There will be no waste associated with the proposed subdivision.

5.6.9 Energy

There is no impact in terms of energy.

5.6.10 Noise and Vibration

There are no noise or vibration impacts associated with the proposal.

5.6.11 Natural Hazards

Under the Hawkesbury City Council's Bushfire Management Risk Plan for the site, the land is identified as bushfire prone. Attached is a Bushfire Threat Evaluation Report prepared by Control Line Consulting which demonstrates that the hazard will be managed in an acceptable way.

5.6.12 Technological Hazards

There are no technological hazards.

5.6.13 Safety, Security & Crime Prevention

It is considered that the proposal has no impact in terms of safety, security and crime prevention.

5.6.14 Social Impact in the Locality

It is considered that the proposal will have a positive social impact in that it will allow seniors to purchase a retirement dwelling with title to the dwelling and the land upon which it is constructed. This provides long term financial security that cannot be obtained with all retirement villages.

5.6.15 Economic Impact in the Locality

The proposed development represents an appropriate economic use of the land.

5.6.16 Cumulative Impacts

There are no cumulative impacts. The development is compliant with the relevant requirements of State Environmental Planning Policy No. 5.

5.7 Suitability of Site for the Proposed Development

The site is considered to be suitable for the proposal.

The proposed development represents *"the promotion and coordination of the orderly and economic use and development of land"* as stated in the Objects of the Environmental Planning & Assessment Act, 1979.

5.8 The Public Interest

Approval of this development is considered to be in the public interest. There is no negative impact.

6 Conclusion

This statement of environmental effects has been prepared for a community title subdivision of the approved seniors living development located on the north-east corner of Old Bells Line of Road Vincents Road Kurrajong. The proposal is to create 20 allotments including 18 dwellings lots, one community title lot and a large vacant lot.

It is concluded that the subdivision is compliant with all relevant statutory provisions and is recommended for approval.