Shire of Chittering
Local Planning Scheme No. 6

Scheme Amendment Request



Prepared for Riverside Investments (WA) No 2 Pty Ltd
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Lot 2 Reserve Road

Scheme Amendment Request

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Section

1.0

Introduction

1.0 Introduction

This report has been prepared in support of a Scheme Amendment request to the *Shire of Chittering Local Planning Scheme No.6* (LPS 6) for Lot 2 Reserve Road, Chittering (the subject site).

The Amendment seeks to apply the 'R5' residential density code over an undeveloped portion of Lot 9002 Reserve Road, and to modify the Military Considerations (RAAF) Special Control Area.

The Scheme Amendment request is suitable for the land taking into account:

- The subject site is capable of being provided with reticulated potable water and power;
- The upcoding would provide for a mix of low-density lot sizes;
- Modifications to the Special Control Area will make the scheme provisions more fit-for-purpose, and reduce the need for "any development" from needing development approval; and
- This recoding and an amendment to the Structure Plan will ensure that development of the subject site is delivered in a coordinated manner.

The subject site is strategically important for the local government area as it is in proximity to the Muchea Industrial Park, and provides housing opportunities and choice for residents interested in living within the region. The subject site has a strong relationship with existing and future strategic infrastructure, investment and economic activity. In addition, the subject site enjoys improved accessibility and travel times due to the completion of NorthLink WA. The Scheme Amendment will leverage upon these opportunities.

The Scheme Amendment is submitted in parallel with a Structure Plan amendment. These amendments were prepared to ensure that the modifications are aligned and ensure coordination between the LPS 6 and the Lot 2 Reserve Road and Lot 9001 Rosewood Drive Structure Plan. This ensures orderly and proper planning of the subject site and its future subdivision and development outcomes.

1.1 The Proponent, Legal Description and Ownership

1.1.1 Subject Site

The Scheme Amendment refers to the site that originally was known to as Lot 2, No. 200 Reserve Road Chittering, depicted in Figure 1 and Figure 2. A subdivision approval was granted in 2016 for 105 residential lots on a portion of Lot 2 Reserve Road. One homestead lot, one public drinking water source lot, and 30 lots have since been created as detailed in Appendix H. A further 23 lots are under construction. The balance of the site is currently known as Lot 9002 Reserve Road.

1.1.2 Ownership

Riverside Investments (WA) No 2 Pty Ltd is the landowner of Lot 2 Reserve Road and Lot 9001 Rosewood Drive, and is the developer for the Wildflower Ridge Estate. Riverside Investments (WA) No 2 Pty Ltd was the proponent for the Scheme Amendment 55 and the Lot 2 Reserve Road and Lot 9001 Rosewood Drive Structure Plan.

Aqua Ferre (Muchea) Pty Ltd, trading as Muchea Water, is the Water License Holder. Muchea Water is a specific-purpose company that brings together water strategists, engineers, hydrologists, financiers and investors. Muchea Water's major shareholder is Riverside Investments (WA) No 2 Pty Ltd, which holds a 51% interest.

1.1.3 Legal Description and Ownership

One homestead lot, one public drinking water source lot, and 30 lots. A further 23 lots are under construction.

Relevant land details and legal descriptions of lots are contained in Appendix H.

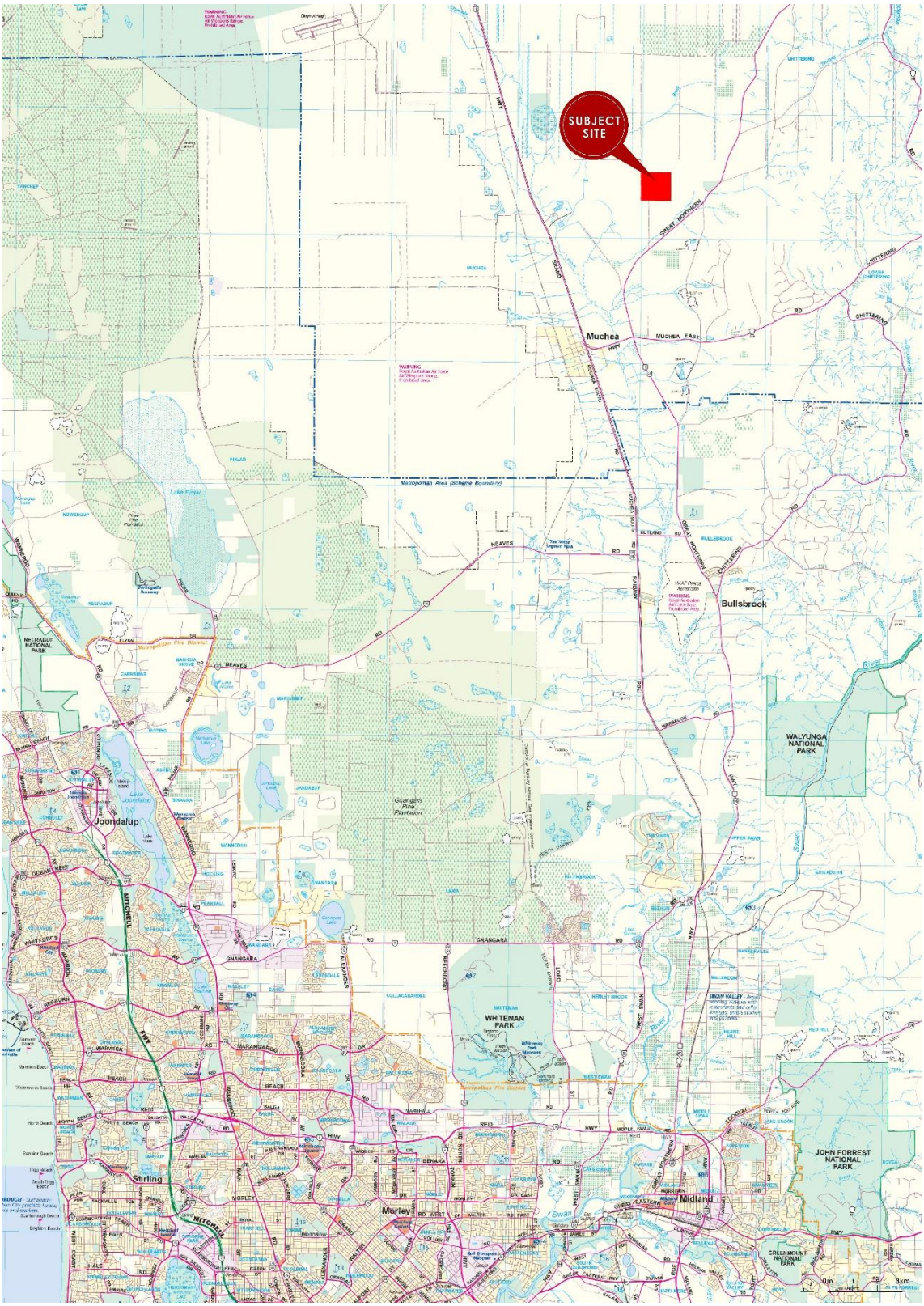


Figure 1 Location Plan

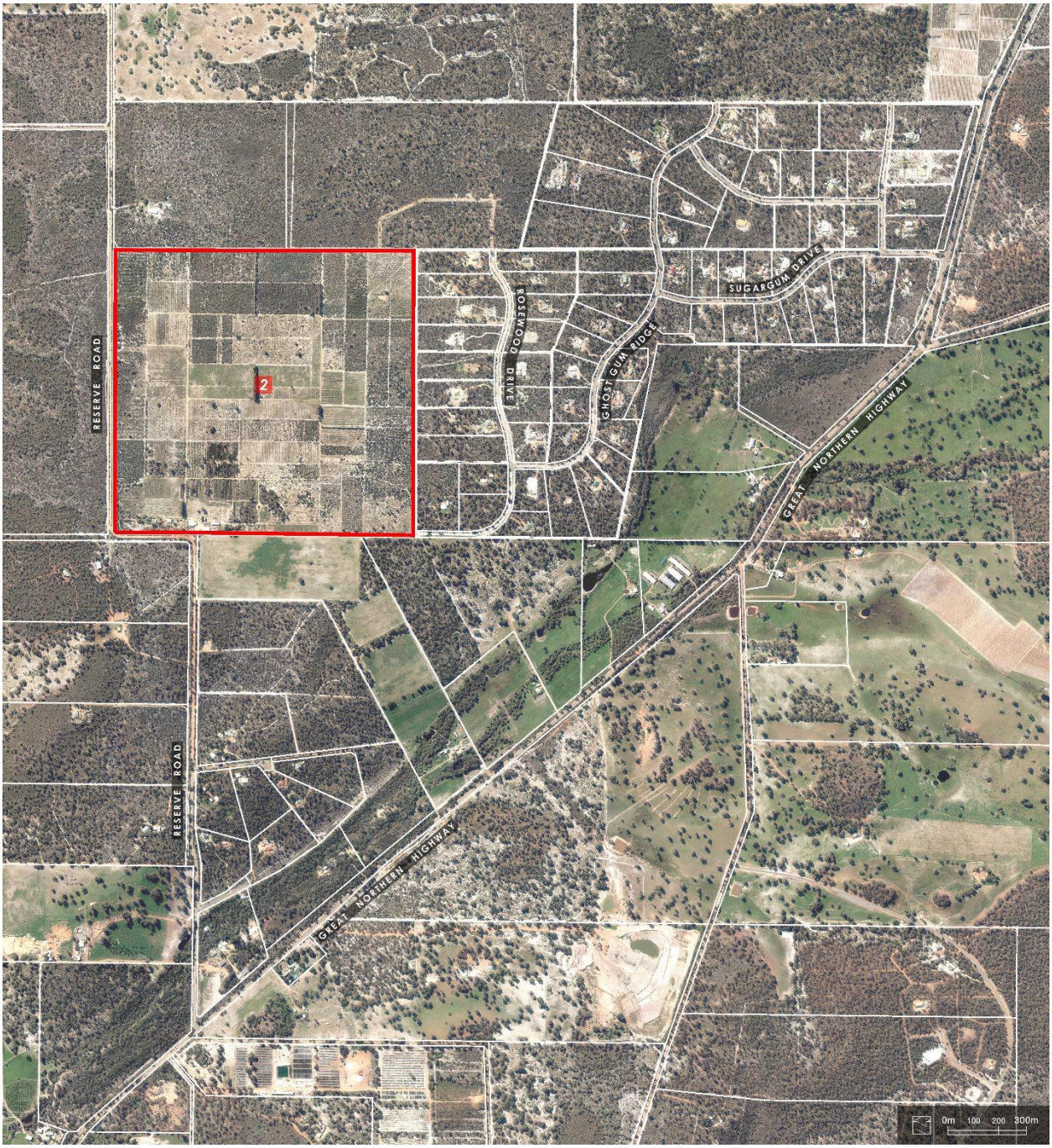


Figure 2 Aerial Photo

1.2 Background

Proposals for development of the subject site were progressed between 2007 and 2016 to facilitate use and development, as outlined below:

- The Shire of Chittering endorsed a development plan and fire management plan for Lot 2 Reserve Road on 17 December 2007.
- A subdivision application for Lot 2 Reserve Road was granted conditional approval by the WAPC on 20 December 2011 (WAPC ref: 145031) to facilitate the creation of 110 single residential lots and public open space. Lot sizes ranged from 7,503m^2 to 4 hectares, with an average lot size of 1.0417 hectares. The subdivision approval lapsed on 20 December 2015.
- The WAPC granted approval to a development plan for Lot 7 (now Lot 9001) Rosewood Drive in June 2009.
- A subdivision application for Lot 9001 Rosewood Drive was granted conditional approval by the Commission on 8 July 2013 (WAPC ref: 147754) to facilitate the creation of 45 single residential lots and public open space. Lot sizes ranged from 1-1.25 hectares, with an average lot size of 1.04 hectares. This subdivision approval lapsed on 8 July 2017.
- The WAPC granted approval to the Lot 2 Reserve Road and Lot 9001 Rosewood Drive Structure Plan on 3 May 2016. This determination was made by the WAPC pursuant to Part 4, clause 22(1)(a) of the Deemed Provisions. This Structure Plan remains in effect.
- Scheme Amendment 55 to the LPS 6 was gazetted on 18 March 2016. The Scheme Amendment rezoned Lot 2 Reserve Road to 'Residential R2' and Lot 9001 Rosewood Drive to 'Rural Conservation'. These zones are in effect.
- A subdivision application for Lot 2 Reserve Road was granted conditional approval by the WAPC on 23 November 2016 (WAPC ref: 153430). The subdivision proposed to create 105 residential lots, the public drinking water source site and the public open space area. The developer has acted on the subdivision approval insofar that the homestead lot, drinking water source site, and approximately half of the lots are in the process of being titled or are to be created. A recent amendment to the *Planning and Development Act 2005* came into effect on 8 July 2020 and some of those changes related to automatic extensions to subdivision approvals. The subdivision approval received a new expiry date until 23 November 2022 and remains in effect.

1.3 Other Approval Processes

1.3.1 Amendment to Structure Plan

The subject site will be developed for residential purposes in accordance with the Lot 2 Reserve Road and Lot 9001 Rosewood Drive Structure Plan. A Structure Plan amendment was submitted to the local government to ensure alignment with this Scheme Amendment request.

The Structure Plan is supported with several technical reports which are also appended to this Scheme Amendment:

- Site and Soil Evaluation (refer Appendix B);
- Local Water Management Strategy Addendum (refer Appendix C);
- Bushfire Management Plan (refer Appendix D);
- Landscape Masterplan (refer Appendix E);
- Traffic Report (refer Appendix F); and
- Environmental Assessment (refer Appendix G).

1.4 Pre-lodgement Consultation

1.4.1 Department of Planning, Lands and Heritage

On 17 June 2020, the proponent met with officers of the Department of Planning, Lands and Heritage. The proponent provided the Department with an overview of the proposal, a sketch of the amended Structure Plan, and confirmation of the process for the Scheme Amendment and Structure Plan amendment.

1.4.2 Shire of Chittering

A meeting with the proponent, TBB and officers of the Shire of Chittering was held on 2 July 2020. The proponent and TBB provided the Shire with an overview of the proposed amendments, a sketch of the amended Structure Plan, and a discussion in relation to the proposed lodgement of a Scheme Amendment and Structure Plan amendment to give effect to the modifications being sought.

The Shire's officers provided in-principle support to the proposed Scheme Amendment modifications, and offered to review draft documentation prior to formal lodgement. A copy of the draft Scheme Amendment request was submitted to the Shire's officers on 14 August 2020. In response, the Shire provided feedback and advice in respect to the proposed changes. Further, the Shire also suggested incorporating modifications to the Military Considerations SCA that the local government, Department of Planning, Lands and Heritage and Department of Defence had previously collaborated and updated. These are included as they also are relevant to the future development of housing within the Residential zoned land.

Section

2.0

Site & Context

2.0 Locational Context

2.1.1 Regional Context

The subject site is situated in the rapidly growing north-east region and is approximately 50km north of Perth, 22km south of the Bindoon townsite, and 40km south of Gingin. The Midland and Joondalup centres provide comprehensive commercial, retail and service opportunities. These centres and the Muchea Industrial Park also provide significant employment opportunities.

The subject site is well connected to Great Northern Highway, Brand Highway and NorthLink WA.

2.1.2 District Context

The subject site is located 2.5km north of the Great Northern Highway, between Chittering and Muchea. Bullsbrook, located approximately 20km to the south, is the largest centre within close proximity to the site.

Education facilities within a 20km radius include Gingin District High School (Kindergarten-Yr10), Bindoon Primary School (Kindergarten-Yr6) and Immaculate Heart College (Private, Kindergarten-Yr12). Toodyay District High School (Kindergarten-Yr10) is located 45km east of the subject site.

The subject site benefits from key health facilities located at Joondalup Private Hospital, St John of God Midland public and private hospitals and the Northam Regional Hospital. The subject site is also serviced by a number of health facilities located within a 20km radius at Gingin Medical Centre, Bindoon Medical Centre and Bullsbrook Family Medical Centre.

Local conveniences are provided at the Muchea IGA X-Press (within 10km from the site), Bullsbrook IGA, Bindoon IGA and Gingin IGA X-Press.

2.1.3 Local Context

Lot 9000 to the north and land fronting Rosewood Drive to the east is zoned 'Rural Residential' (refer Figure 3 in section 3.2.2). Lots fronting Rosewood Drive contain existing dwellings and outbuildings. Lot 9000 remains undeveloped.

To the north, Lot 9001 Rosewood Drive is zoned 'Rural Conservation' however remains undeveloped. Lot 9001 is part of the structure plan area.

Other large land parcels to the north, west and south of the subject site are zoned as 'Agricultural Resource' and 'Rural Conservation'.

The above reaffirms the strong relationship the site has with the existing regional, district and local context in support of the Structure Plan amendment and Scheme Amendment.

2.2 Site Conditions and Constraints

2.2.1 Site Description

The subject site is situated on the Dandaragan Plateau east of the Darling Scarp, in the Brockman River Catchment. The subject site occurs on low sand hills with slopes gently to the east, with topography varying from approximately 140m to 165m AHD.

The free draining sandy soils show no evidence of definable watercourses or streamlines. Rocky Creek to the south is the only nearby watercourse and any runoff would be by means of dissipated flows through the porous soils and percolation into the water table, which flows in a southerly direction to Rocky Creek and then to Ellen Brook.

Lot 2 Reserve Road, with the exception of some stands of trees, has been cleared of native vegetation due to it previously operating as a plant nursery. A brick and tile dwelling in the south west corner of the property has been retained throughout the Scheme Amendment 55 rezoning, endorsement of the Structure Plan, and subdivision.

2.2.2 Vegetation

360 Environmental were engaged to address environmental matters associated with the subject site as part of the related Structure Plan amendment process. A summary of the advice is outlined below:

- 360 Environmental notes that the development is in the Ellen Brook sub-catchment of the Swan – Avon Lower Swan catchment, however consider that this observation has no implications with regards to the adequacy of the findings of previous environmental reports;
- A previous flora survey was conducted and included in the previous environmental report section for the environmental vegetation survey; and
- 360 Environmental performed database searches as part of its review and it was found that none of the flora species listed in the previous report were considered for conservation significance.

2.2.2.1 Surveys

A basic ecological assessment was undertaken for Lot 2 Reserve Road by Belleng VDM Pty Ltd in December 2005. The report recommendations were reflected in the endorsed Structure Plan. A summary of the findings is outlined below:

- The existing vegetation on-site comprises a mosaic of planted vegetation, due to the site previously being a plant nursery. The site was highly disturbed by non-declared weedy grasses; and
- There was the identification of one mature Blackbutt (*Eucalyptus pilularis*) on the southern boundary of the site which may provide fauna habitat, however it was considered that given the isolation of the tree from surrounding areas it was unlikely to be used as habitat for expected fauna to inhabit the area.

2.2.2.2 Dieback Considerations

Based on the previous site investigations by VDM Environmental, there were no dieback implications over the subject site. However, the following dieback mitigation measures were proposed to be put in place whilst the site was being developed:

- Ensuring, by visual inspection and/or cleaning, that vehicles, plant and equipment, footwear and bicycles were cleaned when entering an un-infested area;
- Ensuring that any basic raw material (rock, stone, gravel, soils and sands) being used on-site were free of the plant pathogen;
- When planting seedlings that were sourced from nurseries, it is essential that plant stock is uninfected and sterilised soil is utilised. Care is taken during seedling transport to ensure that seedlings do not come into contact with infested soil or plants; and
- Water draining from areas likely to be infested should be directed away from un-infested areas.

2.2.3 Landform and Soils

2.2.3.1 Acid Sulfate Soils

The subject site is located in the Low to No Risk of Actual (ASS) and Potential Acid Sulfate Soils (PASS) at depths of >3m. In consideration of the topographical and geological location of the site coupled with the Low to No Risk classification of the land, acid sulfate soils are not considered to be a site constraint.

No potentially contaminating land uses and/or activities were identified and there were no records of contamination for the subject site. In the absence of visible signs of staining and/or residues at the surface of past and/or current contamination, no further assessments were deemed necessary.

2.2.3.2 Bulk Earthworks

Site works and earthworks have been undertaken in accordance with the subdivision approval. Other preparatory works for development would include the following:

- Demolition of selected existing outbuildings, slab structures and remnant improvements. The retained dwelling is within a created lot;
- Removal of reticulation and nursery/agricultural related services other than in areas where landscaping treatments will require the retention of vegetation (where appropriate and compliant with the Bushfire Management Plan); and
- Stripping and grubbing of areas to be earthworked and with due regard to vegetation retention and bushfire management.

Consideration of landscape treatments for road verges, common areas and site entries will be an important feature of the redevelopment strategy, being mindful of bushfire management requirements.

It is anticipated that the bulk earthwork operations for the Structure Plan area will be completed using available site materials with some importation of additional fill, if and as required.

2.2.4 Environmental Considerations

With respect to environmental considerations (refer to Appendix G), the following are relevant to the Scheme Amendment:

- Lot 2 Reserve Road has been cleared of remnant vegetation previously to facilitate its use as a plant nursery. As such, vegetation on-site is not representative of endemic vegetation complexes. Vegetation cover varied significantly and included open paddocks, scrub and shrubland. Vegetation will be cleared in accordance with the subdivision approval that is in effect, or other subdivision approvals as issued by the WAPC over time;
- A Site Soil Evaluation assessment (refer to Appendix B) was conducted to confirm the soil capability for on-site sewage treatment;
- A Local Water Management Strategy Addendum (LWMS, refer to Appendix C) has been prepared in support of the Structure Plan amendment; and
- Bush fire matters will be addressed by a Bushfire Management Plan (refer Appendix D) prepared in support of the Structure Plan. The upcoding is supported by the Bushfire Management Plan on the basis that it is capable of meeting the acceptable solutions under the current planning framework.

Section

3.0

Planning Framework

3.0 Planning Framework

3.1 State Planning Framework

3.1.1 SPP 3.0: Urban Growth and Settlement

SPP 3 guides the planning of urban settlements to promote sustainable and well-planned settlement patterns across the state; build on existing communities to concentrate services and infrastructure; manage growth and development of urban areas; promote sustainable and liveable neighbourhood forms; and to coordinate new development. This Scheme Amendment is consistent with these policy outcomes.

3.1.2 SPP 3.7: Planning in Bushfire Prone Areas

SPP 3.7 assists in identifying, addressing and reducing the risk of bushfire to people, property and infrastructure by encouraging a conservative approach to strategic planning, subdivision, development and other planning decisions within bushfire prone areas. The requirements of SPP 3.7 are addressed through the Lot 2 Reserve Road and Lot 9001 Rosewood Drive Structure Plan which has had regard to the provisions of the policy and its Guidelines. A Bushfire Management Plan has been prepared to support the Structure Plan amendment, which provides the necessary requirements for future subdivision and development.

3.1.3 Development Control Policy 2.2 Residential Subdivision

Development Control (DC) Policy 2.2 addresses requirements for the subdivision of land into residential lots. The policy facilitates the supply of residential lots with a housing diversity and mix of lot sizes which reflect the statutory provisions of local planning schemes, availability of reticulated sewerage, electricity and water and the need for frontage to public streets for access.

Residential subdivision will be guided by the Structure Plan. The amendment to the Lot 2 Reserve Road and Lot 9001 Rosewood Drive Structure Plan has also been prepared so that it would deliver residential lots that are:

- constructed in a consistent and coordinated approach throughout the Structure Plan area;
- delivered with a suitable level of amenity, services and access; and
- have regular shapes and lot sizes appropriate for the R2 and R5 density codings. The Structure Plan will seek to ensure lots are also oriented to maximise opportunities for passive solar design and other factors.

The Scheme Amendment is consistent with the relevant policy objectives and policy measures.

3.1.4 Development Control Policy 2.3 Public Open Space in Residential Areas

The basic component of DC Policy 2.3 – Public Open Space in Residential Areas (WAPC, 2002) is the requirement that the subdivider should give up 10% of the gross subdivisible area of a conditional subdivision, free of cost, for public open space. The principles of DC 2.3 apply within the subject site.

As per the endorsed Structure Plan, the local government did not support the physical provision of 10% Public Open Space. As a compromise, the developer proposed to enter into a deed of agreement with the local government to provide additional facilities within the proposed Public Open Space within Lot 2 Reserve Road. It is anticipated that the public open space within Lot 2 Reserve Road will be developed and will incorporate facilities and other infrastructure as per the deed of agreement.

Additionally, the developer proposed a 20-hectare Conservation Lot within Lot 9001 Rosewood Drive that would protect vegetation in perpetuity. The 20-hectare Conservation Lot is the equivalent of 10% land area of the Structure Plan area. It was understood the state and local governments did not wish to manage the Conservation Lot; thus it would be managed in accordance with the Nature Conservation Covenant Program.

3.1.5 Development Control Policy 2.5 Special Residential Zones

Having regard to DC Policy 2.5 – Special Residential Zones (WAPC, 1998) the Commission considers lots of between 2,000 square metres and one hectare can be created in suitable locations, to ensure that the use and development of such lots are subject to appropriate standards and controls, and to protect the character and amenity of adjacent rural areas. The Commission also considers such residential areas should have access to services and facilities.

As such, the developer and local government considered a deed of agreement as a suitable arrangement to provide additional facilities within the public open space, above the standard level of public open space as per WAPC policy. The amenity and character of adjacent rural areas is protected through the:

- management requirements of the Bushfire Management Plan;
- on-site detention and filtration of stormwater in accordance with the LWMS;
- provision of potable water supply via a licensed water provider; and
- low density scale of development being proposed.

3.1.6 Government Sewerage Policy

The *Government Sewerage Policy 2019* (DPLH, 2019) generally requires a connection to sewer but allows some exemptions. Exemptions apply for areas outside of public drinking water source areas and sewage sensitive areas, and without an established reticulated sewerage scheme. The Chittering locality does not have an established reticulated sewerage scheme and continuing from the original endorsed Structure Plan, alternative sewage treatment is proposed.

The policy measures of the *Government Sewerage Policy 2019* (DPLH, 2019) set a minimum lot size of 950m^2 and average lot size 1,000m^2 for unsewered residential areas, and therefore the minimum and average lot sizes at the R2 and R5 density codes can be accommodated.

From the *Supplementary Geotechnical Report (Winter) – Lot 2 Reserve Road Chittering* (CMW Geosciences, 2016) the soils were classified as sandy over laterite. Therefore, the soil categories 4 (clay loams), 5 (light clays), and 6 (medium to heavy clay) referred to in the *Government Sewerage Policy* do not apply. This ensures that the site is suitable for alternative sewerage treatment.

The *Government Sewerage Policy* refers to a 30m buffer to the drinking water site. This 30m buffer is self-contained within the site as provided within the dimensions of the created lot.

3.1.7 Muchea Employment Node Structure Plan

The *Muchea Employment Node Structure Plan* (WAPC, 2011) provides a 20-year land use planning framework for serviced based uses such as transport, livestock, fabrication, warehousing, wholesaling and general commercial use.

It is recognised that the Muchea Employment Node (Muchea Industrial Park) should be supported by a local workforce. Population growth within the Shire is seen as an important contributor towards ensuring jobs are taken up by residents, with the proposed development assisting in attracting new residents to the area.

3.2 Local Planning Framework

3.2.1 Local Planning Strategy

The Shire of Chittering Local Planning Strategy was endorsed by the Western Australian Planning Commission on 10 October 2019, and replaced the previous strategy endorsed in 2004. It establishes the direction for future population growth and sets out broad strategies and actions for housing, industrial and business uses. It outlines the settlement pattern, as well as environmental protection and bushfire risk management.

The Local Planning Strategy identifies:

- the subject site to be within the Reserve Road planning precinct;
- the Lot 2 Reserve Road & Lot 9001 Rosewood Drive Structure Plan, which is acknowledged by the Strategy;
- Lot 2 Reserve Road is identified for Residential; and

- Lot 9001 Rosewood Drive is identified for rural residential with the identified conservation lot as an indicative high conservation value area and the balance of the lot depicted for environmental conservation.

The Local Planning Strategy discusses the Reserve Road planning precinct to support future serviced residential development and associated facilities. The Strategy supports appropriate linkages with existing subdivisions and to plan for provision of additional community facilities and services for the future population. These matters are addressed by the Structure Plan. It is considered that the Scheme Amendment request is consistent with and suitably contemplated by the Local Planning Strategy.

3.2.2 Local Planning Scheme No. 6

3.2.2.1 Existing zoning

The subject site is currently zoned 'Residential R2' under the Shire of Chittering Local Planning Scheme No. 6, refer to Figure 3. The objectives of the 'Residential R2' zone are:

> *"To designate areas for low density residential development in a rural setting, in which natural environmental values are conserved as far as possible.*
>
> *To meet the demand for lifestyle lots with a minimum lot size of 5,000m^2.*
>
> *To ensure development is sited and designated to achieve an integrated and harmonious character within each estate."*

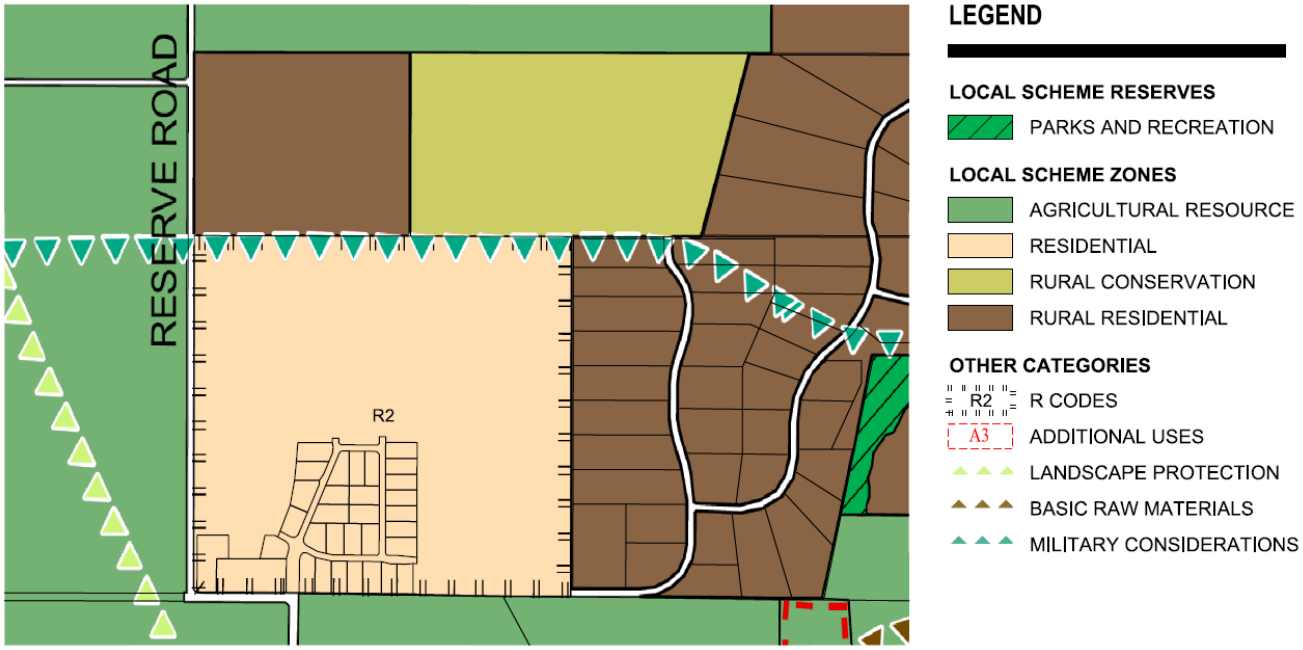


Figure 3 Shire of Chittering Local Planning Scheme No. 6 – current zoning

It is proposed to amend the zone and Scheme Map, described further in sections 4.1.2 and 4.1.3 of this report.

3.2.2.2 Land Use

The existing set of land uses in the Residential zone provides some flexibility in terms of land use, whilst having regard to the objectives of the area and the zone objectives. The existing set of land uses are summarised in Table 1.

Table 1 List of Land Uses in the current Residential R2 zone

Land Use	Residential zone
Aged Persons Accommodation	A
Ancillary Accommodation	P

Land Use	Residential zone
Bed and Breakfast	A
Child Care Premises	A
Civic Use	D
Community Purpose	D
Family Daycare	A
Home Business	A
Office	D
Residential Building	A
Single House	P

This list of land uses is proposed to be expanded via the Scheme Amendment request, as detailed in section 4.1.4 of this report.

3.2.3 Local Planning Policies

Between February and April 2020, Council resolved to revoke thirteen local planning policies including several policies that had previously been considered for the endorsed structure plan. As such, those revoked policies are not discussed. The following policies still apply.

3.2.3.1 Local Planning Policy 18 – Setbacks

Consistent with the policy statement 5.1 in LPP 18 – *Setbacks* (SoC, 2007) the setbacks in the Residential zone would be in accordance with the Residential Design Codes.

3.2.3.2 Local Planning Policy 22 – Fences

LPP 22 – *Fences* (SoC, 2007) provides the following statements in relation to general fencing requirements in all zones:

- As a condition of planning consent the Council may require fencing to exclude the keeping of animals and poultry and the cultivation of crops, vines and fruit from watercourses, areas liable to flooding and/or land where soil erosion or other land degradation may occur;
- The erection of any fence or gate to prevent access to a strategic fire break is prohibited;
- Applications for planning consent for fences may be dealt with by the Chief Executive Officer under delegation issued by Council in accordance with Section 5.42 of the Local Government Act; and
- Planning consent is not required for the repair or replacement of an existing fence.

Where fencing is proposed that facilitates continuous access to Fire Service Access Routes, the Structure Plan intends to require fencing (if proposed) to be to a rural standard. Such a standard minimises the visual impact of fencing; rural type fences also allow for the movement of fauna through the vegetation corridors. Gates will be included as required to ensure access through/onto properties for fire crews in the case of fire.

Section

4.0

Proposed Amendment

4.0 Proposed Amendment

4.1 Purpose of Amendment

The primary purpose of the Scheme Amendment is to apply an 'R5' density code to a portion of the subject site, as shown on the Scheme Amendment map in Appendix A. In addition, the Scheme Amendment seeks to make the following modifications:

- Renaming the Residential R2 zone to Residential zone, and updating the zone objectives;
- Updating the Development Provisions for the Residential zone;
- Inserting two additional land uses in the Residential zone; and
- Amending the Military Considerations Special Control Area to reflect changes that have been developed between the Shire, Department of Planning, Lands and Heritage, and the Department of Defence.

4.1.1 Residential Zone Objectives

By introducing an 'R5' density code, it is no longer appropriate for the zone to be named as 'Residential R2'. The existing objectives of the 'Residential R2' zone are also considered to be estate-specific. It is appropriate for the objectives to be modified.

The Scheme Amendment proposes to rename the zone from 'Residential R2' to 'Residential' and to replace the zone objectives with those contained in the Model Provisions, Schedule 1 of the *Planning and Development (Local Planning Schemes) Regulations 2015*.

The amended 'Residential' zone objectives would be as follows:

a) provide for a range of housing and a choice of residential densities to meet the needs of the community.

b) facilitate and encourage high quality design, built form and streetscapes throughout residential areas.

c) provide for a range of non-residential uses, which are compatible with and complementary to residential development.

The residential density codes would be superimposed on the Scheme Map, as per clause 4.2.3 of the Scheme.

4.1.2 Residential Zone Development Provisions

The Scheme Amendment request proposes to modify the Development Provisions in clause 4.19 of the Scheme to be less estate-specific, by:

- Changing the heading and initial paragraph to remove mention of 'Lot 2 Reserve Road' or 'R2'. This helps ensure the zone is more suitable for other areas that could potentially be zoned/rezoned to residential.
- Updating paragraph (i) with corrected references to require a Local Water Management Strategy (it previously said Local Water Management Plan), and updating the government agency from 'Department of Water' to 'Department of Water and Environmental Regulation'. Note, the subject site had an approved LWMS and Drinking Water Source Protection Plan. A LWMS addendum is appended, refer Appendix C.
- Updating paragraph (ii) so that the clause requires development to be serviced by a reticulated potable water supply, or if no supply is available, that a supply is planned to be provided. This helps to also consolidate two similarly worded clauses together. Note, the developer has provided a water supply site as per the endorsed Structure Plan and the subdivision approval. The subject site is capable of being provided with reticulated potable water and power services.
- Modifying paragraph (iv). Given that a BMP will apply to the land, it is considered that the building setbacks to the rural residential zoned land should be based upon vegetation separation distances. For a 'Class A – Forest', Method 1 as per AS 3959-2018 Table 2.5 would calculate a 27m separation distance for achieving a BAL-29 rating. Noting that the rural residential zoned land has a 3m firebreak within their properties, this 27m requirement and the additional 3m of width of

the existing firebreak effectively creates a distance of 30 metres. This 30m measurement is half of the previous 60m building exclusion area that was required under paragraph (iv). Note, the BMP is appended, refer Appendix D.

- Paragraph (v) would be renumbered to (iv), and would be retained. It currently is written as follows – "the keeping of livestock is not permitted".

It is noted that the Local Planning Strategy identified other locations for Residential opportunities. The changes to the provisions would ensure they can apply to other locations in the local government area that may be rezoned to Residential in the future. It is also noteworthy that the Structure Plan amendment is appended with technical studies that address the requirements of these scheme provisions.

4.1.3 Proposed R5 Density Coding

It is proposed to retain the 'R2' density code over lots that are created or under construction. Retaining lots in the 'R2' density code is deliberate. If these sites were recoded to R5, there is the potential for such lots to be re-subdivided in the future, and newly subdivided lots may be delivered in a battle-axe configuration. The 'R2' density with its minimum lot sizes of 5,000m^2 prevents future re-subdivision.

The amendment proposes to apply the 'R5' density coding to the balance of Lot 2 Reserve Road. A Structure Plan amendment would ensure that future subdivision and development would seamlessly link with existing roads and future lots would be coordinated to maintain the character and amenity of the locality. The Structure Plan amendment will provide Public Open Space that is centrally located within the subject site.

The R-Codes will control minimum lot sizes, minimum boundary setbacks, minimum frontage widths of lots and other relevant site requirements for lots in the R2 and R5 density codes.

The R5 density will provide additional lot diversity and choice, whilst addressing land affordability. Lots would be provided with reticulated power and water, and be within convenient access to Public Open Space. The increased density provides for an increase in lot yield which helps increase the local population and providing additional rates revenue for the local government. The range of lot sizes would be beneficial to supporting the more recent economic recovery measures being implemented by government.

4.1.4 Inserting Land Uses

Schedule 2 – Zoning Table of LPS 6 outlines the permissibility of certain land uses. These were summarised for the current zone in section 3.2.2.2 and Table 1 of this report. It is proposed that several uses be included to broaden the potential use of residential land.

Home Store

It is proposed that 'Home Store' be inserted as an 'A' discretionary land use in the 'Residential' zone and 'Townsite' zone, and 'X' in all other zones. A number of other local planning schemes allow for a similar type of land use to be considered relevant zones. A Home store is defined in LPS 6 as:

> *Home Store means any shop with a net lettable area not exceeding 100m^2 attached to a dwelling and which is operated by a person resident in the dwelling.*

This provides the possibility for a small retail store attached to a dwelling, which may be of a suitable scale that would not detrimentally impact upon the character or amenity of the location. It would be clearly secondary to the predominant use of the site as a residential property.

Holiday House

It is proposed to insert Holiday House as an 'A' discretionary use in the 'Residential' zone and 'Townsite' zone; a 'D' use in other rural type zones; and 'X' in industrial type zones. A Holiday House is defined as:

> *Holiday House means a single dwelling on one lot used to provide short-term accommodation but does not include a bed and breakfast*.

There is a growing trend for peer-to-peer accommodation. By including this land use, it would provide the potential for the short-term leasing of houses in the residential zone. This is proposed to be a discretionary land use, as there are several considerations that may impact upon the character and amenity of the locality. Thus, a development application ensures these matters are adequately addressed.

4.1.5 Modifications to Military Considerations Special Control Area

Lot 2 Reserve Road is situated inside of the Military Considerations Special Control Area (SCA). The purpose of the SCA is that dwellings within the SCA should address noise attenuation measures associated with aircraft noise sourced from the RAAF Air Base Pearce and its flight paths.

The SCA is currently worded in a way that development approval is required for "any development". Currently, the scheme provisions are not overly effective as the level of noise from aircraft in the area does not trigger a requirement for noise attenuating measures to be incorporated into a dwelling design.

Through the proposed modifications to the SCA, the local government will have a more fit-for-purpose set of provisions that will control building height, non-reflective roof surfaces and ensure certain areas are developed appropriately to include noise attenuation measures.

It is understood the local government had collaborated with the Department of Defence and the Department of Planning, Lands and Heritage in order to arrive at the mutually-agreed modifications to clause 5.5 for the Military Considerations Area. These modifications are included in this Scheme Amendment request.

The proposed modifications to the clause 5.5 provisions would achieve an outcome whereby landowners within the Structure Plan area (or the SCA more broadly) would no longer need to obtain development approval for "any development", as dwellings would typically be exempted from this requirement by the *Planning and Development (Local Planning Schemes) Regulations 2015*. This will result in quicker local government approval processing times (as only building permits will be required). The modifications would reduce the need for obtaining development approval for all dwellings, leading to cost savings for residents and less administrative burden for the local government.

4.2 Type of Amendment

It is considered this type of Scheme Amendment is 'Standard', having regard to the matters outlined in r.34 of the *Planning and Development (Local Planning Schemes) Regulations 2015*. The matters are outlined in Table 2 pertain to the classification of a standard amendment.

Table 2 Matters pertaining to classification as a 'Standard' Amendment

Standard Amendment	
(a) an amendment relating to a zone or reserve that is consistent with the objectives identified in the scheme for that zone or reserve;	The amendment relates to the Residential zone, and the amendment modifies the objectives however these modifications are to bring the objectives into alignment with the Model Provisions in the *Regulations*.
(b) an amendment that is consistent with a local planning strategy for the scheme that has been endorsed by the Commission;	As per section 3.2.1, it is considered the amendment is consistent with the Shire of Chittering Local Planning Strategy.
(c) an amendment to the scheme so that it is consistent with a region planning scheme that applies to the scheme area, other than an amendment that is a basic amendment;	No region scheme applies.
(d) an amendment to the scheme map that is consistent with a structure plan, activity centre plan or local development plan that has been approved under the scheme for the land to which the amendment relates if the scheme does not currently include zones of all the types that are outlined in the plan;	The Structure Plan amendment and Scheme Amendment are both proposed so that both the LPS 6 and Structure Plan will remain consistent. The Structure Plan contains zones from the LPS 6.
(e) an amendment that would have minimal impact on land in the scheme area that is not the subject of the amendment;	The Scheme Amendment and Structure Plan amendment have been subject to technical studies and assessment, refer to Appendices B-G inclusive. Minimal to negligible

Standard Amendment	
(f) an amendment that does not result in any significant environmental, social, economic or governance impacts on land in the scheme area;	impacts have been determined having regard to the Military Considerations SCA and for the Structure Plan the matters have been addressed including traffic, site soil capability, environmental, social, bushfire management, and local water management.
(g) any other amendment that is not a complex or basic amendment.	Not applicable.

A standard amendment would be advertised for a minimum 42 days. It is anticipated that concurrent advertising of the Scheme Amendment and Structure Plan amendment can be possible. That would ensure the community and referral bodies are provided with comprehensive information and supporting studies that will be appended to the Structure Plan.

5.0 Conclusion

The subject site is strategically located within the path of anticipated future urban expansion of the region and has a strong relationship with existing and future strategic infrastructure and activity within the region. The previous Scheme Amendment 55 rezoned the site to Residential which helped to address the Department's desire to see increased density of development on Lot 2 Reserve Road and represented a logical progression of land development.

This report outlines the rationale for a Scheme Amendment Request to up-code part of Lot 2 Reserve Road from 'R2' to 'R5'. Textual modifications to the scheme text are required to reflect the density codes and ensure alignment. In addition, modifications to the Special Control Area prepared by the Shire of Chittering in collaboration with the Department of Planning, Lands and Heritage and Department of Defence have also been included.

The Scheme Amendment request is considered to be suitable for the land taking into account:

- The subject site is capable of being provided with reticulated potable water and power services;
- The R5 density code would provide for a mix of low-density lot sizes within the site;
- The proposed land uses to be inserted are commonly identified in residential zones and are not considered to be detrimental to the character or amenity of the zone;
- Modifications to the Military Considerations Special Control Area will make the scheme provisions more fit-for-purpose, and reduce the need for any development from needing development approval; and
- An amendment to the Structure Plan will ensure alignment with the Scheme Amendment in order to ensure development of the subject site is delivered in a coordinated manner.

The Shire of Chittering is respectfully requested to initiate the Scheme Amendment. The following Appendix A provides the Scheme Amendment Map and text, adoption page and approval page.

APPENDIX A

Scheme Amendment

Shire of Chittering
Local Planning Scheme No. 6

Amendment No. 69

Recoding part of Lot 2 Reserve Road, Chittering to 'R5'

FORM 2A

Planning and Development Act 2005
Resolution Deciding to Adopt Amendment to Local Planning Scheme
Shire of Chittering
Local Planning Scheme No.6
Amendment No.69

Resolved that the Local Government pursuant to Section 75 of the *Planning and Development Act 2005*, amend the above Local Planning Scheme by:

1. Recoding Lot 9002 Reserve Road, Chittering from 'Residential R2' to 'Residential R5', and amending the Scheme maps accordingly.

2. Deleting clause 3.2.10 and replace with the following:

   3.2.10 Residential Zone

   The objectives of the Residential zone are to:

   a) provide for a range of housing and a choice of residential densities to meet the needs of the community.

   b) facilitate and encourage high quality design, built form and streetscapes throughout residential areas.

   c) provide for a range of non-residential uses, which are compatible with and complementary to residential development.

3. Amending clause 3.3.2 to remove reference to 'R2' density code, as follows:

   The symbols used in the cross reference in the Zoning Table have the following meanings:
   'P' means that the use is permitted by the Scheme providing the use complies with the relevant development standards and the requirements of the Scheme.
   'D' means that the use is not permitted unless the local government has exercised its discretion by granting Development approval.
   'A' means that the use is not permitted unless the local government has exercised its discretion by granting Development approval after giving special notice in accordance with clause 64 of the deemed provisions.
   'X' means a use is not permitted by the Scheme.

   A number of cells in the zoning table are blank. The corresponding land uses for these blank spaces are X (prohibited) in the Residential zone.

4. Amending clause 4.19 and 4.19.1 to remove reference to 'R2' density code and 'Lot 2 Reserve Road', as follows:

   4.19 DEVELOPMENT PROVISIONS – RESIDENTIAL ZONE

   4.19.1 The following applies to future subdivision and development in the Residential Zone:

5. Deleting subclause 4.19.1 and replace with the following:

   (i) Prior to subdivision, a local water management strategy is to be prepared and approved by the local government in consultation with the Department of Water and Environmental Regulation.

(ii) Development to be serviced by reticulated potable water (including water for firefighting purposes) by a licensed water provider. Where a water service is not available, an area of land is to be identified for water supply infrastructure and associated buffers.

(iii) For proposed lots located within the eastern portion of Lot 2 Reserve Road, Chittering that adjoin rural residential land, habitable buildings are to be located outside a 27 metre building exclusion area (measured from the rear boundary).

(iv) The keeping of livestock is not permitted.

6. Amending Schedule 2 – Zoning Table to remove reference to 'R2' density code from the Residential zone name; and insert the following uses and associated permissibilities against the relevant zones:

a. 'Home Store' as –

- 'A' use in the Residential zone;
- 'A' use in the Townsite zone; and
- 'X' in all other zones

b. 'Holiday House' as –

- 'A' use in the Residential zone;
- 'A' use in the Townsite zone;
- 'X' use in the Light Industrial zone;
- 'D' use in the Agricultural Resource zone;
- 'D' use in the Rural Residential zone;
- 'D' use in the Rural Smallholdings zone;
- 'D' use in the Rural Retreat zone;
- 'D' use in the Rural Conservation zone;
- 'X' use in the General Industry zone; and
- 'D' use in the Environmental Conservation zone.

7. Deleting clause 5.5 Military Considerations (RAAF) and replace with the following:

5.5.1 The Military Considerations Special Control Area (for RAAF Base Pearce, Gingin Airfield and Muchea Air Weapons Range flight paths) is delineated on the Scheme Map.

5.5.2 Purpose

5.5.2.1 To protect the integrity of the operations of the RAAF Base Pearce, RAAF Gingin Airfield and Muchea Air Weapons Range and associated flight paths by ensuring that development complies with the height limit requirements set out by the Department of Defence.

5.5.2.2 Ensure sensitive land uses within the designated flight paths are built to mitigate impacts associated with aircraft noise.

5.5.3 Planning Requirements

5.5.3.1 In addition to development which otherwise requires approval under the Scheme, development approval is required for any development within this Special Control Area that meets one or more of the following:

a) Is 15 metres or greater in height.

b) Is a habitable building that is identified as being within an Australian Noise Exposure Forecast (ANEF) zone greater than 20 ANEF.

Note: The ANEF chart for the RAAF Base Pearce and RAAF Gingin Airfield Defence Aviation Area is available from the local government's website or on request from the Department of Defence.

5.5.3.2 Any new dwelling located within the 20 ANEF contour shall be constructed so as to comply with any noise attenuation measures required by Australian Standard AS 2021 Aircraft Noise Intrusion – Building Siting and Construction, or to achieve the following:

a) An indoor design sound level of 50dB(A) or less for all sleeping areas and dedicated lounges;

b) An indoor design sound level of 55dB(A) or less for all other habitable spaces; and

c) An indoor design sound level of 60dB(A) or less for bathroom, toilets and laundries.

5.5.3.3 The roofing material of any building within the Special Control Area shall be non-reflective.

5.5.4 Relevant Considerations

In considering any Application for Development approval the local government shall have regard to:

a) whether the proposal is compatible with current and future Defence Force flying operations associated with RAAF Base Pearce, RAAF Gingin Airfield and Muchea Air Weapons Range;

b) whether any buildings proposed for human occupation requires noise attenuation measures in accordance with Australian Standard 2021; and

c) whether the proposal constitutes a hazard or interference to aircraft flying in the area including but not limited to: excess building height, extraneous outdoor lighting and increased risk of bird strike to aircraft.

5.5.5 Referrals of Applications for Development approval

The local government may refer any Application for Development approval to the relevant authority responsible for defence aviation.

8. Amending the 'List of Contents' to reflect the modifications accordingly.

9. Pursuant to Regulation 35 of the *Planning and Development (Local Planning Schemes) Regulations 2015*, determines that the amendment is a 'Standard Amendment' for the following reasons:

1. The amendment relates to a zone that is consistent with the objectives identified in the scheme for that zone (Residential).

2. The amendment is consistent with the Local Planning Strategy for the Shire that has been endorsed by the Commission; as the amendment will facilitate the strategies and actions of the Strategy to accommodate much of the shire's future population growth at the Reserve Road precinct (Section 3.1.2; 3.5.4).

3. The amendment seeks to amend the Scheme maps consistent with a Structure Plan that will be advertised and progressed concurrently to the amendment, to replace the existing Structure plan that has been approved under the scheme for the land to which the amendment relates.

4. The amendment will have minimal impact on land in the scheme area that is not the subject of the amendment.

5. The amendment will not result in any significant environmental, social, economic or governance impacts on land in the scheme area, as supported by the technical appendices.

6. The amendment is not a complex or basic amendment.

Dated this …….. day of …… 20……..

……..……..

CHIEF EXECUTIVE OFFICER

Planning and Development Act 2005
RESOLUTION TO AMEND LOCAL PLANNING SCHEME
Shire of Chittering Local Planning Scheme No.6
Amendment No.69

Resolved that the Local Government pursuant to section 75 of the *Planning and Development Act 2005*, amend the above Local Planning Scheme by:

1. Recoding Lot 9002 Reserve Road, Chittering from 'Residential R2' to 'Residential R5', and amending the Scheme maps accordingly.

2. Deleting clause 3.2.10 and replace with the following:

   3.2.10 Residential Zone

   The objectives of the Residential zone are to:

   a) provide for a range of housing and a choice of residential densities to meet the needs of the community.

   b) facilitate and encourage high quality design, built form and streetscapes throughout residential areas.

   c) provide for a range of non-residential uses, which are compatible with and complementary to residential development.

3. Amending clause 3.3.2 to remove reference to 'R2' density code, as follows:

   The symbols used in the cross reference in the Zoning Table have the following meanings:
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   'D' means that the use is not permitted unless the local government has exercised its discretion by granting Development approval.
   'A' means that the use is not permitted unless the local government has exercised its discretion by granting Development approval after giving special notice in accordance with clause 64 of the deemed provisions.
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   A number of cells in the zoning table are blank. The corresponding land uses for these blank spaces are X (prohibited) in the Residential zone.

4. Amending clause 4.19 and 4.19.1 to remove reference to 'R2' density code and 'Lot 2 Reserve Road', as follows:

   4.19 DEVELOPMENT PROVISIONS – RESIDENTIAL ZONE

   4.19.1 The following applies to future subdivision and development in the Residential Zone:

5. Deleting subclause 4.19.1 and replace with the following:

   (i) Prior to subdivision, a local water management strategy is to be prepared and approved by the local government in consultation with the Department of Water and Environmental Regulation.

(ii) Development to be serviced by reticulated potable water (including water for firefighting purposes) by a licensed water provider. Where a water service is not available, an area of land is to be identified for water supply infrastructure and associated buffers.

(iii) For proposed lots located within the eastern portion of Lot 2 Reserve Road, Chittering that adjoin rural residential land, habitable buildings are to be located outside a 27 metre building exclusion area (measured from the rear boundary).

(iv) The keeping of livestock is not permitted.

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- 'A' use in the Residential zone;
- 'A' use in the Townsite zone; and
- 'X' in all other zones

b. 'Holiday House' as –

- 'A' use in the Residential zone;
- 'A' use in the Townsite zone;
- 'X' use in the Light Industrial zone;
- 'D' use in the Agricultural Resource zone;
- 'D' use in the Rural Residential zone;
- 'D' use in the Rural Smallholdings zone;
- 'D' use in the Rural Retreat zone;
- 'D' use in the Rural Conservation zone;
- 'X' use in the General Industry zone; and
- 'D' use in the Environmental Conservation zone.

7. Deleting clause 5.5 Military Considerations (RAAF) and replace with the following:

5.5.1 The Military Considerations Special Control Area (for RAAF Base Pearce, Gingin Airfield and Muchea Air Weapons Range flight paths) is delineated on the Scheme Map.

5.5.2 Purpose

5.5.2.1 To protect the integrity of the operations of the RAAF Base Pearce, RAAF Gingin Airfield and Muchea Air Weapons Range and associated flight paths by ensuring that development complies with the height limit requirements set out by the Department of Defence.

5.5.2.2 Ensure sensitive land uses within the designated flight paths are built to mitigate impacts associated with aircraft noise.

5.5.3 Planning Requirements

5.5.3.1 In addition to development which otherwise requires approval under the Scheme, development approval is required for any development within this Special Control Area that meets one or more of the following:

a) Is 15 metres or greater in height.

b) Is a habitable building that is identified as being within an Australian Noise Exposure Forecast (ANEF) zone greater than 20 ANEF.

Note: The ANEF chart for the RAAF Base Pearce and RAAF Gingin Airfield Defence Aviation Area is available from the local government's website or on request from the Department of Defence.

5.5.3.2 Any new dwelling located within the 20 ANEF contour shall be constructed so as to comply with any noise attenuation measures required by Australian Standard AS 2021 Aircraft Noise Intrusion – Building Siting and Construction, or to achieve the following:

a) An indoor design sound level of 50dB(A) or less for all sleeping areas and dedicated lounges;

b) An indoor design sound level of 55dB(A) or less for all other habitable spaces; and

c) An indoor design sound level of 60dB(A) or less for bathroom, toilets and laundries.

5.5.3.3 The roofing material of any building within the Special Control Area shall be non-reflective.

5.5.4 Relevant Considerations

In considering any Application for Development approval the local government shall have regard to:

a) whether the proposal is compatible with current and future Defence Force flying operations associated with RAAF Base Pearce, RAAF Gingin Airfield and Muchea Air Weapons Range;

b) whether any buildings proposed for human occupation requires noise attenuation measures in accordance with Australian Standard 2021; and

c) whether the proposal constitutes a hazard or interference to aircraft flying in the area including but not limited to: excess building height, extraneous outdoor lighting and increased risk of bird strike to aircraft.

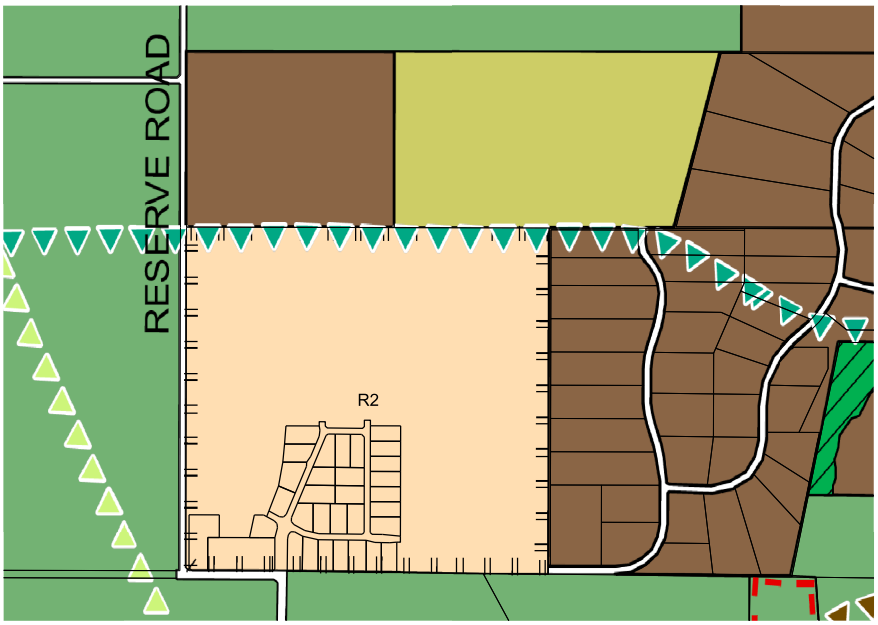
5.5.5 Referrals of Applications for Development approval

The local government may refer any Application for Development approval to the relevant authority responsible for defence aviation.

8. Amending the 'List of Contents' to reflect the modifications accordingly.

SHIRE OF CHITTERING
Local Planning Scheme No.6
Amendment No. 69

EXISTING



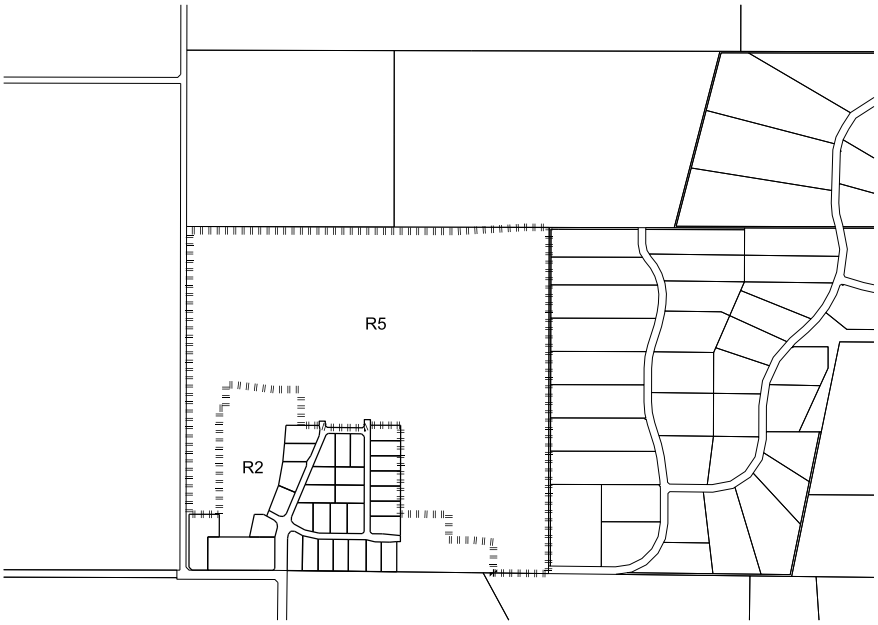
LEGEND

LOCAL SCHEME RESERVES
- PARKS AND RECREATION

LOCAL SCHEME ZONES
- AGRICULTURAL RESOURCE
- RESIDENTIAL
- RURAL CONSERVATION
- RURAL RESIDENTIAL

OTHER CATEGORIES
- R2 — R CODES
- A3 — ADDITIONAL USES
- LANDSCAPE PROTECTION
- BASIC RAW MATERIALS
- MILITARY CONSIDERATIONS

PROPOSED



LEGEND

OTHER CATEGORIES
- R5 — R CODES

scale: 1:25000@A4 | 1:12500@A2
plan: 05/096/031A
0 250 500m
date: 22/09/2020

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ALL AREAS AND DIMENSIONS DISPLAYED ARE SUBJECT TO DETAIL SURVEY.

FORM 6A

COUNCIL ADOPTION

This Standard Amendment was adopted by resolution of the Council of the Shire of Chittering at the Ordinary Meeting of the Council held on the ____ day of _____, 20___.

.....
SHIRE PRESIDENT
.....
CHIEF EXECUTIVE OFFICER

COUNCIL RESOLUTION TO ADVERTISE

by resolution of the Council of the Shire of Chittering at the Ordinary Meeting of the Council held on the ____ day of _____, 20___, proceed to advertise this Amendment.

.....
SHIRE PRESIDENT
.....
CHIEF EXECUTIVE OFFICER

COUNCIL RECOMMENDATION

This Amendment is recommended _____ by resolution of the Shire of Chittering at the Ordinary Meeting of the Council held on the ____ day of _____, 20___ and the Common Seal of the Shire of Chittering was hereunto affixed by the authority of a resolution of the Council in the presence of:

.....
SHIRE PRESIDENT

.....
CHIEF EXECUTIVE OFFICER

WAPC ENDORSEMENT (r.63)

.....
DELEGATED UNDER S.16 OF THE P&D ACT 2005

DATE.....

APPROVAL GRANTED

.....
MINISTER FOR PLANNING

DATE.....

APPENDIX B

Site and Soil Evaluation

360 environmental

Lot 2 Reserve Road and
Lot 9001 Rosewood Drive, Chittering

Site and Soil Evaluation

Prepared for

Riverside Investments Pty Ltd

November 2020

people • planet • professional

Document Reference	Revision	Prepared by	Reviewed by	Admin Review	Submitted to Client	
					Copies	Date
4010AA_Rev0	Internal Draft	VG	KL	-	-	21/10/2020
4010AA_Rev1	Client Draft	VG	KL	LI	1x electronic	22/10/2020
4010AA_Rev2	Client Final	VG	KL	LI	1x electronic	02/11/2020

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Executive Summary

This Site and Soil Evaluation (SSE) has been prepared to support the Structure Plan application at Lot 2 Reserve Road and Lot 9001 Rosewood Drive, Chittering.

The residential development is not able to be serviced by a reticulated sewerage network. Wastewater management via an alternate treatment system (ATS) located in each lot is proposed to manage all household wastewater from the toilet, bathroom, kitchen, and laundry.

The site is not located in a sewerage sensitive area and has previously obtained Structure Plan approval and Lot 2 has also recently obtained Subdivision approval. A modified Structure Plan application which proposes to increase the density of Lots in Lot 2 only is proposed while development of Lot 9001 will remain consistent with the previously approved Lot 2 Reserve Road and Lot 9001 Rosewood Drive Structure Plan.

This SSE has been prepared in accordance with AS/NZS 1547 Onsite domestic wastewater management and the Government Sewerage Policy (DPLH, 2019) and examines the environmental aspects of the site in relation to sewerage collection, treatment and on-site disposal to ensure adequate management over time.

The SSE includes a description of the:

- Soil profile to a depth of 2.0 m
- Results of soil infiltration testing
- Description of groundwater levels
- Site topography and any other features affecting the design and operation of an ATU system including the recommendations from a winter geotechnical investigation.

The SSE demonstrates that each lot is able to accommodate an appropriately sized treatment system and effluent land application area. An Application to Construct or Install an Apparatus for the Treatment of Sewerage will be submitted to the Shire of Chittering prior to the installation of the ATS and a domestic ATU which has been certified to Australian Standard AS 1546.3 and approved by the Department of Health will be installed

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Appendix A Geotechnical Investigations

1 Introduction

1.1 Background

In accordance with the Government Sewerage Policy (DPLH 2019), Riverside Investments Pty Ltd have engaged 360 Environmental to prepare a Site and Soil Evaluation to support the Structure Plan application at Lot 2 Reserve Road and Lot 9001 Rosewood Drive, Chittering (the site, Figure 1).

The residential development is not able to be serviced by a reticulated sewerage network. Wastewater management via an alternate treatment system (ATS) located in each lot is proposed to manage all household wastewater from the toilet, bathroom, kitchen, and laundry.

The site has previously obtained Structure Plan approval and Lot 2 has also obtained Subdivision approval. A modified Structure Plan application which proposes to increase the density of Lots in Lot 2 only is proposed while development of Lot 9001 will remain consistent with the previously approved Lot 2 Reserve Road and Lot 9001 Rosewood Drive Structure Plan.

The Government Sewerage Policy (DPLH, 2019) did not exist when the previous planning approvals were obtained. The Site and Soil Evaluation has been prepared to support the modified Structure Plan application and comply with the recent Government Sewerage Policy to demonstrate the site is able to accommodate a suitable wastewater management system and not impact public health or the environment

1.2 Proposed Development

The total area covered by the Structure Plan is 195 ha. Lot 2 Reserve Road includes 318 Residential lots and 2.79 ha of public open space (POS). Lot 9001 Rosewood Drive includes 36 Rural Conservation lots and a 22.22 ha Conservation lot.

Lot sizes range from 0.21 ha to 1.195 ha.

A lot located in the south west corner of Lot 2 will contain a bore which will be used to supply potable water to the development and is shown in the Structure Plan (Figure 2) as a public drinking water source site.

1.3 Local Planning Context

The site has previously obtained Structure Plan and subdivision approval and subdivision works have commenced on Lot 2 to provide an access road and potable water supply infrastructure.

A modified Structure Plan application which includes the reconfiguration of the residential density codes on Lot 2, which include applying the R2 density code to created lots and lots under construction, and an R5 density code for the balance of Lot 2.

The modifications to the approved Structure Plan affect Lot 2 only, Lot 9001 remains consistent with the previously approved Reserve Road and Rosewood Drive Structure Plan.

The site previously obtained Structure Planning and subdivision approval between 2007 to 2016, as outlined below.

- The Shire of Chittering endorsed a development plan and fire management plan for Lot 2 Reserve Road on 17 December 2007.
- A subdivision application for Lot 2 Reserve Road was granted conditional approval by the Commission on 20 December 2011 (WAPC ref: 145031) to facilitate the creation of 110 single residential lots and Public Open Space. Lot sizes ranged from 7,503 m^2 to 4 hectares, with an average lot size of 1.0417 hectares. The subdivision approval lapsed on 20 December 2015.
- The WAPC granted approval to a development plan for Lot 7 (now Lot 9001) Rosewood Drive in June 2009.
- A subdivision application for Lot 9001 Rosewood Drive was granted conditional approval by the Commission on 8 July 2013 (WAPC ref: 147754) to facilitate the creation of 45 single residential lots and Public Open Space. Lot sizes ranged from 1-1.25 hectares, with an average lot size of 1.04 hectares. This subdivision approval lapsed on 8 July 2017.
- The WAPC granted approval to the Lot 2 Reserve Road and Lot 9001 Rosewood Drive Structure Plan on 3 May 2016. This determination was made by the WAPC pursuant to Part 4, clause 22(1)(a) of the Deemed Provisions.
- Scheme Amendment 55 to the LPS six was gazetted on 18 March 2016. The Scheme Amendment rezoned Lot 2 Reserve Road to 'Residential R2' and Lot 9001 Rosewood Drive to 'Rural Conservation'.
- A subdivision application for Lot 2 Reserve Road was granted conditional approval by the Commission on 23 November 2016 (WAPC ref: 153430). The subdivision proposed to create 105 residential lots, the public drinking water source site and the Public Open Space area. The developer has acted on the subdivision approval insofar that some lots have been created.

2 Existing Environment

2.1 Location

The site is located on Reserve Road and Rosewood Drive, within the Shire of Chittering, approximately 50 km north of Perth and 20 km north of Bullsbrook.

2.2 Climate

Chittering has a dry subtropical climate featuring hot dry summers, and mild rainy winters. Climate data from the Gingin Aero station located approximately 20.4 km away between 1996 to 2020 indicates the annual mean maximum temperature is 25.7°C and the annual mean minimum temperature is 11 °C. The mean annual rainfall is 620.7 mm (BoM, 2020).

2.3 Topography

The site topography based on 10 m contours varies between approximately 165 metres Above Height Datum (mAHD) in the northern boundary of Lot 9001 and less than 135 mAHD in the south eastern corner of Lot 2 (Figure 3). The site generally slopes from north to south.

2.4 Soil Types

2.4.1 Regional Geology

Soil/Soil-landscape series mapping (DAF, 2007) at 1:20 000 indicates the site is within the 222Mb-3, 222Mb-1 and 222Mb-4 soil units (Figure 4). Theses geological units are described as:

- 222Mb-3; Mogumber 3 Subsystem - Gently inclined undulating slopes and minor drainage headwaters. Deep grey siliceous or bleached sands
- 222Mb-1; Mogumber 1 Subsystem - Undulating broad crests and very gentle upper slopes <10% with common lateritic duricrust outcrop and shallow gravelly sands
- 222Mb-4; Mogumber 4 Subsystem - Gently to moderately inclined slopes <10% with shallow gravelly sands and few areas of lateritic outcrop.

2.4.2 Geotechnical Investigation

A Geotechnical Investigation (CMW Geosciences, March 2016) has been completed at the site. A supplementary winter Geotechnical Investigation was also carried out in August 2016 (CMW Geosciences, August 2016) (Appendix 2). The field investigations involved the excavation of 30 test pits with adjacent dynamic cone penetrometer tests, two pavement dippings, four hand auger boreholes, 11 soakage tests, and in-situ falling head permeability tests and laboratory testing on samples obtained from both the existing pavement materials and the underlying natural subgrade material.

The Geotechnical Investigations (CMW, March 2016) has identified the Site as having the following soil profile:

- SAND (SP): loose to medium dense, white, grey, and yellow, predominantly medium grained sand containing roots and rootlets and darker colouring in top 0.5 m; overlying
- GRAVEL/COBBLES/BOULDERS: fine to coarse grained, sub-angular to sub-rounded, red brown, of lateritic origin, uncemented to well cemented, with sand.

The additional winter investigation was completed to assess the ground conditions and soil permeability during late winter conditions. This investigation included digging a further 14 test pits to a depth of 2m with a backhoe and completing 11 in situ soakage tests. Groundwater was not encountered in any of the test pits or percolation test locations.

Further recommendations regarding the required earthworks and site treatment are provided in Section 3.2.

2.5 Public Drinking Water Source Areas

There are additional wastewater management system design criteria to follow if a site is located in a Public Drinking Water Source Area (PDWSA). The extract below is from the *DWER Public Drinking Water Source Area Mapping Tool* with the orange marker and label demonstrating that the Site is not shown to be located within a PDWSA.

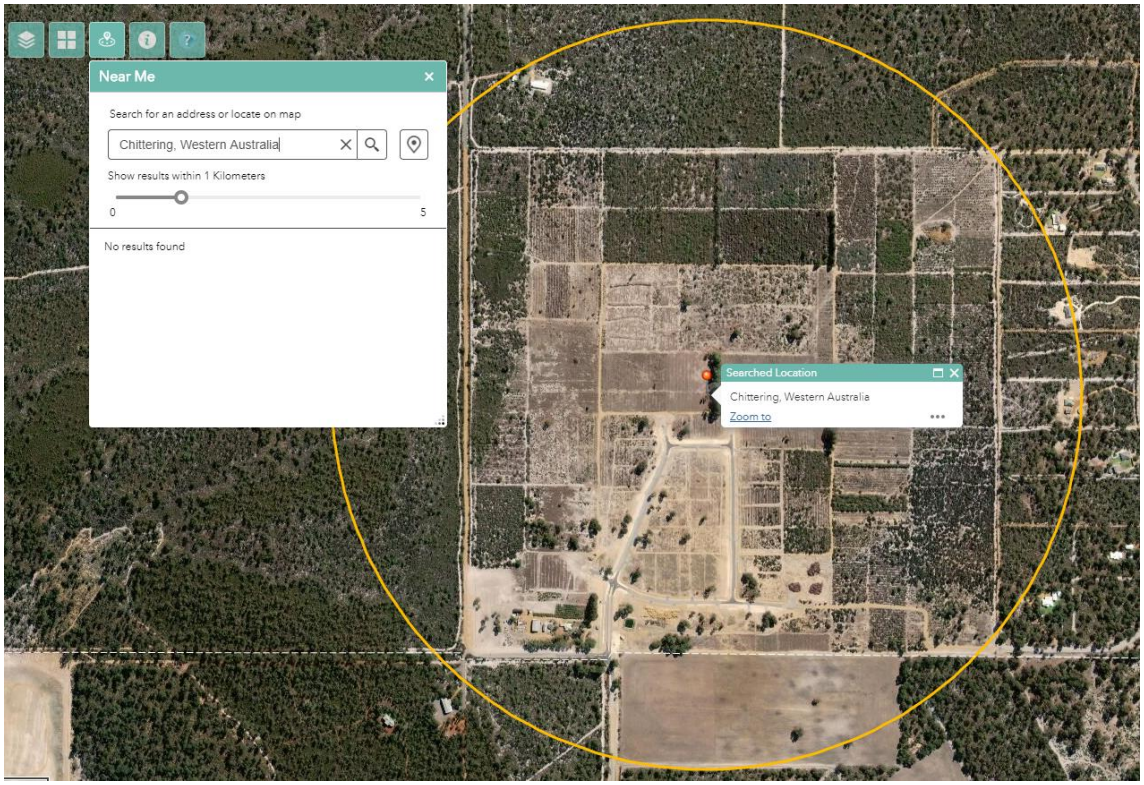


Plate 1: PDWSA Mapping

Potable water for households within the development will be supplied from the confined artesian aquifer (Perth-Leederville Parmelia Aquifer). The site has a licence to abstract 288,800 kL/yr of groundwater from the Leederville aquifer and the abstraction bore, and associated infrastructure has been installed in the south west corner of Lot 9001. This area is marked on the Structure Plan (Figure 2) as being a 'Public Drinking Water Source Site'.

A Drinking Water Source Protection Plan (DWSPP) (Aqua Ferre Pty Ltd, 2016) has been prepared and approved by the Department of Health. The DWSPP:

- Recommends to maximise the protection of the drinking water supply source
- Recommends that the water source area should be protected and proclaimed as a water reserve. This involves a water reserve area of a minimum 30 m around the bore at the ground surface to mitigate the risk of surface contamination
- Recommends a restricted area, for new bores, of 1,000 m within the aquifer to reduce the risk to the available quantity
- Identifies potential drinking water quality contamination risks from land use activities within the water reserve
- Provides strategies to manage these potential risks.

An onsite sewerage system is not to be located within

- A wellhead protection zone or on crown land within a reservoir protection zone, or
- 100 m of any bore used for public drinking water supply where
- A wellhead protection zone or reservoir protection zone has not been assigned, or
- Where existing lots would be rendered undevelopable by the wellhead protection zone.

The site complies with the above criteria.

2.6 Surface Water

No surface water features, or surface drainage lines exist on the site. The site is located between Yalyal Brook in the north and Rocky Creek in the south, however, is not within the 100 Year Annual Recurrence Index (ARI) floodplain of any watercourse (Figure 5).

An extract from the DWER Floodplain Mapping Tool is provided below in Plate 2 with the red marker indicating the sites location which confirms the site is not impacted by flooding.



Plate 2: DWER Flood Mapping

An onsite sewerage system is not to be located within:

- 100m of a waterway and not within a foreshore area
- 100m of a drainage system that discharges directly into a waterway or significant wetland without treatment.

The site complies with the above criteria and is therefore not located in a Sewerage Sensitive Area.

2.7 Wetlands

The Department of Biodiversity Conservation and Attractions regional wetland mapping confirms there are no wetlands located on site. The mapping identifies the nearest wetland to be Chandala Lake which is a Conservation category wetland located over 4.5km northwest of the Site.

An onsite sewerage system is not to be located within:

- 100m of a significant wetland or wetland buffer.

The site complies with the above criteria.

2.8 Groundwater

2.8.1 Groundwater Aquifers

The Site is located in the Eclipse Hill groundwater sub-area. Three separate aquifer systems occur in this area: the Perth Superficial aquifer, the Leederville aquifer and Yarragadee aquifer (DoW, 2014).

2.8.2 Groundwater Levels

Vertical separation from groundwater is a critical consideration when determining whether the site is capable of disposing stormwater on site.

The Perth Groundwater Atlas (DWER 2020b) provides data on the groundwater levels across the Perth Metropolitan area. However, the maximum groundwater contours dataset does not extend across the site, with the nearest contour (at 60 mAHD) mapped 1 km east of the site.

The original water management strategy (VDM, 2008a) prepared for the site indicated that groundwater level was greater than 30m below surface.

As the site is not located in a sewerage sensitive area or a public drinking water source area, the discharge point of the onsite sewerage system should be at least 0.6m to 1.5m above the highest groundwater level.

Given the clearance to groundwater, the Site is able to comply with this design criteria.

2.8.3 Groundwater Licences

The below extract from the DWER Water Register mapping tool indicates there are two licensed bores within the local vicinity of the site.

1. WRI No. – 150204
   Allocation – 1500 kL

   Aquifer – Perth-Leederville-Parmelia

   Distance from site – approximately 500 m

2. WRI No. – 152450
   Allocation – 4750 kL

   Aquifer - Gingin - Southern Scarp Semi-confined - Perth - Mirrabooka

   Distance from site – approximately 1 km

   The on-site sewerage system is not to be located within 30m of a private bore used for household/drinking water purposes.

   The site complies with the above criteria.

3 Wastewater Management

3.1 Effluent Disposal and Drainage

The Shire of Chittering needs to be made aware of the drainage and site preparation recommendations provided in the supplementary winter Geotechnical Investigation (CMW Geoscience, August 2016), provided in Appendix A when assessing the individual applications from lot owners when applying to install an apparatus for the treatment of sewerage.

The winter investigation concluded that groundwater was not encountered in any of the test pit or percolation test locations and perched water was also not encountered in the select few locations where ground refusal was encountered. A majority of Lot 2 was found to have a minimum clearance to seasonal, permanent or perched water of at least 0.5m within the sand soil profile. Proposed lots other than those specifically referred to in the Western Lots section below can be designed with a loading infiltration rate of 30 l/m^2/day for an alternating system and 15l/m2/day for a non-alternating system.

Lots situated on the western boundary of Reserve Road however have been identified in the Site Investigation Plan contained in the supplementary winter Geotechnical Investigation (Appendix A) as possibly having shallow laterite, including caprock and gravel through to boulders present within the top 0.5m over parts of the lot. The winter Geotechnical Investigation concluded that despite the lots containing caprock and gravel, a minimum area of 150 m^2 of suitable effluent disposal area would be available.

Owners purchasing the western lots will be required to complete additional geotechnical investigations to support their applications to install an apparatus for the treatment of sewerage and demonstrate a suitable effluent irrigation area.

3.2 Site Preparation

If a suitable effluent disposal area cannot be found on a given lot, the winter Geotechnical Investigation recommends the following minor earthworks.

Placement of fill material comprising of clean granular soil over the desired effluent disposal area. All proposed fill must be moisture conditioned and compacted in layers not exceeding 300mm to achieve at least 95% compaction. Upon completion of the above earthworks. Upon completion of the above earthworks, the site can be designed with a loading infiltration rate of 30 l/m2/day for an alternating system and 15l/m2/day for a non-alternating system.

Alternatively, where laterite is present an excavator and rock breaker may be used to break through any caprock layer. This solution would need to be assessed on a lot by lot basis with additional percolation testing undertaken.

Any alternate combination of earthworks and effluent disposal system as approved by the Department of Health and or Shire of Chittering.

3.3 Discharge Loading Rates

The discharge loading rates are to be in accordance with Supplement Schedule 9 of the Health Regulations 1974.

For residential areas based on the occupancy of six persons in a five-bedroom house, a sewage design flow of 150 L/person/day is to be sized.

3.4 Proposed Treatment Systems

The site is not located within a Sewerage Sensitive Area. A Primary Treatment System, previously known as an Aerobic Treatment Unit (ATU) is to be used to treat wastewater to a standard which is able to be irrigated to garden areas/turf through surface or sub surface irrigation systems, or disposed into leach drains, soakwells or aquasafe drains.

3.5 Land Application Area

3.5.1 Surface Irrigation

Surface irrigation requires significantly larger land application areas than leach drains. If space is not a constraint however, an irrigation system is significantly more economical to use than other options including leach drains.

The DoH Code of Practice (DoH, 2015) required a minimum effluent irrigation area of 150 m^2 for surface irrigation and requires the disposal area to maintain at least 300 mm of permeable soil above an underlying limiting layer e.g. rock or hard pan. At all times the disposal area shall be maintained over its entire surface area with 100 mm of friable soil and a 50mm top cover of mulching material (pine bark, etc.).

The Government Sewerage Policy 2019 supersedes the DoH Code of Practice (DoH, 2015) and provides the following calculation to calculate the required irrigation land application area as follows:

1. Estimated Hydraulic Loading (L/day)
   = Occupancy rate (persons) x design loading rate (L/person/day).
2. Calculate land application area (m2)
   = hydraulic load (L/day) x conversion factor.

The conversion factor for Primary treatment units for gravel and sands is 0.377.

For gravels and sand soil type, the minimum application area for a primary treatment system is 339 m^2 (excludes setbacks) which exceeds the DoH Code of Practice.

