CONLAN PROPERTY GROUP

LAND CAPABILITY ASSESSMENT
FOR
ON-SITE WASTEWATER MANAGEMENT
AT
204 KILLINGWORTH ROAD, KILLINGWORTH

REPORT No. A220105 APRIL 2022

By

Paul Williams, B.App.Sc.

Paul Williams & Associates Pty Ltd

CONSULTANTS IN THE EARTH SCIENCES

IMPORTANT NOTE

The land capability assessment report consists of this cover sheet, two written sections, three drawings and four appendices.

The report elements are not to be read or interpreted in isolation.

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ASSESSOR'S ACADEMIC & PROFESSIONAL QUALIFICATIONS

Paul Williams is the Director and principal earth scientist at Paul Williams & Associates Pty Ltd.
He has a Bachelors Degree in Applied Science (Geology and Land Use) (awarded in 1978) and has since specialised in vadose zone hydrology, soil science, onsite effluent disposal design and engineering geology.

He is a member of the Foundation and Footings Society (Vic) Inc.

All fieldwork and analyses are undertaken by, or directly supervised by Paul Williams.

ASSESSOR'S PROFESSIONAL INDEMNITY INSURANCE

Policy Number:	NPP-13384-PI
Period of Cover:	14/2/2022 – 14/2/2023
Geographical Coverage:	Worldwide (excluding U.S.A.)
Retro-active Date:	Unlimited
Limit of Indemnity:	$4,000,000
Underwriting Company:	Certain Underwriters at Lloyd's

EXECUTIVE SUMMARY

The proposed development at 204 Killingworth Road, Killingworth, is suitable for sustainable on-site effluent disposal.

It is proposed to subdivide an allotment of 36.3 hectares (approximately) into 16 lots ranging in size from 2.001 hectares to 3.284 hectares, as shown in Drawing 2.

Each allotment is able to support a residence and associated onsite wastewater system.

Proposed Lot 10 contains an existing residence and onsite effluent disposal system. We are advised that the onsite system is functioning satisfactorily and there is no surficial evidence to the contrary.

The site is in the Rural Living Zone and is not in Special Water Supply Catchment.

The site is not sewered. For design purposes, mains water (equivalent) is assumed.

Table 1
Description of Development

Parameter	Site specific element
SPI Number	2\PS436440
Property Address	204 Killingworth Road, Killingworth.
Owner	Conlan Property Group
Contact	Ellen Hogan (Ellen Hogan and Associates) 0400 418 422 ellen.hogan@bigpond.com
Locality	Killingworth
Zoning and Overlays	Rural Living Zone
Area	36.3 hectares (16 allotments ranging from 2.001 hectares to 3.284 hectares).
Usable Lot Area	At least double proposed land application areas.
Soil Texture	Category 4/6 (loam) over Category 6 (sodic light and medium clay).
Soil Depth	0.7m to 0.85m and locally deeper (1.4m+).
Soil Structure	Moderately well to weakly structured.
Soil Constraints	Shallow soils, low ksat, sodic/magnesic clays (Category 6 soils).
Permeability	0.03m/day after renovation.
Slope	LAA restricted to areas with slope ranging from 3.5% to 15%.
Distance to Surface Waters	60m (minimum) to dams and watercourse.
Water Supply	Mains equivalent (assumed for design purposes).
Wastewater Load	900 litres (5-bedroom dwellings).
Availability of Sewer	Not available

The assessment has been made in the context of prioritising public and environmental health with a design compromise between rational wastewater reuse and sustainable wastewater disposal.

Our field testing which included soil profile logging and sampling, laboratory testing, permeability testing and subsequent reporting including water and nutrient balance modelling and risk assessment has revealed that on-site effluent disposal is rational and sustainable.

The Land Capability Hazard/Risk (DWMP A1.1) is 1 (Medium Risk).

Effluent shall be treated to at least the 20/30 standard and distributed by subsurface irrigation utilising the processes of evapotranspiration and deep seepage.

The irrigation area has been determined for the mean wet year and satisfies the requirements of *SEPPs (Waters of Victoria)* in that the effluent irrigation system cannot have any detrimental impact on the beneficial use of surface waters or groundwater.

For the proposed development increases in effluent volume above 900 litres/day are possible.

With regard to density of development and cumulative risk the assessment has considered risk associated with subsurface flows and surface flows.

In regard to subsurface flows, it is clear that provided the on-site system is adequately designed, constructed, operated and maintained the risk to surface and ground waters is negligible. Once the effluent is placed underground, the extraordinary long travel times via ground water to surface waters ensures adequate nutrient attenuation.

In regard to surface flows, it is clear that provided the on-site system is adequately designed, constructed, operated and maintained, the risk to surface and ground waters is no greater than for a sewered development.

The results of the land capability assessment and risk analysis indicate that primary effluent and trench systems are not appropriate for this site.

Where risk is defined as the product of consequences and frequency, risk can be reduced to negligible levels if effluent is treated to a secondary level and disposed via pressure compensated subsurface irrigation, as described in Section 2, below.

Residential use requires AWTS or sand filter with pressure compensated subsurface irrigation and load balancing facility/function.

Intermittent (e.g., holiday) use requires sand filter with pressure compensated subsurface irrigation and load balancing facility/function.

The LCA supports a conservative, scientifically based, well-founded wastewater management system with inherent multiple barriers of safety.

Cumulative risk from the development is extremely low. The risk of serious or irreversible damage is extremely low.

All requirements of the *Environment Protection Amendment Act 2018* and ancillary documents can be met.

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A220105 – APRIL 2022

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SECTION 1. SITE INVESTIGATION

1.1 INTRODUCTION

On instruction from the land owner, an investigation was undertaken to assess land capability for on-site effluent disposal at 204 Killingworth Road, Killingworth.

It is proposed to subdivide an allotment of 36.3 hectares (approximately) into 16 lots ranging in size from 2.001 hectares to 3.284 hectares, as shown in Drawing 2.

Each allotment is able to support a residence and associated onsite wastewater system.

Proposed Lot 10 contains an existing residence and onsite effluent disposal system. We are advised that the onsite system is functioning satisfactorily and there is no surficial evidence to the contrary.

The site is in the Rural Living Zone and is not in Special Water Supply Catchment.

The site is not sewered. For design purposes, mains water (equivalent) is assumed.

The assessment has been made in the context of prioritising public and environmental health with a design compromise between rational wastewater reuse and sustainable wastewater disposal.

1.2 INVESTIGATION METHOD

The site investigation was carried out in accordance with the *Environment Protection Amendment Act 2018* and ancillary documents. This report is in accordance with or exceeds the requirements of *Murrindindi Shire Domestic Wastewater Management Plan* and *Code of Practice - Onsite Wastewater Management, E.P.A.* Publication 891.4, July 2016. Guidance has been sought from *Approaches for Risk Analysis of Development with On-site Wastewater Disposal in Open, Potable Water Catchments,* Dr Robert Edis, April 2014. *AS/NZS 1547:2012*, *Guidelines for Wastewater Irrigation*, E.P.A. Publication 168, April 1991, *Wastewater Subsurface Drip Distribution*, Tennessee Valley Authority, March, 2004, *AS 2223, AS 1726, AS 1289, AS 2870* and *Australian Laboratory Handbook of Soil and Water Chemical Methods*.

Our capability assessment involved the mapping of unique land-soil unit(s) which were defined in terms of significant attributes including; climate, slope, aspect, vegetation, soil profile characteristics (including colloid stability, soil reaction trend and electrical conductivity), depth to rock, proximity to surface waters and escarpments, transient soil moisture characteristics and hydraulic conductivity.

Exploratory boreholes were push-tube sampled and existing exposures were viewed. The soil profile was logged and representative soil samples were taken for laboratory testing.

Water and nutrient balance analyses were based on the mean monthly rainfall data for Yea and mean evaporation data for Lake Eildon (G-M Water) and were undertaken in accordance with *Guidelines for Wastewater Irrigation, E.P.A.* Publication 168, April 1991 (Part), *AS/NZS 1547:2012* and in-house methods.

The results of the investigation and *in situ* and laboratory testing are given in Section 1.3, below, and in Appendix A, to this report.

1.3 CAPABILITY ASSESSMENT

We have used the attributes determined by the investigation to define one (1) land-soil unit, as follows:-

1.3.1 Land-Soil Unit A. This land-soil unit consists of gently to steeply sloping terrain comprising mid to upper slopes, as shown in Drawing 2 and Figures 1 and 2.

1.3.1.1 Climate. The general area receives a mean annual rainfall of 638mm, a 9th decile annual rainfall of 808mm and a mean annual evaporation of 1157mm. Mean rainfall exceeds mean evapotranspiration in May through August (i.e., for 4 months).

Rainfall and evaporation data are presented in Appendix B, to this report.

1.3.1.2 Slope and Aspect. The site occupies consists of gentle to steep slopes with grades ranging from less than 5% to 30%, with local grades (e.g., dam walls, berms) sloping up to around 50%, as shown in Drawing 2.

All land application areas can be placed on land sloping at less than 15% grade.

The unit is exposed to the prevailing winds and is subject to full winter sunshine.

1.3.1.3 Vegetation and Land Use. The unit is vegetated with dense pasture grasses and isolated *Eucalyptus spp*, as shown in Figures 1 and 2.

1.3.1.4. Slope Stability. For the encountered subsurface conditions, slope degree and geometry and for the proposed range of hydraulic loadings, the stability of the ground slopes within the disposal areas are unlikely to be compromised.

