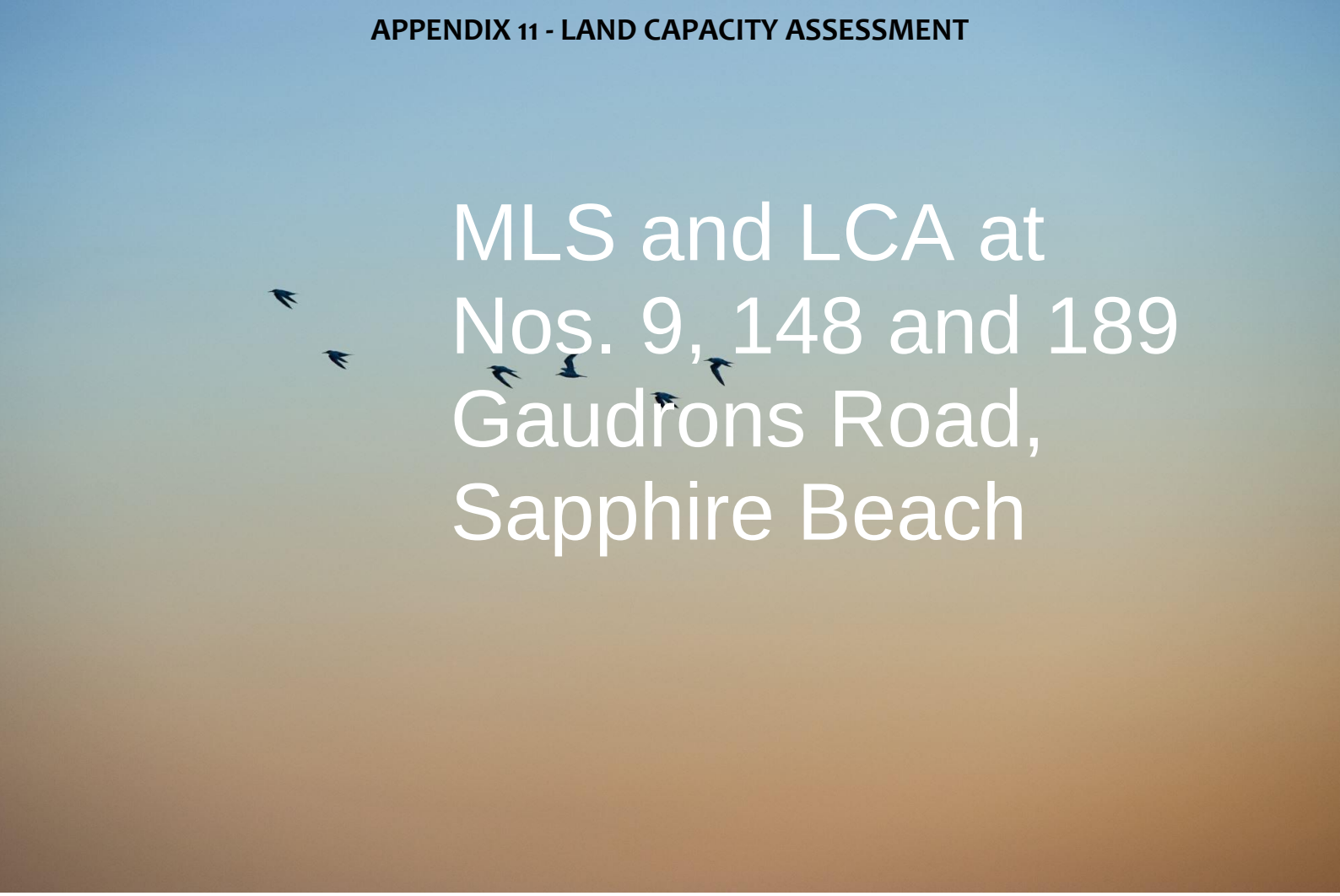

MLS and LCA at Nos. 9, 148 and 189 Gaudrons Road, Sapphire Beach

15 June 2021

For: Factor X Solutions Pty Ltd: Stephen Sawtell

Authored by: Strider Duerinckx

Ref	Ver	Date	Distribution
2021-71-02	A	25/11/20	Client, Planner
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1 Introduction

Earth Water Consulting Pty Limited (EWC) were engaged by Stephen Sawtell to undertake a Minimum Lot Size (MLS) and Land Capability Assessment (LCA) for the proposed subdivision of Nos. 9, 148 and 189 Gaudrons Road, Sapphire Beach, as shown on Figure 1.

The purpose of the MLS and LCA is to show that wastewater from an On-site Sewage Management System (OSMS) can be sustainably applied on the proposed lots.

2 Proposed Development

Based on plans of the proposed subdivision layout by Ian G Evison & Partners, it is understood that it is proposed to subdivide the subject properties as follows in **Table 1** and shown in Figures 2-4.

A single road per property will be constructed on No. 9 and No. 189 to allow vehicular access to the proposed lots.

Table 1: Property Details

Existing Property	Lot & DP	Existing Size (m^2)	Proposed No. of Lots	Proposed Building Envelopes (m^2)	Proposed Lot Size (m^2)
No. 9	L11, DP1141269	52,939	3	1 @ 1,500	6,700-25,000
No. 148	L7, DP555490	20,496	2	NIL additional	10,000-10,500
No. 189	L2, DP5550362	44,594	4	3 x @ 1,344 to 1,395	10,000-10,400

3 Scope of Work

The MLS and LCA were undertaken by Strider Duerinckx of EWC. The study methodology included:

- A desktop review of Site conditions including geology, hydrogeology, soils, and landscape features;
- A site inspection to map site and soil constraints plus an audit of the existing dwelling OSMS in relation to the proposed subdivision boundary;
- Drilling of two boreholes to assess soil conditions across the Site;
- Assessment of a range of site constraints including landform, slope, aspect, drainage, flooding and proximity to sensitive environments;
- A minimum lot size analysis involving the review of a number of nearby lot sizes, developed, constrained and available land area footprints;
- Analysis of selected soil sample for a range of chemical properties including pH, EC, dispersibility, PSorp, CEC and ESP;

- Estimation of likely wastewater loads (quantity and quality) from future dwellings on the proposed lot, and undertake confirmation water and nutrient balance modelling to size suitable land application areas;
- Determining an appropriate level of wastewater treatment and the preferred method of land application of effluent to overcome the constraints on the proposed lots.

4 Site Details

The properties are zoned RU2 (rural landscape), except for a thin sliver of the southern edge of No.189 which is zoned E2 (environmental conservation).

4.1.1 No. 9 Gaudrons Road

No. 9 is located at about 30mAHD in the lower eastern portion of Gaudrons Road, on the southern side. The property straddles a ridgeline, with intermittent drainage present along the southern boundary draining east under the Pacific Highway, and along the northwestern boundary draining north. Both are First-order streams in accordance with the Strahler ordering system. Surface slopes are relatively shallow, and the property is currently an operating mixed banana plantation and hothouse fig farm, containing two dwellings and a number of sheds.

Photograph 1 – Looking east across Proposed Lot 1

Photograph 2 – Looking south across Proposed Lot 3

4.1.1 No. 148 Gaudrons Road

No. 148 is located at about 160mAHD on the northern side of Gaudrons Road, and is bisected by an incised intermittent First-order intermittent gully. The property is steely sloping down to the east and north to this gully across rocky ground. An existing dwelling is located in the southeastern corner of the property and a second dwelling along the western boundary. The property is a former banana plantation farm that has a number of disused access tracks but is now only used for hobby goat rearing.

Photograph 3 – Looking northwest from gully to illegal dwelling.

Photograph 4 – Looking north from existing dwelling towards gully.

4.1.2 No. 189 Gaudrons Road

No. 189 is located at about 190mAHD on the southern side of Gaudrons Road. The property has been heavily cleared, is generally east facing and is former banana plantation land crisscrossed by former agricultural tracks. A new road will be constructed generally along one of these. A number of First-order intermittent gullies drain east from the property. An existing dwelling is located in the northern edge of the property adjacent to Gaudrons Road.

Photograph 5 – Looking east towards Lot 2 building envelope (centre) and proposed EMA on right hand side.

Photograph 6 – Looking west across Lot 4 proposed EMA.

Photograph 7 – Looking north across Lot 3 proposed EMA.

4.2 Existing OSMS

4.2.1 No. 9 Gaudrons Road

Two separate OSMS's service the existing dwellings. Both consist of a new 3kL poly septic tank, draining to a single absorption bed located downslope to the west of the dwelling. The approximate locations are shown on Figure 4.

Based on the proposed Lot 1-2 boundary, the existing OSMS are satisfactorily located and no upgrade works are required.

Photograph 8 – Looking south at the existing OSMS on No. 9. The absorption trench for the southern tank runs parallel to slope from the tank past the tree and shed (background). The absorption trench for the northern house runs from the tank under the gravel and lawn in the foreground.

4.2.2 No. 148 Gaudrons Road

There are two existing OSMS's also at 148 Gaudrons Road. The existing approved dwelling has a 3kL poly septic tank and an absorption trench field both located downslope to the north of the dwelling.

The trench could not be located but given the positioning is likely located on an existing built up terrace (Figure 5). The OSMS is located well away from the subdivision boundary and no further works are required.

The OSMS attached to the second dwelling (on the western boundary) is located downslope to the east, and consists of a hand built besser block tank and an unknown land application method. There was no obvious outlet on the tank, which appeared to be in poor condition and cracked. Though the OSMS is located well away from the proposed subdivision boundary, it is failing and needs to be rectified.

Photograph 9 – Looking east at the existing absorption trench for the house on No. 148. The absorption trench is likely on the level terrace.

Photograph 10 – Looking northeast at the existing septic tank for the second dwelling on No. 148. The absorption trench location is uncertain.

4.2.3 No. 189 Gaudrons Road

The existing dwelling at 189 Gaudrons Road also has a septic tank and absorption trench combination OSMS. The 3kL poly septic tank is located downslope to the southeast of the dwelling, with a single absorption trench south of the septic tank (Figure 6).

Photograph 11 – Looking northeast at the existing septic tank beneath dark bush off the cnr of the dwelling (middle of photo) and absorption trench in grassed and mowed strip.

4.3 Site Constraints

4.3.1 No. 9 Gaudrons Road

Table 2 summarises the Site constraints for the primary and reserve EMAs for each of the proposed lots. These are discussed in terms of the degree of limitation they present (i.e. minor, moderate or major limitation) for on-site effluent application. Reference is made to the rating scale described in Table 4 of DLG (1998). Site features are presented in Figure 5.

