SHOALHAVEN CITY COUNCIL EFFLUENT DISPOSAL STUDY JERBERRA ESTATE ST GEORGES BASIN

G12023/1-AD 27 January 2000

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Coffey III

Geotechnical | Resources | Environmental | Technical | Project Management

G12023/1-AD LPF;ck 27 January 2000

Shoalhaven City Council Bridge Road NOWRA NSW 2541

Attention: Mr Steve Robertson

Dear Sir,

RE: EFFLUENT DISPOSAL STUDY JERBERRA ESTATE ST GEORGES BASIN

Coffey Geosciences Pty Ltd (Coffey) are pleased to present five copies of our report at the above site.

Should you require further information regarding the report, please do not hesitate to contact either, Andrew Dawkins in our Sydney office on 9888 7444 or the undersigned.

For and on behalf of

COFFEY GEOSCIENCES PTY LTD

LAURIE FOX Senior Environmental Geologist

Distribution: Original held by Coffey Geosciences Pty Ltd 1 copy to Coffey Geosciences Pty Ltd 5 copies to Shoalhaven City Council

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Coffey Geosciences Pty Ltd ACN 056 335 516

EXECUTIVE SUMMARY

Coffey Geosciences Pty Ltd (Coffey) were commissioned by Shoalhaven City Council (the Council) to carry out an effluent study at Jerberra Estate, St Georges Basin. The study was commissioned by Council to provide additional information on the suitability of the site for rural residential subdivision. The potential development area is 85 hectares and currently contains one legal and a number of illegal dwellings. The development is understood to contain 153 lots ranging from 860m² to 1.76ha with 102 lots less than 4000m².

The objective of the study is to ascertain whether effluent disposal for rural residential development is feasible and will meet the objective of nil pollutant export from the site The following scope of work was carried out:

- desk study including a review of published information, aerial photographs, Council records and information held on Council files;
- site walkover by a senior environmental geologist;
- field investigation including the excavation of fifteen test pits and the collection of soil samples;
- laboratory analysis of selected samples for a suite of physical and chemical analytes;
- assessment of the data and reporting of the results including a discussion on the suitable lot size for effluent disposal

The study has identified three terrain units related to landform and soil types. Unit 3, low lying land, is not considered suitable for on-site effluent disposal because of the potential for flooding and the height of the seasonal water table. Unit 3 comprises about 10% of the study area. Unit 1 Ridgeline and Unit 2, Side-slopes are considered suitable with the following major limitations to effluent disposal;

- low soil permeability in clay B horizons;
- erosion potential.

As the effluent disposal system would largely be based on evapotranspiration and nutrient up take in the root zone, significant percolation to the B horizon is not envisaged. To lower the risk of soil erosion, irrigation areas should be well grassed, well drained and preferably located on slopes less than 5° from the horizontal, that is, largely within Unit 1 Ridgeline The potential locations for irrigation fields are indicated on Drawing G12023/1-4.

Based on the preliminary data collected for this study, it is considered that there are only two feasible options for waste-water disposal, either individual aerated water treatment system (AWTS) or a common effluent scheme (CES) for the estate

The recommended minimum lot size for an individual AWTS is about 2,500m² of which about 1500m² is recommended as the minimum area required for irrigation. It should be noted that, because of the site constraints, the AWTS irrigation field would need to be located within those areas indicated on Drawing G12023/1-4. These areas should be regarded as indicative only and would require further field survey to establish more accurate boundaries

The minimum lot size is based on preliminary calculations of the water balance, and assumed nutrient loading (nitrogen and phosphorous), hydraulic loading, the number of people per household and the area of a site devoted to social and recreational use. The minimum area for irrigation represents a nil pollutant export of nutrients from the site based on the available data and assumptions regarding the waste-water quantity and quality. The assumptions on which the lot size and irrigation areas are calculated are anticipated to change with more detailed data.

The responsibility for operation and maintenance of the individual AWTS lies with the householder Generally AWTS are not as suitable for use where occupancy is sporadic (such as a holiday homes) since servicing should be carried out at each start-up. Householders need to be aware of system limitations and correct operating use.

A CES would involve preliminary treatment of sewerage on each individual site, through say a septic tank. The waste-water would then be collected and piped to a centralised treatment plant and a fixed irrigation field Based on the size of the potential irrigation field, as indicated on Drawing G12023/1-4 and assuming a minimum irrigation area of 1500m² per household, it is estimated that about 85 households could potentially utilise the CES. These estimates are based on the current data and will be subject to change when more information becomes available.

Preliminary construction and maintenance guidelines for the CES irrigation field include the following:

- the irrigation field should be landscaped, with minimum vegetated buffer distances of:
 - 40m from the edge of drainage;
 - 6m from property boundaries, buildings and swimming pools;
 - irrigation fields should not include areas of ponded water or shallow rock exposures unless substantial ground improvements are made;
- sprinklers with a throw of not more than 2m, producing coarse droplets, not a fine mist, should be used to lower the risk of aerosol dispersion and wind drift of effluent. The spray height should not be more than 400mm above the finished level of the surface irrigation disposal area;
- effluent quality should conform to the requirements of Environmental Health Protection Guidelines (1998) and the NSW EPA This may be superseded if the EPA require the disposal system to be licensed, in which case the effluent quality requirements will be provided;
- effluent should not be used for irrigation of fruit and vegetables;
- disposal areas should be carefully managed to ensure that the infiltration capacity of the soil is
 maintained as outlined below and that the vegetation cover is well established. Irrigation disposal
 methods are primarily designed to ensure most of the treated effluent is held in the soil profile, taken
 up by plants or lost as evaportranspiration with only a small percentage infiltrating below the topsoil.
 No effluent should be allowed to run-off from the site and it would be necessary to store effluent for
 several days during prolonged rain events.
- Field grass cuttings should be mowed regularly and removed from site;
- earth bunding to about 0 3m height should be installed around the field to provide temporary storage within the irrigation field. Wet weather storage overflows from the field should be intercepted by a downstream catch drain and diverted into stormwater pond/dam if possible;
- effluent quality should be maintained with regular servicing of the treatment plants This service should be provided by the manufacturer in the form of an ongoing servicing contract. The servicing contract usually requires six monthly or annual maintenance, depending on the systems selected. De-sludging of the plants will also be required from time to time depending on the volume of effluent processed.