1.3.1.5 Subsurface Profile. The unit is underlain by metasedimentary rocks of Devonian Age.

The general subsurface profile consists of:-

- A topsoil (A_1-horizon) layer of grey-brown and brown, moist, medium dense silty sand and sandy silt with some clay of low plasticity (loam), with a soil reaction trend of 5.6 to 6.2 pH and electrical conductivity of 0.17 to 0.85 dS/m, to depths of 0.1 to 0.2m, overlying,
- A sporadic slopewash (A_2-horizon) layer of light grey, light grey-brown and grey, moist, medium dense clayey-sandy gravel (gravel), with a soil reaction trend of 5.4 to 6.1 pH and electrical conductivity of 0.36 to 0.46 dS/m, 0.0 to 0.2m thick, overlying,
- A residual soil (B-horizon) layer of orange-brown and orange-grey-brown, moist, poorly-structured, dispersive, silty clay of low plasticity (light and medium clay), with a soil reaction trend of 5.4 to 7.6, electrical conductivity of 0.12 to 1.05 dS/m and free swell of zero to 20%, to depths of 0.4 to 0.8m, and locally to 1.4m+, overlying,
- An extremely weathered (B-horizon) layer of light brown and orange-brown, moist, poorly-structured, dispersive, silty clay and sandy clay of low plasticity (light and medium clay), with a soil reaction trend of 5.8 to 7.5, electrical conductivity of 0.12 to 0.26 dS/m and free swell of zero to 20%, to depths of 0.6 to 0.8m, and locally to 1.4m+, overlying,
- Extremely to highly and highly weathered, highly fractured siltstone and sandstone.

Borehole logs are presented in Appendix A2.

1.3.1.6 Soil Permeability. The *in-situ* permeability tests were attempted on 27th April 2022.

The field testing was abandoned due to spontaneous dispersion of the soil clay fraction.

Where the soils are dispersive *insitu* permeability testing realises inaccurate, low or nil results.

The hydraulic conductivity can be estimated by using test waters containing calcium chloride and/or by laboratory assessment of colloid stability and determination of ameliorant quantities (e.g., gypsum/lime requirement) and swell potential.

A conservative estimate of permeability has been deduced as follows (see Code 3.6.1):-

Profile analysis in accordance with AS/NZS 1547:2012 and our laboratory determined dispersion and swell potential shows the colluvial and residual clay soils (and clay fractions) to be dispersive. They are therefore by definition Category 6 soils with saturated hydraulic conductivity less than 0.06m/day.

Similar dispersive soils have responded positively (with sufficiently improved hydraulic capability) following applications of gypsum.

For the limiting poorly-structured clay and clayey soils and assuming renovation by gypsum application we have adopted an estimated and conservative design saturated hydraulic conductivity of 0.035m/day.

1.3.1.7 Basement Material Permeability. From the literature and from examination of exposures in the vicinity, the hydraulic conductivity of the basement material (fractured metasediments) could be in excess of 0.5m/day (adopt 1m/day for buffer design).

1.3.1.8 Colloid Stability. The results of the Emerson Crumb Tests, Dispersion Index tests and observations of any discolouration of water in the boreholes indicate that all encountered materials range from non-dispersive (topsoils) to dispersive (most clay materials).

The Emerson Class was 2 and 5 and the Dispersion Index was 0 to 13.

The electrical conductivity was determined for all horizons using a 1:5 soil/water extract and converted to EC (saturation extract).

The determined electrical conductivity (EC_{se}) ranged from 0.12 dS/m to 1.05 dS/m.

Soil reaction trend ranged from 5.6 pH to 7.6 pH which is within a tolerable range.

Exchangeable Sodium was 22.8% (desirable range is <5%).

Exchangeable Magnesium was 41.9% (desirable range is 12% to 15%).

Exchangeable Calcium was 18.4% (desirable range is 65% to 70%).

Exchangeable Hydrogen was 14.7% (desirable range is less than 20%)

The adjusted CEC was 17.01 (desirable range is 15+).

The Calcium/Magnesium ratio was 0.44 (desirable range is 2 to 4).

To improve the subsoil permeability and to maintain stable soil peds, the exchangeable Calcium needs to be increased while the exchangeable Sodium and Hydrogen need to be decreased.

To achieve a suitable cation balance, gypsum needs to be added to the soil – see Section 2.2.8, below.

1.3.1.9 AS1547:2012 Soil Classification. In accordance with *AS/NZS1547:2012* the residual materials can be classified as Category 6 soils (sodic/magnesic medium clays).

1.3.1.10 Surface Drainage. Surface drainage is in multiple directions, as shown in Drawings 1 and 2.

All land application areas are located at least 60 metres from any surface waters, as shown in Drawing 2.

1.3.1.11 Groundwater. No ground water was encountered in the boreholes.

Subsurface flow direction will generally reflect natural surface flow direction.

There are no groundwater bores within a significant distance of any proposed land application areas.

The Victorian groundwater data base and our bore logs indicate groundwater is deeper than 5 metres of the surface.

Regionally the groundwater is contained in the underlying fractured metasediments. The yield is low and quality is moderate to poor (1,000 to 3,500 mg/litre TDS) with beneficial use including most stock and salt tolerant plants watering.

1.3.1.12 Nutrient Attenuation. Clay soils (as found on this site) can fix large amounts of phosphorous. Phosphate-rich effluent seeping through these soils will lose most of the phosphorous within a few metres.

The limiting nutrient for this site is nitrogen. No phosphorous balance is required.

Nitrogen, contained in organic compounds and ammonia, forms nitrate-N and small amounts of nitrite-N when processed in an aerated treatment plant. Several processes affect nitrogen levels within soil after irrigation. Alternate periods of wetting and drying with the presence of organic matter promote reduction to nitrogen gas (denitrification). Plant roots absorb nitrates at varying rates depending on the plant species (see Appendix B), however nitrate is highly mobile, readily leached, and can enter groundwater via deep seepage and surface waters via overland flow and near-surface lateral flow.

Based on the water and nutrient balance (see Appendix B), and assuming 30mg/litre N in the effluent (general case) and 20mg/litre P, a denitrification rate of 20%, with N uptake of 220 kg/ha/year for the an appropriate grass cover equivalent to a rye/clover mix) and sequential zoned dosing of the irrigation area, a conservative estimate can be made of the nitrogen content in the deep seepage and lateral flow.

For the general case, and without considering further expected denitrification below the root zone and in the groundwater (reported to be in the vicinity of 80%), denitrification in the lateral flow (external to the irrigation areas but within the curtilage of each allotment) and plant uptake in the lateral flow, the irrigation area would need to be 360m^2 for 900 litres/day of effluent for complete attenuation.

For a 5-bedroom residence, the hydraulic component of the water and nutrient balance has shown that an irrigation area of 480m^2 for slopes up to 10% grade and 576m^2 for slopes between 10% grade and 20% grade would be required to limit surface rainwater flows to episodic rain events.

For the development and to satisfactorily attenuate nitrogen on-site and to accommodate the design hydraulic loading, the application rate should not exceed **1.9mm/day** for slopes up to 10% grade and **1.6mm/day** for slopes between 10% grade and 20% grade.

1.4 RISK MANAGEMENT & MITIGATION

The *Environment Protection Amendments Act 2018 and ancillary documents including SEPP (Waters of Victoria)* require that the proposal be assessed on a risk-weighted basis and cumulative effects[a] be considered.

The risk has been assessed within the framework of the *Murrindindi Shire Domestic Wastewater Management Plan* considering the surficial and subsurface physical, chemical and biochemical conditions of the site and surrounds and climatic conditions affecting the site along with the sensitivity and proximity of the receiving environment.

A multiple risk reduction approach is used in assessing this development, with components listed below:

1.4.1 Water Usage. With respect to daily effluent production, the systems are overdesigned. Current best practice allows for a (continuous) daily effluent flow of 900 litres, as per *Code of Practice - Onsite Wastewater Management,* E.P.A. Publication 891.4, July 2016.

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[a] We would contend that there can be no significant cumulative effect if the provisions of *SEPP (Waters of Victoria)* are met (i.e., all wastes contained onsite).

1.4.2 Secondary Treatment. The LCA recommends AWTS and sand filters. These systems generate a much higher quality of effluent than septic systems.

1.4.3 Block Size. Many under-performing effluent fields are placed on blocks where area is limited. Limited area can lead to inadequately sized or inappropriately placed effluent fields and a lack of options should the daily effluent volumes increase.

For the subject sites, size is not a constraining factor.

1.4.4 Management Plan. Historically, inadequate maintenance has played a major part in the failure of onsite effluent disposal systems. There is a management plan within the LCA (see Appendix D). This plan gives guidance on the implementation of mandatory operation, maintenance and inspection procedures.

1.4.5 Sizing of Treatment Systems. No specific proprietary treatment plant is recommended, however treatment plants or sand filters must have current JAS/NZS accreditation, which match effluent volumes with plant capacity.

1.4.6 Load Balancing. The development will generate significant and intermittent waste flows. Hence, load-balancing is an integral and essential component of the wastewater treatment system. Load balancing enables short-term storage and sustainable flows to the distribution area over extended time. The load balancing facility also provides temporary storage should the plant fail or if there is a power outage – see Section 2.2.2.2, below.

1.4.7 Zoned Dosing. The LCA stipulates that the effluent area is (automatically) irrigated sequentially by time or zone to promote the creation of transient aerobic and anaerobic soil conditions.

The effluent field is sized conservatively for nitrogen attenuation, using pasture grass (rye/clover eq mix), which has a nitrogen uptake of 220 kg/ha/year. Zoned dosing will increase the efficiency of the field for removing nitrogen from the soil.

Undersized effluent fields are at risk of becoming anaerobic for long periods, with the risk of microbial build-up. This leads to secretion of microbial polysaccharides, which coat soil particles and restrict the ability of the soil to adsorb nutrients and attenuate pathogens. Polysaccharides can also coat the interior of pipes and block drainage holes if drainage is slow due to the field being overloaded with effluent. This can lead to effluent surcharge from the ends of the drainage pipes, forming preferential flow paths through overlying soil and draining overland to nearby surface waters.

The alternating aerobic and anaerobic conditions created by zoned dosing prevent the build-up of microbial polysaccharides, and ensures efficient renovation of effluent.

1.4.8 Pressure Compensated Subsurface Disposal. Conservatively sized irrigation areas with pressure compensated subsurface disposal and zoned dosing deliver effluent directly into the soil. Under saturated conditions, water flow is downwards in the direction of maximum hydraulic gradient. For a surface flow containing effluent to occur, the effluent would have to rise, *against gravity*, through at least 150mm of soil. Under unsaturated conditions, water flow is multi-directional due to capillary forces and matrix suction. The atmosphere provides a capillary break with capillary forces and matrix suction reducing to zero at the air/soil interface. Gravitational forces outweigh the capillary forces and matrix suction long before the surface is reached. Hence, any surface flow from the effluent area cannot contain any effluent, regardless of the intensity and duration of rain events. Surface flow can only consist of **rainfall** in excess of soil storage capacity and hydraulic conductivity.