Table 2: No. 9 Site Constraints

Constraint	Degree of Limitation		
	Minor	Moderate	Major
Landform: Lot 1, 2, 3 – Waxing planar crest to mid slope	All lots		
Exposure: Lot 1, 2, 3 - Good exposure. Minimal trees near the proposed EMAs.	All lots		
Slope: Lot 1, 2- Gentle slopes of 0-10% to the east and west. Lot 3 – Moderate slopes of 10-20% to the southeast.	1-2	3	
Rocks and Rock Outcrops: No rock outcrops were observed on the Site.	All lots		
Erosion Potential: Active erosion is lower on the gentle slopes and higher on steeper. Erodible subsoils are present.	All lots		
Climate: The Site experiences a sub-tropical-temperate climate, typical of north-eastern NSW.	All lots		
Vegetation: All lots – cleared former agricultural	All lots		
Fill: No filling at the proposed EMAs	All lots		
Surface Waters: Intermittent drainage line along the western boundary line, draining to the north. Intermittent drainage line along southeastern corner draining east. Lot 1, 2, 3 - >40m	All lots		

Constraint	Degree of Limitation		
	Minor	Moderate	Major
Groundwater: (NSW Office of Water: Groundwater Bore Search) A number of licensed bores are located along Gaudrons Road. The closest bores to No.9 are GW071130 and GW073072 located to the south and west of the property. 71130 was drilled to 61m with a hardrock aquifer encountered at 41m depth and a SWL of 18m depth. 73072 was drilled to 44m with a SWL of 18m depth. Groundwater vulnerability? Clay subsoil, distance and deep groundwater depth indicate that the risk to groundwater would be minimal.			All lots
Stormwater run-on and upslope seepage: The positions of the proposed EMAs on or just off a local crest means that runon would be minimal.	All lots		
Flood Potential: The property is not impacted by 1:100 year flood extents on the CHCC flood mapping.	All lots		

4.3.1 No. 148 Gaudrons Road

Table 3 summarises the Site constraints for the primary and reserve EMAs for each of the proposed lots. Site features are presented in Figure 6.

Table 3: No. 148 Site Constraints

Constraint	Degree of Limitation		
	Minor	Moderate	Major
Landform: Lot 1, 2 - Waxing planar mid slope	1, 2		
Exposure: Lot 1, 2 - Good exposure. Minimal trees near the proposed EMAs.	1, 2		
Slope: Lot 1, 2 – Steep slopes of 33-35% to the east and north.			1,2

Constraint	Degree of Limitation		
	Minor	Moderate	Major
Rocks and Rock Outcrops: No rock outcrops were observed on the Site but numerous weathered angular cobbles .		Both lots	
Erosion Potential: Active erosion is lower on the gentle slopes and higher on steeper. Erodible subsoils are present.			Both lots
Climate: The Site experiences a sub-tropical-temperate climate, typical of north-eastern NSW.	Both lots		
Vegetation: All lots – cleared former agricultural	Both lots		
Fill: No significant filling present	Both lots		
Surface Waters: Intermittent drainage line bisects the property draining northeast. Lot 1,2 – 40m buffer extends onto the lots		Both lots	
Groundwater: (NSW Office of Water: Groundwater Bore Search) A number of licensed bores are located along Gaudrons Road. The closest bores to No.148 are GW072518 and GW072526 located to the south of the property. Both bores were drilled to 67m with a hardrock aquifer encountered at 62m depth. Groundwater vulnerability? Clay subsoil, distance and deep groundwater depth indicate that the risk to groundwater would be minimal.			Both lots
Stormwater run-on and upslope seepage: The positions of the proposed EMAs on steep midslopes means that runon would be experienced.		Both lots	
Flood Potential:	Both lots		

Constraint	Degree of Limitation		
	Minor	Moderate	Major
The property is not impacted by 1:100 year flood extents on the CHCC flood mapping.			

4.3.1 No. 189 Gaudrons Road

Table 4 summarises the Site constraints for the primary and reserve EMAs for each of the proposed lots. Site features are presented in Figure 7.

Table 4: No. 189 Site Constraints

Constraint	Degree of Limitation		
	Minor	Moderate	Major
Landform: Lot A – Liner convergent mid slope Lot 1 – Linear divergent midslope Lot 3 – Linear divergent to convergent Lot 2 – Linear planar	1, 2	A, 3	
Exposure: Lot 1, 2, 3, 4 - Good exposure. Minimal trees near the proposed EMAs.	All lots		
Slope: Lot 1, 2, 3, a4 - Steep slopes of >30%.			All lots
Rocks and Rock Outcrops: No rock outcrops were observed on the Site but given landscape position would be expected.		All lots	
Erosion Potential: Erosion risk is higher on steeper slopes. Erodible subsoils are present.		All lots	
Climate: The Site experiences a sub-tropical-temperate climate, typical of north-eastern NSW.	All lots		
Vegetation: All lots – cleared former agricultural	All lots		

Constraint	Degree of Limitation		
	Minor	Moderate	Major
Fill: None observed.	All lots		
Surface Waters: Intermittent drainage bisects the proposed lots 1 and 2. Lot 2, 3 - >40m Lot A, 1 – 40m buffer extends onto the lots	3, 2	A, 1	
Groundwater: (NSW Office of Water: Groundwater Bore Search) A number of licensed bores are located along Gaudrons Road. The closest bore to No.189 is GW301923 located to the west of the property. No drillers log is available, but the elevated position in the landscape and nearby drillers logs suggest a deep hard rock aquifer. Groundwater vulnerability? Clay subsoil, distance and deep groundwater depth indicate that the risk to groundwater would be minimal.			All lots
Stormwater run-on and upslope seepage: The positions of the proposed EMAs on steeply sloping midslopes means runon would be expected .		All lots	
Flood Potential: The property is not impacted by 1:100 year flood extents on the CHCC flood mapping.	All lots		

4.4 Soil Survey and Description

4.4.1 Regional Soils

We reviewed the Soil Landscapes of the Coffs Harbour 1:100,000 Sheet (Milford, 1999) which indicates that No. 9 Gaudrons Road is underlain by the Megan Soil Landscape, No.148 by the Suicide Soil Landscape and No.189 by the Bobo Soil Landscape (**Error! Reference source not found.**).

Table 5: Soil Landscape

Existing Property	Soil Landscape	Type	Typical Profile	Limitations
No. 9	Megan	Erosional	moderately deep to deep (>100 cm), well drained structured Red Earths, Brown Earths, Brown or Red Podzolic Soils, with moderately deep to deep (>100 cm), structured Yellow Earths and Yellow Podzolic Soils in drier situations, and moderately deep to deep (>120 cm), well-drained in the moistest sites.	strongly acid, stony (localised) soils of high erodibility, aluminium toxicity potential and low subsoil fertility. Steep slopes (localised); mass movement hazard (localised); high water erosion hazard (localised); foundation hazard (localised).
No. 148	Suicide	Colluvial	moderately deep to deep (>100 cm), welldrained, stony structured Yellow Earths on crests and upper slopes, with stony Lithosols and structured Red Earths on mid-slopes and footslopes.	strongly acid stony soils with low wet bearing strength, strong subsoil acidity and low fertility. Steep slopes; mass movement hazard; high run-on; high water erosion hazard; foundation hazard; rockfall hazard (localised).
No. 189	Bobo	Colluvial	moderately deep, weakly structured Red Earths, with deep, imperfectly drained Red Podzolic Soils on footslopes and very shallow, well-drained Lithosols on very steep slopes with shallow soils.	strongly acid, stony, shallow (localised) soils with low fertility, high aluminium toxicity potential and low wet bearing strength. Very steep slopes; high mass movement hazard; high water erosion hazard; severe foundation hazard; shallow soils (localised on steepest slopes); rockfall hazard (localised on steepest slopes); rock outcrop (localised).

4.4.2 No.9 Gaudrons Soils

Soils were assessed by drilling three (3) boreholes (Figure 5) to 1.2m depth or refusal (Appendix A). In general, these soils comprised:

- Approximately 100-200mm of clay loam topsoil, dark brown to pale brown, no mottling, with earthy structure and up to 10% quartz gravel; overlying
- Approximately 600mm of light clay, orange brown, with slight red brown mottling increasing with depth, strong structure and up to 5% gravel; overlying
- At least 400mm of medium clay with silt, pale orange to pale grey with red brown mottling, and up to 30% phyllite gravel; overlying

Competent bedrock was not encountered in the boreholes. The borehole logs are provided in Appendix A.

Photograph 12 – BH3 soil profile.

4.4.3 No.148 Gaudrons Soils

Soils were assessed by one (1) borehole to 1.2m depth or refusal (Figure 6). In general, these soils comprised:

- Approximately 100mm of sandy clay loam topsoil, dark brown, no mottling, with earthy structure and up to 20% gravel; overlying
- Approximately 500mm of sandy clay loam, brown, earthy to strong structure and up to 20% angular metasediment gravel; overlying
- At least 600mm of silty clay, pale yellow brown, with slight pale grey mottling up to 30% angular gravel.

Competent bedrock was not encountered in the boreholes. The borehole logs are provided in Appendix A.

Photograph 13 – BH4 soil profile.

4.4.4 No.189 Gaudrons Soils

Soils were assessed by drilling two (2) boreholes and observing one cutting (Figure 7) to 1.2m depth or refusal. In general, these soils comprised:

- Approximately 250mm of clay loam topsoil, dark brown, no mottling, with earthy structure and up to 10% quartz gravel; overlying

- Approximately 100mm of clay loam pale brown, with 5-40% angular (in cutting) gravel; overlying
- Approximately 500mm of light clay, strong orange brown, strong structure and 5-40% (in cutting) gravel; overlying
- Up to 300mm of light to silty clay, pale orange brown, with slight pale yellow mottling, and up to 5% gravel.

Competent bedrock was not encountered in the boreholes, but BH6 refused on gravel at 1m depth. The borehole logs are provided in Appendix A.

Photograph 14 – BH5 soil profile.

4.5 Soil Chemistry

Error! Reference source not found. summarises the key soil physical and chemical assessments. Reference is made to the rating scale described in Table 6 of DLG (1998). Two samples were selected for laboratory analysis (BH1 0.6-0.8 and BH5 0.5-0.8). The laboratory report is included in Appendix B.