To ensure acceptable long term performance of the effluent disposal system, EPA Licensing Agreements generally require monitoring and testing of downstream ground and surface waters adjacent to the disposal areas. Monitoring should be conducted periodically (usually once/year) or after uncontrolled discharges into the rivers/creeks have occurred.

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1 INTRODUCTION

Coffey Geosciences Pty Ltd (Coffey) were commissioned by Shoalhaven City Council (the Council) to carry out an effluent study at Jerberra Estate, St Georges Basin The study was in general accordance with our proposal dated 29 January 1999 (Proposal No GP12532/1-AB).

The study was commissioned by Council to provide additional information on the suitability of the site for rural residential subdivision. The potential development area is 85 hectares and currently contains one legal and a number of illegal dwellings The development is understood to contain 153 lots ranging from 860m² to 1.76ha with 102 lots less than 4000m².

1.1 Objectives and Scope of Work

The objective of the study is to ascertain whether effluent disposal for rural residential development is feasible and will meet the objective of nil pollutant export from the site.

The following scope of work was carried out:

- desk study including a review of published information, aerial photographs, Council records and information held on Council files;
- site walkover by a senior environmental geologist;
- field investigation including the excavation of fifteen test pits and the collection of soil samples;
- laboratory analysis of selected samples for a suite of physical and chemical analytes;
- assessment of the data and reporting of the results including a discussion on the suitable lot size for effluent disposal.

2. BACKGROUND

The study area was registered as a subdivision in 1922 and individual lots have been bought and sold since that time though there has been no guarantee (from Council) that future development approval would be granted Following submissions from the Pacific Pastures Progress Association the Council commissioned Mitchell McCotter and Associates in 1994 to carry out an Environmental Study of the site to support a rezoning application (Report No 93152RP1) The main conclusions of the report with respect to effluent disposal were:

- there were three practical options for waste-water management, namely:
 - individual on-site disposal systems for each dwelling;
 - collective package treatment plant for all dwellings within the estate;
 - connection to the existing reticulated sewerage system
- for individual on-site systems aerated water treatment systems (AWTS) were preferable with a recommended minimum irrigation area of 470m²;
- a collective package treatment system was feasible and would require about 14 ha for irrigation.

It should be noted that there is no supporting data regarding the calculations of irrigation area within the copy of the Mitchell McCotter (1994) report supplied to Coffey. The assumptions upon which these calculations are based are therefore unknown and the data cannot be verified.

3. SITE CHARACTERISTICS

3.1 Site Description

The site is located approximately 150km south of Sydney and about 5km from Tomerong, the nearest township. The site is rectangular in shape and has an area of about 85 hectares of which approximately 20% has been cleared Drawing G12023/1-2 show the locality of the site and Drawing G12023/1-1 shows the current lot layout and street configuration. The majority of the site is without power, town water and sewer.

There are several unsealed roads that traverse the study area. There is evidence of erosion in the form of rilling and minor gullying along the road alignments Most of the site is timbered apart from some individual lots where clearing has taken place.

3.2 Topography and Drainage

The highest elevation on the site occurs towards Pine Road in the west and is about 50m above Australian Height Datum (AHD) The site slopes gently (< 5 degrees from the horizontal) down towards the east along a broad ridgeline that separates two drainage catchments. The side slopes generally range from about 5 to 10 degrees from the horizontal and comprise north and south facing slopes

The two catchments form the headwaters of Moona Moona Creek which flows in an easterly direction and eventually discharging to Jervis Bay, some 5km to the east. Drawing G12023/1-2 shows the catchment configuration and the regional setting of the site. The catchment shown on Drawing G12023/1-2 is about 10 km² and the study area comprises about 8% of the catchment area. According to Mitchell McCotter (1994) the study site comprises about 2% of the total Moona Moona Creek catchment.

3.3 Soils Geology and Hydrogeology

Published geological information (Ulladulla 1:250,000 sheet) indicates that the site is underlain by rocks belonging to the Wandandian Siltstone formation, part of the Shoalhaven Group This formation consists of siltstone, silty sandstone and is pebbly in part This rock type differs from that described in the Mitchell McCotter (1994) Report where Nowra sandstone is given as the underlying geology Nowra sandstone outcrops further west of the study area.

There is little published information regarding the soil types in the study area. Mitchell McCotter (1994) inferred soil types from the 1:100,000 Kiama Sheet on the assumption that similar geology will produce similar soils. The Wandandian Siltstone does not occur on the Kiama Sheet and therefore inferring soil types from that sheet for the study area is not appropriate.

Site specific soil descriptions found in Mitchell McCotter (1994), give two soil types for the study area, namely:

- duplex soils where the soil texture shows a distinct contrast with depth ie soils where a sand or loam topsoil (A Horizon) overlies a clay subsoil (B Horizon)
- gradational soils where the soil texture shows a gradual change with depth.

Groundwater beneath the study area is expected to occur generally within the weathered rock, between 5m and 10m depth Groundwater flow would follow the surface topography and discharge zones would most likely occur along drainage depressions eventually providing base flow for Moona Moona Creek

3.4 Climatic Conditions

Most of the site would receive considerable sun with little sheltered areas. The existing tree cover, however, means that parts of the ground surface would be shaded during each day. As is common along the east cost of southern and central NSW, north facing slopes are generally drier than south facing slopes. This is because of the prevailing southerly wind patterns which would account for the majority of the rainfall within the study area. The south facing slopes would be expected to remain wetter for longer periods of time than the north facing slopes.

Average rainfall in the Jervis Bay region is 1,177mm. The wettest months are January to March and October and November. Evaporation exceeds rainfall in all months except June Further information on rainfall and evaporation is given in Mitchell McCotter (1994).

4. STUDY METHODOLOGY

4.1 Fieldwork and Mapping

Fieldwork was carried out on 8 and 9 of March 1999 and consisted of a site walkover and mapping by a senior environmental geologist who noted topographic features, drainage characteristics, slope morphology and soils. Fifteen test pits were excavated in selected areas corresponding to the terrain units identified during the field mapping The test pits were excavated by a rubber tyred backhoe in the full-time presence of an environmental engineer from our Wollongong office

Test pits were excavated to a maximum depth of 2 5m and samples of both topsoil (A Horizon) and subsoil (B Horizon) were collected for texture classification and later laboratory analysis. Drawing G12023/1-1 shows the approximate location of the test pits and a description of the soils, using the Unified Classification System, is included in Appendix A.