Note: For a pressure compensated distribution network to function properly, lines **must** be placed parallel to contours and/or horizontal for even effluent distribution. This requirement, alone, requires a high level of quality assurance at the design and construction phases.

1.4.9 Oversized Effluent Areas. Design effluent areas are oversized and are based on conservative estimates of renovation and complete attenuation of nitrogen. The deep seepage rate is less than the hydraulic conductivity of the limiting layer.

1.4.10 Reserve Areas. Although reserve areas are not required for subsurface irrigation (*Code of Practice*, 2016), they have been stipulated.

Drawing 2 shows that all of the proposed allotments can accommodate a primary and reserve land application area with alternate locations possible.

1.4.11 Buffer Distances. Buffer distances are set out in the *Code of Practice* to allow for attenuation of pathogens and nutrients, should an overland effluent surcharge occur.

All land application areas are located at least 60m from non-potable surface waters (dam and watercourse) and at least 20m from the nearest groundwater bore.

The time taken for groundwater to reach the nearest surface waters can be estimated by using the Darcy equation (which states that velocity is the product of the hydraulic conductivity and the hydraulic gradient). From the literature, the regional gradient is about 0.005.

Flow times can be estimated for groundwater to flow the 60m (minimum) to the nearest surface waters at this site.

For a conservative basement hydraulic conductivity of 1m/day[b] with a hydraulic gradient of 0.005, the time taken for groundwater to flow a distance of 60m is over 30 years (and would require an unrealistic rise in the local water table).

For perched groundwater flows in the topsoil materials (estimated hydraulic conductivity of 0.6m/day) and a hydraulic gradient equivalent to the maximum ground slope (up to 20%), the time taken for perched groundwater to flow a distance of 60m is over 1 year and assumes no evapotranspiration during this time.

For a surface effluent discharge on a 20% slope and for the prevailing soil hydraulic characteristics, the estimated maximum travel distance of effluent before reabsorption is less than 2m[c].

1.4.12 System Failure. A properly designed and constructed onsite effluent system consisting of the treatment plant and the irrigation area can suffer degrees of failure. Failure can take the form of mechanical (plant), accidental (toilet blockages, damaged irrigation lines, high BOD influent), operational (power outage, overloading) and maintenance (failure to check filters, failure to participate in maintenance programme).

1.4.12.1 Mechanical Breakdown. Mechanical plant breakdown typically involves compressor and pump malfunction causing no aeration and high-water levels, respectively. Both of these situations are alarmed (both audible and visual). The proposed plants will benefit from a service contract providing 24-hour repair cycles. If the alarms were ignored (or malfunctioned) and the household continued to produce waste until the load balancing tank and plant capacities were exceeded (at least 3 days), a mixture of septic and raw effluent would back up to the interior of the units and/or surcharge through the plant hatches. It is difficult to imagine how this outcome could be allowed to manifest. In addition, a plant malfunction with the residents absent could not cause an effluent surcharge because no influent would be produced during this period.

1.4.12.2 Accidents. Toilet blockages and accidentally damaged irrigation lines could allow localised surface surcharge of treated effluent. This is why minimum buffers to surface waters have been maintained. High BOD influent (e.g., dairy or orange juice) can realise a lesser quality than 20/30 standard for some weeks. Provided the high BOD influent is not continuous, the soils will continue to satisfactorily renovate the effluent.

1.4.12.3 Operational Breakdown. Operational failures including power outages and transient hydraulic overloading are accommodated by the load balancing facility, as described in Section 1.4.6, above.

1.4.12.4 Maintenance Breakdown. Maintenance breakdowns such as failure to clean line filters can lead to expensive pump repairs and in extreme cases leakage (of 20/30 standard effluent) from the outlet pipe. This leakage would occur in proximity to the dwelling and would be noticed and acted on.

Refusal to participate in the management programme would be acted on by the responsible authority within one maintenance cycle.

[b] This is a conservatively high figure to demonstrate maximum possible flow rates. A conservatively low figure was used for calculation of effluent application rates (see recommendations) to demonstrate irrigation sustainability.

[c] Source: *Approaches for Risk Analysis of Development with On-site Wastewater Disposal in Open, Potable Water Catchments* (Dr Robert Edis April 2014).

AWTS and pumped systems have mechanical components which can malfunction and will age. The management plan including the maintenance and monitoring programmes are essential to ensure safe onsite effluent disposal.

1.4.13 Risk Summary. With regard to density of development and cumulative risk the assessment has considered risk associated with subsurface flows and surface flows.

In regard to subsurface flows, it is clear that provided the on-site system is adequately designed, constructed, operated and maintained (see items 1.4.1 through 1.4.12.4), the risk to surface and ground waters is negligible. Once the effluent is placed underground, the extraordinary long travel times via ground water to surface waters ensures adequate nutrient attenuation.

In regard to surface flows, it is clear that provided the on-site system is adequately designed, constructed, operated and maintained (see items 1.4.1 through 1.4.12.4), the risk to surface and ground waters is no greater than for a sewered development. Indeed, it could be considered that the risk is less than for a sewered development because there can be no mains failure (because there is no mains).

The LCA recommends a conservative, scientifically based, well founded wastewater management system with inherent multiple barriers of safety. Cumulative risk from the development is also extremely low. The risk of serious or irreversible damage is extremely low.

The Land Capability Hazard/Risk (DWMP A1.1) is **1 (Medium Risk).**

All requirements of the *Environment Protection Amendment Act 2018* and ancillary documents have been met.

Figure 1: Land-soil unit A (typical of northern allotments), viewed from west to east.

Figure 2: Land-soil unit A (typical of southern allotments), viewed from south to north.

SECTION 2. RECOMMENDATIONS

2.1 APPLICATION

The following recommendations are based on the results of our assessment, and are made in accordance with the *Environment Protection Amendment Act 2018* and ancillary documents, *Code of Practice - Onsite Wastewater Management,* E.P.A. Publication 891.4, July 2016, *AS 1726*, and *AS/NZS 1547:2012*.

They are based on the mean saturated hydraulic conductivity of the limiting clayey materials and are designed to demonstrate the viability of on-site effluent disposal for a residence and a daily effluent production of up to 900 litres and are considered to be conservative.

2.2 SUBSURFACE IRRIGATION

2.2.1 General. Based on the results of the water balance analysis and considering the prevailing surficial and subsurface conditions including soil profile thickness[d] and slope and on condition that adequate site drainage is provided (as described in Section 2.4, below), on-site irrigation systems are appropriate for effluent disposal for land-soil unit A where slopes are less than 20% grade.

2.2.2 Effluent. Effluent will be generated from a residence and will include black and grey water (all wastes).

2.2.2.1 Effluent Quality. Effluent shall be treated by AWTS or sand filter to a standard that meets or exceeds the water quality requirements of the 20/30 standard for BOD/SS.

2.2.2.2 Effluent Quantity. The daily effluent volume of 900 litres has been calculated from *Code of Practice - Onsite Wastewater Management,* E.P.A. Publication 891.4, July 2016, Table 4 and assumes mains water (equivalent) and WELS-rated water-reduction fixtures and fittings – minimum 4 Stars for dual-flush toilets, shower-flow restrictors, aerator taps, flow/pressure control valves and minimum 3 Stars for all appliances.

2.2.2.3 Load Balancing. Transient hydraulic loads in excess of the expected daily load may occur. In addition, and in the case of power outages and/or mechanical breakdown, the load balancing tank/function can act as a temporary storage.

We recommend that the effluent treatment system be fitted with a load balancing facility or equivalent function to allow transient high hydraulic loads to be retained and distributed to the irrigation area during periods of low load.

2.2.3 Application Rates and Irrigation Areas. An irrigation area and application rate has been determined from the results of the water and nutrient balance analyses and *AS/NZS 1547:2012, Appendix M*.

Note: The irrigation area is directly proportional to the design daily hydraulic loading. The irrigation area can be reduced for smaller or increased for larger design daily hydraulic loads.

2.2.3.1 Hydraulic Loading. To satisfy the requirement for no surface discharge in the mean wet year and allowing for slope, effluent shall be applied at an application rate not exceeding 1.9mm/day for slopes up to 10% and 1.6mm/day for slopes between 10% and 20%.

2.2.3.2 Nutrient Loading. The requirements of *SEPPs (Waters of Victoria)* would be satisfied with effluent applied at an application rate not exceeding 2.5mm/day.

2.2.3.3 Design Loading. To satisfy the requirement for no surface discharge in the mean wet year and allowing for slope, effluent shall be applied at an application rate not exceeding **1.9mm/day** for slopes up to 10% and **1.6mm/day** for slopes between 10% and 20%.

2.2.4 General Requirements. For subsurface irrigation, it is assumed that the design, construction, operation and maintenance are carried out in accordance with *AS/NZS1547:2012* and a “system specific” JAS/ANZ accreditation, as appropriate.

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[d] Minimum 1400mm required for evapotranspiration-absorption trenches.

The irrigation area is to be a dedicated area. To prevent stock and vehicular movements over the area, the effluent area shall be "fenced".

2.2.5 Subsurface Distribution System. A distribution network design similar to that shown in *AS/NZS1547:2012, Figure M1* is appropriate.

2.2.5.1 Ground Preparation and Excavations. Preparation of the ground is to include the redistribution of topsoil to form a free draining, smooth surface. Pipe excavations shall only be undertaken in drier periods when soil moisture contents are relatively low and when heavy rainfall and storms are not normally expected.

2.2.5.2 Pump System and Pipe works. Uniform delivery pressure of the effluent throughout the distribution system is essential. Percolation or drip rates shall not vary by more than 10% from the design rate over the whole of the system (i.e., pressure compensated).

The distribution pipes shall be placed coincident with slope contours. The dripper system is to provide an effective even distribution of effluent over the whole of the design area. Line spacing shall be no closer than 1000mm.

2.2.6 Sequential Zoned Irrigation. The efficiency of irrigation effluent disposal systems can be highly variable. We recommend that as part of the daily irrigation process, the effluent area be irrigated sequentially by zones or time to promote the creation of transient aerobic and anaerobic soil conditions.