The effluent irrigation areas can be reduced if required on those lots containing caprock if required by using a secondary treatment unit which treats the water to a higher standard and requires a smaller effluent irrigation area. The minimum effluent application area for a secondary treatment unit on a lot containing gravel and sand is 180 m^2.

Additionally, the irrigation area also needs to:

- Have warning signs displayed advising that effluent is being used and is not suitable for human contact or consumption
- Achieve minimum setbacks from certain features such as buildings, boundaries and paved areas, to avoid human exposure to the effluent
- Not be altered or reduced in size without approval
- Be maintained by the landowner so that irrigation lines are accessible for maintenance
- Be planted out with salt and nutrient resistant plants to avoid puddling or runoff of effluent.

3.5.2 Flatbed Leach Drains

Leach drains provide an alternate method to infiltrate the effluent, rather than through surface or sub surface irrigation if preferred. For primary treated effluent, the following calculation is used to determine the length of leach drains required.

Land application area for leach drains (m2):
= Hydraulic loading (L/day)÷ 20 ÷ Infiltrative Area (IA)
(IA of Atlantis Corporation flatbed leach drains = 2.6m2/m).

The Atlantis Flatbed Leach drains are in 2.6m module lengths. And a minimum of two rows of leach drains are required to allow for maintenance to be completed.

The land application area for using flatbed leach drains is 17.3m.

3.6 Conclusion

The SSE demonstrates that each lot can accommodate an appropriately sized treatment system and effluent land application area. An Application to Construct or Install an Apparatus for the Treatment of Sewerage will be submitted to the Shire of Chittering prior to the installation of the ATS and a domestic ATS which has been certified to Australian Standard AS 1546.3 and approved by the Department of Health will be installed.

4 References

Bureau of Meteorology (BoM) 2020. Weather and Climate Data, accessed 29 July 2020 from http://www.bom.gov.au/climate/data/. Commonwealth of Australia.

CMW Geosciences, 2016a, *Proposed Subdivision Development, Lot 2 Reserve Road, Chittering WA, Roadway Geotechnical Investigation Report*

CMW Geosciences, 2016b, *Supplementary Winter Geotechnical Report for Proposed Subdivision, Lot 2, Reserve Rd*, Chittering

Department of Health (DoH) 2015. Code of Practice for the Design, Manufacture, Installation and Operation of Aerobic Treatments Units (ATUs) Serving Single Dwellings

Department of Planning, Lands and Heritage (DPLH) 2019. Government Sewerage Policy

Department of Water and Environment Regulation (DWER), 2020b, *The Water Register, Government of Western Australia.* Available from: http://www.water.wa.gov.au/ags/WaterRegister/. Government of Western Australia.

Department of Water and Environment Regulation (DWER), 2020c, Perth Groundwater Atlas. Available at: https://maps.water.wa.gov.au/#/webmap/gwm. Government of Western Australia.

VDM Environmental, 2008a, Lot 2 Reserve Road, Chittering & Surrounds Water Management Strategy

5 Limitations

This report is produced strictly in accordance with the scope of services set out in the contract or otherwise agreed in accordance with the contract. 360 Environmental makes no representations or warranties in relation to the nature and quality of soil and water other than the visual observation and analytical data in this report.

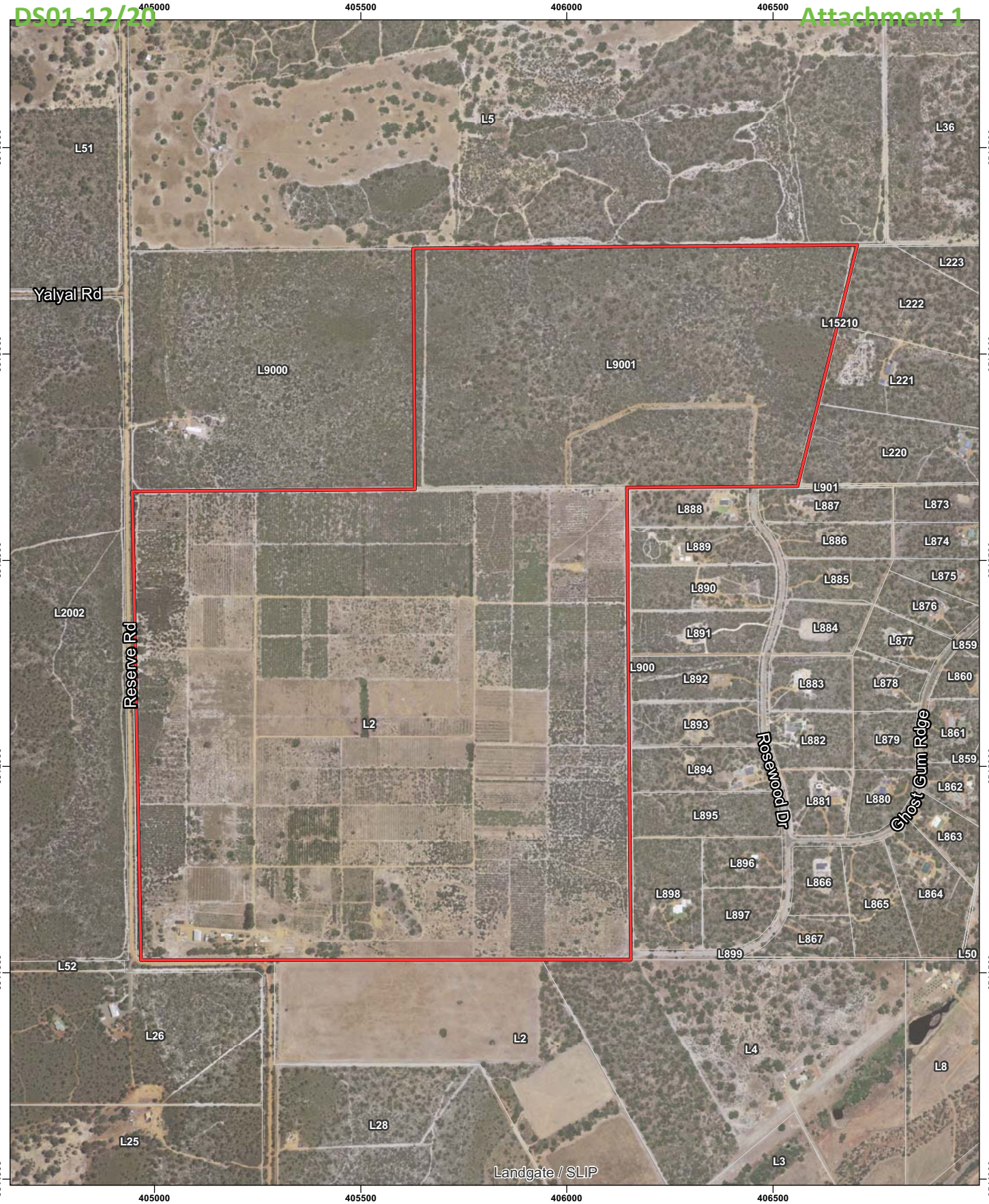
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Aspects of this report, including the opinions, conclusions, and recommendations it contains, are based on the results of the investigation, sampling and testing set out in the contract and otherwise in accordance with normal practices and standards. The investigation, sampling and testing are designed to produce results that represent a reasonable interpretation of the general conditions of the site that is the subject of this report. However, due to the characteristics of the site, including natural variations in site conditions, the results of the investigation, sampling and testing may not accurately represent the actual state of the whole site at all points.

It is important to recognise that site conditions, including the extent and concentration of contaminants, can change with time. This is particularly relevant if this report, including the data, opinions, conclusions, and recommendations it contains, are to be used a considerable time after it was prepared. In these circumstances, further investigation of the site may be necessary.

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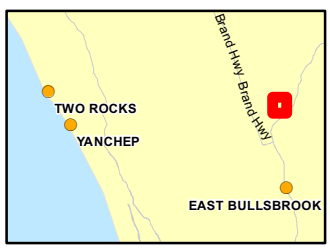
- Site Location
- Lot Boundaries

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- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY MAP



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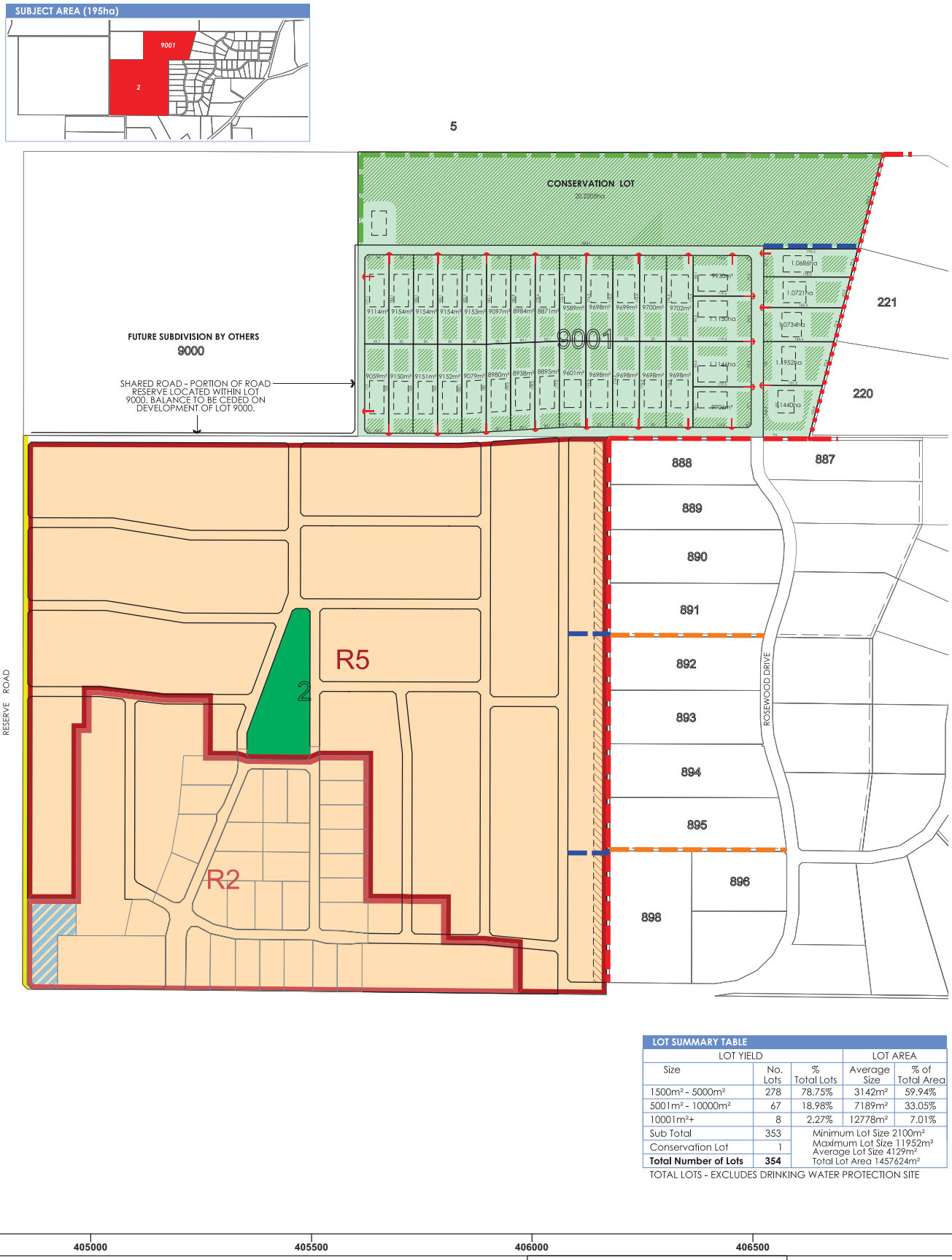
Lot 2 Reserve Road and Lot 9001 Rosewood Drive, Chittering

Site and Soil Evaluation

Figure 1
Site Location

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LOT SUMMARY TABLE

LOT YIELD			LOT AREA	
Size	No. Lots	% Total Lots	Average Size	% of Total Area
1500m² - 5000m²	278	78.75%	3142m²	59.94%
5001m² - 10000m²	67	18.98%	7189m²	33.05%
10001m²+	8	2.27%	12778m²	7.01%
Sub Total	353	Minimum Lot Size 2100m²		
Conservation Lot	1	Maximum Lot Size 11952m²		
Total Number of Lots	**354**	Average Lot Size 4129m²		
		Total Lot Area 1457624m²		

TOTAL LOTS - EXCLUDES DRINKING WATER PROTECTION SITE

Legend

LAND USE
- RESIDENTIAL
- RURAL CONSERVATION
- PUBLIC OPEN SPACE

OTHER
- INDICATIVE BUILDING ENVELOPE
- PUBLIC DRINKING WATER SOURCE SITE
- VEGETATION RETENTION
- BUILDING EXCLUSION AREA (27m FROM REAR LOT BOUNDARY)
- INDICATIVE SHARED CROSSOVER

FIRE SERVICE ACCESS ROUTE
- EXISTING 5.0m RESERVE (widening to 6.0m)
- EXISTING 6.0m RESERVE
- EXISTING 6.0m EASEMENT
- PROPOSED 6.0m EASEMENT

FIREBREAK
- PROPOSED 3.0m FIREBREAK (IN ACCORDANCE WITH SHIRE OF CHITTERING FIREBREAK NOTICE)

- RESERVE ROAD - ROAD WIDENING (10m)

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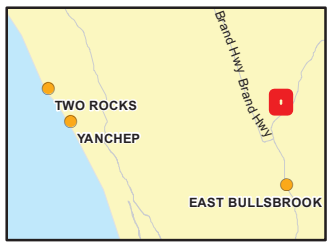
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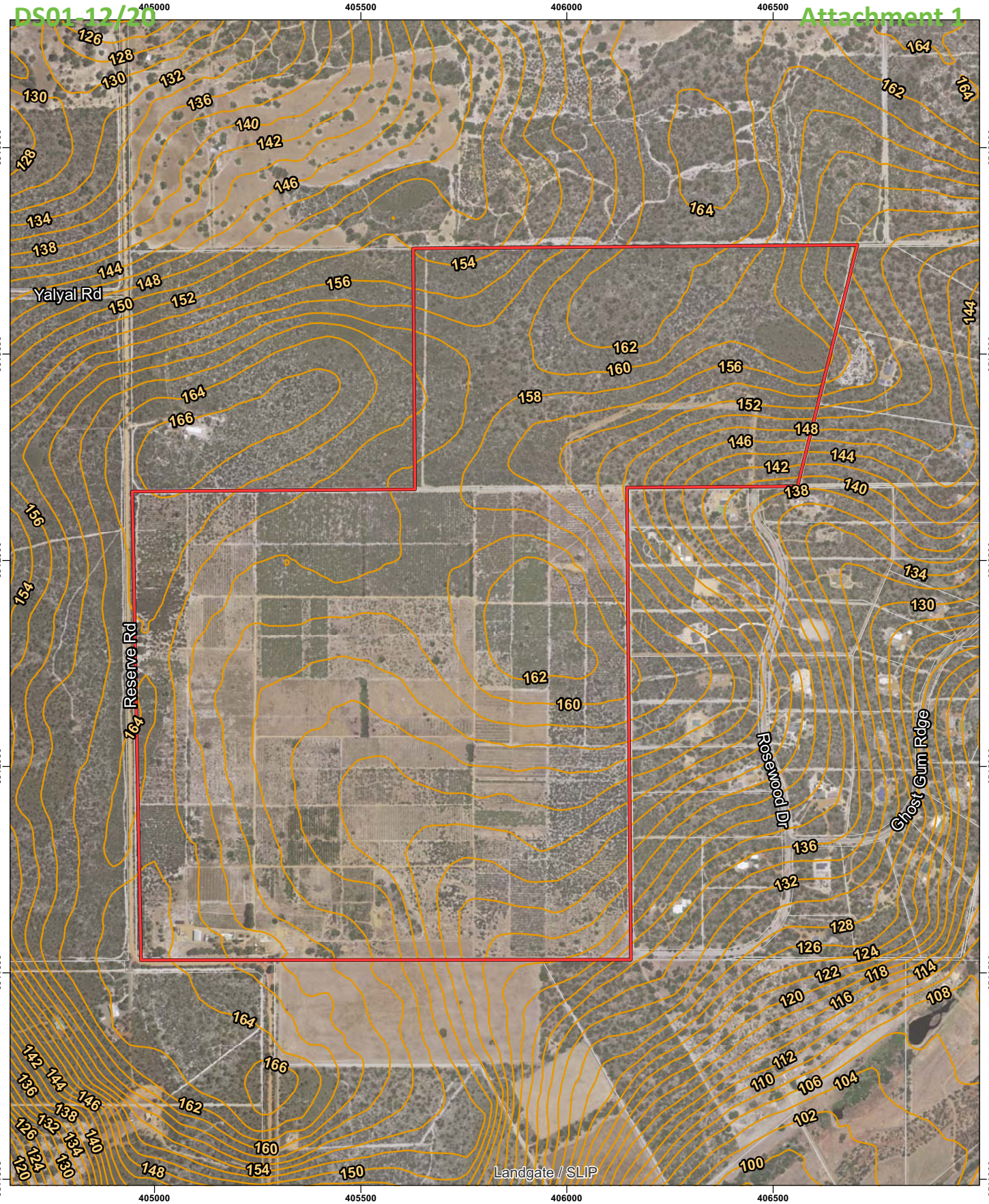
Lot 2 Reserve Road and Lot 9001 Rosewood Drive, Chittering

Site and Soil Evaluation

Figure 2
Structure Plan

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- Site Location
- Lot Boundaries
- Contour 2m interval (mAHD)

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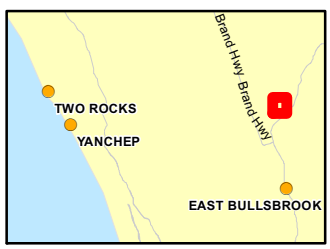
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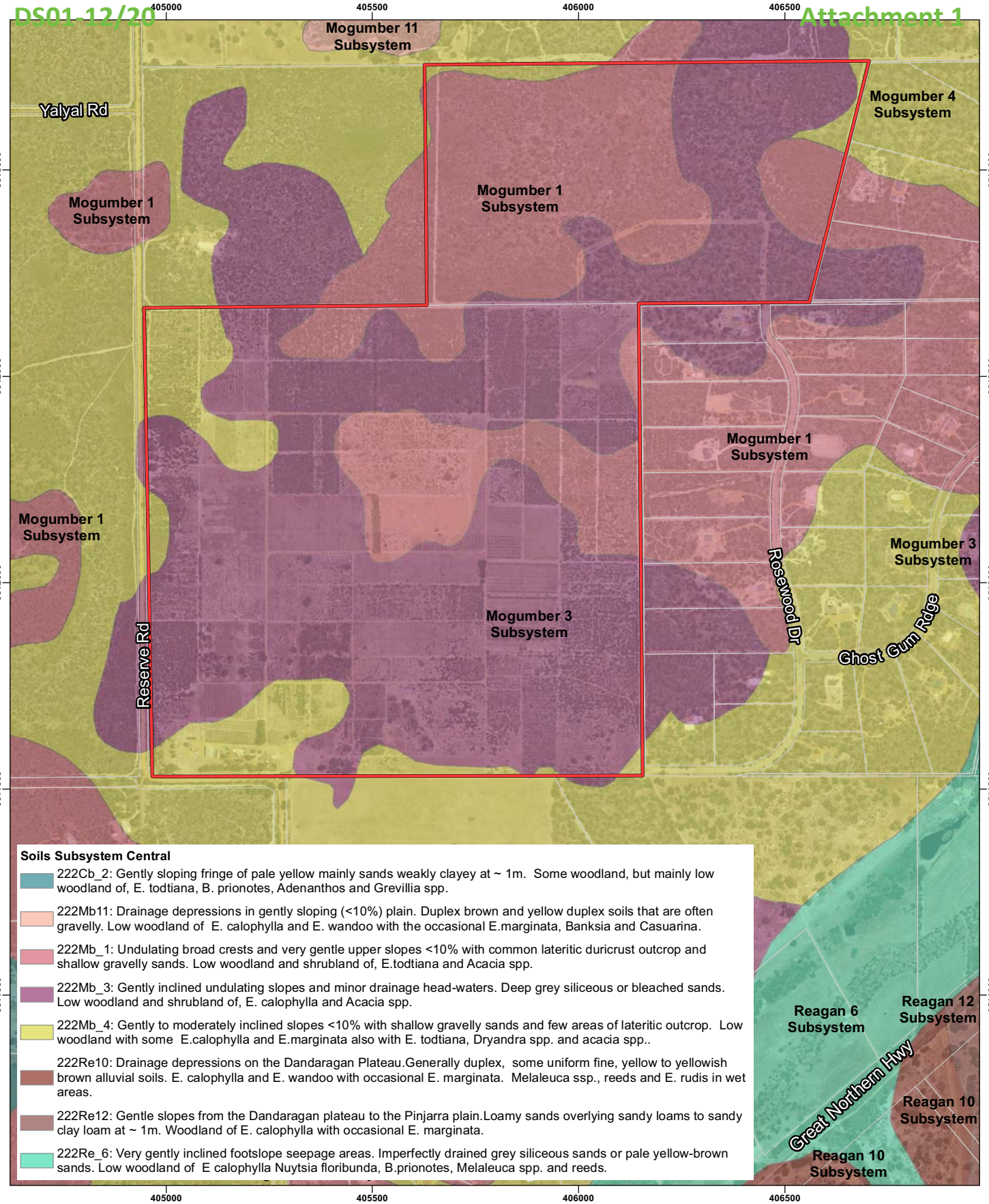
Lot 2 Reserve Road and Lot 9001 Rosewood Drive, Chittering

Site and Soil Evaluation

Figure 3
Topography

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Soils Subsystem Central

- 222Cb_2: Gently sloping fringe of pale yellow mainly sands weakly clayey at ~ 1m. Some woodland, but mainly low woodland of, E. todtiana, B. prionotes, Adenanthos and Grevillia spp.
- 222Mb11: Drainage depressions in gently sloping (<10%) plain. Duplex brown and yellow duplex soils that are often gravelly. Low woodland of E. calophylla and E. wandoo with the occasional E.marginata, Banksia and Casuarina.
- 222Mb_1: Undulating broad crests and very gentle upper slopes <10% with common lateritic duricrust outcrop and shallow gravelly sands. Low woodland and shrubland of, E.todtiana and Acacia spp.
- 222Mb_3: Gently inclined undulating slopes and minor drainage head-waters. Deep grey siliceous or bleached sands. Low woodland and shrubland of, E. calophylla and Acacia spp.
- 222Mb_4: Gently to moderately inclined slopes <10% with shallow gravelly sands and few areas of lateritic outcrop. Low woodland with some E.calophylla and E.marginata also with E. todtiana, Dryandra spp. and acacia spp..
- 222Re10: Drainage depressions on the Dandaragan Plateau.Generally duplex, some uniform fine, yellow to yellowish brown alluvial soils. E. calophylla and E. wandoo with occasional E. marginata. Melaleuca ssp., reeds and E. rudis in wet areas.
- 222Re12: Gentle slopes from the Dandaragan plateau to the Pinjarra plain.Loamy sands overlying sandy loams to sandy clay loam at ~ 1m. Woodland of E. calophylla with occasional E. marginata.
- 222Re_6: Very gently inclined footslope seepage areas. Imperfectly drained grey siliceous sands or pale yellow-brown sands. Low woodland of E calophylla Nuytsia floribunda, B.prionotes, Melaleuca spp. and reeds.

Legend

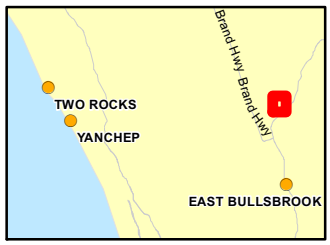
- Site Location
- Lot Boundaries

0 130 260 390 Meters
1:12,500 @ A4

N

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY MAP



Powered By SLIP ENABLER

- LOCALITY MAP SOURCED FROM LANDGATE 2017
- OTHER DATA SOURCED LANDGATE 2018
- AERIAL PHOTOGRAPHY SOURCED LANDGATE 2018
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360 environmental
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PROJECT ID	DATE
4010	19/10/2020

HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

CREATED	CHECKED	APPROVED	REVISION
LF	KL	KL	0

Riverside Investments Pty Ltd

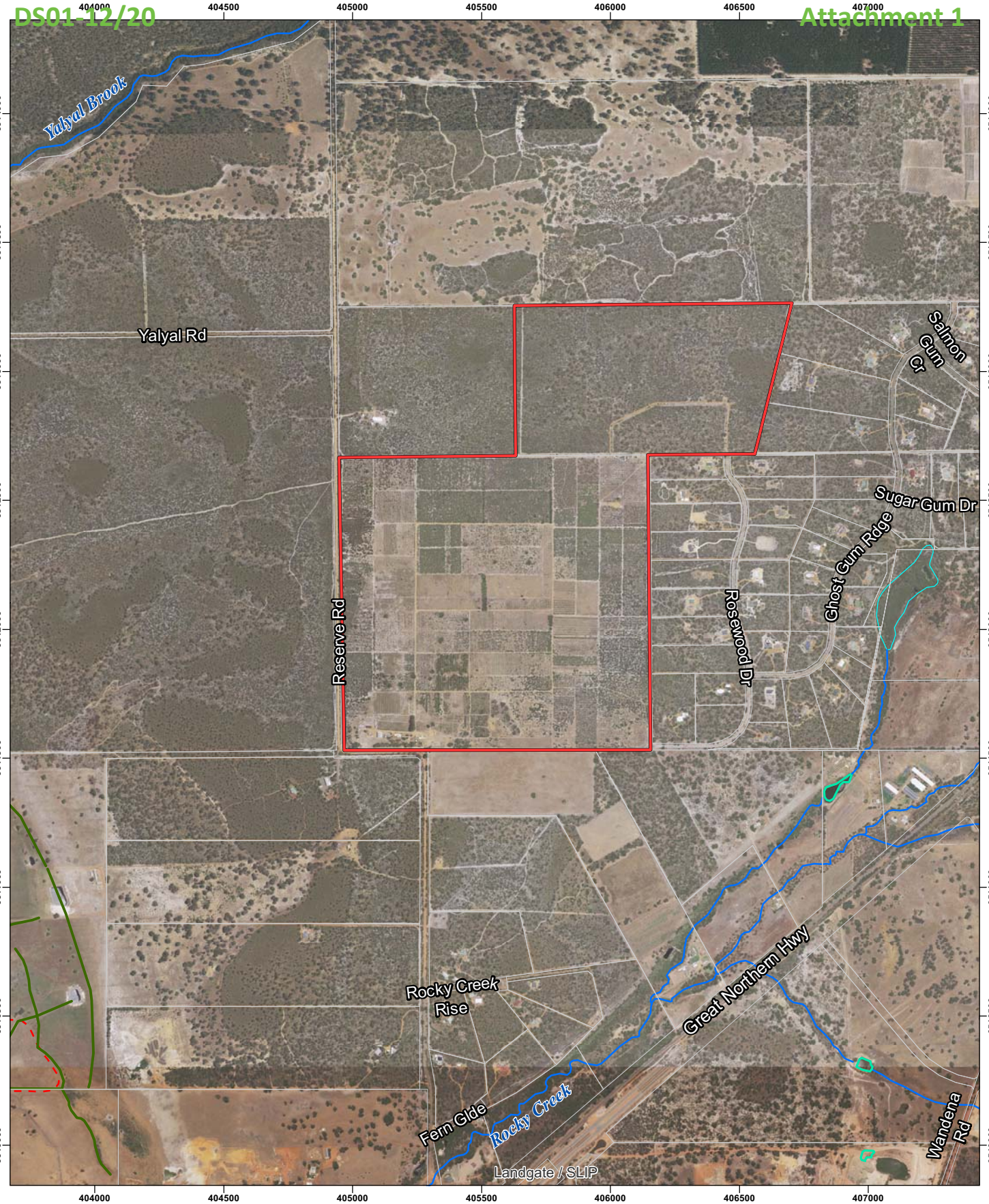
Lot 2 Reserve Road and Lot 9001 Rosewood Drive, Chittering

Site and Soil Evaluation

Figure 4
Soil Types

K:\Projects\10. WAM\4010 Phase 1 Site and Soil Evaluation\4010 F04 Soil Types.mxd

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Legend

- Site Location
- Lot Boundaries

Hydrography

- Watercourse - minor
- Drain - major
- Lake
- Marsh Area
- Area Subject to Inundation

Powered By SLIP ENABLER

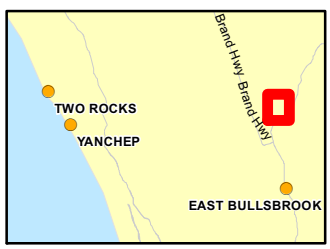
- LOCALITY MAP SOURCED FROM LANDGATE 2017
- OTHER DATA SOURCED LANDGATE 2018
- AERIAL PHOTOGRAPHY SOURCED LANDGATE 2018
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0 210 420 630 Meters
1:20,000 @ A4

N

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY MAP



360 environmental
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PROJECT ID	DATE
4010	19/10/2020

HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

CREATED	CHECKED	APPROVED	REVISION
LF	KL	KL	0

Riverside Investments Pty Ltd

Lot 2 Reserve Road and Lot 9001 Rosewood Drive, Chittering

Site and Soil Evaluation

Figure 5
Hydrological Features

K:\Projects\10. WAM\4010 Phase 1 Site and Soil Evaluation\4010 F05 Hydrological Features.mxd

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Figure 1: Site Location

Figure 2: Structure Plan

Figure 3: Topography

Figure 4: Soil Types

Figure 5: Hydrological Feature

Appendices

Appendix A
Geotechnical Investigations

02 March 2016

PROPOSED SUBDIVISION DEVELOPMENT
LOT 2 RESERVE ROAD, CHITTERING, WA
ROADWAY GEOTECHNICAL INVESTIGATION REPORT

Riverside Investments (WA) No.2 P/L

Ref. PER2016-0395AB, Rev0

Unit 19 Wembley Green Offices,
127 Herdsman Parade, Wembley, WA 6014
www.cmwgeosciences.com

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Appendix A – Site Photographs

Appendix B – Test Pit and Hand Auger Borehole Logs

Appendix C – In-situ Permeability Test Results

Appendix D – Laboratory Test Results

1 INTRODUCTION

CMW Geosciences Pty Ltd (CMW) was authorised by Stephen Seward to carry out a geotechnical investigation at Lot 2 Reserve Road, Chittering by way of a signed authorisation dated 29 February 2016. The scope of work and associated terms and conditions of our engagement were detailed in our services proposal letter referenced PER2016-0395AA, Rev1 dated 21 January 2016.

2 SCOPE OF WORK

The purpose of this report is to describe the investigation completed, the ground conditions encountered and to provide recommendations with respect to geotechnical aspects of the proposed subdivision road design and construction, including near surface permeability characteristics, design subgrade CBR for road design and earthworks recommendations for road construction.

3 SITE DESCRIPTION

The proposed development site comprises an area of approximately 135ha and is located on Reserve Road, Chittering, WA, as shown on the attached Site Location Plan – Figure No. 1.

The site slopes from the west/northwest to the east/southeast with existing ground levels ranging from RL 165m AHD in the northwest corner to RL136m AHD at the southeast corner.

The site is bound to the west and southwest by Reserve Road, open paddock to the south, semi-rural lots to the east and to vegetated bushland to the north. The lot is segregated into smaller rectangular sub-lots, many of which are fenced and irrigated and showing evidence of previous or current planting with a variety of native/introduced plants, shrubs and trees. A gravel pit is situated within the northeast part of the site. A sand pit is located within the central southern portion of the lot. A collection of abandoned/dumped farm machinery and equipment, building products and general household/farm waste is situated in the vicinity of the latter sand pit, both at the surface and within shallow excavations.

A single storey residential dwelling is situated to the south west of the lot as well as several farm sheds and equipment. A production water well appears to be present to the extreme south west corner of the lot.

Selected photographs of the site are included in Appendix A. The attached Site Plan – Figure No. 2 depicts the approximate locations of the gravel/sand pits.

4 PROPOSED DEVELOPMENT

The draft development plans by Taylor Burell Barnett indicate that lot 2 will be subdivided into smaller lots of between 0.5ha and 1.5ha in size and associated roads, access ways and a public open space will be constructed.

At the time of undertaking this investigation and of writing this report the project was in the early stages of planning. It is anticipated that the geotechnical investigation will provide details of preliminary feasibility options for the site, particularly with respect to the proposed roadways.

5 FIELD INVESTIGATION

Following a dial before you dig search, the field investigation was carried out on 8 February 2016. All fieldwork was carried out under the direction of CMW Geosciences Pty Ltd in general accordance with AS1726 (1993), Geotechnical Site Investigations. The scope of fieldwork completed was as follows:

- Undertake a walkover survey of the site to assess the general landform and site conditions;
- Thirteen test pits, denoted TP01 to TP14 (excluding TP12), were excavated using a backhoe fitted with a 600mm wide toothed rock bucket to depths of between 0.1 and 3.4m below existing ground levels. Representative bulk samples were collected to provide samples for subsequent laboratory testing. Engineering logs and photographs of the test pits are presented in Appendix B. It must be noted that TP12 was replaced with HA04 due to the potential presence of buried services in the area;
- Two pavement dippings (TP15 and TP16) were undertaken in order to assess and sample the current pavement material (where present and applicable) and were terminated due to shallow refusal on dense to very dense ferricrete (laterite). Engineering logs and photographs of the pavement dippings are presented in Appendix B;
- Four hand auger boreholes, denoted HA01 to HA04, were drilled using a 100m diameter auger to target depths of up to 1.5m below existing ground levels to visually observe the near surface soil profile and to facilitate in-situ permeability testing. Engineering logs of the hand auger boreholes are presented in Appendix B ;
- Dynamic Cone Penetrometer (DCP) tests were carried out adjacent to each test pit, in general accordance with AS1289.6.3.2, to depths of up to 1m to provide soil density profiles and to provide a subgrade CBR value for pavement design purposes. Graphical results of the DCP testing are presented on the test pit logs in Appendix B; and
- In-situ falling head permeability tests were completed in the open standpipe piezometers established in HA01 and HA03 at depths of 1.5m. HA01 and HA02 were located in the central POS space and HA03 was located in the proposed drainage area in the south eastern corner of the site. Results of the permeability tests are presented in Appendix C;

The approximate locations of the respective investigation sites referred to above are shown on the attached Site Plan (Figure No. 02).

6 LABORATORY TESTING

Laboratory testing was carried out generally in accordance with the requirements of the current edition of AS 1289 (where applicable). All testing was scheduled by CMW and carried out by Cardno, a NATA registered Testing Authority.

Laboratory testing was undertaken on samples obtained from both the existing pavement materials and the underlying natural subgrade (sand) material in order to make an assessment of the current condition of the existing pavements, assist in subgrade CBR design values and to assess the suitability for reuse of the pavement materials.

The extent of testing carried out to provide the geotechnical parameters required for this study are presented in Table 1. Two of each test were undertaken on subgrade material from the test pits and two on the pavement dipping material.

Table 1: Laboratory Test Schedule Summary

Type of Test	Test Method	Quantity
Particle size distribution	AS1289.3.6.1	4
Soaked CBR tests	AS1289.6.1.1	4
Maximum dry density	AS 1289.5.5.1	4

Certificates for the test results outlined above are presented in Appendix D.

7 GROUND MODEL

7.1 Geology

Published geological maps (Ref. Muchea Sheet 2034 I and Part of 2134 IV) and the CMW investigation database for the area depict the land as being underlain by colluvial sands with laterite to the west and south of the site.

7.2 Subsurface Conditions

The ground conditions encountered and inferred from the investigation were considered to be generally consistent with the published geology for the area and can be generalised according to the following subsurface sequence:

SAND (SP)	loose to medium dense, white, grey and yellow, predominantly medium grained sand containing roots and rootlets and darker colouring in top 0.5m; overlying
GRAVEL/COBBLES/BOULDERS	fine to coarse grained, sub-angular to sub-rounded, red brown, of lateritic origin, uncemented to well cemented, with sand;

The distribution of these units is summarised in Table 2 below:

Table 2: Summary of Soil Stratigraphy

Description	Depth to base of layer (m)		
	Minimum	Maximum	Average
SAND*	0	3.1	1.6
GRAVEL/COBBLES/BOULDERS**	-	-	-

Notes: * Strata not encountered in TP15 and TP16, ** Base of strata not encountered

Individual test pit and hand auger logs should be consulted to assess levels in terms of m AHD. Levels have been estimated based on the provided survey data.

7.3 Pavement Dipping

At test pit location TP15 and TP16 (pavement dippings) it appeared that a thin sheet of gravelly clayey sand/gravelly sand has been placed directly on the in situ cemented gravel/cobbles/boulders to form Reserve Road. These sections correspond to the areas of laterite shown on the referenced geology map for the area. The pavement profile investigated identified the thickness of pavement layers which are detailed in Table 3 below.

Table 3: Summary of the Pavement Layers

Description	Thickness of layer (m)		
	Minimum	Maximum	Average
Basecourse Material: Gravelly SAND	0.05	0.2	0.125
Subgrade comprising cemented GRAVEL/COBBLES	>0.2		

7.4 Laboratory Test Results

Results of the civil engineering laboratory tests provided in Appendix D are summarised in Table 3 below:

Table 3: Summary of Civil Engineering Laboratory Test Results

Test Location	Depth (m bgl)	Material	Gravel (%)	Sand (%)	Fines (%)	LL (%)	PL (%)	PI (%)	LS (%)	MC (%)	OMC (%)	MMDD (t/m^2)	CBR (%)
TP9	0.6 – 0.8	SG	0	96	4	-	-	-	-	-	14.5	1.79	20
TP13	0.3 – 0.5	SG	54	43	3	-	-	-	-	-	9.0	2.22	90
TP15	0.1 – 0.3	BC	22	71	7	-	-	-	-	-	10.5	2.05	45
TP16	0.0 – 0.1	BC	33	57	10	-	-	-	-	-	7.0	2.11	110

Note: Gravel, sand and fines percentages are by weight, LL = liquid limit, PL = plasticity limit, PI = plasticity index, LS = linear shrinkage, NO = Not obtainable, NP = Non Plastic, MC = Natural Moisture Content, OMC = Optimum Moisture Content, MMDD = Modified Maximum Dry Density, CBR = California Bearing Ratio, BC = basecourse, SG = subgrade

7.5 Groundwater

Groundwater was not encountered during our investigation. However, increased moisture was observed in some instances below the sand unit where the gravel/cobble/boulder unit was mostly uncemented laterite gravels.

It is possible that perched groundwater may occur during and following periods of rainfall above cemented laterite layers.

7.6 Permeability

The results of the constant and rising head permeability tests carried out were used to estimate the soil coefficient of permeability in accordance with the methods described in Horslev (1951). The results varied between approximately 1 x 10^{-5} (1m/day) and 6 x 10^{-5} m/sec (5m/day). Full results are contained in Appendix C.

8 GEOTECHNICAL ASSESSMENT AND RECOMMENDATIONS

8.1 Geohazards

Uncontrolled Fill comprising farm/household waste was encountered in the vicinity of TP13/Sand Pit location to the central southern boundary of the site. Further geotechnical and environmental investigation is suggested in this area once the proposed development and building envelope details are confirmed. Environmental investigation may also be prudent for the area of the lot occupied by sheds and agricultural equipment.

8.2 General Earthworks

We anticipate that minor cut to fill bulk earthworks may be required to form finished road levels. This activity is considered appropriate for the site subject to the earthworks construction recommendations described below:

8.2.1 Topsoil Strip and Subgrade Preparation

We propose the following general recommendations for the topsoil stripping:

- All vegetation should be stripped and removed from the proposed roadway;

- Existing trees must be removed and it must be ensured that their root systems are completely grubbed out. The soil beneath all tree root systems must be re-compacted and filled with compacted clean sand; and,
- Topsoil, root mats or otherwise unsuitable organic material should be removed and cut to waste or alternatively blended with clean sand fill at a minimum ratio of 3:1 (topsoil:sand fill). Following vegetation clearing, a 100mm thick topsoil strip should be considered appropriate for most of the site, however where thick root mats or otherwise unsuitable material is present to a greater depth then this should be removed and cut to waste or blended at the above ratio.

8.2.2 Bulk Earthworks

We recommend the following during bulk earthworks:

- Following topsoil stripping, the upper 300 mm of the exposed subgrade must be moisture conditioned and compacted to achieve at least 95% dry density ratio based on Modified Compaction (AS1289 5.1.1). Any loose, soft, or organic materials observed during this proof roll must be removed and replaced with compacted clean sand fill.
- Site won material from proposed cut earthworks is considered suitable for use in bulk earthworks subject to the material being sandy in nature, free of organic or deleterious inclusions with a fines content of less than 12% and a maximum particle size of 150mm;
- Sandy fill material must be moisture conditioned and compacted in layers not exceeding 300 mm with a suitable roller to achieve at least 95% dry density ratio based on Modified Compaction (AS1289 5.2.1);
- Imported sand bulk fill materials will need to be free of organic or deleterious inclusions with a fines content of less than 12% and a maximum particle size of 150mm; and
- Permanent road embankment batters constructed from compacted sand (as detailed above) may be formed to a gradient of up to 1V:2H (27 degrees) to maximum heights of 3m, provided no load bearing structures are located within 2m of the batter crest. Temporary cut batters in natural sand above the water table may be excavated to a gradient of up to 1V:1.5H (33.5 degrees) to maximum heights of 3m, provided no load bearing structures are located within 2m of the batter crest. Cut batters exceeding this 3m height must be benched (minimum 1.5m wide level benches).

The technical and control requirements for Engineered Fill, including site observation and compaction testing, are outlined in AS3798. We recommend that this work is completed under the direction and control of a suitably experienced Geotechnical Engineer familiar with the contents of this report.

8.2.3 Earthworks Monitoring

Variations in ground conditions may occur between test locations. If conditions other than those described above are encountered, then further advice should be sought without delay. During earthworks, site visits should be made by a Geotechnical Engineer who is familiar with the contents of this report to ensure that topsoil stripping is carried out adequately, proof compaction and cut to fill earthworks are conducted in accordance with AS3798-2007, and to audit the compaction of fill earthworks. Earthworks control testing should be undertaken in accordance with the guidelines set out in AS3798-2007. CMW would be pleased to perform this function if required.

In particular, following the topsoil strip and prior to filling we strongly recommend that the removal of all uncontrolled fill is verified by a suitably qualified geotechnical professional.

8.3 Drainage Systems

On-site drainage systems within the central POS area may be designed on the basis of a soil coefficient of permeability of 2.5m/day whilst the proposed drainage system in the south eastern corner of the site may be designed on the basis of a soil coefficient of permeability of 1m/day. Drainage systems must be located a distance of at least 3m away from any proposed building foundations or retaining wall.

8.4 Pavements

8.4.1 Existing Pavement Materials

The pavement dipping's completed (TP15 and TP16) adjacent to the existing roadways indicate that the existing pavement typically comprises a thin layer of basecourse type material comprising gravelly sand to an average thickness of 125mm. The subgrade material in these areas comprised cemented gravel and cobbles (laterite).

Field and laboratory testing indicate that the basecourse material has CBR values ranging from 45% to 110%, at 98% MMDD.

8.4.2 Subgrade CBR

Subject to our recommendations provided in Section 8.2 of this report, a design subgrade CBR value of 15% for the sandy soils across the site is considered suitable. A design subgrade CBR value of 15% is also considered suitable for compacted sand fill material.

It should be noted that CBR testing was completed as part of this investigation to assist in assessing a suitable design subgrade CBR. Our recommended design value is also based on an assessment of subgrade variability, in-situ DCP test results and published literature.

It is recommended that appropriate QA / QC testing be undertaken on subgrade and pavement materials during construction.

9 FURTHER WORK

As detailed in Section 8.1, further geotechnical and environmental investigation is suggested in this area once the proposed development details are confirmed. Environmental investigation may also be prudent for the area of the lot occupied by sheds and agricultural equipment.

10 LIMITATIONS

The findings contained within this report are the result of limited discrete investigations conducted in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site. Under no circumstances, can it be considered that these findings represent the actual state of the ground conditions away from our investigation locations.

If the ground conditions encountered during construction are significantly different from those described in this report and on which the conclusions and recommendations were based, then we must be notified immediately.

This report has been prepared for use by Riverside Investments (WA) No. 2 Pty Ltd in relation to the Lot 2 Reserve Road, Chittering, WA project in accordance with generally accepted consulting practice. No other warranty, expressed or implied, is made as to the professional advice included in this report. Use of this report by parties other than Riverside Investments (WA) No. 2 Pty Ltd and their respective consultants and contractors is at their risk as it may not contain sufficient information for any other purposes.

11 CLOSURE

We trust this is sufficient for your present needs. If you have any queries, please do not hesitate to contact the undersigned.

For and on behalf of
CMW Geosciences Pty Ltd





Alex Petty
Site Investigation Team Leader

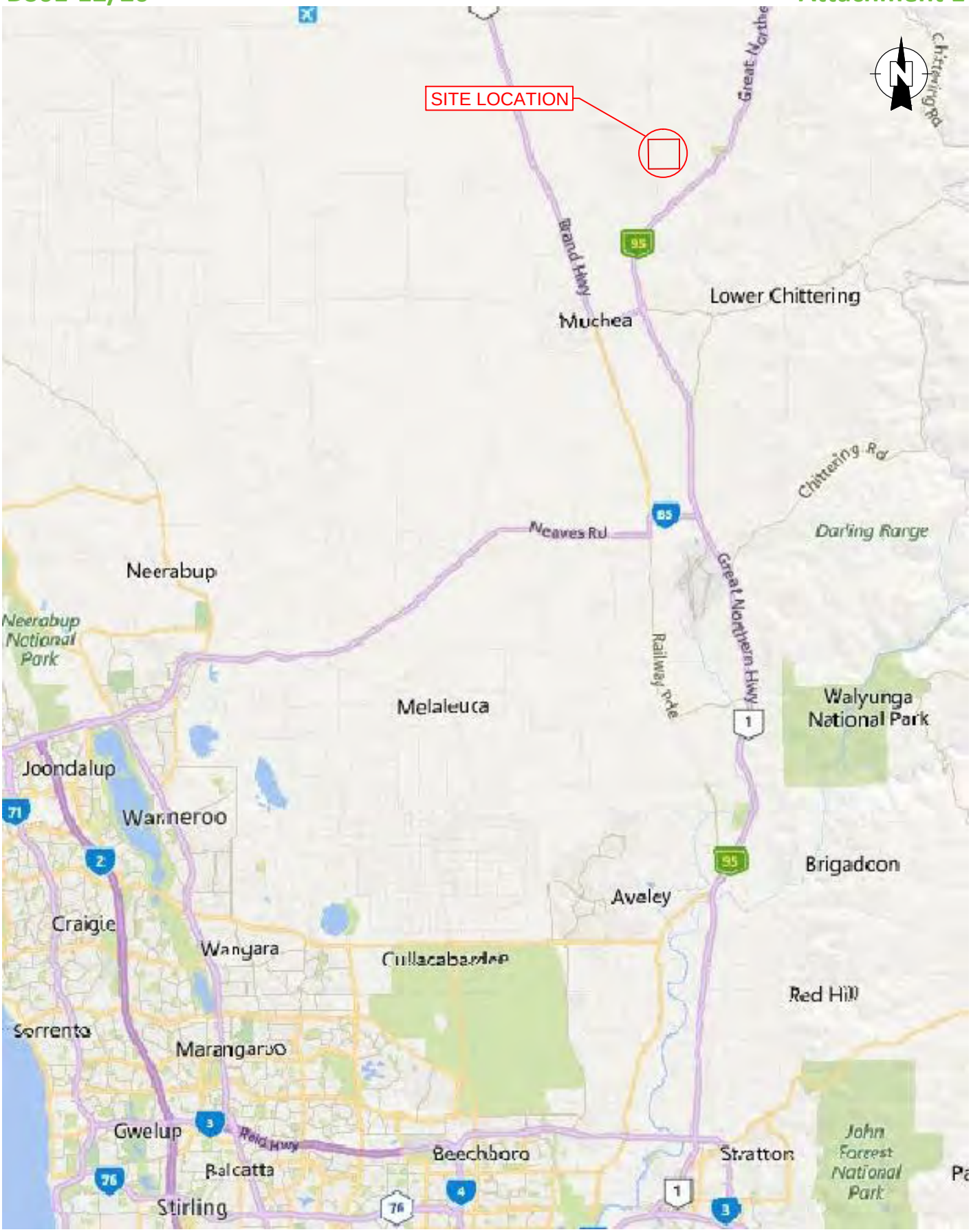
Philip Mather
Principal Engineering Geologist

Distribution: 1 copy to Riverside Investments (WA) No. 2 Pty Ltd (electronic)
Original held by CMW Geosciences Pty Ltd

12 REFERENCES

- AS 1289, *Methods of testing soils for engineering purposes,* Standards Australia, Sydney
- AS 1726 (inc. amendments 1 & 2), *Geotechnical Site Investigations,* Standards Australia, Sydney, 1993
- AS 3798 (inc. amendment 1), *Guidelines on earthworks for commercial and residential developments,* Standards Australia, Sydney, 2007
- Hvorslev J M, *Time lag and soil permeability in ground-water observations,* Bull. 36, 50 pp., U.S. Corps of Eng., Waterways Exp. Sta., Vicksburg, Miss., 1951
- *Muchea Sheet 2034 I and Part of 2134 IV*, Perth Metropolitan Region Environmental Geology Series, Geological Survey of Western Australia, 1986

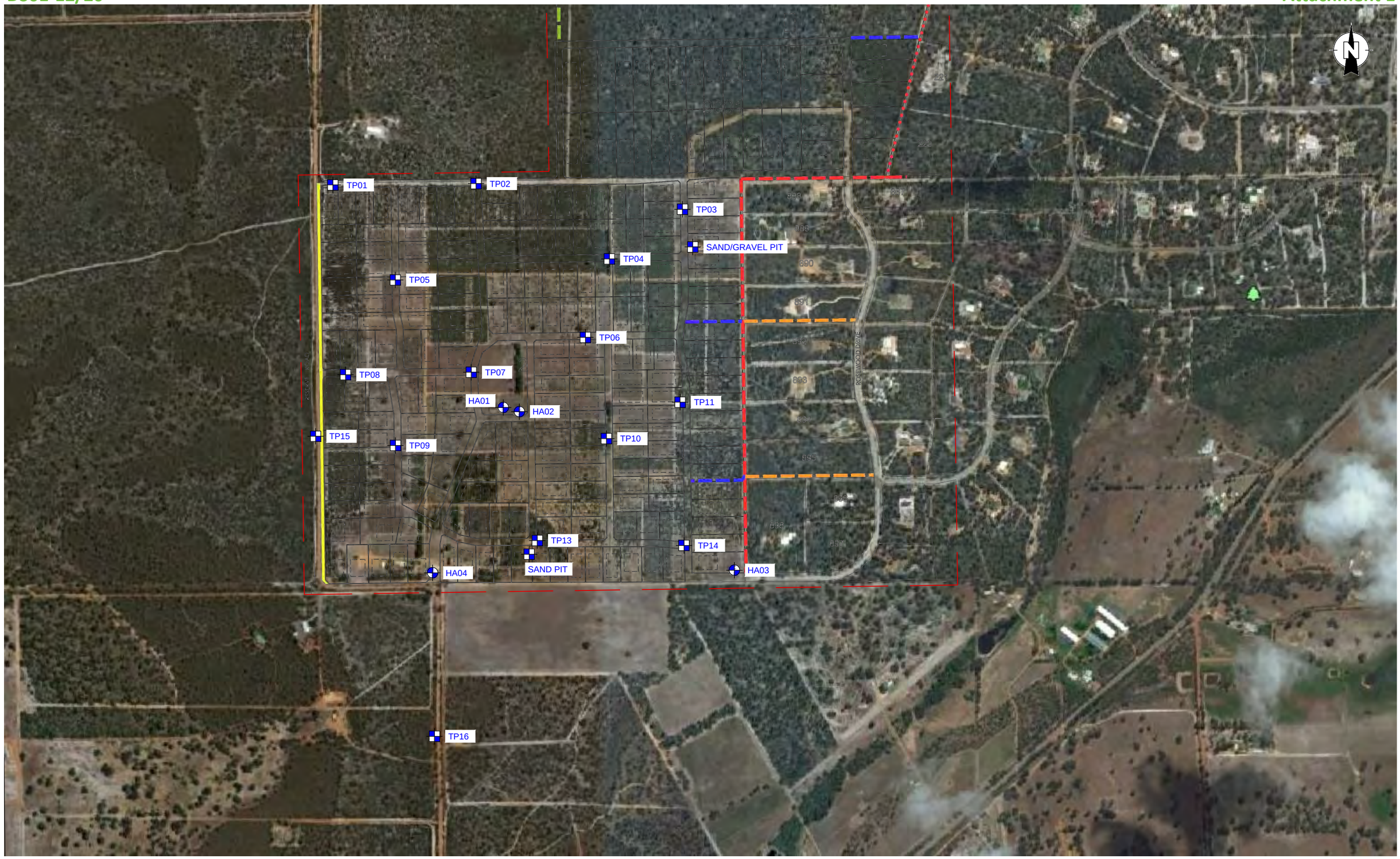
Figures



NOTE: IMAGERY SOURCED FROM BING.COM

CMW Geosciences Pty Ltd
Chapman Morton Woodward

CLIENT: RIVERSIDE INVESTMENTS (WA) NO. 2 PTY LTD		DRAWN: DE	PROJECT: PER2016-0395
PROJECT: SUBDIVISION DEVELOPMENT LOT 2, RESERVE ROAD, CHITTERING, WA		CHECKED: SVK	FIGURE: 01
		REVISION: 0	SCALE: 1:200,000
TITLE: SITE LOCATION PLAN		DATE: 15/02/2016	SHEET: A4 P



LEGEND:

- HA01 — HAND AUGER (HA) LOCATION
- TP01 — TEST PIT (TP) LOCATION

1:10 000 — 0 100 200 300 400 500 m

CMW Geosciences Pty Ltd
Chapman Morton Woodward

CLIENT: RIVERSIDE INVESTMENTS (WA) NO. 2 PTY LTD		DRAWN: DE	PROJECT: PER2016-0395
PROJECT: SUBDIVISION DEVELOPMENT LOT 2, RESERVE ROAD, CHITTERING, WA		CHECKED: SVK	FIGURE: 02
		REVISION: 0	SCALE: 1:10,000
TITLE: SITE INVESTIGATION PLAN		DATE: 15/02/2016	SHEET: A3 L

Appendix A
Site Photographs



Plate 1

Sand/gravel pit near TP03, looking east



Plate 2

Sand pit near TP13, looking east

Appendix B
Hand Auger and Test Pit Logs and Photographs

BOREHOLE LOG - HA 01

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project ID: PER2016-0395
Date: 08/02/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405474m N.6512032m
Elevation: 152 m (AHD)

Hole Diameter: 100mm
Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Structure & other observations
				152.0	0		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey.	D		
							... from 0.5m, yellow.	M		
					1					
							Borehole terminated at 1.50 m			
					2					
					3					
					4					

Termination reason: Target Depth Reached.
Remarks: Groundwater not encountered. Falling head permeability test undertaken.

BOREHOLE LOG - HA 02

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project ID: PER2016-0395
Date: 08/02/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405520m N.6512020m
Elevation: 151 m (AHD)

Hole Diameter: 100mm
Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Structure & other observations
				151.0	0		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey.	D		
							... from 0.5m, yellow	M		
					1					
							Borehole terminated at 1.50 m			
					2					
					3					
					4					

Termination reason: Target Depth Reached.
Remarks: Groundwater not encountered. Falling head permeability test undertaken.

BOREHOLE LOG - HA 03

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project ID: PER2016-0395
Date: 08/02/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.406131m N.6511570m
Elevation: 138 m (AHD)

Hole Diameter: 100mm
Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Structure & other observations
				138.0	0		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey.	D		
							... from 0.5m, yellow.	M		
					1					
							Borehole terminated at 1.50 m			
					2					
					3					
					4					

Termination reason: Target Depth Reached.

Remarks: Groundwater not encountered. Falling head permeability test undertaken.

BOREHOLE LOG - HA 04

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project ID: PER2016-0395
Date: 08/02/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405273m N.6511562m
Elevation: 159 m (AHD)

Hole Diameter: 100mm
Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Structure & other observations
				159.0	0		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, grey to yellow.	D		
							... from 0.5m, yellow.	M		
					1					
							Borehole terminated at 1.30 m			
					2					
					3					
					4					

Termination reason: Refusal on Laterite Gravel.
Remarks: Groundwater not encountered.

TEST PIT LOG - TP 01

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

CMW Geosciences Pty Ltd
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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.404990m N.6512664m
Elevation: 166 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey and white, trace roots and rootlets to 1m depth.	D	L to MD		
			164.8	1		CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, cobbles and boulders to 0.6m diameter (iron cemented). *... from 1.5m mixed with grey cemented sand and gravel lumps.*	D to M			
			163.6	2		Borehole terminated at 2.400 m				
				3						

Termination Reason: Refusal/Hard Digging
Remarks: Groundwater not encountered.

TEST PIT LOG - TP 02

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405397m N.6512668m
Elevation: 161 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & other observations
				0		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey to white, trace roots and rootlets to 0.3m depth.	D	L to MD		
				1			M			
				2		*... from 2m, pale yellow and pale grey.*				
			158.5			GRAVEL: fine to coarse grained, sub-angular to sub-rounded, red brown (laterite) with fine to coarse grained sand.				Apparent increase in moisture content in gravel.
			158.0	3		Borehole terminated at 3.000 m				

Termination Reason: End of Test Pit. Backfilled.
Remarks: Groundwater not encountered.

TEST PIT LOG - TP 03

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405984m N.6512595m
Elevation: 157 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey to pale brown, trace roots and rootlets to 0.5m depth.	D	L to MD	5 10 15	
				1			M			
			155.2			GP: GRAVEL: fine to coarse grained, sub-angular to sub-rounded, (laterite), red brown, with sand, with cobbles to 150mm.				Apparent increase in moisture content in gravel.
				2		*... from 2.5m, becoming very weakly to weakly cemented.*				
			154.4			Borehole terminated at 2.600 m				
				3						

Termination Reason: End of Test Pit. Refusal. Backfilled.
Remarks: Groundwater not encountered.

TEST PIT LOG - TP 04

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405776m N.6512454m
Elevation: 160 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
				1		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale brown to yellow, trace roots and rootlets to full depth (2.1m).	D	L to MD	5 10 15	
				2		*... from 2m becoming very weakly to weakly cemented.*				
			157.9			Borehole terminated at 2.100 m				
				3						

Termination Reason: End of Test Pit. Refusal on Cemented Sand.
Remarks: Groundwater not encountered. Backfilled.

TEST PIT LOG - TP 05

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405167m N.6512394m
Elevation: 159 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale brown, trace roots and rootlets to 0.4m depth.	D			
						... from 0.5m pale brown and pale yellow.		L to MD		
				1						
							M			Pit walls collapsing from 1.5m depth.
				2						
			156.5			Borehole terminated at 2.500 m				
				3						

Dynamic Cone Penetrometer (Blows/100mm): 5 10 15

Termination Reason: Collapse.

Remarks: Groundwater not encountered. Backfilled.

TEST PIT LOG - TP 06

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405708m N.6512231m
Elevation: 158 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace roots and rootlets to 0.3m depth.	D	L to MD		
				1		*... from 1m, pale yellow to yellow.*	M			
				2		*... from 2m becoming yellow/orange.*				Apparent increase in moisture content in gravel.
			155.6			GP: GRAVEL: fine to coarse grained, sub-angular to sub-rounded, red brown (laterite), with fine to coarse grained sand.				Pit walls collapsing from 2.5m depth.
			155.3			Borehole terminated at 2.700 m				
				3						

Termination Reason: End of Test Pit. Slow Digging.
Remarks: Groundwater not encountered. Backfilled.

TEST PIT LOG - TP 07

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405383m N.6512132m
Elevation: 153 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey, trace roots and rootlets to 0.4m depth.	D	L to MD	5 10 15	
						... from 0.5m, pale yellow.				
				1			M			Pit walls collapsing from 1.5m depth.
						... from 1.9m, yellow/orange.				
				2						
			150.5			Borehole terminated at 2.500 m				
				3						

Termination Reason: Collapse.
Remarks: Groundwater not encountered. Backfilled.

TEST PIT LOG - TP 08

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405026m N.6512125m
Elevation: 162 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & other observations
			161.7	0		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace roots and rootlets to 0.3m depth.		L to MD		Laterite gravel and cobbles sparsely scattered at surface.
						CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, cobbles and boulders (iron cemented).	D			
				1						
				2						
			159.6			Borehole terminated at 2.400 m				
				3						

Termination Reason: Refusal/Hard Digging.
Remarks: Groundwater not encountered. Backfilled.

TEST PIT LOG - TP 09

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 2

Logged by: SVK
Checked by: AP

Position: E.405168m N.6511924m
Elevation: 158 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace roots and rootlets to 0.5m depth.	D			
	0.6 - 0.8	B				*... from 0.5m, grey to white.*		L to MD		
				1						
				2			M			
				3		*... from 3m, becoming iron cemented, orange brown.*				
			154.9			GP: GRAVEL: fine to coarse grained, sub-angular to sub-rounded (laterite), red brown gravel, with cobbles to 100mm.				
						Continued on next sheet				

Termination Reason: Target Depth Reached.
Remarks: Groundwater not encountered. Backfilled

TEST PIT LOG - TP 09

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 2 of 2

Logged by: SVK
Checked by: AP

Position: E.405168m N.6511924m
Elevation: 158 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & other observations
			154.6			Borehole terminated at 3.400 m				
				4						
				5						
				6						

Termination Reason: Target Depth Reached.
Remarks: Groundwater not encountered. Backfilled

TEST PIT LOG - TP 10

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405768m N.6511943m
Elevation: 152 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & other observations
				1		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey then yellow, trace roots and rootlets to 0.5m. depth. *... from 0.5m, yellow.*	D	L to MD		
			149.7	2		GP: GRAVEL: fine to coarse grained, sub-angular to sub-rounded, orange brown (laterite), with fine to coarse grained sand.				Apparent increase in moisture content in gravel.
			149.3	3		Borehole terminated at 2.700 m				

Termination Reason: Cemented Gravel/ Slow Digging.
Remarks: Groundwater not encountered. Backfilled

TEST PIT LOG - TP 11

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405977m N.6512047m
Elevation: 155 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey to grey, trace roots and rootlets to 0.6m depth.		L to MD	5 10 15	
				1		*... from 1m, pale grey and white*	D			
				2						Pit walls collapsing from 2.0m depth.
			152.7			GP: GRAVEL: fine to coarse grained, sub-angular to sub-rounded, (laterite) red brown, with cobbles and boulders to 300mm.				Apparent increase in moisture content in gravel.
			152.5			Borehole terminated at 2.500 m				
				3						

Termination Reason: Collapse.
Remarks: Groundwater not encountered. Backfilled

TEST PIT LOG - TP 13

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

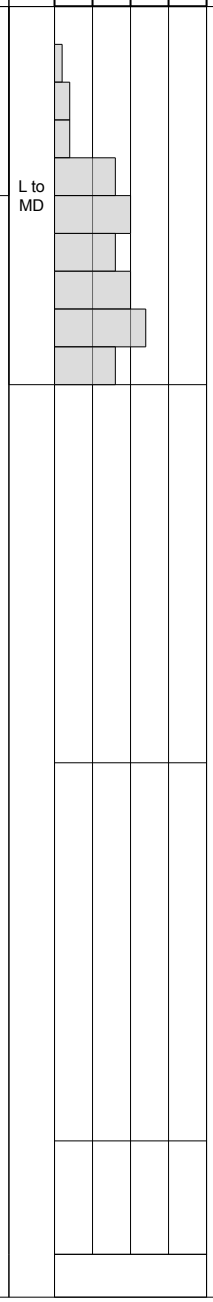
Logged by: SVK
Checked by: AP

Position: E.405571m N.6511654m
Elevation: 153 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
	0.3 - 0.5	B	152.6			SP: SAND: fine to coarse grained, sub-angular to sub-rounded, grey to orange brown with gravel, trace roots and rootlets to 0.4m depth.	D			
			152.5			CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, cobbles and boulders (iron cemented). Borehole terminated at 0.500 m		L to MD		



Termination Reason: Refusal on Laterite.
Remarks: Groundwater not encountered. Backfilled.

TEST PIT LOG - TP 14

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405988m N.6511640m
Elevation: 145 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, grey and pale brown, trace roots and rootlets to 0.7m depth.	D			
	0.6 - 0.8	B		1				L to MD		
							M			
	2.8	B	142.2	2		GRAVEL/COBBLES: fine to coarse grained, sub-angular to sub-rounded, grey gravel and cobbles of cemented sand to 150mm.				
			142.0	3		Borehole terminated at 3.000 m				

Termination Reason: Target Depth Reached.
Remarks: Groundwater not encountered. Backfilled.

TEST PIT LOG - TP 15

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.404941m N.6511950m
Elevation: 163 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
	0.1 - 0.3	B	162.8			SW: Gravelly SAND: fine to coarse grained, sub-angular to sub-rounded, (laterite), red brown, fine to coarse grained, sub-angular to sub-rounded gravel (laterite and cemented sand).	D	MD to D	5 10 15	Laterite outcropping at surface to immediate west on firebreak.
			162.7			CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, gravel and cobbles (laterite).				
						Borehole terminated at 0.300 m				
				1						
				2						
				3						

Termination Reason: Refusal on cemented gravel/cobbles/boulders (laterite).
Remarks: Groundwater not encountered.

TEST PIT LOG - TP 16

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405279m N.6511098m
Elevation: 161 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests		RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & other observations
	Depth	Type & Results								
	0.0 - 0.0	B	161.0			SW: GRAVELLY CLAYEY SAND: fine to coarse grained, sub-angular to sub-rounded, red brown, fine to coarse grained sub-angular to sub-rounded gravel (laterite), low plasticity clay. Borehole terminated at 0.050 m	D			Road is cut approximately 1m into laterite hillside.

Termination Reason: Refusal on cemented gravel/cobbles/boulders (laterite).
Remarks: Groundwater not encountered. Backfilled.



Plate 1

TP01 - Spoil



Plate 2

TP01



Plate 3

TP02 - Spoil



Plate 4

TP02



Plate 5

TP03 - Spoil



Plate 6

TP03



Plate 7

TP04 - Spoil



Plate 8

TP04



Plate 9

TP05 - Spoil



Plate 10

TP05



Plate 11

TP06 - Spoil



Plate 12

TP06



Plate 13

TP07 – Spoil



Plate 14

TP07



Plate 15

TP08 – Spoil



Plate 16

TP08



Plate 17

TP09 - Spoil



Plate 18

TP9



Plate 19

TP10 - Spoil



Plate 20

TP10



Plate 21

TP11 - Spoil



Plate 22

TP11



Plate 23

TP13 - Spoil



Plate 24

TP13



Plate 25

TP14 - Spoil



Plate 26

TP14



Plate 27

TP15 – Pit and Spoil



Plate 28

Nearby TP15, spade on ferricrete/laterite



Plate 29

TP16 – Pit and Spoil

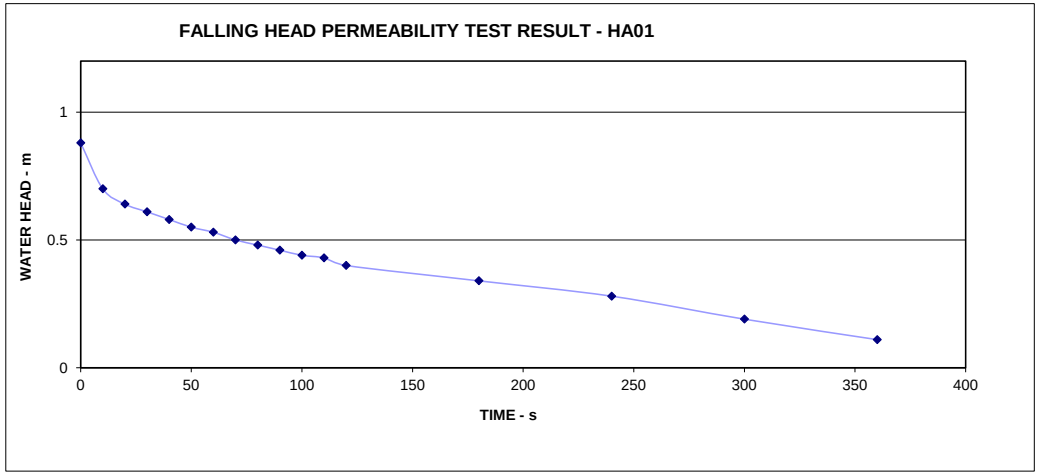


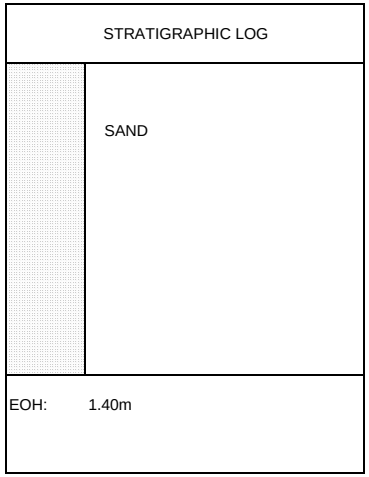
Plate 30

Nearby TP16, depicting road cutting into hill side

Appendix C
In-situ Permeability Test Results

CLIENT: Riverside Investments (WA) No.2 Pty Ltd
SITE NAME: Lot 2 Reserve Road
LOCATION: Chittering
JOB NUMBER: PER2016-0395
DATE: 8/02/2016





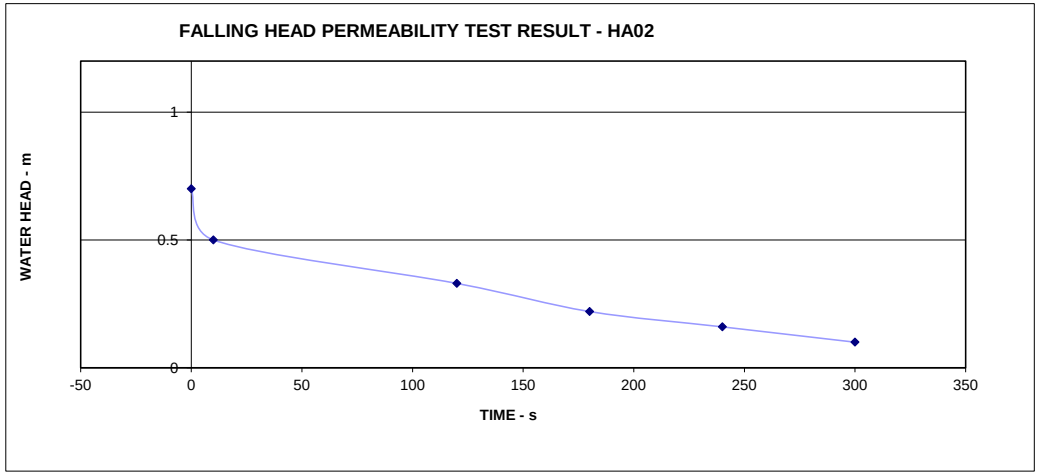
HVORSLEV CASE G:
Soakage out base and sides of test hole with no overlying restrictive layer:

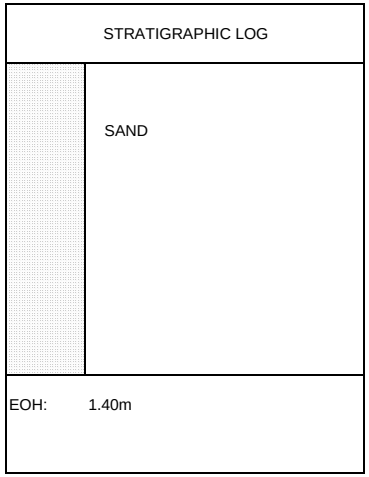
$$\text{Hydraulic conductivity (k)} = \frac{d^2 \times \ln(2.m.L/D)}{8.L.(t2 - t1)} \times \ln \frac{H1}{H2}$$

where
d = D = test hole diameter (m) = 0.085 m
m = transformation ratio = 1
L = average soakage length (m)
t = time (secs)
H1 = piezometric head for t = t1
H2 = piezometric head for t = t2

Elapsed Time (s)	t2 - t1 (secs)	Piezometric Head H (m)	Average L (m)	ln (H1/H2)	Hydraulic Conductivity k (m/sec)	k (m/day)
0		0.88				
10	10	0.7	0.79	0.23	7.65E-05	6.61
20	10	0.64	0.67	0.09	3.33E-05	2.88
30	10	0.61	0.63	0.05	1.86E-05	1.61
40	10	0.58	0.60	0.05	2.02E-05	1.75
50	10	0.55	0.57	0.05	2.20E-05	1.90
60	10	0.53	0.54	0.04	1.57E-05	1.36
70	10	0.5	0.52	0.06	2.55E-05	2.20
80	10	0.48	0.49	0.04	1.84E-05	1.59
90	10	0.46	0.47	0.04	1.97E-05	1.70
100	10	0.44	0.45	0.04	2.11E-05	1.82
110	10	0.43	0.44	0.02	1.11E-05	0.96
120	10	0.4	0.42	0.07	3.59E-05	3.10
180	60	0.34	0.37	0.16	1.43E-05	1.24
240	60	0.28	0.31	0.19	1.87E-05	1.62
300	60	0.19	0.24	0.39	4.25E-05	3.67
360	60	0.11	0.15	0.55	6.92E-05	5.98
				Average =	2.89E-05	2.497865

CLIENT: Riverside Investments (WA) No.2 Pty Ltd
SITE NAME: Lot 2 Reserve Road
LOCATION: Chittering
JOB NUMBER: PER2016-0395
DATE: 8/02/2016





HVORSLEV CASE G:
Soakage out base and sides of test hole with no overlying restrictive layer:

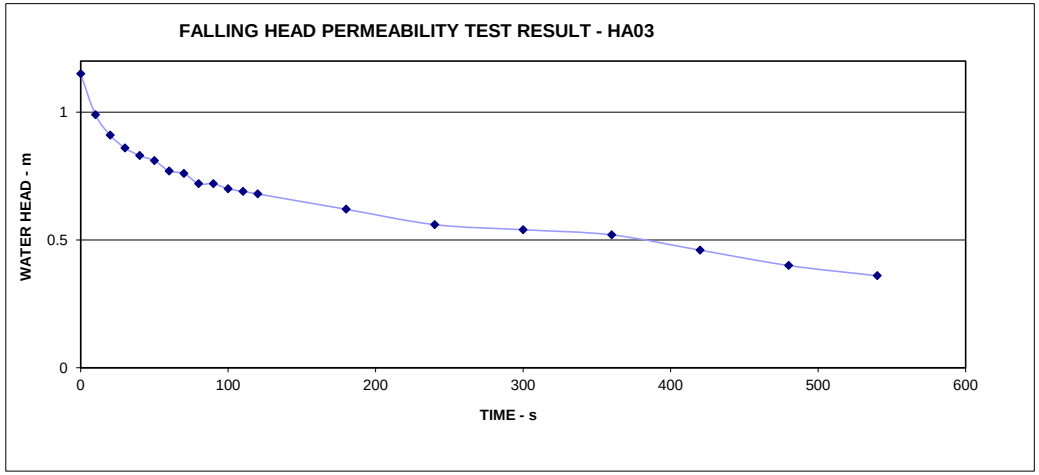
$$\text{Hydraulic conductivity (k)} = \frac{d^2 \times \ln(2.m.L/D)}{8.L.(t2 - t1)} \times \ln \frac{H1}{H2}$$

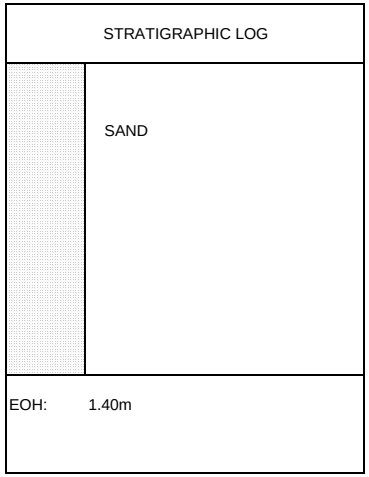
where
d = D = test hole diameter (m) = 0.085 m
m = transformation ratio = 1
L = average soakage length (m)
t = time (secs)
H1 = piezometric head for t = t1
H2 = piezometric head for t = t2

Elapsed Time (s)	t2 - t1 (secs)	Piezometric Head H (m)	Average L (m)	ln (H1/H2)	Hydraulic Conductivity k (m/sec)	k (m/day)
0		0.7				
10	10	0.5	0.60	0.34	1.34E-04	11.58
120	110	0.33	0.42	0.42	1.87E-05	1.62
180	60	0.22	0.28	0.41	4.14E-05	3.58
240	60	0.16	0.19	0.32	3.78E-05	3.26
300	60	0.1	0.13	0.47	6.08E-05	5.26

Average = 5.86E-05 5.060919

CLIENT: Riverside Investments (WA) No.2 Pty Ltd
SITE NAME: Lot 2 Reserve Road
LOCATION: Chittering
JOB NUMBER: PER2016-0395
DATE: 8/02/2016





HVORSLEV CASE G:
Soakage out base and sides of test hole with no overlying restrictive layer:

$$\text{Hydraulic conductivity (k)} = \frac{d^2 \times \ln(2.m.L/D)}{8.L.(t2 - t1)} \times \ln \frac{H1}{H2}$$

where
d = D = test hole diameter (m) = 0.085 m
m = transformation ratio = 1
L = average soakage length (m)
t = time (secs)
H1 = piezometric head for t = t1
H2 = piezometric head for t = t2

Elapsed Time (s)	t2 - t1 (secs)	Piezometric Head H (m)	Average L (m)	ln (H1/H2)	Hydraulic Conductivity k (m/sec)	k (m/day)
0		1.15				
10	10	0.99	1.07	0.15	4.08E-05	3.52
20	10	0.91	0.95	0.08	2.49E-05	2.15
30	10	0.86	0.89	0.06	1.75E-05	1.51
40	10	0.83	0.85	0.04	1.13E-05	0.98
50	10	0.81	0.82	0.02	7.95E-06	0.69
60	10	0.77	0.79	0.05	1.69E-05	1.46
70	10	0.76	0.77	0.01	4.46E-06	0.39
80	10	0.72	0.74	0.05	1.89E-05	1.63
90	10	0.72	0.72	0.00	0.00E+00	0.00
100	10	0.7	0.71	0.03	1.01E-05	0.87
110	10	0.69	0.70	0.01	5.22E-06	0.45
120	10	0.68	0.69	0.01	5.35E-06	0.46
180	60	0.62	0.65	0.09	5.83E-06	0.50
240	60	0.56	0.59	0.10	6.83E-06	0.59
300	60	0.54	0.55	0.04	2.55E-06	0.22
360	60	0.52	0.53	0.04	2.70E-06	0.23
420	60	0.46	0.49	0.12	9.21E-06	0.80
480	60	0.4	0.43	0.14	1.13E-05	0.98
540	60	0.36	0.38	0.11	9.14E-06	0.79
600	60	0.28	0.32	0.25	2.39E-05	2.06
				Average =	1.11E-05	0.959381

Appendix D
Laboratory Test Results

DS01-12/20

Cardno Geotech Pty Ltd
ABN: 48 137 480 034
Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: Geotech Bunbury
Phone: 08 9726 2187 Fax: 08 9721 2348
Email: paul.kent@cardno.com

Attachment 1

PARTICLE SIZE DISTRIBUTION REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5176-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP09 Depth 0.6-0.8m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	19/02/2016 Page 1 of 1

Test Procedures:	AS1289.3.6.1
Sample Number	5029/S/11199
Sampling Method	Tested As Received
Date Sampled	11/02/2016
Sampled By	Client Sampled
Date Tested	17/02/2016
Material Source	-

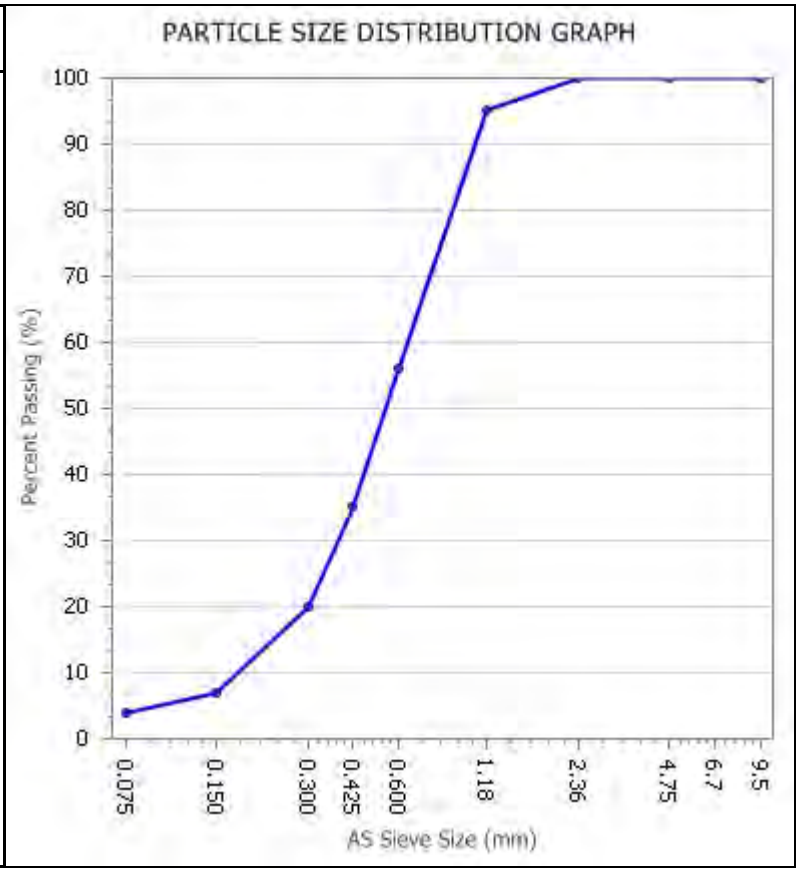
Sample Location

Test Request

Area

Material Type Yellow SAND

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
9.5		**100**	
4.75		**100**	
2.36		**100**	
1.18		**95**	
0.600		**56**	
0.425		**35**	
0.300		**20**	
0.150		**7**	
0.075		**4**	