Table 6: Soil Assessment

Parameter	Constraint		
	Minor	Moderate	Major
Depth to bedrock or hardpan (m): Boreholes were terminated at 1.2m depth often in extremely weathered bedrock. No.9- It is believed that competent bedrock will be located at >1.5m based on soil landscape and position. Nos. 148 and 189 – It is believed that competent bedrock depth will be variable and may be present within 1m depth in places.	No.9		Nos. 148 and 189
Depth to high soil watertable: The depth of the vadose zone (i.e. non-saturated soil material above watertable) was greater than 1.2m at the time of the investigation. The depth to the permanent	All properties		

Parameter	Constraint		
	Minor	Moderate	Major
groundwater aquifer is expected to be more than 20m depth based on local groundwater bores.			
Coarse Fragments (%): No.9- The subsoils contained <20% coarse fragments. Nos. 148 and 189 – Gravelly colluvial soils were encountered with gravels and cobbles up to 40%	No. 9		Nos. 148 and 189
Hydraulic loading rate: Soil structure: Strong Soil texture: Light clay Permeability category: Category 5a Hydraulic loading recommended: 8mm/day for primary, and 12mm/day secondary treated effluent into an absorption bed field and 3mm/day for SSI. Reasons for the hydraulic loading recommendation: Strongly structured clay subsoils.		All properties	
pH: 4.36-4.33 pH Units from. Strongly acidic soils.			All properties
Electrical Conductivity (dS/m): 0.589-0.407dS/m. Not saline.	All properties		
Dispersiveness: Class 3/6 (Slake 3) for both samples. The instability of these aggregates is expected to increase slightly with the application of effluent.		All properties	
Sodicity (ESP): ESP of 1.2-1.7%. The ESP infers a minimal potential for structural degradation.	All properties		
Cation Exchange Capacity: CEC was measured between7.3-9.0cmol/kg, which indicates that the soils have a moderate ability to accept and release excess nutrients from effluent.		All properties	
Phosphorus Adsorption: Psorp of 11,186-16,824kg/ha were reported in the subsoils.	All properties		

5 Minimum Lot Size (MLS) Analysis

A minimum lot size analysis and modelling were completed to determine the maximum lot density suitable for subdivision on the Site.

5.1 Methodology

When considering the suitability for a lot to sustainably manage wastewater on-site, we typically refer to 'available effluent management area'. This broadly refers to available areas (i.e. not built out or used for a conflicting purpose) where OSMS will not be unduly constrained by site and soil characteristics. Available area on a developed a lot is determined by the following factors:

- total building area (including dwellings, sheds, pools etc.) which includes a defined building envelope but may extend beyond with additional improvements to a property, such as driveways and paths (impervious areas), and gardens/vegetated areas unsuitable for effluent reuse;
- dams, intermittent and permanent watercourses running through lots;
- maintenance of appropriate buffer distances from property boundaries, buildings, driveways and paths, dams and watercourses;
- flood prone land;
- excessive slope;
- excessively shallow soils;
- heavy (clay) soils with low permeability;
- excessively poor drainage, shallow groundwater and/or stormwater run-on; and
- excessive shading by vegetation.

The residual areas (areas not otherwise occupied by improvements, buffers, restrictions or conservation vegetation) were then calculated for the selected lots (Figure 8), and the available area compared to the wastewater envelope required.

5.2 MLS Buffer Distances

Buffer distances from EMAs are typically enforced to minimise risk to public health, maintain public amenity and protect sensitive environments. Generally, adopted environmental buffers for secondary treated effluent land applied into absorption trenches/ beds based on DLG (1998) are:

- 250m from domestic groundwater bores;
- 100m from permanent watercourses;
- 40m from intermittent watercourses and dams;
- 6m from downslope property boundaries and 3m from upslope property boundaries; and
- 6m from downslope buildings and 3m from upslope buildings.

In addition, developed areas such as inground water tanks and swimming pools were also buffered.

Secondary treatment was selected for modelling purposes. Primary treatment may be possible on a case by case for the proposed lots on No.9 and 189 Gaudrons Road subject to soil depth and buffer requirements for such OSMS.

5.3 MLS Comparative Lots Assessed

Six nearby R5 zoned representative lots were selected that have already been subdivided (**Error! Reference source not found.**) (Figure 7). The lots ranged in size from 1,689-4,212m^2 area. The next available lot sizes greater than this on Gaudrons Road were 20,000m^2, and given the 6000-10,000m^2 proposed for the properties the larger lot size was not considered appropriate to compare to. As such the smaller 1,689-4,212m^2 provide a worst case scenario of OSMS restrictions.

Table 7: Comparative Lots Assessed

Address	Lot Area (m^2)
39-41 Gaudrons Road	4,005
45 Gaudrons Road	4,001
75 Gaudrons Road	4,212
79 Gaudrons Road	1,689
81 Gaudrons Road	1,788
160 Gaudrons Road	2,830

The properties typically included a dwelling, garage/shed, landscaped trees, shrubs and gardens, driveways, water tanks, and recreational space. This development style will be similar to that proposed for the Site and therefore minimum lot size and development potential should be consistent.

5.4 MLS Assessed Available EMA

Error! Reference source not found. shows the assessment of available effluent management areas for each of the assessed lots. As is evident, the variability of lot sizes, on-lot improvements and restrictions of developed lots makes selection of a “typical” lot difficult, however comparison of the site constraints indicates that minimum lot size is the most significant issue to address.

Table 8: Minimum Lot Size Assessment Results

Id	Lot Area (m^2)	Developed Area (m^2)[1]	Total Restricted Area (m^2)[2]	Available Eff. Application Area (m^2)	Percent of Lot Available for Eff. Disp. (%)	>630m^2 Area Available for Secondary Treatment?
39-41	4,005	1,293	2,142	1,873	47	Yes
45	4,001	1,166	2,154	1,843	46	Yes
75	4,212	1,564	2,377	1,827	43	Yes
79	1,689	630	1,546	143	8	No
81	1,788	771	1,788	0	0	No
160	2,830	560	1,808	1,022	36	Yes

1. House, driveway, shed etc
2. Includes developed area, protected vegetation and buffers to waterways and boundaries

5.5 Discussion

A comparison of nearby properties suggests that:

- From the sample selection of lots investigated, three of the lots are significantly smaller than the nominated minimum 6,000m^2 lot size, being 1,689 1,788 and 2,830m^2. Of these only the 2,830m^2 property (No. 160) is available effluent management area. This is because the existing dwelling is located hard against the southern boundary with no associated sheds, garages, swimming pools etc. The other two small lots by nature of the lot size and buffer constraints to site features have in effect no available effluent management area and wastewater application is compromised;
- The remaining three properties of 4,001-4,212m^2 have each about 1,800m^2 of available unconstrained area for effluent application. Allowing for additional developed footprint such as sheds and swimming pools that may not be present currently, and constraints such as buffers to gullies and protected forest vegetation, the minimum 630m^2 footprint typically required for a secondary treatment and land application OSMS would still be able to be met;
- As such, given the low slopes and limited site and soil constraints, a minimum 6,000m^2 lot sizing at No.9 Gaudrons Road would be considered acceptable;
- The oversteep slopes of >30% with shallow stony soils at No.148 Gaudrons Road require more specialized design and construction, and a minimum 10,000m^2 lot size is considered prudent and acceptable; and
- Though deeper soils are present on No.189 Gaudrons Road pose no limitation (minor only), this positive is offset by the steep slopes of +30%, presence of numerous convergent-divergent landforms with separating frequent First-order gullies, and E2 zoning along the southern portion. As such a minimum 10,000m^2 lot size is considered prudent and acceptable.

6 Recommended OSMS Combination

Due to the cost of reticulated sewerage provision by Council, it is expected that the Site will not be sewered in the foreseeable future.

Based on the site and soil constraints and subdivision boundaries, the minimum treatment and land application combination selected for No.9, 148 and 189 Gaudrons Road are:

- Treatment to a secondary standard and subsurface application into an appropriately sized absorption bed or subsurface irrigation field.

During development application for a particular dwelling, with judicious placement of the dwelling and improvements, and limiting wastewater generation volumes, alternative OSMS combinations may be considered acceptable including treatment to a primary standard and land application by subsurface absorption, or wet or dry compost systems.

7 Effluent Management Areas

7.1 Design Hydraulic Load

For hydraulic loading purposes a proposed dwelling of four bedrooms on unlimited tank water was assumed for the proposed lots. AS/NZS1547:2012 recommends that a wastewater generation load of 150L per person per day for households supplied by tank with backup water be used as a basis for wastewater system design. The hydraulic load for the existing and proposed dwellings is based on 1.5 persons per bedroom. The design hydraulic loading for a four bedroom dwelling under full occupancy is presented in **Error! Reference source not found.**.

Table 9: Proposed Design Hydraulic Load

No. of Bedrooms	Design Wastewater Load (L/day)
4	900

7.2 Sizing of Effluent Management Areas

Water balance modelling was undertaken to determine sustainable effluent application rates, and from this estimate the necessary size of the EMA required for effluent to be applied from a primary treatment system trench or beds. The procedures used in the water balance generally follow the *AS/NZS 1547:2012* standard and DLG (1998) Guideline. The water balance used is a monthly nominated area model. These calculations determined minimum EMAs for given effluent loads for each month of the year. The water balance can be expressed by the following equation:

$$\text{Precipitation} + \text{Effluent Applied} = \text{Evapotranspiration} + \text{Percolation} + \text{Storage}$$

The input data and results for the primary treated trench/ bed water balance are presented in **Error! Reference source not found.**, and calculation sheets in Appendix C.

A conservative nutrient balance was also undertaken, which calculates the minimum buffer around a trench or bed to enable nutrients to be assimilated by the soils and vegetation. The nutrient balance used here is based on the simplistic DLG (1998) methodology, but improves this by more accurately accounting for natural nutrient cycles and processes. It acknowledges that a proportion of nitrogen will be retained in the soil through processes such as ammonification (the conversion of organic nitrogen to ammonia) and a certain amount will be lost by denitrification, microbial digestion and volatilisation. A summary of the nutrient balance is provided in **Error! Reference source not found.**.