The inspection regime described in Section 2.2.7, below, is to be strictly adhered to.

2.2.7 Inspections and Monitoring. We recommend that the mandatory testing and reporting as described in the *Code of Practice - Onsite Wastewater Management,* E.P.A. Publication 891.4, July 2016, include an annual (post spring) report on the functioning and integrity of the distribution system and on the functioning and integrity of the cut-off drains and outfall areas.

It is expected that the frequency of inspections and monitoring will intensify as systems age.

2.2.8 Soil Renovation. To improve the subsoil permeability (such that adequate salt leaching can be achieved) and to maintain stable soil peds, the exchangeable calcium needs to be increased while the exchangeable sodium and magnesium need to be decreased.

To improve the existing soil permeability and to maintain water-stable peds (under irrigation with saline effluent), soil renovation in the form of gypsum ($CaSO_4.2H_2O$) application is required.

Application rates are related to water (irrigation and mean rainfall) available to dissolve the gypsum. The water required to dissolve 1 kilogram of gypsum is about 400 litres.

To achieve optimum cation balance gypsum needs to be applied at a rate of about 1.25 kg/m^2.

2.2.8.1 Slopes up to 10% Grade. Initially, gypsum shall be broadcast over the effluent area at the rate of 1kg/m^2, followed by deep ripping to a depth of at least 600mm.

Gypsum is to be fine ground "Grade 1" agricultural quality.

For further required applications, we recommend that a proprietary "liquid" gypsum product (typically CaCl + polyacrylamide + wetting agent + water) be applied via the irrigation network

Depending on the proprietary product, 1 litre of liquid "gypsum" is approximately equivalent to 95 kg dry gypsum.

Therefore, for a theoretical application rate of 1kg/m^2, 1 litre of liquid gypsum would be required for every 95m^2 of irrigation area.

In this instance, about 5 litres would be required for an equivalent application of 1kg/m^2 dry gypsum over the whole irrigation area (480m^2).

We recommend that following the initial (before ripping) dry gypsum application, liquid gypsum be applied through the irrigation network at the rate of 1.25 litre/application after 2 months.

An application of 1.25 litre through the irrigation network is recommended every 3-years.

2.2.8.2 Slopes Between 10% Grade and 20% Grade. Initially, gypsum shall be broadcast over the effluent area at the rate of 1kg/m^2, followed by deep ripping to a depth of at least 600mm.

Gypsum is to be fine ground “Grade 1” agricultural quality.

For further required applications, we recommend that a proprietary “liquid” gypsum product (typically CaCl + polyacrylamide + wetting agent + water) be applied via the irrigation network

Depending on the proprietary product, 1 litre of liquid “gypsum” is approximately equivalent to 95 kg dry gypsum.

Therefore, for a theoretical application rate of 1kg/m^2, 1 litre of liquid gypsum would be required for every 95m^2 of irrigation area.

In this instance, about 6 litres would be required for an equivalent application of 1kg/m^2 dry gypsum over the whole irrigation area (576m^2).

We recommend that following the initial (before ripping) dry gypsum application, liquid gypsum be applied through the irrigation network at the rate of 1.5 litre/application after 2 months.

An application of 1.5 litre through the irrigation network is recommended every 3-years.

2.2.9 AWTS and Sand Filter. It is assumed that the design, construction, operation and maintenance of all treatment elements are carried out in accordance with *AS/NZS1547:2012* and a current JAS-ANZ accreditation.

The AWTS or sand filter are to be sized to successfully treat a daily hydraulic load of 900 litres and a nutrient load of 360 grams BOD.

The sand filter shall have a minimum plan area of 18m^2 with the sand media complying to the *Code* Appendix G. The sand media must have less than 5% fines, effective size (D10) between 0.25 and 0.60mm and uniformity coefficient (D60/D10) less than 4mm.

Note: The sand filter plan area can be proportioned to suit different design hydraulic loads. The plan area is determined by dividing the hydraulic load by 50.

2.3 RESERVE AREA

The expected design life of fifteen years may vary due to construction and maintenance vagaries and possible effluent volume increases through the chain of ownership.

There is sufficient available area on the allotment for extension/duplication of the effluent areas.

2.4 SITE DRAINAGE.

Our recommendations for on-site effluent disposal have allowed for incident rainfall only and are conditional on the installation of a shallow cut-off drain, which shall be placed upslope of the disposal area.

Care shall be taken to ensure that the intercepted and diverted surface waters are discharged well away and down slope of the disposal field.

Cut-off drain detail is shown in Drawing 3.

The owner shall also ensure that any upslope site works do not divert and/or concentrate surface water flows onto the disposal area.

2.5 BUFFER DISTANCES

The water balance analysis has shown that potential surface (rain water) flows from the effluent area would be restricted to episodic events.

The estimated hydraulic properties of the upper soil materials and hydraulic gradient have been used to evaluate (via Darcy’s Law) the buffer distances with respect to subsurface flows.

Our analysis and evaluation have shown that the default setback distances given in *Code of Practice - Onsite Wastewater Management,* E.P.A. Publication 891.4, July 2016, Table 5 and *Approaches for Risk Analysis of Development with On-site Wastewater Disposal in Open, Potable Water Catchments,* Dr Robert Edis, April 2014 are conservative and can be applied without amendment.

For a building located downslope of an effluent field, your engineer shall evaluate the integrity of building foundations with respect to the assigned buffer distance.

2.6 SUMMARY OF RECOMMENDATIONS

Our capability assessment has shown that at least one rational and sustainable on-site effluent disposal method (20/30 standard subsurface irrigation) is appropriate for the proposed development, subject to specific design criteria, described above, and in particular, the requirement for soil amelioration.

A management plan is presented in Appendix D, to this report.

Paul R. WILLIAMS B.App.Sc.
PRINCIPAL HYDROGEOLOGIST
& ENGINEERING GEOLOGIST

Paul Williams & Associates Pty Ltd
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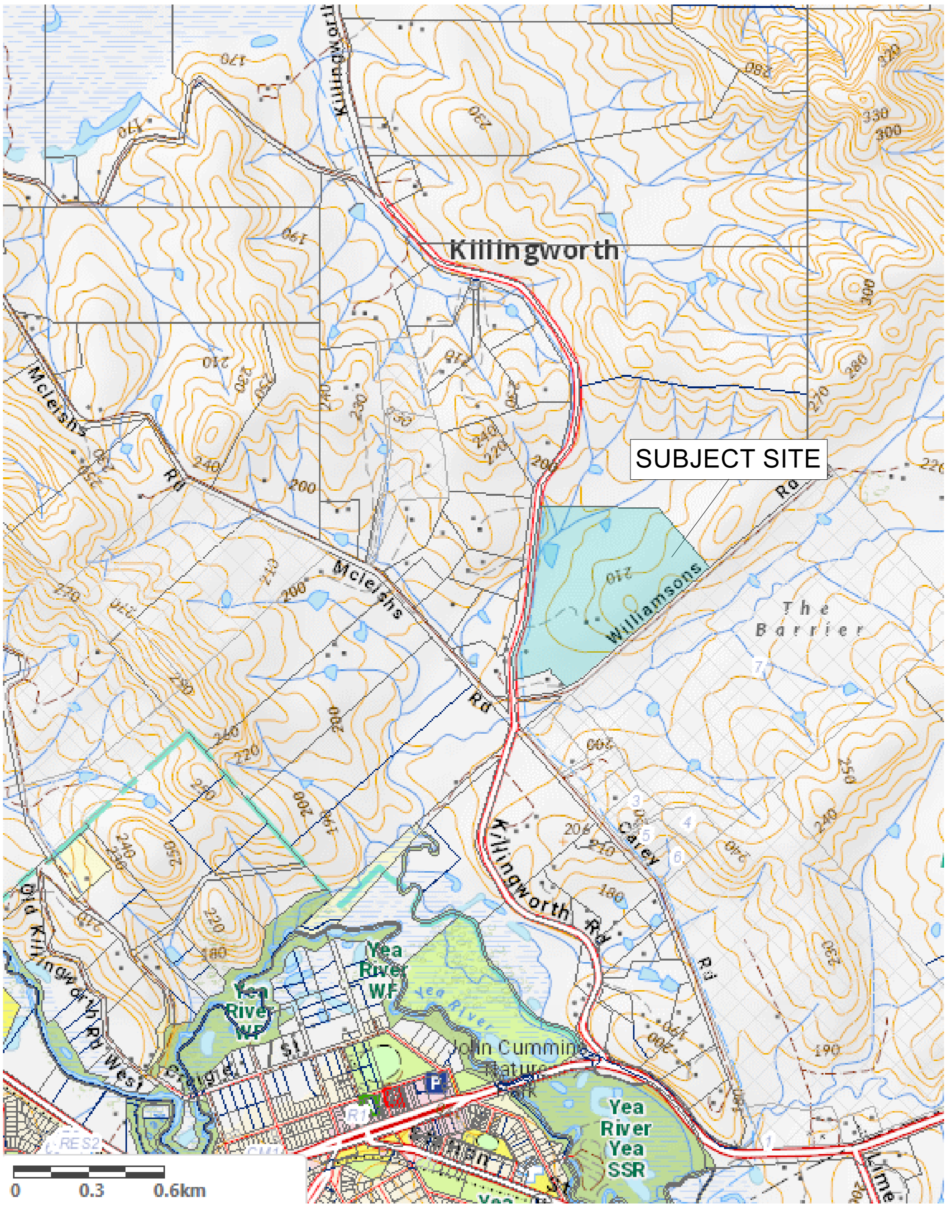

LOCATION OF SUBJECT SITE		
204 KILLINGWORTH ROAD, KILLINGWORTH		
CONLAN PROPERTY GROUP		
Scale: 1:30,000	Drawn: P.R.W.	Report Number: A220105
Contour Interval: 10m	Date: April 2022	Drawing Number: 1