4.2 Laboratory Analysis

4.2.1 Physical Testing

The following physical testing program was implemented:

- Emerson crumb test on four samples;
- pH on four samples; and
- Electrical conductivity on four samples

Samples were dispatched to our Sydney materials testing laboratory who is NATA registered for the tests performed. The original laboratory reports are included in Appendix B1.

4.2.2 Chemical Testing

The following chemical testing program was implemented:

- Phosphorus adsorption on four samples;
- Exchangeable sodium percentage (ESP) on four samples; and
- Cation exchange capacity (CEC) on four samples.

Samples were dispatched under standard Coffey Chain of Custody documentation to Sydney Analytical Laboratories (SAL) who are NATA registered for the tests performed. The original laboratory reports are included in Appendix B2

5. FIELDWORK AND MAPPING RESULTS

5.1 Terrain Units

Three terrain units were identified from the desk study and the field mapping and are shown on Drawing G12023/1-3. The three units are;

UNIT 1 RIDGELINE	This unit is characterised by gentle slopes, generally less than 5 degrees from the horizontal, shallow soil profiles comprising a clayey sand A horizon overlying a sandy silty clay B horizon Weathered rock is generally encountered within 1.5m depth. Groundwater in this unit would be expected to be at a depth of about 10m or greater. This unit comprises about 30% of the study area.
UNIT 2 SIDESLOPES	Flanking the ridgeline are the side-slopes. These are characterised by slopes of between 5 to 10 degrees from the horizontal and deeper soil profiles (than Unit 1) The soil types are similar to the Unit 1 soils though the B horizon extends to a greater depth Groundwater would be expected to be at a depth of between 5 and 10m. This unit comprises about 60% of the study area.
UNIT 3 LOW LYING LAND	Low-lying land was identified in the north-east corner and then along the southern boundary of the study area This unit is characterised by gently sloping to near level terrain and gradational soils comprising sandy clay A horizons overlying silty clay B horizons. Groundwater would be expected to vary seasonally and be generally less than 3 0m depth This unit comprises about 10% of the study area

5.2 Subsurface Conditions

The subsurface conditions encountered at the test pit locations consisted of:

- Topsoil comprising silty clayey sand, fine grained light grey to a depth of 0.35m (A HORIZON); overlying
- Sandy silty clay and silty clay, medium to high plasticity light grey, mottled red to depth of about 1 9m (B HORIZON); overlying
- Extremely to highly weathered rock comprising weathered sandstone (C HORIZON)

Groundwater was not encountered in the test pits.

5.3 Soil Texture Classification

Ten soil samples were classified according to their texture and principal profile forms (PPF) as described in Northcote (1979). The results are summarised in Table 1.

CLASSIFICA	ATION			A
soil. Horizon	terrain Unit	DESCRIPTION	PRINCIPAL PROFILE FORM ¹ (PPF)	ESTIMATED PERMEABILITY ² m/day
A	2	Sandy Clay Loam	Duplex	01 to 0.5
В		Medium to Heavy Clay		<0.06
A	3	Sandy Clay Loam	Gradational	0 1 to 0 5
В		Fine Sandy Clay Loam		0.1 to 0 5
A	1	Sandy Clay Loam	Duplex	0.1 to 0.5
В		Medium to Heavy Clay		<0.06
A	1	Sandy Clay	Duplex	0 06 to 0 1
В		Medium to Heavy Clay		<0 06
A	2	Sandy Clay Loam	Gradational	0 1 to 0.5
В		Sandy Clay		0 06 to 0 1
	SOIL HORIZON A B A B A B A B A A	HORIZON UNIT A 2 B A 3 B A 1 B A 1 B A 2 A 2	SOIL. HORIZONTERRAIN UNITDESCRIPTIONA2Sandy Clay LoamBMedium to Heavy ClayA3Sandy Clay LoamBFine Sandy Clay LoamBSandy Clay LoamA1Sandy Clay LoamBMedium to Heavy ClayA1Sandy Clay LoamBMedium to Heavy ClayA1Sandy Clay LoamBMedium to Heavy ClayA1Sandy Clay LoamA1Sandy ClayA2Sandy Clay Loam	SOIL HORIZONTERRAIN UNITDESCRIPTIONPRINCIPAL PROFILE FORM1 (PPF)A2Sandy Clay LoamDuplexBMedium to Heavy ClayMedium to Heavy ClayA3Sandy Clay LoamGradationalBFine Sandy Clay LoamGradationalA1Sandy Clay LoamDuplexA1Sandy Clay LoamDuplexBMedium to Heavy ClayDuplexBMedium to Heavy ClayDuplexA1Sandy Clay LoamBMedium to Heavy ClayDuplexA1Sandy ClayDuplexA2Sandy Clay LoamGradational

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Notes:

Principal Profile as per Northcote (1979);

Permeability estimated from Hazelton and Murphy (1992)

The texture classification show that there are two principal profile forms (PPF) namely duplex soils and gradational soils. This confirms earlier data contained in Mitchell McCotter (1994). The estimated soil permeabilities for Terrain Units 1 and 2 are similar and generally range from 0.06 to 0.1m/day for the B horizon clays.