Table 10: Inputs and Results of Primary Treatment Modelling

Data Parameter	Units	Value	Comments
Hydraulic load	L/day	900	6 persons occupancy.
Precipitation	mm/month	Coffs Harbour	BoM, Median monthly.
Pan Evaporation	mm/month	Coffs Harbour MO	BoM, mean monthly.
Retained rainfall	unitless	0.85	Proportion of rainfall that remains onsite and infiltrates the soil, allowing for 15% runoff.
Crop Factor	unitless	0.6-0.8	Expected annual range for vegetation based on monthly values.
Design Loading Rate (DLR) - Primary	mm/day	12	Maximum rate for design purposes, based on strongly structured light clay subsoils.
Effluent total nitrogen concentration	mg/L	30	Target effluent quality for secondary treatment systems.
Effluent total phosphorus concentration	mg/L	12	Target effluent quality for primary treatment systems.
Soil phosphorus sorption capacity	kg/ha	11,500	Value based on soil testing.
Nitrogen uptake rate by plants	kg/Ha/yr	250	Conservative estimated value.
Phosphorus uptake rate by plants	kg/Ha/yr	25	Conservative estimated value.
Design life of system (for nutrient management)	years	50	Reasonable minimum service life for system.
Minimum primary treatment trench/ bed basal area for hydraulic load (m^2)			85m^2 (115m^2 absorption trench field footprint)
Minimum area for total phosphorus load (m^2)			313m^2
Minimum area for total nitrogen load (m^2)			315m^2

Based on modelling an EMA and reserve EMA of 315m^2 each have been nominated for a four bedroom dwelling, totally 630m^2. The proposed locations of the EMAs are shown on Figures 9-11.

The actual size and configuration of the EMAs will be dependent on a wastewater management plan at the time of dwelling development planning and application to install or upgrade an OSMS.

8 Buffers

Buffer distances or setbacks from EMAs are required to minimise risk to public health, maintain public amenity and protect sensitive environments. The buffers from DLG (1998) are presented in **Error! Reference source not found.** below.

Table 11: Available Buffers

Site Feature	DLG (1998) Buffer	Achievable?
Intermittent watercourses, drainage channels and dams	40m	**Yes**
Permanent waterways	100m	**Yes**
Domestic groundwater bore	250m	**No, licensed bores are located with 250m of portions of each property.**
Property boundary	Secondary - 6m downslope of, and 3m sideslope or upslope of	**Yes**
Driveway and building	6m downslope of / 3m upslope of	**Yes**

Although some of the recommended EMAs fall within the 250m buffer to a domestic groundwater bore required by DLG (1998), the guideline did not provide any scientific justification for that buffer and the document is about 22 years old. AS/NZS1547:2012, a more recent document a national standard provides the ability to risk assess buffers based on site and soil constraints. The maximum risk assessed buffer in AS/NZS1547:2012 to bores or wells is 50m for primary treated wastewater, shallow high resource groundwater, aquifers in highly porous soils or rock, and surface or above ground effluent land application. The recommended minimum OSMS combination poses a lower risk than this worst case, and the local groundwater aquifer is relatively deep at >40m depth beneath a substantial clay capping layer. As such a lesser risk assessed buffer would be expected.

In any case, all recommended EMAs would be located >50m from the nearest bores.

9 Conclusions & Recommendations

Having undertaken a minimum lot size and land capability assessment for the proposed subdivision of No.9, 148 and 189 Gaudrons Road, EWC consider that there is the opportunity for the sustainable

application of wastewater following subdivision of the existing properties into smaller lots (**Error! Reference source not found.**).

Table 12: Summary of Development Recommendations

Property	Minimum Lot Size (m^2)	Minimum OSMS Combination*
9	6,000	Secondary treatment and subsurface bed or subsurface irrigation land application, 630m^2.
148	10,000	
189	10,000	
*Subject to final design, and primary treatment may be acceptable on a case by case basis.		

For any future system we recommend that:

- A dwelling specific OSMS should be designed by an experienced professional, taking into account the assumptions and recommendations contained in this report; and
- An OSMS should be installed by a suitably qualified plumber, ensuring that effluent is distributed evenly across the entire area serviced.

10 References

Coffs Harbour City Council (2015) *On-site Sewage Management Strategy 2015*, Coffs Harbour.

Department of Local Government et al. (1998). *Environment & Health Protection Guidelines: On-site Sewage Management for Single Households*.

Milford, H. B., (1999) *Soil Landscapes of the Coffs Harbour 1:100 000 Sheet*, Department of Land and Water Conservation Soil Landscape Series.

Standards Australia / Standards New Zealand (2012*). AS/NZS 1547:2012 On-site Domestic-wastewater Management*.