Remarks

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Accreditation Number: 5029

Approved Signatory: Paul Kent

Form ID: W9Rep Rev 2

DS01-12/20

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Davenport WA 6230

Laboratory: Geotech Bunbury
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Email: paul.kent@cardno.com

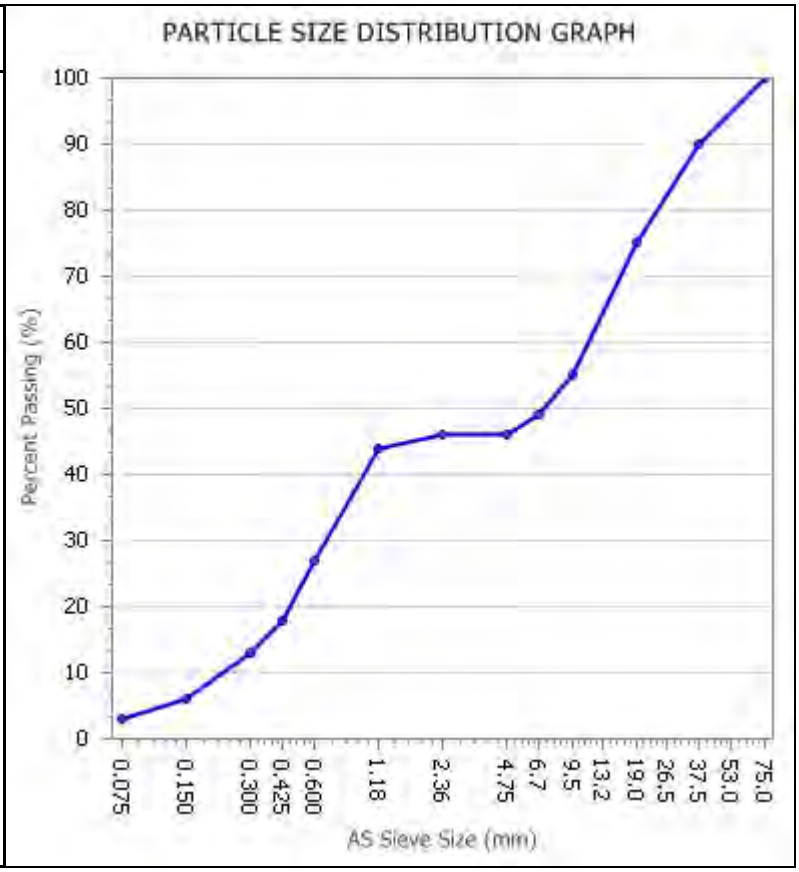
Attachment 1

PARTICLE SIZE DISTRIBUTION REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5197-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP13 Depth 0.3-0.5m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	22/02/2016 Page 1 of 1

Test Procedures:	AS1289.3.6.1		
Sample Number	5029/S/11200	Sample Location	
Sampling Method	Tested As Received	Test Request	
Date Sampled	11/02/2016	Area	
Sampled By	Client Sampled		
Date Tested	16/02/2016		
Material Source	-	Material Type	Brown Sandy GRAVEL

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
75.0		**100**	
37.5		**90**	
19.0		**75**	
9.5		**55**	
6.7		**49**	
4.75		**46**	
2.36		**46**	
1.18		**44**	
0.600		**27**	
0.425		**18**	
0.300		**13**	
0.150		**6**	
0.075		**3**	



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DS01-12/20

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Laboratory: Geotech Bunbury
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Email: paul.kent@cardno.com

Attachment 1

PARTICLE SIZE DISTRIBUTION REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5180-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP15 Depth 0.1-0.3m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	22/02/2016 Page 1 of 1

Test Procedures:	AS1289.3.6.1
Sample Number	5029/S/11201
Sampling Method	Tested As Received
Date Sampled	11/02/2016
Sampled By	Client Sampled
Date Tested	16/02/2016
Material Source	-

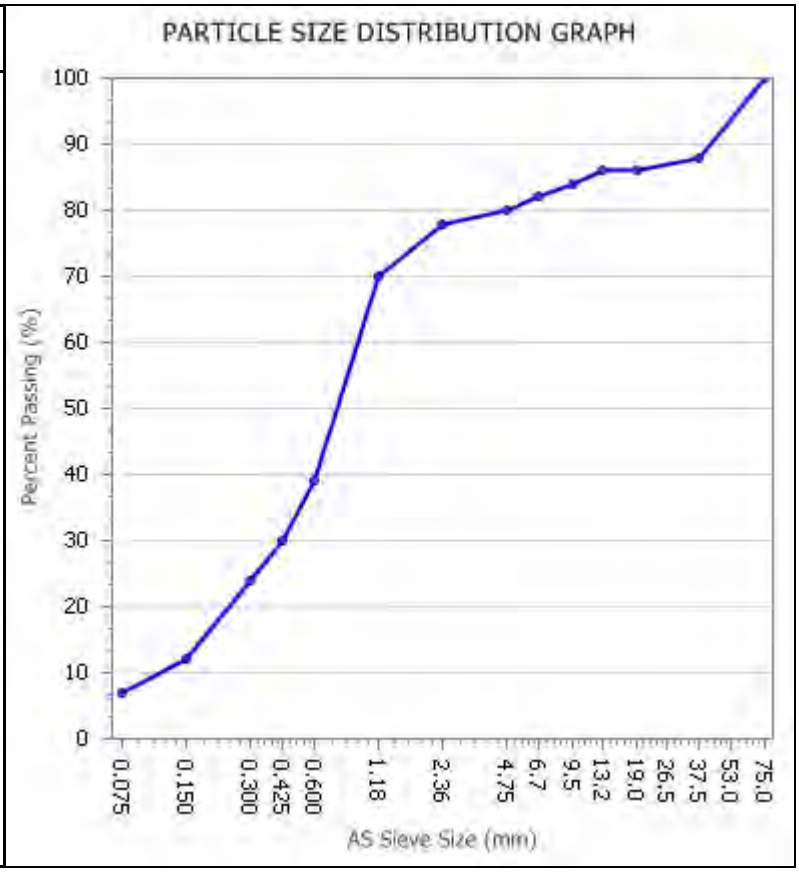
Sample Location

Test Request

Area

Material Type Brown gravelly SAND

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
75.0		**100**	
37.5		**88**	
19.0		**86**	
13.2		**86**	
9.5		**84**	
6.7		**82**	
4.75		**80**	
2.36		**78**	
1.18		**70**	
0.600		**39**	
0.425		**30**	
0.300		**24**	
0.150		**12**	
0.075		**7**	



Remarks

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DS01-12/20

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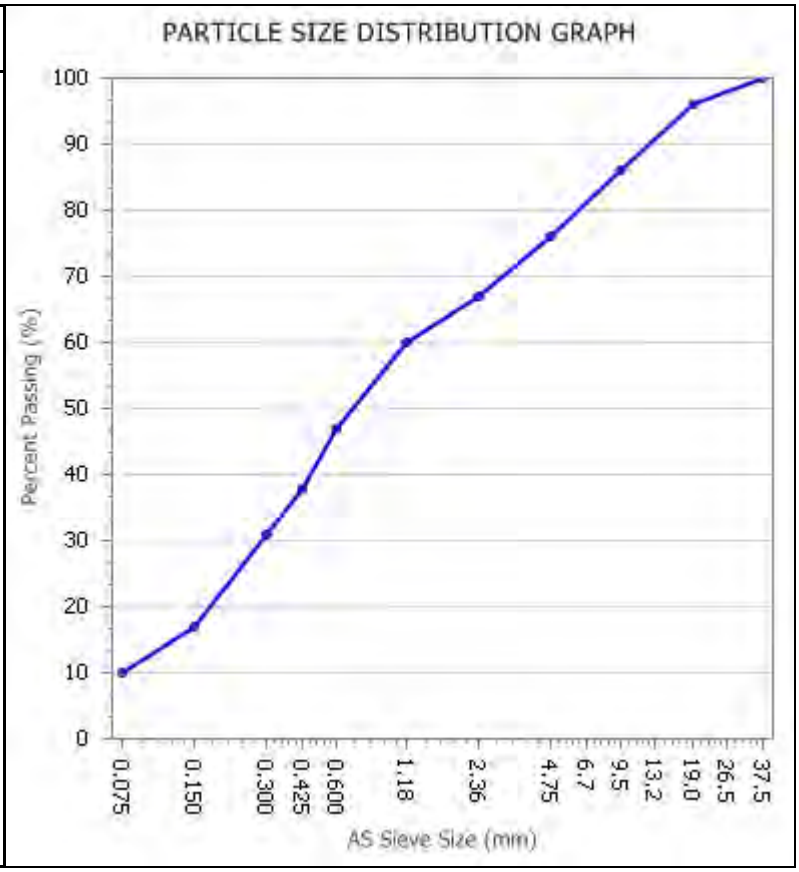
Attachment 1

PARTICLE SIZE DISTRIBUTION REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5181-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP16 Depth 0.0-0.1m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	22/02/2016 Page 1 of 1

Test Procedures:	AS1289.3.6.1		
Sample Number	5029/S/11202	Sample Location	
Sampling Method	Tested As Received	Test Request	
Date Sampled	11/02/2016	Area	
Sampled By	Client Sampled		
Date Tested	17/02/2016		
Material Source	-	Material Type	Brown Gravelly Clayey SAND

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
37.5		**100**	
19.0		**96**	
9.5		**86**	
4.75		**76**	
2.36		**67**	
1.18		**60**	
0.600		**47**	
0.425		**38**	
0.300		**31**	
0.150		**17**	
0.075		**10**	



Remarks

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Accreditation Number: 5029

Approved Signatory: Paul Kent
Form ID: W9Rep Rev 2

DS01-12/20

Cardno Geotech Pty Ltd
ABN: 48 137 480 034
Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: Geotech Bunbury
Phone: 08 9726 2187 Fax: 08 9721 2348
Email: paul.kent@cardno.com

Attachment 1

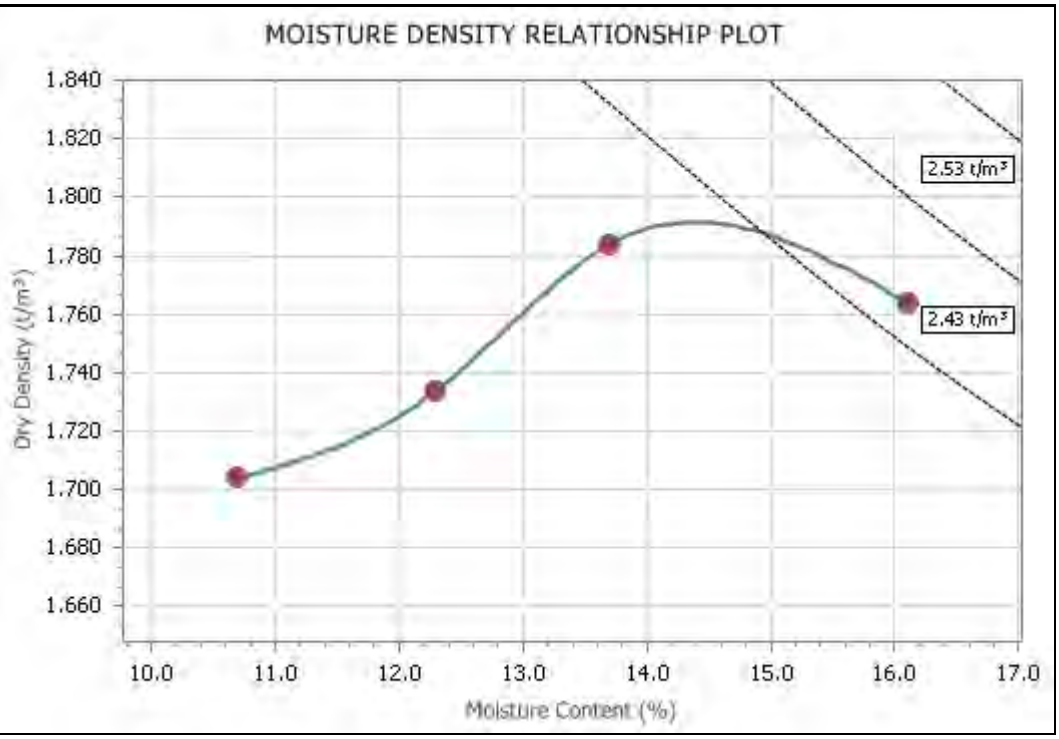
MOISTURE DENSITY RELATIONSHIP REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5106-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP09 Depth 0.6-0.8m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	17/02/2016 Page 1 of 1

Test Procedures	AS1289.5.2.1, AS1289.2.1.1	Sample Location	
Sample Number	5029/S/11199	Test Request	
Sampling Method	Tested As Received	Area	
Date Sampled	11/02/2016		
Sampled By	Client Sampled		
Date Tested	16/02/2016	Compactive Effort	Modified
Material Source		Fraction Tested (mm)	< 19.0mm
Material Type		Percent Oversize (%)	0.0
Material Description	White SAND		

Moisture / Density Relationship Data

Moisture Content (%)	Dry Density (t/m³)
10.7	1.704
12.3	1.734
13.7	1.784
16.1	1.764



Maximum Dry Density (t/m³):	1.79	Optimum Moisture Content (%):	14.5

Remarks

NATA

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Accreditation Number: 5029

Approved Signatory: Janine Fischer
Form ID: W4Rep Rev 1

Cardno Geotech Pty Ltd
ABN: 48 137 480 034
Address: 72 McCombe Road, Davenport WA 6230
Laboratory: Geotech Bunbury
Phone: 08 9726 2187 Fax: 08 9721 2348
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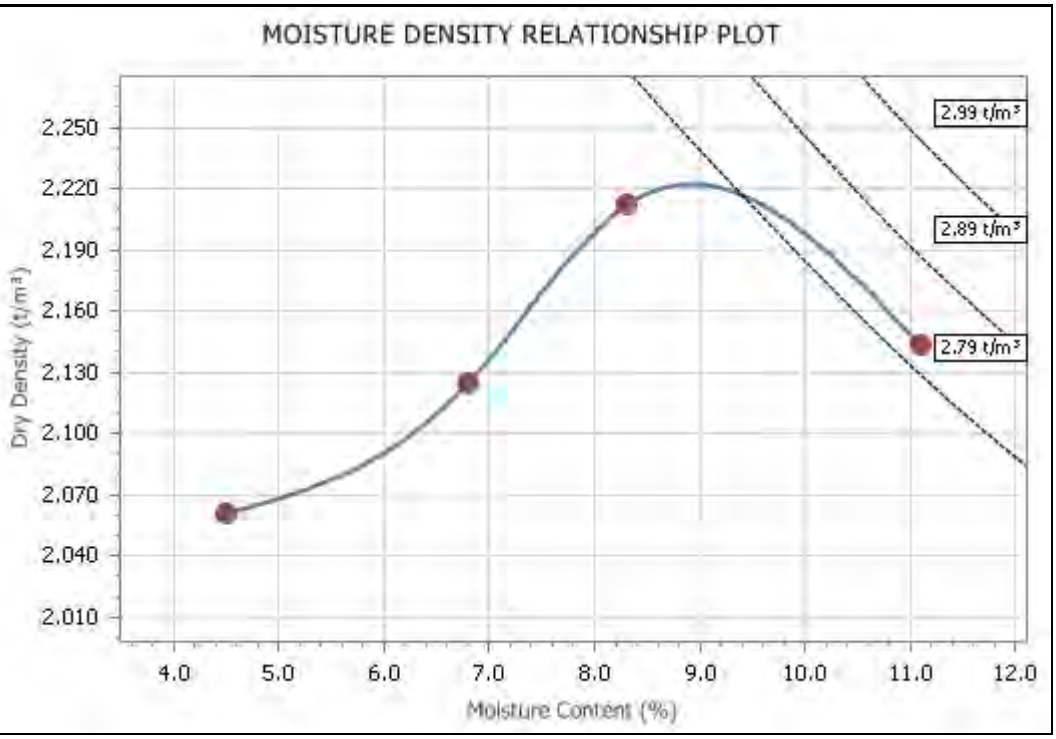
MOISTURE DENSITY RELATIONSHIP REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5107-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP13 Depth 0.3-0.5m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	17/02/2016 Page 1 of 1

Test Procedures	AS1289.5.2.1, AS1289.2.1.1	Sample Location	
Sample Number	5029/S/11200	Test Request	
Sampling Method	Tested As Received	Area	
Date Sampled	11/02/2016		
Sampled By	Client Sampled		
Date Tested	15/02/2016	Compactive Effort	Modified
Material Source		Fraction Tested (mm)	< 19.0mm
Material Type		Percent Oversize (%)	14.6
Material Description	Brown Rocky SAND		

Moisture / Density Relationship Data

Moisture Content (%)	Dry Density (t/m³)
4.5	2.061
6.8	2.125
8.3	2.212
11.1	2.143



Maximum Dry Density (t/m³):	2.22	Optimum Moisture Content (%):	9.0

Remarks

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Approved Signatory: Janine Fischer
Form ID: W4Rep Rev 1

Cardno Geotech Pty Ltd
ABN: 48 137 480 034
Address: 72 McCombe Road, Davenport WA 6230
Laboratory: Geotech Bunbury
Phone: 08 9726 2187 Fax: 08 9721 2348
Email: paul.kent@cardno.com

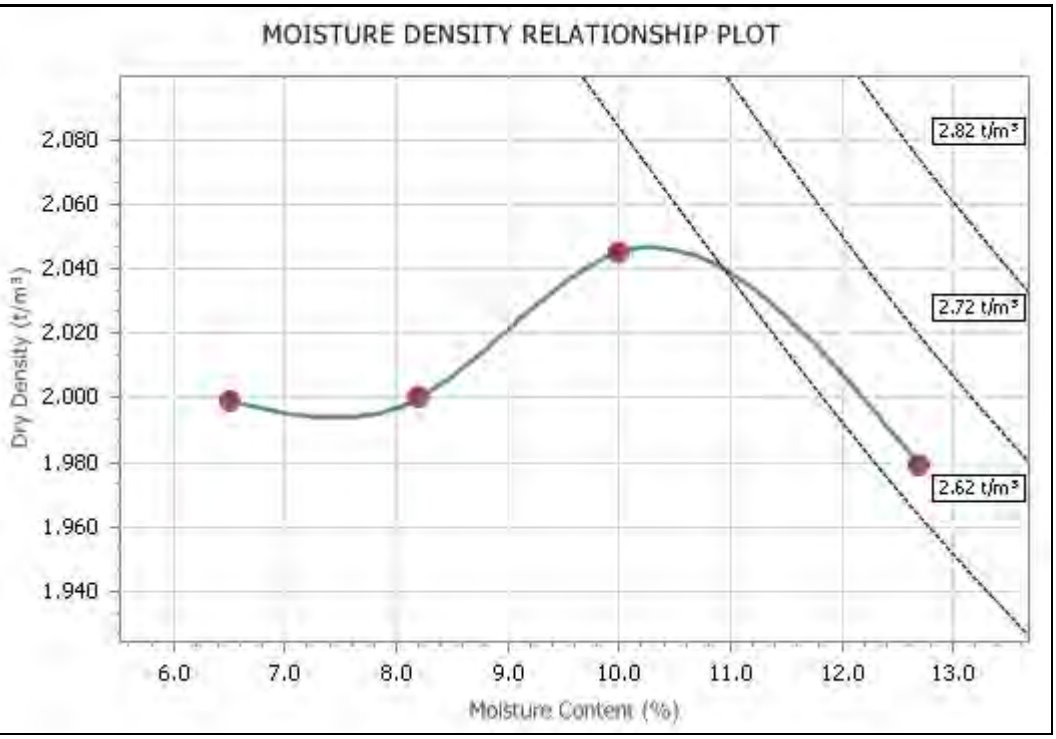
MOISTURE DENSITY RELATIONSHIP REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5108-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP15 Depth 0.1-0.3m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	17/02/2016 Page 1 of 1

Test Procedures	AS1289.5.2.1, AS1289.2.1.1	Sample Location	
Sample Number	5029/S/11201	Test Request	
Sampling Method	Tested As Received	Area	
Date Sampled	11/02/2016		
Sampled By	Client Sampled		
Date Tested	16/02/2016	Compactive Effort	Modified
Material Source		Fraction Tested (mm)	< 19.0mm
Material Type		Percent Oversize (%)	6.7
Material Description	Brown Gravelly SAND		

Moisture / Density Relationship Data

Moisture Content (%)	Dry Density (t/m³)
6.5	1.999
8.2	2.000
10.0	2.045
12.7	1.979



Maximum Dry Density (t/m³):	2.05	Optimum Moisture Content (%):	10.5

Remarks

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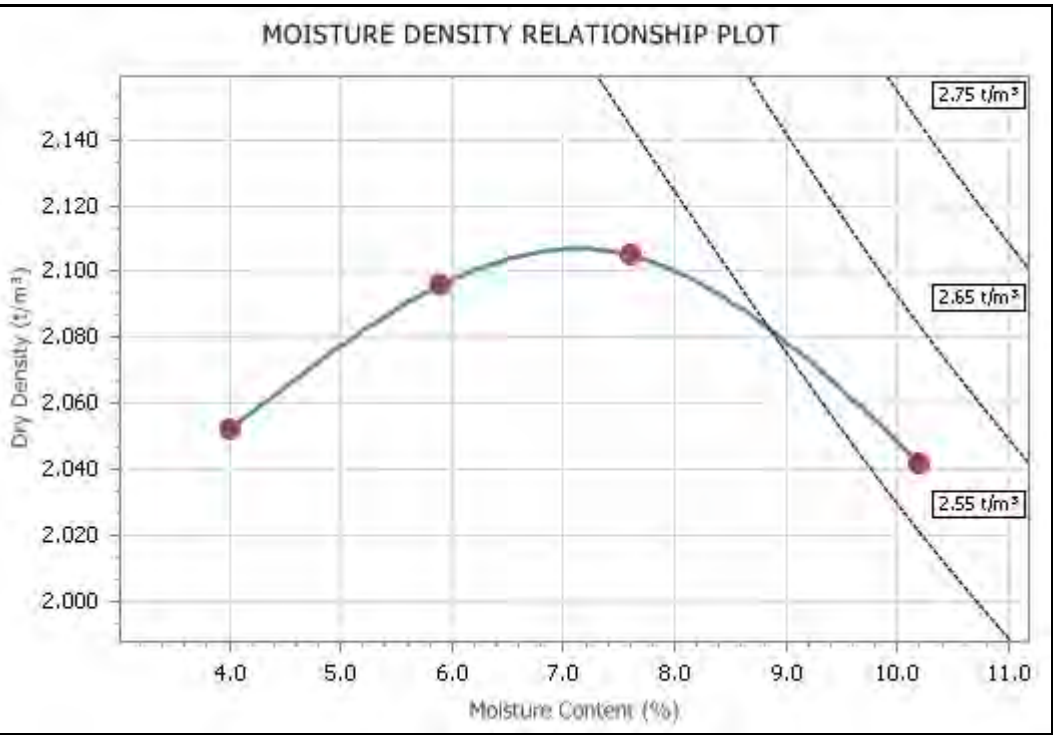
MOISTURE DENSITY RELATIONSHIP REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5109-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP16 Depth 0.0-0.1m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	17/02/2016 Page 1 of 1

Test Procedures	AS1289.5.2.1, AS1289.2.1.1	Sample Location	
Sample Number	5029/S/11202	Test Request	
Sampling Method	Tested As Received	Area	
Date Sampled	11/02/2016		
Sampled By	Client Sampled		
Date Tested	15/02/2016	Compactive Effort	Modified
Material Source		Fraction Tested (mm)	< 19.0mm
Material Type		Percent Oversize (%)	2.7
Material Description	Brown GRAVEL		

Moisture / Density Relationship Data

Moisture Content (%)	Dry Density (t/m³)
4.0	2.052
5.9	2.096
7.6	2.105
10.2	2.042



Maximum Dry Density (t/m³):	2.11	Optimum Moisture Content (%):	7.0

Remarks

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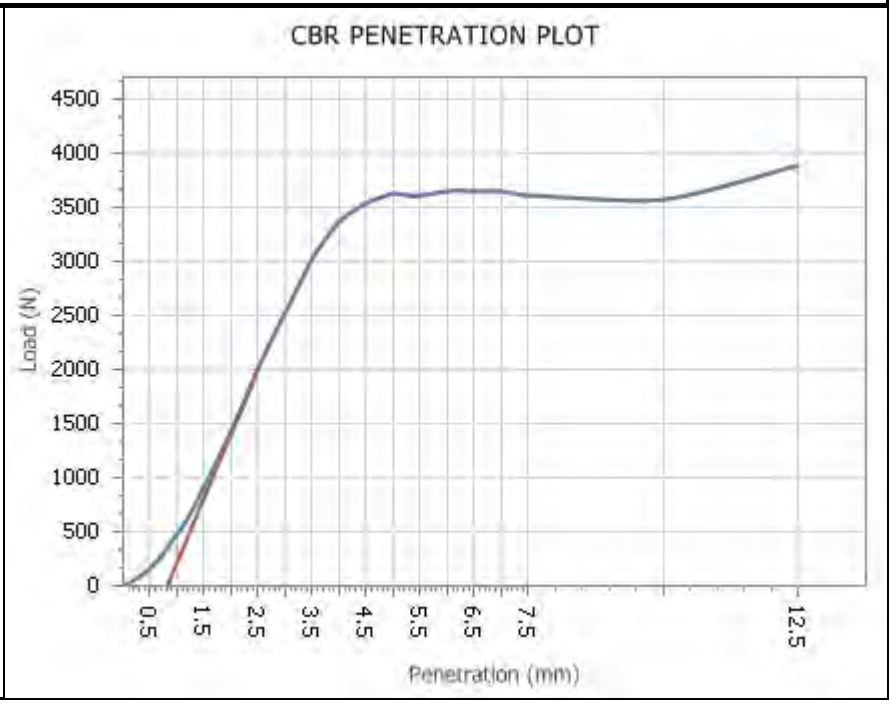
CALIFORNIA BEARING RATIO REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5188-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP09 Depth 0.6-0.8m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	22/02/2016 Page 1 of 1

Test Procedures	AS1289.6.1.1, AS1289.5.2.1, AS1289.2.1.1

		Sample Location	
Sample Number	5029/S/11199	Test Request	
Sampling Method	Tested As Received	Area	
Date Sampled	11/02/2016		
Sampled By	Client Sampled		
Date Tested	22/02/2016		
Material Source	-	Material Limit Start	-
Material Type	White SAND	Material Limit End	-
Client Reference	-	Compactive Effort	Modified
Material Description	White SAND		

Maximum Dry Density (t/m³):	1.79
Optimum Moisture Content (%):	14.5
Field Moisture Content (%):	2.3
Sample Percent Oversize (%)	0.0
Oversize Included / Excluded	Excluded
Target Density Ratio (%):	95
Target Moisture Ratio (%):	100
Placement Dry Density (t/m³):	1.72
Placement Dry Density Ratio (%):	96.5
Placement Moisture Content (%):	12.9
Placement Moisture Ratio (%):	89.5
Test Condition / Soaking Period:	Soaked / 4 Days
CBR Surcharge (kg)	4.5
Dry Density After Soak (t/m³):	1.73
Moisture (top 30mm) After Soak (%)	13.6
Moisture (remainder) After Soak (%)	15.6
CBR Swell (%):	0.0
Minimum CBR Specification (%):	-
CBR Value @ 2.5mm (%):	**20**



Remarks

NATA

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Accredited for compliance with ISO/IEC 17025

Accreditation Number: 5029

Approved Signatory: Janine Fischer
Form ID: W7Rep Rev 1

Cardno Geotech Pty Ltd
ABN: 48 137 480 034
Address: 72 McCombe Road, Davenport WA 6230

Laboratory: Geotech Bunbury
Phone: 08 9726 2187 Fax: 08 9721 2348
Email: paul.kent@cardno.com

CALIFORNIA BEARING RATIO REPORT

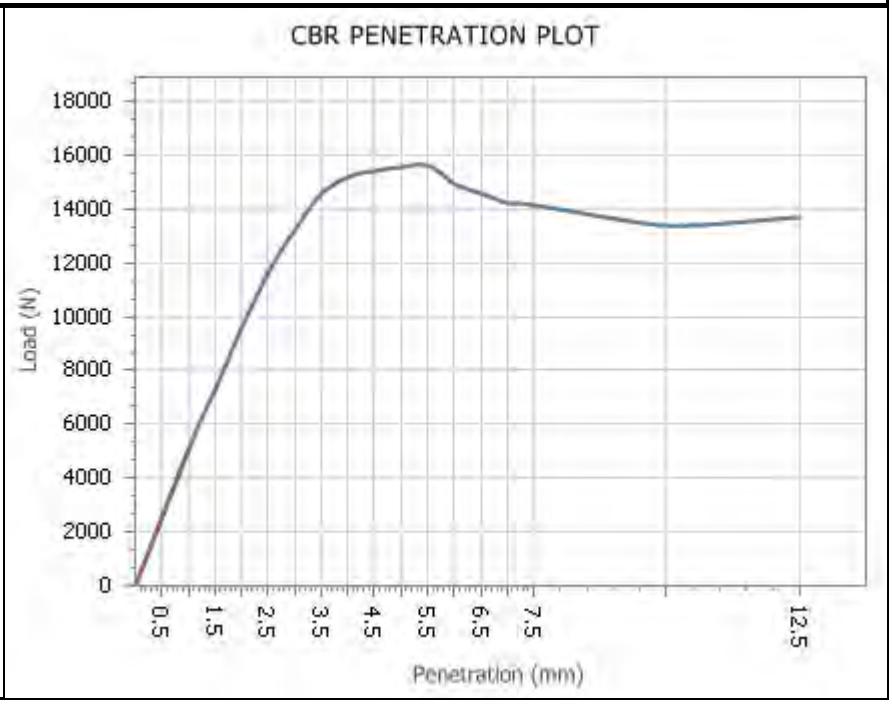
Client:	CMW Geosciences	Report Number:	5029/R/5185-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP13 Depth 0.3-0.5m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	22/02/2016 Page 1 of 1

Test Procedures	AS1289.6.1.1, AS1289.5.2.1, AS1289.2.1.1

		Sample Location	
Sample Number	5029/S/11200	Test Request	
Sampling Method	Tested As Received	Area	
Date Sampled	11/02/2016		
Sampled By	Client Sampled		
Date Tested	22/02/2016		
Material Source	-	Material Limit Start	-
Material Type	-	Material Limit End	-
Client Reference	-	Compactive Effort	Modified

Material Description	Brown Rocky SAND

Maximum Dry Density (t/m³):	2.22
Optimum Moisture Content (%):	9.0
Field Moisture Content (%):	2.9
Sample Percent Oversize (%)	15.0
Oversize Included / Excluded	Excluded
Target Density Ratio (%):	95
Target Moisture Ratio (%):	100
Placement Dry Density (t/m³):	2.12
Placement Dry Density Ratio (%):	95.5
Placement Moisture Content (%):	8.5
Placement Moisture Ratio (%):	95.5
Test Condition / Soaking Period:	Soaked / 4 Days
CBR Surcharge (kg)	4.5
Dry Density After Soak (t/m³):	2.12
Moisture (top 30mm) After Soak (%)	9.5
Moisture (remainder) After Soak (%)	9.9
CBR Swell (%):	0.0
Minimum CBR Specification (%):	-
CBR Value @ 2.5mm (%):	**90**



Remarks

NATA

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CALIFORNIA BEARING RATIO REPORT

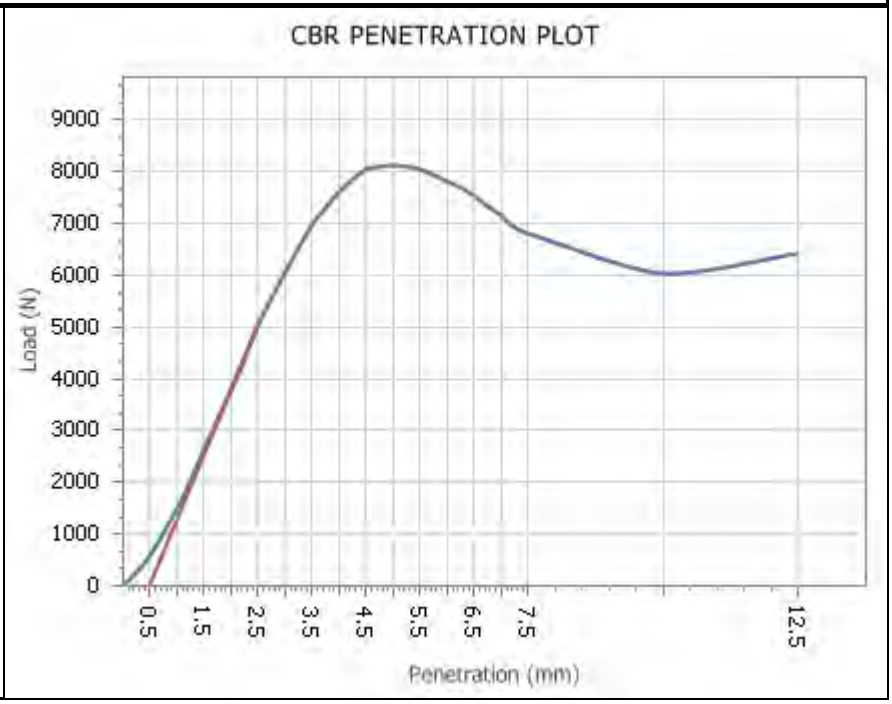
Client:	CMW Geosciences	Report Number:	5029/R/5186-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP15 Depth 0.1-0.3m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	22/02/2016 Page 1 of 1

Test Procedures	AS1289.6.1.1, AS1289.5.2.1, AS1289.2.1.1

Sample Number	5029/S/11201	Sample Location	
Sampling Method	Tested As Received	Test Request	
Date Sampled	11/02/2016	Area	
Sampled By	Client Sampled		
Date Tested	22/02/2016		
Material Source	-	Material Limit Start	-
Material Type	Brown gravelly SAND	Material Limit End	-
Client Reference	-	Compactive Effort	Modified

Material Description	Brown Gravelly SAND

Maximum Dry Density (t/m³):	2.05
Optimum Moisture Content (%):	10.5
Field Moisture Content (%):	2.6
Sample Percent Oversize (%)	7.0
Oversize Included / Excluded	Excluded
Target Density Ratio (%):	98
Target Moisture Ratio (%):	100
Placement Dry Density (t/m³):	2.01
Placement Dry Density Ratio (%):	98.0
Placement Moisture Content (%):	10.1
Placement Moisture Ratio (%):	98.0
Test Condition / Soaking Period:	Soaked / 4 Days
CBR Surcharge (kg)	4.5
Dry Density After Soak (t/m³):	1.99
Moisture (top 30mm) After Soak (%)	11.4
Moisture (remainder) After Soak (%)	10.3
CBR Swell (%):	1.0
Minimum CBR Specification (%):	-
CBR Value @ 2.5mm (%):	**45**



Remarks

NATA

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Approved Signatory: Janine Fischer
Form ID: W7Rep Rev 1

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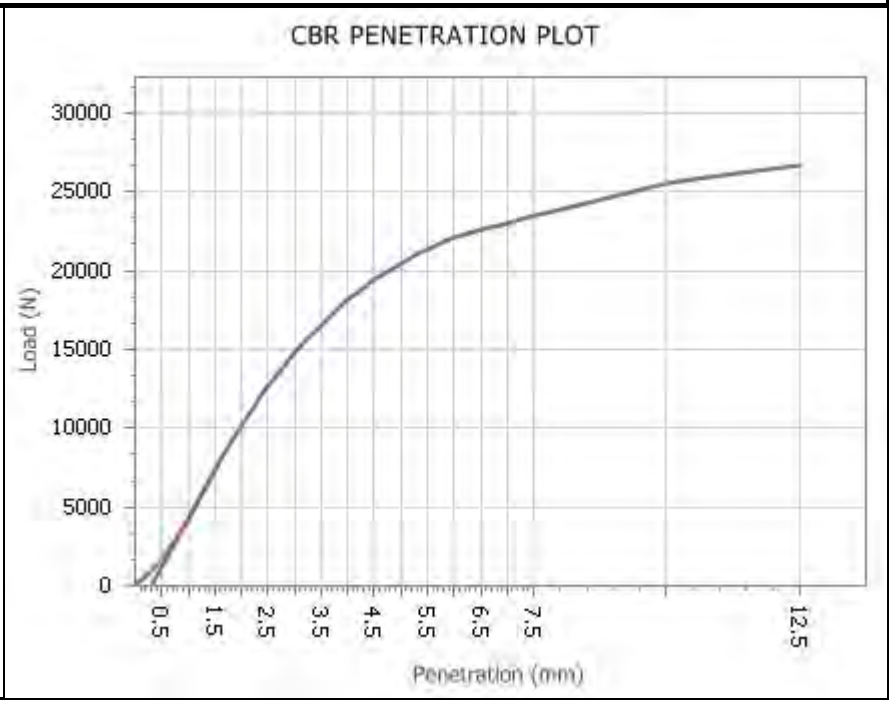
Client:	CMW Geosciences	Report Number:	5029/R/5187-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP16 Depth 0.0-0.1m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	22/02/2016 Page 1 of 1

Test Procedures	AS1289.6.1.1, AS1289.5.2.1, AS1289.2.1.1

		Sample Location	
Sample Number	5029/S/11202	Test Request	
Sampling Method	Tested As Received	Area	
Date Sampled	11/02/2016		
Sampled By	Client Sampled		
Date Tested	22/02/2016		
Material Source	-	Material Limit Start	-
Material Type	Brown Gravelly Clayey SAND	Material Limit End	-
Client Reference	-	Compactive Effort	Modified

Material Description	Brown GRAVEL

Maximum Dry Density (t/m³):	2.11
Optimum Moisture Content (%):	7.0
Field Moisture Content (%):	1.9
Sample Percent Oversize (%)	3.0
Oversize Included / Excluded	Excluded
Target Density Ratio (%):	98
Target Moisture Ratio (%):	100
Placement Dry Density (t/m³):	2.06
Placement Dry Density Ratio (%):	98.0
Placement Moisture Content (%):	7.2
Placement Moisture Ratio (%):	101.5
Test Condition / Soaking Period:	Soaked / 4 Days
CBR Surcharge (kg)	4.5
Dry Density After Soak (t/m³):	2.08
Moisture (top 30mm) After Soak (%)	10.2
Moisture (remainder) After Soak (%)	10.0
CBR Swell (%):	-1.0
Minimum CBR Specification (%):	-
CBR Value @ 5.0mm (%):	**110**



Remarks

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Accredited for compliance with ISO/IEC 17025

NATA

Accreditation Number: 5029

Approved Signatory: Janine Fischer
Form ID: W7Rep Rev 1

3 August 2016 Document Ref: PER2016-0395AD Rev2

Riverside Investment (WA) No. 2 Pty Ltd
c/o 3rd Wave Capital
48 King St
Perth
WA 6000

Attention: Stephen Seward

Dear Stephen,

RE: SUPPLEMENTARY WINTER GEOTECHNICAL REPORT FOR PROPOSED SUBDIVISION LOT 2, RESERVE RD, CHITTERING, WA

1 INTRODUCTION

CMW Geosciences Pty Ltd (CMW) was authorised by Riverside Investments (WA) No. 2 Pty Ltd to carry out additional geotechnical investigation (winter investigation) at Lot 2, Reserve Road, Chittering, WA in accordance with our short form proposal letter dated 30 June 2016 (Ref. PER2016-0395AC Rev0). The site is proposed to be developed into R2 residential (ranging from 5,000m^2 to 8,857m^2) and Public Open Space (POS) areas.

CMW has previously investigated this site under the authorisation of Riverside Investments (WA) No.2 Pty Ltd during March (summer investigation) earlier this year. The following scope of work is additional and supplementary to this initial investigation (Ref. PER2016-0395AB Rev1) with the intention of providing a more detailed analysis of ground conditions and soil permeability during late winter conditions for Department of Health (DOH) approval.

2 COUNTRY SEWERAGE POLICY (CSP) REQUIREMENTS

As required by the CSP, a geotechnical investigation and report under late winter conditions has been undertaken to determine soakage test recommendations with relation to Schedule 8 and to assess the possibility of a perched water table during and following periods of rainfall. The CSP requires a minimum depth to the seasonal or permanent water table, from the natural ground surface, of at least 0.5m for onsite effluent disposal. Based on advice from the Department of Health (DoH) an area in the order of 150m^2 satisfying this minimum soil depth to water is typically considered sufficient for onsite effluent disposal. The effluent disposal area would typically be situated in the vicinity residential dwellings.

A late winter geotechnical report is required to demonstrate that the development complies with the CSP criteria for onsite waste water disposal. Our recent geotechnical site investigation complies with this by providing representative information across the site relating to:

- Site topography and detail information
- Soil profile to a depth of at least 2m

- Soil permeability
- The water table encountered to a depth of 2m

3 SITE DESCRIPTION

The proposed development site comprises an area of approximately 135ha and is located on Reserve Road, Chittering, WA.

The site slopes from the west/northwest to the east/southeast with existing ground levels ranging from RL 165m AHD in the northwest corner to RL136m AHD at the southeast corner.

The site is bound to the west and southwest by Reserve Road, open paddock to the south, semi-rural lots to the east and vegetated bushland to the north. The lot is segregated into smaller rectangular sub-lots, many of which are fenced and irrigated and showing evidence of previous or current planting with a variety of native/introduced plants, shrubs and trees. A gravel pit is situated within the northeast part of the site. A sand pit is located within the central southern portion of the lot. A collection of abandoned/dumped farm machinery and equipment, building products and general household/farm waste is situated in the vicinity of the latter sand pit, both at the surface and within shallow excavations.

A single storey residential dwelling is situated to the south west of the lot as well as several farm sheds and equipment. A production water well is present to the extreme south west corner of the lot.

4 FIELDWORK

All fieldwork was carried out under the direction of CMW Geosciences Pty Ltd in general accordance with AS1726 (1993), Geotechnical Site Investigations. The scope of fieldwork completed was as follows:

- Complete an additional 14 tests pits, denoted TP17 to TP30 to depths of up to 2m. This was conducted using a backhoe fitted with a 600mm wide toothed rock bucket to assess ground conditions across the site. Engineering logs and photographs of the test pits are presented in Appendix A;
- Complete 11 in-situ soakage tests in accordance with Schedule 8 of the Health Regulations (Treatment of Sewage and Disposal of Effluent and Liquid Waste) 1974 to assist with DOH application approval. Results of the soakage tests and subsequent infiltration rating are presented in Table 2;
- Complete an additional investigation of the landfill waste area previously identified to assess the extent and nature of the deposited material;
- Compile all information into a geotechnical report (this letter) outlining the scope of work completed, the ground conditions encountered, including groundwater, soil permeability and providing recommendations to the CSP criteria for onsite wastewater disposal.

The approximate locations of the respective investigation sites referred to above are shown on the attached Site Investigation Plan (Figure No. 01). Test locations were positioned to provide additional coverage of the site with respect to the previous summer investigation.

5 SOIL PROFILE

5.1 Geology

Based on our review of the geological references for the area (Ref. Muchea Sheet 2034 I and Part of 2134 IV) and the CMW investigation database depict the land as being underlain by colluvial sands with laterite outcrops to the west and south of the site.

5.2 Subsurface Conditions

The ground conditions encountered and inferred from the investigation were generally consistent with the published geology and our previous investigation of the site. The ground model described below is based on this winter's current investigation only with related depths and conditions encountered from the CMW site investigation on 17 July 2016. The ground model can be generalised according to the following subsurface sequence:

SAND (SP)	fine to coarse grained (predominantly medium grained), white, pale grey and yellow-brown sand; trace root and rootlets to 1.0m depth, overlying;
GRAVEL/COBBLES/BOULDERS	fine to coarse grained, sub-angular to sub-rounded, red-brown (of lateritic origin), uncemented to well cemented; with sand.

The distribution of these units is summarised in Table 1 below:

Table 1: Summary of Soil Stratigraphy Encountered

Description	Depth to base of layer (m)		
	Minimum	Maximum	Average
SAND*	0.3	>2.0	-
Laterite GRAVEL/COBBLES/BOULDERS**	-	-	-

Notes: *Base of strata not encountered in TP17, TP19 – TP22, TP24, TP27 – TP30
**Strata not encountered at all test locations, where encountered base not determined.

Test pit logs and photographs are included in Appendix A.

6 PERCOLATION TEST RESULTS

The results of percolation tests conducted in accordance with Schedule 8 are summarised in Table 2 below:

Table 2. Summary of Percolation Test Results In Accordance With Schedule 8

Test Location	Depth (mm)	Soil Type	Time For Water to Fall 25mm	Loading Infiltration Rate (L/m^2/day)	
				Alternating System	Non-alternating System
SO01	260	Sand	4:30min	30	15
SO02	300	Sand	32s	30	15
SO03	300	Sand	29s	30	15
SO04	300	Sand	42s	30	15
SO05	180	Laterite	>60min	*As approved by Executive Director	
SO06	270	Sand	39s	30	15
SO07	290	Sand	37s	30	15

SO08	290	Sand	2:10min	30	15
SO09	280	Sand	34s	30	15
SO10	300	Sand	40s	30	15
SO11	300	Sand	2:55min	30	15
*Any rock layer must have a loading infiltration rate approved by the executive director in accordance with Clause 5 of Schedule 8.					

7 WATER TABLE

Groundwater was not encountered during our winter investigation in any of the test pit or percolation test locations. We note that perched water was not encountered within test pit locations TP18 or TP26 where refusal was met on laterite at approximately 0.4m and 1.6m depth respectively. Similarly perched water was not encountered at percolation test locations SO01 and SO05 where refusal was inferred / met at approximately 0.3m and 0.2m respectively.

8 RECOMMENDATIONS

8.1 General Lots

The majority of the site has a minimum soil depth to seasonal, permanent or perched water table of least 0.5m based on the CMW winter investigation and fall within the 'Sand' soil type as defined by Table 1 in Schedule 8. Proposed lots other than those specifically referred to in the Western Lots section below of the site can be designed with a loading infiltration rate of 30 L/m^2/day for an alternating system and 15 L/m^2/day for a non-alternating system in accordance with Schedule 8.

8.2 Western Lots

Specific proposed lots situated towards the western boundary of Reserve Road are identified on the Site Investigation Plan (Figure No. 01) and may have shallow laterite (caprock and gravel through to boulders) present within the top 0.5m over parts of the lot as observed/inferred at test locations TP18, SO01 and SO05 during the winter investigation and at test locations TP08 during the summer investigation within this area. During both CMW investigations laterite outcropping was observed along Reserve Road where it bounds the western extent of the site.

Laterite outcropping is likely present in the western extents of lots that adjoin Reserve Road and may also be locally present elsewhere on these lots or immediately adjoining lots. However based on our site investigations and understanding of the local geology it is anticipated that at least 150m^2 of suitable effluent disposal area with a minimum soil depth to seasonal, permanent or perched water table of least 0.5m and classified as 'Sand' soil type as defined by Table 1 in Schedule 8 will be found somewhere on the proposed lots. Additional geotechnical investigation should be undertaken to confirm this assumption by investigating the stratigraphy within the top 0.5m of proposed building envelopes. Prospective buyers and the Shire of Chittering should be made aware of this requirement and likely remediation measures as covered below if required.

Where a suitable effluent disposal area cannot be found on a given lot then the following recommendations are made for minor earthworks:

- Placement of 500mm of fill material comprising of clean granular soil with <10% fines content (<75 micron) over the desired effluent disposal area. All proposed fill must be moisture conditioned and compacted in layers not exceeding 300mm to achieve at least 95% compaction with respect to MMDD. This shall be judged to occur where at least 8 blows per 300mm penetration is achieved

when tested with a PSP. Upon the completion of above earthworks requirements the site can then be designed with a loading infiltration rate of 30 L/m^2/day for an alternating system and 15 L/m^2/day for a non-alternating system in accordance with Schedule 8;

- Alternatively where laterite is present and the depth and underlying strata can be proved by a machine borehole local excavation using an excavator and rock breaker may be attempted to break through the layer. This solution would need to be assessed on a lot by lot basis with additional percolation testing undertaken; and
- Any alternative combination of earthworks and effluent disposal system as approved by the DoH and / or Shire of Chittering.

Where subsequent investigations identify a minimum soil depth to seasonal, permanent or perched water table of least 0.5m and fall within the 'Sand' soil type as defined by Table 1 in Schedule 8 or 500mm of clean granular fill is placed then the general recommendations above with respect to loading infiltration can be applied.

We have assumed that proposed lots will be at approximately existing site levels.

9 LANDFILL WASTE AREA

The landfill waste area identified in our initial summer investigation was further investigated to determine the extent of the area and the potential for contamination as required by the DOH. Our site investigation included the visual inspection of the area and excavation of certain areas with the backhoe to determine if the landfill was buried to a certain depth. The results of inspection concluded that the landfill waste area consists of scrap metal and farming waste on the surface with an extent as defined by the shaded area in the attached Figure No. 1 – Site Plan.

10 CLOSURE

The findings contained within this report are the result of limited discrete investigations conducted in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site. Under no circumstances, can it be considered that these findings represent the actual state of the ground conditions away from our investigation locations.

If the ground conditions encountered during construction are significantly different from those described in this report and on which the conclusions and recommendations were based, then we must be notified immediately.

This report has been prepared for use by Riverside Investment (WA) No. 2 Pty Ltd in relation to Lot 2, Reserve Road, Chittering project in accordance with generally accepted consulting practice. No other warranty, expressed or implied, is made as to the professional advice included in this report. Use of this report by parties other than Riverside Investment (WA) No. 2 Pty Ltd and their respective consultants and contractors is at their risk as it may not contain sufficient information for any other purposes.

For and on behalf of
CMW Geosciences Pty Ltd

Compiled by:



John Newman

Geotechnical Engineer

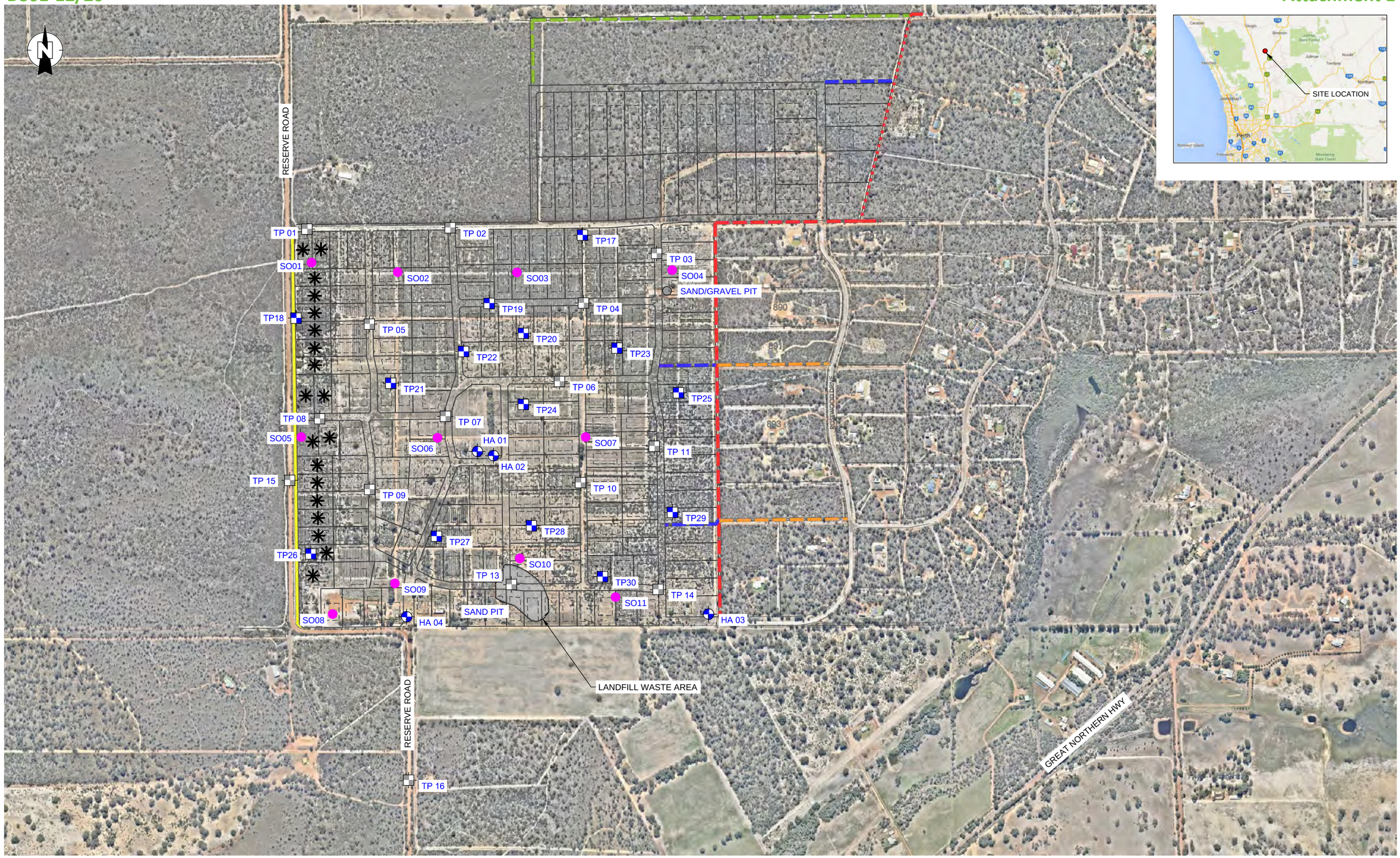
Approved by:



Craig Butterworth

Director / Principal Geotechnical Engineer

Distribution: 1 copy to Riverside Investment (WA) No. 2 Pty Ltd (electronic)
Original held by CMW Geosciences Pty Ltd



LEGEND:

- HA01 — HAND AUGER (HA) LOCATION
- TP01 — TEST PIT (TP) LOCATION
- SO01 — SOAKAGE TEST (SO) LOCATION
- TP01 — PREVIOUS TEST PIT (TP) LOCATION
- WESTERN LOTS

NOTES:

1. IMAGE FROM NEARMAP 02.04.16

1:10 000 — 0 100 200 300 400 500 m

CMW Geosciences Pty Ltd
Chapman Morton Woodward

CLIENT: RIVERSIDE INVESTMENTS (WA) NO. 2 PTY LTD	DRAWN: DE	PROJECT: PER2016-0395
PROJECT: SUBDIVISION DEVELOPMENT LOT 2, RESERVE ROAD, CHITTERING, WA	CHECKED: JN	FIGURE: 01
	REVISION: 1	SCALE: 1:10,000
TITLE: SITE INVESTIGATION PLAN	DATE: 22/07/2016	SHEET: A3 L

TEST PIT LOG - TP17

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405773m N.6512647m
Elevation: 155 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.40m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, yellow-brown; trace roots to 0.8m depth.				
				1			M			Pit walls collapsing from 1.6m depth.
			153.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP18

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.404959m N.6512411m
Elevation: 164 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 0.90m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
			163.7			SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; trace rootlets to 0.2m depth.	M			
			163.6			CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, gravel and cobbles (laterite).				
						Test pit terminated at 0.400 m				
				1						
				2						

Termination Reason: Refusal on cemented gravel/cobbles/boulders (laterite).
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP19

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405508m N.6512453m
Elevation: 159 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; with roots to 0.5m depth.				
						...from 0.5m depth, becoming grey-white.				
				1			M			
						...from 1.7m depth, becoming yellow-brown.				Pit walls collapsing from 1.8m depth.
			157.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP20

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405605m N.6512368m
Elevation: 158 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 2.50m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey-brown; trace roots and rootlets to 0.2m depth.				
						...from 0.3m depth, becoming yellow-brown.				
				1			M			Pit walls collapsing from 1.0m depth.
			156.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP21

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405228m N.6512226m
Elevation: 159 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey (locally stained brown); trace roots and rootlets to 0.3m depth.				
						...from 0.3m depth, becoming yellow-brown.				
				1			D-M			Pit walls collapsing from 1.2m depth.
			157.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP22

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405435m N.6512316m
Elevation: 157 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, brown; trace roots and rootlets to 0.4m depth.				Thin buried reticulation pipe.
						...from 0.3m depth, becoming yellow-brown.				
				1			M			
			155.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP23

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405871m N.6512326m
Elevation: 163 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.20m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; trace roots and rootlets to 0.5m depth.				Thin buried reticulation pipe.
							M			
				1		*...from 0.7m depth, becoming cream-brown.*				
			161.7			CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, gravel and cobbles (laterite).				
			161.6			Test pit terminated at 1.400 m				
				2						

Termination Reason: Refusal on cemented gravel/cobbles/boulders (laterite).
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP24

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405605m N.6512166m
Elevation: 154 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.80m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, brown.				
						...from 0.3m depth, becoming pale grey.				
				1			D-M			Pit walls collapsing from 1.4m depth.
			152.2			SW: Gravelly SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey-red brown; up to 30% fine to medium grained, sub-angular to sub-rounded gravel (of laterite).				
			152.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP25

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.406046m N.6512199m
Elevation: 160 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; trace rootlets to 0.4m depth.	M			Thin buried reticulation pipe.
			158.9	1		SW: Gravelly SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey-red brown; up to 40% fine to coarse grained, sub-angular to sub-rounded gravel (of laterite).				
			158.6			CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, gravel and cobbles (laterite).				
			158.2			Test pit terminated at 1.800 m				
				2						

Termination Reason: Refusal on cemented gravel/cobbles/boulders (laterite).
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP26

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405001m N.6511741m
Elevation: 163 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
			162.5	1		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, black-brown; with gravel; trace rootlets to 0.2m depth. *...from 0.3m depth, becoming pale grey.* SW: Gravelly SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; up to 30% fine to coarse grained, sub-angular to sub-rounded gravel (of laterite); with cobbles and boulders (iron cemented).	M			
			161.4			CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, gravel and cobbles (laterite).				
			161.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP27

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405358m N.6511791m
Elevation: 155 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; trace roots to 1.0m depth.				
				1		*...from 0.2m depth, becoming yellow-brown.*	M			
			153.0	2		Test pit terminated at 2.000 m				Pit wall collapse at 2.0m depth.

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP28

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405628m N.6511821m
Elevation: 152 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 2.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey.				Thin buried reticulation pipe.
						...from 0.8m to 1.0m depth, trace roots.				
				1			M			Pit walls collapsing from 1.5m depth.
			150.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP29

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.406029m N.6511859m
Elevation: 148 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
				1		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; trace roots and rootlets to 0.5m depth.	M			
			146.5			SW: Gravelly SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; up to 30% fine to coarse grained, sub-angular to sub-rounded gravel (of iron cemented sand).				
			146.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP30

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405830m N.6511676m
Elevation: 145 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components)	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; trace rootlets to 0.8m depth.				
				1			M			Pit walls collapsing from 1.6m depth.
			143.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





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people • planet • professional

APPENDIX C

Local Water Management Strategy Addendum

360 environmental

Lot 2 Reserve Road and Lot 9001
Rosewood Drive, Chittering

Local Water Management Strategy Addendum

Prepared for

Riverside Investments WA Pty Ltd

November 2020

people planet professional

Document Reference	Revision	Prepared by	Reviewed by	Admin Review	Submitted to Client	
					Copies	Date
4010BA_Rev0	Internal Draft	VG	KL			
4010BA_Rev1	Client Draft	VG	KL	LI	1x electronic	03/11/2020
4010BA_Rev2	Client Final	KL				

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Executive Summary

Riverside Investments WA Pty Ltd (the proponent) have previously received Structure Planning approval for a rural residential development at Lot 2 Reserve Road and Lot 9001 Rosewood Drive, Chittering (the Site). An amended Structure Plan has been prepared which reconfigures the residential density codes in Lot 2 Reserve Road only, with the development of Lot 9001 to remain consistent with the previously approved Lot 2 Reserve Road and Lot 9001 Rosewood Drive Structure Plan.

A Local Water Management Strategy (LWMS) was prepared to support the Lot 2 Reserve Road and Lot 9001 Rosewood Drive Structure Plan (360 Environmental, 2016). The LWMS was approved by the Department of Water and Environmental Regulation (DWER) in August 2016.

As the previous LWMS was prepared in 2016 and complies with the Better Urban Water Management guidelines (WAPC, 2008) and the LWMS guidelines (Department of Water, 2008), this addendum has been prepared to discuss the important components of water management at the site including potable water supply and wastewater disposal, and those aspects of water management which may have been impacted by the amended Structure Plan such as the proposed stormwater management design.

The total area covered by the Structure Plan is 195 ha. Lot 2 Reserve Road includes 318 Residential lots and 2.79 ha of public open space. Lot 9001 Rosewood Drive includes 36 Rural Conservation lots and a 22.22 ha Conservation lot. Lot sizes range from 0.21 ha to 1.195 ha.

The changes made to the amended Structure Plan are minimal. The minimum lot size in Lot 2 Reserve Road has decreased, and therefore the area of road reserves has increased slightly.

The stormwater modelling has been revised to represent the increased road reserves and to follow the latest water modelling techniques discussed in ARR 2019. The stormwater management principles will remain entirely consistent with the previously approved LWMS (360 Environmental, 2016). Key elements of the stormwater management system include:

- Lot 2 Reserve Road has been divided into three sub catchments (Figure 3) to manage water as close to source as possible and use catchment scale water management techniques
- A POS area at the centre of Lot 2 will feature a drainage basin amongst passive and active POS areas to manage stormwater from Catchment 1
- Due to the size of the lots, lot connections are not required and minimal runoff from lots is expected
- A treatment train approach to maintain water quality and protect the receiving environment will be adopted which includes at source infiltration within lots and the road reserve is proposed to replicate the predevelopment hydrological regime

- Frequent events (first 15mm) will be infiltrated within Lots using soakwells and from road reserves using roadside swales and a bio-retention area within the drainage basin in the POS
- Minor (5yr ARI event) and Major (100yr ARI event) will be retained and infiltrated onsite within the POS (catchment 1) and roadside swales (Catchment 2-3).

In accordance with the Better Urban Water Management guidelines (WAPC, 2008), an Urban Water Management Plan will be prepared as a Condition of subdivision approval which will provide the final earthworks strategy, detailed landscaping design and detailed design of all stormwater management infrastructure including road side swales and drainage basin.

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1 Introduction

1.1 Background

Riverside Investments WA Pty Ltd (the proponent) have previously received Structure Planning approval for a rural residential development at Lot 2 Reserve Road and Lot 9001 Rosewood Drive, Chittering (the Site). An amended Structure Plan has been prepared which reconfigures the residential density codes in Lot 2 Reserve Road only, with the development of Lot 9001 to remain consistent with the previously approved Lot 2 Reserve Road and Lot 9001 Rosewood Drive Structure Plan.

360 Environmental Pty Ltd (360 Environmental) prepared a Local Water Management Strategy (LWMS) to support the Lot 2 Reserve Road and Lot 9001 Rosewood Drive Structure Plan (360 Environmental, 2016). The LWMS was approved by the Department of Water and Environmental Regulation (DWER) in August 2016.

The proponent has now engaged 360 Environmental to prepare a LWMS to support the amended Structure Plan. As the previous LWMS was prepared in 2016 and complies with the Better Urban Water Management guidelines (WAPC, 2008) and the LWMS guidelines (Department of Water, 2008), an addendum to the previous LWMS has been prepared to discuss the aspects of water management which may have been impacted by the amended Structure Plan only.

1.2 Proposed Development

The total area covered by the Structure Plan is 195 ha. Lot 2 Reserve Road includes 318 Residential lots and 2.79 ha of public open space (POS). Lot 9001 Rosewood Drive includes 36 Rural Conservation lots and a 22.22 ha Conservation lot.

Lot sizes range from 0.21 ha to 1.195 ha.

A lot located in the south west corner of Lot 2 will contain a bore which will be used to supply potable water to the development and is shown in the Structure Plan (Figure 2) as a public drinking water source site.

1.3 Local Planning Context

The site has previously obtained Structure Plan and subdivision approval and subdivision works have commenced on Lot 2 to provide an access road and potable water supply infrastructure.

A modified Structure Plan application which includes the reconfiguration of the residential density codes on Lot 2, which include applying the R2 density code to created lots and lots under construction, and an R5 density code for the balance of Lot 2.

The modifications to the approved Structure Plan affect Lot 2 only, Lot 9001 remains consistent with the previously approved Reserve Road and Rosewood Drive Structure Plan.

The site previously obtained Structure Planning and subdivision approval between 2007 to 2016, as outlined below.

- The Shire of Chittering endorsed a development plan and fire management plan for Lot 2 Reserve Road on 17 December 2007.
- A subdivision application for Lot 2 Reserve Road was granted conditional approval by the Commission on 20 December 2011 (WAPC ref: 145031) to facilitate the creation of 110 single residential lots and Public Open Space. Lot sizes ranged from 7,503 m^2 to 4 hectares, with an average lot size of 1.0417 hectares. The subdivision approval lapsed on 20 December 2015.
- The WAPC granted approval to a development plan for Lot 7 (now Lot 9001) Rosewood Drive in June 2009.
- A subdivision application for Lot 9001 Rosewood Drive was granted conditional approval by the Commission on 8 July 2013 (WAPC ref: 147754) to facilitate the creation of 45 single residential lots and Public Open Space. Lot sizes ranged from 1-1.25 hectares, with an average lot size of 1.04 hectares. This subdivision approval lapsed on 8 July 2017.
- The WAPC granted approval to the Lot 2 Reserve Road and Lot 9001 Rosewood Drive Structure Plan on 3 May 2016. This determination was made by the WAPC pursuant to Part 4, clause 22(1)(a) of the Deemed Provisions.
- Scheme Amendment 55 to the LPS six was gazetted on 18 March 2016. The Scheme Amendment rezoned Lot 2 Reserve Road to 'Residential R2' and Lot 9001 Rosewood Drive to 'Rural Conservation'.
- A subdivision application for Lot 2 Reserve Road was granted conditional approval by the Commission on 23 November 2016 (WAPC ref: 153430). The subdivision proposed to create 105 residential lots, the public drinking water source site and the Public Open Space area. The developer has acted on the subdivision approval insofar that some lots have been created.

2 Existing Environment

2.1 Site Environmental Characteristics

A summary of the existing environment is provided below in Table 1. No aspect of the existing environment has changed since the LWMS (360 Environmental, 2016) was completed.

Table 1: Existing Environment

Environmental Parameter	Description
Location	The site is located on Reserve Road and Rosewood Drive, within the Shire of Chittering, approximately 50 km north of Perth and 20km north of Bullsbrook.
Climate	Chittering has a dry subtropical climate featuring hot dry summers, and mild rainy winters. Climate data from the Gingin Aero station located approximately 20.4 km away between 1996 to 2020 indicates the annual mean maximum temperature is 25.7°C and the annual mean minimum temperature is 11 °C. The mean annual rainfall is 620.7 mm (BoM, 2020).
Topography	The site topography varies between approximately 165 meters Above Height Datum (mAHD) in the northern boundary of Lot 9001 and less than 135 mAHD in the south eastern corner of Lot 2. The site generally slopes from north to south.
Geotechnical Investigation	A Geotechnical Investigation (CMW Geosciences, March 2016) has been completed at the site and a supplementary winter Geotechnical Investigation was also carried out in August 2016 (CMW Geosciences, August 2016). The Geotechnical Investigations (CMW, March 2016) has identified the Site as having the following soil profile: • SAND (SP): loose to medium dense, white, grey, and yellow, predominantly medium grained sand containing roots and rootlets and darker colouring in top 0.5 m; overlying • GRAVEL/COBBLES/BOULDERS: fine to coarse grained, sub-angular to sub-rounded, red brown, of lateritic origin, uncemented to well cemented, with sand. The additional winter investigation was completed to assess the ground conditions and soil permeability during late winter conditions. Groundwater was not encountered in any of the test pits or percolation test locations. The results of the constant and rising head permeability tests varied between approximately 1 x 10-5 m/sec (1 m/day) and 6 x 10-5 m/sec (5m/day). An infiltration rate of 2.5 m/day was recommended for the design on stormwater infrastructure.
Surface Water	No surface water features, or surface drainage lines exist on the site or in the vicinity of the site.
Groundwater	The Site is located in the Eclipse Hill groundwater sub-area. Three separate aquifer systems occur in this area: the Perth Superficial aquifer, the Leederville aquifer and Yarragadee aquifer.

Environmental Parameter	Description
	The original water management strategy (VDM, 2008) prepared for the site indicated that maximum groundwater levels were greater than 30m below surface.
Wetlands	There are no mapped wetlands located at the site.
Water Resources	The DWER online Public Drinking Water Source Area Mapping Tool and Proclaimed Area Maps indicates the site is not located in a Public Drinking Water Source Area or Proclaimed Surface Water Area.
Flora and Fauna	VDM undertook a Basic Ecological Assessment for Lot 2 during 2005 that included assessing the flora, vegetation, and fauna habitat within the Site (VDM, 2005). The assessment identified 48 flora taxa. The assessment found that due to isolation of the existing vegetation, the project area is unlikely to provide core habitat for significant fauna species and does not have any functional role as a corridor or linkage for significant flora or fauna. No currently listed conservation-significant flora species or communities pursuant to the Western Australian Wildlife Conservation Act 1950 or the Commonwealth EPBC Act were recorded during any of the biological surveys. 360 Environmental undertook a Black Cockatoo Habitat Assessment during April 2015 (360 Environmental, 2015). The assessment found that the Site offers potential foraging, roosting, and breeding habitat for Black Cockatoos. During the survey, no Black Cockatoos were heard or observed in the Site or seen flying over. 151 potential breeding trees were recorded within the project area, none of which contained hollows with suitable dimensions for Black Cockatoo breeding.

3 Water Supply

3.1 Potable Water

Potable water for households will be supplied by the water service provider Aqua Ferre (Muchea Water) Pty Ltd who have a licence to provide water supply services from the artesian aquifer (Perth-Leederville Parmelia Aquifer) to the site and other developments in the region. The Site has a total water entitlement of 288,800 kL/annum from the Leederville Aquifer which is greater than 350m below ground level. The revised Structure Plan will achieve 354 lots and assuming three occupants per lot and 60 kL/person/year, the total water requirement will be approximately 63,720 kL/yr

The original LWMS (360 Environmental, 2016) (Appendix A), provides a Drinking Water Source Protection Plan (in Appendix F of the LWMS) and an Asset Management Plan (in Appendix G of the LWMS) which have been endorsed by the Department of Health.

The potable water supply is consistent with the previous LWMS, as the number of lots has increased, the potable water requirement was recalculated to demonstrate the site will have a sufficient potable water supply.

Rainwater tanks can be incorporated by lot owners if preferred, however are not required to supply potable water as a reticulated potable water supply will be provided to each lot.

3.2 Irrigation Water

At the development scale, the Public Open Space (POS) is 2.79 ha. The revised landscaping plans are provided in Appendix B which illustrate the landscaping will include 0.5006 ha of turf, an adventure playground, a bbq area and supplementary replanting to complement the existing vegetation which will be retained where possible to minimise irrigation and on-going maintenance requirements.

The reticulated area in the POS will be approximately 0.9 ha and the Site southern entry from Reserve Rd requiring irrigation is 0.22 ha. It is estimated that approximately 8,400 kL/yr of groundwater is required for irrigation. This is based on the recommended Department of Water and Environmental Regulation irrigation rate for public open space of 7,500 kL/ha/yr.

The site has a second groundwater licence (WRI number 201854) for an allocation of 20,650kL to take water from the Surficial aquifer. This licence will be used for irrigation. Again, this strategy is consistent with the previously approved LWMS, however the irrigation water requirements have been discussed since the landscaping plan has been revised slightly and to demonstrate the site will have a suitable irrigation water supply and allocation remaining for construction activities if required.

4 Wastewater Disposal

4.1 Site and Soil Evaluation

The site is not able to be serviced by a reticulated sewerage network as wastewater infrastructure does not extend to the area. Wastewater management via an alternate treatment system (ATS) located in each lot is proposed to manage all household wastewater from the toilet, bathroom, kitchen, and laundry.

A Site and Soil Evaluation (360 Environmental, 2020) has been prepared to support the modified Structure Plan application and comply with the recent Government Sewerage Policy (DPLH, 2019) to demonstrate each lot is able to accommodate a suitable wastewater management system and not impact public health or the environment.

The site is not located in a 'Sewerage Sensitive Area' and primary treatment of wastewater is proposed. An Application to Construct or Install an Apparatus for the Treatment of Sewerage will be submitted to the Shire of Chittering prior to the installation of the ATS and a domestic ATU which provides primary treatment, and is certified to Australian Standard AS 1546.3 and approved by the Department of Health will be installed.

5 Stormwater Management

5.1 Design Principles

The changes made to the amended Structure Plan are minimal. The development of Lot 9001 has not changed, and the drainage design will remain consistent with the previously approved LWMS. The lot sizes in Lot 2 Reserve Road have reduced slightly, and therefore the area of road reserves has increased.

The stormwater modelling has been revised to follow the modelling techniques discussed in ARR 2019.

The stormwater management principles will remain entirely consistent with the previously approved LWMS (360 Environmental, 2016). As the length of road reserves has increased, further stormwater modelling has been completed to confirm the sizing of the proposed drainage basin and roadside swales.

Key elements of the stormwater management system include:

- Lot 2 Reserve Road has been divided into three sub catchments (Figure 3) to manage water as close to source as possible and use catchment scale water management techniques
- A POS area at the centre of Lot 2 will feature a drainage basin amongst passive and active POS areas to manage stormwater from Catchment 1
- Due to the size of the lots, lot connections are not required and minimal runoff from lots is expected
- A treatment train approach to maintain water quality and protect the receiving environment will be adopted which includes at source infiltration within lots and the road reserve is proposed to replicate the predevelopment hydrological regime
- Frequent events (first 15mm) will be infiltrated within Lots using soakwells and from road reserves using roadside swales and a bio-retention area within the drainage basin in the POS
- Minor (5yr ARI event) and Major (100yr ARI event) will be retained and infiltrated onsite within the POS (catchment 1) and roadside swales (Catchment 2-3).

5.2 Stormwater Modelling

5.2.1 Frequent Events (first 15mm)

The installation of soakwells is proposed in all lots to infiltrate the first 15mm of rainfall owing to the large lot sizes. Conditions to infiltrate frequent events is possible given the Sites significant clearance to groundwater and subsurface conditions. Impervious areas, such as driveways, paving and roofs will be connected directly to the soakwells. It is anticipated that most of the area on the lots will retain trees/vegetation to promote infiltration.

A bio-retention basin within the POS in catchment 1 and roadside swales in catchment 2 and 3 will be installed to capture road reserve runoff in the frequent rainfall event.

5.2.2 Minor and Major Events (5yr ARI to 100yr ARI)

Roadside swales throughout the Site will also be sized to ensure serviceability of the road network during the 5 yr ARI event and allow for infiltration throughout the road network.

The major drainage system will consist of the roads, roadside swales, and the drainage basin. Events larger than the 5 yr ARI event in catchment 1 will be conveyed via the road network to the drainage basin within the POS (Figure 4). For catchment 2, the larger events will be retained within the roadside swales. To determine the requirements for the drainage basin and the roadside swales, hydrologic modelling has been undertaken with the model XP-Storm.

The following parameters have been used to determine runoff using the XP-Storm model:

- Catchment 1 drains towards a drainage basin located in the POS. Catchment 2 and 3 will drain towards road size swales will retain and infiltrate all rainfall events up to the 1% AEP event
- The Shire of Chittering 20 m road reserve – typical road section for a rural living street has been followed to size the road size swales
- Rainfall for the Site is based on ARR 2019.

The modelling has assumed that Lots will remain 80% permeable, impervious areas are connected to soakwells which will be capable of infiltrating the first 15 mm and achieve an infiltration rate of 2.5 m/day, as recommended in the Geotechnical Investigation (CMW, 2016b).

A runoff coefficient of 70% has been applied for the road reserves owing to the existence of permeable swales on the sides of the roads, again the recommended infiltration rate of 2.5 m/day has been applied to the roadside swales.

The stormwater system was designed to contain the 5 yr and 100 yr ARI events within the roadside swales, basin and POS area. The modelling result demonstrates that the roadside swales retain the 100 yr ARI event have a maximum depth of approximately 0.8 m.

The proposed stormwater management system is presented in Figure 3 to 6 and the drainage basin design is detailed in Table 2 to 4.

Table 2: Drainage Basin Design Details – Catchment 1

Post-Development Catchment	Catchment 1
Catchment Area	64.14 ha
Catchment Breakdown	
Lots (Residential R2)	51.33 ha
Road Reserve	10.02 ha
POS	2.79 ha

Post-Development Catchment		Catchment 1	
Storage Data			
Type		Retention (Infiltration) Basin	
Side Slopes		1:6 (v:h)	
Base Invert		150 m AHD	
Base Area		0.83 ha	
5yr ARI Event		**100yr ARI Event**	
Top Water Level	0.88 ha	Top Water Level Area	1.1 ha
Flood Storage	2,051 m^3	Flood Storage	11,410 m3
Flood Rise	0.24 m	Flood Rise	1.18 m
Top Water Level	150.24 mAHD	Top Water Level	151.18 mAHD
Critical Duration	3 hr	Critical Duration	9 hr
Time to Empty	5 hrs	Time to Empty	19.5 hrs

Table 3: Drainage Basin Design Details – Catchment 2

Post-Development Catchment		Catchment 2	
Catchment Area		59.22 ha	
Catchment Breakdown			
Lots (Residential R2)		50.83 ha	
Road Reserve		8.39 ha	
POS		NA	
Storage Data			
Type		Roadside Swale	
Side Slopes		1:3 (v:h)	
Base Width		1.3 m	
Depth		0.8 m	
Base Area		0.46 ha	
5yr ARI Event		**100 yr ARI Event**	
Top Water Level Area	1.06 ha	Top Water Level Area	2.1 ha

Post-Development Catchment		Catchment 2	
Flood Storage Required	2,203 m^3	Flood Storage Required	9,948 m^3
Flood Storage Provided	10,372 m^3	Flood Storage Provided	10,372 m^3
Flood Rise	0.29 m	Flood Rise	0.78 m
Critical Duration	3 hr	Critical Duration	6 hr
Time to Empty	5.5 hrs	Time to Empty	14.5 hrs

Table 4: Drainage Basin Design Details – Catchment 3

Post-Development Catchment		Catchment 3	
Catchment Area		9.27 ha	
Catchment Breakdown			
Lots (Residential R2)		7.19 ha	
Road Reserve		2.08 ha	
POS		NA	
Storage Data			
Type		Roadside Swale	
Side Slopes		1:3 (v:h)	
Base Width		1.3 m	
Depth		0.8 m	
Base Area		0.08 ha	
5yr ARI Event		**100yr ARI Event**	
Top Water Level Area	0.2 ha	Top Water Level Area	0.38 ha
Flood Storage Required	423 m^3	Flood Storage Required	1,755 m^3
Flood Storage Provided	1935 m^3	Flood Storage Provided	1,935 m^3
Flood Rise	0.3 m	Flood Rise	0.75 m
Critical Duration	3 hr	Critical Duration	6 hr
Time to Empty	5.5 hrs	Time to Empty	14.0 hrs

6 Groundwater Management

No groundwater management measures including permanent dewatering or control of groundwater levels with subsoil drainage are to be implemented owing to the existing significant clearance to groundwater and size of the development lots.

7 Implementation Strategy

Following approval of the Structure Plan application, a Subdivision application will be lodged to allow for the staged development of the site to occur.

As a LWMS has been prepared, an Urban Water Management Plan (UWMP) will be completed as a Condition of subdivision approval. Due to the type of development and size of the lots, it is expected that the UWMP will be a brief document which will include the following information.

- Earthworks plan
- Detailed landscaping plans and irrigation design
- Engineering plans to show the detailed design of the road reserves including the roadside swales and drainage basin in Catchment 1
- Construction period management strategies
- Further details regarding the potable water supply and wastewater management system (if required).

8 Limitations

This report is produced strictly in accordance with the scope of services set out in the contract or otherwise agreed in accordance with the contract. 360 Environmental makes no representations or warranties in relation to the nature and quality of soil and water other than the visual observation and analytical data in this report.

In the preparation of this report, 360 Environmental has relied upon documents, information, data, and analyses ("client's information") provided by the client and other individuals and entities. In most cases where client's information has been relied upon, such reliance has been indicated in this report. Unless expressly set out in this report, 360 Environmental has not verified that the client's information is accurate, exhaustive or current and the validity and accuracy of any aspect of the report including, or based upon, any part of the client's information is contingent upon the accuracy, exhaustiveness and currency of the client's information. 360 Environmental shall not be liable to the client or any other person in connection with any invalid or inaccurate aspect of this report where that invalidity or inaccuracy arose because the client's information was not accurate, exhaustive and current or arose because of any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to 360 Environmental.

Aspects of this report, including the opinions, conclusions, and recommendations it contains, are based on the results of the investigation, sampling and testing set out in the contract and otherwise in accordance with normal practices and standards. The investigation, sampling and testing are designed to produce results that represent a reasonable interpretation of the general conditions of the site that is the subject of this report. However, due to the characteristics of the site, including natural variations in site conditions, the results of the investigation, sampling and testing may not accurately represent the actual state of the whole site at all points.

It is important to recognise that site conditions, including the extent and concentration of contaminants, can change with time. This is particularly relevant if this report, including the data, opinions, conclusions, and recommendations it contains, are to be used a considerable time after it was prepared. In these circumstances, further investigation of the site may be necessary.