6. LABORATORY RESULTS

6.1 Physical Testing Results

The results of the physical testing are presented in Table 2 below:

TABLE 2: SUMMARY OF PHYSICAL TESTING RESULTS

PARAMETERS/ SAMPLE IDENTIFICATION	SOIL HORIZON/ TERRAIN UNIT	EMERSON CLASS	pH (UNITS)	ELECTRICAL CONDUCTIVITY (mS/cm)
JTP9 (0 4 to 0 5m)	B horizon Unit 1	2	5.1	0.56
JTP12 (0 4 to 0.5m)	B horizon Unit 1	6	47	0.04
JPT3 (0.5 to 0.6m)	B horizon Unit 2	5	5.2	0 07
JPT10 (0.4 to 0 5m)	B horizon Unit 2	5	53	0 03

The Emerson class number for B horizons in both Terrain Unit 1 and 2 show a moderate erodibility potential. The pH in both units is acidic and the electrical conductivity is low to moderate

6.2 Chemical Testing Results

The results of the chemical testing are presented in Table 3. The results shown are considered representative of the soil profile, including the A horizon, to the depths indicated by the sampling

TABLE 3: S	SUMMARY	OF CHEMICAL	TESTING	RESULTS
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PARAMETER/ SAMPLE IDENTIFICATION	SOIL HORIZON/ TERRAIN UNIT	PHOSPHORUS ADSORPTION CAPACITIES (mg/kg)	EXCHANGEABLE SODIUM PERCENTAGE (ESP) %	CATION EXCHANGE CAPACITY (CEC) meq %
JTP 4 (0 6-0 7m)	B horizon / Unit 2	600	2.0	8.0
JPT 7 (0.4-0 5m)	B horizon / Unit 3	44	0.9	23
JTP 11 (0 4-0 5m)	B horizon / Unit 1	550	29	75
JPT 14 (0.4-0.5m)	B horizon / Unit 2	560	2.0	6.0

Terrain Unit 1 and 2 show a moderate to high phosphorus adsorption capacity with a low ESP and CEC Based on the chemical results the B horizon clays in units 1 and 2 have relatively low salinity and have a low capacity for metals adsorption.

Terrain unit 3, B horizon clays have a lower phosphorus adsorption capacity, low salinity and low capacity for metals adsorption.

7. PRELIMINARY WATER BALANCE

The following calculations have generally been based on Appendix 6 of the Environmental & Health Protection Guidelines On-Site Sewage Management for Single Households (1998). In compiling the preliminary water balance, the following assumptions have been made:

- each dwelling will have three bedrooms and is expected to accommodate five people and generate 1000 litres of waste-water per day as per the Environmental & Health Guidelines (1998);
- the dwelling is part of a subdivision on land identified as suitable for re-development using on-site sewage management;
- average nutrient loading rates and waste-water concentrations have been taken from Table 14 of the Environmental & Health Protection Guidelines (1998);
- the percolation rate is 5mm/week;
- 520m² has been allowed for the dwelling footprint, vehicular access and social and recreational space

The water balance calculations are presented in Appendix C. A summary of the preliminary calculations is provided below:

- Design waste-water flow rate:	1000 I/day
- Recommended Irrigation Area:	1480m ² (based on nitrogen loading)
- Recommended Wet Weather Storage:	53m ³ (based on hydraulic loading)
- Recommended minimum lot size:	2,500m² (1480 + 1020)

The recommended minimum lot size refers to the irrigation area, combined with an assumed area of 1020m², comprising a single storey dwelling, vehicular access areas, social and recreational areas. It should be noted that by applying the buffer distances set out in Section 8 1 the minimum lot size may increase

It should be noted that the preliminary water balance indicates that precipitation and irrigation (inputs) exceeds evapotranspiration and percolation (outputs) during five months of the year (ie from February to July). Using this model, there would be periods when irrigation would not be possible, such as during high rainfall events and storage of effluent would be required

8. SITE CONSTRAINTS

8.1 Buffer Distances

The following buffer distances are recommended for on-site disposal systems from the Environmental and Health Protection Guidelines (1998):-

- 100m to permanent surface water creeks, rivers, lakes;
- 250m to domestic groundwater well;
- 40m to other waters farm, dams intermittent creeks drainage channels;
- 6m from driveways and property boundaries;
- 15m to dwelling;
- 6m to swimming pool;
- 3m to paths and walkways
- 8.2 Physical Features

The site specific physical features are presented in Table 4 and have been compared to the rating system given in the Environmental and Health Protection Guidelines (1998)

	FEATURE (UNITS)	RELEVANT DISPOSAL SYSTEM	TERRAIN UNIT	JERBERRA ESTATE	EPH GUIDELINES (1998) ¹
					LIMITATIONS
1	Depth to rock	Surface and subsurface irrigation	All units	1 0 to 1.5m	Moderate Limitation
		Absorption	All units	1.5m	Minor Limitation
2	Depth to	Surface and subsurface	Units 1& 2	+3m *	Minor Limitation
	Watertable	irrigation	Unit 3	1-3m *	Major Limitation
		Absorption	All units	same as above	same as above
3	Soil Permeability	All land application	All units	A horizon - 0.1 to 0 5*	Minor Limitation
	(m/day)	systems		B horizon<0 06 to 0 5 *	Major Limitation
4	рН	All land application systems	All units	5 0 (average)	Moderate Limitation
5	ESP %	Surface and subsurface irrigation (0-0 4m)	All units	2.0 to 2.9	Moderate Limitation
		Absorption (0-1.5m)	All units	same as above	same as above
6	Electrical Conductivity (ds/cm)	All land application system	All units	0.001 to 0.05	Minor Limitation
7	CEC (% meq)	Surface and subsurface	Units 1 & 2	6 to 8	Mod Limitation
		irrigation	Unit 3	2	Major Limitation

TABLE 4: PRELIMINARY SITE ASSESSMENT RATING FOR ON-SITE SYSTEM



TAB	LE 4: PRELIMINAR	Y SITE ASSESSMENT RAT	ING FOR ON-S	ITE SYSTEM (CONTINU	ED)	
	FEATURE	RELEVANT DISPOSAL	TERRAIN	JERBERRA ESTATE	EPH GUIDELINE	
		SYSTEM	UNITS		LIMITATIONS	
8	Phosphorus sorption (Kg/ha)	All land application systems	All units	7200	Minor Limitation	
9	Flood Potential	Al land application	Units 1 & 2	above 1 in 20 year *	Minor Limitation	
		systems	Unit 3	below 1 in 20 years *	Major Limitation	
10	Exposure	All land application systems	All units	High sun & wind exposure	Minor Limitation	
11	Slope	All application systems	All units	5-10° from horizontal *	Minor Limitation	
12	Landform	All application systems	Unit 1 and 2	Ridges & slopes	Minor Limitation	
			Unit 3	Floodplain	Major Limitation	
13	Erosion Potential	All application systems	All units	Emerson Class 2,5	Moderate to Major	
				Evidence of erosion (rills) along roadways	Limitation	
14	Site Drainage	All application systems	Unit 1 and 2	Fair to good	Minor Limitation	
			Unit 3	poor	Major Limitation	
15	Land Area	All systems	All units	Land areas available	Minor Limitation	
16	Rock & Rock Outcrops	All land application systems	All units	Less than 10% of area*	Minor Limitation	

Notes:

Environmental and Health Protection Guidelines for On-site Sewage Management for Single Households (1998)

* - estimate only.