FIGURES

APPENDIX 11 - LAND CAPACITY ASSESSMENT

LEGEND

Property Boundary

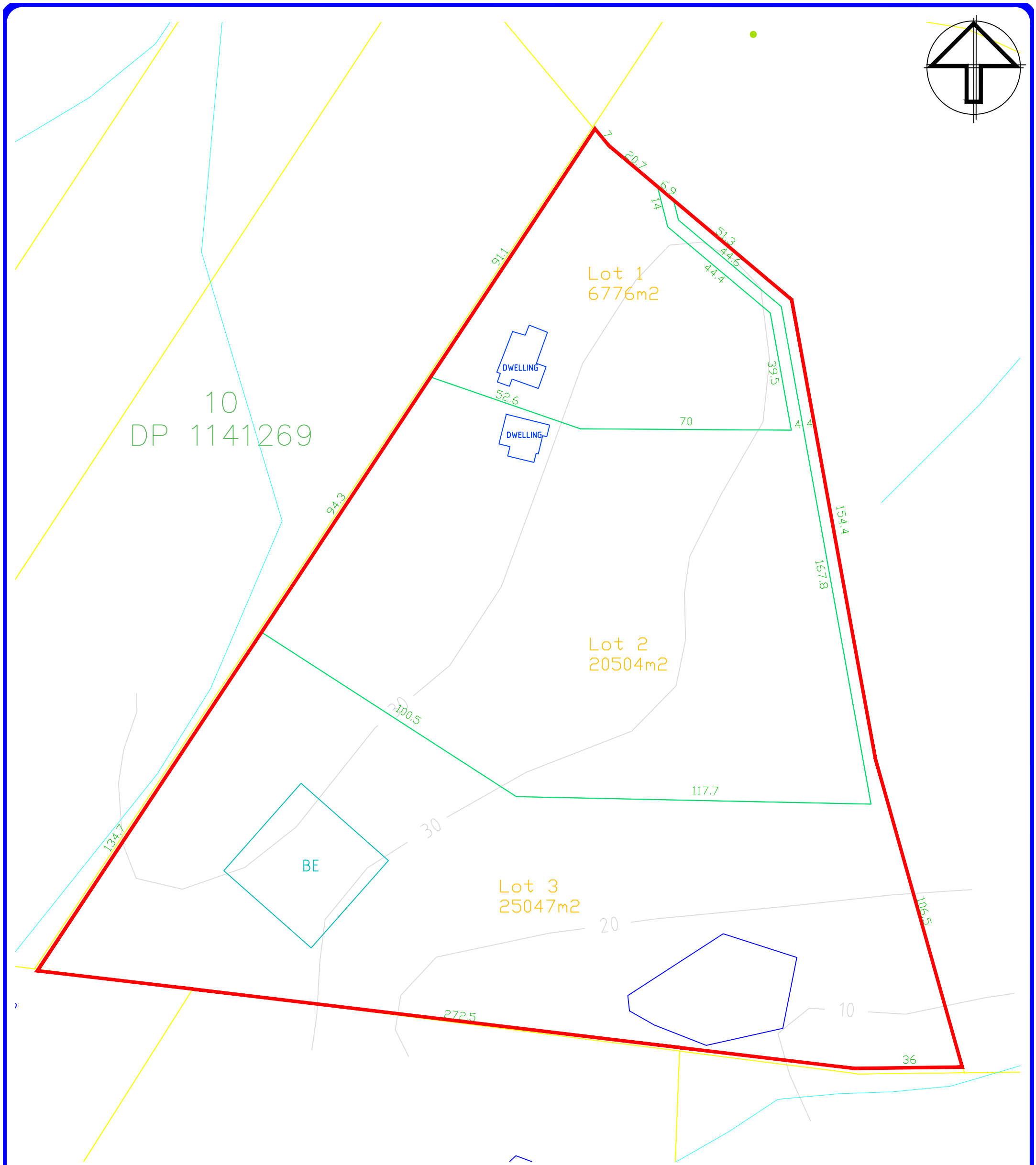
Adjacent Properties

Drainage Alignment

Dams

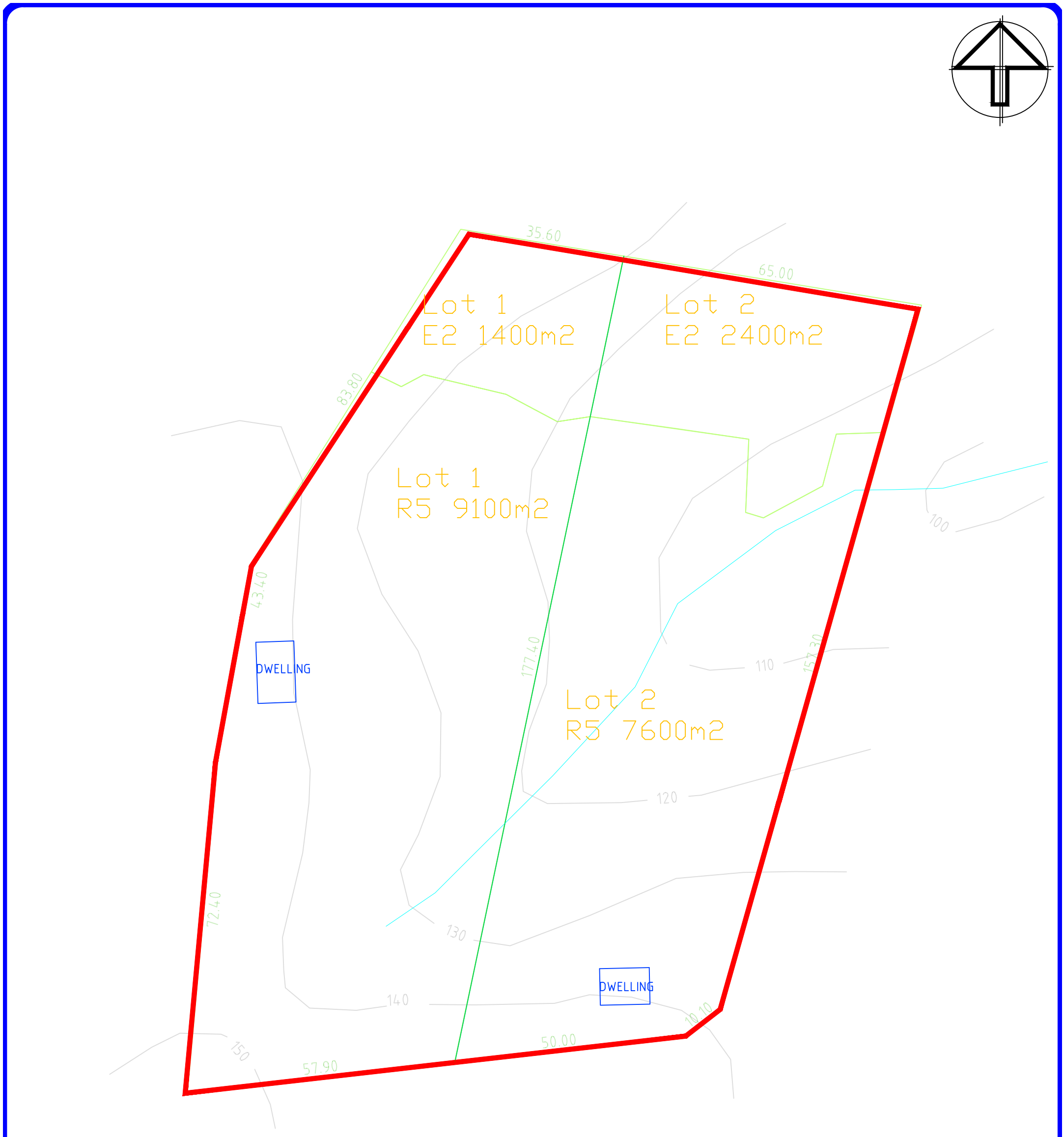
EARTH WATER CONSULTING

TITLE: Site Location			PROJECT: LCA for Proposed Subdivision of No. 9, 148 and 189 Gaudrons Road, Sapphire Beach		CLIENT: Bowen, Duce & Hunter
FIGURE: Figure 1					
SHEET: 1 OF 1	ISSUE: A	AUTHOR: SD	DATE: 30/10/20	SCALE: 1:7000	PROJECT: 2021-71

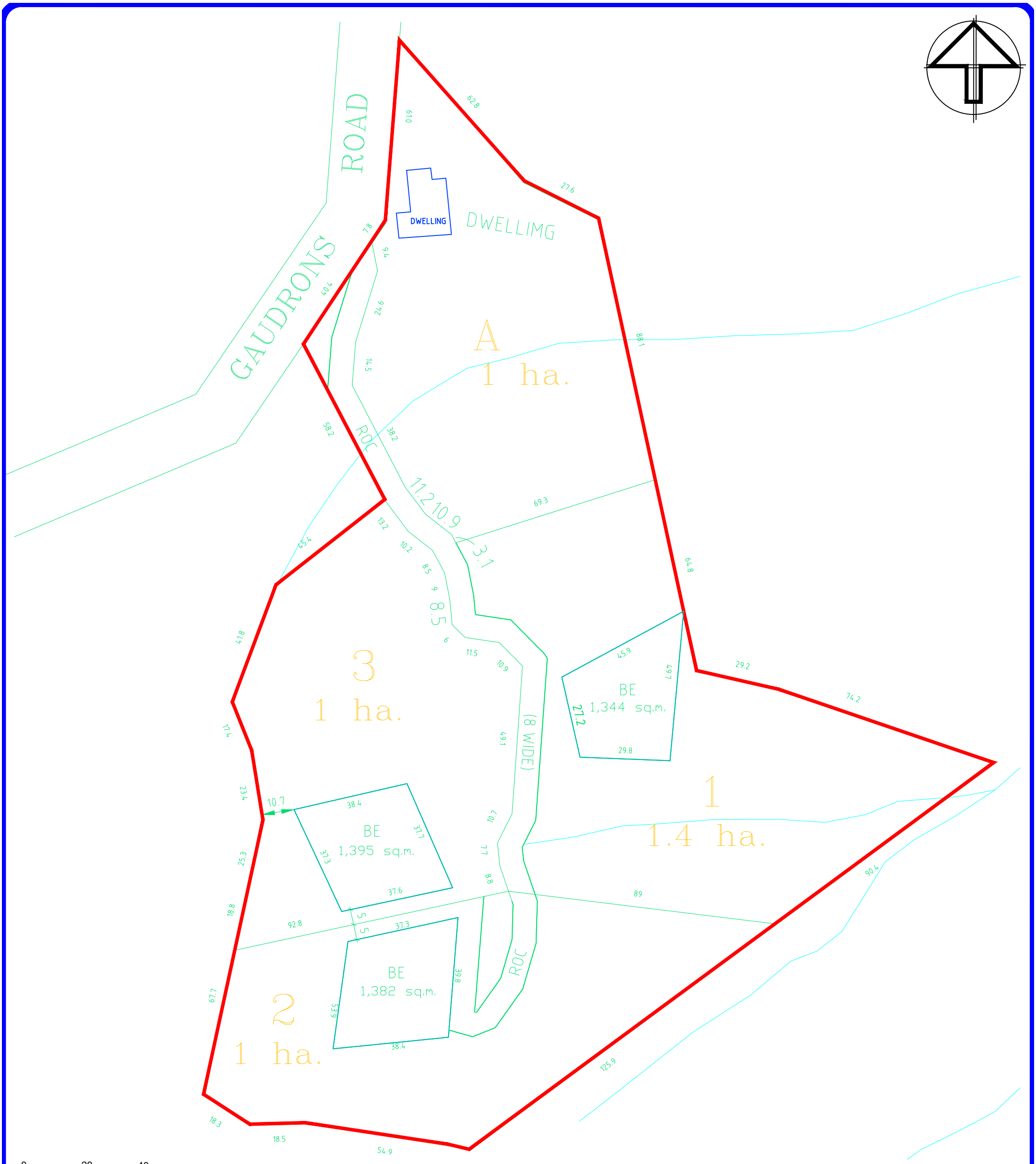


EARTH WATER CONSULTING

TITLE: No.9 Gaudrons Road Proposed Development Layout			FIGURE: Figure 2
			SHEET: 1 OF1 ISSUE: D
PROJECT: LCA for Proposed Subdivision of No. 9, 148 and 189 Gaudrons Road, Sapphire Beach			CLIENT: Bowen, Duce & Hunter
AUTHOR: SD	DATE: 15/6/21	SCALE: 1:1200	PROJECT: 2021-71



TITLE: No.148 Gaudrons Road Proposed Development Layout			FIGURE: Figure 3
			SHEET: 1 OF 1 / ISSUE: B
PROJECT: LCA for Proposed Subdivision of No. 9, 148 and 189 Gaudrons Road, Sapphire Beach			CLIENT: Bowen, Duce & Hunter
AUTHOR: SD	DATE: 15/6/21	SCALE: 1:800	PROJECT: 2021-71



TITLE: No.189 Gaudrons Road Proposed Development Layout			FIGURE: Figure 4
			SHEET: 1 OF1 ISSUE: A
PROJECT: LCA for Proposed Subdivision of No. 9, 148 and 189 Gaudrons Road, Sapphire Beach			CLIENT: Bowen, Duce & Hunter
AUTHOR: SD	DATE: 30/10/20	SCALE: 1:1200	PROJECT: 2021–71

APPENDIX 11 - LAND CAPACITY ASSESSMENT

0 20 40

Horizontal Scale (metres) 1:1200

LEGEND

- Property Boundary
- Contour Line (2m)
- Drainage Alignment
- Fenceline
- Existing Dwelling
- Existing Treatment Tank
- Existing EMA
- Slope % — Slope Direction
- Borehole Location

EARTH WATER CONSULTING

TITLE: No.9 Gaudrons Road Existing Property Layout			FIGURE: Figure 5
			SHEET: 1 OF1 ISSUE: B
PROJECT: LCA for Proposed Subdivision of No. 9, 148 and 189 Gaudrons Road, Sapphire Beach			CLIENT: Bowen, Duce & Hunter
AUTHOR: SD	DATE: 15/6/21	SCALE: 1:1200	PROJECT: 2021-71

0 16 24 36

Horizontal Scale (metres) 1:800

LEGEND

- Property Boundary
- Contour Line (2m)
- Drainage Alignment
- Fenceline
- Existing Dwelling
- Existing Treatment Tank
- Existing EMA
- Slope % — Slope Direction
- Borehole Location

EARTH WATER CONSULTING

TITLE: No.148 Gaudrons Existing Property Layout			FIGURE: Figure 6
			SHEET: 1 OF1 ISSUE: A
PROJECT: LCA for Proposed Subdivision of No. 9, 148 and 189 Gaudrons Road, Sapphire Beach			CLIENT: Bowen, Duce & Hunter
AUTHOR: SD	DATE: 30/10/20	SCALE: 1:800	PROJECT: 2021-71

0 20 40

Horizontal Scale (metres) 1:1200

LEGEND

- Property Boundary
- Contour Line (2m)
- Drainage Alignment
- Fenceline
- Existing Dwelling
- Existing Treatment Tank (S)
- Existing EMA
- Slope % — Slope Direction
- Borehole Location

EARTH WATER CONSULTING

TITLE: No.189 Gaudrons Road Existing Property Layout			FIGURE: Figure 7
			SHEET: 1 OF1 ISSUE: A
PROJECT: LCA for Proposed Subdivision of No. 9, 148 and 189 Gaudrons Road, Sapphire Beach			CLIENT: Bowen, Duce & Hunter
AUTHOR: SD	DATE: 30/10/20	SCALE: 1:1200	PROJECT: 2021-71