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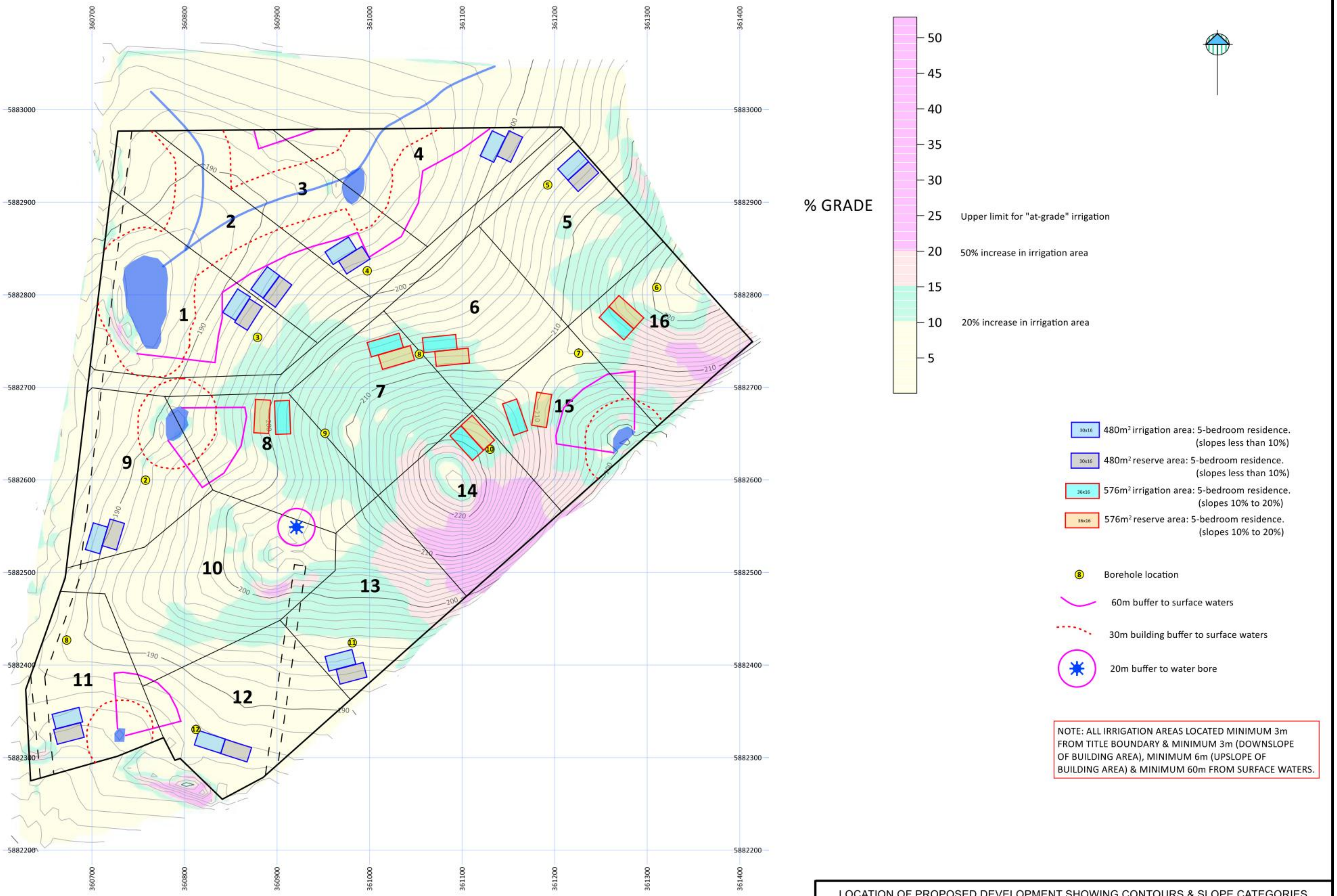
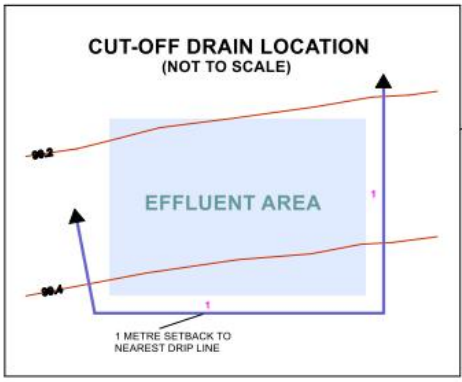


NOTE: ALL IRRIGATION AREAS LOCATED MINIMUM 3m FROM TITLE BOUNDARY & MINIMUM 3m (DOWNSLOPE OF BUILDING AREA), MINIMUM 6m (UPSLOPE OF BUILDING AREA) & MINIMUM 60m FROM SURFACE WATERS.

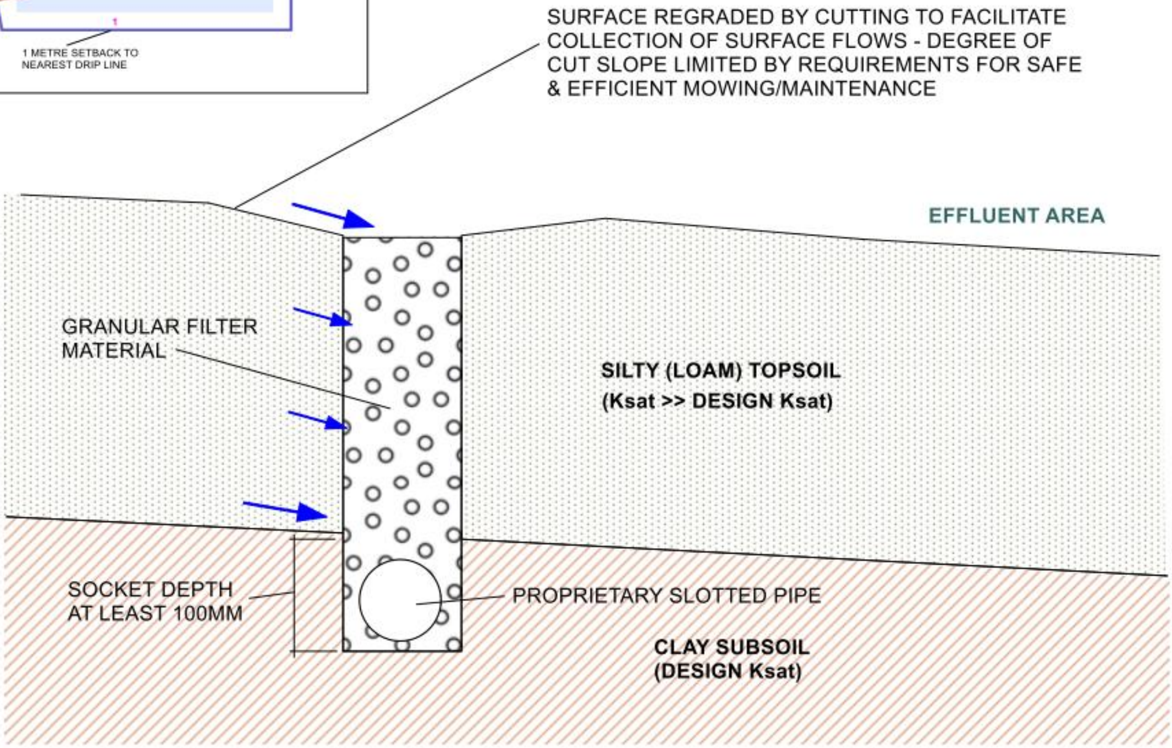
REDUCED LEVELS & COORDINATES SUPPLIED BY MILLAR & MERRIGAN PTY LTD
SUBDIVISION LAYOUT SUPPLIED BY RODNEY AUJARD & ASSOCIATES
CONTOUR & SLOPE MODELING BY PAUL WILLIAMS & ASSOCIATES PTY LTD

LOCATION OF PROPOSED DEVELOPMENT SHOWING CONTOURS & SLOPE CATEGORIES		
204 KILLINGWORTH ROAD, KILLINGWORTH		
CONLAN PROPERTY GROUP		
Scale: 1:4,000	Drawn: P.R.W.	Report Number: A220105
Contour Interval: 1m	Date: April 2022	Drawing Number: 2

Paul Williams & Associates Pty Ltd
CONSULTANTS IN THE EARTH SCIENCES



NOTE: CUT-OFF DRAIN LOCATION IS SCHEMATIC ONLY. FINAL LOCATION TO BE DETERMINED BY DESIGN ENGINEER AS PART OF SITE DRAINAGE DESIGN.



NOTES:
1. DRAIN TO BE DESIGNED, CONSTRUCTED & MAINTAINED TO ENSURE THAT NO SURFACE & PERCHED GROUNDWATER FLOWS ENTER THE IRRIGATION AREA.
2. DRAIN TO BE LOCATED ON ALL UPSLOPE SIDES OF IRRIGATION AREA (NO CLOSER THAN 1m FROM NEAREST SUBSURFACE DISTRIBUTION LINE).
3. DRAIN TO HAVE UNSPECIFIED FALL.
4. MINIMUM SOCKET DEPTH OF 100mm INTO CLAY SUBSOIL (WHERE ENCOUNTERED) OR AT LEAST 300mm DEEP.
5. DRAIN CROSS SECTIONAL AREA RELATED TO DESIGN FLOWS AS DETERMINED BY A SUITABLY QUALIFIED AND EXPERIENCED ENGINEER.
6. OFF-SITE DRAIN OUTFALL TO LEGAL POINT OF DISCHARGE SUBJECT TO LOCAL AUTHORITY REQUIREMENTS.
7. ON-SITE DRAIN OUTFALL TO INCLUDE APPROPRIATE ENERGY DISSIPATION TO AVOID EROSION.
8. ALL DRAINS AND OUTFALL AREAS SUBJECT TO POST-SPRING INSPECTION.

NOTE: DRAWING NOT TO BE USED FOR SET-OUT PURPOSES

CUT-OFF DRAIN DETAIL FOR 20/30 STANDARD EFFLUENT IRRIGATION FIELDS		
DUPLEX/GRADATIONAL SOIL PROFILES		
Scale: 1:10 (Approximately)	Drawn: P.R.W.	Report Number: SPEC 014
Contour Interval: N/A	Date: 2022	Drawing Number: 3

APPENDICES

APPENDIX A1
SOIL PERMEABILITY

Where the soils are dispersive *insitu* permeability testing realises inaccurate, low or nil results.

The hydraulic conductivity can be estimated by using test waters containing calcium chloride and/or by laboratory assessment of colloid stability and determination of ameliorant quantities (e.g., gypsum/lime requirement) and swell potential.