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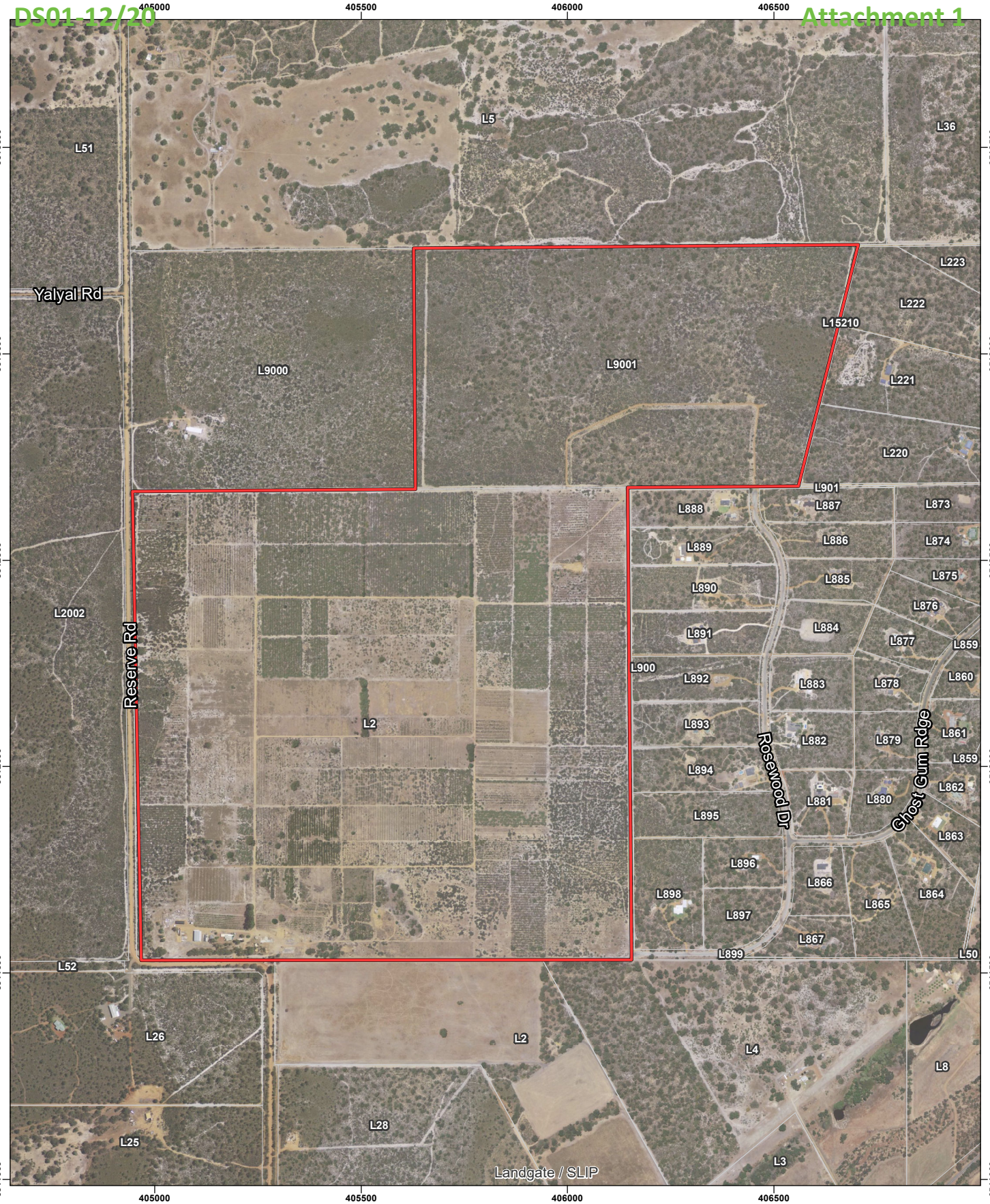
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Figures

DS01-12/20

Attachment 1



Legend

- Site Location
- Lot Boundaries

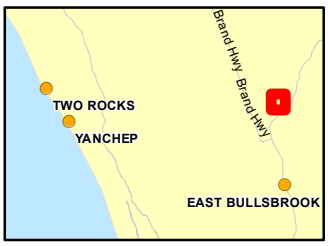
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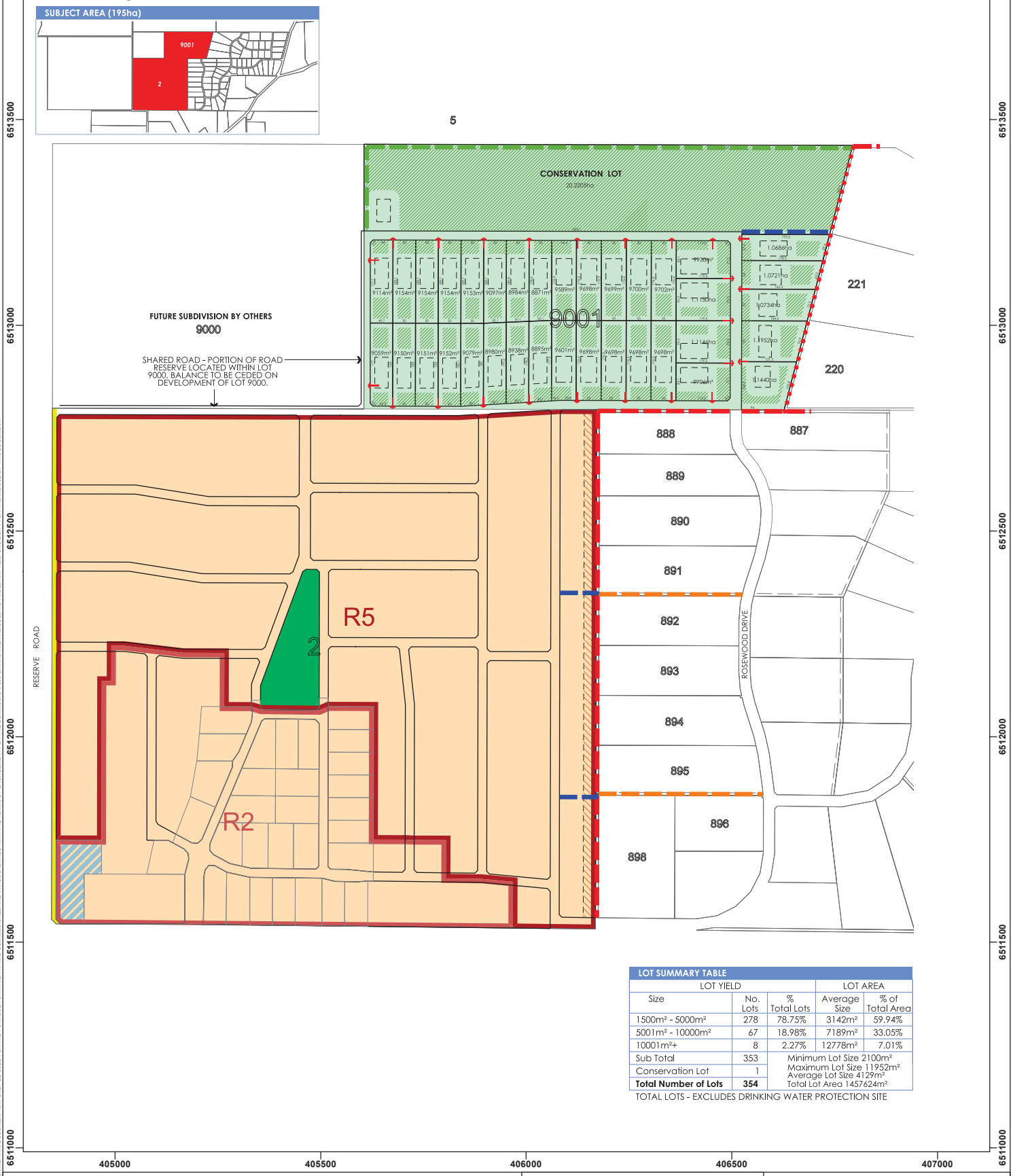
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Local Water Management Strategy

Figure 1
Site Location

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LOT SUMMARY TABLE

LOT YIELD			LOT AREA	
Size	No. Lots	% Total Lots	Average Size	% of Total Area
1500m² - 5000m²	278	78.75%	3142m²	59.94%
5001m² - 10000m²	67	18.98%	7189m²	33.05%
10001m²+	8	2.27%	12778m²	7.01%
Sub Total	353	Minimum Lot Size 2100m² Maximum Lot Size 11952m² Average Lot Size 4129m² Total Lot Area 1457624m²		
Conservation Lot	1			
Total Number of Lots	**354**			

TOTAL LOTS - EXCLUDES DRINKING WATER PROTECTION SITE

Legend

LAND USE
- RESIDENTIAL
- RURAL CONSERVATION
- PUBLIC OPEN SPACE

OTHER
- INDICATIVE BUILDING ENVELOPE
- PUBLIC DRINKING WATER SOURCE SITE
- VEGETATION RETENTION
- BUILDING EXCLUSION AREA (27m FROM REAR LOT BOUNDARY)
- INDICATIVE SHARED CROSSOVER

FIRE SERVICE ACCESS ROUTE
- EXISTING 5.0m RESERVE (widening to 6.0m)
- EXISTING 6.0m RESERVE
- EXISTING 6.0m EASEMENT
- PROPOSED 6.0m EASEMENT

FIREBREAK
- PROPOSED 3.0m FIREBREAK (IN ACCORDANCE WITH SHIRE OF CHITTERING FIREBREAK NOTICE)

- RESERVE ROAD - ROAD WIDENING (10m)

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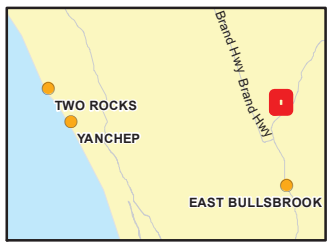
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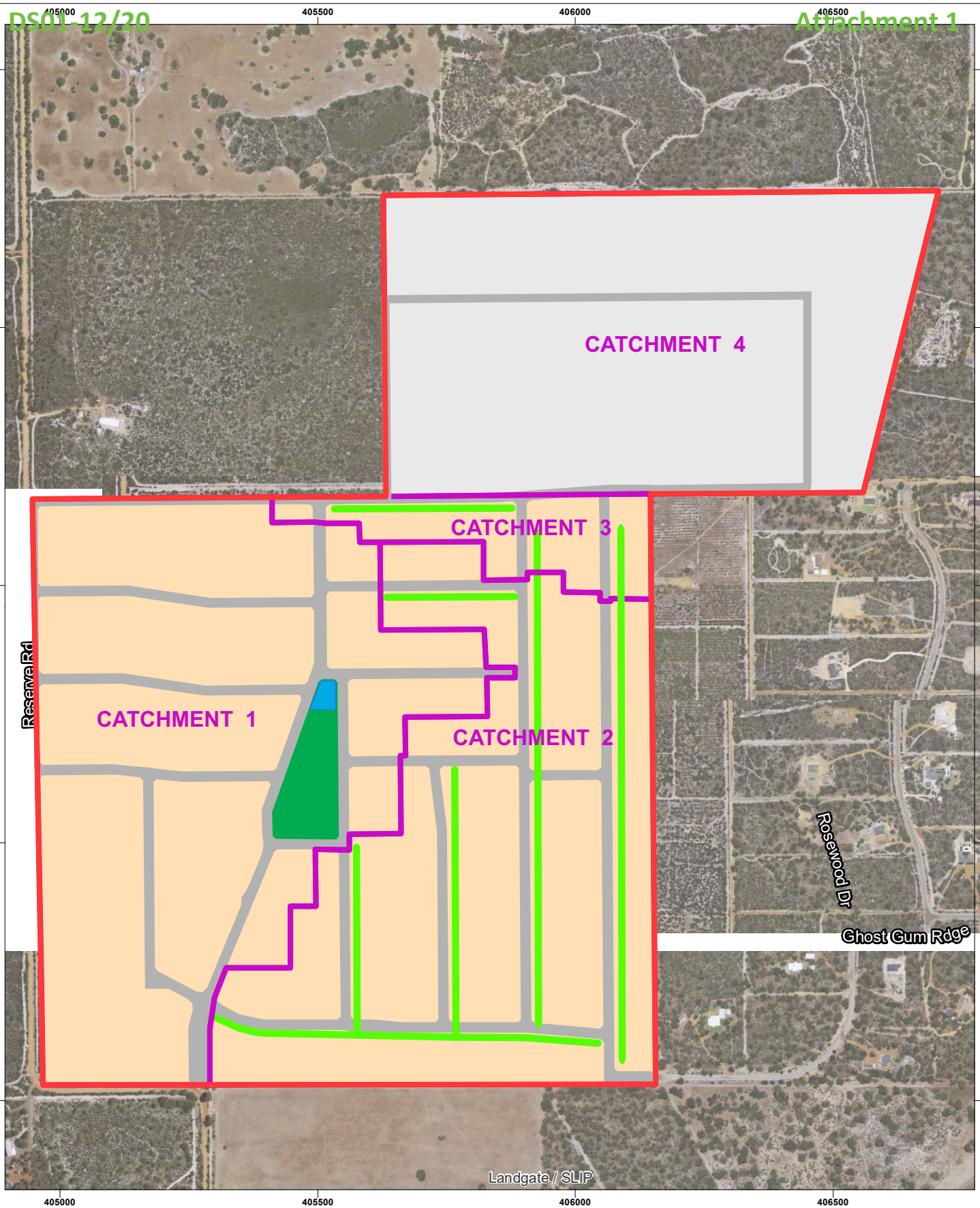
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Lot 2 Reserve Road and Lot 9001 Rosewood Drive, Chittering
Local Water Management Strategy

Figure 2
Structure Plan

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Legend

- Site Location
- Roadside Swales
- Proposed Catchments
- Infiltration Basin
- Public Open Space
- Road

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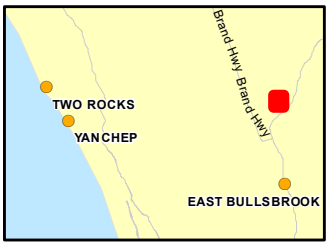
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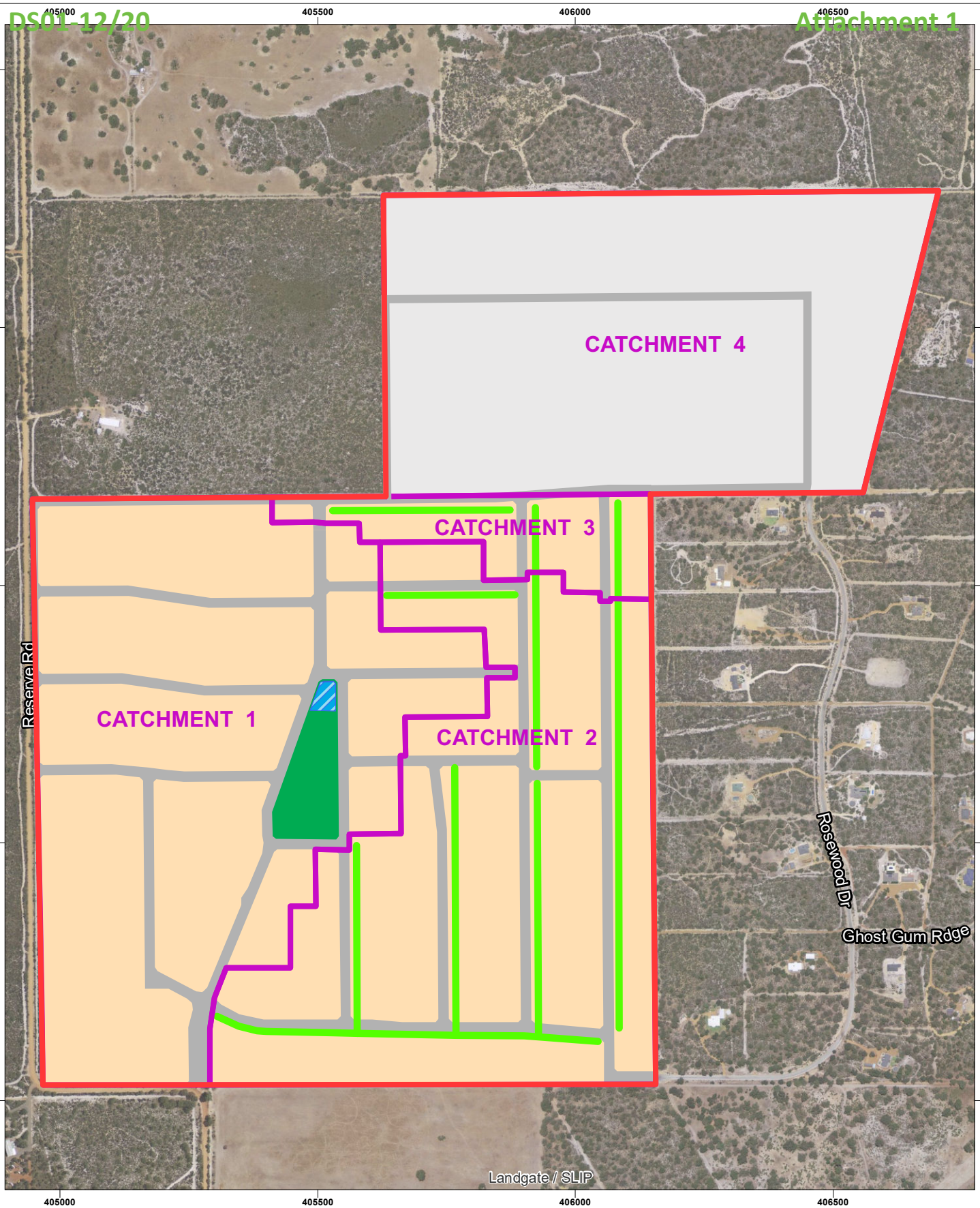
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Local Water Management Strategy

Figure 3
Conceptual Stormwater System

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Legend

- Site Location
- Proposed Catchments
- Public Open Space
- Road
- Inundation 1 Year
- Infiltration Basin

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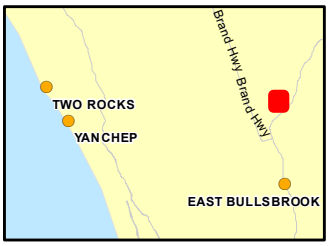
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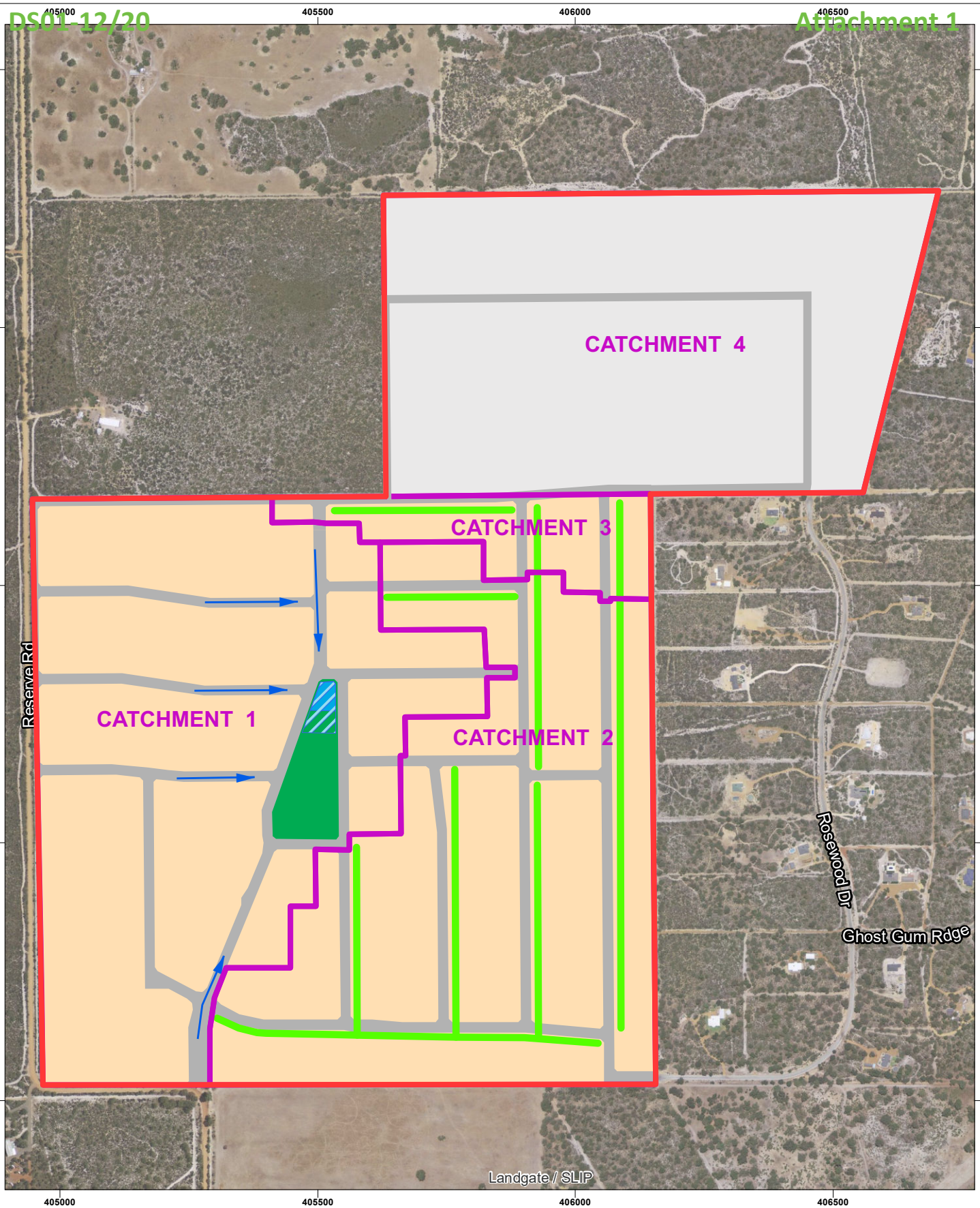
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Local Water Management Strategy

Figure 4
Stormwater 1 Year ARI Event Plan

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Legend

- Site Location
- Roadside Swales
- Proposed Catchments
- Public Open Space
- Road
- Inundation 5 Years
- Infiltration Basin
- Flow Direction

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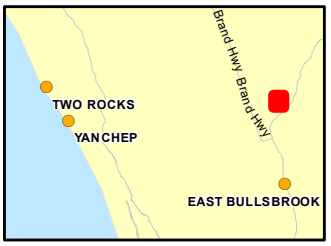
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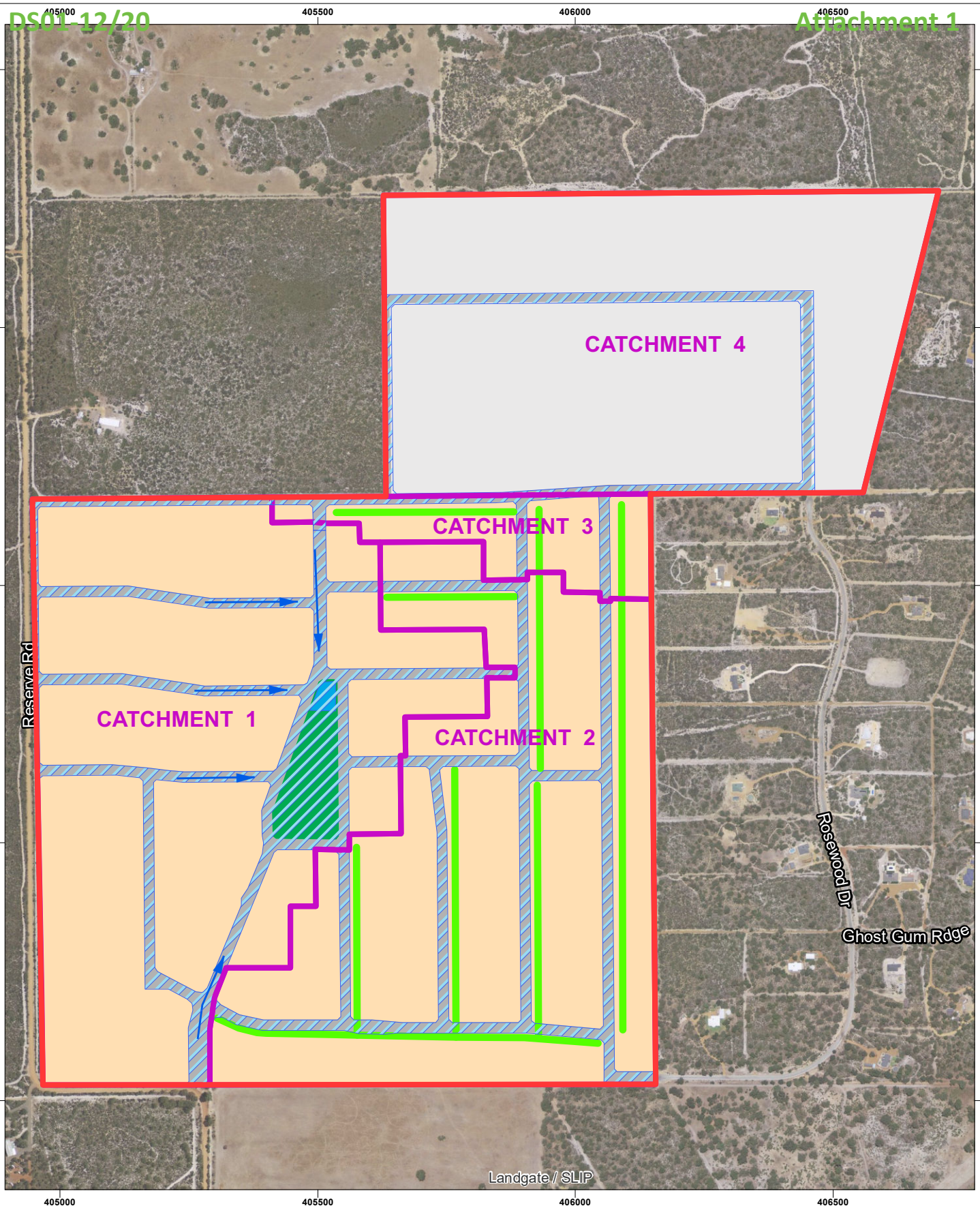
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Local Water Management Strategy

Figure 5
Stormwater 5 Years ARI Event Plan

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Legend

- Site Location
- Roadside Swales
- Proposed Catchments
- Public Open Space
- Road
- Inundation 100 Years
- Infiltration Basin
- Flow Direction

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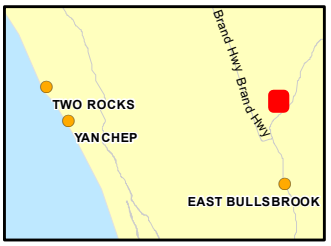
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Local Water Management Strategy

Figure 6
Stormwater 100 Years ARI Event Plan

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Appendices

Appendix A
Local Water Management Strategy (360 Environmental, 2016)

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Lot 2 Reserve Road and Lot 9001 Rosewood Drive, Chittering

Local Water Management Strategy

Prepared for:

Riverside Investments WA Pty Ltd

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people planet professional

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Executive Summary

Key Water Management Principles (Adapted from State Planning Policy 2.9, Stormwater Management Manual for WA & Better Urban Water Management)

Integration of water and land use planning
Ensure stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity
Ensure stormwater management is part of total water cycle management
Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse
Define stormwater quality management objectives in relation to the sustainability of the receiving environment
Recognise the need for site specific solutions and implement appropriate non-structural and structural solutions
Integrate Stormwater Treatment into the landscape
Add value while minimising development costs

Category	Objectives	Site Considerations	Key Management Features
Water Sustainability To maximise the reuse or stormwater and minimise use of potable water particularly for non-drinking water purposes.	Promote efficient use of potable water and alternative water sources. Potable water consumption target of not more than 40-60kL/person/yr. Maintain appropriate aquifer levels.	The site currently has a groundwater Licence's for the Leederville aquifer. There is allocation available from the Surficial and Yarragadee Aquifer. The Leederville Aquifer is fully allocated. The Site is not located within any Public Drinking Water Source Areas.	The existing licence to take water from the artesian aquifer is the main source of potable water. The superficial aquifer is the secondary water supply for the Site. Households will adhere to waterwise home guidelines. Local, native waterwise plants will be used in landscaping.
Stormwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from flooding.	Retain natural drainage lines and minimise use of piped drainage systems. Frequent events (≤1yr ARI) retained and infiltrated within property boundaries, using soakwells where possible. Large events (>1yr ARI) contained in landscape retention/detention areas, road reserves, POS and linear multiple use corridors. Retain runoff (≤100yr ARI) within the Site.	There are no surface water features (wetlands, waterways or drains) within the Site. There is minimal runoff from the site during high-intensity storm owing to the sandy soil and vegetation cover. The site as suitable for disposal of stormwater through infiltration.	Existing catchment will be maintained. Frequent events (≤1yr ARI) will be infiltrated through soakwells on lots, road drains and the bio-retention basin within the POS Major events (up to 100yr ARI) will be retained and infiltrated within the POS (Lot 2).
Groundwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from water-logging.	Maintain appropriate recharge characteristics and groundwater levels, and minimise impervious areas. Ensure adequate separation from maximum groundwater levels, including the use of subsoil drainage and importation of fill, where required. Maximise infiltration close to source or high in the catchment.	According to the Perth maximum groundwater contours and water management strategy (VDM, 2008a) there is sufficient clearance to groundwater for development across the Site. No areas of water-logging were identified on site. Further groundwater data will be provided in the UWMP.	No direct measures, subsoil drainage or lowering of groundwater are proposed for managing groundwater across the Site. Imported granular fill must comply with the material requirements as stated in AS3798. Final lot levels and clearance to groundwater will be provided in the UWMP following refinement of any earthwork design.
Water Quality To maintain or improve the surface water and groundwater quality within development areas relative to pre-development conditions.	Install bio-retention areas, sized at ≥2% of constructed impervious areas for treatment of frequent (≤1yr ARI) events. Apply a treatment-train approach to flows prior to discharge. Implement non-structural controls, such as education programs.	Groundwater samples were collected at the DoW Monitoring Bore (61602501) to determine the groundwater quality of the artesian aquifer. Results indicated that the artesian aquifer contains a suitable water quality with most parameters below their respective drinking water quality criteria; except for iron and manganese exceeding ANZECC guidelines.	A treatment train approach to water quality improvement is adopted. Frequent events will be infiltrated close to source by soakwells, drains and bio-retention area. Further measures will be outlined in the UWMP.
Protection of Receiving Environments To retain natural drainage systems and protect ecosystem health.	Maintain pre-development hydrological and water quality conditions. Retain seasonal wetlands and vegetation and apply appropriate buffers. No direct drainage to conservation category wetlands.	There are no Bush Forever or Environmentally Sensitive Areas on the Site. The Site is not located within or directly adjacent to any geomorphic wetlands, with the nearest system approximately 4.5km west.	The treatment train approach (above) will provide water quality improvement measures and protection to receiving environments.
Public Health and Risk To minimise the public risk, including risk of injury or loss of life to the community.	Prevent flooding (0.3m clearance from 100yrARI water levels to lots), water logging and erosion of waterways/slopes/banks. Immobile stormwater infiltrated within 96hrs to prevent mosquitos. Manage acid sulphate soils and contamination risks.	No flooding or water logging was identified. Regional mapping indicates there is no ASS risk. No contaminated sites exist on or within 3km of the Site.	The habitable floor level will be >0.5m above the 100yr ARI flood level and >1.2m the maximum groundwater level to prevent water logging. Stormwater will be infiltrated within 96hrs to prevent standing water and mosquito breeding.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.	Integrate stormwater structures into the landscape and POS. Retain remnant vegetation, where possible. Minimise the use of artificial/piped drainage systems. Conserve Aboriginal Heritage and environmentally sensitive areas.	The Site is surrounded by native bush. There are no areas of Aboriginal Heritage on this Site.	Stormwater structures will be integrated into the POS Design. Remnant vegetation will be retained (where possible).
Further Planning To ensure delivery of best practice stormwater management through planning.	Integrate water management with urban planning and ensure all BUWM (WAPC, 2008) requirements are fulfilled. Apply WSUD approach to road, lot and POS layouts.	The guiding water management document for the Site is Lot 2 Reserve Road, Chittering & Surrounds Water Management Strategy (VDM, 2008a) which provides a summary of key water objectives just for Lot 2 in the Site.	The UWMP will document the final stormwater management strategy incorporating any additional engineering, planning and landscaping requirements.
Implementation/ Construction To ensure delivery of best practice stormwater management through high quality developed areas in accordance with sustainability and precautionary principles.	Prevent impacts on the hydrological regime during construction. Apply sediment control measures during construction to prevent excessive waterways/slopes/banks erosion. Utilised a non-potable water source for dust-suppression. Monitor water quality, flows, and levels near sensitive environments.	The UWMP will need to adjust strategies/plans in the context of the new information. There is sufficient clearance to groundwater to prevent the need for ongoing dewatering.	Direct impacts from construction activities, such as dust, erosion and waste disposal will be managed through appropriate site practices. Where possible, the timing of construction works be undertaken to minimise impacts on the water cycle.
Post-Development To implement stormwater systems that are economically viable in the long term.	Consider the maintenance requirements. Following completion of construction, monitor groundwater and surface water near sensitive environments.	Trees and vegetation on the conservation lot will be retained and the stormwater will be managed separately within its boundary.	No post-development groundwater water quantity or quality monitoring program is considered across the Site.

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1 Introduction

360 Environmental Pty Ltd (360 Environmental) have been commissioned by Riverside Investments (the Client) to prepare this Local Water Management Strategy (LWMS) to accompany the submission of a Local Structure Plan (LSP) for Lot 2 Reserve Road and Lot 9001 Rosewood Drive in Chittering (the Site). The Site is approximately 195 hectares (ha) in size and is located in the Shire of Chittering. It is approximately 70 kilometres (km) north of the Perth CBD (Figure 1).

The proposed development will influence the total water cycle as a result of an increase in impervious areas, the clearing of small amounts of native vegetation, cut and fill and changes to existing stormwater infrastructure. The LWMS has been prepared to provide strategies and plans for total water cycle management across the Site in accordance with the principles of Water Sensitive Urban Design (WSUD) and the guiding documents in Section 1.2. It provides a summary of local and regional environmental data that informs management strategies for stormwater, groundwater, protection of receiving environments and water conservation. A strategy for implementing the total water cycle management during construction and post-development is also provided.

A checklist for the LWMS requirements is included in Appendix A and outlines the compliance of this document with the Better Urban Water Management (BUWM) (WAPC, 2008) framework.

1.1 Planning Background

The BUWM framework (WAPC, 2008) integrates water management into the land use planning process to ensure planning strategies include total water cycle management and WSUD.

The Site is located within the Shire of Chittering's local government area and is currently zoned as Rural Residential under the Town Planning Scheme (TPS No. 6) (DPI, 2004). The LSP has been developed to coordinate the provision and planning for land use development at the site (Figure 3). This LWMS has been prepared in support of the LSP.

1.2 Guiding Documents

The Lot 2 Reserve Road, Chittering & Surrounds Water Management Strategy (Appendix B) previously prepared by VDM in 2008 provided an outline of proposed water supply and water use for Lot 2 and surroundings. It provides details of the available groundwater licenses, water usage and water quality and outlines key elements of water supply, wastewater and storm water management. This information has been integrated into the LWMS and is referenced accordingly.

The LWMS has also been prepared with consideration for the following guidelines and policy documents:

- State Planning Policy 2.9 Water Resources (WAPC, 2006);
- Stormwater Management Manual for Western Australia (DoW, 2004-07);
- Better Urban Water Management (WAPC, 2008);
- Interim: Developing a Local Water Management Strategy (DoW, 2008);
- Decision Process for Stormwater Management in Western Australia (DoW, 2009);
- Guidance Note 3: Preparation and Assessment of Water Management Reports (DoW, 2013); and
- Shire of Chittering Town Planning Scheme No. 6 District Zonning Scheme (DPI, 2004)

1.3 Design Objectives

A summary of the key principles and objectives for the Site, based on the guiding documents, is provided in Table 1.

Table 1: LWMS Key Principles and Objectives.

Key Water Management Principles (Adapted from State Planning Policy 2.9, Stormwater Management Manual for WA & Better Urban Water Management).	
Integration of water and land use planning Ensure stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity Ensure stormwater management is part of total water cycle management Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse Define stormwater quality management objectives in relation to the sustainability of the receiving environment Recognise the need for site specific solutions and implement appropriate non-structural and structural solutions Integrate Stormwater Treatment into the landscape Add value while minimising development costs	
Category	**LWMS Objectives**
Water Sustainability To maximise the reuse or stormwater and minimise use of potable water particularly for non-drinking water purposes.	Promote efficient use of potable water and alternative water sources. Potable water consumption target of not more than 40-60kL/person/yr. Maintain appropriate aquifer levels.
Stormwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from flooding.	Retain natural drainage lines and minimise use of piped drainage systems. Frequent events (≤1yr ARI) retained and infiltrated within property boundaries, using soakwells where possible. Large events (>1yr ARI) contained in landscape retention/detention areas, road reserves, POS and linear multiple use corridors. Retain runoff (≤100yr ARI) within the Site.
Groundwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from water-logging.	Maintain appropriate recharge characteristics and groundwater levels, and minimise impervious areas. Ensure adequate separation from maximum groundwater levels, including the use of subsoil drainage and importation of fill, where required. Maximise infiltration close to source or high in the catchment.
Water Quality To maintain or improve the surface water and groundwater quality within development areas relative to pre-development conditions.	Install bio-retention areas, sized at ≥2% of constructed impervious areas for treatment of frequent (≤1yr ARI) events. Apply a treatment-train approach to flows prior to discharge. Implement non-structural controls, such as education programs.
Protection of Receiving Environments To retain natural drainage systems and protect ecosystem health.	Maintain pre-development hydrological and water quality conditions. Retain seasonal wetlands and vegetation and apply appropriate buffers. No direct drainage to conservation category wetlands.
Public Health and Risk To minimise the public risk, including risk of injury or loss of life to the community.	Prevent flooding (0.3m clearance from 100yrARI water levels to lots), water logging and erosion of waterways/slopes/banks. Immobile stormwater infiltrated within 96hrs to prevent mosquitos. Manage acid sulphate soils and contamination risks.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.	Integrate stormwater structures into the landscape and POS. Retain remnant vegetation, where possible. Minimise the use of artificial/piped drainage systems. Conserve Aboriginal Heritage and environmentally sensitive areas.
Further Planning To ensure delivery of best practice stormwater management through planning.	Integrate water management with urban planning and ensure all BUWM (WAPC, 2008) requirements are fulfilled. Apply WSUD approach to road, lot and POS layouts.
Implementation/ Construction To ensure delivery of best practice stormwater management through high quality developed areas in accordance with sustainability and precautionary principles.	Prevent impacts on the hydrological regime during construction. Apply sediment control measures during construction to prevent excessive waterways/slopes/banks erosion. Utilised a non-potable water source for dust-suppression. Monitor water quality, flows, and levels near sensitive environments.
Post-Development To implement stormwater systems that are economically viable in the long term.	Consider the maintenance requirements. Following completion of construction, monitor groundwater and surface water near sensitive environments.

2 Proposed Development

A brief summary of the pre-development land use and proposed development are provided below.

2.1 Land Use

The Site is located within the Shire of Chittering (Figure 1). Lot 2 has been historically cleared and used as a commercial wild flower farm with small section of original bushland still present. It consists of four residences to the south west corner and Rocky Creek is within 1.5km south of Lot 2.

Lot 9001 is densely vegetated and has no current land uses. Surrounding land uses include rural land developments and semi-rural bushlands (Figure 2).

2.2 Development Features

The proposed development features approximately 242 residential lots, ranging in size from 5000m^2 to 14245m^2, as shown in Figure 3 and Appendix C. A Conservation Lot (about 20ha) is also proposed in the northern section of Lot 9001. This will contribute towards protection of land identified as the Indicative High Conservation Value Area.

The layout of this development has considered the existing environmental and drainage conditions, as well as surrounding land use and planning constraints.

Public Open Space (POS) which will be partially utilised for drainage is proposed centrally within Lot 2. This area is downslope from the majority of Lot 2. Landscaping plans of the Site are provided in Appendix E.

3 Site Characteristics

The pre-development environmental conditions provide opportunities and constraints for water management on the site. A summary of the environmental characteristics are provided in this Section.

3.1 Previous Studies

The environmental characterisation of the Site is based on a desktop assessment, field visit by 360 Environmental staffs and a review of the following documents:

- Lot 2 Reserve Road, Chittering & Surrounds Water Management Strategy (VDM, 2008a);
- Proposed Rural Residential Development, Lot 2 Reserve Road, Chittering: Basic Ecological Assessment (VDM, 2005);
- Proposed Residential Development, Lot 7 Reserve Road, Muchea: Vegetation Survey, Report (VDM, 2008b);
- Lot 7 Reserve Road, Muchea Vegetation Survey (VDM, 2014);
- Proposed Subdivision Development, Lot 2 Reserve Road, Chittering WA, Roadway Geotechnical Investigation Report (CMW, 2016a)
- Supplementary Winter Geotechnical Report for Proposed Subdivision, Lot 2, Reserve Rd, Chittering, WA (CMW, 2016b)
- Chittering Black Cockatoo Assessment (360 Environmental, 2015); and
- Lot 2 Reserve Road & Lot 9001 Rosewood Drive, Chittering Proposed Development Plan Report (TBB, 2015);

3.2 Topography

The Site (approximately 195ha) is located beside the Reserve Road and is 2km west of the Great Northern Highway (Figure 2).

Topography of the Site (based on 10m contours) varies between around 165 meters Above Height Datum (mAHD) in the northern boundary of Lot 9001 and less than 135mAHD in the south eastern corner of Lot 2 (Figure 2). The site generally slopes from north to south.

3.3 Climate

The climate of the south western region of Western Australia is characterised by the Koppen Climate Classification as Dry Subtropical featuring long, hot, dry summers, and mild, rainy winters. The dominate rainfall mechanisms are frontal systems caused by cold fronts associated with low pressure systems that extend across southern Australian

between May and October. During the summer months, thunderstorms and ex-tropical cyclones can bring intense rainfall.

The weather station at Marbling Rainfall Station (009024), approximately 8km south east of the site, provides a climate dataset of approximately 78 years (BoM, 2013a). As demonstrated in Figure 4, there is a variation in the annual totals, ranging between 409mm (2010) and 1,186mm (1955). The data indicates a decreasing trend in annual and winter rainfall totals, particularly since 2000 where the annual average rainfall has decreased from 757mm to 664mm (approximately a 12% decrease). Winter rainfall (May-August) has decreased by 18% during the same period.

Evaporation, as shown in Figure 4, is highest between November and March. A comparison of the mean monthly rainfall and evaporation totals demonstrates that the region is water limited between September and April. Between May and August rainfall exceeds evaporation.

The key rainfall characteristic for hydrological analysis is the Intensity-Frequency-Duration (IFD), a statistic derived from frequency analysis to provide estimates of rainfall intensity for a given duration and return periods. Analysis of rainfall and hydrology in the LWMS is based on IFDs published in Australian Rainfall and Runoff (AR&R1987) (Engineers Australia, 1987) and are summarised in Table 2.

Table 2: Rainfall IFDs for Chittering (BoM, 2013b)

	IFD Rainfall Intensity (mm/hr)				
Duration	1 Year	2 Year	5 Year	10 Year	100 Year
1Hr	15.1	19.6	24.9	28.5	47.5
3Hrs	7.54	9.75	12.2	13.8	22.4
6Hrs	4.87	6.27	7.75	8.75	14
12Hrs	3.14	4.03	4.95	5.57	8.81
24Hrs	2.01	2.57	3.15	3.54	5.54
72hr	0.921	1.18	1.43	1.6	2.49

3.4 Geotechnical

The central tile sheet of the 1: 20,000 Soil/Soil-landscape series mapping (DAF, 2007) indicates that the Site is located within the 222Mb-3, 222Mb-1 and 222Mb-4 soil units (Figure 5). Theses geological units are described as below:

- 222Mb-3; Mogumber 3 Subsystem - Gently inclined undulating slopes and minor drainage head-waters. Deep grey siliceous or bleached sands.
- 222Mb-1; Mogumber 1 Subsystem - Undulating broad crests and very gentle upper slopes <10% with common lateritic duricrust outcrop and shallow gravelly sands.

- 222Mb-4; Mogumber 4 Subsystem - Gently to moderately inclined slopes <10% with shallow gravelly sands and few areas of lateritic outcrop.

A geotechnical investigation of the Site was conducted by CMW Geosciences in March 2016 in support of the proposed residential development of the Site. An additional geotechnical investigation (winter investigation) was also carried out in August 2016 (Appendix D). The investigations included the excavation of 30 test pits with adjacent dynamic cone penetrometer tests, two pavement dippings, four hand auger boreholes, 11 soakage tests, in-situ falling head permeability tests and laboratory testing on samples obtained from both the existing pavement materials and the underlying natural subgrade material. The locations of the boreholes and test pits are shown in Figure 5.

A summary of the soil profile encountered at the borehole locations is provided below (CMW, 2016a):

- SAND (SP): loose to medium dense, white, grey and yellow, predominantly medium grained sand containing roots and rootlets and darker colouring in top 0.5m; overlying
- GRAVEL/COBBLES/BOULDERS: fine to coarse grained, sub-angular to sub-rounded, red brown, of lateritic origin, uncemented to well cemented, with sand

The winter investigation (CMW, 2016b) depicted the land as being underlain by colluvial sands with laterite outcrops to the west and south of the site.

Groundwater was not encountered in any of the investigations and the results of the constant and rising head permeability tests varied between approximately 1 x 10^{-5}m/sec (1m/day) and 6 x 10^{-5}m/sec (5m/day).

3.5 Groundwater

The underlying aquifers, pre-development groundwater quality and depth of water below the surface require consideration for management of the total water cycle and are discussed below.

3.5.1 Aquifers

The Site is situated in the Eclipse Hill groundwater sub-area. Groundwater resources below this region feature three separate aquifer systems; the Perth Superficial aquifer, the Leederville aquifer and Yarragadee aquifer (DoW, 2014). The shallowest aquifer, the Perth Superficial, consist of variable sequences of fine and medium sand with minor silt and limestone (mainly Bassendean Sand) that interfinger with a sequence of clay and clayey sand towards the foothills of the Gingin and Darling scarps (Guildford Clay) (DoW, 2010). Recharge to the superficial aquifer occurs through direct infiltration of rainfall, which migrates downward to the water table or less permeable layers, at which point groundwater flows laterally to the aquifer. Water is lost from the aquifer through

evapotranspiration from wetlands and shallow groundwater areas, to the ocean and downward leakage to the Leederville Aquifer.

The Leederville Aquifer is a major confined aquifer that consists of sandstones, siltstones and shales. It is a major groundwater source for the Perth region. The deeper Yarragadee aquifer is confined and occurs at depths about 450m below ground surface. As with the Leederville, the Yarragadee is a major groundwater source for the Perth region.

3.5.2 Groundwater Levels

The Perth Groundwater Atlas (DoW, 2012) provides the maximum groundwater level covering mostly Perth metropolitan area. These contours do not extend across the Site, with the nearest contour (60mAHD) 1km to the east (Figure 6). Ground water level within the Site is anticipated to be significantly higher than 60mAHD. According to the surface elevation (Section 3.2), there will be a sufficient clearance to groundwater for development across the Site.

The previous water management strategy (VDM, 2008a) indicated that groundwater level was greater than 30m below surface.

3.5.3 Groundwater Quality

No Site specific groundwater monitoring (of the superficial aquifer) has been undertaken, owing to the vegetation on Lot 9001 and depths reported in VDM, 2008a. Groundwater samples were collected at the Department of Water Monitoring Bore 61602501 (Figure 6) in 1981 to determine physiochemical parameters and nutrients (VDM, 2008a). Groundwater quality within the artesian aquifer was being assessed against the ANZECC guidelines and is provided with the results in Table 3.

The groundwater salinity of the artesian aquifer is considered fresh within the Site owing to the range of TDS (DoW, 2012).

Table 3 indicates that the artesian aquifer contains a suitable water quality. Most parameters are well below their respective drinking water quality criteria except for large concentration of iron and manganese.

Table 3: Groundwater Monitoring Results

Parameters	ANZECC* (2000)	Pre-Development Monitoring	
		Sample 1	Sample 2
Physical Properties			
pH	6.5 – 8.5	7	6.8
Electrical Conductivity (Us/cm^2)	-	560	550
Total Dissolved Solids (mg/L)	500	360	350
Sodium (Na) (mg/L)	69	68	180
Potassium (K) (mg/L)	-	7.6	7.6
Calcium (Ca) (mg/L)	-	7.7	7.9
Manesium (Mg) (mg/L)	-	5.4	5.3
Hardness (as $CaCO_3$) (mg/L)	200	41	42
Chloride (Cl) (mg/L)	250	120	120
Fluoride (F) (mg/L)	1.5	0.3	0.3
Arsenic (As) (mg/L)	0.007	< 0.001	< 0.001
Nitrate (NO_3) (mg/L)	-	< 0.20	< 0.20
Sulphate (mg/L)	250	14	14
Iron, Fe (Soluble) (mg/L)	***0.3***	6.0	6.3
Aluminum (mg/L)	0.2	0.1	0.1
Manganese (Mn) (mg/L)	***0.1***	0.1	0.1

*ANZECC & ARMCANZ (2000) guideline values (Lowland Rivers) adopted.

3.6 Surface Water

No surface water features or surface drainage lines exist on the Site owing to the sandy soil and vegetation cover. The Site is located between Yalyal Brook in the north and Rocky Creek in the south and is not within 100 Year Annual Recurrence Index (ARI) Floodplain development control area.

3.7 Water Resources

The site is located within the Eclipse Hill groundwater subarea of the Gingin Groundwater Area. An Aquifer Allocation Report requested in August 2015 shows that there is approximately 1,248,893kL available in the surficial aquifer (DoW, 2015). There is an existing groundwater Licence's in Lot 2 for the Leederville aquifer with an annual volume of 288,800kl (Table 4). The Licence is currently held by the Water Corporation. Transfer of this Licence is addressed in the Drinking Water Source Protection Plan (DWSPP) (Appendix F) and the Asset Management Plan (Appendix G).

The site is not within Public Drinking Water Source Areas (PDWSA), or Proclaimed Surface Water Areas.

Table 4: Groundwater License Details

Licence Number	Licence Allocation	Groundwater Area	Groundwater Subarea	Issue Date	Expiry Date
GWL59907	288,800kL	Gingin	Cowalla Confined	8/08/2013	7/08/2023

3.8 Environmental

Several environmental features either influence or are dependent on the total water cycle for this site. A brief summary of these is provided below.

3.8.1 Land Use Change

Aerial photography shows that Lot 2 was vegetated prior to 1979. Between 1979 and 1983, Site clearing was started to make way for commercial wild flower farm. The Rosewood Ramble was built east of Lot 2 between 2000 and 2005.

Lot 9001 has always been densely vegetated without any significant changes in the land use type. Rosewood Ramble was extended to the southern section of Lot 9001 after 2008 (Figure 7).

3.8.2 Aboriginal Heritage

The Government of Western Australia's State Heritage Office has not identified any areas of Aboriginal or European heritage within the site. A search of the Department of Aboriginal Affairs (DAA), Aboriginal Heritage Inquiry System (AHIS) identified that the closest aboriginal site is about 2km west of the Site (DAA, 2014).

3.8.3 Flora and Fauna

VDM undertook a Basic Ecological Assessment for Lot 2 during 2005 that included assessing the flora, vegetation and fauna habitat within the Site (VDM, 2005). The assessment identified 48 flora taxa.

The assessment found that due to isolation of the existing vegetation, the project area is unlikely to provide core habitat for significant fauna species and does not have any functional role as a corridor or linkage for significant flora or fauna.

No currently listed conservation-significant flora species or communities pursuant to the Western Australian Wildlife Conservation Act 1950 or the Commonwealth EPBC Act were recorded during any of the biological surveys.

360 Environmental undertook a Black Cockatoo Habitat Assessment during April 2015 (360 Environmental, 2015). The assessment found that the Site offers potential foraging, roosting and breeding habitat for Black Cockatoos. During the survey, no Black Cockatoos were heard or observed in the Site or seen flying over. 151 potential breeding trees were recorded within the project area, none of which contained hollows with suitable dimensions for Black Cockatoo breeding.

3.8.4 Wetlands

The Site is not located within or adjacent to any geomorphic wetlands. Regional mapping identifies the nearest wetland as Chandala Lake a Conservation Category Wetland located over 4.5km northwest of the Site (Figure 8) (DER, 2013).

3.8.5 Acid Sulfate Soils

Regional Acid Sulphate Soil (ASS) mapping indicates the Site is predominately "no known risk" of ASS occurring on the Site within 3m of the natural surface. The nearest "moderate to low risk" area is approximately 2km west (downstream) of the Site.

3.8.6 Contaminated Sites

A search of the DER Contaminated Sites Database identified no record of the site having a contaminated site classification (DER, 2014). The nearest registered contaminated site, registered as "Contaminated - Remediated required" is located 3km south west of the site.

No visual signs of contamination were identified during site investigations by 360 Environmental Scientists. Furthermore, the review of historical imagery did not identify any significant historical causes for concern of contamination, apart from nearby market gardens.

3.9 Summary

Based on the geotechnical, hydrological and environmental information described in Section 3, the site is considered to pose a low level of risk for development, based on the DoW's Guidance Note 3 (DoW, 2013). The Site conditions fulfil the criteria of >5m depth to groundwater and infiltration on site (5m/day). It does not contain any natural waterways or environmentally sensitive area, and there is adequate groundwater allocation available which supports a low level of risk. The developments will be proposed in a way to retain the flows within the Site boundaries. The strategies for urban water management and implementation have been prepared in consideration to account for the Low level of risk.

A summary of the Site considerations for water management are provided below.

3.9.1 Gap Analysis

Based on the numerous studies for the Site and field work that has been completed to date, there are not considered to be any significant data gaps that would further enhance water management concepts, and design, for the proposed development.

3.9.2 Site Considerations

The desktop assessment and previous investigations have identified a number of constraints and opportunities that require consideration in management of the total water cycle. These are summarised in Table 5.

Table 5: Key Site Considerations

Key Water Management Principles (Adapted from State Planning Policy 2.9, Stormwater Management Manual for WA & Better Urban Water Management).	
Integration of water and land use planning Ensure stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity Ensure stormwater management is part of total water cycle management Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse Define stormwater quality management objectives in relation to the sustainability of the receiving environment Recognise the need for site specific solutions and implement appropriate non-structural and structural solutions Integrate Stormwater Treatment into the landscape Add value while minimising development costs	
Category	**Site Considerations**
Water Sustainability To maximise the reuse or stormwater and minimise use of potable water particularly for non-drinking water purposes.	The site currently has a groundwater Licence's for the Leederville aquifer. There is allocation available from the Surficial and Yarragadee Aquifer. The Leederville Aquifer is fully allocated. The Site is not located within any Public Drinking Water Source Areas.
Stormwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from flooding.	There are no surface water features (wetlands, waterways or drains) within the Site. There is minimal runoff from the site during high-intensity storm owing to the sandy soil and vegetation cover. The site as suitable for disposal of stormwater through infiltration.
Groundwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from water-logging.	According to the Perth maximum groundwater contours and water management strategy (VDM, 2008a) there is sufficient clearance to groundwater for development across the Site. No areas of water-logging were identified on site. Further groundwater data will be provided in the UWMP.
Water Quality To maintain or improve the surface water and groundwater quality within development areas relative to pre-development conditions.	Groundwater samples were collected at the DoW Monitoring Bore (61602501) to determine the groundwater quality of the artesian aquifer. Results indicated that the artesian aquifer contains a suitable water quality with most parameters below their respective drinking water quality criteria; except for iron and manganese exceeding ANZECC guidelines.
Protection of Receiving Environments To retain natural drainage systems and protect ecosystem health.	There are no Bush Forever or Environmentally Sensitive Areas on the Site. The Site is not located within or directly adjacent to any geomorphic wetlands, with the nearest system approximately 4.5km west.
Public Health and Risk To minimise the public risk, including risk of injury or loss of life to the community.	No flooding or water logging was identified. Regional mapping indicates there is no ASS risk. No contaminated sites exist on or within 3km of the Site.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.	The Site is surrounded by native bush. There are no areas of Aboriginal Heritage on this Site.
Further Planning To ensure delivery of best practice stormwater management through planning.	The guiding water management document for the Site is Lot 2 Reserve Road, Chittering & Surrounds Water Management Strategy (VDM, 2008a) which provides a summary of key water objectives just for Lot 2 in the Site.
Implementation/ Construction To ensure delivery of best practice stormwater management through high quality developed areas in accordance with sustainability and precautionary principles.	The UWMP will need to adjust strategies/plans in the context of the new information. There is sufficient clearance to groundwater to prevent the need for ongoing dewatering.
Post-Development To implement stormwater systems that are economically viable in the long term.	Trees and vegetation on the conservation lot will be retained and the stormwater will be managed separately within its boundary.

4 Water Sustainability Initiatives

The supply of water and sustainable and efficient use within the proposed development, are key components of the LWMS.

4.1 Water Supply

Potable water for households within the development will be supplied from the artesian aquifer (Perth-Leederville Parmelia Aquifer). As discussed in Section 3.7, the Site has a total water entitlement (license to abstract groundwater) of 288,800kL/annum from the Leederville Aquifer. Assuming 242 lots on Site, three occupants (per lot) and 60kL/person/year, the total water requirement is 43,560kL. At the development scale, the Public Open Space (POS) reticulated area (0.9ha) and the Site southern entry from Reserve Rd (0.22ha) require a total water of 8,400kL/yr for irrigation. This is based on the Department of Agriculture and Food (DAF, 2016) advice and the irrigation rate of 7,500kL/ha/yr for the POS. There is sufficient remaining allocation for construction activities.

To reduce demand on the deeper aquifer rainwater tanks may be considered.

Water efficiency measures will be implemented regardless of the water source or availability (Section 4.2).

Further detail of the Water supply is provided in DWSPP (Appendix F) and the Asset Management Plan (Appendix G). These reports will be submitted to the Department of Health for endorsement. Once they are finalised and approved, a brief LWMS Amendment letter will be prepared to outline any discrepancies (if required).

4.2 Water Conservation

The DoW supports sustainable and efficient use of drinking water, including fit-for-purpose and a demonstration of sustainable potable water use. Significant savings in scheme water are possible through conservation measures provided by Water Corporation (2014) and through the Building Codes of Australia.

The implementation of water conservation measures should be promoted as part of any new residential development. Consistent with these measures, households within the development will feature:

- Showerheads installed with a rating better than the minimum WELS 3 Star.
- Taps installed with a rating better than minimum WELS 4 Star.
- Dual flush toilets with a rating better than minimum WELS 4 Star.
- Water using appliances, such as washing machines and dishwashers installed with a rating of WELS 4 Star or better.

- Hot water systems located less than 20m from the point of use and / or a recirculation or heat pump is installed.
- Encourage outdoor design which minimises heat absorption and encourage the use of evaporative vs refrigerated air conditioning.

Conservation measures for ex-household use include:

- Garden designs will incorporate waterwise or endemic plant species.
- Garden beds will be mulched to a minimum of 5cm.
- Garden beds will use dripper or subsurface irrigation systems.
- Grouping of garden plants according to water needs
- Consideration of climatic factors when designing garden beds (e.g. sun and wind exposure)
- Minimal use of lawn areas.

As well as water efficient design, the promotion of water efficient behaviour should also be encouraged, including:

- Familiarisation with optimal tap and device settings;
- Observation and regular checking for leaks and maintenance requirements both indoor and outdoor;
- Use of pool covers;
- Use of fans as an alternative to air conditioning;
- Outdoor design which maximises heat reflection and ventilation

The type of vegetation throughout the development, both within private gardens and POS, significantly influences the water use throughout the development. For the Site, extensive turfed areas are not proposed, with the majority of the POS to be planted with local, native vegetation.

Estimates of water use and potential savings through these measures will be provided in the UWMP, following the finalisation of the lot layouts and sizes.

4.3 Waste Water Management

Waste water from the development will be treated onsite. Effluent from the households will be based on all in-house water usage and will be treated through HDWA approved aerobic treatment systems (VDM, 2008a). The effluent product is suitable to be used only for the landscaping purposes.

The late winter geotechnical report (CMW, 2016b) demonstrates that the development complies with the Country Sewerage Policy (CSP) criteria for onsite waste water disposal. This report indicated that the majority of the site has a minimum soil depth to

seasonal, permanent or perched water table of least 0.5m and can be designed with a loading infiltration rate of 30 L/m^2/day for an alternating system and 15 L/m^2/day for a non-alternating system.

Specific proposed lots situated towards the western boundary of Reserve Road (Figure 5) may have shallow laterite (caprock and gravel through to boulders) present within the top 0.5m over parts of the lot. However it is anticipated that at least 150m^2 of suitable effluent disposal area will be found somewhere on these lots (CMW, 2016b).

Earthworks recommendations where a suitable effluent disposal area cannot be found on a given lot are made by CMW and presented in Appendix D.

5 Stormwater Management Strategy

The stormwater management strategy has been prepared in accordance with the guiding principles (Section 1.2) and site considerations (Section 3). The strategies preserve and enhance the ecological and social aspects of the Site and provide measures to mitigate the risk of flooding and waterlogging on the development.

5.1 Stormwater Management Concepts

The stormwater management system concepts for development of the Site have been prepared to meet the objectives and principles of BUWM and outlined in Table 1 (Section 1.2) and WSUD. In addition, the proposed conceptual design is consistent with the previous studies (Section 3.1). Specifically the system will retain catchment runoff within the property boundary.

Key elements of the stormwater management conceptual design are:

- Maintain the existing flow directions within the Site through earthworks and alignment of road networks. The Site is divided into three catchments (Figure 9). A POS area at the centre of Lot 2 in Catchment 1 will feature drainage infrastructure amongst passive and active POS uses.
- Adopt a treatment train approach to water quality management and protection of receiving environments, including infiltration of frequent events close to source and bio-retention area within the POS.
- Frequent events (≤1yr ARI Event) will be mostly infiltrated within the majority of lots through the use of soakwells, with runoff from roads infiltrated via the road drains and bio-retention basin within the POS.
- Major events (≤100yr ARI Event) will be retained and infiltrated onsite within the POS and roadside swales.
- The basin within the POS will provide aesthetic values for the community and alleviate the need for fenced drainage sumps.
- No direct groundwater management measures (permanent dewatering or control of groundwater levels) are to be implemented owing to the existing clearance to groundwater.

5.2 Stormwater Management System

A major and minor approach to the design of stormwater management systems has been adopted for the Site. The minor system consists of roads, kerbs and small drains deigned to convey runoff up to the 5yr ARI event and ensure serviceability of the road network. The major system consists of roads, roadside swales, POS and drainage basin alignments and provides protection of the community from extreme flooding events (up

to the 100yr ARI event) that exceed the capacity of the minor system. Details of these systems are described below.

5.2.1 Minor System (Frequent Events)

Management of the frequent event (1yr 1hr) is largely related to the protection of receiving environments. Runoff from this event is most likely to mobilise pollutants within the catchment and therefore measures are required to retain and treat this storm event on site.

Installation of soakwells is proposed in all lots owing to the minimum lot area of 5000m^2 and clearances required from the building footprint. Therefore 1yr 1hr event (approximately 16mm) runoff will be retained within the lot boundary and infiltrated using soakwells. Impervious areas, such as driveways, paving and roofs will be connected directly to the soakwells. Infiltration is supported by the clearance to groundwater at the proposed lots locations (generally >30m) and favourable subsurface conditions (Section 3.4). It is anticipated that the majority of area on the lots will retain trees/vegetation to promote infiltration.

A bio-retention basin within the POS in catchment 1 and roadside swales in catchment 2 will be installed to capture road reserve runoff in the 1yr 1hr ARI event (Figure 9). Roadside swales throughout the Site will also be sized to ensure serviceability of the road network during the 5yr ARI event and allow for infiltration throughout the road network.

5.2.2 Major System (Extreme Events)

The major drainage system will consist of the roads, roadside swales and the drainage basin. Events larger than the 5yr ARI event in catchment 1 will be conveyed via the road network to the drainage basin within the POS (Figure 10). For catchment 2, the larger events will be retained within the roadside swales. In order to determine the requirements for the drainage basin and the roadside swales, hydrologic modellings were undertaken with the model XP-Storm.

The following parameters have been used to determine runoff using the XP-Storm model:

- Catchment 1 (total area of 68ha) drain towards lowland POS area featuring drainage infrastructure. A slope value of 0.012 was used in this catchment.
- For roadside swale design, the worst scenario of the narrowest lot and steepest road were considered.
- Rainfall for the Site is based on 1987 IFD Data (Section 3.3).

Table 6 outlines the runoff coefficients used in the post-development model. Proposes lots within the Site are fairly large with the minimum area of 5000m^2. A review on the existing lots in the surroundings indicated that the average building sizes are about 800 and 850m^2 which would not be more than 20% of the smallest proposed lot area.

Knowing that more than 80% of the lots area is permeable, impervious areas are connected directly to the soakwells and rainwater tanks and the buildings are located within distances of the roads that causes more losses, it would be unlikely to have more than 5% runoff from the Residential R2 lots. A runoff coefficient of 70% has been applied for the roads owing to the existence of permeable drains and swales on sides of the roads.

It should be noted that these values are conservative estimates and the breakdown of lot densities are estimates only and will be confirmed in the UWMP.

Table 6: Post-Development Runoff Coefficients

Land Use	Catchment Area (ha)			Runoff Coefficient	Comment
	#1	#2	#3		
Lots (Residential R2)	56.1	52.4	8.9	5%	16mm of initial loss was considered on for lots to account for lot connections to the soakwells.
Lots (Conservation & Rural Conservation)	0	0	54.1	0%	No runoff was considered for these lots according to the large permeable areas and also lot connections to the soakwells.
Road Reserve	8.8	6.3	5.5	70%	Includes road, footpaths and verges.
POS	2.7	0	0	10%	The POS was assumed to have the same runoff characteristics prior to-development.

Hydrographs generated in XP-Storm were imported in the PONDS model to determine the infiltration and storage volumes. The PONDS software calculates infiltration areas and volumes, based on the finite-difference groundwater model MODFLOW, developed by the US Geological Survey.

The PONDS mode was configured with the following parameters:

- Water table elevation of 120mAHD (Section 3.5);
- Basin Invert of 150mAHD and roadside swale details as in Appendix E;
- Infiltration rates of 2.5 and 5m/day for the basin and swales respectively;
- Porosity of 30%;
- Horizontal Hydraulic Conductivity (K_{hor}) of 10m/day (DoW, 2010);
- Conservative base of Superficial Aquifer of 5mAHD (DoW, 2012); and
- Hydrographs generated from XP-Storm.

The stormwater system was designed to contain the 5yr and 100yr ARI events within the roadside swales, basin and POS area. The modelling result demonstrates that the roadside swales retain the 100yr ARI event have a maximum depth of about 0.8m in the worst scenario. The proposed stormwater management system is presented in Figure 10 and the drainage basin design is detailed in Table 7.

Table 7: Drainage Basin Design Details – Catchment 1

Post-Development Catchment		Catchment 1	
Catchment Area		68ha	
Catchment Breakdown			
Lots (Residential R2)		56.1ha	
Road Reserve		8.8ha	
POS		2.7ha	
Storage Data			
Type		Retention (Infiltration) Basin	
Side Slopes		1:6 (v:h)	
Base Invert		150mAHD	
Base Area		0.21ha	
5yr ARI Event		**100yr ARI Event**	
Top Water Level Area	0.33ha	Top Water Level Area	1.15ha
Flood Storage	2517m^3	Flood Storage	6518m^3
Flood Rise	0.94m	Flood Rise	1.51m
Top Water Level	150.94mAHD	Top Water Level	151.51mAHD
Critical Duration	12hr	Critical Duration	24hr
Time to Empty	12hrs (72hr Event)	Time to Empty	24hrs (72hr Event)

Flow paths for the 1yr, 5yr and 100yr ARI events are shown in Figure 10 and demonstrate areas that are inundated during each event. Similarly, a cross section of the stormwater system is shown with the maximum water levels. The system allows for minimum habitable floor levels to be at least 0.5m above the proposed top water level in the basin.

The proposed basin design is conceptual only. The UWMP will provide the final configuration that may be modified following a review of additional earthwork and road design levels. Associated landscaping and engineering drawings will also be included in the UWMP.

5.3 Groundwater Management

Based on the Perth Groundwater Atlas groundwater contours (Section 3.5.2) there is sufficient clearance between the groundwater and the natural surface across the Site where lots are proposed (Figure 6). No direct measures, including subsoil drainage or lowering of groundwater are proposed for managing groundwater. Final lot levels and clearance to groundwater will be provided in the UWMP following refinement of the earthwork design.

Where fill is imported, imported granular fill must comply with the material requirements as stated in AS3798: Guidelines on Earthworks for Commercial and Residential Developments (Australian Standard, 2007).

5.4 Protection of Receiving Environments

There are no existing wetlands or waterways within the Site that require ongoing management and the water retention systems are designed to ensure minimal retention times by allowing the water to drain freely through the Site's sandy soils. The downstream receiving environment is the superficial aquifer.

Protection of the superficial aquifer involves managing the post-development use of nutrients and the export of pollutants off site. A treatment train approach, including the use of structural and non-structural controls, will be implemented to achieve this protection.

Non-structural controls are an essential part of the treatment train process as they contribute to the reduction stormwater volumes and pollutants. They differ from structural controls as they are not fixed, permanent infrastructure and can offer relatively inexpensive and flexible approaches (DoW, 2004-2007). Implementation of these non-structural controls occurs during various stages of development

For this site, the following non-structural controls will be implemented:

- Planning: residential lot density, basin location
- Construction: erosion and dust control
- Maintenance: street sweeping, stormwater infrastructure maintenance
- Education: WSUD community education
- Monitoring: pre-development and post-development

Structural controls for the Site will be implemented to retain and infiltrate the frequent (up to 1yr 1hr) events close to source throughout the catchment. Runoff from impervious areas, such as driveways, paving and the roof will be directed to soakwells and bio-retention basin to promote infiltration. This is based on BMPs as outlined in the Stormwater Management Manual of Western Australia (DoW, 2004-2007). Specific targets for improvement in water quality are discussed in Section 6.

6 Implementation Strategy

The success of the water management strategies relies heavily on their implementation throughout all stages of development including further planning, construction and post-development.

6.1 Subdivision Phase

Following approval of the LSP, a Subdivision Application will be submitted. In support of this application, an Urban Water Management Plan will be prepared.

The UWMP will document the final water management plans for this Site. It will include a summary of the site conditions in a number of plans; environmental, geotechnical, surface water, groundwater and Site condition plans.

A key focus of the UWMP will be to provide detail of the final stormwater system design, including engineering drawings of infrastructure, details of control point inverts, and the locations and clearance to groundwater. Further information that is obtained from additional monitoring and details on the final lot density will allow for an analysis of the conceptual designs provided in the LWMS.

The following information will also be provided in the UWMP:

- Details on the roads finished levels and grades, provided in engineering drawings.
- Further detail of the landscaping design, including POS areas and water requirements, and water use sustainability initiatives.
- Details, design and relevant approvals for water and wastewater servicing
- Design of non-structural controls.
- Measures to mitigate mosquito populations.

6.2 Construction Phase

Water management during the construction phase of the project requires consideration of direct impacts from construction activities and maintaining pre-development hydrological performance prior to completion of the post-development stormwater system.

6.2.1 Abstraction Licensing

Water will be required for construction activities such as dust suppression and dewatering, and for irrigation of POS. The existing licence discussed in Section 3.7 will cover these activities and all abstractions will be carried out in accordance to conditions of this licence.

Dewatering is not considered likely given the separation to groundwater across the Site. However, any dewatering undertaken will occur in a manner consistent with a dewatering licence.

6.2.2 Management of Subdivisional Works

Potential impacts from construction activities related to the water cycle include:

- Nuisance dust generation during bulk earthworks
- Erosion of exposed surfaces
- Inappropriate disposal of waste building material

All of these potential impacts are manageable through appropriate engineering design and appropriate site management practices. Contractors and staff will be notified of the requirement to implement management practices to limit any potential impacts resulting from construction activities.

Timing of the construction activities will be dependent on a number of factors not related to water management. Where possible, the construction schedule should allow for work to be undertaken when impacts on the water cycle will be minimised. For example, excavation work is more appropriate between January and April when groundwater levels are at a minimum.

6.3 Post Development

Following the completion of construction activities, maintenance of the stormwater system and assessment of the system performance will be required to determine whether additional water management measures are required.

6.3.1 Maintenance

Operation and maintenance of the stormwater management system will initially be the responsibility of the developer, until handover of the development to the Shire of Chittering. The following measures will be undertaken to ensure the system functions correctly:

- Removal of debris to prevent blockages
- Assessment of the health of vegetation in the POS and removal and replacement of dead plants where necessary.

6.3.2 Monitoring Program

Water quality objectives are to be managed as per Water Sensitive Urban Design (WSUD) principles and Best Management Practices (BMPs) using bio-retention system in POS area. This is industry standard and as such water quality treatment cannot practicably be expected to be improved upon beyond these design controls.

As stated in Section 3.9, the Site is also considered to be low risk from a surface water, groundwater and environmental management perspective. Therefore any post-development groundwater water quality monitoring program to assess the performance of the stormwater management system is not considered necessary for this Site.

6.4 Roles and Responsibilities

Table 8 details the roles and responsibilities for water management during the subdivision and construction phase of the development and post-development.

Table 8: Roles and Responsibilities

Action	Developer	Shire of Chittering / DoW
Preparation of UWMP	✓	
Assessment / Approval of the UWMP		✓
Construction of Stormwater System	✓	
Construction Landscape & Irrigation System	✓	
Construction Street, kerbs and small drains	✓	
Maintenance & Street Sweeping Prior to Handover	✓	
Maintenance & Street Sweeping Following Handover		✓

7 Conclusion

The key management strategies from the LWMS, discussed in detail in Sections 4 to 7 are summarised in Table 9.

Table 9: Key Management Features

Key Water Management Principles (Adapted from State Planning Policy 2.9, Stormwater Management Manual for WA & Better Urban Water Management).	
Integration of water and land use planning Ensure stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity Ensure stormwater management is part of total water cycle management Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse Define stormwater quality management objectives in relation to the sustainability of the receiving environment Recognise the need for site specific solutions and implement appropriate non-structural and structural solutions Integrate Stormwater Treatment into the landscape Add value while minimising development costs	
Category	**Key Management Features**
Water Sustainability To maximise the reuse or stormwater and minimise use of potable water particularly for non-drinking water purposes.	The existing licence to take water from the artesian aquifer is the main source of potable water. The superficial aquifer is the secondary water supply for the Site. Households will adhere to waterwise home guidelines. Local, native waterwise plants will be used in landscaping.
Stormwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from flooding.	Existing catchment will be maintained. Frequent events (≤1yr ARI) will be infiltrated through soakwells on lots, road drains and the bio-retention basin within the POS Major events (up to 100yr ARI) will be retained and infiltrated within the POS (Lot 2).
Groundwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from water-logging.	No direct measures, subsoil drainage or lowering of groundwater are proposed for managing groundwater across the Site. Imported granular fill must comply with the material requirements as stated in AS3798. Final lot levels and clearance to groundwater will be provided in the UWMP following refinement of any earthwork design.
Water Quality To maintain or improve the surface water and groundwater quality within development areas relative to pre-development conditions.	A treatment train approach to water quality improvement is adopted. Frequent events will be infiltrated close to source by soakwells, drains and bio-retention area. Further measures will be outlined in the UWMP.
Protection of Receiving Environments To retain natural drainage systems and protect ecosystem health.	The treatment train approach (above) will provide water quality improvement measures and protection to receiving environments.
Public Health and Risk To minimise the public risk, including risk of injury or loss of life to the community.	The habitable floor level will be >0.5m above the 100yr ARI flood level and >1.2m the maximum groundwater level to prevent water logging. Stormwater will be infiltrated within 96hrs to prevent standing water and mosquito breeding.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.	Stormwater structures will be integrated into the POS Design. Remnant vegetation will be retained (where possible).
Further Planning To ensure delivery of best practice stormwater management through planning.	The UWMP will document the final stormwater management strategy incorporating any additional engineering, planning and landscaping requirements.
Implementation/ Construction To ensure delivery of best practice stormwater management through high quality developed areas in accordance with sustainability and precautionary principles.	Direct impacts from construction activities, such as dust, erosion and waste disposal will be managed through appropriate site practices. Where possible, the timing of construction works be undertaken to minimise impacts on the water cycle.
Post-Development To implement stormwater systems that are economically viable in the long term.	No post-development groundwater water quantity or quality monitoring program is considered across the Site.

8 Limitations

This report is produced strictly in accordance with the scope of services set out in the contract or otherwise agreed in accordance with the contract. 360 Environmental makes no representations or warranties in relation to the nature and quality of soil and water other than the visual observation and analytical data in this report.

In the preparation of this report, 360 Environmental has relied upon documents, information, data and analyses ("client's information") provided by the client and other individuals and entities. In most cases where client's information has been relied upon, such reliance has been indicated in this report. Unless expressly set out in this report, 360 Environmental has not verified that the client's information is accurate, exhaustive or current and the validity and accuracy of any aspect of the report including, or based upon, any part of the client's information is contingent upon the accuracy, exhaustiveness and currency of the client's information. 360 Environmental shall not be liable to the client or any other person in connection with any invalid or inaccurate aspect of this report where that invalidity or inaccuracy arose because the client's information was not accurate, exhaustive and current or arose because of any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to 360 Environmental.

Aspects of this report, including the opinions, conclusions and recommendations it contains, are based on the results of the investigation, sampling and testing set out in the contract and otherwise in accordance with normal practices and standards. The investigation, sampling and testing are designed to produce results that represent a reasonable interpretation of the general conditions of the site that is the subject of this report. However, due to the characteristics of the site, including natural variations in site conditions, the results of the investigation, sampling and testing may not accurately represent the actual state of the whole site at all points.

It is important to recognise that site conditions, including the extent and concentration of contaminants, can change with time. This is particularly relevant if this report, including the data, opinions, conclusions and recommendations it contains, are to be used a considerable time after it was prepared. In these circumstances, further investigation of the site may be necessary.