The major limitations to the use of on-site effluent treatment systems in Terrain Units 1 and 2 are the following:

- low soil permeability in clay B horizons;
- erosion potential;

In addition to the above Unit 3 has major limitations with respect to landform, site drainage and cation exchange capacity and this unit is not considered suitable for on-site effluent disposal

The study has identified three terrain units related to landform and soil types. Unit 3, low lying land, is not considered suitable for on-site effluent disposal because of the potential for flooding and the height of the seasonal water table. Unit 3 comprises about 10% of the study area. Unit 1 Ridgeline and Unit 2, Side-slopes are considered suitable with the following major limitations to effluent disposal;

- low soil permeability in clay B horizons;
- erosion potential

As the effluent disposal system would largely be based on evapotranspiration and nutrient up take in the root zone, significant percolation to the B horizon is not envisaged. To lower the risk of soil erosion, irrigation areas should be well grassed, well drained and preferably located on slopes less than 5° from the horizontal, that is largely within Unit 1 Ridgeline. The potential locations for irrigation fields are indicated on Drawing G12023/1-4.

Based on the preliminary data collected for this study, it is considered that there are only two feasible options for waste-water disposal, either individual aerated water treatment system (AWTS) or a common effluent scheme (CES) for the estate

The recommended minimum lot size for an individual AWTS is about 2,500m² of which about 1500m² is recommended as the minimum area required for irrigation. It should be noted that, because of the site constraints, the AWTS irrigation field would need to be located within those areas indicated on Drawing G12023/1-4. These areas should be regarded as indicative only and would require further field survey to establish more accurate boundaries

The minimum lot size is based on preliminary calculations of the water balance, and assumed nutrient loading (nitrogen and phosphorous), hydraulic loading, the number of people per household and the area of a site devoted to social and recreational use The minimum area for irrigation represents a nil pollutant export of nutrients from the site based on the available data and assumptions regarding the waste-water quantity and quality The assumptions on which the lot size and irrigation areas are calculated are anticipated to change with more detailed data

The responsibility for operation and maintenance of the individual AWTS lies with the householder. Generally AWTS are not as suitable for use where occupancy is sporadic (such as a holiday homes) since servicing should be carried out at each start-up. Householders need to be aware of system limitations and correct operating use.

A CES would involve preliminary treatment of sewerage on each individual site, through say a septic tank. The waste-water would then be collected and piped to a centralised treatment plant and a fixed irrigation field Based on the size of the potential irrigation field as indicated on Drawing G12023/1-4 and assuming a minimum irrigation area of 1500m² per household, it is estimated that about 85 households could potentially utilise the CES These estimates are based on the current data and will be subject to change when more information becomes available.

Preliminary construction and maintenance guidelines for the CES irrigation field include the following:

the irrigation field should be landscaped, with minimum vegetated buffer distances of:

- 40m from the edge of drainage;

- 6m from property boundaries, buildings and swimming pools;

- irrigation fields should not include areas of ponded water or shallow rock exposures unless substantial ground improvements are made;
- sprinklers with a throw of not more than 2m, producing coarse droplets, not a fine mist, should be used to lower the risk of aerosol dispersion and wind drift of effluent. The spray height should not be more than 400mm above the finished level of the surface irrigation disposal area;
- effluent quality should conform to the requirements of Environmental Health Protection Guidelines (1998) and the NSW EPA. This may be superseded if the EPA require the disposal system to be licensed, in which case the effluent quality requirements will be provided;
- effluent should not be used for irrigation of fruit and vegetables;
- any disposal areas should be carefully managed to ensure that the infiltration capacity of the soil is
 maintained as outlined below and that the vegetation cover is well established Irrigation disposal
 methods are primarily designed to ensure most of the treated effluent is held in the soil profile, taken
 up by plants or lost as evaportranspiration with only a small percentage infiltrating below the topsoil.
 No effluent should be allowed to run-off from the site and it would be necessary to store effluent for
 several days during prolonged rain events
- Field grass cuttings should be mowed regularly and removed from site;
- earth bunding to about 0.3m height should be installed around the field to provide temporary storage within the irrigation field. Wet weather storage overflows from the field should be intercepted by a downstream catch drain and diverted into stormwater pond/dam if possible;
- effluent quality should be maintained with regular servicing of the treatment plants This service should be provided by the manufacturer in the form of an ongoing servicing contract. The servicing contract usually requires six monthly or annual maintenance, depending on the systems selected. De-sludging of the plants will also be required from time to time depending on the volume of effluent processed

To ensure acceptable long term performance of the effluent disposal system, EPA Licensing Agreements generally require monitoring and testing of downstream ground and surface waters adjacent to the disposal areas. Monitoring should be conducted periodically (usually once/year) or after uncontrolled discharges into the rivers/creeks have occurred

The following analytical suite is recommended:

- biological oxygen demand (BOD);
- suspended solids;
- pH, electrical conductivity (EC), Total Dissolved Solids (TDS);
- ammonia, total keldahl nitrogen, and nitrate; and
- total Phosphorous

The frequency of testing may change with results. Baseline data of existing surface and groundwaters would also be required prior to the operation commencing.