A conservative estimate of permeability has been deduced as follows (see Code 3.6.1):-

Profile analysis in accordance with AS/NZS 1547:2012 and our laboratory determined dispersion and swell potential shows the alluvial, colluvial and residual clay soils (and clay fractions) to be dispersive. They are therefore by definition Category 6 soils with saturated hydraulic conductivity less than 0.06m/day.

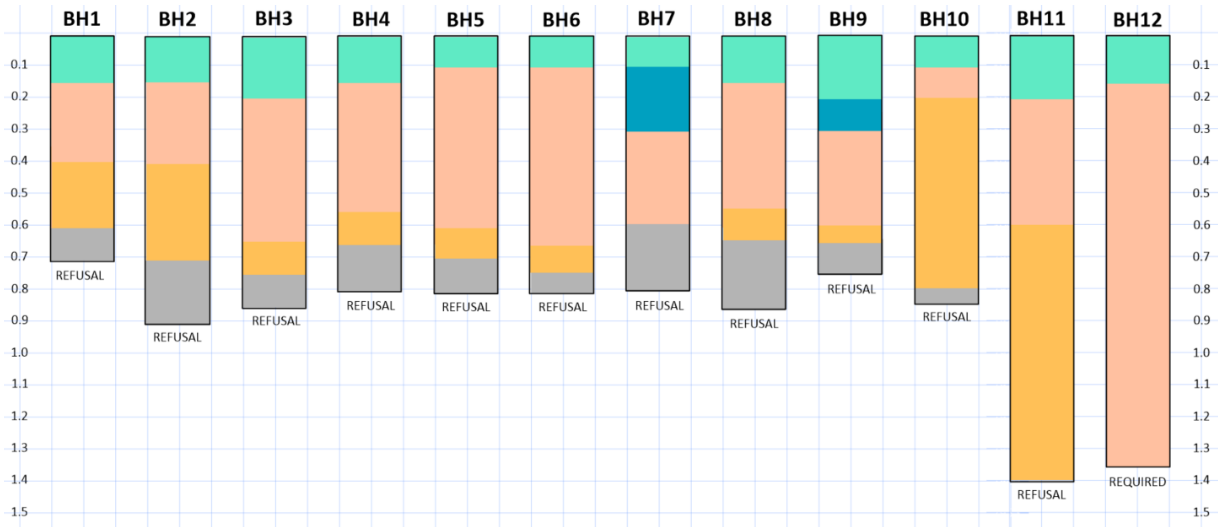
Similar dispersive soils have responded positively (with sufficiently improved hydraulic capability) following applications of gypsum.

For the limiting poorly-structured clay and clayey soils and assuming renovation by gypsum application we have adopted an estimated and conservative design saturated hydraulic conductivity of 0.035m/day.

Peak deep seepage is conservatively estimated at 3.0mm/day (<10% k_{sat}).

From the literature and from examination of exposures in the vicinity, the hydraulic conductivity of the basement rocks would be in excess of 0.05m/day (adopt 1m/day for buffer design).

APPENDIX A2
LOGS OF BOREHOLES



Silty SAND, Sandy SILT; grey-brown, brown, some clay of low plasticity, non-dispersive **(loam) TOPSOIL (Cat 3/4)**

Clayey-sandy GRAVEL; light grey, light grey-brown, grey, low plasticity, gravel fine to coarse, non-dispersive **(light clay) SLOPEWASH (Cat 4)**

Silty CLAY; orange-brown, orange-grey-brown, low plasticity, dispersive, **(light and medium clay) RESIDUAL SOIL (Cat 6)**

Silty CLAY, Sandy CLAY; light-brown, orange brown, low plasticity, dispersive, containing some fine to coarse gravel **(medium clay) EW SILTSTONE (Cat 6)**

Clayey GRAVEL; grey, light grey-brown, low plasticity, dispersive **(GRAVEL) HIGHLY WEATHERED SILTSTONE (with clay matrix)**

For locations of boreholes refer Drawing 2.

APPENDIX A3
SELECTED SOIL PROFILE PHOTOGRAPHS
LAND-SOIL UNIT A

BOREHOLE BH2 (Lot 9): Shallow residual profile.

BOREHOLE BH 4 (Lot 3): Shallow residual profile.

BOREHOLE BH 6 (Lot 16): Shallow residual profile.

APPENDIX A3
SELECTED SOIL PROFILE PHOTOGRAPHS
LAND-SOIL UNIT A

BOREHOLE BH8 (Lot 7): Shallow residual profile.

BOREHOLE BH 10 (Lot 14): Shallow residual profile.

BOREHOLE BH 12 (Lot 12): Deep residual profile.

APPENDIX A4
SUMMARY OF LABORATORY TEST RESULTS
LAND-SOIL UNIT A

Property	**LAND-SOIL UNIT A**			
Depth (average)	0-20cm	20-60cm	60+cm	Desirable
Horizon	A	B_1	B	-
pH	5.6-6.2	5.4-7.6	5.8-7.5	-
EC (dS/m)	0.17-0.85	0.12-1.05	0.12-0.26	-
Exchangeable Sodium %	-	14.4-22.8	-	0.5%–5%
Exchangeable Magnesium %	-	41.9	-	12%-15%
Exchangeable Calcium %	-	18.4	-	65%-70%
Exchangeable Hydrogen %		14.7	-	<20%
CEC ($cmol^+$/kg)	-	18.31	-	15+
Calcium/Magnesium Ratio	-	0.44	-	2-4
Gypsum Req (t/ha)	-	1.17	-	-
Lime Req (t/ha)	-	nil	-	-
Emerson	5	1, 2 and 5	2, 5	-
Dispersion Index	0	0-13	10-113	-
Free Swell (%)	-	0-20	0-20	-
Ksat (m/day)[1]	<0.6	<0.06	<0.06	-
Soil Permeability Category[1]	4	6	6	-
AS/NZS 1547 Classification	loam	light clay	light clay	-

1. After renovation including gypsum application. Estimated by visual tactile methods, AS/NZS1547, AS1289 and database or by insitu measurement as shown.

All test results in green highlight from SWEP Analytical Laboratories.
All test results in blue highlight from in-house laboratory.

APPENDIX B

Paul Williams & Associates Pty Ltd

A220105

WATER/NITROGEN BALANCE (20/30 irrigation): No wet-month storage.

Rainfall Station: Yea/ **Evaporation Station:** Lake Eildon (G-M Water)

Location: Killingworth
Date: April, 2022
Client: Conlan Property Group

ITEM	UNIT	#	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Days in month:		D	31	28	31	30	31	30	31	31	30	31	30	31	365
Evaporation (Mean)	mm	A	173	159	121	76	44	31	33	53	68	105	130	163	1157
Rainfall (Mean)	mm	B1	41	38	42	50	56	59	60	65	63	60	53	47	638
Effective rainfall	mm	B2	33	31	33	40	45	47	48	52	50	48	42	38	507
Peak seepage Loss[1]	mm	B3	93	84	93	90	93	90	93	93	90	93	90	93	1095
Evapotranspiration(IXA)	mm	C1	121	111	85	46	22	14	13	24	37	68	91	114	746
Waste Loading(C1+B3-B2)	mm	C2	181	165	144	96	70	57	58	65	77	113	139	169	1335
Net evaporation from lagoons (10(0.8A-B1xlagoon area(ha)))	L	NL	0	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Wastewater	L	E	27900	25200	27900	27000	27900	27000	27900	27900	27000	27900	27000	27900	328500
Total Irrigation Water(E-NL)/G	mm	F	58	53	58	56	58	56	58	58	56	58	56	58	684
Irrigation Area(E/C2)annual.	m^2	G													**480**
Surcharge/Storage	mm	H	-123	-112	-86	-40	-12	0	0	-7	-21	-55	-83	-111	**0**
Actual seepage loss	mm	J	-30	-28	7	50	81	90	93	86	69	38	7	-18	521
Direct Crop Coefficient:		I	0.7	0.7	0.7	0.6	0.5	0.45	0.4	0.45	0.55	0.65	0.7	0.7	Pasture:

Rainfall Retained:	80	%	K
Lagoon Area:	0	ha	L
Wastewater(Irrigation):	900	L	M
Seepage Loss (Peak):	3	mm	N
Irrig'n Area(No storage):	**480**	m^2	P2
Application Rate:	**1.9**	mm	Q
Nitrogen in Effluent:	30	mg/L	R
Denitrification Rate:	20	%	S
Plant Uptake:	220	kg/ha/yr	T
Average daily seepage:	1.4	mm	U
Annual N load:	7.88	kg/yr	V
Area for N uptake:	**358**	m^2	W
Application Rate:	**2.5**	mm	X
Irrig'n Area (slopes 10%-20%)	**576**	m2	Z
Application Rate:	**1.6**	mm	Z1

1. Seepage loss (peak) equals deep seepage plus lateral flow: 3mm (<10% ksat after renovation)

CROP FACTOR

#	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
M	0.7	0.7	0.7	0.6	0.5	0.45	0.4	0.45	0.55	0.65	0.7	0.7	Pasture:
N	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	Shade:
P2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	Fescue:
Q	1	1	1	1	1	1	1	1	1	1	1	1	Woodlot

NITROGEN UPTAKE:

Species:	Kg/ha.yr	pH	Species:	Kg/ha.yr	pH	Species:	Kg/ha.yr	pH
Ryegrass	200	5.6-8.5	Bent grass	170	5.6-6.9	Grapes	200	6.1-7.9
Eucalyptus	90	5.6-6.9	Couch grass	280	6.1-6.9	Lemons	90	6.1-6.9
Lucerne	220	6.1-7.9	Clover	180	6.1-6.9	C cunn'a	220	6.1-7.9
Tall fescue	150-320	6.1-6.9	Buffalo (soft)	280	6.1-6.9	P radiata	150	5.6-6.9
Rye/clover	220		Sorghum	90	5.6-6.9	Poplars	115	5.6-8.5

Increase land application area by 20%.