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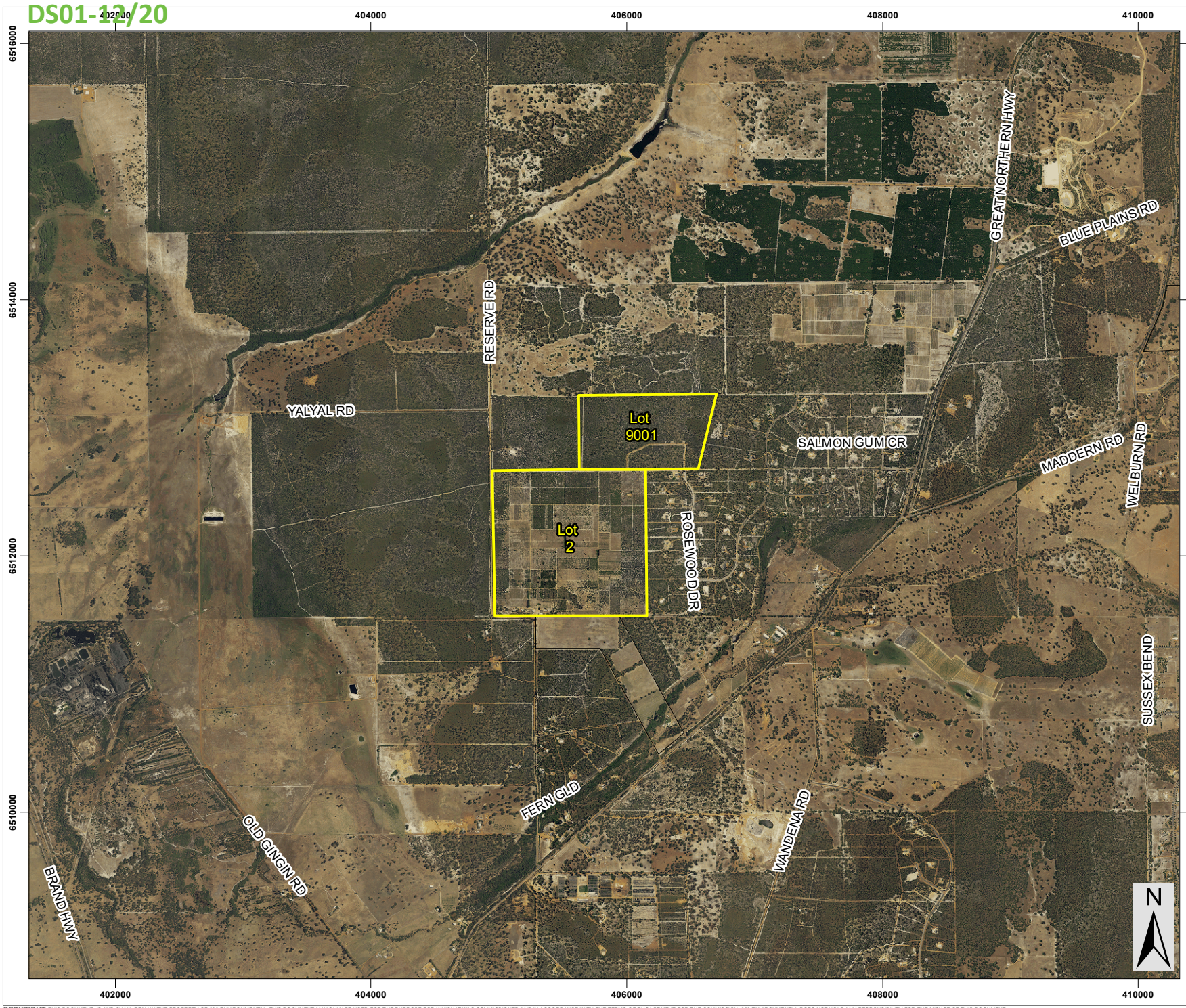
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FIGURES

DS01-12/20

Attachment 1



Legend

Site Location (195 ha)

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
- CADASTRE SOURCED SLIP SERVICES JULY 2015
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LOCALITY MAP



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HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

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Riverside Investments WA Pty Ltd
Reserve Road, Chittering

Local Water Management Strategy

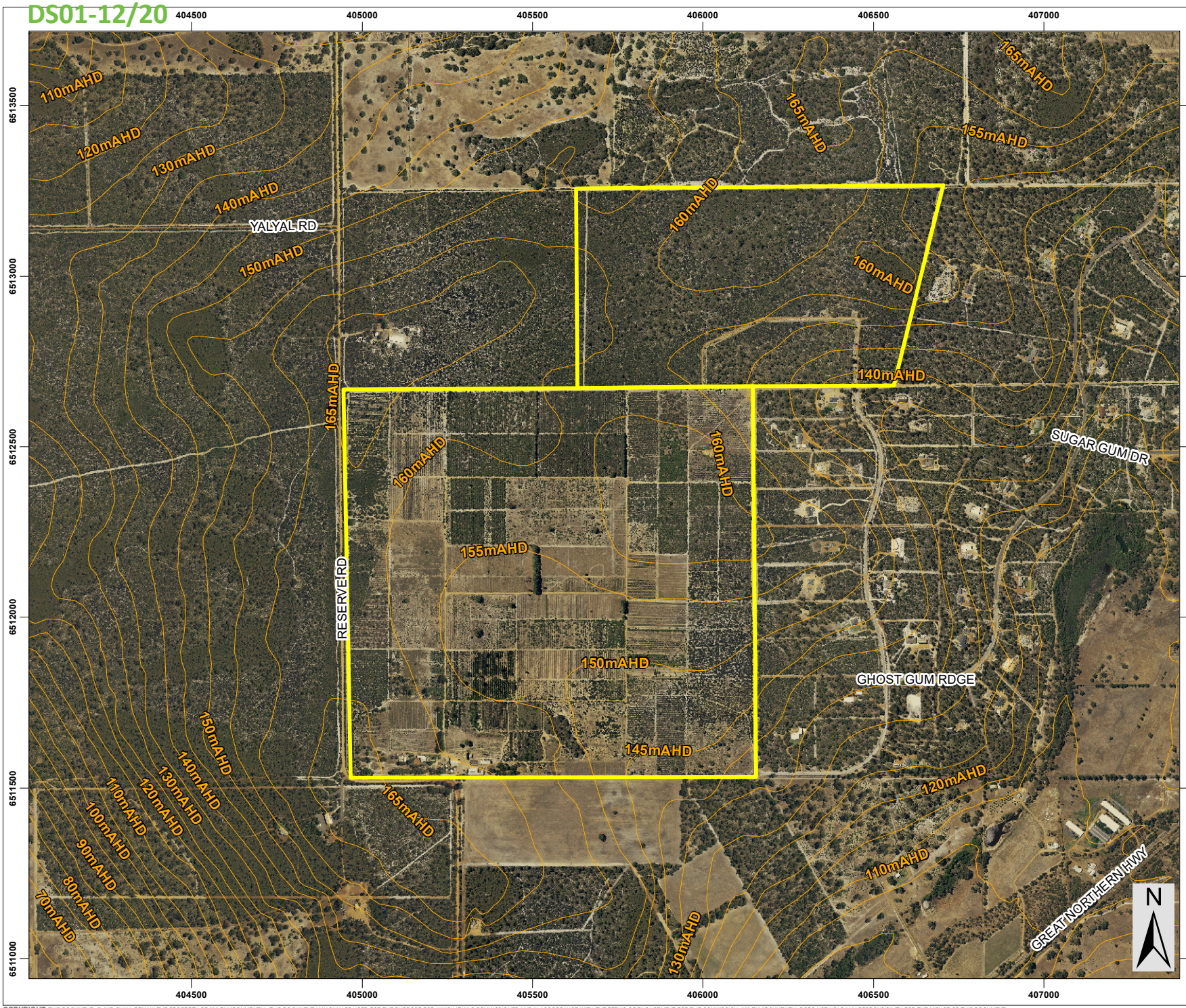
Figure 1 - Location Plan

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Attachment 1



Legend

- Site Location (195 ha)
- Elevation

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
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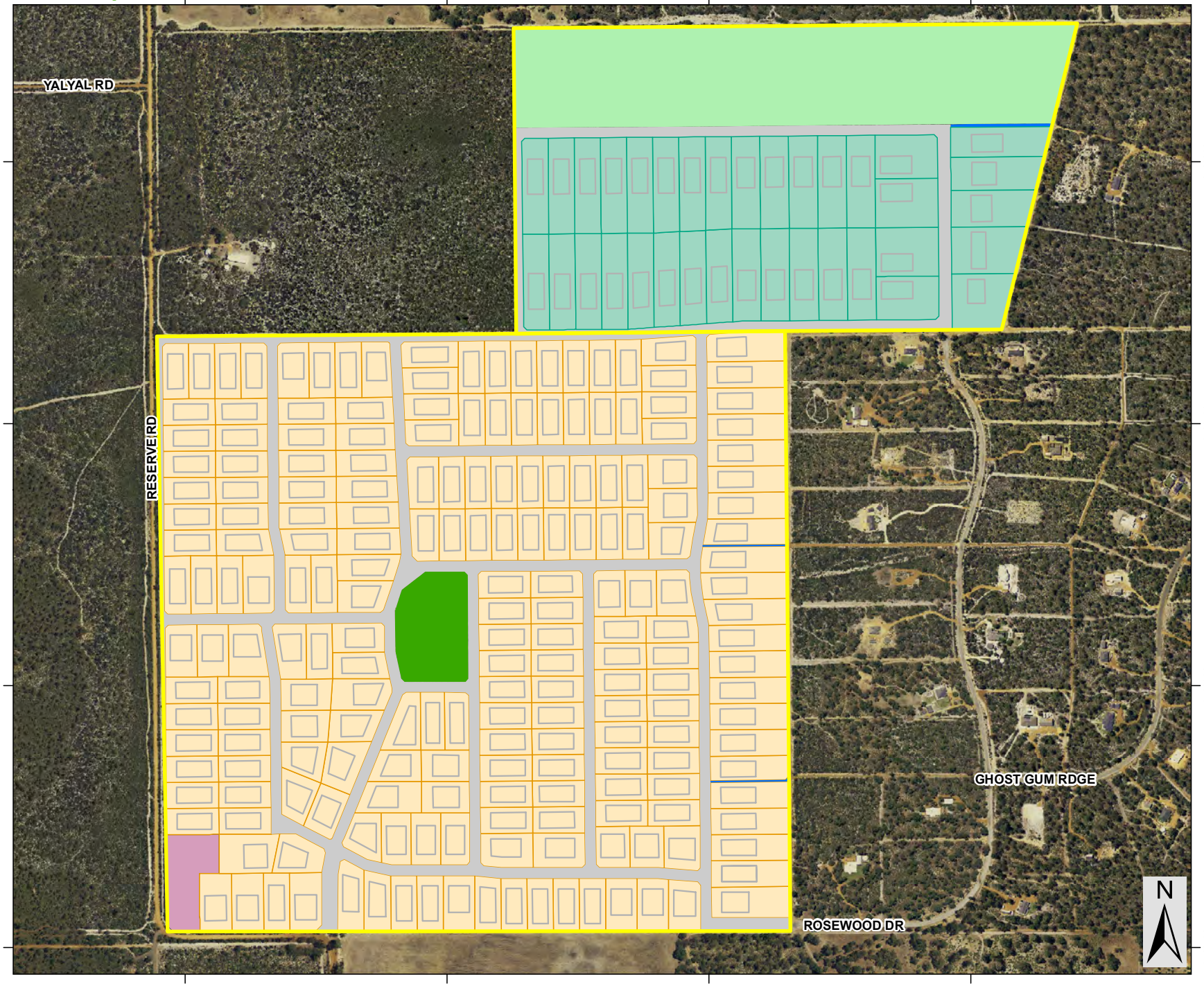
Figure 2 - Aerial Photography and Topography

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Attachment 1



Legend

- Site Location (195 ha)

Proposed Development Plan

- Conservation Lot
- Drinking Water Protection Site
- Public Open Space
- Residential R2
- Rural Conservation
- Road
- Proposed Easement
- Proposed Buildings

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
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GDA 1994 MGA Zone 50

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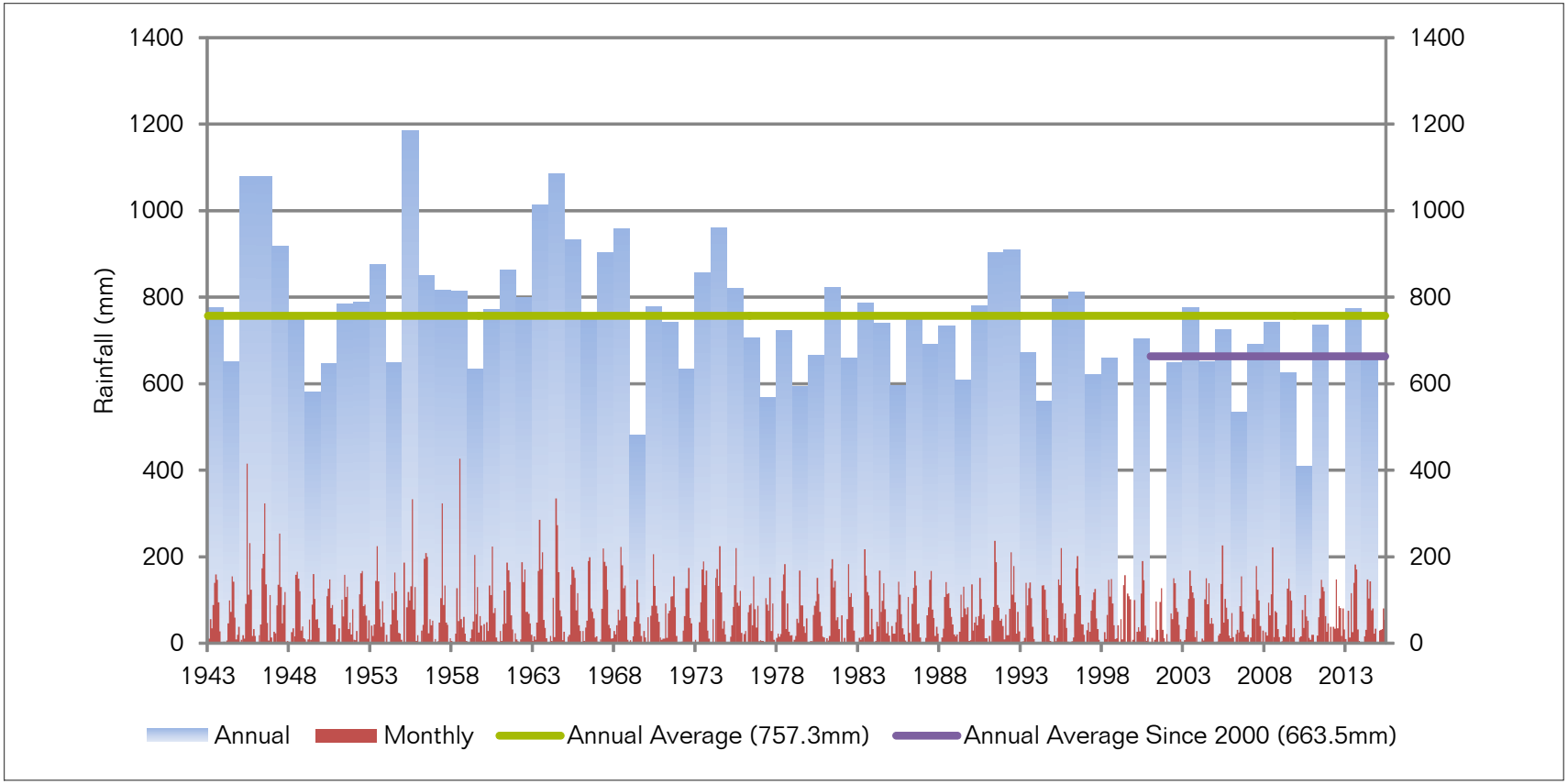
Riverside Investments WA Pty Ltd
Reserve Road, Chittering

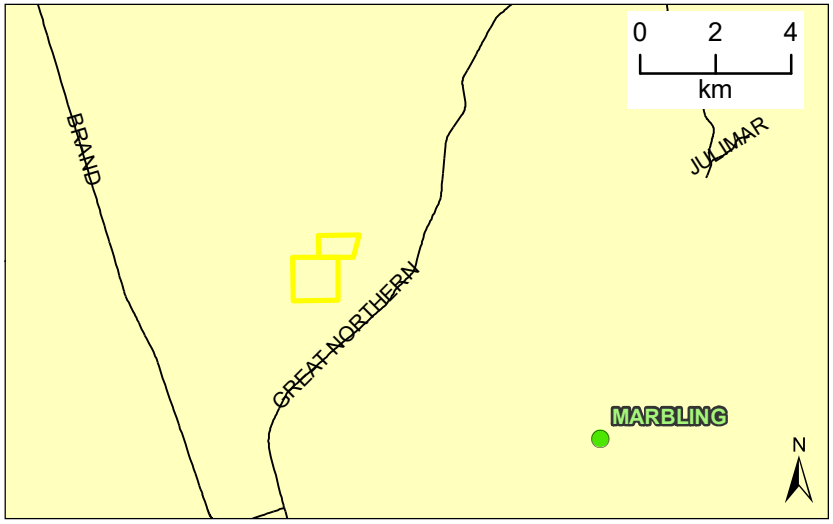
Local Water Management Strategy

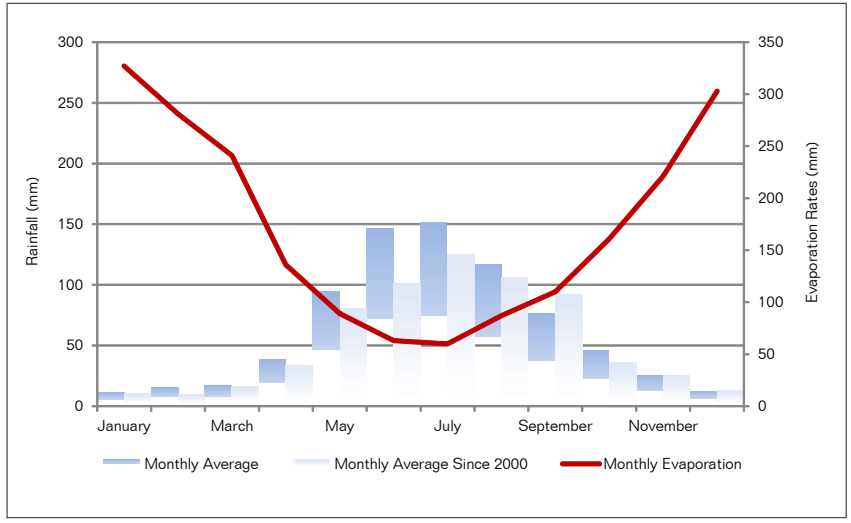
Figure 3 -
Proposed Debvelopment Plan

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Legend

- Site Location (195 ha)
- Weather Stations

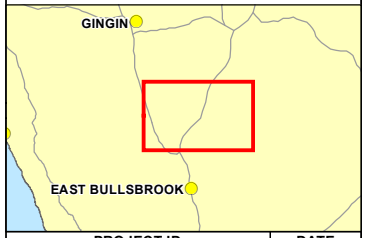
- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
- LOCALITY MAP SOURCED FROM LANDGATE 2006
- STREET DIRECTORY MAP SOURCED FROM STREETSMART 2008
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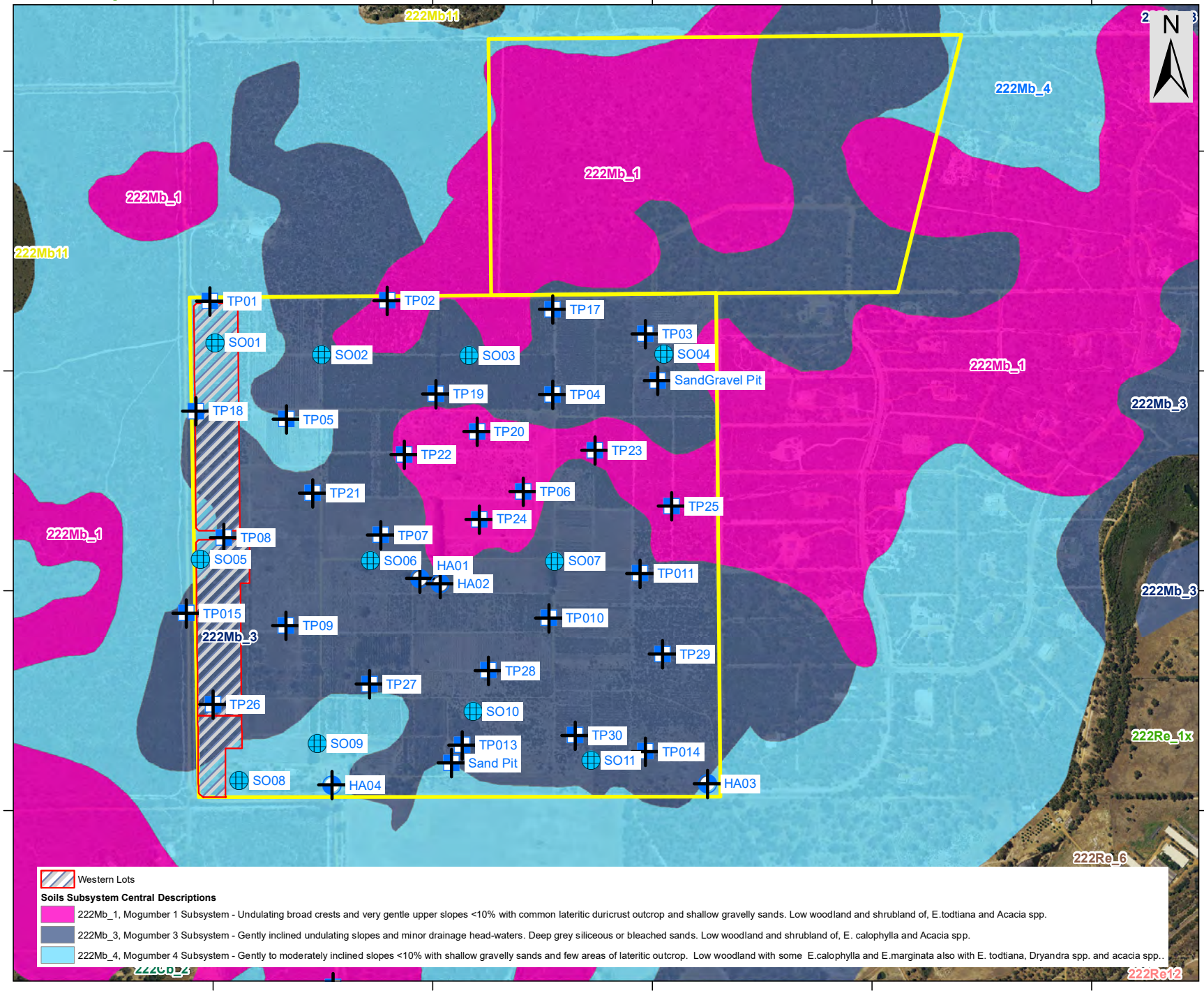
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Reserve Road, Chittering

Local Water Management Strategy

Figure 4 -
Rainfall and Evaporation Data

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Legend

- Site Location (195 ha)
- Hand Auger Location
- Soakage Test Location
- Test Pit Location
- Western Lots

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
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LOCALITY MAP



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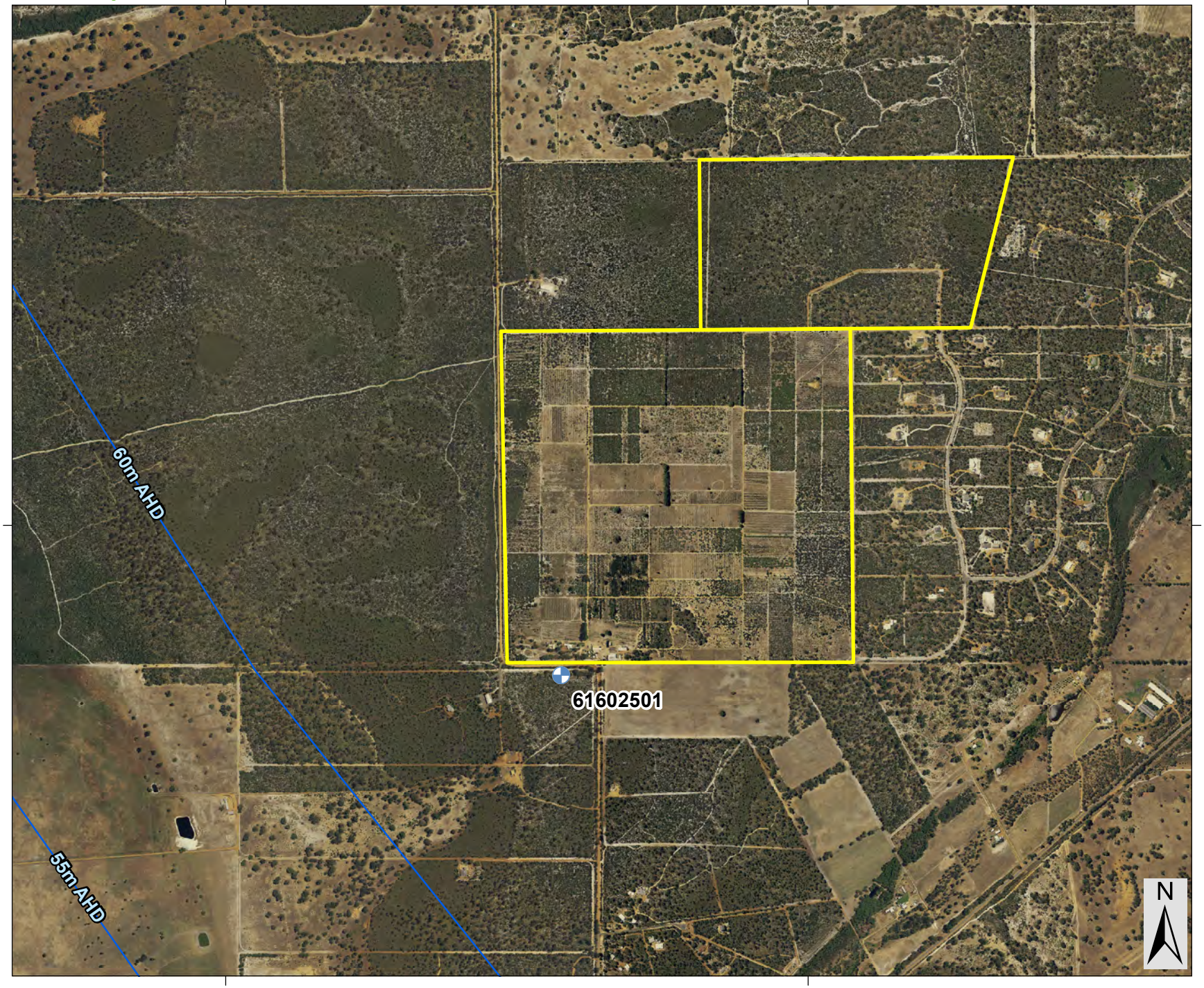
Local Water Management Strategy

Figure 5 -
Geology Information

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Attachment 1



Legend

- Site Location (195 ha)
- Groundwater Contour (Min)

Site Type

- Groundwater WIN Bore

NOTE:
The Groundwater contours shown in the map are the north eastern boundary of the groundwater mapping.

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
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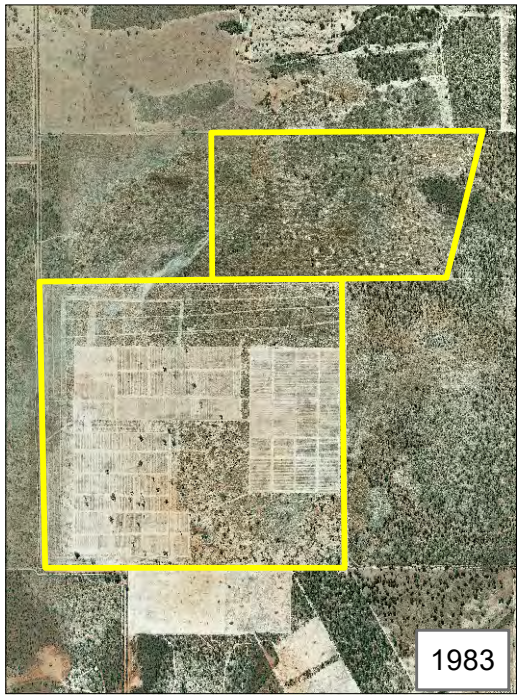
Local Water Management Strategy

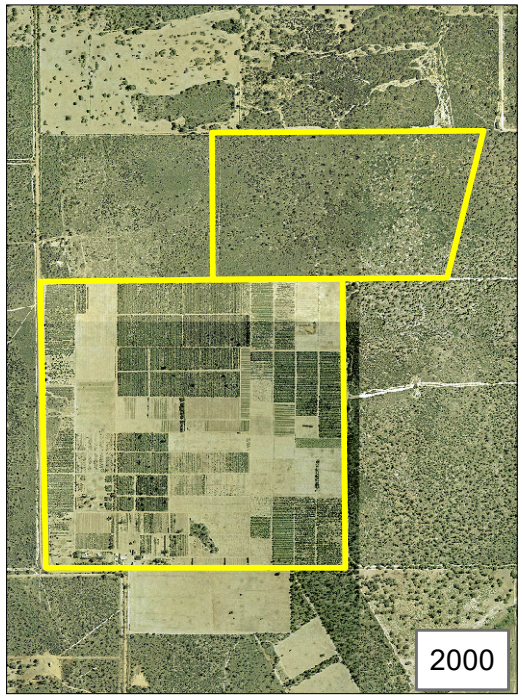
Figure 6 -
Groundwater Levels

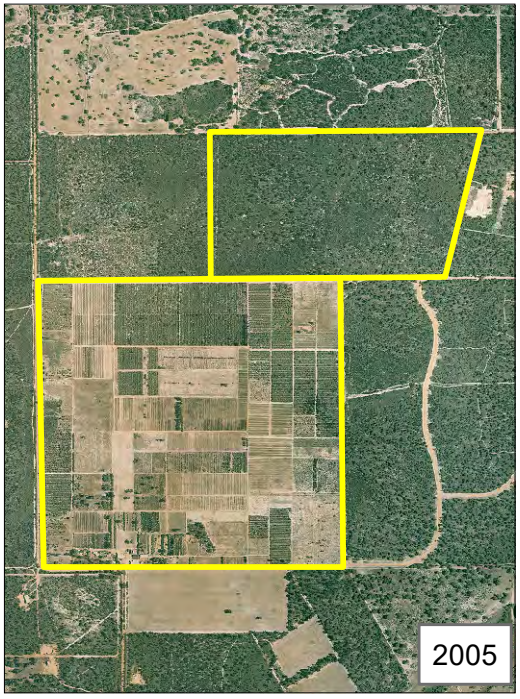
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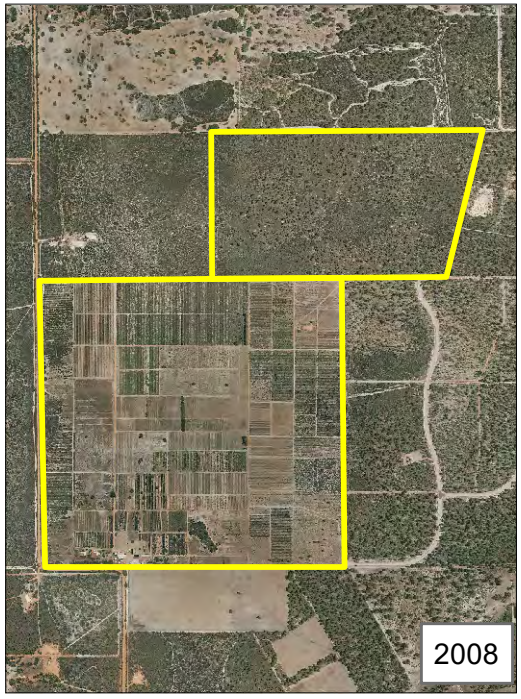
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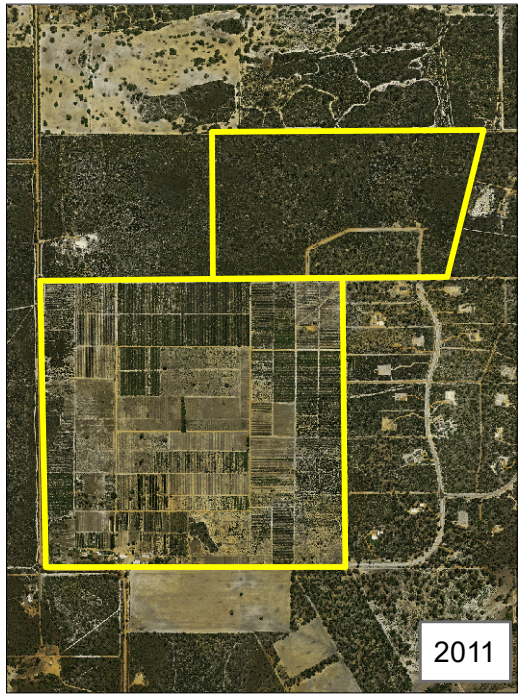










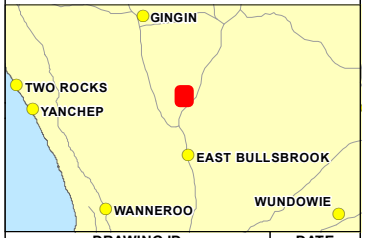


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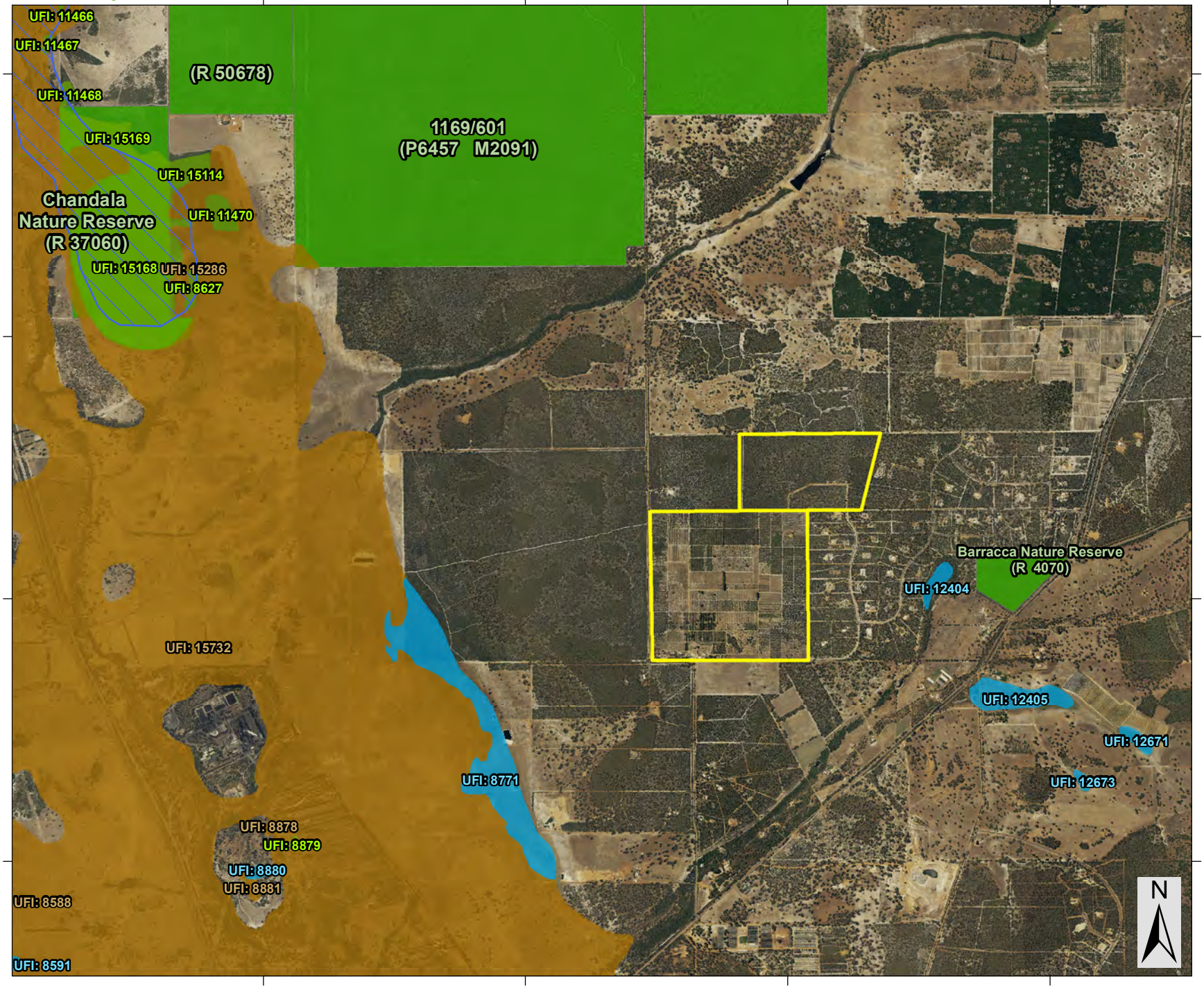
Local Water Management Strategy

Figure 7 - Historical Imagery

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Attachment 1



Legend

- Site Location (195 ha)
- Directory of Important Wetlands DIWA Australia
- DPaW Managed Lands

Geomorphic Wetlands

- Conservation
- Resource Enhancement
- Multiple Use

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
- CADASTRE SOURCED SLIP SERVICES JULY 2015
- DIWA SOURCED DOE 2008
- GEOMORPHIC WETLANDS SOURCED DPAW 2015
- DPAW MANAGED LANDS SOURCED DPAW 2015
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GDA 1994 MGA Zone 50

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Local Water Management Strategy

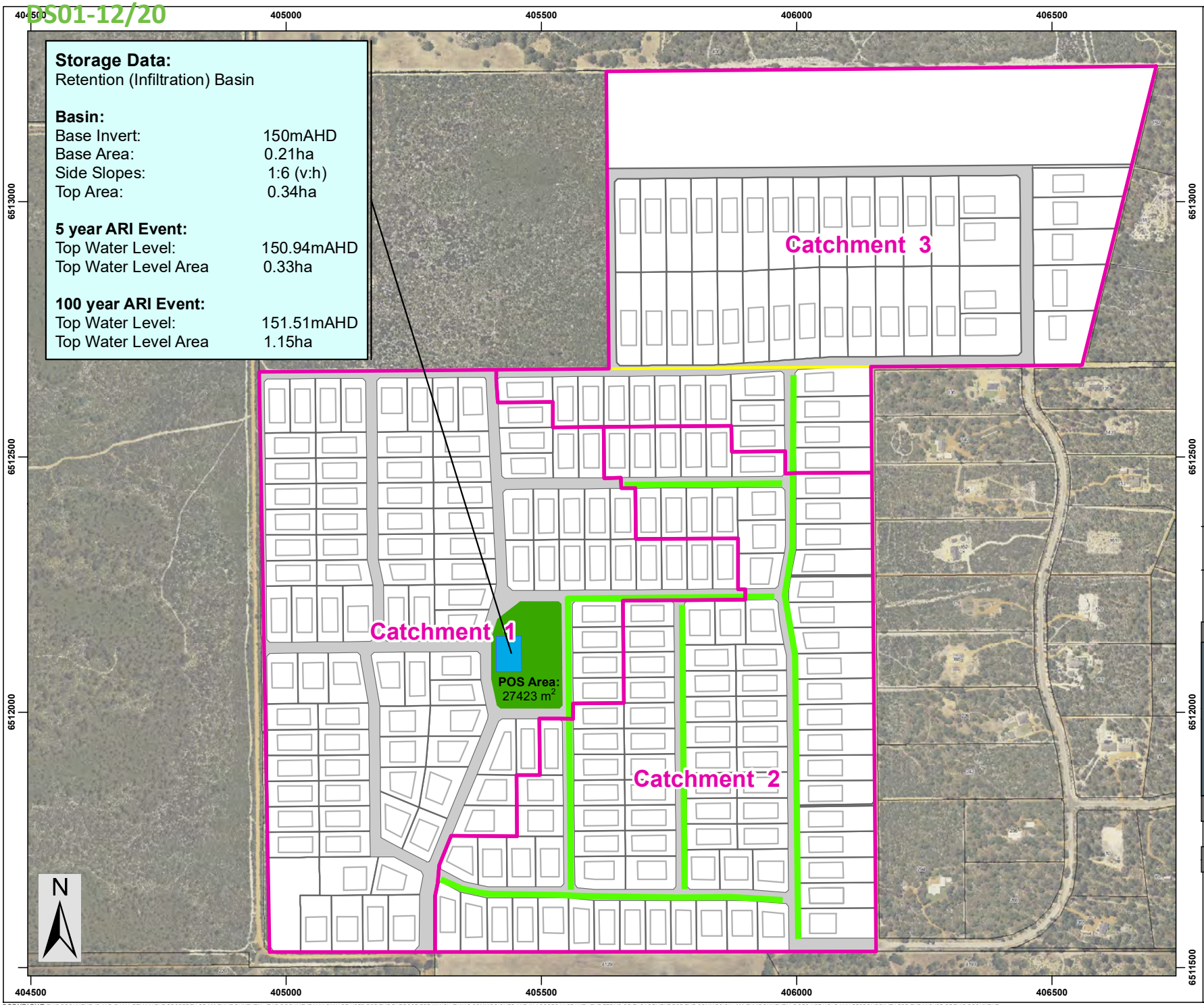
Figure 8 -
Regional Environmental Features

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PS01-12/20

Attachment 1



Legend

- Roadside Swales
- Site Location (195 ha)
- Proposed Catchments
- Infiltration Basin
- Lots
- Public Open Space
- Road

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
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- ELEVATION SOURCED GA 2008
- AERIAL PHOTOGRAPHY SOURCED LANDGATE FEB 2015 (© Western Australian Land Information Authority 2015)

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LOCALITY MAP



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HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

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Reserve Road, Chittering

Local Water Management Strategy

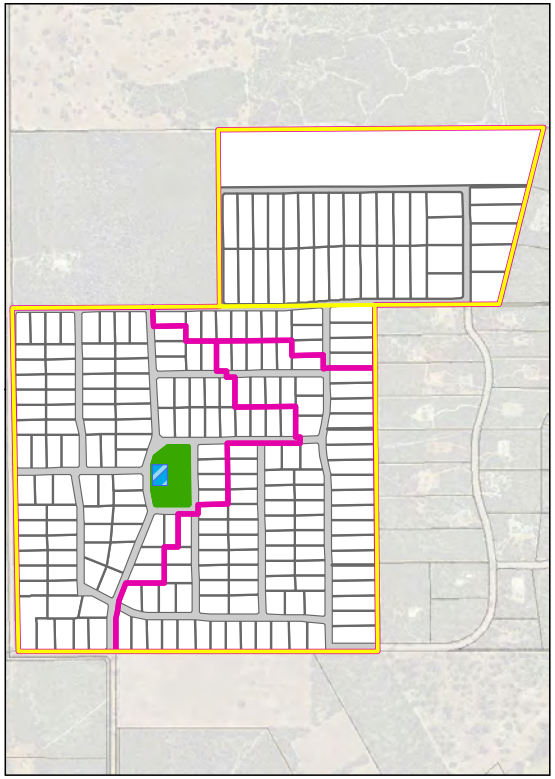
Figure 9 -
Conceptual Stormwater System

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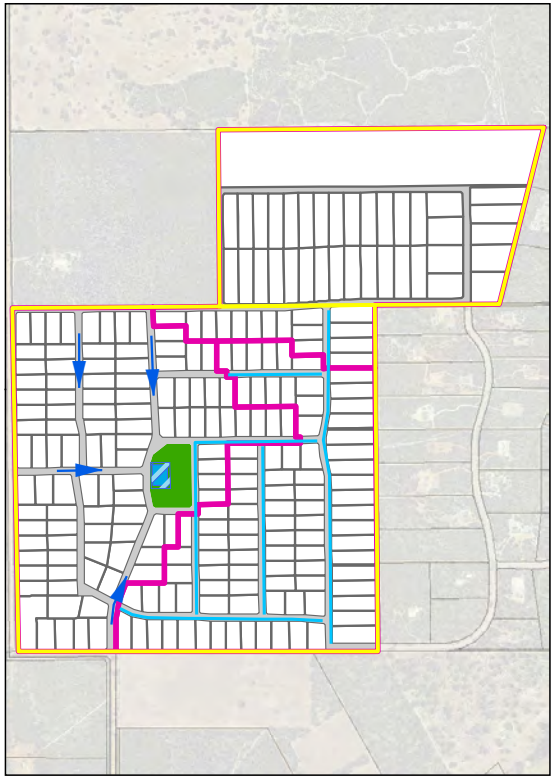
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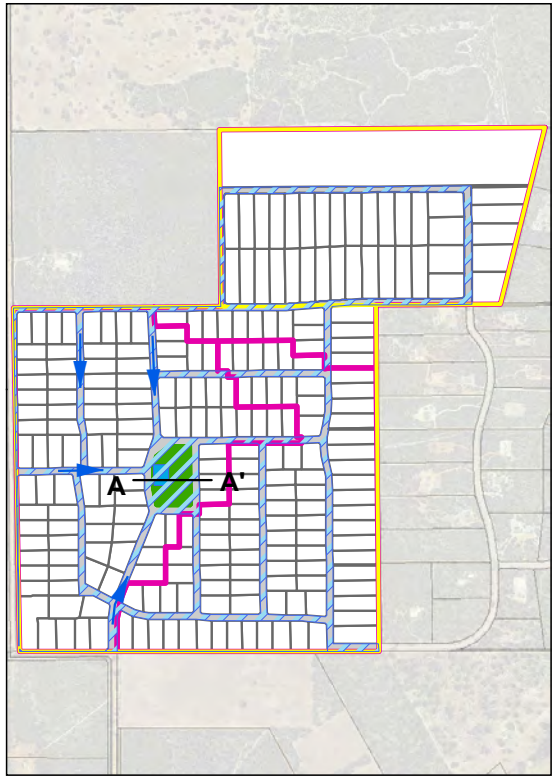
1 Year ARI Event Plan

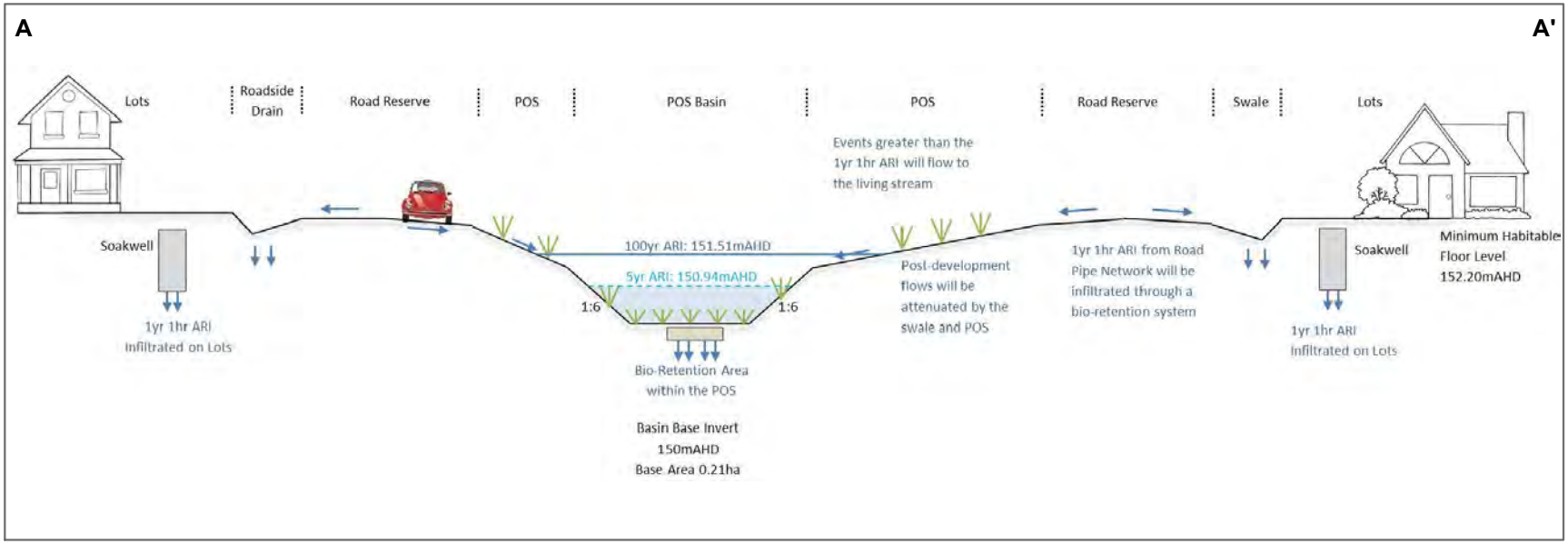


5 Year ARI Event Plan



100 Year ARI Event Plan





Attachment 1

Legend

- Flow Direction
- Site Location (195 ha)
- Inundation
- Infiltration Basin
- Lots
- Public Open Space
- Road

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
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LOCALITY MAP



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Local Water Management Strategy

Figure 10 -
Stormwater Event Plan

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APPENDIX A

Local Water Management Strategy Checklist, Better Urban Water Management (WAPC, 2008)

Local Water Management Strategy Item	Required Deliverable	Deliverable		☐	Comment
		LWMS Reference	Comment		
Executive Summary					
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements and requirements for BMP's and critical control points	Executive Summary	The executive summary is a table of the key points of the proposed Local Water Management Strategy	☑	
Introduction					
Total water cycle management – principles & objectives Planning background Previous Studies		Section 1.1, 1.2 and Table 1	A summary of the guiding documents and design principles are outlined. Specific objectives for the site are summarised in Table 1.	☑	
Proposed Development					
Structure plan, zoning and land use. Key landscape features Previous land Use	Site context plan Structure Plan	Section 2, App B, Figure 3, Figure 7	The proposed LSP is provided in Appendix C with lot, road and POS layouts shown in Figure 3. Historical aerial photos are presented in Figure 7.	☑ ☑	
Landscape- proposed POS areas, POS credits, water source, bore(s),	Landscape Plan	Section 2, Section 4, App B,	POS areas are described in Section 2 and App B, and	☑	

lake details (if applicable), irrigation areas.			water saving measures in Section 4.		
Design Criteria					
Agreed design objectives and source of objective		Section 1, Table 1	Site specific design objectives and criteria are summarised in Table 1.	☑	
Pre-development environment					
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		Section 3, Table 5	This is presented in Section 3, and key site considerations are summarised in Table 5	☑	
Site conditions – existing topography. Contours, aerial photo underlay, major physical features	Site condition plan	Section 3.2, Section 3.8.1, Figure 2	A pre-development aerial photo is shown in Figure 2. Existing land use is discussed in Section 3.8.1.	☑	
Geotechnical – topography, soils including acid sulphate soils and infiltration capacity, test pit locations	Geotechnical Plan	Section 3.4, Section 3.8.5, Figure 5	The geotechnical investigation is summarised in Section 3.4. ASS is discussed in Section 3.8.5.	☑	
Environmental – areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting data where appropriate	Section 3.8, Figure 8	Figure 8 demonstrates the wetland locations. Other environmental factors are discussed in Section 3.8	☑	
Surface Water – topography, 100 year floodway and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	Section 3.6	Section 3.6 described the surface water features.	☑	

Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus details of groundwater monitoring and testing	Section 3.5, Figure 6	Groundwater monitoring results are discussed in Section 3.5. Water levels are presented in Figure 6.	☑	
Water use sustainability initiatives					
Water efficiency measures – private and public open spaces including method of enforcement		Section 4.2	Section 4.2 outlines water conservation measures.	☑	
Water supply (fit-for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		Section 4.1	Water supply options are discussed in Section 4.1.	☑	
Wastewater management		Section 4.3	Section 4.3 provides the wastewater management strategy.	☑	
Stormwater management strategy					
Flood protection – peak flow rates, volumes and top water levels at control points, 100 year flow paths and 100 year detentions storage areas	100 year event Plan Long section of critical points	Section 5.1, Section 5.2.2, Figure 9, Figure 10, Table 6, Table 7	The management strategies for the 100yr ARI event are discussed in Section 5.2.2. Table 6, Table 7, Figures 9 and Figures 10 provide the control points and levels.	☑	
Manage serviceability – storage and retention for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	5yr event Plan	Section 5.1, Section 5.2.2, Figure 9, Figure 10, Table 7	The 5yr event plan is provided in Figure 10. Table 7 outlines volumes and levels. Section 5.2.2 discusses serviceability.	☑	

Protect ecology – detention areas for the 1 yr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1yr event Plan Typical cross sections	Section 5.1, Section 5.2.1, Section 5.4, Figure 9, Figure 10	Section 5.1 and 5.2.1 outline the stormwater management strategy for the 1yr ARI event. Measures to protect receiving environments are discussed in Section 5.4.	☑	
Groundwater management strategy					
Post development groundwater levels, fill requirements (including existing and likely final surface levels), outlet controls, and subsoils areas/exclusion zones	Groundwater/subsoil Plan	Section 5.3	Section 5.3 provides the management plans for groundwater.	☑	
Actions to address acid sulphate soils or contamination		Section 5.3,	The measures to mitigate ASS risk are provided in Section 5.3	☑	
The next stage – subdivision and urban water management plans					
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design		Section 6.1	The requirements for the UWMP are outlined in Section 6.1.	☑	
Monitoring					
Recommended future monitoring plan including timing, frequency, locations and parameters, together with		Section 6.3.2	post-development monitoring is discussed in Section 6.3.2.	☑	

arrangements for ongoing actions					
Implementation					
Developer Commitments		Section 6	The developer's commitments through subsequent phases of development are discussed in Section 6.	☑	
Roles, responsibilities, funding for implementation		Section 6.4, Table 8	Table 8 outlines the roles and responsibilities beyond the LWMS.	☑	
Review		Section 7	Opportunities for review are discussed in Section 6.	☑	

APPENDIX B

Lot 2 Reserve Road, Chittering and Surrounds Water Management Strategy (VDM, 2008a)

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LOT 2 RESERVE ROAD, CHITTERING AND SURROUNDS WATER MANAGEMENT STRATEGY

Date: 8th September 2008

Introduction

VDM Environmental have been commissioned by Riverside Investments (WA) No. 2 to undertake a water balance and conceptual water model for the proposed land development at Lot 2 Reserve Road, Chittering. The land development has an overall area of approximately 113 hectares, and is proposed to be subdivided into 110 1-hectare lots.

The site has two groundwater supplies; 288,800kl/annum supply from the Leederville-Parmelia aquifer and a 263,700kl/annum supply from the surficial aquifer. It is proposed that the Leederville-Parmelia aquifer be utilised as a domestic water supply for Lot 2 and surrounding development area.

Site Location

The site is located within the local government area of the Shire of Chittering, and is approximately 60 kilometres north of Perth along the Great Northern highway (refer Figure 1: Preliminary Draft Structure Plan). The site has been historically cleared for use as a wildflower farm.

Lot 2 has been used as a commercial wild flower farm with small pockets of original bushland still present. The southern-most portion adjacent to the subject site contains houses, stores, farming equipment and wild flowers.

Surrounding land uses include rural residential lots, rural retreat (native vegetation) and limited horticulture. The native vegetation of the subject site and surrounding area includes areas of dense scrub-heath and Banksia woodland, as well as scattered areas of coastal blackbutt. Plantation stands of Marri, Wandoo, and Red-gums are also evident.

Proposed development Summary

The proposed development is for approximately 100 lots, ranging in size between 500 square metres and 1 hectare. An area of approximately 2 hectares is set aside for Public Open Space. An area for a water supply system is located at the south-west corner of the subdivision.

Chittering Region

The Shire of Chittering is located on the northern boundary of the Perth Metropolitan Area and borders the City of Swan. The Northern and Eastern boundaries and shared with the Shires of Victoria Plains and Toodyay, respectively. To the southwest is the City of Wanneroo and northwest boundary borders the Shire of Gingin.

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The shire covers an area of approximately 1,220m^2, and includes the townships of Bindoon, Muchea and Wannamal (Refer Figure 2: Local Planning Strategy).

Widespread urban land use expansion is limited, due to the Gnangara Mound, Air Force Based and Julimar State Forest located around the shire.

Population Projections

The region has an approximate population of 3,320 (Shire of Chittering website, 2006) with the majority of the population between ages 40 and 59 (www.homepriceguide.com.au). As at 2001, the shire had no formal industrial or light industrial area.

Population projects are speculative and depend upon various elements such as employment, availability of developed land, and essential services (i.e. water supply, power, and telecommunications). The Australian Bureau of Statistics estimated the population growth of Chittering as tabulated below (Table 1).

Table 1. Estimated and Projected Population
(source: Australian Burea of Statistics & Department for Planning and Infrastructure 1999)

Year	Population No.	Change No.	Change %
1994	2289	-	-
1999	2594	305	13.3
2001 (Actual Data)	2755	161	3.1
2006	3500	745	5.4
2011	5000	1500	8.5
2016	8000	3000	12.5

Planning Information

The Shire of Chittering outlines a range of issues pertaining to regional growth in their local planning strategy (2001 to 2015). In respect to water supplies, the growth rate and future population of the shire is highly dependent on the local surface and groundwater supplies, quantity and quality. Pollution and unplanned use of these resources have the potential to limit its availability, thereby adversely impacting potential economic and population growth.

Currently, the whole of the shire forms part of the 'Swan River and Tributaries Catchment Surface Water Area' proclaimed under the Rights in Water and Irrigation Act (1914). This was gazetted on 3 October 1970.

The following points have been noted from the Shire of Chittering's Local Planning Strategy (2001 – 2015), with particular importance to the proposed development at Lot 2 Reserve Road:

- *Expanding Rural Residential developments in the Shire, more specifically the southern and eastern parts, place additional demands on the ground water for secondary domestic and fire fighting purposes. Existing and planned Rural Residential developments in the area could benefit from a planned/coordinated water supply system.*

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- *Similarly, the Shire's horticultural and agricultural industry could continue to expand, particularly in the Chittering Valley area, if a planned water supply system is introduced in the area.*

- *The council will encourage cooperation between relevant service agencies and private operators towards:*

  - *The development of policy and provision of infrastructure;*
  - *The utilisation of the available water resources in a sustainable manner; and*
  - *The distribution of potable and non-potable water supplies to the local community.*

- *The Water Corporation is proposing to provide a reticulated water scheme to all rural residential areas in the southern part of the shire.*

- *Any reticulation system for horticultural purposes should also utilise surface catchment and wherever possible 'grey water', to make use of this valuable and scarce resource.*

Regional Aquifer Information

Based on geology and geomorphology, the Brockman River Catchment can be divided into four distinct ground water zones (WRC, SLUI2, 2002):

- West of the Darling Fault, the sediments of the Dandaragan Plateau form part of a regional aquifer.
- East of the Darling Fault the crystalline rocks of the Darling Plateau can be subdivided into two fractured-rock ground water zones. Fractured-rock aquifer Zone A is roughly coincidental with the Chittering Metamorphic Belt and the minor valley systems. East of this zone is fractured-rock aquifer Zone B, on the lateritic uplands.
- Traversing both the Dandaragan Plateau and Darling Plateau are alluvial and colluvial deposits that contain the surficial aquifers.

Local Aquifers:

The area is underlain by two aquifers (from surface):

- The Mirrabooka Aquifer (generally a confined or artesian aquifer) at the surface. At Lot 2 this aquifer is unconfined: *the surficial aquifer.*
- The Leederville Aquifer underlies the Mirrabooka Aquifer at depth and is confined or artesian: *the artesian aquifer.*

Both aquifers comprise sand and sandstone formations with the confining layers comprising inter-bedded shales and siltstones (discontinuous in some places) i.e. the Kardinya Shale separates the Mirrabooka Aquifer from the underlying confined Leederville Aquifer. The Mirrabooka aquifer receives recharge by direct precipitation (a gently undulating landscape blanketed by duricrusts and gravels on crests and grey

sands in broad shallow depressions) and consequently water quality is generally good. The Leederville Aquifer receives direct recharge elsewhere (where deep valleys incised to expose the aquifer enabling infiltration from stream flow; recharge estimated at 14,300m^3/d, Bulletin 142) but locally recharge comprises leakage from the overlying Mirrabooka Aquifer.

The following information, gleaned from the Perth Groundwater Atlas (2nd Edition, 2004) and Bulletin 142 *Hydrogeology and Groundwater Resources of the Perth Region, WA* (Davidson, 1995), is pertinent to an assessment of the local aquifers pertaining to both water supplies and ground water quality.

- Surficial: Mirrabooka Aquifer, unconfined and multi-layered, between ground level (between 140 and 165mAHD) to 110 mbgl (30mAHD) below surface. Ground water contains excellent salinity, expressed in concentrations of Total Dissolved Solids (TDS), of 350mg/L (fresh). Depth to ground water level is unknown. Ground water is expected to drain in a south-easterly direction and then in a south-westerly direction towards the Swan River where it may discharge as stream base flow. The permeability, k, and transmissivity, T (the product of permeability and saturated aquifer thickness, b), of the aquifer is expected to be high.
- Artesian: Leederville Aquifer, confined and multi-layered, between 110 mbgl (30mAHD) and 420mbgl (-500mAHD). Ground water contains excellent salinity, expressed in concentrations of Total Dissolved Solids (TDS), of between 250mg/L and 350mg/L (fresh). Depth to ground water level in 1981 was 86.7mAHD (elevation of borehole and depth to ground water level are not recorded on DoE data files); currently the ground water level is at 53.8mAHD (surface elevation assumed at 165mAHD and ground water level 111.2mbgl). Ground water is expected to drain in a westerly direction towards the coast where it may discharge offshore into the ocean as base flow. The permeability, k, and transmissivity, T (the product of permeability and saturated aquifer thickness, b), of the aquifer is expected to be high. The aquifer is estimated to store 120 million m^3 in total with elastic or confined storage of about 20 million m^3.

Aquifer Vulnerability

The unconsolidated sandy aquifers are vulnerable to ground water contamination due their high permeability and poor attenuation characteristics. However, since the ground water level is deeper than 30m below surface and in the presence of thick shale units (>30m) having a low permeability, the area may be regarded as having a very low vulnerability to contamination from agricultural, industrial and urban activities.

The site is regarded as having a moderately high risk with regard to on-site effluent disposal (the risk of degradation of land can be overcome with careful planning however) and no risk with regard to salinity due to the large permeability of the sandy soils that facilitate rapid drainage.

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Recharge

Infiltration of rainfall results in recharging of the ground water regime. All recharge contribute to aquifer throughflow (Bulletin 142). The area has a Mediterranean climate and receives some 800mm per annum (90% between April and October). Potential annual evaporation is 1,800mm (exceeded by rain between May and August). Recharge, as a percentage of the mean annual precipitation (MAP = 800mm), has been estimated (Bulletin 142) as:

- Between 7.3% and 8.5% to between 13% (tritium dating) and 22% (chloride balancing).
- Between 36% and 40% across areas with where market gardens exist.
- Between 15% and 20% net which equates to some 118mm/a or 161,259m^3/a across Lot 2.

Groundwater License Information

At the time of purchase of Lot 2, the site had 2 groundwater licences; one licence for the Parmelia-Leederville, with a second licence for the Surficial aquifer. During the development process, it was fond that no surificial bores were located on the subject site. The Department of Water has provided an Exploratory Licence (CAW No. 163070 (1)) for the surficial aquifer for 273,600 kl/annum. The site has a current groundwater licence for the Perth-Leederville-Parmelia aquifer for an annual volume of 288,800kl. This is documented in Table 2.

Table 2. Details of Water Licence

Licence No.	***GWL 59907 (2)***		
Licensee(s)	**Riverside Investments (WA) Pty Ltd**		
Description of Water Source	Gingin Perth-Leederville-Parmelia	Annual Water Entitlement	288800 kl
Location of Water Source	Lot 2 on Diagram 52612 – Volume/Folio 1481/704 – Lot 2 Reserve Road, Chittering		
Authorised Activities	Taking of Water for	Location of Activity	
	Household Purposes	Lot 2 on Diagram 52612 – Volume/Folio 1481/704 – Lot 2 Reserve Road, Chittering	
	Irrigation of 0.1 hectares of lawns and gardens		
	Irrigation of 2 ha of pasture		
	Irrigation of 30.3 ha of native plants		
	Water use for ostriches		
Duration of License	From 25 March 2007 to 25 March 2017		

Ground Water Protection and Beneficial Use

Lot 2 Reserve Road is not located within the Swan Coastal Plain Underground Water Pollution Control Area (UWPCA) and Public Water Supply Area (PWSA) controlled by

the Department of Environment i.e. a Priority 3 public water supply ground water catchment area declared over land where water supply must co-exist with other land uses. Boreholes for domestic use and irrigation are subject to licensing.

Beneficial use of ground water in the area includes abstraction for domestic and agricultural (irrigation) water supplies from the superficial and confined aquifers.

There is one existing borehole (2004-0940) within a 1km radius from Lot 2 but several within a 2km radius from the site, particularly to the south and south-east. Most of these penetrate the superficial Mirrabooka Aquifer only.

Borehole Testing

Discharge testing (refer Appendix A: Borehole Test Data) of existing Borehole 20025333 (Leederville Artesian Aquifer) indicated that this borehole, in its current condition with the existing equipment, is capable of delivering **4.0 l/s for at least 12 hours per day**. It has been reported by K.S. Black (WA) Pty Ltd that the condition of both the borehole and equipment are unsatisfactory and that the borehole should be capable of yielding at least 11.0 l/s (estimate based on existing equipment and infrastructure). The volume of water that can be delivered by existing infrastructure is thus estimated at:

- Minimum (4.0L/s) 172.8kL/12hr-d i.e. 63,072kL/a or 22% of the licensed allocation of the artesian aquifer;
- Maximum (11.0L/s) 475.2kL/d i.e. 173,448kL/a or 60% of the licensed allocation of the artesian aquifer provided extensive replacement of existing equipment and rehabilitation of the borehole screen is undertaken.

To abstract the full licensed entitlements from both aquifers, boreholes capable of yielding:

- **Mirrabooka Surficial Aquifer: 17.4L/s for 12 hr-day**
- **Leederville Artesian Aquifer: 18.3L/s for 12 hr-day**

will be required.

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Expected Water Usage

Water usage values are based on the *Water Corporation's Alternative Supply Water Use Model (2007)* (refer Table 3).

Table 3. Demand Management Application
(source: Water Corporation's Alternative Supply Water Use Model, 2007)

Household Use	Estimate	Units	Source	Water Use
Garden Irrigation*	0.002	kL/m^2/day	Water Corporation	Irrigation
Shower	0.050	kL/person/day	Diversity Australia	Drinking Water
Kitchen Sink	0.008	kL/person/day	Diversity Australia	Drinking Water
Bathroom Basin	0.006	kL/person/day	Diversity Australia	Drinking Water
Dishwasher	0.003	kL/person/day	Diversity Australia	Drinking Water
Bath	0.001	kL/person/day	Diversity Australia	Drinking Water
Laundry Trough	0.004	kL/person/day	Diversity Australia	Drinking Water
Leaks	0.029	kL/household/day	Diversity Australia	Drinking Water
Pool	0.020	kL/household/day	Diversity Australia	Drinking Water
Spa	0.002	kL/household/day	Diversity Australia	Drinking Water
Car Washing	0.002	kL/household/day	Diversity Australia	Drinking Water
Evaporative cooling	0.006	kL/household/day	Diversity Australia	Drinking Water
Other	0.004	kL/household/day	Diversity Australia	Drinking Water
Toilet	0.033	kL/person/day	Diversity Australia	Non-Drinking Water
Washing Machine	0.042	kL/person/day	Diversity Australia	Non-Drinking Water

*-based on 10mm x 9 applications x 8 months/365.25 days

Borehole Water Quality

Bacteriological testing by PathWest Laboratory WA indicated water from artesian Borehole 20025333 does not have total coliform, *Faecal* (Thermotolerant) Coliforms and/or *Escherichia coli* bacteria.

Hydrochemical analysis by SGS on samples of water was obtained at the start and close (after 9 hours) of the constant-rate discharge test (refer Appendix B).

The samples were free of sediment, turbidity, odour and colour.

From the borehole data it is evident that the artesian aquifer contains ground water of an excellent quality albeit slightly acidic. Future selections for equipment and fittings have to take due cognisance of the acidity of ground water and the concentrations of the metals iron and manganese. Most analytes are well below their respective drinking water quality criteria except for large concentrations of iron and manganese.

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Table 4. Water Quality Information from bore 20025333

Item	Units	Sample 1	Sample 2	ADWG Guidelines	Notes
pH	pH units	7	6.8	**6.5-8.5**	
Conductivity @ 25oC	Us/cm2	560	550		
Total Dissolved Solids (calculated at NaCl)	mg/L	360	350	**500**	
Sodium, Na	mg/L	69	68	**180**	
Potassium, K	mg/L	7.6	7.6		
Calcium, Ca	mg/L	7.7	7.9		
Magnesium, Mg	mg/L	5.4	5.3		
Hardness (as CaCO3)	mg/L	41	42	**200**	
Iron, Fe (soluble)	mg/L	6	6.3	**0.3**	
Chloride, Cl	mg/L	120	120	**250**	
Bicarbonate, HCO3	mg/L	40	40		
Sulphate	mg/L	14	14	**250**	
Nitrate, NO3	mg/L	<0.2	<0.2		
Flouride, F	mg/L	0.3	0.3	**1.5**	
Free cyanide	mg/L	<0.01	<0.01	**0.08**	
Aluminium, Al	mg/L	0.1	0.1	**0.2**	
Arsenic, As	mg/L	<0.001	<0.001	**0.007**	
Manganese, Mn	mg/L	0.1	0.1	**0.1**	
Lead, Pb	mg/L	<0.005	<0.005	**0.002**	
Cadmium, Cd	mg/L	<0.001	<0.001	**0.002**	
Feacal Thermotolerant Coliforms	CFU/100ml	0	0	**0**	
Total Colifroms	CFU/100ml	0	0	**0**	

Water Supply Assessment

Western Australian Planning Commission (WAPC) Planning Advice 18195 dated 8 September 2005 provided the following planning advice pertaining to water supplies:

- The site is zoned Rural Residential under the Shire of Chittering Town Planning Scheme No. 6 with the northern portion (most, if not all, of the 101.66ha, Portion A, acquired by Riverside Investments WA Pty Ltd, RI) of Lot 2 incorporated in a vegetation protection area. Town Planning Scheme No. 6 specifies that:

  A minimum lot size less than 40,000m^2 without a reticulated water supply is unlikely to be supported because of the requirements of the WAPC Statement of Planning Policy 2.5.

- Under the Rural Residential zoning, the following development requirements pertaining to water resources, apply:

  - Submission of a subdivision application including a development plan containing catchment management recommendations, the listing of any facilities that purchasers of the sub-divided land are required to provide e.g.

potable water supplies, waste disposal, etc., areas where septic tanks can be provided and location of any water courses.

- All residential buildings must include the provision for the storage of water in tanks not less than 120,000 litres in capacity. However, in consultation with the Shire of Chittering, a more desirable size of 50,000 litres has been proposed.
- The construction of dams or extraction of any surface water is not permitted without approval by the Waters and Rivers Commission.
- Appropriate effluent disposal is to be installed to the satisfaction of the Shire and Health Department.
- Clause 5.3.2 of the Statement of Planning Policy 2.5 states that residential lot sizes are to range from 10,000m2 to 40,000m2 depending on local conditions and the mandatory provision of reticulated potable water supply to an appropriate standard.

It seems thus that if a potable water supply is available (see Licences of Waters and Rivers Pertaining the assessment of reticulated water supplies to lots 10,000m^2 in size, the current criteria for regulated water supplies (in terms of the Operating Licence of the Water Corporation) are:

- Plan and design all long-term sources, treatment plants, disinfection systems and distribution/reticulation systems to deliver THM concentrations of less than 100 µg/L (Note: Australian Drinking Water Guideline is 250 µg/L)
- Plan and design systems to supply a maximum flow rate of 4kL/day to each property with a flow rate control device on each service connection to limit the maximum flow to 2.8L/min. Pressure (head) at the service connection should not be lower than 15m for 3 hrs/day and no lower than 2m at any time.
- All customers are to provide their own storage facility to store at least two peak days' water needs.
- Health related quality criteria are subject to negotiation between the Corporation, any land developer and the customer. No criteria are applicable to aesthetic quality. Only chemicals approved by the Department of Health may be added to drinking water. Only materials which comply with AS 4020 or which have been approved by the Department of Health may contact drinking water.

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Proposed Water Management Strategy

The proposed development of Lot 2 Reserve Road in Chittering will require an adequate and reliable supply of potable water to the individual lots throughout the subdivision. To be taken into consideration is the water balance of the water usage as well the necessary treatment measures for the potable water and wastewater effluent.

Lot 2 has a total water entitlement (licences to abstract ground water) of 288,800kL/a, with an exploratory licence currently in place for an additional 273,600kl/annum. Two boreholes in the south-western corner of the property penetrate the Perth-Leederville-Parmelia aquifer. Surficial water from the development is recharged through ground infiltration of rainfall, which is captured within the encompassing Brockman Catchment area, a sub-catchment of the larger Avon River Catchment.

The proposed water supply for the development is as follows:

Water Source	Treatment / Storage / Conveyance	Proposed Use
PRIMARY POTABLE SUPPLY Artesian Aquifer (Perth-Leederville-Parmelia Aquifer)	Treatment for Iron and Manganese Disinfection through chlorine/UV Storage at centralised tank, with pressure package for distribution Conveyance through reticulated water supply	Internal drinking water supplies including: • Bathrooms • Kitchen • Fire Fighting
SECONDARY POTABLE SUPPLY: Surficial Aquifer (Mirrabooka)	Separate bores on each lot based on landscaping water requirements. Lots to be installed at householders cost. Caveat of title to ensure minimal landscaping outside house-pad area.	• Landscaping
EFFLUENT DISPOSAL: Effluent from households	Treatment through a HDWA approved aerobic treatment system Disposal to a sub-surface irrigation system for landscaping	• Landscaping uses
RAINWATER: Collection off roof areas	Storage at tanks located at each lot, preferably below ground or designed into house structure Potential to be integrated into secondary potable supply	Non-drinking sources, including: • Toilets • Washing Machine • Landscaping

Based on the proposed water usage above, and the allocation rates provided in Table 2, the following expected water usage rates are proposed (based on **·2.790 persons per lot,** 2001 ABS Census):

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Table 5. Annual Water Usage for Lot 2 Reserve Road, Chittering

	Option 1 – water usage with no demand management (no rainwater tanks)		Option 2 – water usage with demand management + rainwater tanks		Option 3 - Water usage no demand management[1]	
	Per person usage	Total Household Usage	Per person usage	Total Household Usage	Per person usage	Total Household Usage
	kL/person/ annum	kL/household/ annum	kL/person / annum	kL/household/ annum	kL/person / annum	kL/household/ annum
In-house – Primary Potable Supply	61.89	172.68	34.52	96.30	56.58	201.48
In-house – non-potable Supply	0	0	27.38	76.38	0	0
Expected Effluent Production (for landscaping)	54.16	151.11	54.16	151.11	56.58	190.90
Additional Water for Landscaping[2]	259.82	724.89	259.82	724.89	38.33[3]	106.95

NOTES:
[1] – Based on values provided by the *Domestic Water Use Study In Perth, Western Australia (1998- 2001)*, Water Corporation
[2] - From groundwater bores in surficial aquifer. Bores will be installed by the householder dependent on expected water usage requirements. These values are based on a water utilisation in the house pad area only, with an impervious area of 40%.
[3] – Value based on household average less cottage value of persons (2.79 persons per house).

It can be seen from the above that the water requirements are reasonable in comparison to the water availability. Effluent production was based on all in-house water usage passing through an effluent treatment facility. Additional water for landscaping was based on the expected landscaping water use rates from Table 3, less effluent production. Note that the values provided are worst-case situations (i.e. total irrigation of remaining lot area). Therefore, additional water for landscaping can be reduced (and in some cases removed) through suitable water-wise planting of landscaped areas.

Figure 3 illustrates a generalised schematic of the water supply and re-use models for individual lots within the proposed development.

Expected Total Lots

A preliminary estimate of the total number of lots from the water supply was estimated for the available water supply. These values are shown in Table 6 below.

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Table 6. Expected total lots from Water supply at Lot 2 Reserve Road, Chittering

Water Supply Option	Water Usage Rate (kl/household/day)	Water Usage Rate (kl/household/year)	Number of lots serviced, Demand management No. Lots (No. Persons)[1]
Option 1 – water usage with no demand management (no rainwater tanks)	**0.473**	**172.68**	**1,334 (3,722)**
Option 2 – water usage with demand management + rainwater tanks	**0.264**	**96.30**	**2,392 (6,675)**
Option 3 - Water usage no demand management	**0.552**	**201.48**	**1,144 (3,190)**

[1] – at 1-hectare lots

Appendix C provides general layouts of the water service areas based on the three options provided in Table 6.