APPENDIX 11 - LAND CAPACITY ASSESSMENT

160 Gaudrons Road

MLS 75-81 Gaudrons Road

39-41 and 45 Gaudrons Road

EARTH WATER CONSULTING

0 20 30 40

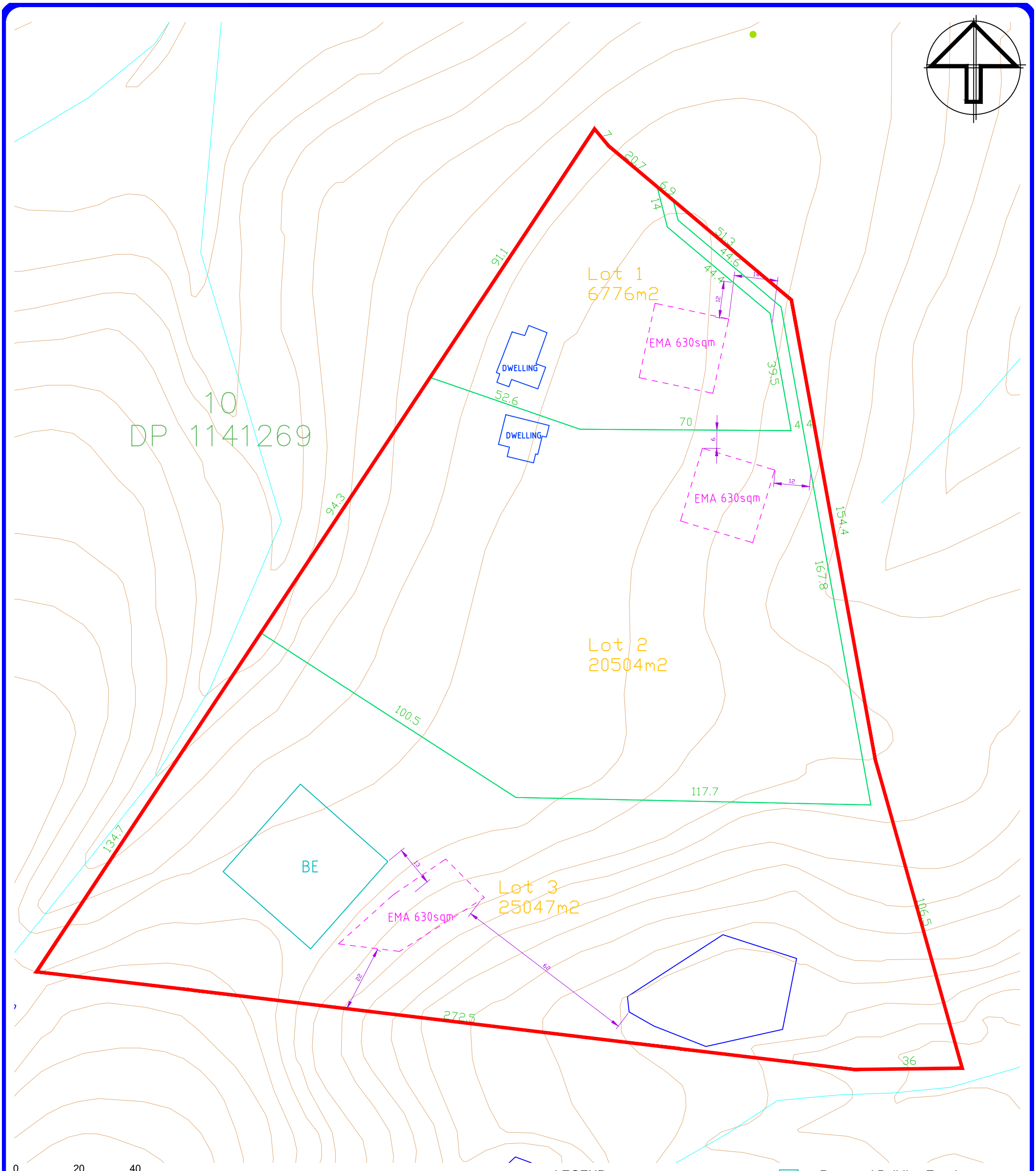
Horizontal Scale (metres) 1:1000

LEGEND

- Property Boundary
- Adjacent Lot
- Drainage Alignment
- EMA Restricted Area
- EMA Available Area

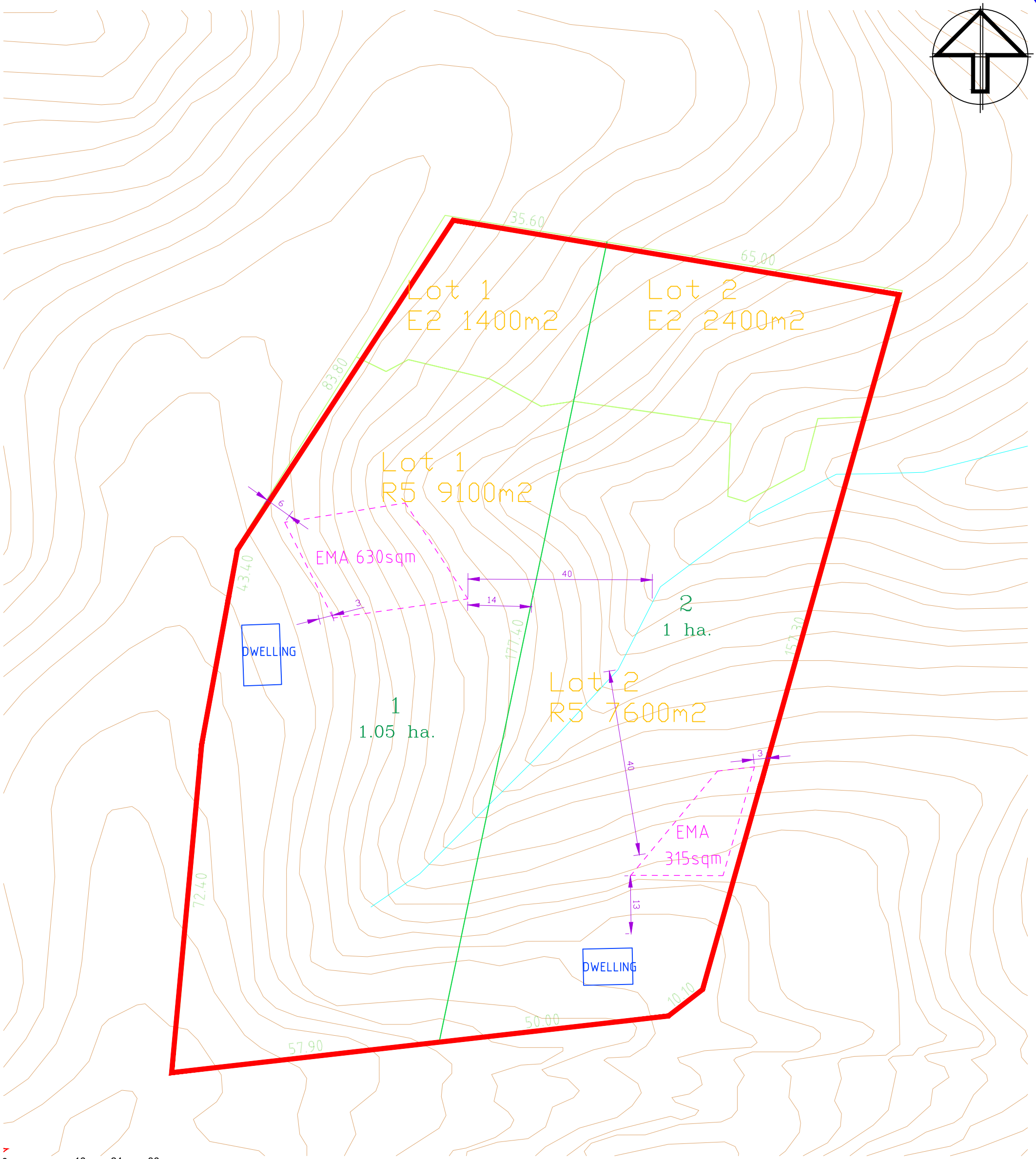
TITLE: Lot Size Comparisons			FIGURE: Figure 8
			SHEET: 1 OF1 ISSUE: A
PROJECT: LCA for Proposed Subdivision of No. 9, 148 and 189 Gaudrons Road, Sapphire Beach			CLIENT: Bowen, Duce & Hunter
AUTHOR: SD	DATE: 15/6/21	SCALE: 1:1000	PROJECT: 2021-71

APPENDIX 11 - LAND CAPACITY ASSESSMENT



EARTH WATER CONSULTING

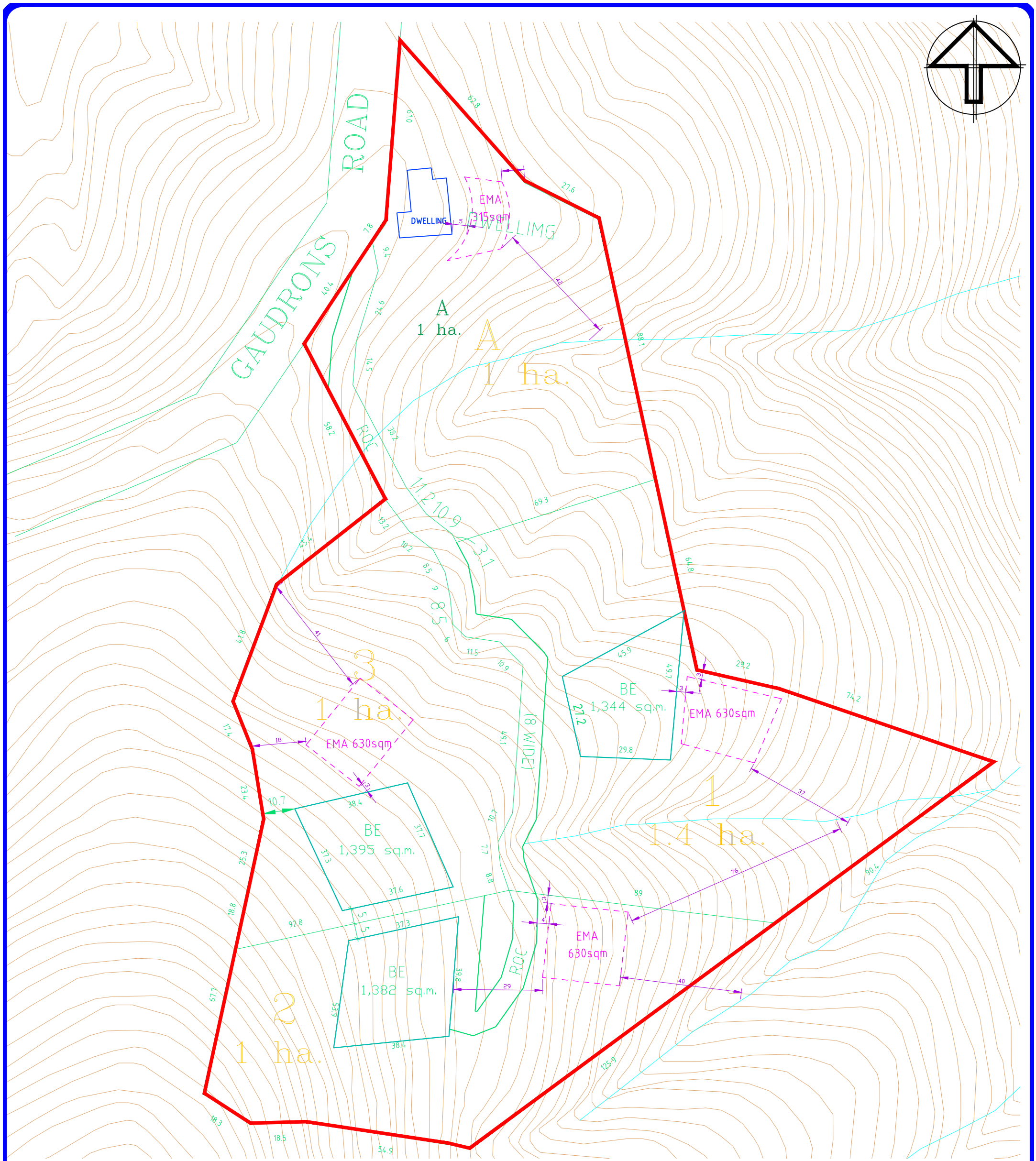
TITLE: No.9 Gaudrons Road Recommended Effluent Management Areas			FIGURE: Figure 9
			SHEET: 1 OF1 ISSUE: B
PROJECT: LCA for Proposed Subdivision of No. 9, 148 and 189 Gaudrons Road, Sapphire Beach			CLIENT: Bowen, Duce & Hunter
AUTHOR: SD	DATE: 15/6/21	SCALE: 1:1200	PROJECT: 2021-71