Coffey

10. LIMITATIONS

The findings contained in this report are the result of discrete/specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site in question. Under no circumstances, however, can it be considered that these findings represent the actual state of this site at all points

In preparing this report, Coffey has relied upon certain verbal information and documentation provided by the client and/or third parties. Coffey did not attempt to independently verify the accuracy or completeness of that information. To the extent that the conclusions in this report are based in whole or in part on such information, they are contingent on its validity. Coffey assume no responsibility for any consequences arising from any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to Coffey

For and on behalf of

COFFEY GEOSCIENCES PTY LTD

LAURÍE FOX

Senior Environmental Geologist

G12023/1-AD 27 January 2000

APPENDIX A

Test Pit Logs



Soil Description

Explanation Sheet



DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic material found in the ground. In practice if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil

Other materials are described using rock description terms

AS1726-1993

The descriptive terms used by Coffey are given below They are broadly consistent with AS1726-1993

UCS & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on the following page

MOISTURE CONDITION

- Looks and feels dry Cohesive and cemented soils hard, friable or powdery Uncemented granular soils run freely Dry through hands
- Soil feels cool and darkened in colour. Cohesive soils can be Moist moulded Granular soils tend to cohere
- Wet As for moist but with free water forming on hands when handled

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2 36 mm
	medium	200 µm to 600µm
	fine	75 μm to 200 μm

MINOR COMPONENTS

TERM	TERM ASSESSMENT GUIDE PROPORTION				
16110	ASSESSMENT GODE	FINERALION			
Trace of	Presence just detectable by feel or eye, but soil properties little or no	Coarse grained soils: ≤ 5%			
	different to general properties of primary component.	Fine grained soils: ≤ 15%			
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component	Coarse grained soils: 5 – 12% Fine grained soils: 15 – 30%			

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH Sµ (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort
Soft	12 – 25	A finger can be pushed into the soil to about 25mm depth
Firm	25 – 50	The soil can be indented about 5mm with the thumb but not penetrated
Stiff	50 - 100	The surface of the soil can be indented with the thumb but not penetrated
Very Stiff	100 – 200	The surface of the soil can be marked but not indented with thumb pressure
Hard	>200	The surface of the soil can be marked only with the thumbnail
Friable	-	Crumbles or powders when scraped by thumbnail

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	9 - 15
Loose	15 - 35
Medium Dense	35 – 65
Dense	65 — 85
Very Dense	85 - 100

SOIL STRUCTURE

	ZONING	CE	MENTING
Layers	Continuous exposure or sample	Weakly cemented	Easily broken up by hand in air or water
Lenses	Discontinuous layers of lenticular shape	Moderately cemented	Effort is required to break up the soil by hand in air or water
Pockets	Irregular inclusions of differential material		

SOIL STRUCTURE

WEATHERED IN PLACE SOILS

Structure and fabric of parent rock visible Extremely weathered material

Residual soil Structure and fabric of parent rock not visible

TRANSPORTED SC Aeolian soil	NLS Deposited by wind
Alluvial soil	Deposited by streams and rivers
Colluvial soil	Deposited on slopes (transported downslope by gravity)
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils
Lacustrine soil	Deposited by lakes
Marine soil	Deposited in ocean basins bays beaches and estuaries

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COL		CH	SILTY CLAY: medium to high plasticity. light grey mottled orange, & red, with a trace of sand fine grained breaks up into pedals 20-50mm in size		
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VERSION	Ψ				SC C	CLAYEY SAND: fine grained, light grey with some silt and roots	ne	D M	L ND		TOPSOIL .
COFEXCA						SILTY CLAY: medium to high plasticity, orange, a trace to some sand fine grained with slight fissuring and a trace of roots	with	¢₩ρ	н		RESIDUAL
					r F	SANDY SILTY CLAY: light grey, mottled orange, s red fissured structure breaks up into 20-50mm pedals gravelly from 0.8-0 9m	SDME				EXTREMELY WEATHERED ROCK
18 / 5/39 12 :16 :12				2		SANDSTONE: fine grained light grey mottled of highly weathered	range –				- HIGHLY WEATHERED ROCK
						Pit JTP10 Terminated at 240 m					
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Se		e and ervations			of 1	
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APPENDIX B

Laboratory Reports

Coffey IIII

B2: Chemical Laboratory Reports



Page 1 of 5

SYDNEY ANALYTICAL LABORATORIES

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Office: PO BOX 48 ERMINGTON NSW 2115

Laboratory: 1/4 ABBOTT ROAD SEVEN HILLS NSW 2147 Telephone: (02) 9838 8903 Fax: (02) 9838 8919 A.C.N. 003 614 695 NATA Reg. 1884



ANALYTICAL REPORT for:

COFFEY GEOSCIENCES PTY LTD

PO BOX 125 NORTH RYDE 2113

ATTN: ANDREW DAWKINS

- JOB NO: SAL7628
- CLIENT ORDER: G12023/1

DATE RECEIVED: 08/04/99

DATE COMPLETED: 16/04/99

TYPE OF SAMPLES: SOILS

NO OF SAMPLES: 4



Issued on 23/04/99 Lance Smith (Chief Chemist)

SYDNEY ANALYTICAL LABORATORIES

ANALYTICAL REPORT

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JOB NO: SAL7628 CLIENT ORDER: G12023/1

SAMPLES	*PHOSPHORUS SORPTION mg/kg	ESP %	CEC MEQ%
1 JTP4/0.6-0.7	600	2.0	8.0
2 JTP7/0.4-0.5	400	0.9	2.3
3 JTP11/0.4-0.5	550	2.9	7.5
4 JTP14/0.4-0.5	560	2.0	6.0
MDL	1	0.1	0.1
Method Code	S9	C35	S7
Preparation	P5	P5	P5

Page 3 of 5

SYDNEY ANALYTICAL LABORATORIES

ANALYTICAL REPORT

JOB NO: SAL7628 CLIENT ORDER: G12023/1

				EXCHAN	GEABLES -		
	SAMPLES	Na MEQ%	K MEQ%	Ca MEQ%	Mg MEQ%	Mn MEQ%	Al MEQ%
1	JTP4/0.6-0.7	0.16	0.12	0.23	3.45	<0.01	3.8
2	JTP7/0.4-0.5	0.02	0.02	0.34	0.70	<0.01	1.0
3	JTP11/0.4-0.5	0.22	0.04	1.45	4.05	<0.01	2.1
4	JTP14/0.4-0.5	0.12	0.06	0.10	2.75	<0.01	2.7
	L	0.01	0.01	0.01	0.01	0.01	U.1
	thod Code	S7	S7	S7	S7	S7	S7
	eparation	P5	P5	P5	P5	P5	P5

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Page 4 of 5

SYDNEY ANALYTICAL LABORATORIES

ANALYTICAL REPORT

JOB NO: SAL7628 CLIENT ORDER: G12023/1

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SAMPLES	Na	K	Ca	Mg	Mn	A]
	MEQ%	MEQ%	MEQ%	MEQ%	MEQ%	MEQ۹
1 JTP4/0.6-0.7	0.32	0.03	<0.01	0.10	<0.01	<0.1
2 JTP7/0.4-0.5	0.10	0.06	0.01	0.17	<0.01	<0.1
3 JTP11/0.4-0.5	0.24	0.42	0.04	0.45	<0.01	<0.1
4 JTP14/0.4-0.5	0.22	0.17	<0.01	0.31	<0.01	<0.1
MDL	0.01	0.01	0.01	0.01	0.01	0.1
Method Code	S7	S7	S7	S7	S7	S7
Preparation	P5	P5	P5	P5	P5	P!