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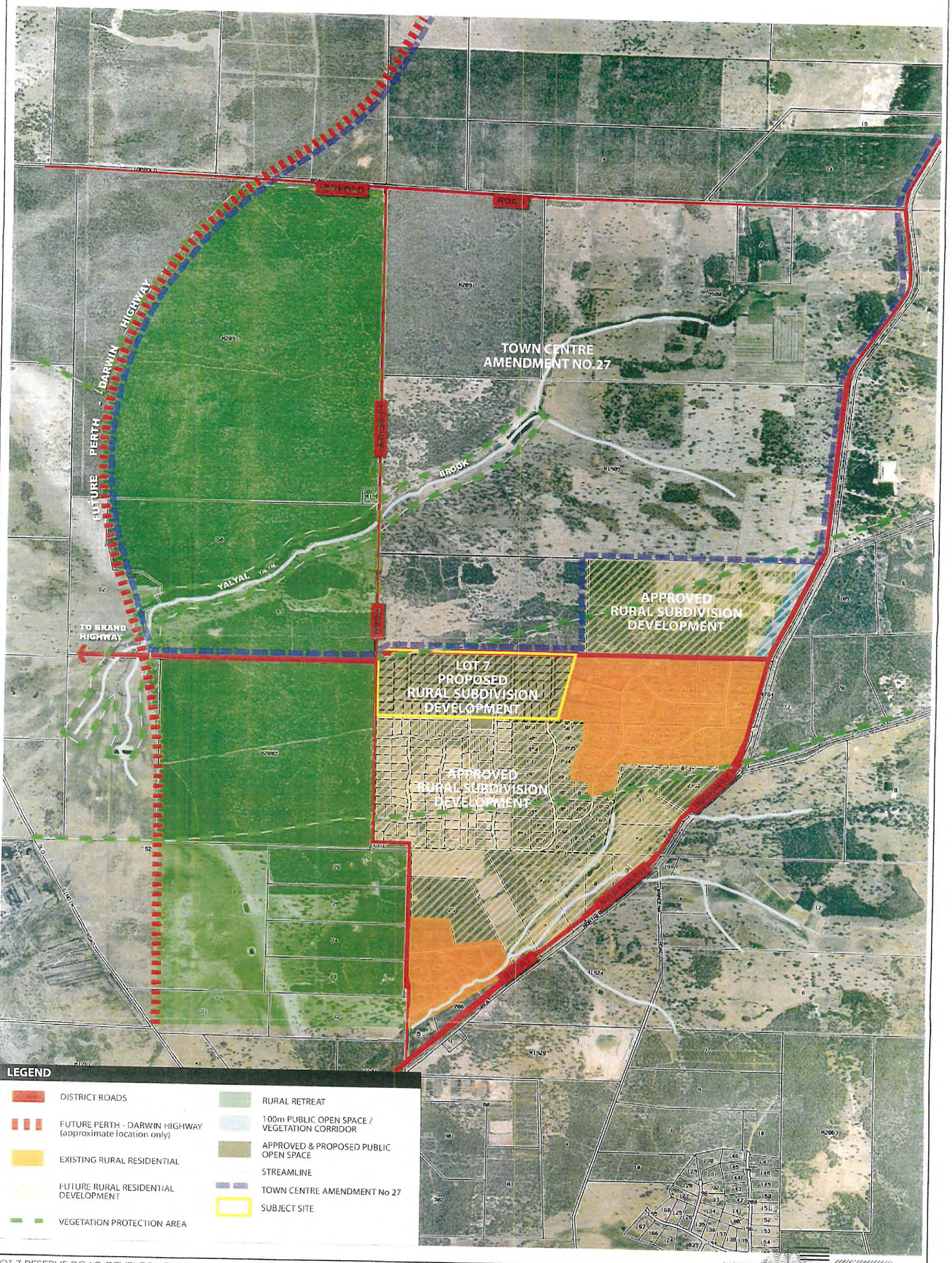
Rhys Houlihan
Senior Environmental Engineer

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FIGURES

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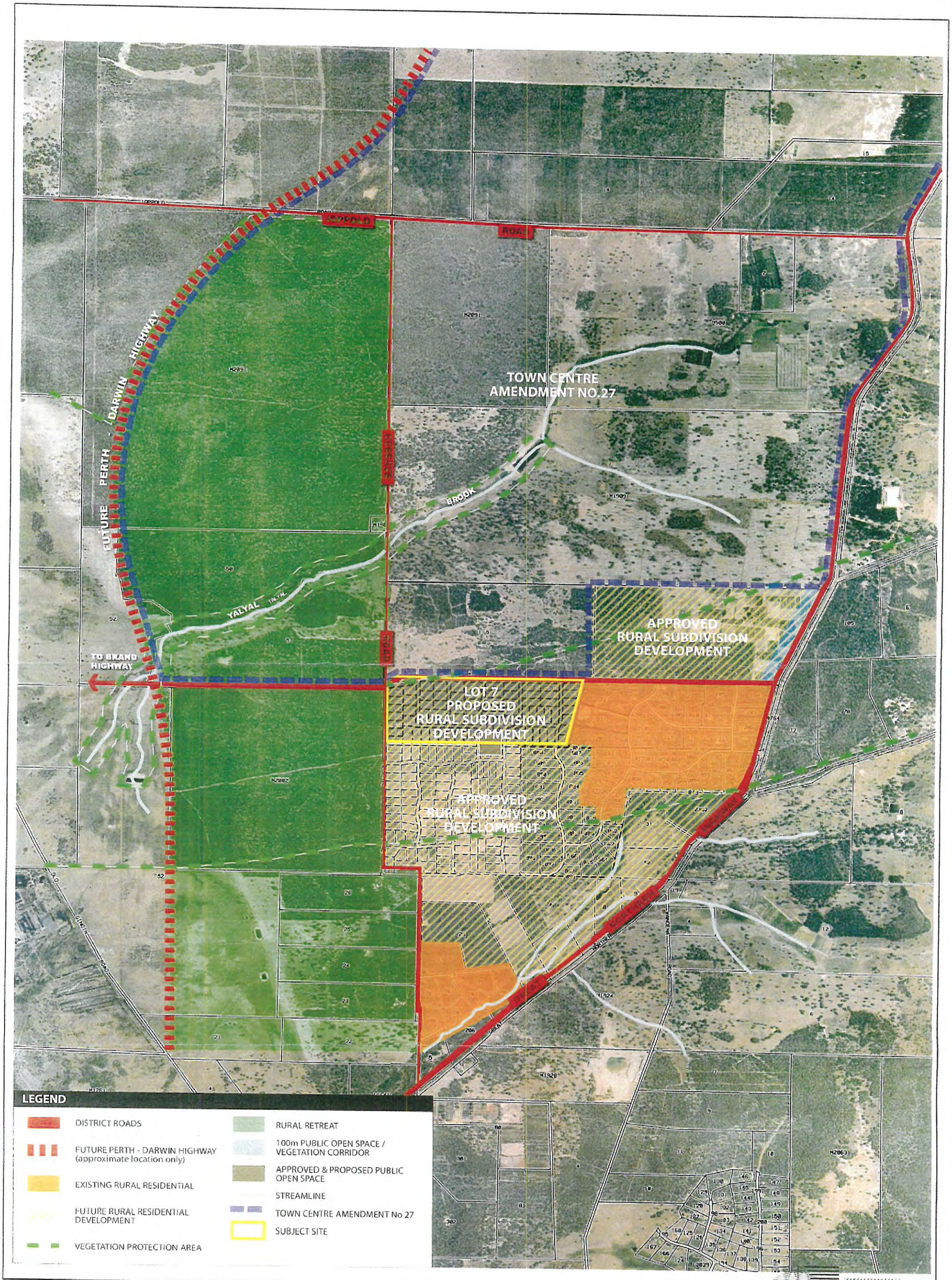


LOT 7 RESERVE ROAD DEVELOPMENT PLAN, CHITTERING

Preliminary Draft District Structure Plan

DATE Jan 2009 | JOB NUMBER 07/066 | 1

TAYLOR BURRELL BARNETT
Town Planning and Design



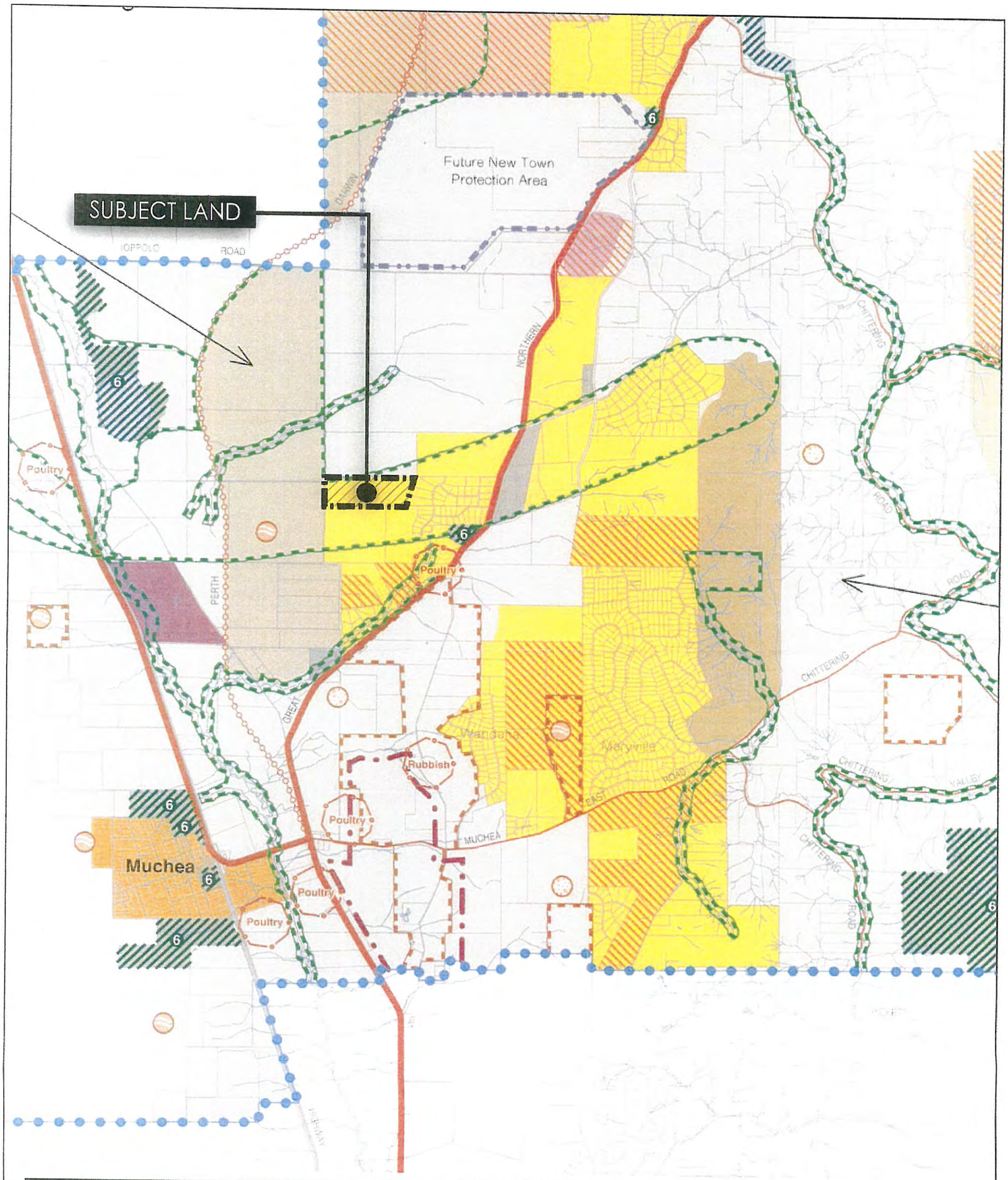
LOT 7 RESERVE ROAD DEVELOPMENT PLAN, CHITTERING

Preliminary Draft District Structure Plan

DATE Jan 2008 JOB NUMBER 07/066

1

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Town Planning and Design



Legend

LOT 7 RESERVE ROAD DEVELOPMENT PLAN, CHITTERING

Local Planning Strategy

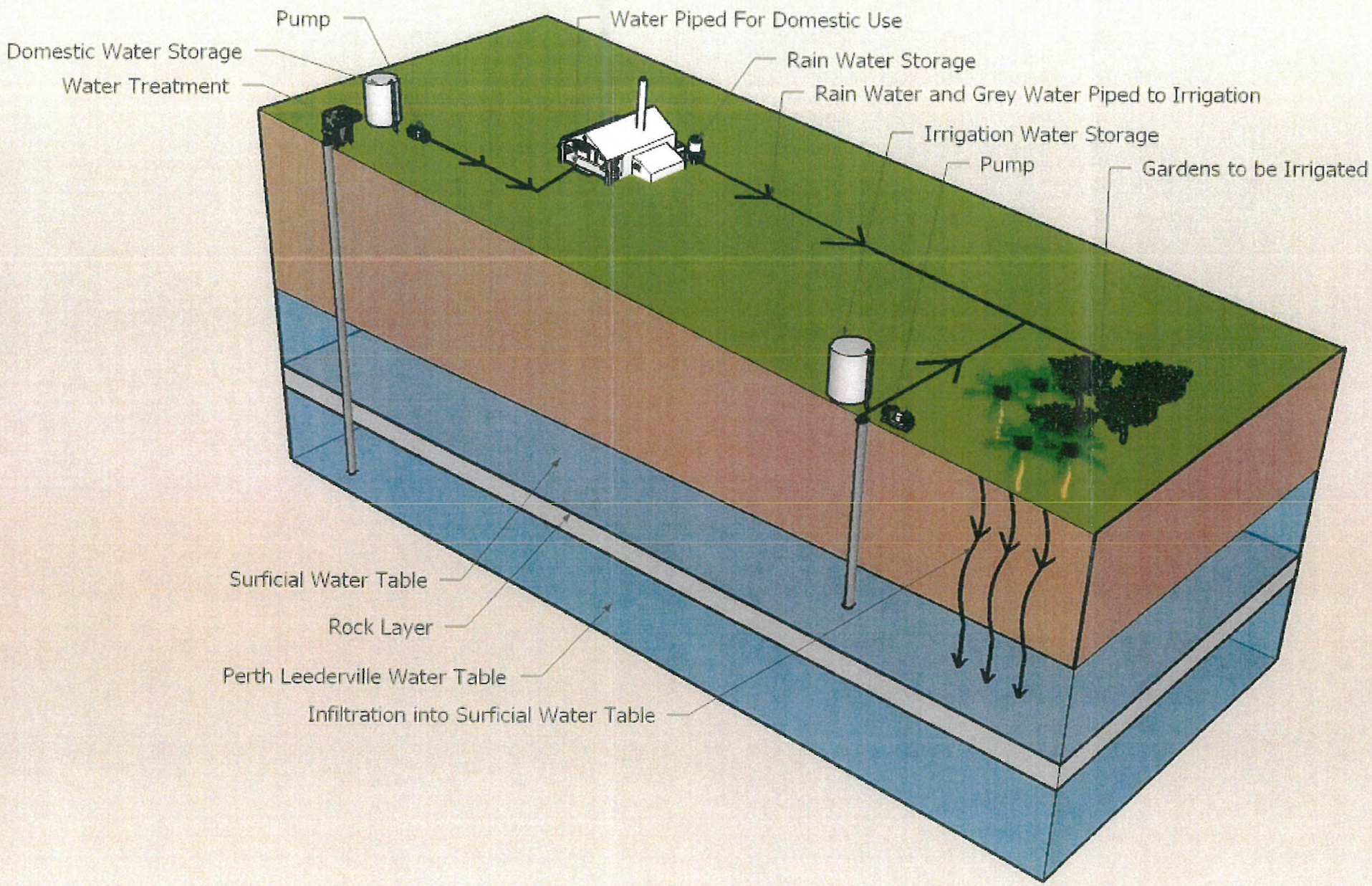
DATE Jan 2008 JOB NUMBER 07/066

0.5km 0km 0.5 1 1.5km

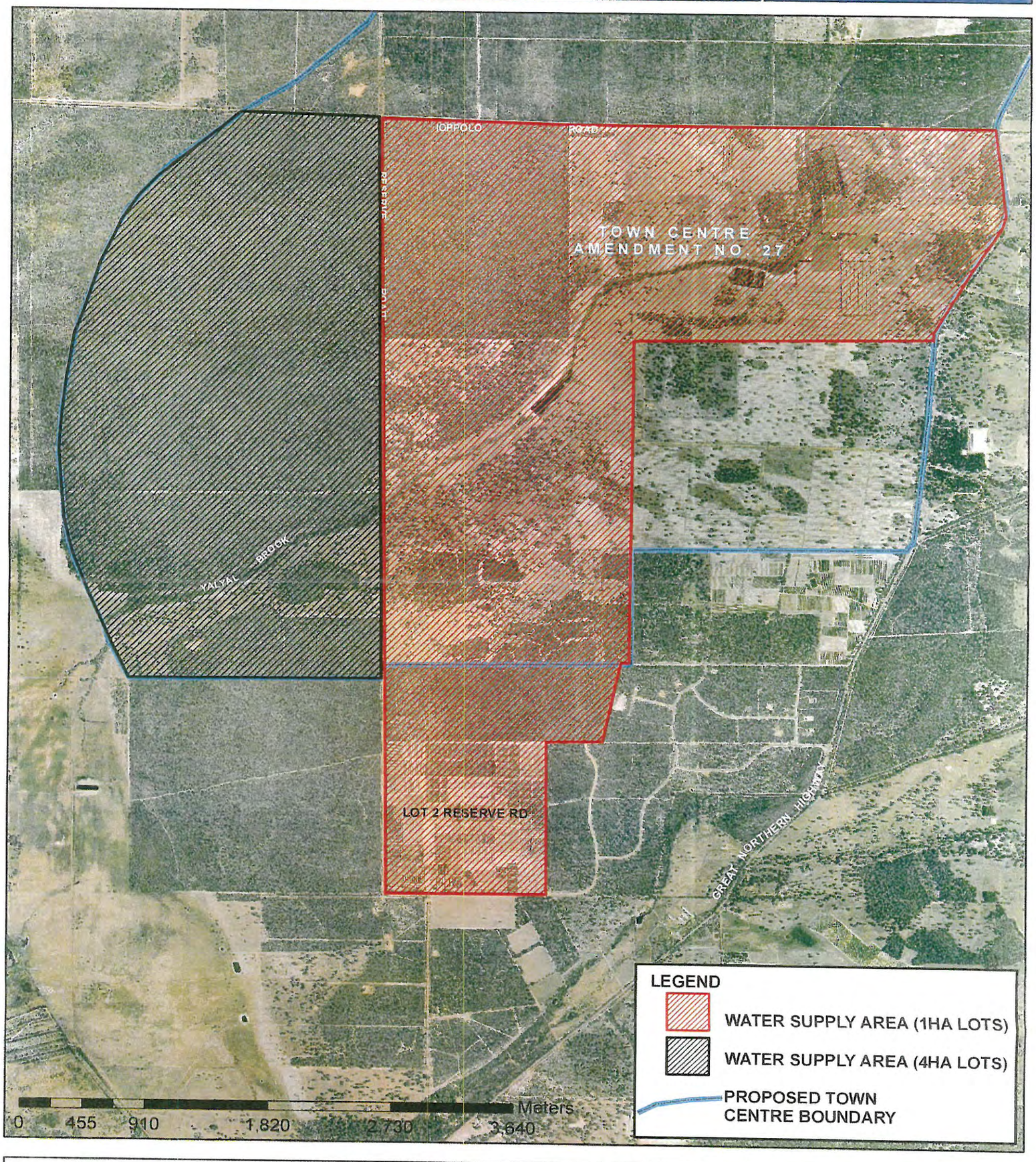
2.

TAYLOR BURRELL BARNETT
Town Planning and Design

FIGURE 3.


Pump
Domestic Water Storage
Water Treatment
Water Piped For Domestic Use
Rain Water Storage
Rain Water and Grey Water Piped to Irrigation
Irrigation Water Storage
Pump
Gardens to be Irrigated
Surficial Water Table
Rock Layer
Perth Leederville Water Table
Infiltration into Surficial Water Table

WATER SUPPLY AREA - OPTION 1
(NO RAINWATER TANKS)



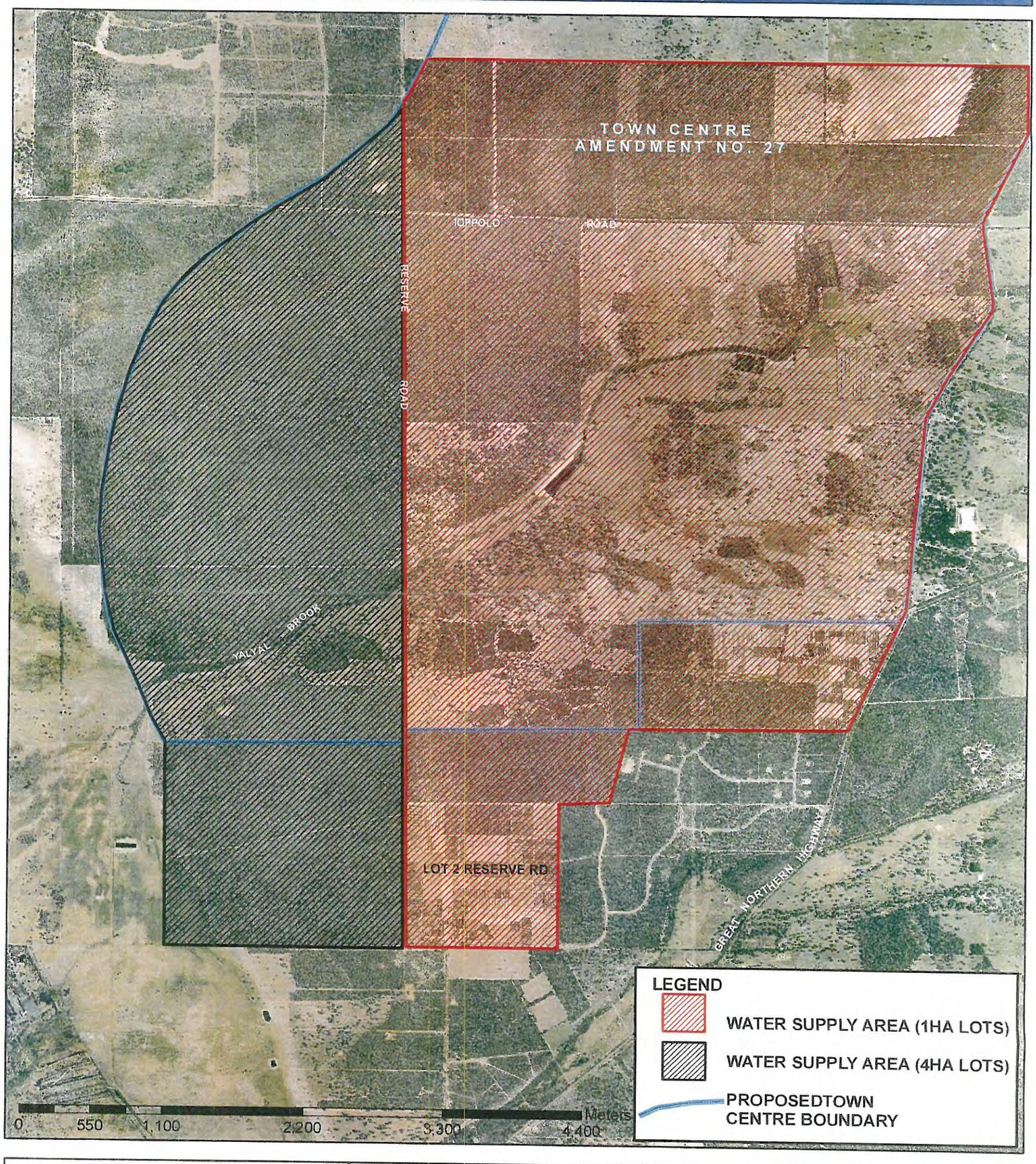
VDM ENVIRONMENTAL

N
W
E
S

LOT 2 RESERVE ROAD, CHITTERING

Total developable area: 2,325 ha
Total lots (1 ha each): 1,449
Total lots (4 ha each): 219

WATER SUPPLY AREA - OPTION 2 (RAINWATER TANKS)



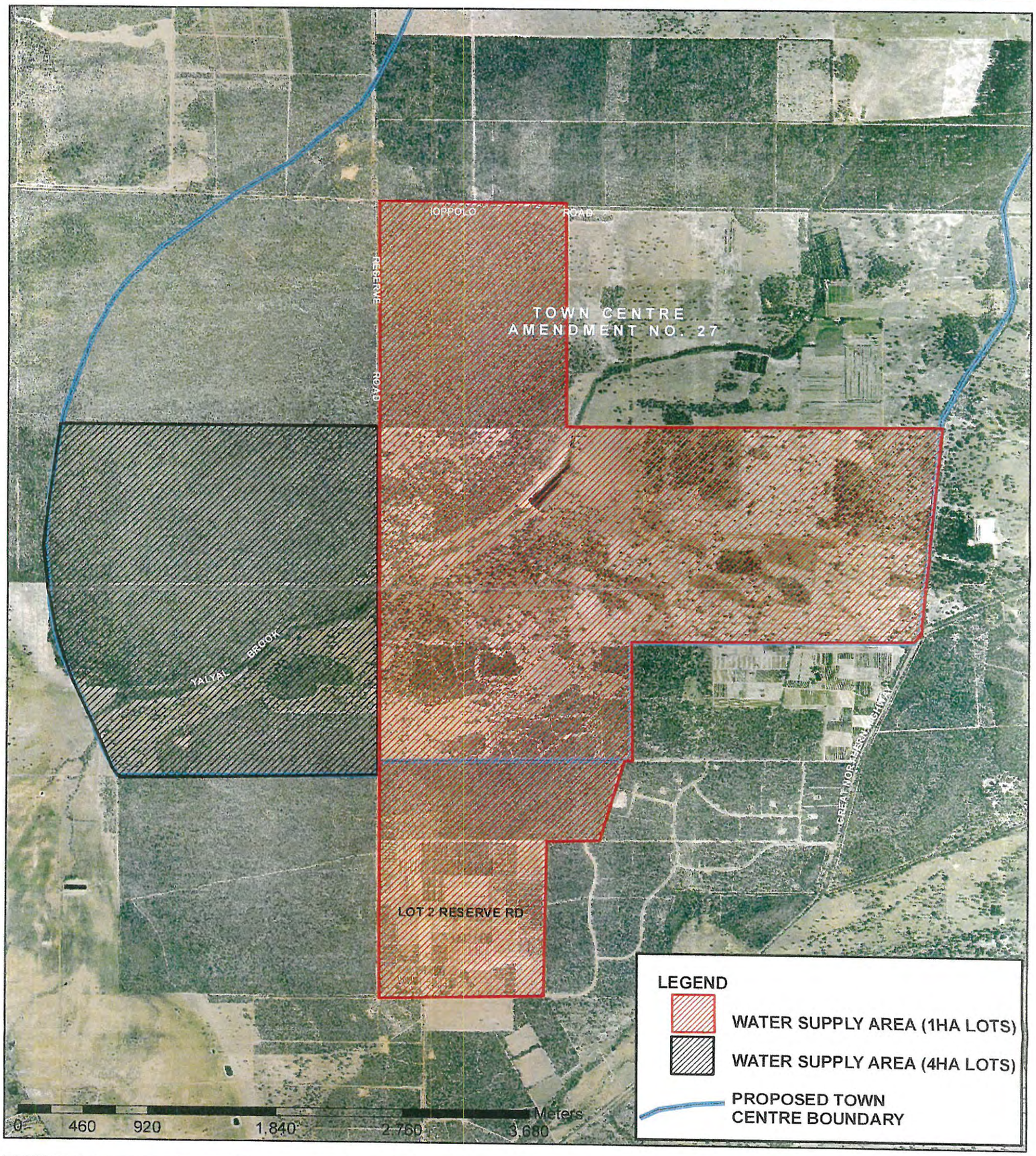
VDM ENVIRONMENTAL

N W E S

LOT 2 RESERVE ROAD, CHITTERING

Total developable area: 3,902 ha
Total lots (1ha each): 2688
Total lots (4 ha each): 303

WATER SUPPLY AREA - OPTION 3
(1,000L/HOUSEHOLD/DAY)



VDM ENVIRONMENTAL

N
W E
S

LOT 2 RESERVE ROAD, CHITTERING

Total developable area: 1,864 ha
Total lots (1ha): 1284
Total lots (4ha): 145

VDM ENVIRONMENTAL

APPENDIX

VDM Projects Pty Ltd t/a VDM Environmental ABN 59 009 351 400 ACN 009 351 400
310 Selby St North, Osborne Park WA 6017 PO Box 1852 Osborne Park DC 6916
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Appendix A

Borehole Test Data

VDM Projects Pty Ltd t/a VDM Environmental ABN 59 009 351 400 ACN 009 351 400
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Subject Site: Lot 2 Reserve Road, Chittering

WIN Site Id	20025333
AWRC Reference	61602501
AWRC Context Name	SWAN COASTAL CATCHMENT 616
AWRC Name	FLORATECH NO 1
AQWABase Reference	2034-1-NE-0104
AQWABase Name	FLORATECH NO 1
Zone	50
Easting	405153.00
Northing	6511488.00
Latitude	-31.527633211
Longitude	116.000966206
Geographic Datum	Geodetic Datum of Australia 1994
Geographic Assessment Method	GDA94 Conversion (Accuracy of 0.05 - 0.9m)
Land District	Swan
Location Map Code	2034-1
1:250,000 Map Code	SH50-14
Location Address	RESERVE RD M2000
Sketch Indicator	N
Geophysical Log Indicator	Y
Route Number	()
River Basin	616 - Swan Coastal
Owning Authority	Floratechnics
Comments	Geophysical log supplied. Approximate salinity from electric log: • 78-84m: 700mg/L. • 228-246m: 1,200mg/L. • 234-240m: 600mg/L. Final yield 1,012m^3/day. Maximum drawdown 10.10m. Full recovery in 30 mins. after 1.5 hrs development. Salinity 600mg/L; after 2hrs 320mg/L; after 2 days 230mg/L. Final pumped sample: 280mg/L.
Drill Method	ROTARY DRILL
Water Supply (m^3/day)	1012.00
TDS (mg/L)	280.00
Water Level (mAHD)	86.730
Top of Screen (m)	225.700
Bottom of Screen (m)	240.900

Depth (no units given)	Stratigraphy	Lithology		
		1	2	3
0.000 – 73.750	Quaternary/Tertiary	Sand	Clay	Laterite
73.750 – 106.680	Cretaceous Sediments	Grit	Sand	None
106.680 – 188.970	Possible Leederville Formation	Shale	Sandy	Carbonaceous
188.970 – 259.080	Leederville Formation	Silt, Silty	Sand	Siltstone

VDM ENVIRONMENTAL

Appendix B

Water Quality Analysis

VDM Projects Pty Ltd t/a VDM Environmental ABN 59 009 351 400 ACN 009 351 400
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VDM GROUP member

SGS

LABORATORY REPORT COVERSHEET

DATE:	28 December 2005
TO:	VDM Group 41 Stuart Street NORTHBRIDGE WA 6003
ATTENTION:	Ms Gemma Connolly
YOUR REFERENCE:	Reserve Rd Chittering
OUR REFERENCE:	93469
SAMPLES RECEIVED:	15/12/05
SAMPLES/QUANTITY:	3 Waters

The above samples were received intact and analysed according to your instructions.
Unless otherwise stated, solid samples are reported on a dry weight basis and liquid samples as received.
Microbiological testwork was subcontracted to ProMicro, Hillarys, report nos. P0534542-44 (NATA 2651).

JANICE TRUESDALE
Manager Perth

CLIENT: VDM Group
PROJECT: Reserve Rd Chittering

OUR REFERENCE: 93469

LABORATORY REPORT

Re: Trans Samples 15/12/2005

This report uses the "Australian Drinking Water Guidelines, 1996" issued by the National Health and Medical Research Council (NHMRC) and the Agriculture and Resource Management Council of Australia and New Zealand to interpret the analytical data.

Although the Heterotrophic Plate Count (HPC) is not a testing requirement for potability, high numbers of bacteria may alter the taste and odour of the water. As a guideline, counts of <500/mL for untreated water are desirable, although counts higher than this, if free from the presence of coliforms are not considered to be necessarily a health hazard. The presence of high numbers of non-coliform bacteria (>1000/mL) may also cause an underestimation in the count of coliform bacteria.

The most common parameters that influence the quality of drinking water have been analysed. The possibility of other contaminants being present however should be ascertained from your local health surveyor. If it is suspected that contamination from specific sources may be present, additional analysis may be necessary. We also recommend regular testing for potability especially when water supply conditions change.

From the tests undertaken, the water sample appears to be good quality drinking water.

pH
The pH limits are set for the reasons that follow as taken from Australian Drinking Water Guidelines, 1996: "Based on the need to reduce corrosion and encrustation in pipes and fittings, the pH of drinking-water should be between 6.5 and 8.5. New concrete tanks and cement-mortar lined pipes can significantly increase pH and a value up to 9.2 may be tolerated provided monitoring indicates no deterioration in microbiological quality." Waters with pH values greater than 11 or less than 4 may adversely affect health but there are currently insufficient data to set health guidelines.

CLIENT: VDM Group
PROJECT: Reserve Rd Chittering

OUR REFERENCE: 93469

LABORATORY REPORT

Re: S1 and S2 Sampled 15/12/2005

This report uses the "Australian Drinking Water Guidelines, 1996" issued by the National Health and Medical Research Council (NHMRC) and the Agriculture and Resource Management Council of Australia and New Zealand to interpret the analytical data.

Although the Heterotrophic Plate Count (HPC) is not a testing requirement for potability, high numbers of bacteria may alter the taste and odour of the water. As a guideline, counts of <500/ml for untreated water are desirable, although counts higher than this, if free from the presence of coliforms are not considered to be necessarily a health hazard. The presence of high numbers of non-coliform bacteria (>1000/mL) may also cause an underestimation in the count of coliform bacteria.

Testing indicates the water sample exceeds either the NHMRC Health or Aesthetic related guidelines and therefore is not good quality drinking water. The cause of the following exceptions should be investigated:

Iron
The level of iron present in the water will cause staining and may impart a metallic taste to the water.

Your local health surveyor may be able to recommend appropriate treatment of the water. Once any treatment has been performed, we recommend the water be resubmitted for potability testing.

CLIENT: VDM Group
PROJECT: Reserve Rd Chittering

OUR REFERENCE: 93469

LABORATORY REPORT

Your Reference Our Reference Date Sampled Type of Sample	Units	Australian Drinking Water Guidelines 2004	Trans 93469-1 15/12/2005 Water	S1 93469-2 15/12/2005 Water	S2 93469-3 15/12/2005 Water
Potability					
pH	pH Units	6.5 - 8.5	6.6	7.0	6.8
Conductivity @25°C	µS/cm	1500	<2	560	550
Total Dissolved Solids (calc as NaCl)	mg/L	1000	<5	360	350
Sodium, Na	mg/L	180	<0.5	69	68
Potassium, K	mg/L		<0.5	7.6	7.6
Calcium, Ca	mg/L		<0.5	7.7	7.9
Magnesium, Mg	mg/L		<0.5	5.4	5.3
Hardness (as $CaCO_3$)	mg/L	200	<5	41	42
Iron, Fe (soluble)	mg/L	0.3	<0.05	6.0	6.3
Chloride, Cl	mg/L	250	<1	120	120
Bicarbonate, HCO_3	mg/L		5	40	40
Sulphate, SO_4	mg/L	500	<1	14	14
Nitrate, NO_3	mg/L	50	<0.2	<0.2	<0.2
Fluoride, F	mg/L	1.5	<0.1	0.3	0.3
Free Cyanide	mg/L	0.08	<0.01	<0.01	<0.01
Aluminium, Al	mg/L	0.2	0.1	0.1	<0.1
Arsenic, As	mg/L	0.007	<0.001	<0.001	<0.001
Manganese, Mn	mg/L	0.5	<0.05	0.10	0.10
Lead, Pb	mg/L	0.01	<0.005	<0.005	<0.005
Cadmium, Cd	mg/L	0.002	<0.001	<0.001	<0.001
Faecal (Thermotolerant) Coliforms	CFU/100mL	0	0	0	0
Total Coliforms	CFU/100 mL		0	0	0
Heterotrophic Plate Count @ 21°C	CFU/mL		1,300	3(Est)	6(Est)
Heterotrophic Plate Count @ 37°C	CFU/mL		540	3(Est)	3(Est)
Sediment	n/a		None	None	None
Odour	n/a		None	None	None
Colour	n/a		None	None	None
Turbidity	n/a		None	None	None

NATA
WORLD RECOGNISED ACCREDITATION

CLIENT: VDM Group
PROJECT: Reserve Rd Chittering

OUR REFERENCE: 93469

LABORATORY REPORT

TEST PARAMETERS	UNITS	LOR	METHOD
Potability			
pH	pH Units		PEI-001
Conductivity @25°C	µS/cm	2	PEI-032
Total Dissolved Solids (calc as NaCl)	mg/L	5	PEI-032
Sodium, Na	mg/L	0.5	PEM-001
Potassium, K	mg/L	0.5	PEM-001
Calcium, Ca	mg/L	0.5	PEM-002
Magnesium, Mg	mg/L	0.5	PEM-002
Hardness (as $CaCO_3$)	mg/L	5	
Iron, Fe (soluble)	mg/L	0.05	PEM-001
Chloride, Cl	mg/L	1	PEI-020
Bicarbonate, HCO_3	mg/L	5	PEI-006
Sulphate, SO_4	mg/L	1	PEI-020
Nitrate, NO_3	mg/L	0.2	PEI-020
Fluoride, F	mg/L	0.1	PEI-027
Free Cyanide	mg/L	0.01	PEI-023
Aluminium, Al	mg/L	0.1	PEM-002
Arsenic, As	mg/L	0.001	PEM-004
Manganese, Mn	mg/L	0.05	PEM-001
Lead, Pb	mg/L	0.005	PEM-003
Cadmium, Cd	mg/L	0.001	PEM-003
Faecal (Thermotolerant) Coliforms	CFU/100mL	0	PM4.3
Total Coliforms	CFU/100 mL	0	PM4.2
Heterotrophic Plate Count @ 21°C	CFU/mL	1	PM4.1
Heterotrophic Plate Count @ 37°C	CFU/mL	1	PM4.1
Sediment	n/a		
Odour	n/a		
Colour	n/a		
Turbidity	n/a		

CLIENT: VDM Group
PROJECT: Reserve Rd Chittering

OUR REFERENCE: 93469

LABORATORY REPORT

NOTES:
LOR - Limit of Reporting.
Where no Guideline is indicated, no guideline value has been set.

In accordance with the Australian Standard methods for Membrane Filtration, if the colony count per plate is outside the range of 20-80, the result derived from this must be shown as an estimation. The reason for this is statistical.

SGS terms and conditions are available from www.au.sgs.com

VDM ENVIRONMENTAL

Appendix C

Water Supply Areas

VDM Projects Pty Ltd t/a VDM Environmental ABN 59 009 351 400 ACN 009 351 400
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VDM GROUP member

1.1 Household Use	Estimate	Units	Source	Water Use	Notes
Garden Irrigation	0.002	kL/m²/day	Water Corporation	Irrigation	10mm*9apps*8months/365.25days
Shower	0.050	kL/person/day	Diversity Australia	Drinking Water	
Kitchen sink	0.008	kL/person/day	Diversity Australia	Drinking Water	
Bathroom basin	0.006	kL/person/day	Diversity Australia	Drinking Water	
Dishwasher	0.003	kL/person/day	Diversity Australia	Drinking Water	
Bath	0.001	kL/person/day	Diversity Australia	Drinking Water	
Laundry trough	0.004	kL/person/day	Diversity Australia	Drinking Water	
Leaks	0.029	kL/household/day	Diversity Australia	Drinking Water	
Pool	0.020	kL/household/day	Diversity Australia	Drinking Water	
Spa	0.002	kL/household/day	Diversity Australia	Drinking Water	
Car washing	0.002	kL/household/day	Diversity Australia	Drinking Water	
Evaporative cooling	0.006	kL/household/day	Diversity Australia	Drinking Water	
Other	0.004	kL/household/day	Diversity Australia	Drinking Water	
Toilet	0.033	kL/person/day	Diversity Australia	Non-Drinking Water	
Washing machine	0.042	kL/person/day	Diversity Australia	Non-Drinking Water	
	0.209	0.201	0.004		
	0.414				

1.2 Household Type	Estimate	Units	Source	Notes
Traditional	2.790	Average # of Residents	2001 ABS Census	
Terraced	1.730	Average # of Residents	2001 ABS Census	
Cottage	1.810	Average # of Residents	2001 ABS Census	
Apartment	1.480	Average # of Residents	2001 ABS Census	
Lifestyle	2.790	Average # of Residents	2001 ABS Census	

1. Rainwater

1.1 Rainfall Collection	Estimate	Units	Source	Notes
Average Annual Rainfall	700	mm/m2/year	Estimate	Metro area only
Rain correction	24	mm/m2/year	http://enhealth.nphp.gov.au/council/pubs/documents/rainwater_tanks.pdf	For evaporation, roof wetting, etc
Efficiency factor	80%	%	Estimate	Conversion of rainfall to rain capture

1.2 Storage capacity	Estimate	Units	Source	Notes
Traditional	2.000	kL/household	Estimate	Total capacity per household
Terraced	2.000	kL/household	Estimate	Total capacity per household
Cottage	2.000	kL/household	Estimate	Total capacity per household
Apartment	5.000	kL/lot	Estimate	Total capacity per lot
Lifestyle	10.000	kL/household	Estimate	Total capacity per household
Schools	10.000	kL/household	Estimate	Total capacity per school
Proportion used for Irrigation (Residential)	0.50	%	Estimate	The remainder is then allocated to Non-drinking water use
Proportion used for Irrigation (Schools)	0.50	%	Estimate	The remainder is then allocated to Non-drinking water use

1.3 Percentage of lot that is roofing	Estimate	Units	Source	Notes
Traditional	50	%	Estimate	
Terraced	50	%	Estimate	
Cottage	50	%	Estimate	
Apartment	50	%	Estimate	
Lifestyle	25	%	Estimate	
Schools	10	%	Estimate	

* - council has recommended 20kl per household.

LOT 2 RESERVE ROAD, CHITTERING - WATER REQUIREMENTS

			kl/person/annum	kl/household/annum
INHOUSE USAGE PER LOT (POTABLE WATER) - LIFESTYLE	0.264	kl/household/day		
EXHOUSE WATER USAGE - from rainwater tank/bore/ATU no pe	0.000	kl/household/day		
	0.264	kl/household/day	34.52	96.30
NON-POTABLE (RAINWATER TANK)	0.209	kl/household/day	27.38	76.38
TOTAL USAGE	0.473	kl/household/day	61.89	172.68

TOTAL WATER SUPPLY	288000	kl/annum		
LOSSES THROUGH WATER TREATMENT PLANT	20%		130.8243728	
	230400	kl/annum		
no. lots, no rainwater tanks (option 1)	1,334	lots	3,722.64	
no. lots, rainwater tanks (option 2)	2,392	lots	6,675.07	
@ 552L/household per day (option 3)	1,144	lots	3,190.47	

Notes:
Input data based on information provided by the Water Corporation's alternate water supply water use model spreadsheet.
All lots at 1 hectare each

Allowance for road reserves	10%
Allowance for Public Open Space	10%

TOTAL LAND REQUIREMENTS

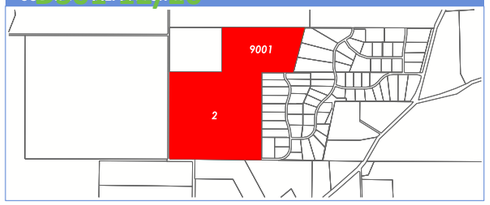
no. lots, no rainwater tanks (option 1)	1,668	lots
no. lots, rainwater tanks (option 2)	2,991	lots
@ 1,000L/household per day (option 3)	1,429	lots

Effluent Production	0.414	**kl/household/day**
	54.16	kl/person/annum
	151.11	kl/household/annum
additional landscaping requriements	0.002	kl/m2/day
expected house pad area	2000	m2
expected pervious area (i.e. Houses, sheds, etc)	60%	
water requiring area	1200	m2
water requirements	876	**kl/household/annum**
TOTALS	876	**kl/household/annum**
less effluent production	151.11	**kl/household/annum**
Irrigation bore requirements	724.89	**kl/household/annum**
	259.82	**kl/person/year**
number of lots from surficial bore	377.44	
Option 3 - Domestic Water Use Study		
Inhouse Usage	155	L/person/day
	56.58	**kl/person/year**
	552	L/household/day
	201.48	**kl/household/year**
Exhouse Usage	707	L/household/day
	258.055	**kl/household/year**
	151.11	
	106.945	**kl/household/year**
	38.33154122	

APPENDIX C

Development Plan (TBB, 2015)

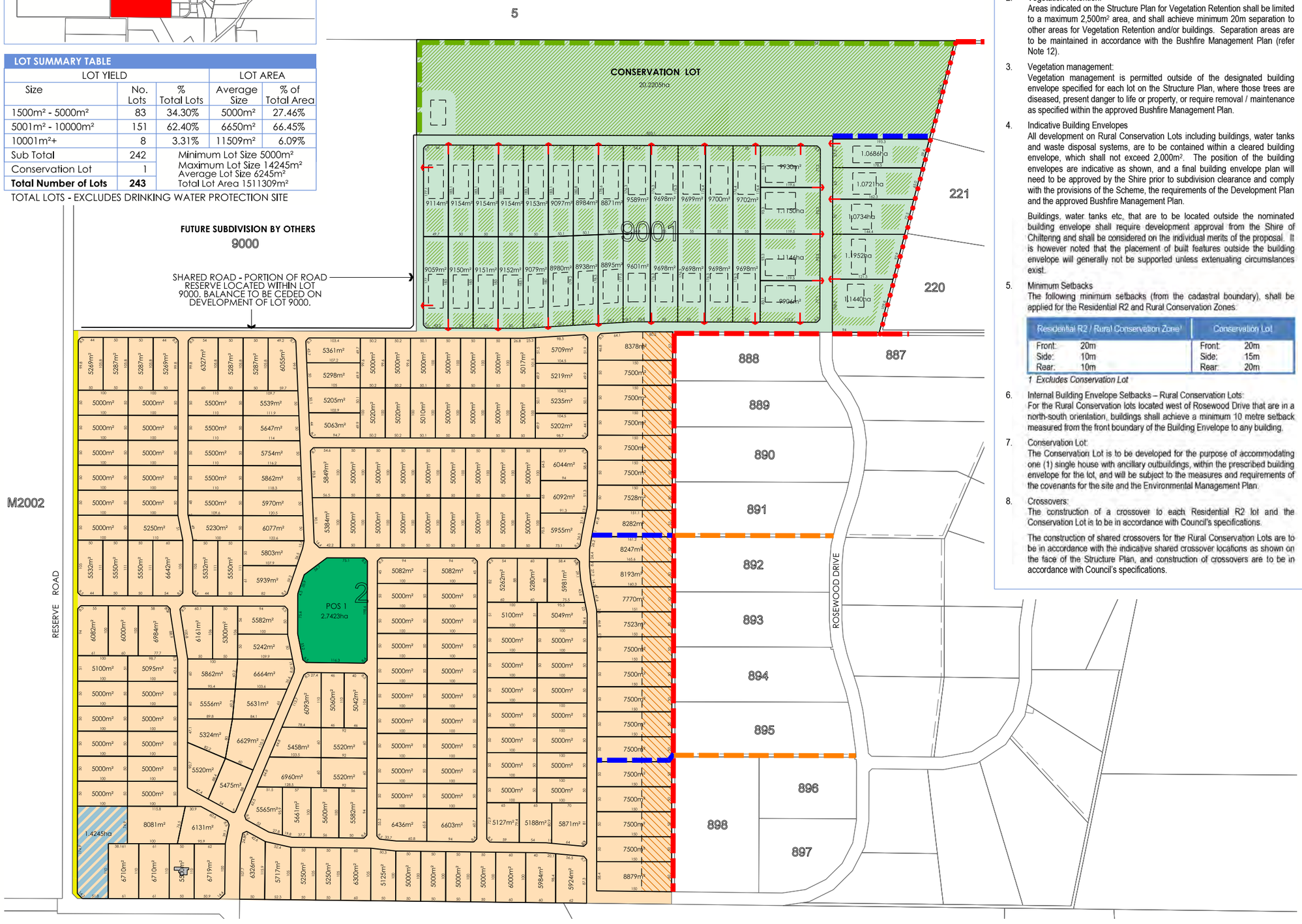
SUBJECT AREA (125ha)



LOT SUMMARY TABLE

LOT YIELD			LOT AREA	
Size	No. Lots	% Total Lots	Average Size	% of Total Area
1500m² - 5000m²	83	34.30%	5000m²	27.46%
5001m² - 10000m²	151	62.40%	6650m²	66.45%
10001m²+	8	3.31%	11509m²	6.09%
Sub Total	242	Minimum Lot Size 5000m²		
Conservation Lot	1	Maximum Lot Size 14245m²		
Total Number of Lots	**243**	Average Lot Size 6245m²		
		Total Lot Area 1511309m²		

TOTAL LOTS - EXCLUDES DRINKING WATER PROTECTION SITE



NOTES

STRUCTURE PLAN REQUIREMENTS

1. Development Requirements and Lot Sizes:
   In considering development and subdivision of the land, the requirements of the Shire of Chittering Town Planning Scheme No. 6 for the 'Rural Conservation' and 'Residential R2' Zones apply, unless otherwise provided for within this Structure Plan.
2. Vegetation Retention:
   Areas indicated on the Structure Plan for Vegetation Retention shall be limited to a maximum 2,500m² area, and shall achieve minimum 20m separation to other areas for Vegetation Retention and/or buildings. Separation areas are to be maintained in accordance with the Bushfire Management Plan (refer Note 12).
3. Vegetation management:
   Vegetation management is permitted outside of the designated building envelope specified for each lot on the Structure Plan, where those trees are diseased, present danger to life or property, or require removal / maintenance as specified within the approved Bushfire Management Plan.
4. Indicative Building Envelopes
   All development on Rural Conservation Lots including buildings, water tanks and waste disposal systems, are to be contained within a cleared building envelope, which shall not exceed 2,000m². The position of the building envelopes are indicative as shown, and a final building envelope plan will need to be approved by the Shire prior to subdivision clearance and comply with the provisions of the Scheme, the requirements of the Development Plan and the approved Bushfire Management Plan.

   Buildings, water tanks etc, that are to be located outside the nominated building envelope shall require development approval from the Shire of Chittering and shall be considered on the individual merits of the proposal. It is however noted that the placement of built features outside the building envelope will generally not be supported unless extenuating circumstances exist.
5. Minimum Setbacks
   The following minimum setbacks (from the cadastral boundary), shall be applied for the Residential R2 and Rural Conservation Zones:

Residential R2 / Rural Conservation Zone[1]		Conservation Lot	
Front:	20m	Front:	20m
Side:	10m	Side:	15m
Rear:	10m	Rear:	20m

   1 Excludes Conservation Lot
6. Internal Building Envelope Setbacks – Rural Conservation Lots:
   For the Rural Conservation lots located west of Rosewood Drive that are in a north-south orientation, buildings shall achieve a minimum 10 metre setback measured from the front boundary of the Building Envelope to any building.
7. Conservation Lot:
   The Conservation Lot is to be developed for the purpose of accommodating one (1) single house with ancillary outbuildings, within the prescribed building envelope for the lot, and will be subject to the measures and requirements of the covenants for the site and the Environmental Management Plan.
8. Crossovers:
   The construction of a crossover to each Residential R2 lot and the Conservation Lot is to be in accordance with Council's specifications.

   The construction of shared crossovers for the Rural Conservation Lots are to be in accordance with the indicative shared crossover locations as shown on the face of the Structure Plan, and construction of crossovers are to be in accordance with Council's specifications.
9. Potable Water:
   A reticulated potable water supply will be provided and available for fire fighting purposes.
10. Land Management:
    The maintenance of any drainage swales, easements, fire breaks/Fire Service Access Routes and Vegetation /re-vegetation areas on private property is the responsibility of the owner/occupier of the respective lot.
11. Bores, Dams and Water Courses:
    The sinking of bores, construction of dams and extraction of surface water is not permitted without prior approval from the Shire and/or any relevant government/service authority
12. Fire Control:
    A Bushfire Management Plan has been prepared by ICS Group and shall apply to the development and ongoing use of the land. Fire Service Access Routes shall be provided in accordance with the Structure Plan.
13. Public Open Space
    Land identified as Public Open Space on the Structure Plan shall be ceded free of cost to the Shire of Chittering at subdivision.
14. Drinking Water Source Protection Site
    Land identified to contain the potable water supply infrastructure and associated buffers and will be registered as a Priority 1 (P1) water source site.
15. Keeping of Livestock
    The keeping of livestock is not permitted.
16. Non-reflective Materials:
    All buildings shall be constructed of non-reflective materials.
17. Effluent Disposal:
    All lots shall be provided with Aerobic Treatment Units (ATUs) with nutrient retention capability for the disposal of waste.
18. Vendor Responsibility:
    The developer/vendor shall inform prospective purchasers of the lots, in writing, of the provisions of the Council's Town Planning Scheme relating to the management of the land, as specified in the Structure Plan, Bushfire Management Plan and Covenants (as applicable).

LEGEND

LAND USE
- RESIDENTIAL R2
- RURAL CONSERVATION
- PUBLIC OPEN SPACE

OTHER
- INDICATIVE BUILDING ENVELOPE
- DRINKING WATER PROTECTION SITE
- VEGETATION RETENTION
- BUILDING EXCLUSION AREA (60m FROM REAR LOT BOUNDARY)
- INDICATIVE SHARED CROSSOVER
- FIRE SERVICE ACCESS ROUTE
  - EXISTING 5.0m RESERVE (widening to 6.0m)
  - EXISTING 6.0m RESERVE
  - EXISTING 6.0m EASEMENT
  - PROPOSED 6.0m EASEMENT
- FIREBREAK
  - PROPOSED 3.0m FIREBREAK (IN ACCORDANCE WITH SHIRE OF CHITTERING FIREBREAK NOTICE)
- RESERVE ROAD - ROAD WIDENING (10m)

STRUCTURE PLAN

Lot 2 Reserve Road & Lot 9001 Rosewood Drive, Chittering

A Riverside Investments (WA) No 2 Pty Ltd Project

0m 40 80 120m

s: 1:4000@A1
d: 1:8000@A3
d: 11 Apr 2016
p: 05/096/025

TAYLOR BURRELL BARNETT

plan 01

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APPENDIX D

Geotechnical Investigation Report (CMW, March 2016)

Supplementary Winter Geotechnical Report (CMW, Aug 2016)

02 March 2016

PROPOSED SUBDIVISION DEVELOPMENT LOT 2 RESERVE ROAD, CHITTERING, WA ROADWAY GEOTECHNICAL INVESTIGATION REPORT

Riverside Investments (WA) No.2 P/L

Ref. PER2016-0395AB, Rev0

Unit 19 Wembley Green Offices,
127 Herdsman Parade, Wembley, WA 6014
www.cmwgeosciences.com

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Appendix A – Site Photographs

Appendix B – Test Pit and Hand Auger Borehole Logs

Appendix C – In-situ Permeability Test Results

Appendix D – Laboratory Test Results

1 INTRODUCTION

CMW Geosciences Pty Ltd (CMW) was authorised by Stephen Seward to carry out a geotechnical investigation at Lot 2 Reserve Road, Chittering by way of a signed authorisation dated 29 February 2016. The scope of work and associated terms and conditions of our engagement were detailed in our services proposal letter referenced PER2016-0395AA, Rev1 dated 21 January 2016.

2 SCOPE OF WORK

The purpose of this report is to describe the investigation completed, the ground conditions encountered and to provide recommendations with respect to geotechnical aspects of the proposed subdivision road design and construction, including near surface permeability characteristics, design subgrade CBR for road design and earthworks recommendations for road construction.

3 SITE DESCRIPTION

The proposed development site comprises an area of approximately 135ha and is located on Reserve Road, Chittering, WA, as shown on the attached Site Location Plan – Figure No. 1.

The site slopes from the west/northwest to the east/southeast with existing ground levels ranging from RL 165m AHD in the northwest corner to RL136m AHD at the southeast corner.

The site is bound to the west and southwest by Reserve Road, open paddock to the south, semi-rural lots to the east and to vegetated bushland to the north. The lot is segregated into smaller rectangular sub-lots, many of which are fenced and irrigated and showing evidence of previous or current planting with a variety of native/introduced plants, shrubs and trees. A gravel pit is situated within the northeast part of the site. A sand pit is located within the central southern portion of the lot. A collection of abandoned/dumped farm machinery and equipment, building products and general household/farm waste is situated in the vicinity of the latter sand pit, both at the surface and within shallow excavations.

A single storey residential dwelling is situated to the south west of the lot as well as several farm sheds and equipment. A production water well appears to be present to the extreme south west corner of the lot.

Selected photographs of the site are included in Appendix A. The attached Site Plan – Figure No. 2 depicts the approximate locations of the gravel/sand pits.

4 PROPOSED DEVELOPMENT

The draft development plans by Taylor Burell Barnett indicate that lot 2 will be subdivided into smaller lots of between 0.5ha and 1.5ha in size and associated roads, access ways and a public open space will be constructed.

At the time of undertaking this investigation and of writing this report the project was in the early stages of planning. It is anticipated that the geotechnical investigation will provide details of preliminary feasibility options for the site, particularly with respect to the proposed roadways.

5 FIELD INVESTIGATION

Following a dial before you dig search, the field investigation was carried out on 8 February 2016. All fieldwork was carried out under the direction of CMW Geosciences Pty Ltd in general accordance with AS1726 (1993), Geotechnical Site Investigations. The scope of fieldwork completed was as follows:

- Undertake a walkover survey of the site to assess the general landform and site conditions;
- Thirteen test pits, denoted TP01 to TP14 (excluding TP12), were excavated using a backhoe fitted with a 600mm wide toothed rock bucket to depths of between 0.1 and 3.4m below existing ground levels. Representative bulk samples were collected to provide samples for subsequent laboratory testing. Engineering logs and photographs of the test pits are presented in Appendix B. It must be noted that TP12 was replaced with HA04 due to the potential presence of buried services in the area;
- Two pavement dippings (TP15 and TP16) were undertaken in order to assess and sample the current pavement material (where present and applicable) and were terminated due to shallow refusal on dense to very dense ferricrete (laterite). Engineering logs and photographs of the pavement dippings are presented in Appendix B;
- Four hand auger boreholes, denoted HA01 to HA04, were drilled using a 100m diameter auger to target depths of up to 1.5m below existing ground levels to visually observe the near surface soil profile and to facilitate in-situ permeability testing. Engineering logs of the hand auger boreholes are presented in Appendix B ;
- Dynamic Cone Penetrometer (DCP) tests were carried out adjacent to each test pit, in general accordance with AS1289.6.3.2, to depths of up to 1m to provide soil density profiles and to provide a subgrade CBR value for pavement design purposes. Graphical results of the DCP testing are presented on the test pit logs in Appendix B; and
- In-situ falling head permeability tests were completed in the open standpipe piezometers established in HA01 and HA03 at depths of 1.5m. HA01 and HA02 were located in the central POS space and HA03 was located in the proposed drainage area in the south eastern corner of the site. Results of the permeability tests are presented in Appendix C;

The approximate locations of the respective investigation sites referred to above are shown on the attached Site Plan (Figure No. 02).

6 LABORATORY TESTING

Laboratory testing was carried out generally in accordance with the requirements of the current edition of AS 1289 (where applicable). All testing was scheduled by CMW and carried out by Cardno, a NATA registered Testing Authority.

Laboratory testing was undertaken on samples obtained from both the existing pavement materials and the underlying natural subgrade (sand) material in order to make an assessment of the current condition of the existing pavements, assist in subgrade CBR design values and to assess the suitability for reuse of the pavement materials.

The extent of testing carried out to provide the geotechnical parameters required for this study are presented in Table 1. Two of each test were undertaken on subgrade material from the test pits and two on the pavement dipping material.

Table 1: Laboratory Test Schedule Summary

Type of Test	Test Method	Quantity
Particle size distribution	AS1289.3.6.1	4
Soaked CBR tests	AS1289.6.1.1	4
Maximum dry density	AS 1289.5.5.1	4

Certificates for the test results outlined above are presented in Appendix D.

7 GROUND MODEL

7.1 Geology

Published geological maps (Ref. Muchea Sheet 2034 I and Part of 2134 IV) and the CMW investigation database for the area depict the land as being underlain by colluvial sands with laterite to the west and south of the site.

7.2 Subsurface Conditions

The ground conditions encountered and inferred from the investigation were considered to be generally consistent with the published geology for the area and can be generalised according to the following subsurface sequence:

SAND (SP)	loose to medium dense, white, grey and yellow, predominantly medium grained sand containing roots and rootlets and darker colouring in top 0.5m; overlying
GRAVEL/COBBLES/BOULDERS	fine to coarse grained, sub-angular to sub-rounded, red brown, of lateritic origin, uncemented to well cemented, with sand;

The distribution of these units is summarised in Table 2 below:

Table 2: Summary of Soil Stratigraphy

Description	Depth to base of layer (m)		
	Minimum	Maximum	Average
SAND*	0	3.1	1.6
GRAVEL/COBBLES/BOULDERS**	-	-	-

Notes: * Strata not encountered in TP15 and TP16, ** Base of strata not encountered

Individual test pit and hand auger logs should be consulted to assess levels in terms of m AHD. Levels have been estimated based on the provided survey data.

7.3 Pavement Dipping

At test pit location TP15 and TP16 (pavement dippings) it appeared that a thin sheet of gravelly clayey sand/gravelly sand has been placed directly on the in situ cemented gravel/cobbles/boulders to form Reserve Road. These sections correspond to the areas of laterite shown on the referenced geology map for the area. The pavement profile investigated identified the thickness of pavement layers which are detailed in Table 3 below.

Table 3: Summary of the Pavement Layers

Description	Thickness of layer (m)		
	Minimum	Maximum	Average
Basecourse Material: Gravelly SAND	0.05	0.2	0.125
Subgrade comprising cemented GRAVEL/COBBLES	>0.2		

7.4 Laboratory Test Results

Results of the civil engineering laboratory tests provided in Appendix D are summarised in Table 3 below:

Table 3: Summary of Civil Engineering Laboratory Test Results

Test Location	Depth (m bgl)	Material	Gravel (%)	Sand (%)	Fines (%)	LL (%)	PL (%)	PI (%)	LS (%)	MC (%)	OMC (%)	MMDD (t/m^2)	CBR (%)
TP9	0.6 – 0.8	SG	0	96	4	-	-	-	-	-	14.5	1.79	20
TP13	0.3 – 0.5	SG	54	43	3	-	-	-	-	-	9.0	2.22	90
TP15	0.1 – 0.3	BC	22	71	7	-	-	-	-	-	10.5	2.05	45
TP16	0.0 – 0.1	BC	33	57	10	-	-	-	-	-	7.0	2.11	110

Note: Gravel, sand and fines percentages are by weight, LL = liquid limit, PL = plasticity limit, PI = plasticity index, LS = linear shrinkage, NO = Not obtainable, NP = Non Plastic, MC = Natural Moisture Content, OMC = Optimum Moisture Content, MMDD = Modified Maximum Dry Density, CBR = California Bearing Ratio, BC = basecourse, SG = subgrade

7.5 Groundwater

Groundwater was not encountered during our investigation. However, increased moisture was observed in some instances below the sand unit where the gravel/cobble/boulder unit was mostly uncemented laterite gravels.

It is possible that perched groundwater may occur during and following periods of rainfall above cemented laterite layers.

7.6 Permeability

The results of the constant and rising head permeability tests carried out were used to estimate the soil coefficient of permeability in accordance with the methods described in Horslev (1951). The results varied between approximately 1 x 10^{-5} (1m/day) and 6 x 10^{-5} m/sec (5m/day). Full results are contained in Appendix C.

8 GEOTECHNICAL ASSESSMENT AND RECOMMENDATIONS

8.1 Geohazards

Uncontrolled Fill comprising farm/household waste was encountered in the vicinity of TP13/Sand Pit location to the central southern boundary of the site. Further geotechnical and environmental investigation is suggested in this area once the proposed development and building envelope details are confirmed. Environmental investigation may also be prudent for the area of the lot occupied by sheds and agricultural equipment.

8.2 General Earthworks

We anticipate that minor cut to fill bulk earthworks may be required to form finished road levels. This activity is considered appropriate for the site subject to the earthworks construction recommendations described below:

8.2.1 Topsoil Strip and Subgrade Preparation

We propose the following general recommendations for the topsoil stripping:

- All vegetation should be stripped and removed from the proposed roadway;

- Existing trees must be removed and it must be ensured that their root systems are completely grubbed out. The soil beneath all tree root systems must be re-compacted and filled with compacted clean sand; and,
- Topsoil, root mats or otherwise unsuitable organic material should be removed and cut to waste or alternatively blended with clean sand fill at a minimum ratio of 3:1 (topsoil:sand fill). Following vegetation clearing, a 100mm thick topsoil strip should be considered appropriate for most of the site, however where thick root mats or otherwise unsuitable material is present to a greater depth then this should be removed and cut to waste or blended at the above ratio.

8.2.2 Bulk Earthworks

We recommend the following during bulk earthworks:

- Following topsoil stripping, the upper 300 mm of the exposed subgrade must be moisture conditioned and compacted to achieve at least 95% dry density ratio based on Modified Compaction (AS1289 5.1.1). Any loose, soft, or organic materials observed during this proof roll must be removed and replaced with compacted clean sand fill.
- Site won material from proposed cut earthworks is considered suitable for use in bulk earthworks subject to the material being sandy in nature, free of organic or deleterious inclusions with a fines content of less than 12% and a maximum particle size of 150mm;
- Sandy fill material must be moisture conditioned and compacted in layers not exceeding 300 mm with a suitable roller to achieve at least 95% dry density ratio based on Modified Compaction (AS1289 5.2.1);
- Imported sand bulk fill materials will need to be free of organic or deleterious inclusions with a fines content of less than 12% and a maximum particle size of 150mm; and
- Permanent road embankment batters constructed from compacted sand (as detailed above) may be formed to a gradient of up to 1V:2H (27 degrees) to maximum heights of 3m, provided no load bearing structures are located within 2m of the batter crest. Temporary cut batters in natural sand above the water table may be excavated to a gradient of up to 1V:1.5H (33.5 degrees) to maximum heights of 3m, provided no load bearing structures are located within 2m of the batter crest. Cut batters exceeding this 3m height must be benched (minimum 1.5m wide level benches).

The technical and control requirements for Engineered Fill, including site observation and compaction testing, are outlined in AS3798. We recommend that this work is completed under the direction and control of a suitably experienced Geotechnical Engineer familiar with the contents of this report.

8.2.3 Earthworks Monitoring

Variations in ground conditions may occur between test locations. If conditions other than those described above are encountered, then further advice should be sought without delay. During earthworks, site visits should be made by a Geotechnical Engineer who is familiar with the contents of this report to ensure that topsoil stripping is carried out adequately, proof compaction and cut to fill earthworks are conducted in accordance with AS3798-2007, and to audit the compaction of fill earthworks. Earthworks control testing should be undertaken in accordance with the guidelines set out in AS3798-2007. CMW would be pleased to perform this function if required.

In particular, following the topsoil strip and prior to filling we strongly recommend that the removal of all uncontrolled fill is verified by a suitably qualified geotechnical professional.

8.3 Drainage Systems

On-site drainage systems within the central POS area may be designed on the basis of a soil coefficient of permeability of 2.5m/day whilst the proposed drainage system in the south eastern corner of the site may be designed on the basis of a soil coefficient of permeability of 1m/day. Drainage systems must be located a distance of at least 3m away from any proposed building foundations or retaining wall.

8.4 Pavements

8.4.1 Existing Pavement Materials

The pavement dipping's completed (TP15 and TP16) adjacent to the existing roadways indicate that the existing pavement typically comprises a thin layer of basecourse type material comprising gravelly sand to an average thickness of 125mm. The subgrade material in these areas comprised cemented gravel and cobbles (laterite).

Field and laboratory testing indicate that the basecourse material has CBR values ranging from 45% to 110%, at 98% MMDD.

8.4.2 Subgrade CBR

Subject to our recommendations provided in Section 8.2 of this report, a design subgrade CBR value of 15% for the sandy soils across the site is considered suitable. A design subgrade CBR value of 15% is also considered suitable for compacted sand fill material.

It should be noted that CBR testing was completed as part of this investigation to assist in assessing a suitable design subgrade CBR. Our recommended design value is also based on an assessment of subgrade variability, in-situ DCP test results and published literature.

It is recommended that appropriate QA / QC testing be undertaken on subgrade and pavement materials during construction.

9 FURTHER WORK

As detailed in Section 8.1, further geotechnical and environmental investigation is suggested in this area once the proposed development details are confirmed. Environmental investigation may also be prudent for the area of the lot occupied by sheds and agricultural equipment.

10 LIMITATIONS

The findings contained within this report are the result of limited discrete investigations conducted in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site. Under no circumstances, can it be considered that these findings represent the actual state of the ground conditions away from our investigation locations.

If the ground conditions encountered during construction are significantly different from those described in this report and on which the conclusions and recommendations were based, then we must be notified immediately.

This report has been prepared for use by Riverside Investments (WA) No. 2 Pty Ltd in relation to the Lot 2 Reserve Road, Chittering, WA project in accordance with generally accepted consulting practice. No other warranty, expressed or implied, is made as to the professional advice included in this report. Use of this report by parties other than Riverside Investments (WA) No. 2 Pty Ltd and their respective consultants and contractors is at their risk as it may not contain sufficient information for any other purposes.

11 CLOSURE

We trust this is sufficient for your present needs. If you have any queries, please do not hesitate to contact the undersigned.

For and on behalf of
CMW Geosciences Pty Ltd





Alex Petty
Site Investigation Team Leader

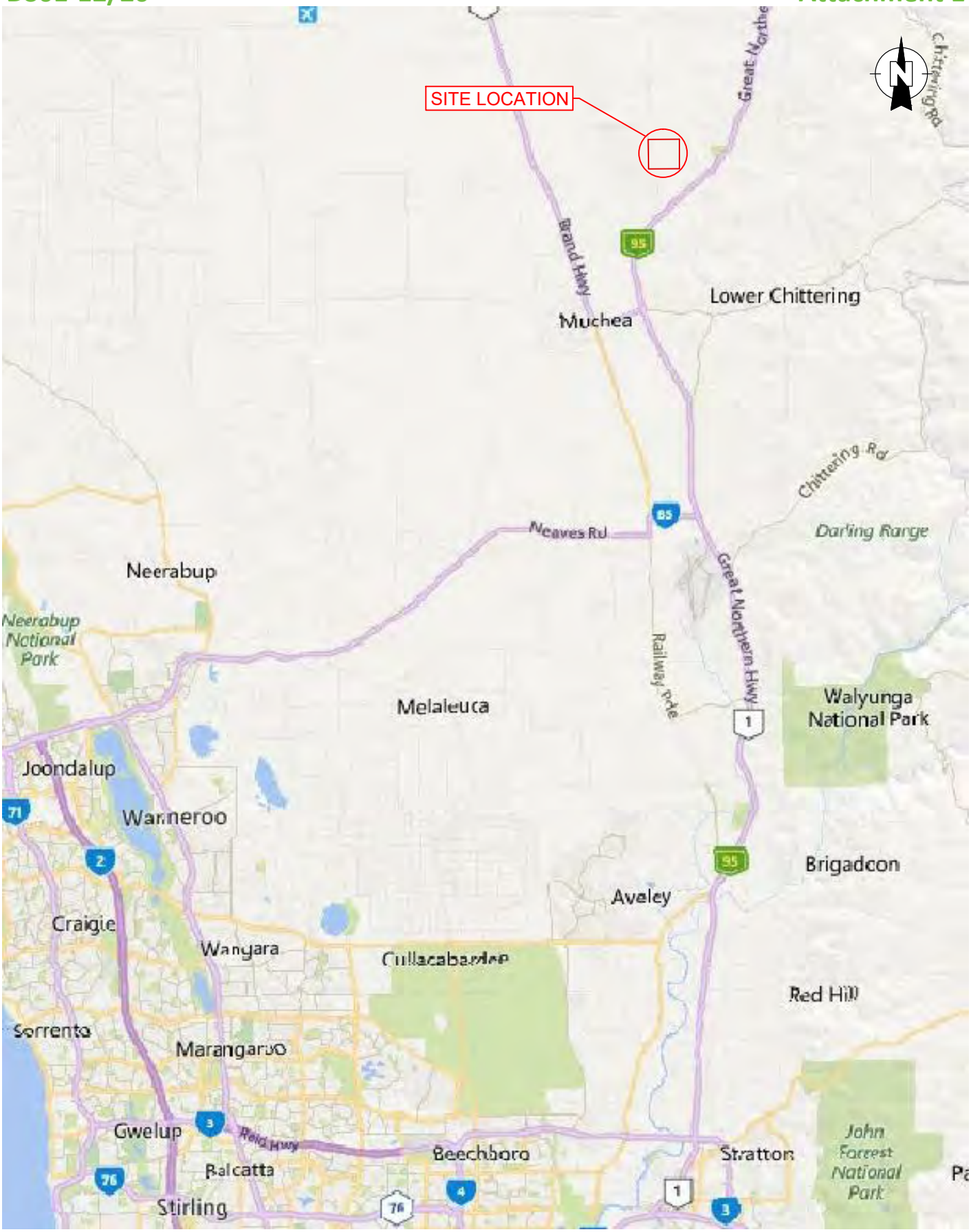
Philip Mather
Principal Engineering Geologist

Distribution: 1 copy to Riverside Investments (WA) No. 2 Pty Ltd (electronic)
Original held by CMW Geosciences Pty Ltd

12 REFERENCES

- AS 1289, *Methods of testing soils for engineering purposes,* Standards Australia, Sydney
- AS 1726 (inc. amendments 1 & 2), *Geotechnical Site Investigations,* Standards Australia, Sydney, 1993
- AS 3798 (inc. amendment 1), *Guidelines on earthworks for commercial and residential developments,* Standards Australia, Sydney, 2007
- Hvorslev J M, *Time lag and soil permeability in ground-water observations,* Bull. 36, 50 pp., U.S. Corps of Eng., Waterways Exp. Sta., Vicksburg, Miss., 1951
- *Muchea Sheet 2034 I and Part of 2134 IV*, Perth Metropolitan Region Environmental Geology Series, Geological Survey of Western Australia, 1986

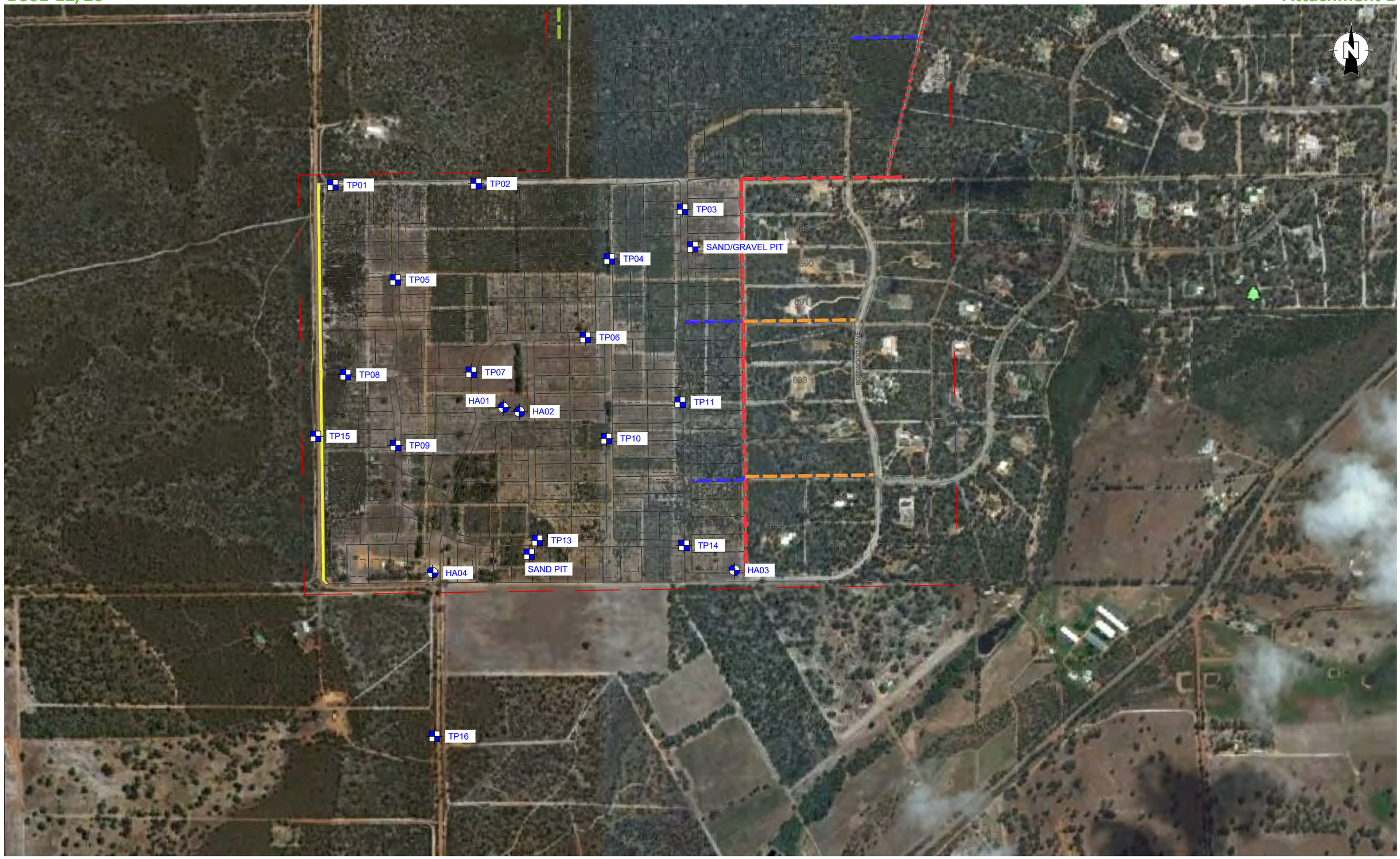
Figures



NOTE: IMAGERY SOURCED FROM BING.COM

CMW Geosciences Pty Ltd
Chapman Morton Woodward

CLIENT: RIVERSIDE INVESTMENTS (WA) NO. 2 PTY LTD		DRAWN: DE	PROJECT: PER2016-0395
PROJECT: SUBDIVISION DEVELOPMENT LOT 2, RESERVE ROAD, CHITTERING, WA		CHECKED: SVK	FIGURE: 01
		REVISION: 0	SCALE: 1:200,000
TITLE: SITE LOCATION PLAN		DATE: 15/02/2016	SHEET: A4 P



LEGEND:

- HA01 HAND AUGER (HA) LOCATION
- TP01 TEST PIT (TP) LOCATION

1:10 000 0 100 200 300 400 500 m

CMW Geosciences Pty Ltd
Chapman Morton Woodward

CLIENT: RIVERSIDE INVESTMENTS (WA) NO. 2 PTY LTD	DRAWN: DE	PROJECT: PER2016-0395
PROJECT: SUBDIVISION DEVELOPMENT LOT 2, RESERVE ROAD, CHITTERING, WA	CHECKED: SVK	FIGURE: 02
	REVISION: 0	SCALE: 1:10,000
TITLE: SITE INVESTIGATION PLAN	DATE: 15/02/2016	SHEET: A3 L

Appendix A
Site Photographs



Plate 1

Sand/gravel pit near TP03, looking east



Plate 2

Sand pit near TP13, looking east

Appendix B
Hand Auger and Test Pit Logs and Photographs

BOREHOLE LOG - HA 01

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project ID: PER2016-0395
Date: 08/02/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405474m N.6512032m
Elevation: 152 m (AHD)

Hole Diameter: 100mm
Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Structure & other observations
				152.0	0		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey.	D		
							... from 0.5m, yellow.	M		
					1					
							Borehole terminated at 1.50 m			
					2					
					3					
					4					

Termination reason: Target Depth Reached.
Remarks: Groundwater not encountered. Falling head permeability test undertaken.

BOREHOLE LOG - HA 02

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project ID: PER2016-0395
Date: 08/02/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405520m N.6512020m
Elevation: 151 m (AHD)

Hole Diameter: 100mm
Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Structure & other observations
				151.0	0		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey.	D		
							... from 0.5m, yellow	M		
					1					
							Borehole terminated at 1.50 m			
					2					
					3					
					4					

Termination reason: Target Depth Reached.
Remarks: Groundwater not encountered. Falling head permeability test undertaken.

BOREHOLE LOG - HA 03

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project ID: PER2016-0395
Date: 08/02/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.406131m N.6511570m
Elevation: 138 m (AHD)

Hole Diameter: 100mm
Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Structure & other observations
				138.0	0		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey.	D		
							... from 0.5m, yellow.	M		
					1					
							Borehole terminated at 1.50 m			
					2					
					3					
					4					

Termination reason: Target Depth Reached.
Remarks: Groundwater not encountered. Falling head permeability test undertaken.

BOREHOLE LOG - HA 04

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project ID: PER2016-0395
Date: 08/02/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405273m N.6511562m
Elevation: 159 m (AHD)

Hole Diameter: 100mm
Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Structure & other observations
				159.0	0		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, grey to yellow.	D		
							... from 0.5m, yellow.	M		
					1					
							Borehole terminated at 1.30 m			
					2					
					3					
					4					

Termination reason: Refusal on Laterite Gravel.
Remarks: Groundwater not encountered.

This report must be read in conjunction with accompanying notes and abbreviations.

TEST PIT LOG - TP 01

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.404990m N.6512664m
Elevation: 166 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey and white, trace roots and rootlets to 1m depth.	D	L to MD	5 10 15	
			164.8	1		CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, cobbles and boulders to 0.6m diameter (iron cemented).	D to M			
						... from 1.5m mixed with grey cemented sand and gravel lumps.				
			163.6	2		Borehole terminated at 2.400 m				
				3						

Termination Reason: Refusal/Hard Digging
Remarks: Groundwater not encountered.

TEST PIT LOG - TP 02

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405397m N.6512668m
Elevation: 161 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components)	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey to white, trace roots and rootlets to 0.3m depth.	D	L to MD	5 10 15	
				1			M			
				2		*... from 2m, pale yellow and pale grey.*				
			158.5			GRAVEL: fine to coarse grained, sub-angular to sub-rounded, red brown (laterite) with fine to coarse grained sand.				Apparent increase in moisture content in gravel.
			158.0	3		Borehole terminated at 3.000 m				

Termination Reason: End of Test Pit. Backfilled.
Remarks: Groundwater not encountered.

TEST PIT LOG - TP 03

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405984m N.6512595m
Elevation: 157 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey to pale brown, trace roots and rootlets to 0.5m depth.	D	L to MD	5 10 15	
			155.2	1		GP: GRAVEL: fine to coarse grained, sub-angular to sub-rounded, (laterite), red brown, with sand, with cobbles to 150mm.	M			Apparent increase in moisture content in gravel.
				2		*... from 2.5m, becoming very weakly to weakly cemented.*				
			154.4			Borehole terminated at 2.600 m				
				3						

Termination Reason: End of Test Pit. Refusal. Backfilled.
Remarks: Groundwater not encountered.

TEST PIT LOG - TP 04

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405776m N.6512454m
Elevation: 160 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale brown to yellow, trace roots and rootlets to full depth (2.1m).		L to MD	5 10 15	
				1			D			
				2		*... from 2m becoming very weakly to weakly cemented.*				
			157.9			Borehole terminated at 2.100 m				
				3						

Termination Reason: End of Test Pit. Refusal on Cemented Sand.
Remarks: Groundwater not encountered. Backfilled.

TEST PIT LOG - TP 05

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405167m N.6512394m
Elevation: 159 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale brown, trace roots and rootlets to 0.4m depth.	D			
						... from 0.5m pale brown and pale yellow.		L to MD		
				1			M			Pit walls collapsing from 1.5m depth.
				2						
			156.5			Borehole terminated at 2.500 m				
				3						

Termination Reason: Collapse.
Remarks: Groundwater not encountered. Backfilled.

TEST PIT LOG - TP 06

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405708m N.6512231m
Elevation: 158 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace roots and rootlets to 0.3m depth.	D	L to MD		
				1		*... from 1m, pale yellow to yellow.*	M			
				2		*... from 2m becoming yellow/orange.*				Apparent increase in moisture content in gravel.
			155.6			GP: GRAVEL: fine to coarse grained, sub-angular to sub-rounded, red brown (laterite), with fine to coarse grained sand.				Pit walls collapsing from 2.5m depth.
			155.3			Borehole terminated at 2.700 m				
				3						

Termination Reason: End of Test Pit. Slow Digging.
Remarks: Groundwater not encountered. Backfilled.

TEST PIT LOG - TP 07

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405383m N.6512132m
Elevation: 153 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey, trace roots and rootlets to 0.4m depth.	D	L to MD	5 10 15	
						... from 0.5m, pale yellow.				
				1			M			Pit walls collapsing from 1.5m depth.
						... from 1.9m, yellow/orange.				
				2						
			150.5			Borehole terminated at 2.500 m				
				3						

Termination Reason: Collapse.
Remarks: Groundwater not encountered. Backfilled.

TEST PIT LOG - TP 08

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405026m N.6512125m
Elevation: 162 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace roots and rootlets to 0.3m depth.		L to MD		Laterite gravel and cobbles sparsely scattered at surface.
			161.7			CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, cobbles and boulders (iron cemented).	D			
				1						
				2						
			159.6			Borehole terminated at 2.400 m				
				3						

Termination Reason: Refusal/Hard Digging.
Remarks: Groundwater not encountered. Backfilled.

TEST PIT LOG - TP 09

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 2

Logged by: SVK
Checked by: AP

Position: E.405168m N.6511924m
Elevation: 158 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace roots and rootlets to 0.5m depth.	D			
	0.6 - 0.8	B				*... from 0.5m, grey to white.*		L to MD		
				1						
							M			
				2						
				3		*... from 3m, becoming iron cemented, orange brown.*				
			154.9			GP: GRAVEL: fine to coarse grained, sub-angular to sub-rounded (laterite), red brown gravel, with cobbles to 100mm.				
						Continued on next sheet				

Termination Reason: Target Depth Reached.
Remarks: Groundwater not encountered. Backfilled

TEST PIT LOG - TP 09

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 2 of 2

Logged by: SVK
Checked by: AP

Position: E.405168m N.6511924m
Elevation: 158 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & other observations
			154.6			Borehole terminated at 3.400 m				
				4						
				5						
				6						

Termination Reason: Target Depth Reached.
Remarks: Groundwater not encountered. Backfilled

TEST PIT LOG - TP 10

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405768m N.6511943m
Elevation: 152 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
				1		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey then yellow, trace roots and rootlets to 0.5m. depth. *... from 0.5m, yellow.*	D	L to MD	5 10 15	
			149.7	2		GP: GRAVEL: fine to coarse grained, sub-angular to sub-rounded, orange brown (laterite), with fine to coarse grained sand.				Apparent increase in moisture content in gravel.
			149.3	3		Borehole terminated at 2.700 m				

Termination Reason: Cemented Gravel/ Slow Digging.
Remarks: Groundwater not encountered. Backfilled

TEST PIT LOG - TP 11

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405977m N.6512047m
Elevation: 155 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
				0		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey to grey, trace roots and rootlets to 0.6m depth.		L to MD		
				1		*... from 1m, pale grey and white*	D			
				2						Pit walls collapsing from 2.0m depth.
			152.7			GP: GRAVEL: fine to coarse grained, sub-angular to sub-rounded, (laterite) red brown, with cobbles and boulders to 300mm.				Apparent increase in moisture content in gravel.
			152.5			Borehole terminated at 2.500 m				
				3						

Dynamic Cone Penetrometer (Blows/100mm): 5 10 15

Termination Reason: Collapse.
Remarks: Groundwater not encountered. Backfilled

TEST PIT LOG - TP 13

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405571m N.6511654m
Elevation: 153 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
	0.3 - 0.5	B	152.6			SP: SAND: fine to coarse grained, sub-angular to sub-rounded, grey to orange brown with gravel, trace roots and rootlets to 0.4m depth.	D			
			152.5			CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, cobbles and boulders (iron cemented). Borehole terminated at 0.500 m		L to MD	5 10 15	

Termination Reason: Refusal on Laterite.
Remarks: Groundwater not encountered. Backfilled.

TEST PIT LOG - TP 14

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405988m N.6511640m
Elevation: 145 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, grey and pale brown, trace roots and rootlets to 0.7m depth.	D			
	0.6 - 0.8	B		1				L to MD		
							M			
	2.8	B	142.2	2		GRAVEL/COBBLES: fine to coarse grained, sub-angular to sub-rounded, grey gravel and cobbles of cemented sand to 150mm.				
			142.0	3		Borehole terminated at 3.000 m				

Termination Reason: Target Depth Reached.
Remarks: Groundwater not encountered. Backfilled.

TEST PIT LOG - TP 15

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.404941m N.6511950m
Elevation: 163 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description: Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & other observations
	0.1 - 0.3	B	162.8			SW: Gravelly SAND: fine to coarse grained, sub-angular to sub-rounded, (laterite), red brown, fine to coarse grained, sub-angular to sub-rounded gravel (laterite and cemented sand).	D	MD to D	5 10 15	Laterite outcropping at surface to immediate west on firebreak.
			162.7			CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, gravel and cobbles (laterite).				
						Borehole terminated at 0.300 m				
				1						
				2						
				3						

Termination Reason: Refusal on cemented gravel/cobbles/boulders (laterite).
Remarks: Groundwater not encountered.

TEST PIT LOG - TP 16

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 08/02/2016

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1:20 Sheet 1 of 1

Logged by: SVK
Checked by: AP

Position: E.405279m N.6511098m
Elevation: 161 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests		RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & other observations
	Depth	Type & Results								
	0.0 - 0.0	B	161.0			SW: GRAVELLY CLAYEY SAND: fine to coarse grained, sub-angular to sub-rounded, red brown, fine to coarse grained sub-angular to sub-rounded gravel (laterite), low plasticity clay. Borehole terminated at 0.050 m	D			Road is cut approximately 1m into laterite hillside.

Termination Reason: Refusal on cemented gravel/cobbles/boulders (laterite).
Remarks: Groundwater not encountered. Backfilled.