PART 2

RAINFALL DATA

Station: Yea — Number: 88067 — Opened: 1885 — Now: Open
Lat: 37.22° S — Lon: 145.43° E — Elevation: 196 m

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	40.9	38.2	41.8	49.8	56.4	59.1	59.7	64.7	62.6	60.1	52.8	47.3	637.7
Lowest	0.0	0.0	0.5	0.0	0.0	1.4	13.0	8.8	12.4	2.5	1.8	0.6	320.8
5th %ile	3.2	1.2	4.2	5.9	16.1	18.2	25.9	22.8	26.4	15.6	9.7	6.6	416.5
10th %ile	7.2	3.4	7.2	11.8	21.4	23.6	29.8	29.3	28.8	23.5	17.0	12.0	482.8
Median	32.9	25.1	31.7	43.4	51.8	56.0	58.1	60.8	58.8	57.8	45.0	39.9	637.5
90th %ile	83.2	72.1	94.9	91.5	99.9	96.0	88.8	99.5	100.0	103.5	91.0	83.2	808.2
95th %ile	107.4	106.5	116.6	109.8	109.4	105.1	98.5	112.0	120.1	119.1	109.7	110.0	853.6
Highest	137.8	277.1	169.6	181.0	152.5	130.8	137.7	151.2	203.1	136.0	194.6	218.2	1058.2

APPENDIX C1

LAND CAPABILITY ASSESSMENT TABLE
(Non-potable water supply catchments)
LAND-SOIL UNIT A-RESIDUAL SOILS

LAND FEATURE	LAND CAPABILITY RISK RATING				AMELIORATIVE MEASURE & RISK REDUCTION
	LOW	MEDIUM	HIGH	LIMITING	
Available land for LAA	Exceeds LAA and duplicate LAA requirements	Meets LAA and duplicate LAA requirements	Meets LAA and partial duplicate LAA requirements	Insufficient LAA area	Non-limiting for trenches & beds: Full reserve area available. Non-limiting for subsurface irrigation: Full reserve area available
Aspect	North, north-east and north-west	East, west, south-east, south-west	South	South, full shade	Multiple aspects (mainly south-west, north-west and north-west).
Exposure	Full sun and/or high wind or minimal shading	Dappled light (Partial shade)	Limited light, little wind to heavily shaded all day	Perpetual shade	Full winter sunshine and full wind exposure.
Slope Form	Convex or divergent side slopes	Straight sided slopes	Concave or convergent side slopes	Locally depressed	Regrade finished LAA surface by smoothing and redistribution of topsoil.
Slope gradient:					
Trenches and beds	<5%	5% to 10%	10% to 15%	>15%	Non-limiting to limiting for trenches.
Subsurface irrigation	<10%	10% to 30%	30% to 40%	>40%	Non-limiting for irrigation.
Site drainage: runoff/run-on	LAA backs onto crest or ridge	Moderate likelihood	High likelihood	Cut-off drain not possible	Cut-off drain required upslope.
Landslip[5]	Potential	Potential	Potential	Existing	Unremarkable
Erosion potential	Low	Moderate	High	No practical amelioration	All runoff to be dispersed without concentrating flows. LAA stabilised with gypsum.
Flood/inundation	Never		<1%AEP	>5% AEP	Unremarkable
Distance to surface waters (m)	Buffer distance complies with Code requirements		Buffer distance does not comply with Code requirements	Reduced buffer distance not acceptable	LAA located at least 60m from watercourse and dams (see Drawings 1 and 2).
Distance to groundwater bores (m)	No bores on site or within a significant distance	Buffer distances comply with Code	Buffer distances do not comply with Code	No suitable treatment method	Existing bore on Lot 10, as shown in Drawing 2.
Vegetation	Plentiful/healthy vegetation	Moderate vegetation	Sparse or no vegetation	Propagation not possible	Existing vegetation suitable for land application areas-oversown with rye/clover mix where required.
Depth to water table (potentiometric) (m)	>2	2 to 1.5	<1.5	Surface	Water table 5m+ (mainly 10m to 50m).
Depth to water table (Seasonal perched) (m)	>1.5	<0.5	0.5 to 1.5	Surface	Perching probable. (Install cut-off drain and design LAA for limiting clay soils)
Rainfall[6] (mean) (mm)	<500	500-750	750-1000	>1000	Non-limiting for trench systems. Non-limiting for subsurface irrigation - Design by water balance.
Pan evaporation (mean) (mm)	1250 to 1500	1000 to 1250	750 to 1000	<750	Design by water balance.
SOIL PROFILE CHARACTERISTICS					
Structure	High or moderately structured	Weakly structured	Structureless, massive or hardpan		Improve and maintain structure by gypsum application.
Fill materials	Nil or mapped good quality topsoil	Mapped variable depth and quality materials	Variable quality and/or uncontrolled filling	Uncontrolled poor quality/unsuitable filling	No fill present.
Thickness: (m)					
Trenches and beds	>1.4		<1.4	<1.2	Non-limiting, high risk and mainly limiting for trench systems.
Subsurface irrigation	1.5+	1.0 to 1.5	0.75 to 1.0	<0.75	Non-limiting for irrigation systems.
Permeability[7] (Limiting horizon) (m/day)	0.15-0.3	0.03-0.15 0.3-0.6	0.01-0.03 0.6-3.0	>3.0 <0.03	After renovation; design by water balance
Permeability[8] (Buffer evaluation) (m/day)	<0.3	0.3-3	3 to 5	>5.0	Evaluate flow times via Darcy's Law (Assume 1m/day for metasediments)
Stoniness (%)	<10	10 to 20	>20		Unremarkable
Emerson number	4, 5, 6, 8	7	2, 3	1	Non-dispersive and dispersive. Apply gypsum to maintain stable peds.
Dispersion Index	0	1-8	8-16		Non-dispersive and dispersive. Apply gypsum to maintain stable peds.
Reaction trend (pH)	5.5-8	4.5-5.5	<4.5>8		Ideal range for grasses.
E.C. (dS/m)	<0.8	0.8-2	2-4	>4.0	Non-limiting for trench systems. Non-limiting for irrigation.
Exchangeable Na (%)	0.5-5	5-10	10-15	>15	22.8: limiting for trenches, non-limiting for irrigation.
Exchangeable Mg (%)	12-17	17-25	25-40	40+	41.9: limiting for trenches, non-limiting for irrigation.
Exchangeable Ca (%)	65-70	40-65	5-40	<5	18.4: High risk for trenches, non-limiting for irrigation.
Adjusted CEC	15+	10-15	5-10	<5	17.1: non-limiting for trenches.
Free swell (%)	<40	40-80	80-120	>120	Low-swelling clay fraction.

There are high-risk and limiting factors for primary effluent trench systems (soil depth, colloid stability).

There are no limiting factors for secondary effluent subsurface irrigation.

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[5] Landslip assessment based on proposed hydraulic loading, slope, profile characteristics and past and present land use.
[6] Mean monthly rainfalls used in water balance analyses.
[7] Saturated hydraulic conductivity from *insitu* testing and data base.
[8] Saturated hydraulic conductivity estimated from AS/NZS1547:2012 and data base.

APPENDIX C2

LAND CAPABILITY HAZARD/RISK
(MURRINDINDI SHIRE DOMESTIC WASTEWATER MANAGEMENT PLAN)

LAND-SOIL UNIT A

SOIL HAZARD

HAZARD TYPE	SCORE	FACTOR	HAZARD	REMARKS
DEPTH HAZARD	1	1.5	1.5	1.5M+ profile thickness.
HYDRAULIC HAZARD	2	1	2	Weakly structured, dispersive light to heavy clays (Category 6 soils).
POLLUTION HAZARD	3	0.5	1.5	High phosphorous sorption capacity, sodic and magnesic.
HAZARD CLASS:			1.67	Sum hazards/3
WEIGHTED AVERAGE HAZARD CLASS:			2	High soil hazard

LCA HAZARD SUBCRITERIA

CRITERIA	SCORE	FACTOR	HAZARD	REMARKS
SLOPE	0	0.4	0	Slope less than 10%.
SOIL	2	0.3	0.6	Weakly structured, dispersive light to heavy clays (Category 6 soils).
CLIMATE	1	0.2	0.2	5 months RF>PET
DRAINAGE CLASS	1	0.1	0.1	Lower colluvial fan slopes.
LCA HAZARD SCORE:			0.9	Sum hazards.
LCA HAZARD SCORE (HEAD CRITERIA):			0	Low risk (risk rduced by soil amelioration and reduced DIR)

LCA CAPABILITY HAZARD

HEAD CRITERIA	SCORE	FACTOR	HAZARD	REMARKS
LCA HAZARD	0	0.5	0	High risk (risk rduced by soil amelioration and reduced DIR)
RECEIVING ENV PROXIMITY	2	0.25	0.5	Buffers to surface waters (dam) intersect property.
RECEIVING ENV SENSITIVITY	2	0.25	0.5	Dam.
LAND CAPABILITY HAZARD			1	Medium Risk.

APPENDIX D

MANAGEMENT PLAN

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A220105-APRIL 2022

MANAGEMENT PLAN
FOR
ON-SITE EFFLUENT DISPOSAL VIA SUBSURFACE IRRIGATION
AT

204 KILLINGWORTH ROAD, KILLINGWORTH

1. INTRODUCTION

This document identifies the significant land-soil unit constraints (as identified in A220105) and their management and day-to-day operation and management of the on-site effluent system.

2. SIGNIFICANT LAND-SOIL UNIT CONSTRAINTS

2.1 Allotment Size. The day-to-day operation and management of on-site effluent systems, as described below, is not constrained by lot size or geometry.

Although all requirements of *SEPPs* have been met or exceeded through conservative design, prudence dictates that individual lot owners assiduously follow the management programme given in Section 4, below.

2.2 Nitrogen Attenuation. To reduce nitrates to insignificant levels, the effluent should not contain more than 30mg/litre total nitrogen.

Provided the irrigation areas are at least as large as those required to satisfy the nitrogen loading, as described in A220105 Sections 1.3.1.13, 1.3.2.13 and 2.2.3.2, and that the (specified) grass is cut and (periodically) harvested, nitrogen will be attenuated on-site.

2.3 Hydraulic Conductivity. The limiting soils of this site are dispersive, low-swelling clays with a low hydraulic conductivity. The hydraulic conductivity is significantly influenced by soil structure, soil colloid stability and swell characteristics. Breakdown or reduction of these soil parameters over time may manifest as reduced performance of the irrigation system. The monitoring and inspection regime detailed in Section 4.7.2, below, should be adhered to.