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RESULTS ON DRY BASIS

Page 5 of 5

SYDNEY ANALYTICAL LABORATORIES

ANALYTICAL REPORT

JOB NO: SAL7628 CLIENT ORDER: G12023/1

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory.

- P5 Sample dried, split and crushed to -150um
- *S9 Phosphorus Sorption Dept of Agriculture Standard Method Determined by APHA 4500F
- C35 Exchangeable Sodium Percentage Silver Thiourea Extract Determined by APHA 3500D
- S7 Cation Exchange Capacity & Exchangeable/Soluble Cations Determined by Silver Thiourea Method

*The laboratory's NATA registration does not cover performance of this service

A preliminary report was faxed on 16/04/99

B1: Physical Laboratory Reports

Coffey III

Coffey Geosciences Pty	Geotechnical Resources Environmental Technical Project Management 142 Wicks Road, North Ryde, NSW, 2113 Ph: (61 2) 9888 7444. Fax: (61 2) 9878 8155
determination of eme client : SHOALHAVEN CITY COUNCIL principal : project : EFFLUENT DISPOSAL STUDY location : JERBERRA ESTATE, ST GEOR	job no : G12023/1 laboratory : SYDNEY date : 15/04/99
test procedure : AS1289.3.8.1-199 sample identification: JTP9 (0.4 - 0.5m) Sample supplied by	7 / CG-Wollongong on the 9/4/99,
test data	immersion of air dried crumbs
air dried crumbs time start of 12/4/99 test: 15:26	does not slake
time dispersion <u>12/4/99</u> commences: <u>15:27</u> time dispersion <u>Not</u>	complete dispersion 1 partial dispersion 2
completed: Observed remoulded material	immersion of remoulded material
time start of test: time dispersion commences:	disperses (3) does not disperse
time dispersion completed:	calcite or gypsum present
material description (CI/CH) CLAY - medium to high plasticity,light brown.	absent vigorous shaking disperses 5 flocculates 6
type of water used: <i>Distilled</i> water temperature: 20.5°	Emerson 2 class number

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	Geotechnical Resources Environmental Technical Project Management 142 Wicks Road, North Ryde, NSW, 2113 Ph: (61 2) 9888 7444, Fax: (61 2) 9878 8155
determination of eme	rson class number
client : SHOALHAVEN CITY COUNCIL principal : project : EFFLUENT DISPOSAL STUDY location : JERBERRA ESTATE, ST GEORG	laboratory : SYDNEY date : 15/04/99
test procedure : AS1289.3.8.1-1997 sample identification: JTP3 (0.5 - 0.6m) Sample supplied by	7 r CG-Wollongong on the 9/4/99.
test data	immersion of air dried crumbs
air dried crumbs time start of 12/4/99 test: 15:27	does not slake slakes does not swell does not swell
time dispersion commences:	complete dispersion 1
time dispersion completed:	partial dispersion (2) no dispersion
remoulded material	immersion of remoulded material
time start of 13/4/99 test:	disperses 3
time dispersion commences:	does not disperse
time dispersion completed:	calcite or gypsum present (4)
material description	absent 🖂
(CI) CLAY - medium plasticity,light brown orange.	vigorous shaking disperses (5) flocculates (6)
type of water used: <i>Distilled</i> water temperature: 20.5°	Emerson class number 5



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	Geotechnical Resources Environmental Technical Project Management 142 Wicks Road, North Ryde, NSW, 2113 Ph: (61 2) 9888 7444, Fax: (61 2) 9878 8155
determination of em client : SHOALHAVEN CITY COUNC principal : project : EFFLUENT DISPOSAL STUD location : JERBERRA ESTATE, ST GEO test procedure : AS1289.3.8.1-19	job no : G12023/1 laboratory : SYDNEY date : 15/04/99 test report :
sample identification: .ITP10 (0 4 - 0 5m	nj <u>by CG-Wollongong on the 9/4/99</u> immersion of air dried crumbs
air dried crumbs time start of 12/4/99 test: 15:25	does not slake slakes swell does not swell 8
time dispersion commences:	complete dispersion 1
time dispersion completed:	partial dispersion (2) no dispersion
remoulded material	immersion of remoulded material
time start of 13/4/99 test: 11:45	disperses (3)
time dispersion commences:	does not disperse
time dispersion completed:	calcite or gypsum present
material description	absent
(CI) CLAY - medium plasticity,orange brown, some fine to medium sand	vigorous shaking disperses (5) flocculates (6)
type of water used: <i>Distilled</i> water temperature: 20.5°	Emerson 5 class number



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Coffey Geosciences Pty I	Ltd A C.N 056 335 516
	Geotechnical Resources Environmental Technical Project Management 142 Wicks Road, North Ryde, NSW, 2113 Ph: (61 2) 9888 7444, Fax: (61 2) 9878 8155
determination of eme	rson class number
client : SHOALHAVEN CITY COUNCIL principal : project : EFFLUENT DISPOSAL STUDY location : JERBERRA ESTATE, ST GEORG	rson class number job no : G12023/1 laboratory : SYDNEY date : 15/04/99 test report :
test procedure : AS1289.3.8.1-1997 sample identification: JTP12 (0.4 - 0.5m) Sample supplied by	7 · CG-Wollongong on the 9/4/99.
test data	immersion of air dried crumbs
air dried crumbs time start of 12/4/99 test: 15:28	does not slake
time dispersion	does not swell (1)
time dispersion completed:	partial dispersion (2) no dispersion (X)
remoulded material	immersion of remoulded material
time start of 13/4/99 test: 11:52	disperses 3
time dispersion commences:	does not disperse
time dispersion completed:	calcite or gypsum present (4)
material description	absent
(Cl) CLAY - medium plasticity,red brown.trace of fine sand.	vigorous shaking disperses 5 flocculates 6
type of water used: <i>Distilled</i> water temperature: <i>20.5</i> °	Emerson class number 6