Plate 1

TP01 - Spoil



Plate 2

TP01



Plate 3

TP02 - Spoil



Plate 4

TP02



Plate 5

TP03 - Spoil



Plate 6

TP03



Plate 7

TP04 - Spoil



Plate 8

TP04



Plate 9

TP05 - Spoil



Plate 10

TP05



Plate 11

TP06 - Spoil



Plate 12

TP06



Plate 13

TP07 – Spoil



Plate 14

TP07



Plate 15

TP08 – Spoil



Plate 16

TP08



Plate 17

TP09 - Spoil



Plate 18

TP9



Plate 19

TP10 - Spoil



Plate 20

TP10



Plate 21

TP11 - Spoil



Plate 22

TP11



Plate 23

TP13 - Spoil



Plate 24

TP13



Plate 25

TP14 - Spoil



Plate 26

TP14



Plate 27

TP15 – Pit and Spoil



Plate 28

Nearby TP15, spade on ferricrete/laterite



Plate 29

TP16 – Pit and Spoil



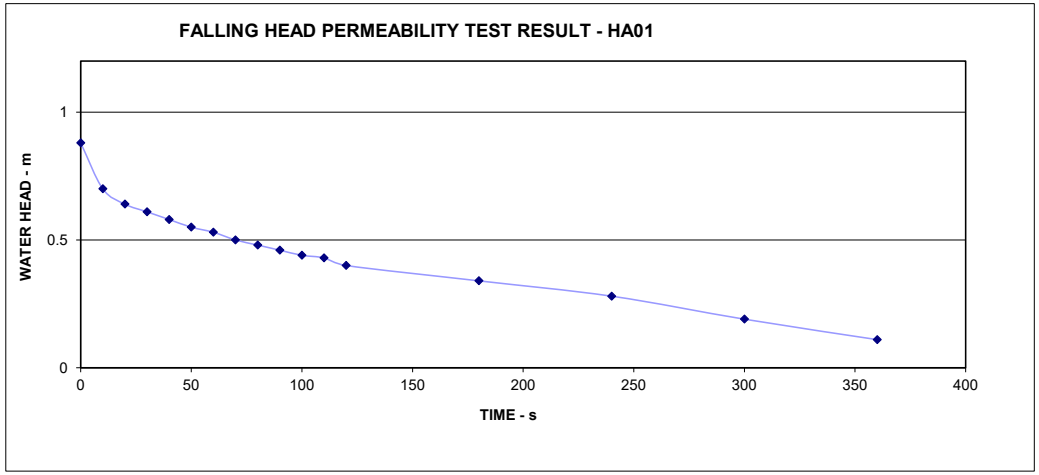
Plate 30

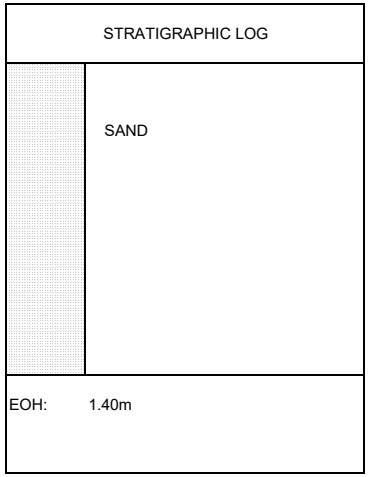
Nearby TP16, depicting road cutting into hill side

Appendix C
In-situ Permeability Test Results

CLIENT: Riverside Investments (WA) No.2 Pty Ltd
SITE NAME: Lot 2 Reserve Road
LOCATION: Chittering
JOB NUMBER: PER2016-0395
DATE: 8/02/2016

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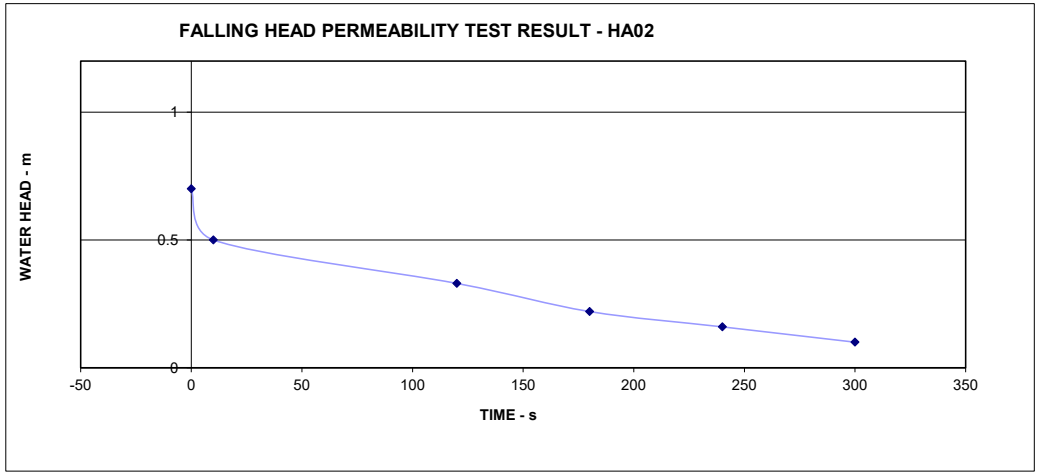
HVORSLEV CASE G:
Soakage out base and sides of test hole with no overlying restrictive layer:

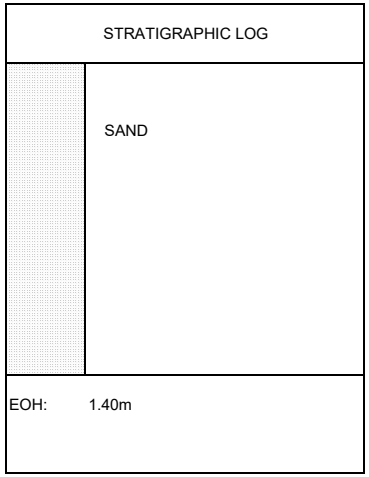
$$\text{Hydraulic conductivity (k)} = \frac{d^2 \times \ln(2.m.L/D)}{8.L.(t2 - t1)} \times \ln \frac{H1}{H2}$$

where
d = D = test hole diameter (m) = 0.085 m
m = transformation ratio = 1
L = average soakage length (m)
t = time (secs)
H1 = piezometric head for t = t1
H2 = piezometric head for t = t2

Elapsed Time (s)	t2 - t1 (secs)	Piezometric Head H (m)	Average L (m)	ln (H1/H2)	Hydraulic Conductivity k (m/sec)	k (m/day)
0		0.88				
10	10	0.7	0.79	0.23	7.65E-05	6.61
20	10	0.64	0.67	0.09	3.33E-05	2.88
30	10	0.61	0.63	0.05	1.86E-05	1.61
40	10	0.58	0.60	0.05	2.02E-05	1.75
50	10	0.55	0.57	0.05	2.20E-05	1.90
60	10	0.53	0.54	0.04	1.57E-05	1.36
70	10	0.5	0.52	0.06	2.55E-05	2.20
80	10	0.48	0.49	0.04	1.84E-05	1.59
90	10	0.46	0.47	0.04	1.97E-05	1.70
100	10	0.44	0.45	0.04	2.11E-05	1.82
110	10	0.43	0.44	0.02	1.11E-05	0.96
120	10	0.4	0.42	0.07	3.59E-05	3.10
180	60	0.34	0.37	0.16	1.43E-05	1.24
240	60	0.28	0.31	0.19	1.87E-05	1.62
300	60	0.19	0.24	0.39	4.25E-05	3.67
360	60	0.11	0.15	0.55	6.92E-05	5.98
				Average =	2.89E-05	2.497865

CLIENT: Riverside Investments (WA) No.2 Pty Ltd
SITE NAME: Lot 2 Reserve Road
LOCATION: Chittering
JOB NUMBER: PER2016-0395
DATE: 8/02/2016





HVORSLEV CASE G:
Soakage out base and sides of test hole with no overlying restrictive layer:

$$\text{Hydraulic conductivity (k)} = \frac{d^2 \times \ln(2.m.L/D)}{8.L.(t2 - t1)} \times \ln \frac{H1}{H2}$$

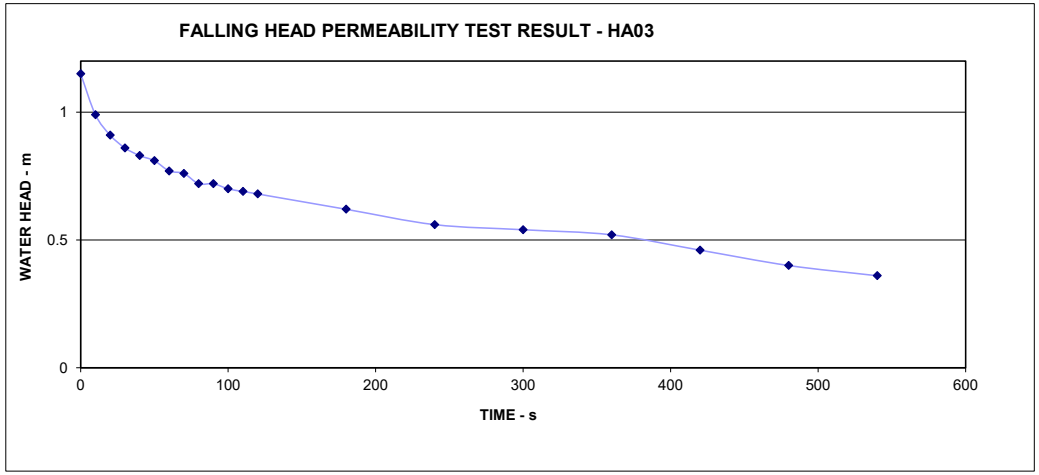
where
d = D = test hole diameter (m) = 0.085 m
m = transformation ratio = 1
L = average soakage length (m)
t = time (secs)
H1 = piezometric head for t = t1
H2 = piezometric head for t = t2

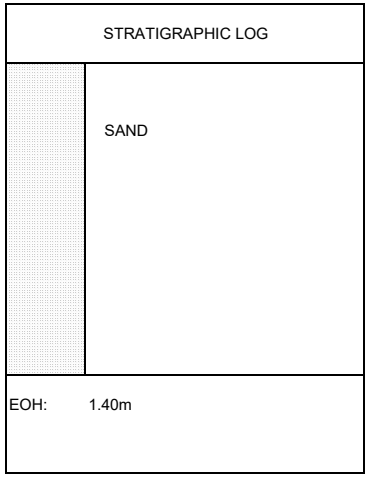
Elapsed Time (s)	t2 - t1 (secs)	Piezometric Head H (m)	Average L (m)	ln (H1/H2)	Hydraulic Conductivity k (m/sec)	k (m/day)
0		0.7				
10	10	0.5	0.60	0.34	1.34E-04	11.58
120	110	0.33	0.42	0.42	1.87E-05	1.62
180	60	0.22	0.28	0.41	4.14E-05	3.58
240	60	0.16	0.19	0.32	3.78E-05	3.26
300	60	0.1	0.13	0.47	6.08E-05	5.26

Average = 5.86E-05 5.060919

CLIENT: Riverside Investments (WA) No.2 Pty Ltd
SITE NAME: Lot 2 Reserve Road
LOCATION: Chittering
JOB NUMBER: PER2016-0395
DATE: 8/02/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward





HVORSLEV CASE G:
Soakage out base and sides of test hole with no overlying restrictive layer:

$$\text{Hydraulic conductivity (k)} = \frac{d^2 \times \ln(2.m.L/D)}{8.L.(t2 - t1)} \times \ln \frac{H1}{H2}$$

where
d = D = test hole diameter (m) = 0.085 m
m = transformation ratio = 1
L = average soakage length (m)
t = time (secs)
H1 = piezometric head for t = t1
H2 = piezometric head for t = t2

Elapsed Time (s)	t2 - t1 (secs)	Piezometric Head H (m)	Average L (m)	ln (H1/H2)	Hydraulic Conductivity k (m/sec)	k (m/day)
0		1.15				
10	10	0.99	1.07	0.15	4.08E-05	3.52
20	10	0.91	0.95	0.08	2.49E-05	2.15
30	10	0.86	0.89	0.06	1.75E-05	1.51
40	10	0.83	0.85	0.04	1.13E-05	0.98
50	10	0.81	0.82	0.02	7.95E-06	0.69
60	10	0.77	0.79	0.05	1.69E-05	1.46
70	10	0.76	0.77	0.01	4.46E-06	0.39
80	10	0.72	0.74	0.05	1.89E-05	1.63
90	10	0.72	0.72	0.00	0.00E+00	0.00
100	10	0.7	0.71	0.03	1.01E-05	0.87
110	10	0.69	0.70	0.01	5.22E-06	0.45
120	10	0.68	0.69	0.01	5.35E-06	0.46
180	60	0.62	0.65	0.09	5.83E-06	0.50
240	60	0.56	0.59	0.10	6.83E-06	0.59
300	60	0.54	0.55	0.04	2.55E-06	0.22
360	60	0.52	0.53	0.04	2.70E-06	0.23
420	60	0.46	0.49	0.12	9.21E-06	0.80
480	60	0.4	0.43	0.14	1.13E-05	0.98
540	60	0.36	0.38	0.11	9.14E-06	0.79
600	60	0.28	0.32	0.25	2.39E-05	2.06
				Average =	1.11E-05	0.959381

Appendix D
Laboratory Test Results

DS01-12/20

Cardno Geotech Pty Ltd
ABN: 48 137 480 034
Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: Geotech Bunbury
Phone: 08 9726 2187 Fax: 08 9721 2348
Email: paul.kent@cardno.com

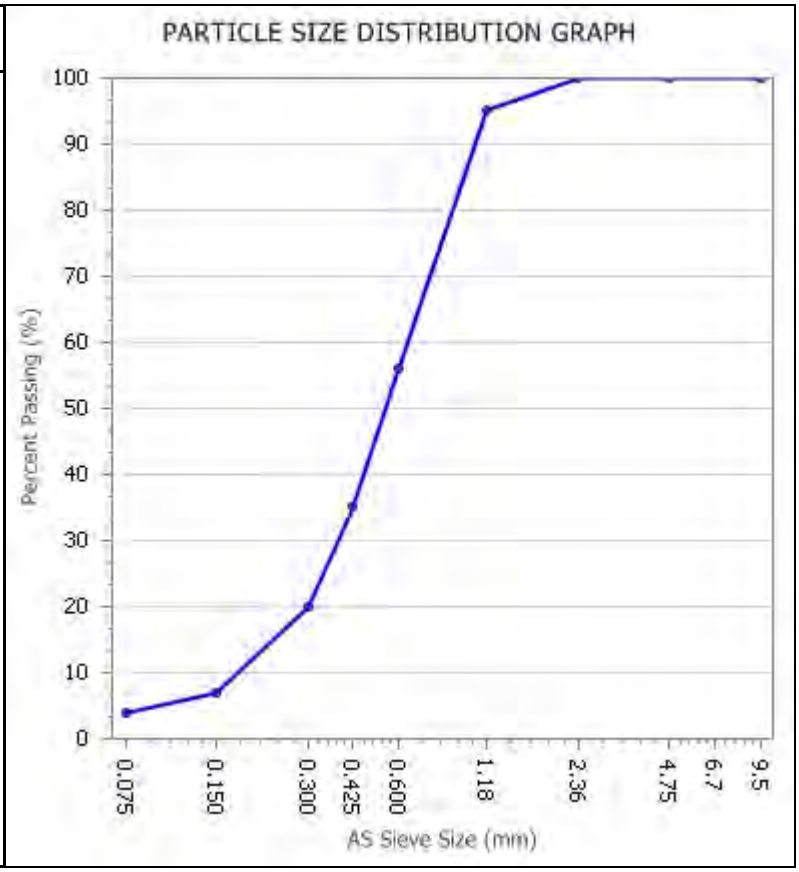
Attachment 1

PARTICLE SIZE DISTRIBUTION REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5176-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP09 Depth 0.6-0.8m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	19/02/2016 Page 1 of 1

Test Procedures:	AS1289.3.6.1		
Sample Number	5029/S/11199	Sample Location	
Sampling Method	Tested As Received	Test Request	
Date Sampled	11/02/2016	Area	
Sampled By	Client Sampled		
Date Tested	17/02/2016		
Material Source	-	Material Type	Yellow SAND

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
9.5		**100**	
4.75		**100**	
2.36		**100**	
1.18		**95**	
0.600		**56**	
0.425		**35**	
0.300		**20**	
0.150		**7**	
0.075		**4**	



Remarks

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Accreditation Number: 5029

Approved Signatory: Paul Kent
Form ID: W9Rep Rev 2

DS01-12/20

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Davenport WA 6230

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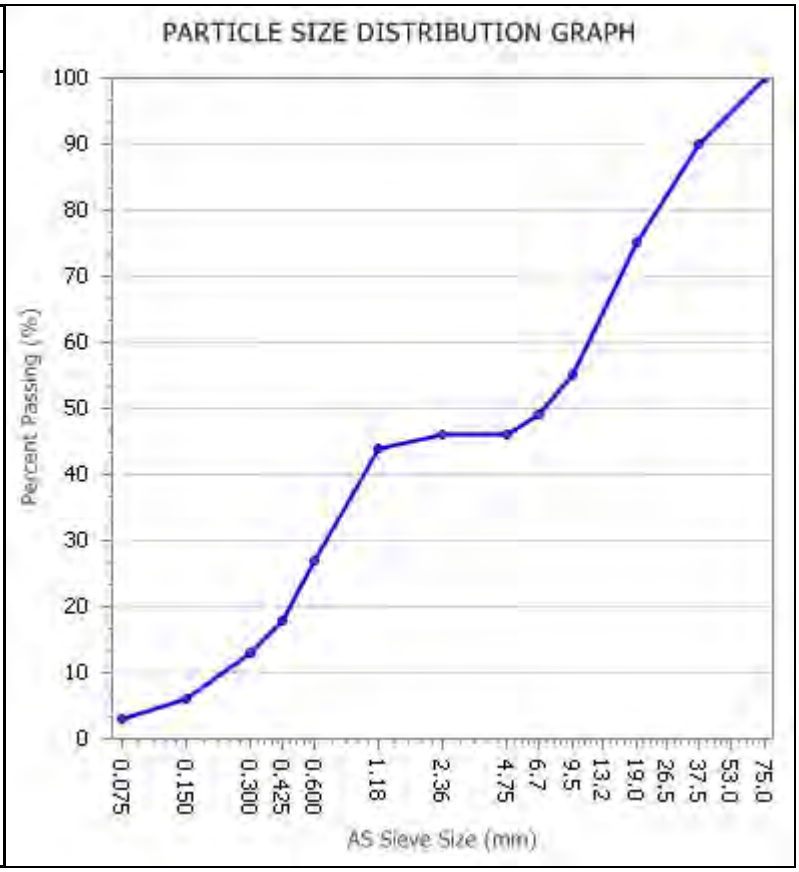
Attachment 1

PARTICLE SIZE DISTRIBUTION REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5197-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP13 Depth 0.3-0.5m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	22/02/2016 Page 1 of 1

Test Procedures:	AS1289.3.6.1		
Sample Number	5029/S/11200	Sample Location	
Sampling Method	Tested As Received	Test Request	
Date Sampled	11/02/2016	Area	
Sampled By	Client Sampled		
Date Tested	16/02/2016		
Material Source	-	Material Type	Brown Sandy GRAVEL

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
75.0		**100**	
37.5		**90**	
19.0		**75**	
9.5		**55**	
6.7		**49**	
4.75		**46**	
2.36		**46**	
1.18		**44**	
0.600		**27**	
0.425		**18**	
0.300		**13**	
0.150		**6**	
0.075		**3**	



Remarks

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DS01-12/20

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Laboratory: Geotech Bunbury
Phone: 08 9726 2187 Fax: 08 9721 2348
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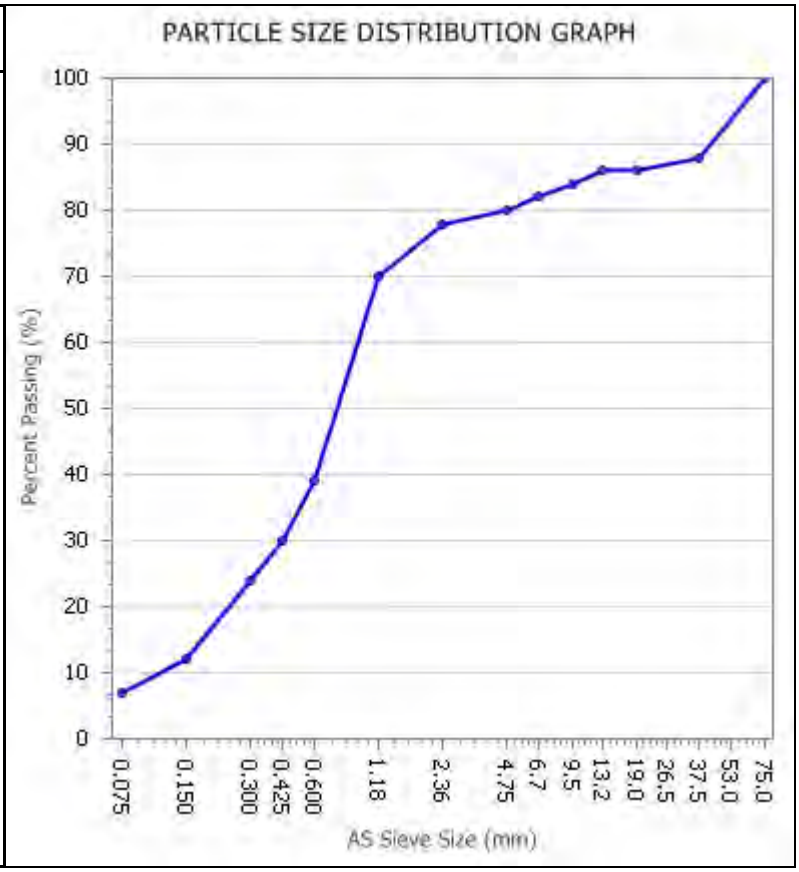
Attachment 1

PARTICLE SIZE DISTRIBUTION REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5180-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP15 Depth 0.1-0.3m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	22/02/2016 Page 1 of 1

Test Procedures:	AS1289.3.6.1		
Sample Number	5029/S/11201	Sample Location	
Sampling Method	Tested As Received	Test Request	
Date Sampled	11/02/2016	Area	
Sampled By	Client Sampled		
Date Tested	16/02/2016		
Material Source	-	Material Type	Brown gravelly SAND

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
75.0		**100**	
37.5		**88**	
19.0		**86**	
13.2		**86**	
9.5		**84**	
6.7		**82**	
4.75		**80**	
2.36		**78**	
1.18		**70**	
0.600		**39**	
0.425		**30**	
0.300		**24**	
0.150		**12**	
0.075		**7**	



Remarks

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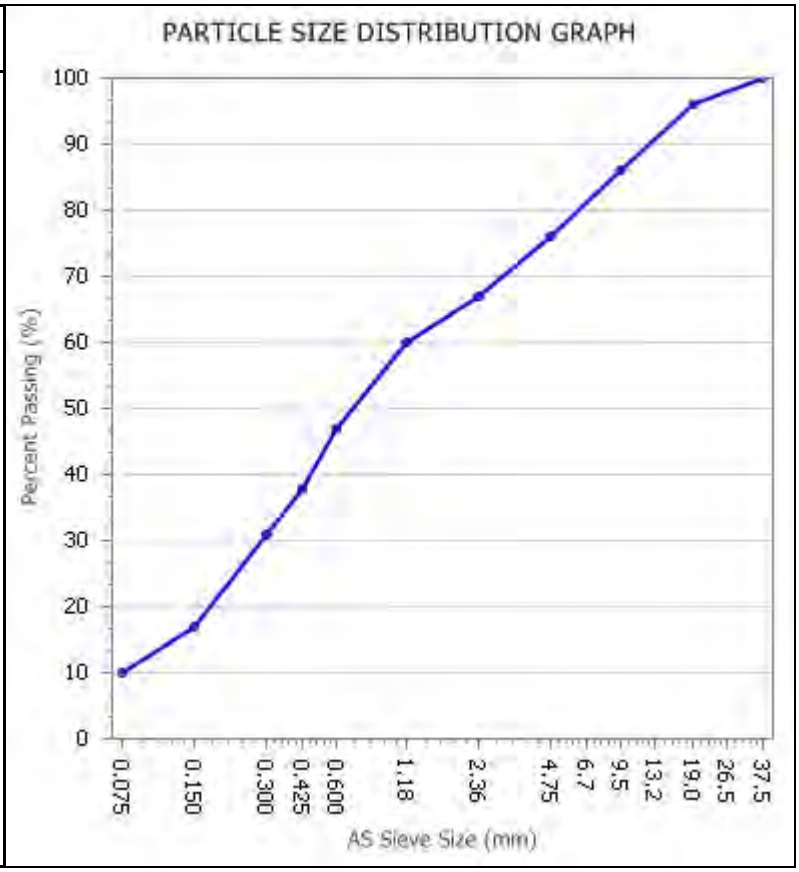
Attachment 1

PARTICLE SIZE DISTRIBUTION REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5181-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP16 Depth 0.0-0.1m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	22/02/2016 Page 1 of 1

Test Procedures:	AS1289.3.6.1		
Sample Number	5029/S/11202	Sample Location	
Sampling Method	Tested As Received	Test Request	
Date Sampled	11/02/2016	Area	
Sampled By	Client Sampled		
Date Tested	17/02/2016		
Material Source	-	Material Type	Brown Gravelly Clayey SAND

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
37.5		**100**	
19.0		**96**	
9.5		**86**	
4.75		**76**	
2.36		**67**	
1.18		**60**	
0.600		**47**	
0.425		**38**	
0.300		**31**	
0.150		**17**	
0.075		**10**	



Remarks

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Approved Signatory: Paul Kent
Form ID: W9Rep Rev 2

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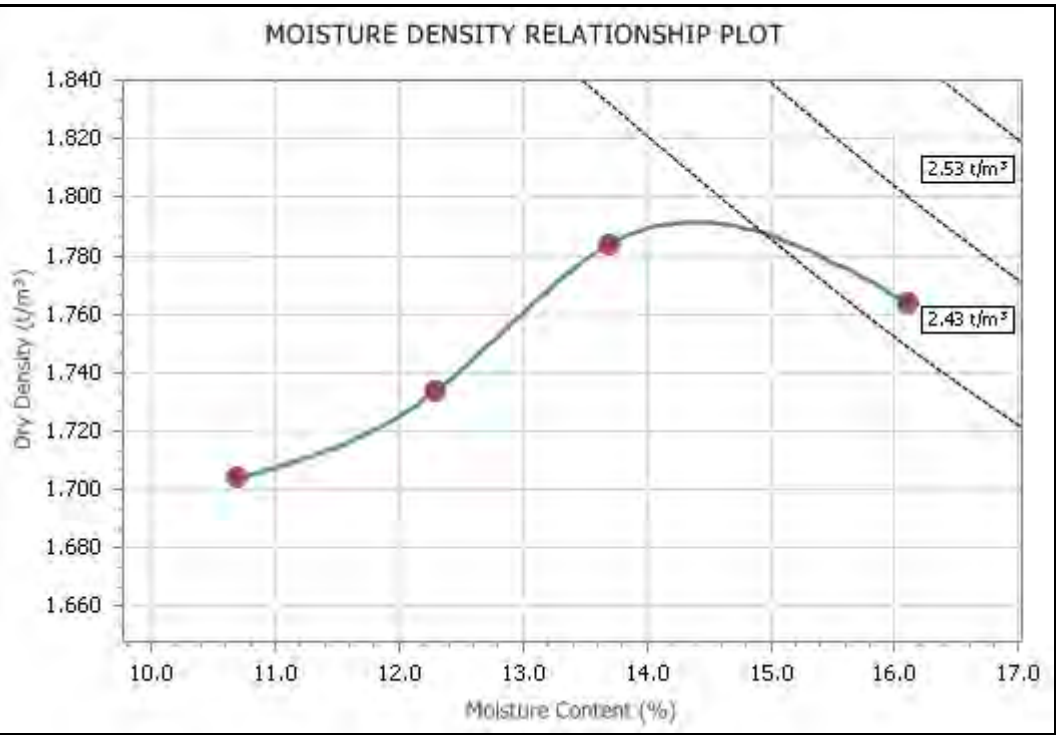
MOISTURE DENSITY RELATIONSHIP REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5106-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP09 Depth 0.6-0.8m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	17/02/2016 Page 1 of 1

Test Procedures	AS1289.5.2.1, AS1289.2.1.1	Sample Location	
Sample Number	5029/S/11199	Test Request	
Sampling Method	Tested As Received	Area	
Date Sampled	11/02/2016		
Sampled By	Client Sampled		
Date Tested	16/02/2016	Compactive Effort	Modified
Material Source		Fraction Tested (mm)	< 19.0mm
Material Type		Percent Oversize (%)	0.0
Material Description	White SAND		

Moisture / Density Relationship Data

Moisture Content (%)	Dry Density (t/m³)
10.7	1.704
12.3	1.734
13.7	1.784
16.1	1.764



Maximum Dry Density (t/m³):	1.79	Optimum Moisture Content (%):	14.5

Remarks

NATA

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Accreditation Number: 5029

Approved Signatory: Janine Fischer
Form ID: W4Rep Rev 1

Cardno Geotech Pty Ltd
ABN: 48 137 480 034
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Email: paul.kent@cardno.com

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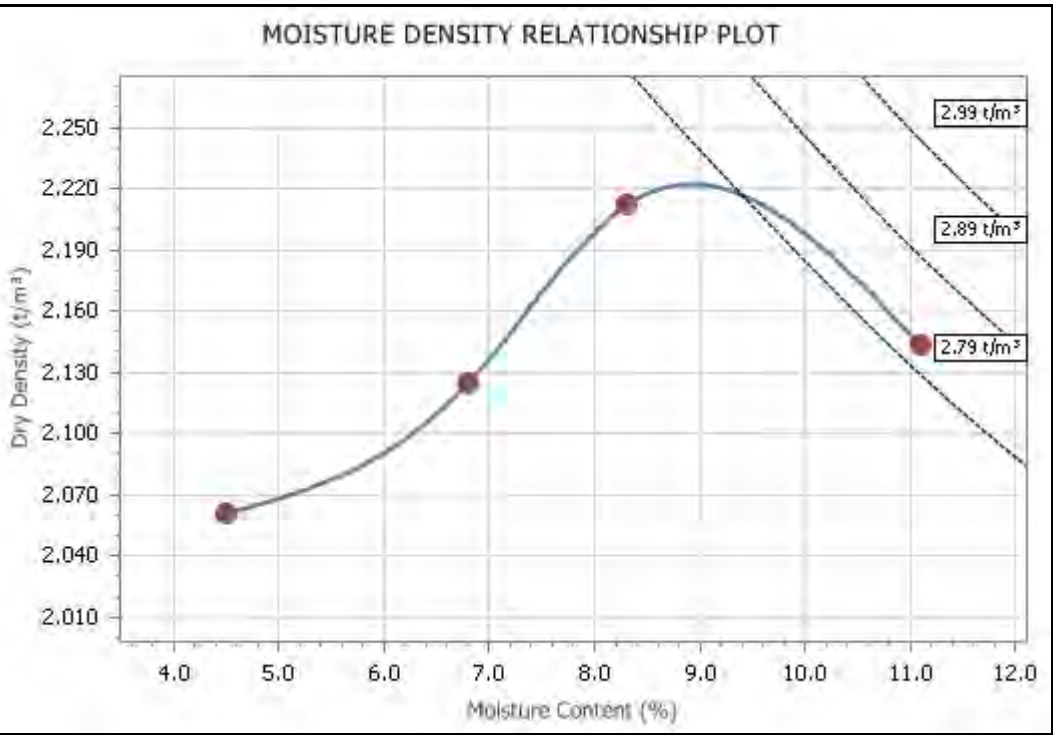
MOISTURE DENSITY RELATIONSHIP REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5107-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP13 Depth 0.3-0.5m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	17/02/2016 Page 1 of 1

Test Procedures	AS1289.5.2.1, AS1289.2.1.1	Sample Location	
Sample Number	5029/S/11200	Test Request	
Sampling Method	Tested As Received	Area	
Date Sampled	11/02/2016		
Sampled By	Client Sampled		
Date Tested	15/02/2016	Compactive Effort	Modified
Material Source		Fraction Tested (mm)	< 19.0mm
Material Type		Percent Oversize (%)	14.6
Material Description	Brown Rocky SAND		

Moisture / Density Relationship Data

Moisture Content (%)	Dry Density (t/m³)
4.5	2.061
6.8	2.125
8.3	2.212
11.1	2.143



Maximum Dry Density (t/m³):	2.22	Optimum Moisture Content (%):	9.0

Remarks

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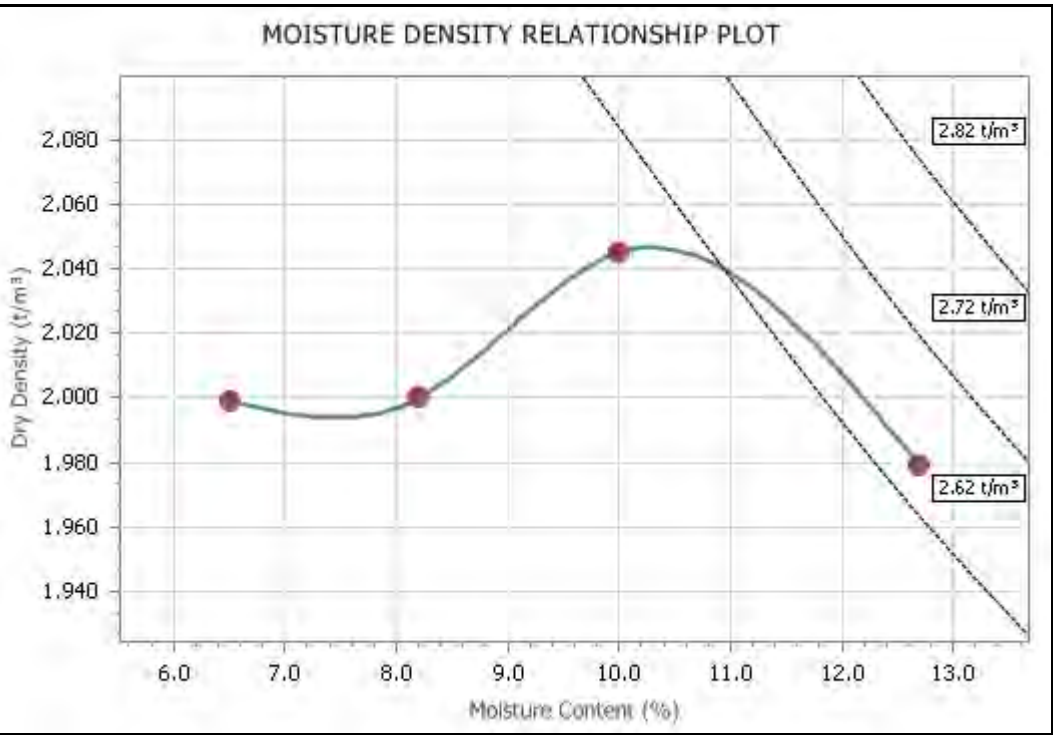
MOISTURE DENSITY RELATIONSHIP REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5108-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP15 Depth 0.1-0.3m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	17/02/2016 Page 1 of 1

Test Procedures	AS1289.5.2.1, AS1289.2.1.1	Sample Location	
Sample Number	5029/S/11201	Test Request	
Sampling Method	Tested As Received	Area	
Date Sampled	11/02/2016		
Sampled By	Client Sampled		
Date Tested	16/02/2016	Compactive Effort	Modified
Material Source		Fraction Tested (mm)	< 19.0mm
Material Type		Percent Oversize (%)	6.7
Material Description	Brown Gravelly SAND		

Moisture / Density Relationship Data

Moisture Content (%)	Dry Density (t/m³)
6.5	1.999
8.2	2.000
10.0	2.045
12.7	1.979



Maximum Dry Density (t/m³):	2.05	Optimum Moisture Content (%):	10.5

Remarks

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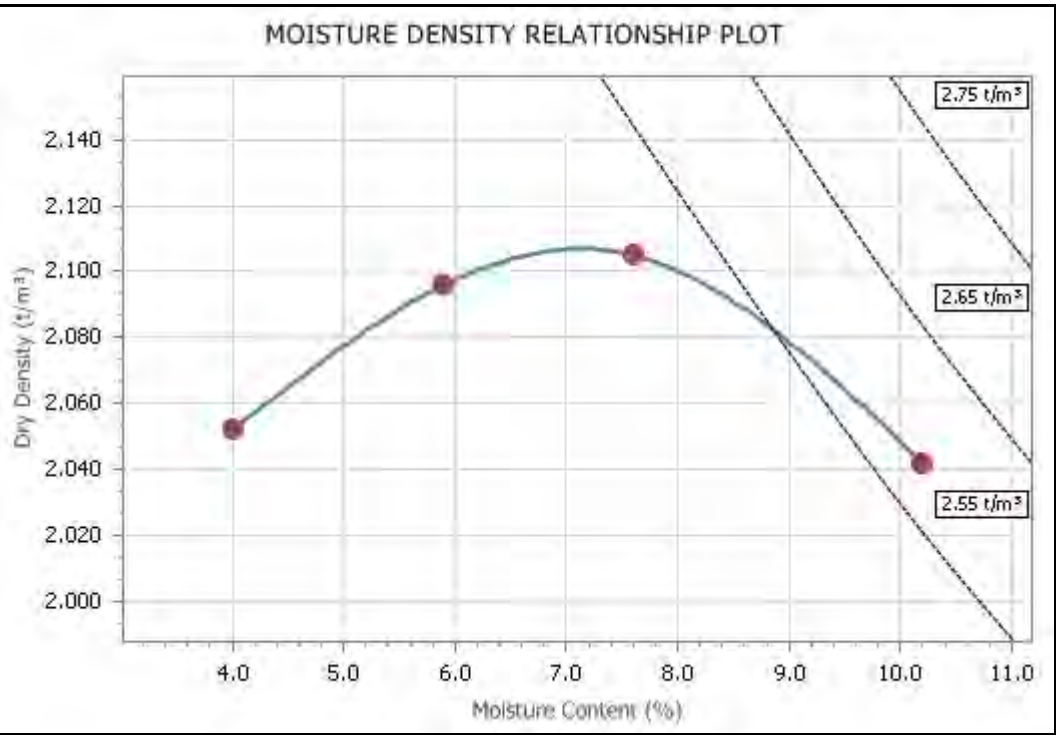
MOISTURE DENSITY RELATIONSHIP REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5109-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP16 Depth 0.0-0.1m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	17/02/2016 Page 1 of 1

Test Procedures	AS1289.5.2.1, AS1289.2.1.1	Sample Location	
Sample Number	5029/S/11202	Test Request	
Sampling Method	Tested As Received	Area	
Date Sampled	11/02/2016		
Sampled By	Client Sampled		
Date Tested	15/02/2016	Compactive Effort	Modified
Material Source		Fraction Tested (mm)	< 19.0mm
Material Type		Percent Oversize (%)	2.7
Material Description	Brown GRAVEL		

Moisture / Density Relationship Data

Moisture Content (%)	Dry Density (t/m³)
4.0	2.052
5.9	2.096
7.6	2.105
10.2	2.042



Maximum Dry Density (t/m³):	2.11	Optimum Moisture Content (%):	7.0

Remarks

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DS01-12/20

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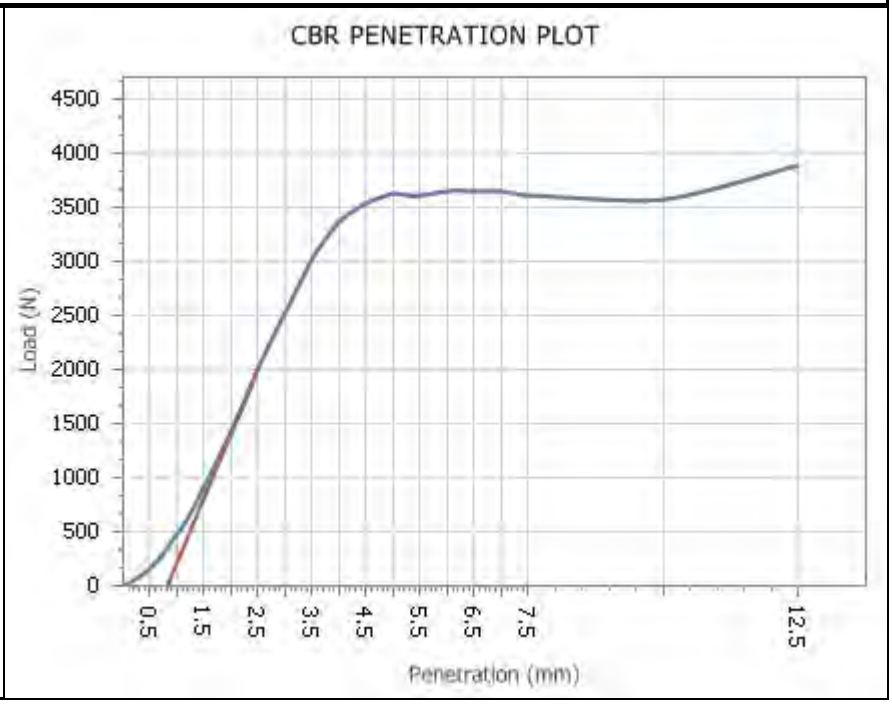
CALIFORNIA BEARING RATIO REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5188-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP09 Depth 0.6-0.8m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	22/02/2016 Page 1 of 1

Test Procedures	AS1289.6.1.1, AS1289.5.2.1, AS1289.2.1.1

		Sample Location	
Sample Number	5029/S/11199	Test Request	
Sampling Method	Tested As Received	Area	
Date Sampled	11/02/2016		
Sampled By	Client Sampled		
Date Tested	22/02/2016		
Material Source	-	Material Limit Start	-
Material Type	White SAND	Material Limit End	-
Client Reference	-	Compactive Effort	Modified
Material Description	White SAND		

Maximum Dry Density (t/m³):	1.79
Optimum Moisture Content (%):	14.5
Field Moisture Content (%):	2.3
Sample Percent Oversize (%)	0.0
Oversize Included / Excluded	Excluded
Target Density Ratio (%):	95
Target Moisture Ratio (%):	100
Placement Dry Density (t/m³):	1.72
Placement Dry Density Ratio (%):	96.5
Placement Moisture Content (%):	12.9
Placement Moisture Ratio (%):	89.5
Test Condition / Soaking Period:	Soaked / 4 Days
CBR Surcharge (kg)	4.5
Dry Density After Soak (t/m³):	1.73
Moisture (top 30mm) After Soak (%)	13.6
Moisture (remainder) After Soak (%)	15.6
CBR Swell (%):	0.0
Minimum CBR Specification (%):	-
CBR Value @ 2.5mm (%):	**20**



Remarks

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Approved Signatory: Janine Fischer
Form ID: W7Rep Rev 1

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Laboratory: Geotech Bunbury
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CALIFORNIA BEARING RATIO REPORT

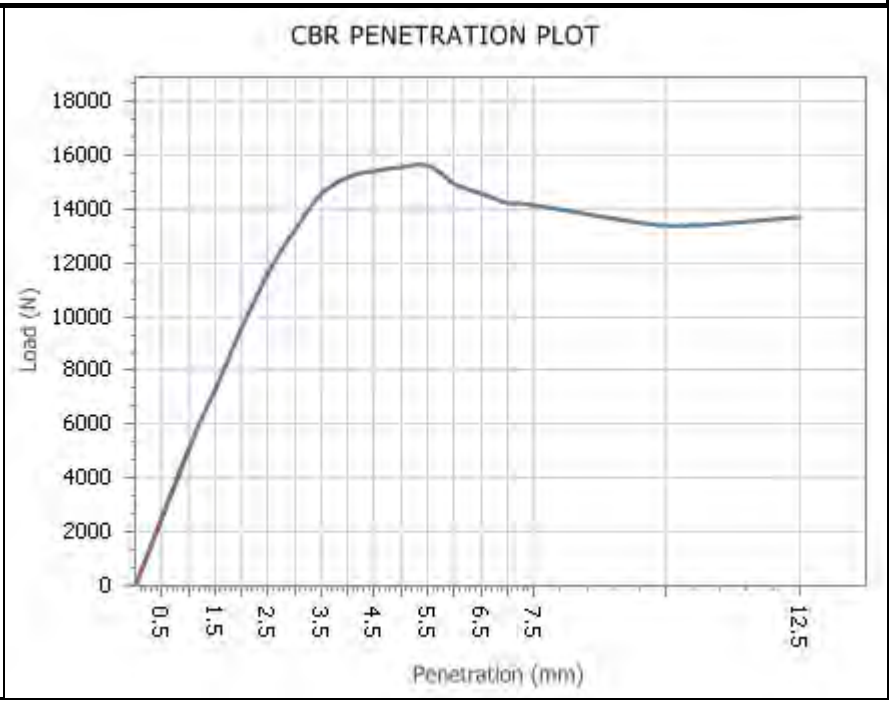
Client:	CMW Geosciences	Report Number:	5029/R/5185-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP13 Depth 0.3-0.5m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	22/02/2016 Page 1 of 1

Test Procedures	AS1289.6.1.1, AS1289.5.2.1, AS1289.2.1.1

		Sample Location	
Sample Number	5029/S/11200	Test Request	
Sampling Method	Tested As Received	Area	
Date Sampled	11/02/2016		
Sampled By	Client Sampled		
Date Tested	22/02/2016		
Material Source	-	Material Limit Start	-
Material Type	-	Material Limit End	-
Client Reference	-	Compactive Effort	Modified

Material Description	Brown Rocky SAND

Maximum Dry Density (t/m³):	2.22
Optimum Moisture Content (%):	9.0
Field Moisture Content (%):	2.9
Sample Percent Oversize (%)	15.0
Oversize Included / Excluded	Excluded
Target Density Ratio (%):	95
Target Moisture Ratio (%):	100
Placement Dry Density (t/m³):	2.12
Placement Dry Density Ratio (%):	95.5
Placement Moisture Content (%):	8.5
Placement Moisture Ratio (%):	95.5
Test Condition / Soaking Period:	Soaked / 4 Days
CBR Surcharge (kg)	4.5
Dry Density After Soak (t/m³):	2.12
Moisture (top 30mm) After Soak (%)	9.5
Moisture (remainder) After Soak (%)	9.9
CBR Swell (%):	0.0
Minimum CBR Specification (%):	-
CBR Value @ 2.5mm (%):	**90**



Remarks

NATA

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Accredited for compliance with ISO/IEC 17025

Accreditation Number: 5029

Approved Signatory: Janine Fischer
Form ID: W7Rep Rev 1

DS01-12/20

Cardno Geotech Pty Ltd
ABN: 48 137 480 034
Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: Geotech Bunbury
Phone: 08 9726 2187 Fax: 08 9721 2348
Email: paul.kent@cardno.com

Attachment 1

CALIFORNIA BEARING RATIO REPORT

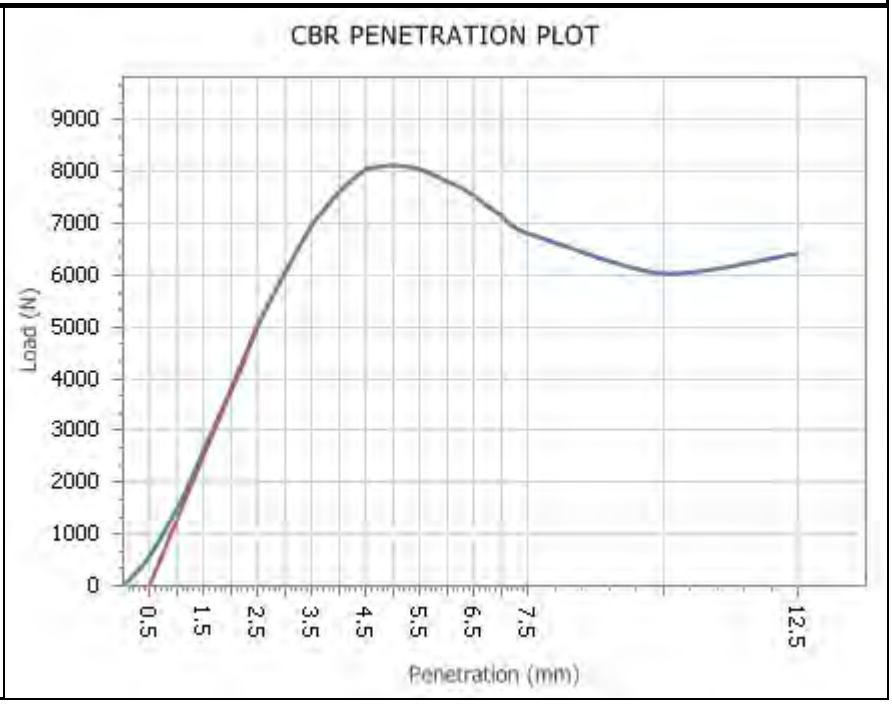
Client:	CMW Geosciences	Report Number:	5029/R/5186-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP15 Depth 0.1-0.3m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	22/02/2016 Page 1 of 1

Test Procedures	AS1289.6.1.1, AS1289.5.2.1, AS1289.2.1.1

Sample Number	5029/S/11201	Sample Location	
Sampling Method	Tested As Received	Test Request	
Date Sampled	11/02/2016	Area	
Sampled By	Client Sampled		
Date Tested	22/02/2016		
Material Source	-	Material Limit Start	-
Material Type	Brown gravelly SAND	Material Limit End	-
Client Reference	-	Compactive Effort	Modified

Material Description	Brown Gravelly SAND

Maximum Dry Density (t/m³):	2.05
Optimum Moisture Content (%):	10.5
Field Moisture Content (%):	2.6
Sample Percent Oversize (%)	7.0
Oversize Included / Excluded	Excluded
Target Density Ratio (%):	98
Target Moisture Ratio (%):	100
Placement Dry Density (t/m³):	2.01
Placement Dry Density Ratio (%):	98.0
Placement Moisture Content (%):	10.1
Placement Moisture Ratio (%):	98.0
Test Condition / Soaking Period:	Soaked / 4 Days
CBR Surcharge (kg)	4.5
Dry Density After Soak (t/m³):	1.99
Moisture (top 30mm) After Soak (%)	11.4
Moisture (remainder) After Soak (%)	10.3
CBR Swell (%):	1.0
Minimum CBR Specification (%):	-
CBR Value @ 2.5mm (%):	**45**



Remarks

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Accredited for compliance with ISO/IEC 17025

NATA

Accreditation Number: 5029

Approved Signatory: Janine Fischer
Form ID: W7Rep Rev 1

DS01-12/20

Cardno Geotech Pty Ltd
ABN: 48 137 480 034
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72 McCombe Road,
Davenport WA 6230

Laboratory: Geotech Bunbury
Phone: 08 9726 2187 Fax: 08 9721 2348
Email: paul.kent@cardno.com

Attachment 1

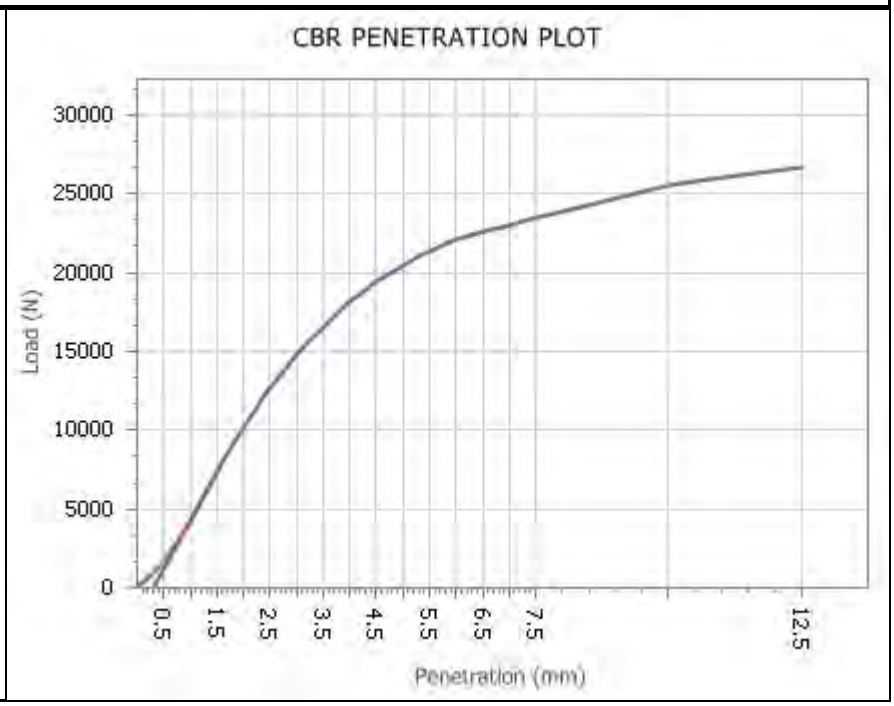
CALIFORNIA BEARING RATIO REPORT

Client:	CMW Geosciences	Report Number:	5029/R/5187-1
Client Address:	19/127 Herdsman Parade, WEMBLEY	Project Number:	5029/P/432
Project:	Riverside Investments (WA) No.2 P/L	Lot Number:	TP16 Depth 0.0-0.1m
Location:	Lot 2 Reserve Road, Chittering WA	Internal Test Request:	5029/T/1921
Component:		Client Reference/s:	PER2016-0395
Area Description:		Report Date / Page:	22/02/2016 Page 1 of 1

Test Procedures	AS1289.6.1.1, AS1289.5.2.1, AS1289.2.1.1

		Sample Location	
Sample Number	5029/S/11202	Test Request	
Sampling Method	Tested As Received	Area	
Date Sampled	11/02/2016		
Sampled By	Client Sampled		
Date Tested	22/02/2016		
Material Source	-	Material Limit Start	-
Material Type	Brown Gravelly Clayey SAND	Material Limit End	-
Client Reference	-	Compactive Effort	Modified
Material Description	Brown GRAVEL		

Maximum Dry Density (t/m³):	2.11
Optimum Moisture Content (%):	7.0
Field Moisture Content (%):	1.9
Sample Percent Oversize (%)	3.0
Oversize Included / Excluded	Excluded
Target Density Ratio (%):	98
Target Moisture Ratio (%):	100
Placement Dry Density (t/m³):	2.06
Placement Dry Density Ratio (%):	98.0
Placement Moisture Content (%):	7.2
Placement Moisture Ratio (%):	101.5
Test Condition / Soaking Period:	Soaked / 4 Days
CBR Surcharge (kg)	4.5
Dry Density After Soak (t/m³):	2.08
Moisture (top 30mm) After Soak (%)	10.2
Moisture (remainder) After Soak (%)	10.0
CBR Swell (%):	-1.0
Minimum CBR Specification (%):	-
CBR Value @ 5.0mm (%):	**110**



Remarks

NATA

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Accredited for compliance with ISO/IEC 17025

Accreditation Number: 5029

Approved Signatory: Janine Fischer
Form ID: W7Rep Rev 1

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3 August 2016 Document Ref: PER2016-0395AD Rev2

Riverside Investment (WA) No. 2 Pty Ltd
c/o 3rd Wave Capital
48 King St
Perth
WA 6000

Attention: Stephen Seward

Dear Stephen,

RE: SUPPLEMENTARY WINTER GEOTECHNICAL REPORT FOR PROPOSED SUBDIVISION LOT 2, RESERVE RD, CHITTERING, WA

1 INTRODUCTION

CMW Geosciences Pty Ltd (CMW) was authorised by Riverside Investments (WA) No. 2 Pty Ltd to carry out additional geotechnical investigation (winter investigation) at Lot 2, Reserve Road, Chittering, WA in accordance with our short form proposal letter dated 30 June 2016 (Ref. PER2016-0395AC Rev0). The site is proposed to be developed into R2 residential (ranging from 5,000m^2 to 8,857m^2) and Public Open Space (POS) areas.

CMW has previously investigated this site under the authorisation of Riverside Investments (WA) No.2 Pty Ltd during March (summer investigation) earlier this year. The following scope of work is additional and supplementary to this initial investigation (Ref. PER2016-0395AB Rev1) with the intention of providing a more detailed analysis of ground conditions and soil permeability during late winter conditions for Department of Health (DOH) approval.

2 COUNTRY SEWERAGE POLICY (CSP) REQUIREMENTS

As required by the CSP, a geotechnical investigation and report under late winter conditions has been undertaken to determine soakage test recommendations with relation to Schedule 8 and to assess the possibility of a perched water table during and following periods of rainfall. The CSP requires a minimum depth to the seasonal or permanent water table, from the natural ground surface, of at least 0.5m for onsite effluent disposal. Based on advice from the Department of Health (DoH) an area in the order of 150m^2 satisfying this minimum soil depth to water is typically considered sufficient for onsite effluent disposal. The effluent disposal area would typically be situated in the vicinity residential dwellings.

A late winter geotechnical report is required to demonstrate that the development complies with the CSP criteria for onsite waste water disposal. Our recent geotechnical site investigation complies with this by providing representative information across the site relating to:

- Site topography and detail information
- Soil profile to a depth of at least 2m

- Soil permeability
- The water table encountered to a depth of 2m

3 SITE DESCRIPTION

The proposed development site comprises an area of approximately 135ha and is located on Reserve Road, Chittering, WA.

The site slopes from the west/northwest to the east/southeast with existing ground levels ranging from RL 165m AHD in the northwest corner to RL136m AHD at the southeast corner.

The site is bound to the west and southwest by Reserve Road, open paddock to the south, semi-rural lots to the east and vegetated bushland to the north. The lot is segregated into smaller rectangular sub-lots, many of which are fenced and irrigated and showing evidence of previous or current planting with a variety of native/introduced plants, shrubs and trees. A gravel pit is situated within the northeast part of the site. A sand pit is located within the central southern portion of the lot. A collection of abandoned/dumped farm machinery and equipment, building products and general household/farm waste is situated in the vicinity of the latter sand pit, both at the surface and within shallow excavations.

A single storey residential dwelling is situated to the south west of the lot as well as several farm sheds and equipment. A production water well is present to the extreme south west corner of the lot.

4 FIELDWORK

All fieldwork was carried out under the direction of CMW Geosciences Pty Ltd in general accordance with AS1726 (1993), Geotechnical Site Investigations. The scope of fieldwork completed was as follows:

- Complete an additional 14 tests pits, denoted TP17 to TP30 to depths of up to 2m. This was conducted using a backhoe fitted with a 600mm wide toothed rock bucket to assess ground conditions across the site. Engineering logs and photographs of the test pits are presented in Appendix A;
- Complete 11 in-situ soakage tests in accordance with Schedule 8 of the Health Regulations (Treatment of Sewage and Disposal of Effluent and Liquid Waste) 1974 to assist with DOH application approval. Results of the soakage tests and subsequent infiltration rating are presented in Table 2;
- Complete an additional investigation of the landfill waste area previously identified to assess the extent and nature of the deposited material;
- Compile all information into a geotechnical report (this letter) outlining the scope of work completed, the ground conditions encountered, including groundwater, soil permeability and providing recommendations to the CSP criteria for onsite wastewater disposal.

The approximate locations of the respective investigation sites referred to above are shown on the attached Site Investigation Plan (Figure No. 01). Test locations were positioned to provide additional coverage of the site with respect to the previous summer investigation.

5 SOIL PROFILE

5.1 Geology

Based on our review of the geological references for the area (Ref. Muchea Sheet 2034 I and Part of 2134 IV) and the CMW investigation database depict the land as being underlain by colluvial sands with laterite outcrops to the west and south of the site.

5.2 Subsurface Conditions

The ground conditions encountered and inferred from the investigation were generally consistent with the published geology and our previous investigation of the site. The ground model described below is based on this winter's current investigation only with related depths and conditions encountered from the CMW site investigation on 17 July 2016. The ground model can be generalised according to the following subsurface sequence:

SAND (SP)	fine to coarse grained (predominantly medium grained), white, pale grey and yellow-brown sand; trace root and rootlets to 1.0m depth, overlying;
GRAVEL/COBBLES/BOULDERS	fine to coarse grained, sub-angular to sub-rounded, red-brown (of lateritic origin), uncemented to well cemented; with sand.

The distribution of these units is summarised in Table 1 below:

Table 1: Summary of Soil Stratigraphy Encountered

Description	Depth to base of layer (m)		
	Minimum	Maximum	Average
SAND*	0.3	>2.0	-
Laterite GRAVEL/COBBLES/BOULDERS**	-	-	-

Notes: *Base of strata not encountered in TP17, TP19 – TP22, TP24, TP27 – TP30
**Strata not encountered at all test locations, where encountered base not determined.

Test pit logs and photographs are included in Appendix A.

6 PERCOLATION TEST RESULTS

The results of percolation tests conducted in accordance with Schedule 8 are summarised in Table 2 below:

Table 2. Summary of Percolation Test Results In Accordance With Schedule 8

Test Location	Depth (mm)	Soil Type	Time For Water to Fall 25mm	Loading Infiltration Rate ($L/m^2/day$)	
				Alternating System	Non-alternating System
SO01	260	Sand	4:30min	30	15
SO02	300	Sand	32s	30	15
SO03	300	Sand	29s	30	15
SO04	300	Sand	42s	30	15
SO05	180	Laterite	>60min	*As approved by Executive Director	
SO06	270	Sand	39s	30	15
SO07	290	Sand	37s	30	15

SO08	290	Sand	2:10min	30	15
SO09	280	Sand	34s	30	15
SO10	300	Sand	40s	30	15
SO11	300	Sand	2:55min	30	15
*Any rock layer must have a loading infiltration rate approved by the executive director in accordance with Clause 5 of Schedule 8.					

7 WATER TABLE

Groundwater was not encountered during our winter investigation in any of the test pit or percolation test locations. We note that perched water was not encountered within test pit locations TP18 or TP26 where refusal was met on laterite at approximately 0.4m and 1.6m depth respectively. Similarly perched water was not encountered at percolation test locations SO01 and SO05 where refusal was inferred / met at approximately 0.3m and 0.2m respectively.

8 RECOMMENDATIONS

8.1 General Lots

The majority of the site has a minimum soil depth to seasonal, permanent or perched water table of least 0.5m based on the CMW winter investigation and fall within the 'Sand' soil type as defined by Table 1 in Schedule 8. Proposed lots other than those specifically referred to in the Western Lots section below of the site can be designed with a loading infiltration rate of 30 L/m^2/day for an alternating system and 15 L/m^2/day for a non-alternating system in accordance with Schedule 8.

8.2 Western Lots

Specific proposed lots situated towards the western boundary of Reserve Road are identified on the Site Investigation Plan (Figure No. 01) and may have shallow laterite (caprock and gravel through to boulders) present within the top 0.5m over parts of the lot as observed/inferred at test locations TP18, SO01 and SO05 during the winter investigation and at test locations TP08 during the summer investigation within this area. During both CMW investigations laterite outcropping was observed along Reserve Road where it bounds the western extent of the site.

Laterite outcropping is likely present in the western extents of lots that adjoin Reserve Road and may also be locally present elsewhere on these lots or immediately adjoining lots. However based on our site investigations and understanding of the local geology it is anticipated that at least 150m^2 of suitable effluent disposal area with a minimum soil depth to seasonal, permanent or perched water table of least 0.5m and classified as 'Sand' soil type as defined by Table 1 in Schedule 8 will be found somewhere on the proposed lots. Additional geotechnical investigation should be undertaken to confirm this assumption by investigating the stratigraphy within the top 0.5m of proposed building envelopes. Prospective buyers and the Shire of Chittering should be made aware of this requirement and likely remediation measures as covered below if required.

Where a suitable effluent disposal area cannot be found on a given lot then the following recommendations are made for minor earthworks:

- Placement of 500mm of fill material comprising of clean granular soil with <10% fines content (<75 micron) over the desired effluent disposal area. All proposed fill must be moisture conditioned and compacted in layers not exceeding 300mm to achieve at least 95% compaction with respect to MMDD. This shall be judged to occur where at least 8 blows per 300mm penetration is achieved

when tested with a PSP. Upon the completion of above earthworks requirements the site can then be designed with a loading infiltration rate of 30 L/m^2/day for an alternating system and 15 L/m^2/day for a non-alternating system in accordance with Schedule 8;

- Alternatively where laterite is present and the depth and underlying strata can be proved by a machine borehole local excavation using an excavator and rock breaker may be attempted to break through the layer. This solution would need to be assessed on a lot by lot basis with additional percolation testing undertaken; and
- Any alternative combination of earthworks and effluent disposal system as approved by the DoH and / or Shire of Chittering.

Where subsequent investigations identify a minimum soil depth to seasonal, permanent or perched water table of least 0.5m and fall within the 'Sand' soil type as defined by Table 1 in Schedule 8 or 500mm of clean granular fill is placed then the general recommendations above with respect to loading infiltration can be applied.

We have assumed that proposed lots will be at approximately existing site levels.

9 LANDFILL WASTE AREA

The landfill waste area identified in our initial summer investigation was further investigated to determine the extent of the area and the potential for contamination as required by the DOH. Our site investigation included the visual inspection of the area and excavation of certain areas with the backhoe to determine if the landfill was buried to a certain depth. The results of inspection concluded that the landfill waste area consists of scrap metal and farming waste on the surface with an extent as defined by the shaded area in the attached Figure No. 1 – Site Plan.

10 CLOSURE

The findings contained within this report are the result of limited discrete investigations conducted in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site. Under no circumstances, can it be considered that these findings represent the actual state of the ground conditions away from our investigation locations.

If the ground conditions encountered during construction are significantly different from those described in this report and on which the conclusions and recommendations were based, then we must be notified immediately.

This report has been prepared for use by Riverside Investment (WA) No. 2 Pty Ltd in relation to Lot 2, Reserve Road, Chittering project in accordance with generally accepted consulting practice. No other warranty, expressed or implied, is made as to the professional advice included in this report. Use of this report by parties other than Riverside Investment (WA) No. 2 Pty Ltd and their respective consultants and contractors is at their risk as it may not contain sufficient information for any other purposes.

For and on behalf of
CMW Geosciences Pty Ltd

Compiled by:



John Newman

Geotechnical Engineer

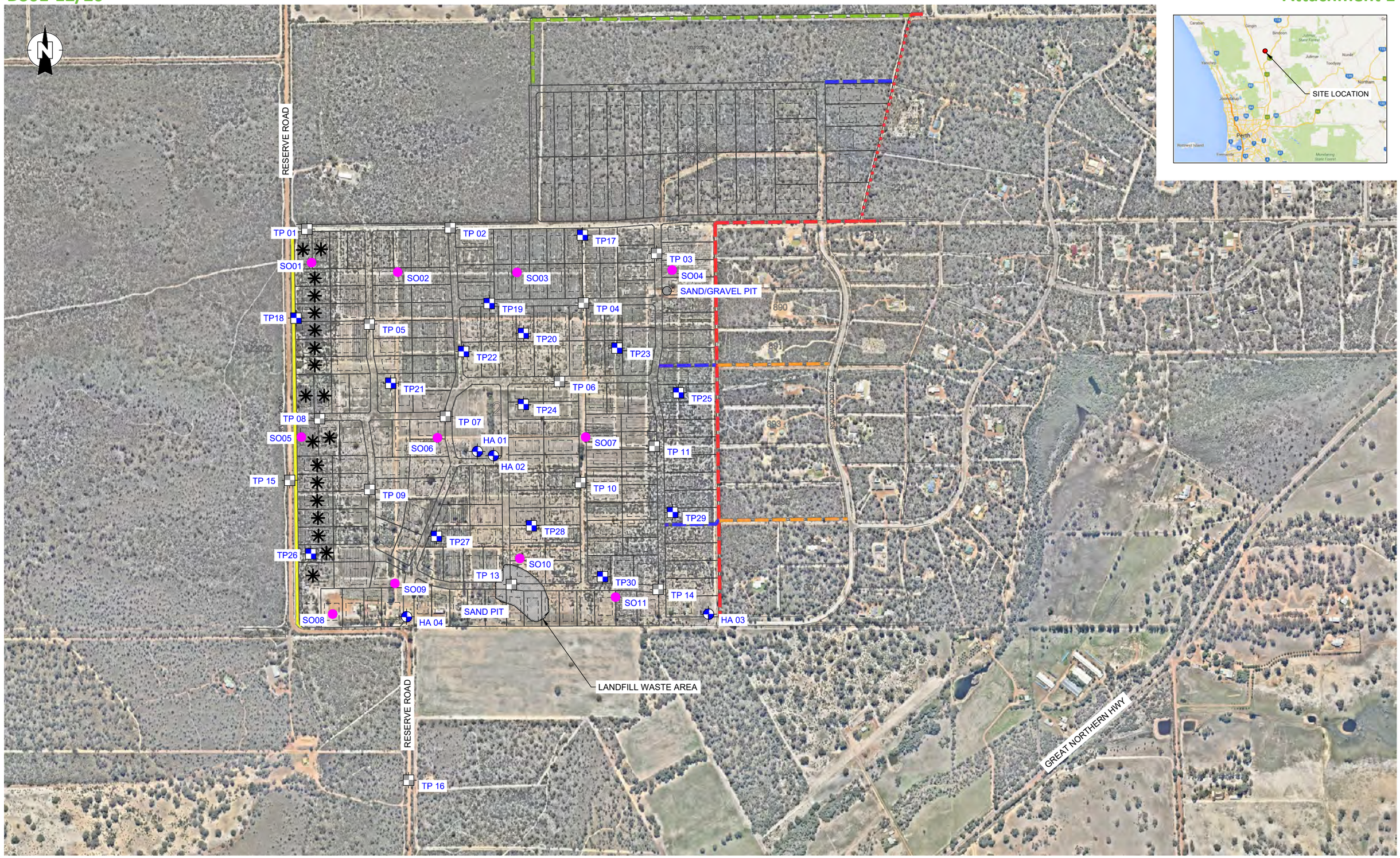
Approved by:



Craig Butterworth

Director / Principal Geotechnical Engineer

Distribution: 1 copy to Riverside Investment (WA) No. 2 Pty Ltd (electronic)
Original held by CMW Geosciences Pty Ltd



LEGEND:

- HA01 — HAND AUGER (HA) LOCATION
- TP01 — TEST PIT (TP) LOCATION
- SO01 — SOAKAGE TEST (SO) LOCATION
- TP01 — PREVIOUS TEST PIT (TP) LOCATION
- WESTERN LOTS

NOTES:

1. IMAGE FROM NEARMAP 02.04.16

1:10 000 — 0 100 200 300 400 500 m

CMW Geosciences Pty Ltd
Chapman Morton Woodward

CLIENT: RIVERSIDE INVESTMENTS (WA) NO. 2 PTY LTD	DRAWN: DE	PROJECT: PER2016-0395
PROJECT: SUBDIVISION DEVELOPMENT LOT 2, RESERVE ROAD, CHITTERING, WA	CHECKED: JN	FIGURE: 01
	REVISION: 1	SCALE: 1:10,000
TITLE: SITE INVESTIGATION PLAN	DATE: 22/07/2016	SHEET: A3 L

TEST PIT LOG - TP17

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405773m N.6512647m
Elevation: 155 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.40m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, yellow-brown; trace roots to 0.8m depth.				
				1			M			Pit walls collapsing from 1.6m depth.
			153.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP18

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.404959m N.6512411m
Elevation: 164 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 0.90m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
			163.7			SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; trace rootlets to 0.2m depth.	M			
			163.6			CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, gravel and cobbles (laterite).				
						Test pit terminated at 0.400 m				
				1						
				2						

Termination Reason: Refusal on cemented gravel/cobbles/boulders (laterite).
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP19

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405508m N.6512453m
Elevation: 159 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; with roots to 0.5m depth.				
						...from 0.5m depth, becoming grey-white.				
				1			M			
						...from 1.7m depth, becoming yellow-brown.				Pit walls collapsing from 1.8m depth.
			157.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP20

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405605m N.6512368m
Elevation: 158 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 2.50m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey-brown; trace roots and rootlets to 0.2m depth.				
						...from 0.3m depth, becoming yellow-brown.				
				1			M			Pit walls collapsing from 1.0m depth.
			156.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP21

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405228m N.6512226m
Elevation: 159 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey (locally stained brown); trace roots and rootlets to 0.3m depth.				
						...from 0.3m depth, becoming yellow-brown.				
				1			D-M			Pit walls collapsing from 1.2m depth.
			157.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP22

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405435m N.6512316m
Elevation: 157 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, brown; trace roots and rootlets to 0.4m depth.				Thin buried reticulation pipe.
						...from 0.3m depth, becoming yellow-brown.				
				1			M			
			155.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP23

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405871m N.6512326m
Elevation: 163 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.20m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; trace roots and rootlets to 0.5m depth.				Thin buried reticulation pipe.
							M			
				1		*...from 0.7m depth, becoming cream-brown.*				
			161.7			CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, gravel and cobbles (laterite).				
			161.6			Test pit terminated at 1.400 m				
				2						

Termination Reason: Refusal on cemented gravel/cobbles/boulders (laterite).
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP24

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405605m N.6512166m
Elevation: 154 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.80m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, brown.				
						...from 0.3m depth, becoming pale grey.				
				1			D-M			Pit walls collapsing from 1.4m depth.
			152.2			SW: Gravelly SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey-red brown; up to 30% fine to medium grained, sub-angular to sub-rounded gravel (of laterite).				
			152.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP25

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.406046m N.6512199m
Elevation: 160 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; trace rootlets to 0.4m depth.	M			Thin buried reticulation pipe.
			158.9	1		SW: Gravelly SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey-red brown; up to 40% fine to coarse grained, sub-angular to sub-rounded gravel (of laterite).				
			158.6			CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, gravel and cobbles (laterite).				
			158.2			Test pit terminated at 1.800 m				
				2						

Termination Reason: Refusal on cemented gravel/cobbles/boulders (laterite).
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP26

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405001m N.6511741m
Elevation: 163 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
			162.5	1		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, black-brown; with gravel; trace rootlets to 0.2m depth. *...from 0.3m depth, becoming pale grey.* SW: Gravelly SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; up to 30% fine to coarse grained, sub-angular to sub-rounded gravel (of laterite); with cobbles and boulders (iron cemented).	M			
			161.4			CEMENTED GRAVEL/COBBLES/BOULDERS: fine to coarse grained gravel, sub-angular to sub-rounded, red brown, gravel and cobbles (laterite).				
			161.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP27

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405358m N.6511791m
Elevation: 155 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; trace roots to 1.0m depth.				
				1		*...from 0.2m depth, becoming yellow-brown.*	M			
			153.0	2		Test pit terminated at 2.000 m				Pit wall collapse at 2.0m depth.

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP28

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405628m N.6511821m
Elevation: 152 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 2.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey.				Thin buried reticulation pipe.
						...from 0.8m to 1.0m depth, trace roots.				
				1			M			Pit walls collapsing from 1.5m depth.
			150.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP29

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.406029m N.6511859m
Elevation: 148 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
				1		SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; trace roots and rootlets to 0.5m depth.	M			
			146.5			SW: Gravelly SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; up to 30% fine to coarse grained, sub-angular to sub-rounded gravel (of iron cemented sand).				
			146.0	2		Test pit terminated at 2.000 m				

Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





TEST PIT LOG - TP30

Client: Riverside Investments (WA) No. 2 Pty Ltd
Project: Lot 2 Reserve Road
Location: Chittering
Project: PER2016-0395
Date: 17/07/2016

CMW Geosciences Pty Ltd
Chapman Morton Woodward

1:20 Sheet 1 of 1

Logged by: JN
Checked by: AP

Position: E.405830m N.6511676m
Elevation: 145 m (AHD)

Plant: JCB 3CX
Contractor: ANH Contracting

Dimensions : 1.00m x 3.00m

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components)	Moisture Condition	Consistency/ Relative Density	Perth Sand Penetrometer (Blows/150mm) 5 10 15	Structure & other observations
						SP: SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey; trace rootlets to 0.8m depth.				
				1			M			Pit walls collapsing from 1.6m depth.
			143.0	2		Test pit terminated at 2.000 m				

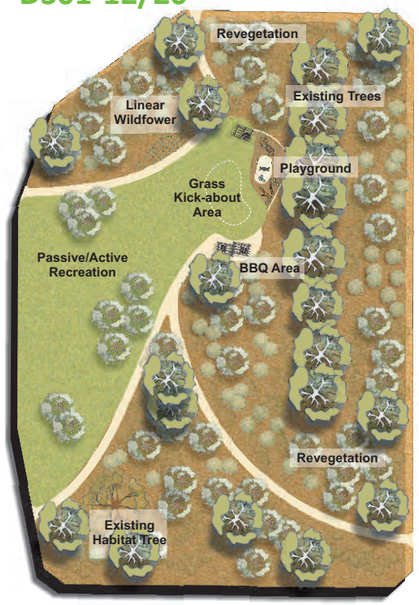
Termination Reason: Target Depth Reached.
Groundwater not encountered. Backfilled.





APPENDIX E

Landscaping and Engineering Plan/Section



1 Central Park

The central park area is to make use of the existing mature stand of Eucalypts as a backdrop to nestle in resident park amenity such as: shade structure(s), junior and senior play equipment focusing on adventure play, a large lawn area for picnicking, BBQ facilities, toilet and water fountain conveniences, lighting, ball and pet play on an active lawn as a contrast to the more arid endemic vegetation. The central park will be organised spatially through the use of desire lines that cross the park providing not only cross access however a circuitous route within the park. The larger areas encourage local planting as a strong suggestion of the sites original landscape woodland.







Vegetation Management Strategy

The landscape architectural (spatial design) recommendation for residential lots is primarily influenced by maintaining 'sense of place', including retention of the integrity of the rural bushland setting. However, this is conversely and equally strongly influenced by State fire management regulations. The approach taken here is to limit bushland planting to no closer than 20m from residences, with areas of remnant or re-planted vegetation to be no more than 2,500m^2 in size. Guided by this simplified description of the fire management regulations, the masterplan, detail plans and elevations indicate planting opportunities for residents for both Lots 2 and Lot 9001.

Note: Existing trees within Lot 2 and Lot 9001 will be retained where possible where the trees are not required for removal for fire management, clearing for roads, building works or vehicle access requirements.

Landscape Intent

The Lot 2 Reserve Road and Lot 9001 Rosewood Drive Landscape Masterplan borrows cues from the sites unique woodland ecology and recent use as a native flower farm





2 Entry & Roads

The entry to Lot 2 from Reserve Road proposes strong formerly planted rows of native wildflowers with specimens transplanted from the site. These rows of flowers can be used by future and surrounding residents for cut specimens or purely for their seasonal striking colour and a reminder of the sites recent history.

Road Easements - The development road easements for both Lots 2 and 9001 are proposed to make the most of the lineal corridor open space by offsetting a non-kerbed rural styled pavement. A one-way cross fall on the road aims to follow the natural fall of the land to an enclosed swale system. These lineal swales will embody WSUD principles and act as a rain gardens infiltrating water run-off close to source. The swale is to be planted with endemic planting between residential crossovers. Residential crossovers will join the swales through a simple culvert and pipe system, to be terminated by another crossover as required.

ucla

LOT 2 RESERVE ROAD AND LOT 9001 ROSEWOOD DRIVE, CHITTERING

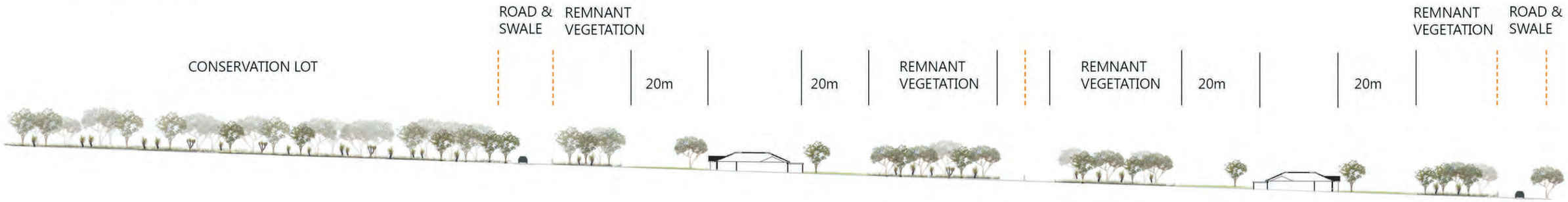
LANDSCAPE MASTERPLAN

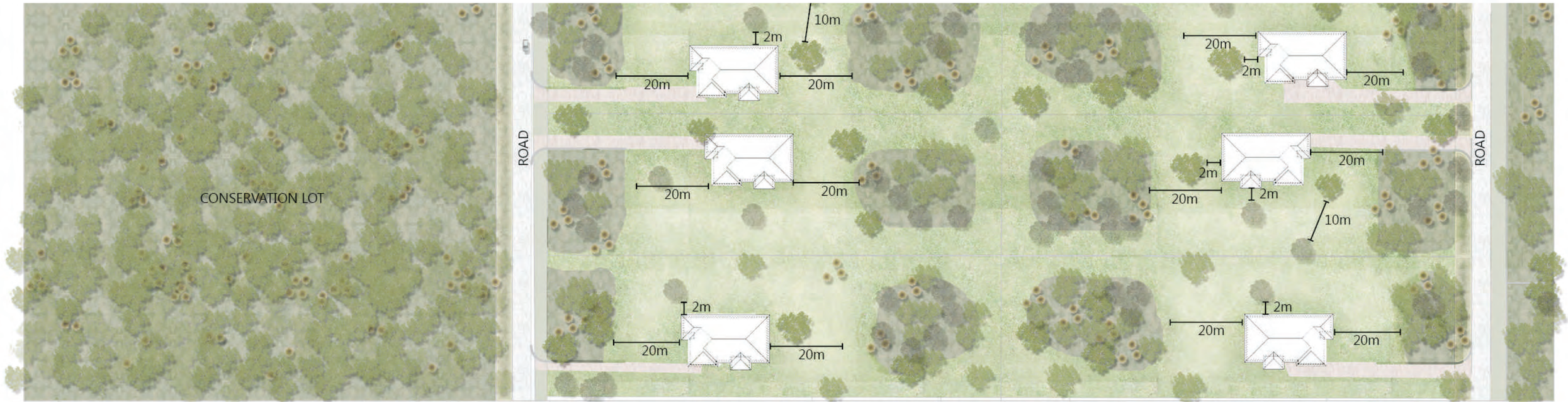
LM2 | 2015-05-22

CHITTERING RESERVE ROAD
INDICATIVE PLAN & SECTION BB
SCALE: 1:1500 AT A3

-------- LOT BOUNDARY

——— 20m SEPERATION





Fire Protection Zone - Maintained 100mm Height

Low Water Use & Non-Weed Turf Species
Zoysia japonica - Empire Zoysia
Sir Walter Buffalo

Native Species
Lepidosperma longitudinale
Lomandra micrantha
Lomandra preissii
Microleana stipoides
Nemcia reticulata
Neurachne alopecuroides
Stipa compressa

Lot 9001 Vegetation Management

Due to the conservation value of Lot 9001, a large parcel of land has been left untouched to the north of this site to provide a strong flora/fauna corridor. In addition the residential lots proposed for this development have been separated to provide green link corridors through the built form. The northern corridor provides a buffer to the conservation lot, with a central corridor allowing a visual and ecological break between residents. A southern corridor provides remnant vegetation and visual woodland buffer to the front of the development and a buffer to the adjoining development.