EARTH WATER CONSULTING

TITLE: No.148 Gaudrons Road Recommended Effluent Management Area			FIGURE: Figure 10
			SHEET: 1 OF1 ISSUE: A
PROJECT: LCA for Proposed Subdivision of No. 9, 148 and 189 Gaudrons Road, Sapphire Beach			CLIENT: Bowen, Duce & Hunter
AUTHOR: SD	DATE: 25/11/20	SCALE: 1:800	PROJECT: 2021-71

APPENDIX 11 - LAND CAPACITY ASSESSMENT



0 20 40

Horizontal Scale (metres) 1:1200

LEGEND

- Property Boundary
- Subdivision Boundary
- Intermittent Drainage
- BE — Proposed Building Envelope
- Recommended Effluent Management Area

EARTH WATER CONSULTING

TITLE: No.189 Gaudrons Road Recommended Effluent Management Area			FIGURE: Figure 11
			SHEET: 1 OF1 ISSUE: B
PROJECT: LCA for Proposed Subdivision of No. 9, 148 and 189 Gaudrons Road, Sapphire Beach			CLIENT: Brown, Duce & Hunter
AUTHOR: SD	DATE: 15/6/21	SCALE: 1:1200	PROJECT: 2021-71

APPENDIX A

APPENDIX 11 - LAND CAPACITY ASSESSMENT

Soil Borelog

Borehole No:	**BH1**
Logged by:	SD
Drilling date:	2/11/2020
Drilling method:	Hand auger
Borehole location:	
Borehole coords:	513868, 6655678

Project ref:	2021-97
Client:	Bowen, Duce & Hunter
Address:	No. 9 Gaudrons Road

PROFILE DESCRIPTION

Depth (m)	Sampling depth/name	Graphic Log	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1			A1	Clay Loam	Strong	Dark Choc Brown	Nil	<10%	SM	Topsoil
0.2			A2	Clay Loam	Strong	Pale Brown	Slight OB	<10%	SM	Colluvium
0.3	S		B1	Light Clay	Strong	Pale Brown	OB	<10% qtz	SM	Residual
0.4										
0.5			B2	Light Clay	Strong	Orange Brown	Reddish Brown	<5%	SM	Residual
0.6										
0.7	S									
0.8										
0.9			B3	Medium Clay	Strong / Moderate	Pale Grey	Strong RB	<5%	SM	Residual
1.0										
1.1										
1.2										
1.3					Borehole terminated at 1.2m					
1.4										
1.5										

Moisture condition

D	Dry	M	Moist	W	Wet / saturated
SM	Slightly moist	VM	Very moist		

APPENDIX 11 - LAND CAPACITY ASSESSMENT

Soil Borelog

Borehole No:	**BH2**
Logged by:	SD
Drilling date:	2/11/2020
Drilling method:	Hand auger
Borehole location:	
Borehole coords:	514062, 6653710

Project ref:	2021-97
Client:	Bowen, Duce & Hunter
Address:	No. 9 Gaudrons Road

PROFILE DESCRIPTION

Depth (m)	Sampling depth/name	Graphic Log	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1			A1	Clay Loam	Strong	Dark Choc Brown	Nil	<10%	SM	Topsoil
0.2	S		B1	Light Clay	Strong	Orange Brown	Reddish Brown	<5%	SM	Residual
0.3										
0.4										
0.5										
0.6										
0.7										
0.8			B2	Medium Clay to Silty Clay	Strong / Moderate	Pale Grey	Strong RB	5-30% Phyllite	SM	Residual grading to XW Bedrock
0.9										
1.0										
1.1	S									
1.2										
1.3					Borehole terminated at 1.2m					
1.4										
1.5										

Moisture condition

D	Dry	M	Moist	W	Wet / saturated
SM	Slightly moist	VM	Very moist		

APPENDIX 11 - LAND CAPACITY ASSESSMENT

Soil Borelog

Borehole No:	**BH3**
Logged by:	SD
Drilling date:	2/11/2020
Drilling method:	Hand auger
Borehole location:	
Borehole coords:	514046, 6655837

Project ref:	2021-97
Client:	Bowen, Duce & Hunter
Address:	No. 9 Gaudrons Road

PROFILE DESCRIPTION

Depth (m)	Sampling depth/name	Graphic Log	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1			A1	Clay Loam	Strong	Dark Choc Brown	Nil	<10%	SM	Topsoil
0.2			B1	Light Clay	Strong	Orange Brown	Reddish Brown	<5%	SM	Residual
0.3										
0.4										
0.5										
0.6										
0.7										
0.8			B2	Medium Clay to Silty Clay	Strong / Moderate	Pale Grey	Strong RB	5-30% Phyllite	SM	Residual grading to XW Bedrock
0.9										
1.0										
1.1										
1.2										
1.3					Borehole terminated at 1.2m					
1.4										
1.5										

Moisture condition

D	Dry	M	Moist	W	Wet / saturated
SM	Slightly moist	VM	Very moist		

APPENDIX 11 - LAND CAPACITY ASSESSMENT

Soil Borelog

Borehole No:	**BH4**
Logged by:	SD
Drilling date:	2/11/2020
Drilling method:	Hand auger
Borehole location:	
Borehole coords:	512714, 6656125

Project ref:	2021-97
Client:	Bowen, Duce & Hunter
Address:	No.148 Gaudrons Road

PROFILE DESCRIPTION

Depth (m)	Sampling depth/name	Graphic Log	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1			A1	Sandy Clay Loam	Moderate	Dark Brown	Nil	5-20%	D	Topsoil
0.2			B1	Sandy Clay Loam	Strong	Brown	Nil	5-20%	SM	Colluvium
0.3	S									
0.4										
0.5										
0.6										
0.7			B2	Silty Clay	Moderate	Pale Yellow Brown	Pale Grey	5-30%	D	XW Bedrock
0.8										
0.9										
1.0										
1.1										
1.2										
1.3					Borehole terminated at 1.2m					
1.4										
1.5										

Moisture condition

D	Dry	M	Moist	W	Wet / saturated
SM	Slightly moist	VM	Very moist		

APPENDIX 11 - LAND CAPACITY ASSESSMENT

Soil Borelog

Borehole No:	**BH5**
Logged by:	SD
Drilling date:	2/11/2020
Drilling method:	Hand auger
Borehole location:	
Borehole coords:	512560, 6655625

Project ref:	2021-97
Client:	Bowen, Duce & Hunter
Address:	No.189 Gaudrons Road

PROFILE DESCRIPTION

Depth (m)	Sampling depth/name	Graphic Log	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1			A1	Clay Loam	Strong	Black	Nil	<10%	SM	Topsoil
0.2										
0.3			A2	Clay Loam	Strong	Pale Brown	Nil	5-40%	SM	Colluvium
0.4										
0.5			B1	Light Clay	Strong	Strong Orange Brown	Nil	5-40%	SM	Residual
0.6	S									
0.7										
0.8										
0.9										
1.0			B2	Light Clay / Silty Clay	Strong	Pale Orange Brown	Yellow	<5%	SM	Residual
1.1										
1.2										
1.3			Borehole terminated at 1.2m							
1.4										
1.5										

Moisture condition

D	Dry	M	Moist	W	Wet / saturated
SM	Slightly moist	VM	Very moist		

APPENDIX 11 - LAND CAPACITY ASSESSMENT

Soil Borelog

Borehole No:	**BH6**
Logged by:	SD
Drilling date:	2/11/2020
Drilling method:	Hand auger
Borehole location:	
Borehole coords:	512675, 6655655

Project ref:	2021-97
Client:	Bowen, Duce & Hunter
Address:	No.189 Gaudrons Road

PROFILE DESCRIPTION

Depth (m)	Sampling depth/name	Graphic Log	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1			A1	Clay Loam	Strong	Dark Brown	Nil	<10%	SM	Topsoil
0.2			B1	Sandy Clay	Strong	Pale Orange	Yellow Brown	<5%	SM	Residual
0.3										
0.4										
0.5										
0.6										
0.7										
0.8								5-25%		
0.9										
1.0									VM	
1.1					Borehole refusal at 1m on gravel					
1.2										
1.3										
1.4										
1.5										

Moisture condition

D	Dry	M	Moist	W	Wet / saturated
SM	Slightly moist	VM	Very moist		

APPENDIX B

APPENDIX 11 - LAND CAPACITY ASSESSMENT

WASTEWATER DISPOSAL SOIL ASSESSMENT

2 samples supplied by Earth Water Consulting Pty Limited on 11/11/2020 - Lab Job No. K0461
Analysis requested by Strider Duerinckx. - **Your Project: Ref: 2021-71**
PO Box 50 BELLINGEN NSW 2454