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1. RUSSELL 16 14 199 Authorised Signature NATA No 431

	Geotechnical	Resources	142 Wig	ks Road, N	Project Management orth Ryde, NSW, 2113 Fax: (61 2) 9878 8155	
est results ent: <i>SHOALHAVEN CITY COUNCIL</i> incipal: oject: <i>EFFLUENT DISPOSAL STUDY</i> pation: <i>JERBERRA ESTATE, ST GEORG</i>	ES BASIN		labo dat	no : pratory : e : : report :	G12023/1 SYDNEY 15/04/99	Coffey B
st procedure : AS1289 4.3.1			test	date :	13/4/99	
Sample			Hq			
Identification		<u></u>	Units		<u></u>	
JTP3 (0.5 - 0.6m)			5.2			
JTP9 (0.4 - 0.5m)			5.1			:
JTP10 (0.4 - 0.5m)			5.3			
JTP 12 (0.4 - 0.5m)			4.7			
			I			

NATA A

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Authorised Signature NATA No 431 () 16 4-199

Form Number L1.0R1 Version 4.0

	Geotechnical	Resources	142	2 Wicks Road, N	Project Management lorth Ryde, NSW, 2113 , Fax: (61 2) 9878 8155	
est results nt : SHOALHAVEN CITY COUNCIL ncipal : ject : EFFLUENT DISPOSAL STUDY ation : JERBERRA ESTATE, ST GEORGE				job no : laboratory : date : test report :	G12023/1 SYDNEY 15/04/99	Coffey
t procedure : Prepared in accordance w	ith AS1289 4.3.1	test method		test date :	13/4/99	
Sample		·····	Electrical C	Conductivity		
Identification			Units	us/cm		
JTP.3 (0.5 - 0.6m)			0.	.07		
JTP9 (0.4 - 0.5m)			0	.56		
JTP10 (0.4 - 0.5m)			0.	.0.3		
JTP 12 (0.4 - 0 5m)			0	.04		

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APPENDIX C

Preliminary Water Balance Calculations

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Design Water Flow Design percolation Rate	1000	σx														
Parameter	Symbol	Formula	Units	Jan	Feb	Mar	April	May	June	July	Aug	Sept	oot O	Nov	Dec	Total
Days in Month Precipitation			days mm/month	31 88	71	ر 80 ع	30 52	31	82	41	38	0° 84	31 72	88	70	777
Evaporation Crop Factor	шо		mm/month	195	160 0.8	146 0.8	120 0.8	96.1 0.8	87 0.8	96.1 0.8	127 0.8	150 0.8	177 0.8	180 0.8	214 0.8	1748
Inputs Precipitation			mm/month	88	71	80	52	72	62	41	38	48	72	84	20	777
Possible Effluent Irrigation	3	(ET + B) - P	mm/month	60	77	59	65	27	29	58	86	94	92	81	123	H = 881
Actual Effluent Production		H/12 (P + I)	mm/month mm/month	162	144	73 153	73 126	73 146	136	114	111	121	145	/3 158	143	1669
Outputs				ł												
Evapotranspiration	ET	EXC	mm/month	156	128	117	96	22	2	12	102	120	141	144	171	1398
Percolation	8	(R / 7) X D	mm/month	22	20	22	21	22	21	22	22	21	22	21	22	
Outputs		ET + B	mm/month	178	148	139	117	66	91	66	124	141	164	165	193	1659
	[6		-	ĺ	,				101	-	04	
Storage Crimitative Strorage	nΣ	(H + I) - (E I + B)	mm		? 17	4 *	20 0	4/ 66	111	126	-13	93 93	75	-0	<u>2</u>	
													1			
Irrigation Area		365 X Q / H	m2	414												
Storage	>	Largest M (V X L)/1000 m3	шш	129 53												

071-Coffey Geosciences Pty Ltd ACN 056 335 516 JOB NO 912023/1 Computations Sheet of Office Shoulhar City Council Client 30 April 1999 Date Principal By Effluent Study Project Checked TOMERONG JERREEM Location FATATE Water Balance Calculations BAZ ANCE NUTRIENT (l)A - ladarea ma C : hubiert conc. (mg/4) a = waslewater flow rate - critical Torading rate Thoron (arwage) 527.5 mg/kg assume 1500 kg 0.7913g/m3 7912 kg/ha/m of foil Assunptins 67 · total phosphoren conc(TP) = 12mg/L in wante water criticail loadeng rate (2p) = 3 mg/m²/day phosphinner sorblu capacity = 7900 kg/ha Amoutop phosphoron, that can be absorbed as without Pabsorber teaching are soyers \mathcal{O} Pabsorbeu = 7900 × 3 = 2631 Rg/ha/m E 0.26 kg/m² of vegetation uptake over soyeers e amount Determin - <u>3 x 365 x 50</u> Puptake 54, 750 mg/M2 = 0.055 kg/m2 = amont of phospherms generated in Soyears -e = 12 × 1000 x 365 × 50

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Coffey Geosciences Pty Ltd ACN 056 335 516 G12023/1 Job No 2 of 2 to / 15 May 1999 Computations Sheet Shouthan City Council Office Client Date Principal Effluent Study Ву Project Checked Location TERRACKA ESTATE Trigation Pgawated wea Paberbea + Publah 219 -72 026 + 0.055 695 m2 B NITROGEN Assumptions (based on Toble 14 of E&H 1999 Euclebra) · 37 mg/2 nitrige concentration in wastewate critical loadi rate 25 mg/m2/d ۲ A \bigcirc 6)angali where A = ara è Frate con waste water low rate \mathcal{O} critical 2 |÷ B7× 1000 A -25 1480 m2 4

APPENDIX D

Drawings

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