2.4 Site Drainage. Our recommendations for on-site effluent disposal have allowed for incident rainfall (not surface flow or lateral subsurface flow) and are conditional on the installation of a cut-off drain, which should be placed upslope of the disposal area. Care should be taken to ensure that the intercepted and diverted surface waters and any perched groundwater is discharged well away and down slope of the disposal field (see Drawing 3).

The owner should also ensure that any upslope works do not divert and/or concentrate surface water flows onto the disposal area.

2.5 Vegetation. The effluent disposal areas have been sized via water balance analyses utilising crop factors for pasture (rye/clover mix).

3. THE ONSITE EFFLUENT SYSTEM

The onsite effluent system consists of the influent (toilets, kitchens, bathroom, laundry), a load balancing tank/facility, the treatment plant/sand filter (a device to treat the effluent to at least the 20/30 standard), the irrigation area including effluent distribution system (delivery pipes and drippers), prescribed irrigation area vegetation, associated infrastructure (cut-off drains, outfall areas, fencing), a service and maintenance programme and on-going management.

4. MANAGEMENT

The owner is required to understand (and ensure that users understand) that sustainable operation of the onsite effluent system is not automatic. Sustainable operation requires on-going management, as outlined below.

4.1 Effluent. Effluent will be generated from a residence and will include black and grey water (all wastes).

4.1.2 Effluent Quality. Effluent should be treated to a standard that meets or exceeds the water quality requirements of the 20/30 standard.

4.1.3 Effluent Quantity. The daily effluent volume of 900 litres has been calculated from *Code of Practice - Onsite Wastewater Management,* E.P.A. Publication 891.4, July 2016, Table 4 and assumes mains water supply (equivalent) and WELS-rated water-reduction fixtures and fittings – minimum 4 Stars for dual-flush toilets, shower-flow restrictors, aerator taps, flow/pressure control valves and minimum 3 Stars for all appliances.

4.2 Treatment Plant. For subsurface irrigation, it is assumed that the design, construction, operation and maintenance are carried out in accordance with *AS/NZS1547:2012* and a current JAS-ANZ accreditation.

4.3 Irrigation Area. The irrigation area has been determined from the results of the water and nutrient balance analyses and AS/NZS 1547:*2012*, *Appendix M*.

4.3.1 Effluent Area Requirement. For a daily effluent flow of 900 litres and to satisfy the requirement for no surface rainwater flow in the mean wet year and on-site attenuation of nutrients, the effluent should be applied to an irrigation area of 480m^2 for slopes up to 10% grade and 576m^2 for slopes between 10% and 20% grade.

Effluent distribution is as detailed in Section 4.3.2, below.

In case of an increase in effluent production through the chain of ownership, there is sufficient area available for duplicating the irrigation areas.

Any landscaping and/or planting proposals require endorsement from the Murrindindi Shire.

4.3.2 Distribution System. The distribution system must achieve controlled and uniform dosing over the irrigation area. A small volume of treated effluent should be dosed at predetermined time intervals throughout the day via a pressurised piping network that achieves uniform distribution over the entire irrigation area.

Uniform delivery pressure of the effluent throughout the distribution system is essential. Drip rates should not vary by more than 10% from the design rate over the whole of the system.

To minimise uneven post-dripper seepage, the distribution pipes must be placed parallel with slope contours.

Line spacing shall be not closer than 1000mm under any circumstances.

To facilitate the creation of transient aerobic and anaerobic soil conditions we recommend that as part of the daily irrigation process, the effluent area be irrigated sequentially by zones or time.

4.3.3 Soil Renovation. To improve the subsoil permeability (such that adequate salt leaching can be achieved) and to maintain stable soil peds, the exchangeable calcium needs to be increased while the exchangeable sodium and magnesium need to be decreased.

To improve the existing soil permeability and to maintain water-stable peds (under irrigation with saline effluent), soil renovation in the form of gypsum ($CaSO_4.2H_2O$) application is required.
Application rates are related to water (irrigation and mean rainfall) available to dissolve the gypsum. The water required to dissolve 1 kilogram of gypsum is about 400 litres.

To achieve optimum cation balance gypsum needs to be applied at a rate of about 1.25 kg/m^2.

4.3.3.1 Slopes up to 10% Grade. Initially, gypsum shall be broadcast over the effluent area at the rate of 1kg/m^2, followed by deep ripping to a depth of at least 600mm.

Gypsum is to be fine ground "Grade 1" agricultural quality.

For further required applications, we recommend that a proprietary "liquid" gypsum product (typically CaCl + polyacrylamide + wetting agent + water) be applied via the irrigation network

Depending on the proprietary product, 1 litre of liquid "gypsum" is approximately equivalent to 95 kg dry gypsum.

Therefore, for a theoretical application rate of 1kg/m^2, 1 litre of liquid gypsum would be required for every 95m^2 of irrigation area.

In this instance, about 5 litres would be required for an equivalent application of 1kg/m^2 dry gypsum over the whole irrigation area (480m^2).

We recommend that following the initial (before ripping) dry gypsum application, liquid gypsum be applied through the irrigation network at the rate of 1.25 litre/application after 2 months.

An application of 1.25 litre through the irrigation network is recommended every 3-years.

4.3.3.2 Slopes Between 10% Grade and 20% Grade. Initially, gypsum shall be broadcast over the effluent area at the rate of 1kg/m^2, followed by deep ripping to a depth of at least 600mm.

Gypsum is to be fine ground "Grade 1" agricultural quality.

For further required applications, we recommend that a proprietary "liquid" gypsum product (typically CaCl + polyacrylamide + wetting agent + water) be applied via the irrigation network

Depending on the proprietary product, 1 litre of liquid "gypsum" is approximately equivalent to 95 kg dry gypsum.

Therefore, for a theoretical application rate of 1kg/m^2, 1 litre of liquid gypsum would be required for every 95m^2 of irrigation area.

In this instance, about 6 litres would be required for an equivalent application of 1kg/m^2 dry gypsum over the whole irrigation area (576m^2).

We recommend that following the initial (before ripping) dry gypsum application, liquid gypsum be applied through the irrigation network at the rate of 1.5 litre/application after 2 months.

An application of 1.5 litre through the irrigation network is recommended every 3-years.

4.3.4 Buffer Distances. The water balance analysis has shown that potential surface rainwater flows from the effluent area would be restricted to episodic events.

The estimated hydraulic properties of the upper soil materials and hydraulic gradient (equivalent to the ground slope and regional gradients) have been used to evaluate (via Darcy's Law) the buffer distances with respect to subsurface flows.

Our analysis and evaluation have shown that the default setback distances given in *Code of Practice - Onsite Wastewater Management,* E.P.A. Publication 891.4, July 2016, Table 5 are conservative and can be applied without amendment.

For a building located downslope of an effluent field, your engineer should evaluate the integrity of building foundations with respect to the assigned buffer distance.

Buffer distances are to be applied exclusive of the irrigation area.

4.3.5 Buffer Planting. All downslope (Title inclusive) buffers may be required to filter and renovate abnormal surface discharges. Hence, they are to be maintained with existing or equivalent groundcover vegetation.

4.3.6 Buffer Trafficking. On all allotments, buffer trafficking should be minimised to avoid damage to vegetation and/or rutting of the surface soils.

Traffic should be restricted to 'turf' wheeled mowing equipment and to maintenance, monitoring and inspections by pedestrians, where possible.

4.4 Vegetation. The system design for on-site disposal includes the planting and maintenance of suitable vegetation, as specified in A220105 and/or similar documents.

Specifically, this irrigation area has been sized (in part) utilising crop factors and annual nitrogen uptake for a rye/clover eq mix.

The grass needs to be harvested (mown and periodically removed from the irrigation area).

Where a variation to recommended grass species is proposed, it must be demonstrated that the nitrogen uptake and crop factors (as specified in A220105 Appendix B – water balance) are met or exceeded.

4.5 Verification. The Council is to be satisfied that the effluent system has been constructed as designed.

4.6 Associated Infrastructure. The following items are an integral part of the onsite effluent system.

4.6.1 Cut-off drains. Cut-off drains are designed to prevent surface and near-surface water flows from entering the effluent area. They should be constructed and placed around the effluent area, as detailed in Drawing 3.

4.6.2 Outfall areas. All pipe outfalls should be at grade and designed to eliminate scour and erosion.

A grassed outfall would normally be adequate. However, should monitoring and inspections reveal rill or scour formation, the outfall will need to be constructed so that energy is satisfactorily dissipated.

Should this situation occur, professional advice is to be sought.

4.6.3 Fencing. The disposal area is to be a dedicated area. Adequate fencing must be provided to prevent stock, excessive pedestrian and vehicular movements over the area.

4.7 Service and Maintenance Programme. The minimum requirements for servicing and maintenance are set out in the relevant JAS-ANZ accreditation and the manufacturer's recommendations.

4.7.1 Treatment Plant. Aerated treatment plants and sand filters should be serviced at least one time per year (or as recommended in the JAS-ANZ accreditation and the effluent should be sampled and analysed as required by the JAS-ANZ accreditation. The local authority is to ensure compliance.

The manufacturer's recommendations are to be followed. Generally, low phosphorous and low sodium (liquid) detergents should be used. Plastics and other non-degradable items should not be placed into the tanks. Paints, hydrocarbons, poisons etc should not be disposed of in sinks or toilets. Advice from a plumber should be obtained prior to using drain cleaners, chemicals and conditioners. It is important to ensure that grease does not accumulate in the tanks or pipes. Grease and similar products should be disposed of by methods other than via the on-site effluent system.

4.7.2 Monitoring and Inspections. We recommend that the mandatory testing and reporting as described in the *Code of Practice - Onsite Wastewater Management,* E.P.A. Publication 891.4, July 2016, include an annual (post spring) and post periods of heavy and/or prolonged rainfall report on the functioning and integrity of the distribution system and on the functioning and integrity of the cut-off drains, outfall areas and soil media.

The effluent areas should be regularly inspected for excessively wet areas and vegetation integrity.

The inspection regime described in A220105, Section 2.2.7, should be strictly adhered to.

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