	SAMPLE 1 BH1 0.6-0.8	**SAMPLE 2 BH5 0.5-0.8**
Job No.	*K0461/1*	*K0461/2*
Description	Medium Clay	Medium Clay
Moisture Content (% moisture)	19	24
Emerson Aggregate Stability Test (SAR 5 Solution) note 12	EAST Class 3/6, Slake 3 [see note 12]	EAST Class 3/6, Slake 3 [see note 12]
Soil pH (1:5 $CaCl_2$)	4.36	4.33
Soil Conductivity (1:5 water dS/m)	0.069	0.047
Soil Conductivity (as EC_e dS/m) [note 10]	0.589	0.407
Native NaOH Phosphorus (mg/kg P)	6.62	8.13
Residual phosphorus remaining in solution from the initial phosphate phosphorus		
Initial Phosphorus concentration (ppm P)	**29.2**	**29.2**
72 hour - 3 Day (ppm P)	11.36	5.96
120 hour - 5 Day (ppm P)	10.96	5.21
168 hour - 7 Day (ppm P)	10.24	5.09
Equilibrium Phosphorus (ppm P)	9.64	4.34
EXCHANGEABLE CATIONS		
Calcium (cmol+/kg)	2.73	1.52
Magnesium (cmol+/kg)	0.87	1.75
Potassium (cmol+/kg)	0.23	0.31
Sodium (cmol+/kg)	0.10	0.12
Aluminium (cmol+/kg)	4.84	3.43
Hydrogen (cmol+/kg)	0.23	0.15
ECEC (effective cation exchange capacity)(cmol+/kg)	9.0	7.3
Exchangeable Calcium %	30.3	20.9
Exchangeable Magnesium %	9.7	24.1
Exchangeable Potassium %	2.5	4.2
Exchangeable Sodium % (ESP)	1.2	1.7
Exchangeable Aluminium %	53.7	47.2
Exchangeable Hydrogen %	2.6	2.0
Calcium/ Magnesium Ratio	3.13	0.87

Notes:

1: ECEC = Effective Cation Exchange Capacity = sum of the exchangeable Mg, Ca, Na, K, H and Al

2: Exchangeable bases determined using standard Ammonium Acetate extract (Method 15D3) with no pretreatment for soluble salts. When Conductivity ≥0.25 dS/m soluble salts are removed (Method 15E2).

3. ppm = mg/kg dried soil

4. Insitu P determined using 0.1M NaOH and shaking for 24 hrs before determining phosphate

5. Soils were crushed using a ceramic grinding head and mill; five 1g subsamples of each soil were used to which 40ml of 0.1M NaCl with Xppm phosphorus was added to each. The samples were shaken on an orbital shaker

6. Exchangeable sodium percentage (ESP) is calculated as sodium (cmol+/kg) divided by ECEC

7. All results as dry weight DW - soils were dried at 6OC for 48hrs prior to crushing and analysis.

8. Phosphorus Capacity method from Ryden and Pratt, 1980.

9. Aluminium detection limit is 0.05 cmol+/kg; Hydrogen detection limit is 0.1 cmol+/kg. However for calculation purposes a value of 0 is used.

10. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm; EC_e conversions: sand loam 14, loam 9.5; clay loam 8.6; heavy clay 5.8

11. 1 cmol+/kg = 1 meq/100g

12. Emerson Aggregate Stability Test (EAST) for Wastewater applications (see Sheet 3 - Patterson, 2015). MEAT Class 1: Slaking, complete dispersion; Class 2: Slaking, some dispersion; Class 3-6: Slaking 1 slight to 3 complete, No dispersion; Class 7: No slaking, yes swelling; Class 8: No slaking, no swelling.

13. Analysis conducted between sample arrival date and reporting date.

14. .. Denotes not requested.

15. This report is not to be reproduced except in full.

16. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer scu.edu.au/eal or on request).

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WORLD RECOGNISED ACCREDITATION
Accreditation No. 14960
Accredited for compliance with ISO/IEC 17025 - Testing

Checked:.....

PHOSPHORUS SORPTION TRIAL

2 samples supplied by Earth Water Consulting Pty Limited on 11/11/2020 - Lab Job No. K0461
Analysis requested by Strider Duerinckx. - Your Project: Ref: 2021-71

Calculations for Equilibrium Absorption Maximum for Soil provided

I.D.	JOB NO.	Equilibrium P mg P/L (in solution)	Added P mg P/L	P Sorb at Equil. mg P/kg	Native P mg P/kg	Equilibrium P Sorption Level µg P/g soil	Divide Ø (from Table)	Equilibrium Absorption Maximum (B) µg P/g soil
BH1 0.6-0.8	**K0461/1**	9.6	29.2	782	7	789	0.76	**1,032**
BH5 0.5-0.8	**K0461/2**	4.3	29.2	994	8	1002	0.65	**1,552**

Calculations for phosphorus sorption capacity

	JOB NO.	Equilibrium Absorption Maximum (B µg P/g soil	multiply by theta of wastewater to be applie (=X)	minus the native P (=Y)	**kg P sorption / hectare (to a depth of 15cm)** (1.95 is a correction factor for density, etc	**kg P sorption / hectare (to a depth of 100cm)** (1.95 is a correction factor for density, etc)
BH1 0.6-0.8	*K0461/1*	1032	(=B x theta)	(=X -native P)	(=Y x 1.95)	(=Y x 1.95 x 100/15)
BH5 0.5-0.8	*K0461/2*	1552	(=B x theta)	(=X - native P)	(=Y x 1.95)	(=Y x 1.95 x 100/15)

EXAMPLE 1 - Calculations for phosphorus sorption capacity using a wastewater phosphorus of 15mg/L P

	JOB NO.	Equilibrium Absorption Maximum (B µg P/g soil	multiply by theta of wastewater to be applie (ie. 0.84)	minus the native P (=Y)	**kg P sorption / hectare (to a depth of 15cm)** (1.95 is a correction factor for density, etc	**kg P sorption / hectare (to a depth of 100cm)** (1.95 is a correction factor for density, etc)
BH1 0.6-0.8	*K0461/1*	1032	867	860	**1,678**	**11,186**
BH5 0.5-0.8	*K0461/2*	1552	1304	1296	**2,526**	**16,842**

Checked:.....

APPENDIX C

APPENDIX 11 - LAND CAPACITY ASSESSMENT

Nominated Area Water Balance & Storage Calculations

Site Address: **9, 148 and 189 Gaudrons Road, Sapphire Beach** **Proj Ref:** 2021-71

Notes:

Flow Allowance		150	l/p/d
No. of bedrooms		4	bdr
Occupancy		1.5	p/room
Design Wastewater Flow	Q	900	L/day
Daily DLR		12.0	mm/day
Crop Factor	C	0.6-0.8	unitless
Retained Rainfall Coefficient	RRc	0.85	untiless
Void Space Ratio	V	0.3	unitless
Nominated Land Application Area	N	85	sqm
Trench/Bed wetted thickness	Ww	0.15	m
Rainfall Data	Coffs Harbour Rainfall Data (monthly median)		
Evaporation Data	Coffs Harbour MO- Average		

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Days in month	D	\	days	31	28	31	30	31	30	31	31	30	31	30	31	**365**
Median Rainfall	R	\	mm/month	151.2	179	205.1	135.9	117.4	90	54.3	40.7	35.4	74.7	130.4	114.1	1612.2
Average Evaporation	E	\	mm/month	192.2	156.8	148.8	117	86.8	69	77.5	105.4	135	161.2	171	192.2	**0**
Crop Factor	C			0.80	0.80	0.80	0.70	0.70	0.60	0.60	0.60	0.70	0.70	0.80	0.80	
OUTPUTS																
Evapotranspiration	ET	ExC	mm/month	154	125	119	82	61	41	47	63	95	113	137	154	**1189.94**
Percolation	B	DLRxD	mm/month	372.0	336	372.0	360.0	372.0	360.0	372.0	372.0	360.0	372.0	360.0	372.0	**4380.0**
Outputs		ET+B	mm/month	525.8	461.44	491.0	441.9	432.8	401.4	418.5	435.2	454.5	484.8	496.8	525.8	**5569.9**
INPUTS																
Retained Rainfall	RR	R*RRc	mm/month	128.52	152.15	174.335	115.515	99.79	76.5	46.155	34.595	30.09	63.495	110.84	96.985	**1128.97**
Effluent Irrigation	W	(QxD)/L	mm/month	328.2	296.5	328.2	317.6	328.2	317.6	328.2	328.2	317.6	328.2	317.6	328.2	**3864.7**
Inputs		RR+W	mm/month	456.8	448.6	502.6	433.2	428.0	394.1	374.4	362.8	347.7	391.7	428.5	425.2	**4993.7**
STORAGE CALCULATION																
Storage remaining from previous month			mm/month		0.0	0.0	38.4	9.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Storage for the month	S	(RR+W)-(ET+B)	mm/month	-230.0	-42.7	38.4	-29.1	-15.8	-24.2	-147.0	-241.4	-355.9	-310.4	-227.7	-335.1	**-461.8**
Cumulative Storage	M		mm	0.0	0.0	38.4	9.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**47.7**
Maximum Bed Storage Depth for Area	BS		mm	**38.43**	Is the calculated storage acceptable?			Yes, storage is conservative								

Nominated trench width	1.2	
Total length based on nominated width	70.8	
No. of beds	4	
Individual bed lengths	17.7	
Individual Bed footprints	21.3	
Spacing between beds	1.5	
Total bed area	165	
Nutrient uptake zone	289	2m buffer nutrient uptake allowance

Nutrient Balance

Proj Ref: 2021-71

Site Address: 9, 148 and 189 Gaudrons Road, Sapphire Beach

Notes:

INPUT DATA

Hydraulic Load		900	L/Day	
Effluent N Concentration		30	mg/L	
% Lost to Soil Processes		0.2	Decimal	
Total N Loss to Soil		5400	mg/day	
Effluent P Concentration		12	mg/L	
Design Life of System		50	yrs	
Crop N Uptake	250	kg/ha/yr =	68	$mg/m^2/day$
Crop P Uptake	25	kg/ha/yr =	7	$mg/m^2/day$
P-sorption analytical result in soil		11500	kg/ha	
% of Predicted P-sorp		0.5	Decimal	

Nitrogen Balance

Nitrogen uptake ability in vegetation	68	$mg/m^2/day$
Nitrgen loading in wastewater	21600	mg/day
Area required for nitrogen	**315**	m^2

Phosphorus Balance

P adsorbed	0.575	kg/m^2
P uptake	0.125	kg/m^2
P generated	219	kg
Area required for Phosphorus	**313**	m^2