Fire management requires areas to be slashed to maintain low fuel areas in the separation zones within the smaller conservation lots of Lot 9001. Vegetation/soil management requires these areas to be immediately established with non-invasive drought resistant pasture/lawn or native herbaceous cover and maintained to no more than 100mm in height. Retention of existing trees are allowed however canopies are required to be 10m apart. Within the fire management zones it is import that topsoil and vegetation roots are not removed during the slashing/clearing process so that the sandy soil exposure is limited. The large conservation lot in Lot 9001 will only require slashing to maintain the area between the house and existing vegetation. Within the smaller conservation lots it is recommended that limited site slashing is undertaken to maintain landscape integrity within this conservation lot and that future residents can take advantage of living within a modified Jarrah Woodland landscape.

Northern Vegetation Corridor

Central Vegetation Corridor

Southern Vegetation Corridor

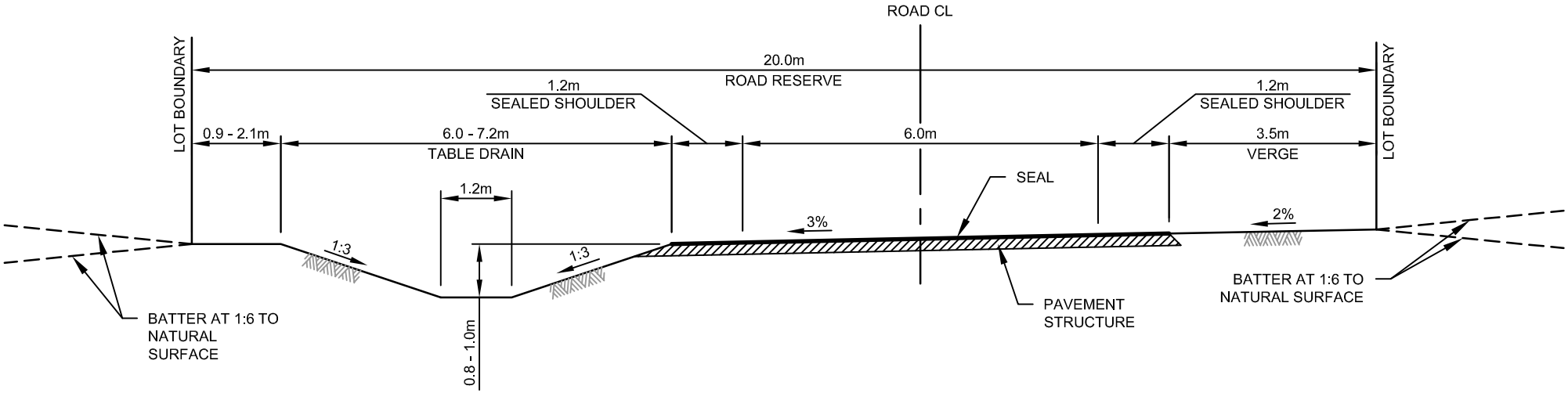
N

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LOT 2 RESERVE ROAD AND LOT 9001 ROSEWOOD DRIVE, CHITTERING

LOT 9001 VEGETATION MANAGEMENT

VM3 | 2015-05-22



20m ROAD RESERVE - TYPICAL ROAD SECTION
SHIRE OF CHITTERING - 'RURAL LIVING STREET'

CLIENT	PROJECT
RIVERSIDE INVESTMENTS (WA)	LOT 2 RESERVE ROAD, CHITTERING

REV	DATE	DRAFT.	APP.	DESCRIPTION
A	03/02/16	RB	CK	ISSUED FOR INFORMATION

SERLING CONSULTING
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PROJECT NUMBER
SC00191.100

SK002 — DRAWING NUMBER

A — REVISION

APPENDIX F

Drinking Water Source Protection Plan

(Aqua Ferre, 2016)

AQUA FERRE PTY LIMITED DRINKING WATER SOURCE PROTECTION PLAN

Version	Date Approved
Version 5.1	August 2016

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Abbreviations

Word	Meaning
ADWG	Australian Drinking Water Guidelines
Aqua Ferre	Aqua Ferre Pty Limited, ACN 121 146 772
Arris	Arris Pty Ltd, ACN 092 739 574
ATU	aerobic treatment unit
DOE	Department of Environment Regulation, Government of Western Australia
DOH	Department of Health, Government of Western Australia
DOW	Department of Water, Government of Western Australia
DWSPP	Drinking Water Source Protection Plan
ERA	Economic Regulatory Authority Western Australia
GL	gigalitre (1 billion litres)
kL	kilolitre (1,000 litres)
km	kilometre
m	metres
MEN	Muchea Employment Node
mg/L	milligram per litre
ML	megalitre (1 million litres)
mm	millimetres
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
pa	per annum
pH	A numeric scale used to specify the acidity or basicity of an aqueous solution
Riverside	Riverside Investments WA (No 2) Pty Ltd, ACN 118 963 072
RIWI Act	Rights in Water Irrigation Act 1914
Sirona	Sirona Capital Pty Ltd, ACN 149 096 284
TDS	total dissolved solids
WAPC	Western Australian Planning Commission
Water Corporation	Water Corporation of Western Australia
WTP	water treatment plant

Summary

This DWSPP has been prepared by Aqua Ferre as part of its plan to develop a reticulated water supply in the Chittering area. The DWSPP sets out basis of protection of the water quality and quantity of the water source to be utilised by Aqua Ferre.

Aqua Ferre intends supplying approximately 157ML of treated potable water to a new residential development at Reserve Road, Chittering, Western Australia, and to a commercial/industrial development at the adjacent MEN.

The new Reserve Road rural living allotment development is located 8km north east of the Muchea town site and 80km north of the Perth central business district. It is also in close proximity (4km) to the proposed MEN on the eastern side of Great Northern Highway. The development is in accordance with the Shire of Chittering's planning scheme (2004). The new residential development involves the creation of approximately 245 rural residential allotments in progressive stages. It is a requirement of the development approval that potable reticulated water is available.

Phase 1 of the MEN development is being undertaken by Sirona which is progressing in part because of its proximity to the development of the Perth–Darwin Highway. The highway is intended to enhance access to metropolitan Perth with linkage to developments in the north of the state. It is the intention of the MEN development that these lots also have a reticulated water resource.

Currently, the area does not have a public water supply scheme. The establishment of a new potable water supply scheme is in progress and this document is in support of the licence application process. This DWSPP is a requirement of DOW as part of its Memorandum of Understanding with Aqua Ferre – the licensed water service provider.

The Reserve Road property currently has a total water entitlement or allocation (licence to abstract water from an artesian aquifer) of 288,800kL/a, sufficient to meet the demands of the planned development. The developer, Riverside, has transferred the Water Licence GWL 59907(3) to the Water Corporation to enable the licence to be changed from an agricultural extraction to public water supply. This water entitlement will be transferred to Aqua Ferre when a water service licence has been granted.

The water supply scheme will see water extraction take place from the confined Leederville Aquifer (and not from the un-confined superficial aquifers). This mitigates the risk of water supply pollution from superficial groundwater sources which is a major concern in the Muchea region. The fact that the source is confined and at depth ensures it has a high level of water quality protection and security.

There is an existing production bore located within the proposed Reserve Road development that was previously used for wildflower irrigation, where the proposed potable WTP will be located. This bore although unused for >10 years has been equipped with a pump to enable water sampling for analysis (Table 6) in support of this document. In the past, water extracted from the Leederville Aquifer has been used for the irrigation of wildflowers, at an abstraction rate greater than that now required for the proposed development. The aquifer therefore has the capability to supply the required potable water without interruption.

Current land use in the Chittering Shire is diverse, but dominated by agricultural activities such as cropping, grazing and other horticultural ventures. The bore will be constructed to the "Minimum Construction Requirement for Water Bores in Australia" (3rd edition, National Uniform Drillers Licensing Committee, 2012). The confining layers of clays and shales that overlie the groundwater resource act as barriers to contamination protecting this valuable resource. Given that the drinking water from the production bore will be drawn from a deep confined aquifer and with an appropriately constructed and sealed bore, there is negligible potential for contamination from surrounding land uses.

The Riverside development will be serviced with ATUs (licensed by DOH) to treat domestic wastewater with onsite disposal of treated effluent on individual lots. The ATU will be installed in line with DOH guidelines and requirements (http://www.public.health.wa.gov.au/cproot/1331/2/approved_aerobic_treatment_units.pdf). This meets the Shire of Chittering's requirement for onsite management and disposal of domestic wastewater. A system such as the Fuji Clean CE–1500EX (http://www.fujiclean.com.au/DomesticSystems.aspx), which is approved by DOH for single dwellings, is capable of removing nutrients down to 1.3mg/L phosphorus and 21.0mg/L nitrogen, equivalent to 4% and 58% reductions, respectively.

This DWSPP has been developed to protect both the water quality and quantity of the proposed Reserve Road development water source. Currently, the Reserve Road development area does not have a proclaimed public drinking water source area. The DWSPP:

- recommends to maximise the protection of the drinking water supply source
- recommends that the water source area should be protected and proclaimed as a water reserve. This involves a water reserve area of a minimum 30m around the bore at the ground surface to mitigate the risk of surface contamination
- recommends a restricted area, for new bores, of 1,000m within the aquifer to reduce the risk to the available quantity
- identifies potential drinking water quality contamination risks from land use activities within the water reserve
- provides strategies to manage these potential risks.

Aqua Ferre has engaged Arris (www.arris.com.au) to prepare the DWSPP. Arris is an experienced consulting firm which provides specialist technical expertise and advice for all types of water treatment systems and solutions.

This DWSPP has been independently reviewed (by Tony Laws, former Manager of Water Source Protection, DOW).

1 Drinking Water Source Overview

1.1 Proposed water supply system

A potable water supply scheme is required to service the rural residential development of Lot 2 Reserve Road, Chittering and Lot 9001 Rosewood Drive, Chittering and the Phase 1 development of the MEN (Figure 1). The proposed new residential development, being developed by Riverside, covers an area of approximately 160 hectares comprising approximately 245 allotments. Each allotment is greater than 5,000m^2 and less than 10,000m^2 with the exception of the areas required to be set aside for public open space and the proposed biodiversity corridor.

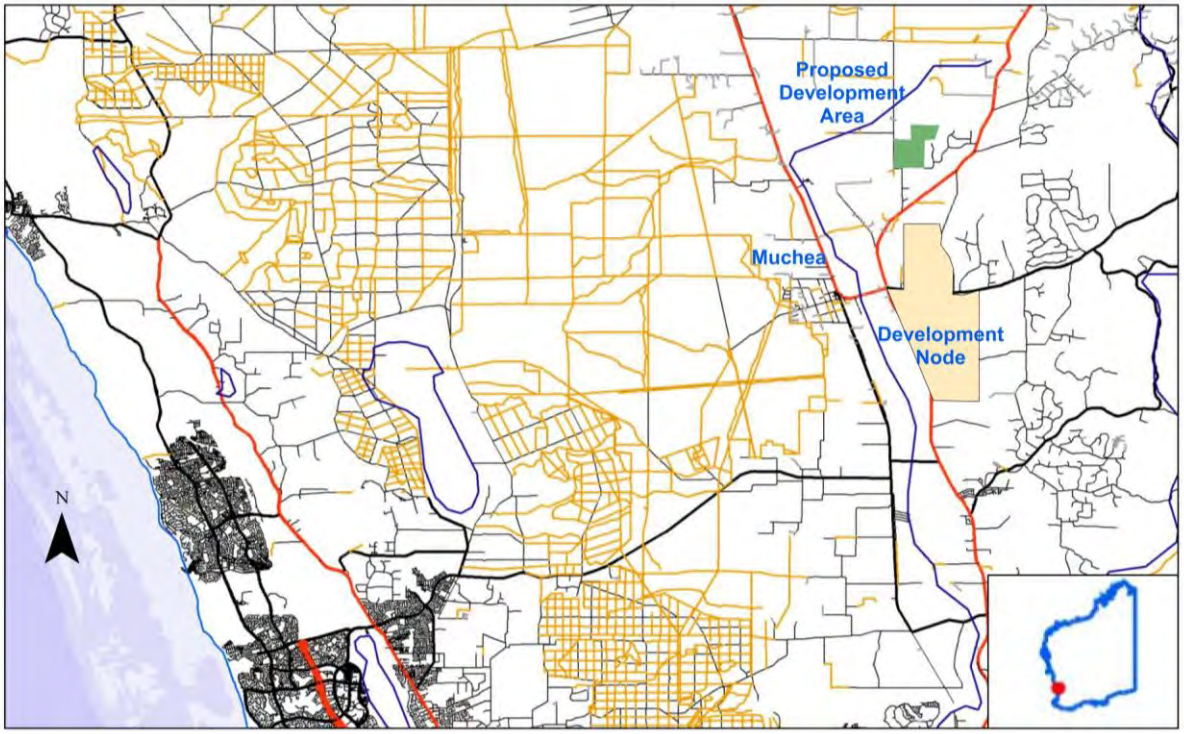


Figure 1 Location of Reserve Road residential development

Aqua Ferre was established to be an independent water service provider and is proposing to build and operate the potable water supply system at the Reserve Road development. Aqua Ferre will follow the required application process to obtain a 'Water Service Licence' from ERA. The proposed raw water for this scheme will be sourced from a new bore into the Leederville Aquifer. The aquifer is confined (Davidson, 1995, p.98) and is proposed as the source of high quality drinking water. The aquifer's water is sourced from deep valleys and some leakage from the overlying Mirrabooka Aquifer (Davidson, 1995, p.98 and p.125–127).

Further evidence that the aquifer is confined is contained in Appendix A, where it can be seen from the log of the existing bore, that the screened aquifer interval is confined below some +80m of shale. The screened interval is 225.7–241m below ground level, and standing water level is 87m; hence, the aquifer is pressurised confirming its confined nature.

The abstraction zone in the aquifer is 240m deep (Appendix A, p.26) and regarded as having a low vulnerability to contamination from agriculture, industrial and urban activity (Davidson, 1995, p.143).

Groundwater supplies are usually more reliable than surface water supplies because they are often not impacted by short-term fluctuations in rainfall and generally are not directly influenced by evaporation.

Table 1 shows the details of the Water Use Licence (licence to take water) granted to Lot 2, Reserve Road under Section 5C of the RIWI Act and subject to the Rights in Water and Irrigation Regulations 2000.

Table 1 Licence to take groundwater

Licence Number	Annual Water Allocation kL/a)	Aquifer
59907 (3)	288,800	Perth – Leederville – Parmelia Artesian

The developer, Riverside, has transferred the water licence GWL 59907(3) to the Water Corporation. This licence will be transferred to Aqua Ferre when a successful Water Service Licence has been obtained from the ERA.

1.2 Water treatment

Appropriate catchment and aquifer management is the first step in water source protection to ensure good quality water supply, as endorsed in the ADWG (NHMRC and NHMMC, 2011).

The proposed WTP design will comprise a pre-treatment stage that will include iron and manganese removal through the use of ozone to the feed water (ozonation). Preliminary chlorine dosing will be introduced in this pre-treatment tank to prevent taste and odour problems due to slime and bacteria growth. The water will then be pressure sand filtered to remove the precipitated material. Wastewater discharged from the oxygenation tank and sand filter will be sent to sludge drying beds for dewatering prior to disposal (Section 3 Methods/Principles of Service Provision, Reticulation System Design, Aqua Ferre, 2016).

Aqua Ferre has designed the treatment plant to provide a very high quality product that meets the ADWG – a requirement of DOW. Ozone has been chosen as a water treatment method due to its reliability, cost effectiveness and as it can be generated on site, limiting the transport and importation of dangerous goods.

The last stage in the treatment chain consists of ozone and a chlorination module for primary and residual disinfection purposes (Section 3 Methods/Principles of Service Provision, Reticulation System Design; Aqua Ferre, 2016). Due to the low pH of feed water, sodium hydroxide will be added to achieve a pH of 7 to 7.5.

The potable water treatment train is described in detail in the "Reticulation System Design" document prepared by Aqua Ferre as part of its plan to develop a reticulated water supply in the Chittering area.

1.3 Catchment details

1.3.1 Physiography

The site lies within the Ellenbrook surface water catchment (Figure 2). The catchment area of Ellenbrook is 715 square km, approximately 50km long north-to-south and 20km wide east-to-west. The Ellenbrook flows south and joins the Swan River near Belhus (Smith and Shams, 2002, p.2).

Three local governments administer the catchment. These are from north to south, the Shires of Gingin covering approximately 21%, Chittering covering 47% and Swan covering 32% of the catchment. From north-to-south the town centres and residential subdivisions near or within the catchment are Gingin, Muchea, Bullsbrook and Ellenbrook.

The Ellenbrook catchment contains sites of environmental and cultural significance including lakes, wetlands and springs of high conservation value. Among this conservation sites are Lake Bambun, Chandala Lake, Twin Swamp and mound springs (Smith and Shams, 2002,

p.11). These features have conservation value because they provide habitat for endangered species and migratory birds, support rare fauna and flora and also have cultural or heritage values. A search of the Aboriginal Heritage Inquiry System (http://maps.dia.wa.gov.au/AHIS2/) shows that there are no registered heritage sites in the area to be protected by this DWSPP.

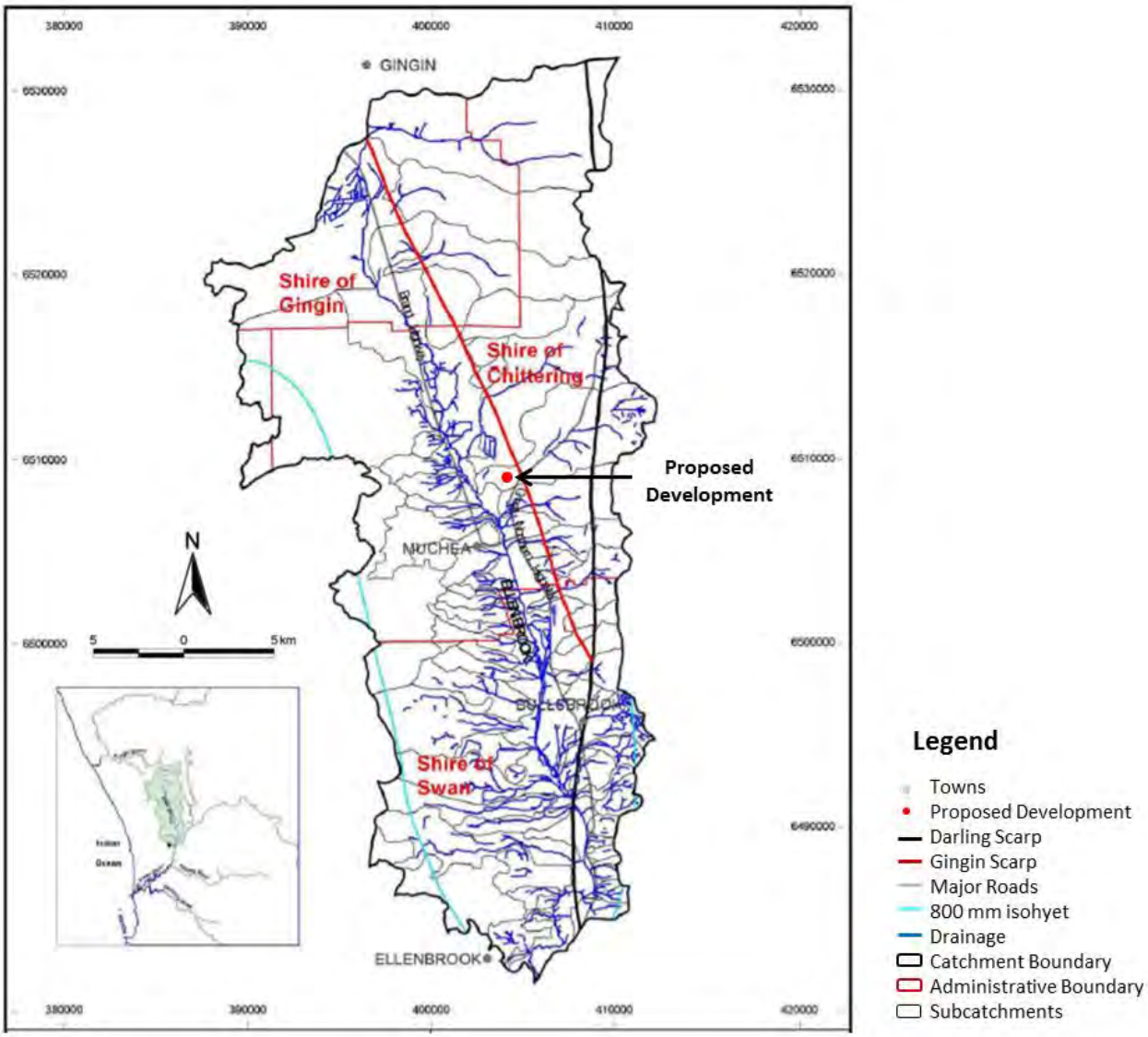
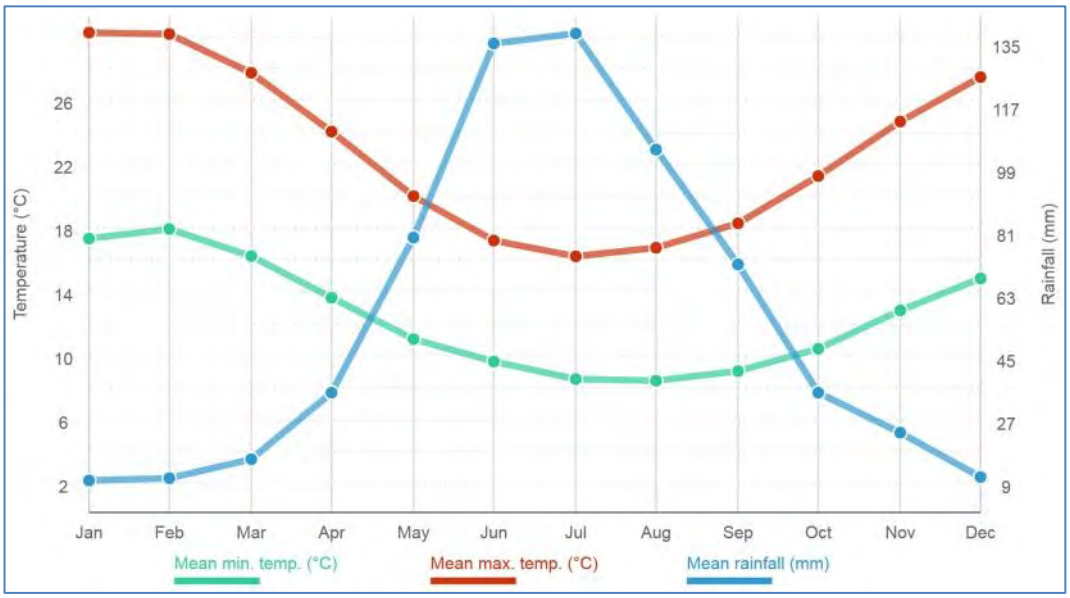


Figure 2 Ellenbrook Catchment (Smith and Shams, 2002)

1.3.2 Climate

The catchment has a "Mediterranean-type climate", with hot dry summers and cool wet winters. The average annual rainfall for the southern region of the catchment is approximately 820mm (Figure 3). This decreases to less than 600mm in the northern region of the catchment where the proposed development is located (Banfield, 2001). The change of season usually takes place between mid-April to mid-May and the growing season typically lasts for about seven months. On average, 90% of the average annual rainfall falls between May and October.

Average daily temperatures typically range between 17°C and 29°C in summer and between 9°C and 18°C in winter. Average annual pan evaporation is 934mm, and the average daily evaporation ranges from 10.8mm in January to 1.8mm in June.



Source: MLA Accessed 2015. (http://www.mla.com.au)

Figure 3 Mean monthly rainfall, minimum and maximum temperatures for Muchea

1.3.3 Hydrogeology

The hydrogeology provides a framework to identify groundwater distribution, flow and quality. The hydrogeology of the Ellenbrook catchment reflects the geology of the three physiographic units shown in Figure 4 and Table 2 (DOW, 1989; Banfield, 2001):

- Darling Plateau comprises crystalline rock, comprising mainly Precambrian gneiss and granite
- Dandaragan Plateau has a thin cover of Cretaceous sands and clay, and some small outcrops of Cretaceous and Jurassic sediments
- Swan Coastal Plain is formed by Tertiary – Quaternary sand and clay.

As the proposed Riverside and MEN developments are located in the Dandaragan Plateau, this section will only refer to this physiographic unit of the catchment.

The surface geology of the Dandaragan Plateau comprises Cretaceous-age sands of Poison Hill Greensand and Molecap Greensand (Smith and Shams, 2002). The two formations are composed of fine to coarse-grained, unconsolidated, yellowish-brown to greenish-grey, glauconitic, silty and locally clayey sandstone (Davidson, 1995). At the surface, they have weathered into laterite caps above deep sand.

The geology and stratification of the site area and its surroundings are shown in Figure 5 (DOW, 1989). Cretaceous-age sand forms the surface geology in the development site. The stratification shows layers of rocks with low permeability, fractured and weathered rocks.

Table 2 Proposed Reserve Road development hydrogeology (DOW, 1989)

	Hydrogeology
Aquifer	Rocks of low permeability, fractured and weathered rocks – local aquifers
Lithology	Sand
Geological age	Cretaceous

There are a number of regional aquifers within the catchment. The property is underlain by the following aquifers (from surface): the Mirrabooka Aquifer, Leederville–Parmelia Aquifer and Yarragadee North (DOW, 1989; Davidson, 1995) (Table 3).

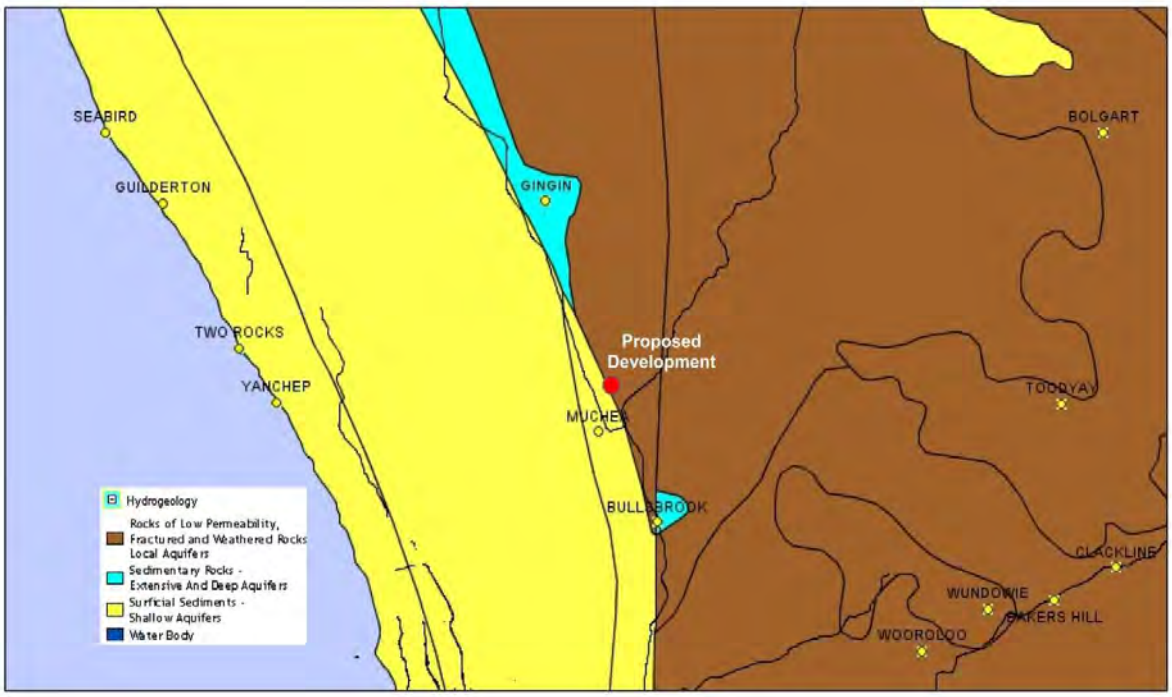


Figure 4 Proposed Reserve Road development hydrogeology (DOW, 1989)

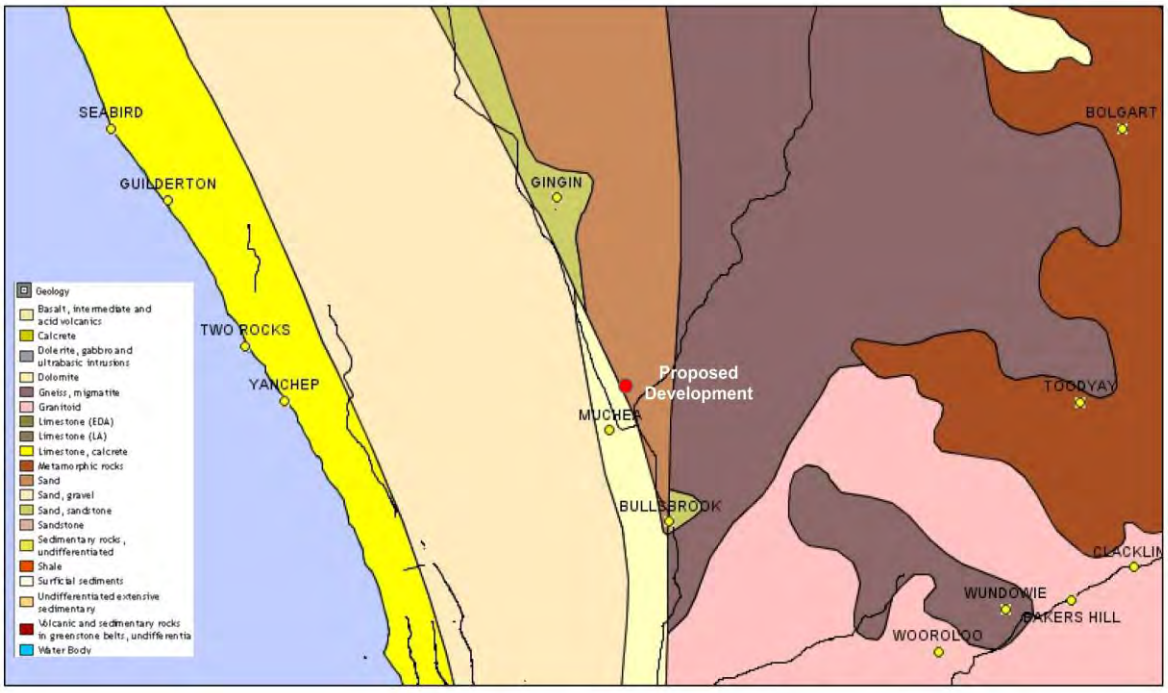


Figure 5 Proposed Reserve Road development geology (DOW, 1989)

1.3.4 Aquifers

The aquifers in the region of the proposed development are described in Table 3 and shown in Figure 6.

Table 3 Aquifers in the region of the proposed development (adapted from DOW, 2015)

Aquifer	Description and Notes	Location
Leederville	• Deep aquifer (sandstone, shale), up to 550m thick • Semi-confined to confined aquifer • Variable water quality, generally fresh groundwater (<1000mg/L TDS) • Good bore yields (up to 3000kL/day) • Provides base flow to Gingin Brook downstream of Mungala Brook confluence • Seawater interface is likely to be offshore	South of Wedge Island and west of the Brand Highway
Leederville – Parmelia	• Interconnected Leederville Formation and Parmelia Group (sandstone, shale) • Semi-confined to the north becoming confined to the south • Generally fresh groundwater (<1000mg/L TDS) • Good bore yields (up to 3000kL/day) • Recharged in north-eastern part of the Gingin groundwater area as well as in the Jurien and Arrowsmith groundwater areas • Contributes to base flow in headwaters of the Gingin Brook and downstream sections • Important for maintaining summer flows in the Moore River	East of the Brand Highway
Lesueur	• Mainly sandstone • Groundwater is fresh-to-brackish	Small area in the northwest of the plan area
Yarragadee	• Deep aquifer (sandstone, shale), up to 2000m thick • Unconfined to confined aquifer • Generally fresh groundwater (<1000mg/L TDS) however high groundwater salinity along the Darling Fault (Scarp) • Very good bore yields (up to 5000kL/day) • Seawater interface is likely to be offshore	Present in most of the plan area



Figure 6 Aquifers in the Gingin Water Allocation Plan region in relation to the proposed development (taken from DOW, 2015)

1.4 Future water supply requirements

There is no existing potable water supply at the proposed development (Figure 6), and so Aqua Ferre proposes to construct a bore into the confined Leederville Aquifer to meet the potable water needs of the Riverside development and MEN. Analyses on the current bore at the site (Table 6) indicate that the quality of the water source is suitable, and the fact that quantity requirements are less than that originally used for the wildflower venture indicates that the quantity required will be available from a properly constructed and developed production bore.

There is a total requirement of 157ML pa of water for the Riverside development (104ML pa) and MEN (Stage 1) development (53ML pa) (per Section 3 Methods/Principles of Service Provision, Reticulation System Design; Aqua Ferre, 2016). This water will be sourced from the Groundwater Licence 59907 (Table 4), and represents approximately 54% of the total water licence of 288,800kL pa.

The water demand for the Riverside and MEN developments is described in detail in the "Reticulation System Design" document (Aqua Ferre, 2016) prepared by Aqua Ferre and its advisors in relation to its licence application to ERA.

1.5 Protection and allocation

1.5.1 Existing water source protection

As this is a new development, there are no existing strategies for water source protection for the site.

1.5.2 Current allocation licence

DOW is responsible for the administration of water resource use in Western Australia under the RIWI Act. Under this Act, the right to use and control surface and groundwater is vested with the Crown. The RIWI Act requires the licensing of groundwater abstraction (pumping water from a bore, spring or soak) within the Act proclaimed groundwater areas and all artesian wells throughout the state.

The proposed potable supply scheme falls within the Gingin groundwater area proclaimed under the RIWI Act. The Reserve Road development site has a licence to abstract water from the Leederville Aquifer with a total allocation of 288,800kL pa. The developer, Riverside, has transferred the licence GWL 59907(3) (Table 4) to the Water Corporation. This licence will be transferred to Aqua Ferre when a successful Water Service Licence application to ERA has been granted.

Table 4 Licence information for the existing bore at the Riverside Development site

Licence Information	
Licence Number	GWL 59907(3)
Licence Type	Groundwater Licence
Issue Date	08.08.2013
Expiry Date	07.08.2023
Licence Allocation	288,800 kL/a
Party	Water Corporation
Groundwater Area	Gingin
Groundwater Subarea	Cowalla Confined
Aquifer	Perth – Leederville – Parmelia
Licence Address	Lot 2 Reserve Road, Chittering

Source: DOW website

1.5.3 Gingin groundwater allocation plan

DOW manages the volume of water that can be taken from rivers and groundwater aquifers by developing water allocation plans. The groundwater resources of the Gingin region are contained in a series of aquifers; namely, unconfined superficial and surficial aquifers, fractured bedrocks and the semi-confined and confined aquifers of Poison Hill, Mirrabooka, Leederville, Leederville Parmelia, Yarragadee, Cattamarra and Lesuer.

The Gingin Groundwater Allocation Plan (DOW, 2015) is a guiding document for the sustainable management of ground water resources that influence the extraction of water at Reserve Road, Chittering. The plan seeks to ensure:

- licensed entitlements can be met reliably in most years
- water source options to support growth in agricultural and horticultural industries are clear
- sufficient water is available to support population growth in local towns, as well as to provide a future groundwater source option for Perth's Integrated Water Supply Scheme
- groundwater-dependent ecosystems and watercourses are protected from over-abstraction
- groundwater quality in the coastal aquifers is protected from seawater intrusion.

The total available for general licensing is approximately 187GL pa. As of 30 January 2015, there was approximately 140GL pa licensed and 30GL pa in licence applications which the department was assessing.

The plan highlights that there is 1382.7ML pa licensed for potable extraction in the lower Chittering from the Leederville – Parmelia Aquifer system with 197.6ML pa being extracted in 2012–13. The report indicates that this is adequate to meet requirements until 2020.

Figure 7 shows the Gingin Groundwater Allocation Plan (DOW, 2015) area and the location of the proposed Riverside development, the location of the groundwater extraction bore and potable WTP. According to report by the Waters and Rivers Commission ("Managing the Water Resources of the Gingin Groundwater Area", 2002), the Reserve Road site falls within the Leederville–Parmelia confined aquifer, sub-area Cowalla. (Refer also to Table 4, extract from DOW website regarding licence information.)



Figure 7 Gingin groundwater allocation area (DOW, 2015)

2 Water Quality Monitoring and Contamination Risks

Groundwater quality varies according to geology and position within the groundwater flow system relative to recharge and discharge. In addition factors such as land use, groundwater abstraction and climate can also affect the quality of groundwater (Davidson, 1995).

DOW measures various water quality parameters in the groundwater reserves, such as salinity, nutrients, and groundwater acidification (Davidson, 1995). Salinity is one aspect of water quality which affects all water users (domestic, agricultural). Salinity can be expressed as TDS measured in mg/L or as electrical conductivity measured in deci-Siemens per metre.

2.1 Water quality

A bore exists on the land to be used for the proposed Reserve Road development (Table 5, Figure 8). The log of the existing bore is found in Appendix A (provided by DOW). A new bore will be constructed under the *Minimum Construction Requirements for Water Bores in Australia* (National Uniform Drillers Licensing Committee, 2012) to meet the requirements of this development.

Table 5 Position and depth data for existing bore at the Riverside development site

Existing Bore Information	
Easting	405153
Northing	6511488
MGA zone number	50
Depth of water abstraction	>225 metres

Aqua Ferre has an ongoing water sampling program from the existing bore to monitor water quality over time. The existing bore has been drilled into the confined Leederville Aquifer and the average values for several parameters are summarised in Table 6 and provided in detail in Appendix B. The average TDS is 294mg/L, well below the maximum set by the ADWG (NHMRC and NRMMC, 2011) for aesthetic purposes. All other parameters are well below the ADWG except for iron (Fe) and manganese (Mn). Thermophilic Amoebae were detected in all samples. Consequently, the bore water will be treated to decrease the levels to meet the requirements as established in the ADWG and by DOH.

The potable water treatment train is described in detail in the "Reticulation System Design" (Aqua Ferre, 2016) document prepared by Aqua Ferre. This sets out the processes that have been included in the design to reduce iron and manganese concentrations and to remove Thermophilic Amoebae. It is noted that in the treatment of these contaminants there will be other non-targeted benefits to water quality.

Table 6 Summary table for analyses conducted on water sampled between April and November 2015 in comparison to the ADWG (NHMRC and NRMMC, 2011), n = 10

Bore Water Quality Analysis (GWL 59907)	Units	Average	Max	Min	ADWG Limits	
					Health	Aesthetic
pH in water	pH Units	**6.58**	7.2	6.2		6.5–8.5
Electrical conductivity water	µS/cm	**494**	520	460		
TDS (grav)	mg/L	**294**	310	270		500
Chloride in water	mg/L	**118**	120	110		250
Fluoride in water	mg/L	**0.3**	0.3	0.3	1.5	
Iodide in water	mg/L	**<1**	<2	<3	0.1	
Bromide	mg/L	**<0.5**	<0.5	<0.5		
Sulphate in water	mg/L	**12.1**	14	6	500	250
Total Cyanide	mg/L	**<0.004**	<0.004	<0.004	0.08	
Sulphide in water	mg/L	**<0.01**	<0.01	<0.01		
Nitrate as NO_3	mg/L	**<0.5**	<0.5	<0.5	50	
Nitrite as NO_2	mg/L	**<0.5**	<0.5	<0.5	3	
Ammonia as N	mg/L	**0.051**	0.15	0.019		0.5
Dissolved CrVI	mg/L	**<0.005**	<0.005	<0.005	0.05	
Hardness as $CaCO_3$	mg/L	**49.7**	58	46		200
Sodium – Dissolved	mg/L	**70.8**	78	66		180
Aluminium –Total	mg/L	**0.05**	0.05	0.05		0.2
Arsenic –Total	mg/L	**0.001**	0.001	0.001	0.007	
Barium – Total	mg/L	**0.0903**	0.1	0.082	0.7	
Beryllium – Total	mg/L	**<0.0005**	<0.0005	<0.0005	0.06	
Boron – Total	mg/L	**0.054**	0.07	0.042	4	
Cadmium – Total	mg/L	**<0.0001**	<0.0001	<0.0001	0.002	
Chromium – Total	mg/L	**<0.001**	<0.001	<0.001		
Copper – Total	mg/L	**0.033**	0.17	0.002	2	1
Iron – Total	mg/L	**10.31**	**16**	**1.7**		0.3
Lead – Total	mg/L	**0.004**	0.004	0.004	0.01	
Molybdenum – Total	mg/L	**0.003**	0.005	0.001	0.05	
Manganese –Total	mg/L	**0.261**	**0.49**	0.027	0.5	0.1
Mercury – Total	mg/L	**<0.00005**	<0.00005	<0.00005	0.001	
Nickel – Total	mg/L	**0.0034**	0.009	0.001	0.02	
Selenium – Total	mg/L	**0.003**	0.003	0.003	0.01	
Silver – Total	mg/L	**<0.001**	<0.002	<0.003	0.1	
Antimony – Total	mg/L	**0.001**	0.001	0.001	0.003	
Tin – Total	mg/L	**0.002**	0.003	0.001		
Uranium – Total	mg/L	**<0.0005**	<0.0005	<0.0005	0.02	
Zinc – Total	mg/L	**0.052**	0.19	0.013		3
Thermophilic Amoebae	cfu/100mL	**D**	**D**	**D**	95% nil	
Thermophilic Naegleria	cfu/100mL	**ND**	ND	ND	95% nil	
Thermotolerant Coliforms	cfu/100mL	**<1**	<1	<1	98% nil	
E.Coli	cfu/100mL	**<1**	<1	<1	98% nil	

*** Red indicates exceedences for both Health and Aesthetic ADWG values**

**** Blue indicates exceedences for aesthetic ADWG value but meets health**

Aqua Ferre will monitor both the raw bore water and the final treated water to ensure DOW requirements and the ADWG are met. The treatment train will have inline monitoring to ensure that water quality meets the AWDG standards. This will be accompanied by water sampling and analysis to demonstrate compliance (Section 3 Methods/Principles of Service Provision, "Reticulation System Design"; Aqua Ferre, 2016).

2.2 Contamination risks

The risk of contamination to the Reserve Road development water source and reserves from potential pollutants resulting from surrounding land uses and surface activities can be considered as negligible because the water is drawn from a confined aquifer at depth. Nonetheless, proper bore construction and maintenance are essential for existing bores and any new bores proposed to be located near drinking water production bores in order to prevent the bores from creating a contamination pathway between surface activities and the aquifer. Hence, all bores be constructed in accordance with "Minimum Construction Requirements for Water Bores in Australia (3rd Edition)" (National Uniform Drillers Licensing Committee, 2012).

The new production bore is located within the proposed Reserve Road development in the south east corner of Lot 2, and the proposed WTP will be constructed in the bore compound. Figure 8 shows the location of the bore and the location of surrounding bores. There are three bores located in a 1km radius from Lot 2, but there are several within a 2km radius from the site, particularly to the south and south east (Figure 8).

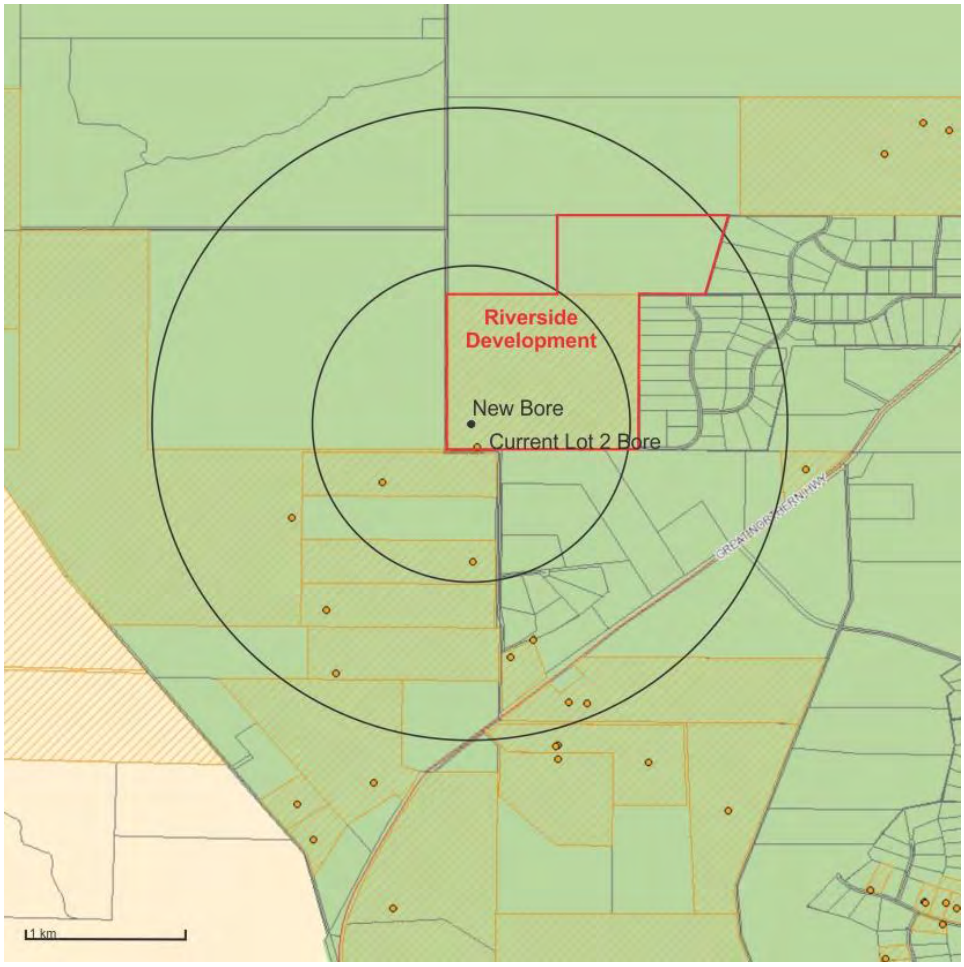


Figure 8 2km and 1km radii bore search from Lot 2 Reserve Road licence

Figure 7, the urban area (Muchea town site) is well down gradient, and as such, is not considered to be a risk of contamination to the water supply. Any potential risk associated with existing and proposed land uses and activities in the area have been identified.

2.3 Contamination risks relevant to the drinking water source

2.3.1 Microbiological

Pathogens are types of micro-organisms that are capable of causing diseases. These include bacteria, protozoa and viruses. In water supplies, pathogens that can cause illness are mostly found in the faeces of humans and domestic animals.

There are a number of pathogens that are commonly known to contaminate water supplies worldwide. These include bacteria (eg salmonella, Escherichia coli and cholera), protozoa (eg cryptosporidium, giardia) and viruses. Escherichia coli counts are a way of measuring these pathogens and are an indicator of faecal contamination.

Pathogen contamination of a drinking water source is influenced by the existence of pathogen carriers (ie humans and domestic animals such as dogs or cattle), their transfer to and movement in the water source and the ability of the pathogen to survive in the water. The percentage of humans in the world that carry various pathogens varies. For example, it is estimated that 0.6–4.3% of people are infected with cryptosporidium worldwide, and 7.4% with giardia (Geldreich, 1996).

The effect on people consuming drinking water that is contaminated with pathogens varies considerably, ranging from mild illness (such as stomach upset or diarrhoea) to death. Preventing the introduction of pathogens into the water source is the most effective barrier in avoiding this public health risk.

The confined nature of the aquifer to be exploited by Aqua Ferre, and the proposed drilling and construction requirements effectively limits any potential occurrences of microbiological contamination to issues within the treatment and reticulation systems. These risks will be mitigated though treatment and disinfection (Section 3 Reticulation System Design, Aqua Ferre, 2016).

2.3.2 Health-related

A number of chemicals (organic and inorganic) in drinking water are of concern from a health perspective because they are potentially toxic to humans. Chemicals that can occur in drinking water sources may be derived from chemicals attached to suspended material in the aquifer, such as soil particles, and may result from natural leaching from mineral deposits or overlying land uses (NHMRC and NRMMC 2004b).

Pesticides include agricultural and household chemicals such as insecticides, herbicides, nematicides (used to control worms), rodenticides and miticides (used to control mites). Contamination of a drinking water source by pesticides and other chemicals may occur as a result of accidental spills and/or incorrect use, overuse or leakage from storage areas.

Nutrients (such as nitrogen) can enter drinking-water supplies as a result of leaching from fertiliser application septic tanks, and from faeces of domestic animals (such as cattle grazing on the land). Nitrate and nitrite (ions of nitrogen) can be toxic to humans at high levels, with infants less than three months old being most susceptible (NHMRC and NRMMC 2004a).

Hydrocarbons (eg fuels, oils) are potentially toxic to humans, and harmful by-products may be formed when they are combined with chlorine in the water treatment process. Hydrocarbons can occur in water supplies due to vehicle accidents, spills during refuelling and leakage from storage areas.

The confined nature of the aquifer will mitigate against potential chemical contamination.

2.3.3 Aesthetic

Impurities in drinking water can affect the aesthetic qualities of water such as its appearance, taste, smell and feel. Such impurities are not necessarily hazardous to human health; for example, water that is cloudy and has a distinctive colour may not be harmful (NHMRC and NRMMC 2004b).

Iron and dissolved organic matter can affect the colour and appearance of water and salinity can affect the taste.

Some properties such as pH (a measure of acidity or alkalinity) can contribute to the corrosion and encrustation of pipes. The *Australian drinking water guidelines* (NHMRC and NRMMC 2004a) set out aesthetic guidelines to meet the aesthetic requirements of consumers and to protect water infrastructure.

The proposed treatment design and schedules for the intended water supply will ensure aesthetic concerns are controlled (Section 3 Reticulation System Design, Aqua Ferre, 2016)

2.3.4 Groundwater bores

Under the provisions of sections 26D and 5C of the RIWI Act a licence is required to construct a bore or extract water (unless exempt under the *Rights in Water and Irrigation Exemption and Repeal* (Section 26C, Order 2001) within a proclaimed groundwater area.

Any bores drilled near to a public drinking water supply bore have the potential to contaminate the drinking water source. For example, a poorly constructed bore may introduce contaminants through surface leakage down the outside of the bore casing into an otherwise uncontaminated aquifer. If a public drinking water source bore is being used nearby, it may abstract some of the contaminated water.

It is important to ensure that any bores are appropriately located and constructed in order to prevent contamination and any other effects on the public drinking water source. This will be assessed through the DOW's water licensing process where applicable under the RIWI Act.

The Aqua Ferre bores will be constructed in accordance with *Minimum construction requirements for water bores in Australia* (National Minimum Bore Specifications Committee 2003).

Protection of the proposed drinking water source should also have regard for the protection of quantity as well as quality. This means that a possible restriction on the construction of further bores within the confined aquifer, within a limited zone (say 1,000m) from the proposed production bore, may need to be considered and developed with DOW.

3 Land Use Assessment

3.1 Existing land use

Land use in the shire is highly diverse (Figure 9). It can be grouped into:

- grazing
- horticulture
- fodder production
- timber production
- mining/basic materials extraction
- industrial
- urban and residential.

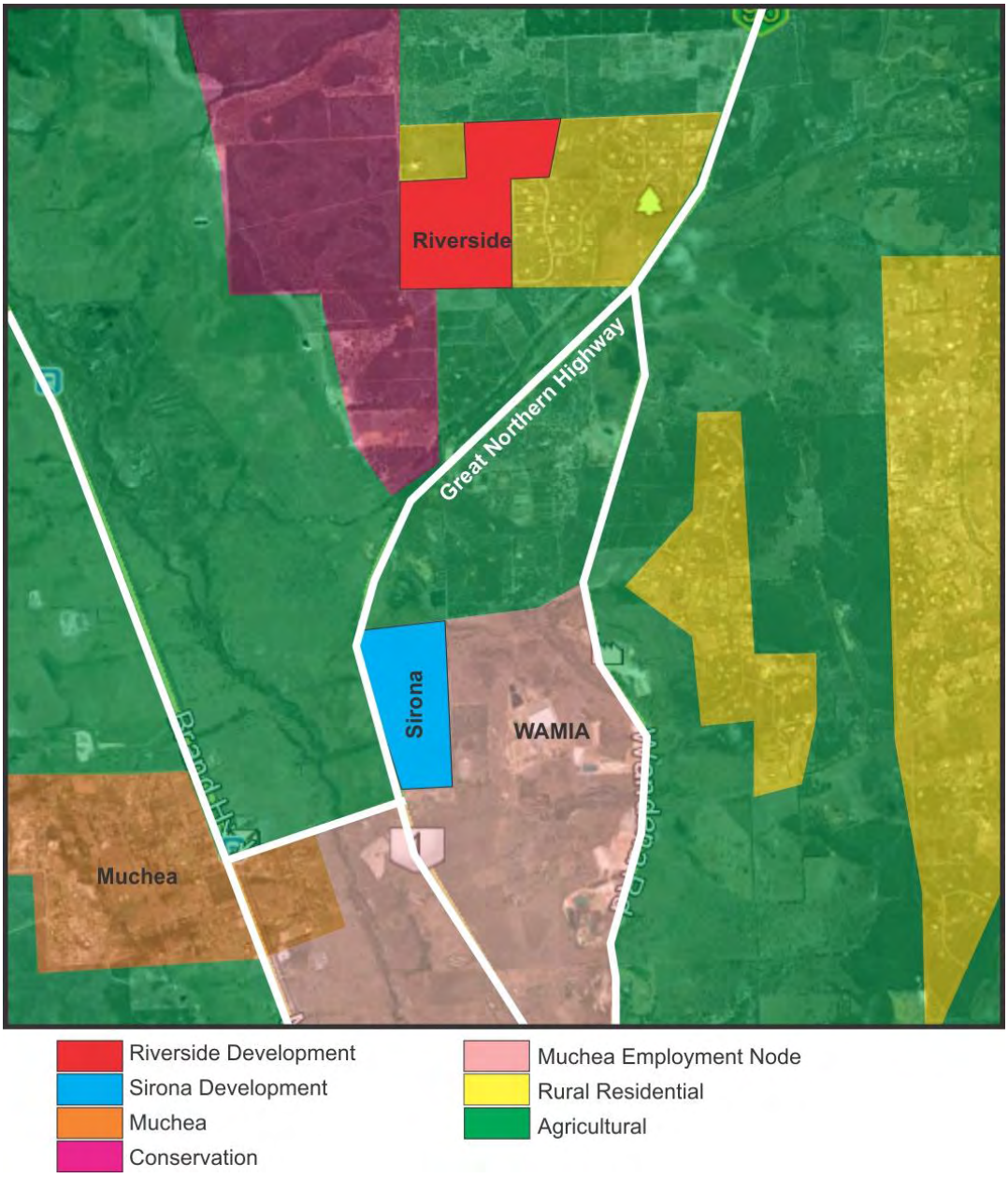


Figure 9 Site and surrounding land uses

The development site has been mainly used in the past as a commercial wildflower farm with small pockets of original bushland still present. The southern portion adjacent to the subject site contains houses, stores, farming equipment and wildflowers (Belleng VDM, 2006).

The predominant land use is agriculture and rural-residential living. The main form of agriculture other than wildflowers is grazing. East of the development is the locality of Chittering Rise, is further low density rural residential living. To the west is predominantly native vegetation with small areas of grazing to the south and south east.

Careful examination of a 1km zone around the wellhead (Figure 1) shows that the predominant land uses are:

- grazing – there is a small area to the south east of the well head which is a low risk activity
- horticulture in Lot 2 – formerly a wildflower farm where there have been no chemical and or fertiliser inputs for ten years (*pers. comm*. Sean Carbone former landholder and current land manager)
- residential – this will largely be the new development on Lot 2, low density residential
- native vegetation – biodiversity corridor, to the west and south of the development which is a low risk land use activity.



Figure 10 Shows the 1km radius from the well head highlighting existing land use

3.2 Water source protection risk assessment

The purpose of the DWSPP is to ensure the protection of groundwater for the drinking water supply. It is therefore important to assess local land use and assess any risks that it presents to water quality (Table 7). The risk matrix has been developed for land uses within a 1km radius of the bore with other significant land uses in the general vicinity.

Given the confined nature of the aquifer, the depth of the abstraction zone, and the presence of thick shales above this zone, the potential for contamination from existing land-uses can be considered negligible.

Aqua Ferre will regularly monitor source water regularly from its bores to identify any changes in water quality. This monitoring will be undertaken to not only assess changes in water quality but also to ensure the water treatment process meets the requirements of the ADWG and mitigates unnecessary cost associated with chemical and further plant additions.

There are three main contamination risks:

- Microbial – pathogens organisms that are capable of causing disease, including bacteria, protazoa and viruses
- Health-related – these include a wide range of chemicals (organic and inorganic) that can contaminate drinking water. Sources of contamination may include: agricultural herbicides and pesticides, inadvertent chemical spills, and nutrients from a wide range of sources
- Aesthetic – impurities in water that can affect the aesthetic quality of water, including: colour, taste, smell, and hardness. These may not be hazardous to health but may impact customers use and enjoyment.

The risk assessment in Table 7 was undertaken by key Arris staff and the findings were reviewed by Tony Laws, the former Manager of Water Source Protection, DOW.

Table 7 Land use risk assessment for the protection of the drinking water source for the Aqua Ferre treatment plant and reticulated water supply

Land Use	Potential for Water Quality Risk		Management Consideration	Preventative Measures	Protection Strategies
	Hazard	**Likelihood**			
Residential • Existing residential development at Chittering Rise • Riverside Development, 245 low density development	Nutrient contamination from septic tank systems and fertiliser use.	Low	The Riverside Development will use approved ATUs (DOH). The Fuji Clean CE1500, ie one such approved system with discharge capability of : • TP (% removal): 1.3 mg/L (84%) • TN (% removal): 21.0 mg/L (58%)	Monitoring of water quality from production bores.	Undertake community education regarding water quality protection and best management practices.
	Pathogen contamination from septic tank systems.	low			
	Chemical contamination from use of household chemicals and pesticides.	Low			
	Hydrocarbon contamination from fuel and oil storage and spills.	Low			
Rural areas: • Flower farm to the north of the Riverside Development • Grazing areas to the south and southeast of the riverside development	Nutrients from animal faeces (eg horses), septic tanks and fertiliser use.	Low	The rural area is currently un-serviced and wastewater is disposed via septic tank systems. Low density livestock grazing activities. Native flower farming, requires low levels of fertiliser application compared to other irrigated horticulture.	Monitoring of water quality from production bores.	Undertake community education regarding water quality protection and best management practices.
	Pathogens from animal faeces and septic tanks.	Low			
	Use of household and agricultural chemicals and pesticides.	Low			
	Hydrocarbon contamination from fuel and oil storage and spills.	Low			

Land Use	Potential for Water Quality Risk		Management Consideration	Preventative Measures	Protection Strategies
	Hazard	**Likelihood**			
Commercial Developments	Increased chemical, nutrient and pathogen loading.	NA	The current land use options and zoning does not allow for commercial development.	None required.	
Recreation Recreation area will be established in the Riverside development	Nutrients from fertiliser use.	Low	The recreational area consists of approximately 2ha. It will be an amenity and recreational area with low maintenance.	Monitoring of water quality from production bores.	• Follow best management practices as recommended in the WQPG Environmental Guidelines for the establishment and maintenance of turf and grasses areas (WRC & DEP 2001). • Pesticide use should be in accordance with Statewide Policy No. 2 – Pesticide use in Public Drinking Water Source Areas (WRC 2000a) and Circular No: PSC88 – Use of herbicides in water catchment areas (DOH 2007).
	Chemicals from pesticide application and aquatic centre.	Low			
Roads	Hydrocarbons from accidents or spills.	Low	Being in a low density residential area there are a low number of local roads. The local emergency responds to spills and accidents.	• Monitoring of water quality from production bores. • Reserve Road is being sealed, as required in the development approval, and fenced bore compounds. • The bore adjacent Reserve Road is >220m deep. • Local Emergency response. • The Great Northern Highway is >1,600m from the extraction bores	• Continue water quality monitoring program. • Follow best management practices recommended in the WQPN *Roads near sensitive water resources* (DOW 2006d). • Signage to indicate the water reserve boundary and emergency contact number should be installed. • Road drainage should be directed away from the bores.
	Chemicals from accidents or spills.	Low			
Waste Disposal	Increased chemical, nutrient and pathogen loading.	Low	The development will have Council waste services provided.	Monitoring of water quality from production bores.	Undertake community education regarding water quality protection and best management practices including the impact of accumulated and stored wastes.

Land Use	Potential for Water Quality Risk		Management Consideration	Preventative Measures	Protection Strategies
	Hazard	Likelihood			
WTP	Increased chemical loading.	Low	The treatment system has been designed to lower the requirement for chemicals being bought on site. Low volumes <700L of Hypochlorite will be stored. Back wash filter residue will be captured in a geo bag and waste water used for on-site irrigation.	Chemicals will be purchased in 20L containers and storages will have appropriate bunding.	Storage and Handling of Workplace Dangerous Goods NATIONAL CODE OF PRACTICE [NOHSC:2017 (2001)]

3.3 Land uses and activities

Land use and activities in the surrounding areas of the development site are not expected to change in the short term other than for the MEN Phase 1. Figure 11 shows the Local Planning Strategy (2001–2015) for the Shire of Chittering (2004).

Residential expansion is anticipated along the western side of the development and some areas are even considered as a priority for development in the shire. The location of the proposed development is considered residential development. North of the development site is considered a reserve area for agriculture. Along the west side is the Gingin Scarp conservation area where horticulture and vegetation clearing are limited by the Shire.

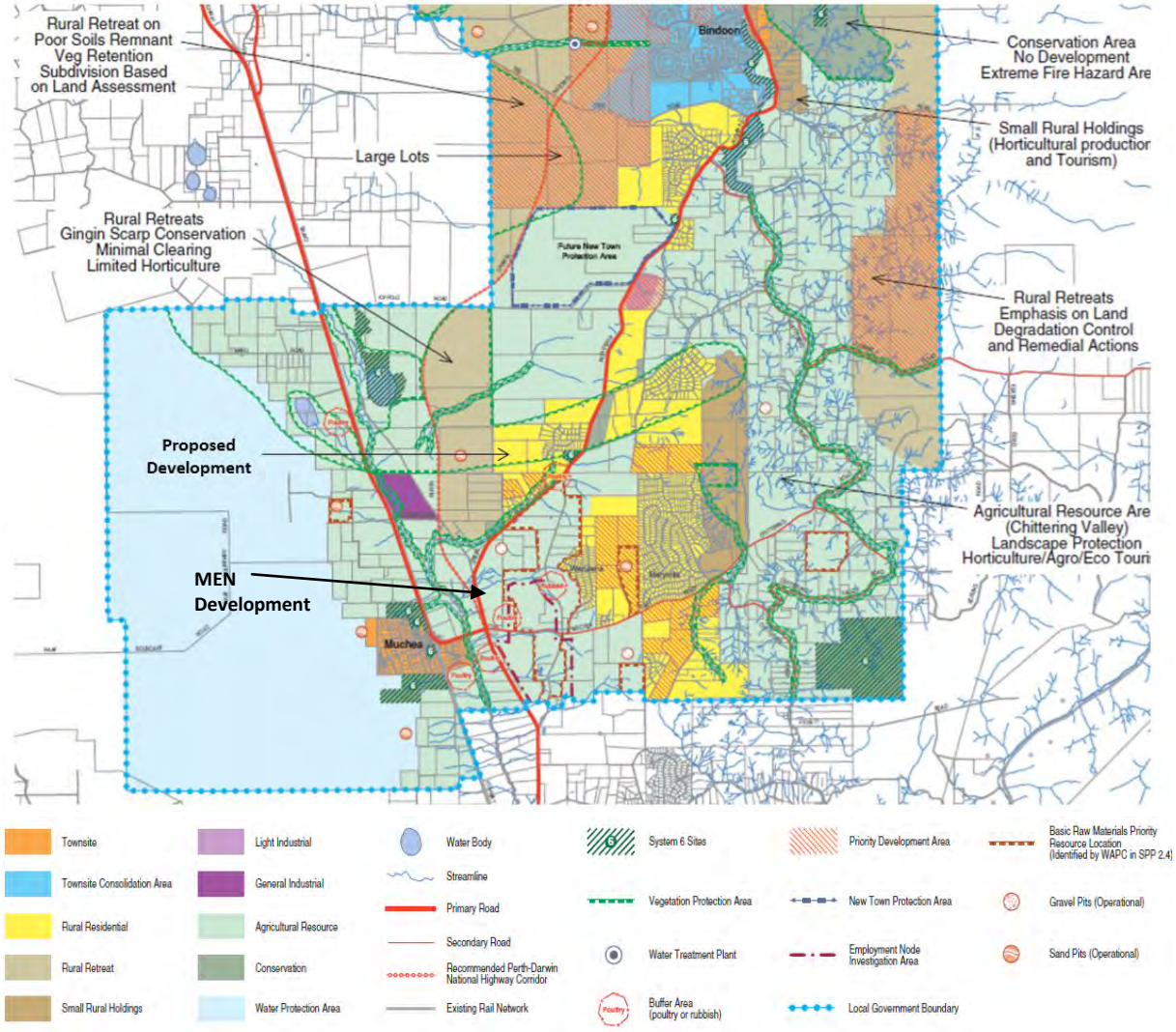


Figure 11 Local Planning Strategy for the Shire of Chittering 2001–2015 (Shire of Chittering, 2004)

The proposed MEN is 4km south of the proposed residential development site, at the intersection of the Brand Highway and Great Northern Highway. This area has been set aside for service-based uses such as transport, livestock, fabrication, warehousing, wholesaling and general commercial (WAPC 2011). The future land use is still under study.

As the MEN is developed, a detailed assessment of land use compatibility with water source protection should be performed due to its proximity to the Reserve Road development site.

It is highly unlikely that the township of Muchea and the MEN will impact water quality due to:

- The regional movement of groundwater from north to south (Figure 12, Leyland, 2011) means that the groundwater at the MEN or the town of Muchea will not interact with groundwater at the extraction bore.
- The separation distances between these areas and the extraction bore, see Figure 11.
- The relatively low extraction volumes which are unlikely to create a cone of depression causing the movement of groundwater from these areas towards the extraction bore.
- The groundwater is being extracted from a confined aquifer where the influence of the township and the MEN will be negligible.
- Site contamination controls imposed on new industries likely to be developed in the MEN are likely to be stringent further mitigating risks.
- The water quality at the extraction bore will be protected by the water source area being protected and proclaimed as a water reserve.
- Protection is mainly from the confined nature of the aquifer rather than from a 30m radius drinking water source protection area.

The proposed drinking water reserve is not expected to be subject to any impact as a result of existing and/or future land use activities because the Leederville–Parmelia Aquifer is confined.

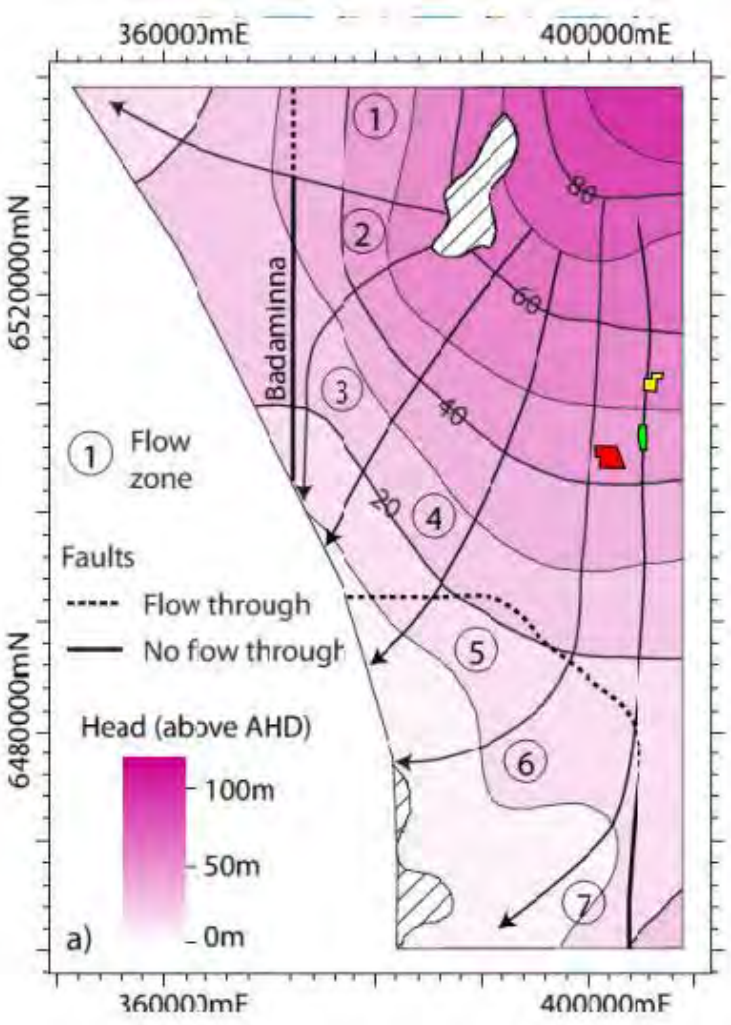


Figure 12 Groundwater flow in the Leederville Aquifer, showing Lot 2 Reserve Road (yellow cell), MEN (green cell) and the township of Muchea (red cell)

4 Water Quality Management, Monitoring and Reporting

A wide range of chemical, physical and microbiological properties can impact on water quality and therefore affect the provision of safe, good quality, aesthetically acceptable drinking water to consumers.

The water quality, monitoring and reporting policies and procedures will include:

- this DWSPP which will follow DOW's Community Drinking Water Sources – Protection and Management (2012)
- a water quality management approach which will be consistent with the ADWG Framework for the Management of Drinking Water Quality (NHMRC and NHMMC, 2011), adapted to a small system
- water quality monitoring procedures which will follow the "Small Community Model Assessable Sampling Grid" (DOW, 2011) and routine reporting which will follow the DOW Systems Compliance and Reporting Requirements for Small Community Water Providers (2011) with quarterly and annually reporting to the department
- procedures for materials that come in contact with water which will follow the DOH Materials and Substances in Contact with Drinking Water specifications (2013)
- emergency reporting procedures which will follow the DOH Systems Compliance and Reporting Requirements for Small Community Water Providers (2011)
- reporting procedures and actions on Amoeba Response will follow the DOH Amoeba Response Protocol (2010)
- analytical methods will follow the American Public Health Association's Standard Methods for the Examination of Water and Wastewater 22nd Edition (2012).

5 Groundwater Source Protection Strategy

5.1 Protection objectives

The objective of the DWSPP is to protect Reserve Road development drinking water, quality and quantity, in order to ensure a reliable, safe drinking water is supplied to consumers.

The measures and management practices recommended in the DWSPP are aimed at avoiding, minimising and/or managing the risk of groundwater contamination, depending on the susceptibility of the source to contamination, the nature of the resource and the existing and proposed land uses in the surrounding areas.

Protecting a drinking water source in not only about protecting its quality; it should also be about ensuring that the available quantity is not compromised. While this strategy can suggest methods of protecting quantity, it is beyond the scope of the report, or the responsibility of the proponent to legislate or restrict other users of groundwater in the area. The responsibility to manage the state's water resources and supply rests with DOW and regulatory authorities.

5.2 Proposed proclamation of Reserve Road water reserve

Water reserves, catchment areas and underground water pollution control areas are collectively known as public drinking water source areas. The protection of the areas relies on statutory and non-statutory measures for water resources management and land-use planning.

This DWSPP recommends proclaiming an area of approximately 30m around the production bore for the Reserve Road development under the *Country Areas Water Supply Act* (1947). This area should be proclaimed as the Reserve Road Water Reserve. This will enable DOW to control potentially polluting activities, to regulate land use, inspect premises and to take the necessary steps to prevent or clean up pollution (DOW, 2009c).

It is important to keep in mind, that the water from the production bore is drawn from a deep confined aquifer protected by an overlying layer of Kardinya shale that sits above the groundwater resource and acts as barrier to contamination. The contamination risks from surrounding land uses to the Reserve Road development water source and reserves are negligible. Nonetheless, proper bore construction and maintenance of existing bores and any new bores proposed to be located near drinking water production bores is required.

Consideration should be given to restricting access to the confined aquifer within say a 1,000m radius of the Aqua Ferre production bores to reduce the risk of interference and the potential to affect reliability of supply. Alternatively bores within that radius should be restricted to the superficial aquifer. Given it is DOW's role to manage water resources, the potential to restrict access to groundwater in the area should be developed in conjunction with the department.

5.3 Priority areas

The Western Australia Government policy for the protection of public drinking water source areas includes a system that defines three specific priority areas:

- Priority 1 areas have the fundamental water quality objective of risk avoidance (eg state forest and other Crown land). These areas are managed to ensure that there is no degradation of the drinking water source by preventing the development of potentially harmful activities in these areas.

- Priority 2 areas have the fundamental water quality objective of risk minimisation (eg land that is zoned rural). These areas are managed to ensure that there is no increased risk of water source contamination/pollution.
- Priority 3 areas have the fundamental water quality objective of risk management (eg areas zoned urban, industrial or commercial). These areas are defined so as to manage the risk of pollution to the water source from catchment activities.

For further information, refer to *Water Quality Protection Note: Land Use Compatibility in Public Drinking Water Source Areas* (DOE, 2004).

The assignation of the priority area ought to be in accordance with current Western Australian Government policy. If the site is proclaimed as a water reserve, it is recommended that the land surrounding the production bore should be identified as a Priority 1. The main reason is because the water from this source is a strategic and fundamental supply to the development, then it should be assigned a high level of protection.

5.4 Land use planning

It is recognised under the *State Planning Strategy* (WAPC, 1997) that the establishment of appropriate protection mechanisms in statutory land-use-planning processes is necessary to secure the long-term protection of drinking water sources. As outlined in the *Statement of Planning Policy No. 2.7 – Public Drinking Water Source Policy* (WAPC, 2003) it is appropriate that the Reserve Road Water Reserve, priority areas and protection zones be recognised in the Shire of Chittering. Any development proposals within the Reserve Road Water Reserve that are inconsistent with advice within the *Water Quality Protection Note – Land compatibility in Public Drinking Water Source Areas* (DOE, 2004a) or recommendations in this plan, should be referred to DOW.

The department's protection strategy for public drinking water source areas provides for lawfully established and operated developments to continue despite their location or facilities posing a level of risk to water quality which would not be accepted for new developments. The department may negotiate with landowners and operators on measures to improve these facilities or processes to lessen the level of water contamination risk.

In critical areas close to production bores, the department may negotiate to purchase land or development rights where the level of contamination risk is considered significant enough to have the potential to compromise the quality of water resources.

Land use and activities in the surrounding areas of the extraction bore site are not expected to change in the short- to medium-term, other than the proposed Riverside development. However, establishing appropriate protection mechanisms in statutory land use planning processes is important to secure the long-term protection of the water source.

The WAPC's *Public Drinking Water Source Policy* (2003) recognises that appropriate protection mechanisms in statutory land use planning processes are necessary to secure the long-term protection of drinking water sources. Thus, in accordance with this policy, it is appropriate that the areas surrounding the source area should be recognised as a special control area in the Shire of Chittering Town Planning Scheme and associated planning approval processes. In addition, any development proposals in the surrounding areas should take into account the Water Quality Protection Note No 25: *Land use compatibility in public drinking water source areas* (DOW, 2004) and seek advice from DOW.

5.5 Best management practices

There are different ways to decrease water contamination risks of water sources by carefully considering design and management practices. There are tools available to provide guidelines for suitable bore construction methods to protect water sources, eg “Minimum Construction Requirements for Water Bores in Australia (3rd Edition)” from the National Water Commission (National Uniform Drillers Licensing Committee, 2012). Given that the aquifer to be developed is confined, with groundwater being under some reasonable pressure, adherence to this document and its recommendations for drilling, construction, and development is of paramount importance to ensure proper protection against contamination risk. Some specific best management practices to be applied are secure fencing to the bore compound and signage showing the name of water service provider and emergency contact numbers.

In addition, there are guidelines available for many land uses, including industry codes of practice, environmental guidelines and water quality protection notes (Appendix C). These guidance tools have been developed in consultation with stakeholders such as industry groups, primary producers, state government agencies and technical advisers. The following water quality protection notes are recommended as best practice for water quality protection:

- Agriculture – dryland crops near sensitive water resources
- Contaminant spills – emergency response
- Light industry near sensitive waters
- Tanks for elevated chemical storage
- Protecting public drinking water source areas
- Rural restaurants, cafés and taverns near sensitive water resources.

The application and understanding of these guidelines will assist business and land managers to reduce the risk that their operations may cause unacceptable environmental impacts.

Education and awareness is another mechanism for water quality protection, especially for people visiting the area who are unfamiliar with the water source location.

A brochure will be produced, describing the Reserve Road Water Reserve, its location and the main threats to water quality and quantity. This brochure will be available to the community and will inform people in simple terms about the drinking water source and the need to protect it. This brochure will be available from the Aqua Ferre website; further to this its availability will be included in water accounts.

5.6 Surveillance and by-law enforcement

The quality of public drinking water sources within country areas of the state is protected under the *Country Areas Water Supply Act* (1947). Declaration of these areas allows existing By-laws to be applied to protect water quality.

Appropriate signage on boundary fences of the proposed water reserve will advise the public about activities that are prohibited or regulated.

DOW considers by-law enforcement, through surveillance of land use activities in public drinking water source areas, as an important mechanism to protect water quality.

5.7 Responding to emergencies

Water contamination may occur due to unforeseen incidents, as well from action taken (such as the use of chemicals) during emergency response.

The Shire of Chittering's Local Emergency Management Advisory Committee shall be familiar with the location and purpose of the water bore within the limits of the development. The fire and rescue services headquarters should be provided with a locality plan and this should be made available to the Hazardous Materials Emergency Advisory Team. Aqua Ferre should have an advisory role to any hazardous materials incidents in, or nearby Reserve Road, Chittering.

A map of the Reserve Road water bore will be made available to any personnel who deal with hazardous material related incidents in the area. Personnel should be highly aware of the potential of hazardous material on the water resource.

6 Recommendations for the DWSPP

The following recommendations are made for the proposed Reserve Road development. The relevant stakeholder in terms of implementation is indicated in brackets at the end of each recommendation.

- proclaim the bore and surrounding land (~30m diameter circle around the bore) a Reserve under the *Country Areas Water Supply Act* (1947) (DOW and Aqua Ferre)
- implement the water source protection strategies identified in this Water Source Protection Plan to ensure the protection of water quality (Aqua Ferre)
- construct a sound boundary fence to the proposed reserve with a secure gate and signage informing any prospective buyers of the private drinking water source, the name and location of the water source provider and an emergency telephone number (Aqua Ferre)
- development and works proposals in the Reserve Road development that are inconsistent with DOW's guidelines and Water Quality Protection Note should be referred to DOW for advice and recommendation (Shire of Chittering and Aqua Ferre)
- a surveillance program should be maintained to identify any incompatible land uses or potential contaminant threats within Reserve Road water drinking source (Water Corporation)
- new land uses not complying with WAPC *State Planning Policy No 2.7: Public Drinking Water Source Policy* (2003) and DOW's *Water Quality Protection Note 25 Land use Compatibility in Public Drinking Water Source Area* in proclaimed areas should be referred to DOW for assessment
- any bores proposed to be installed to use the aquifer in close proximity to the Reserve Road bore should be assessed to determine their location; construction and possible leakage do not pose a contamination risk to this drinking water source (DOW and Aqua Ferre)
- incidents covered under the *State Emergency Management Plan for Hazardous Materials Emergencies* (FESA, 2010) and occurred in the Reserve Road drinking water source should be addressed by Hazardous Materials Emergency Advisory Team, DOW, and Aqua Ferre
- provide a copy of the DWSPP on the Aqua Ferre website (Aqua Ferre).

Implementation of these recommendations should be reviewed one year after the DWSPP is endorsed. A full review and update of the DWSPP should be undertaken by Aqua Ferre every five years.

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8 Appendix A – Log for Existing Bore at Reserve Road

FORML2889

FORM "L" COVER SHEET

DRILLING COMPLETION DATE: 25/02/1981

***BORE LOCATION ADDRESS:** LOT 2, 200 RESERVE ROAD, CHITTERING

PROPERTY PIN NUMBER:
(GIS Property Info.)

***BORE LOCATION CO-ORDINATES:**

MGA Zone Number: 50

Easting Number: 405153

Northing Number: 6511488

***Co-Ordinates Reliability:** Unknown
(Survey, DoW GIS, GPS, Unknown e.g. DoW GIS (WRL) (50m))

***GROUNDWATER SUBAREA NAME – DoW:** ECLIPSE HILL
(e.g. Dardanup)

BASIN NUMBER: 616

LICENCE:

CAW Number:
(Not always shown or required, only used if no GWL #. If only a CAW Licence was issued write this number only and write 'Exempt' if the bore was exempt from licensing).

***GWL Number:** 59907

***GWL DPT ID Number:** 22593

MEDIA REFERENCE: SN1091
(File Number)

***GWL AQUIFER NAME:**
(If only a CAW Licence has been issued write this aquifer and CAW)

WIN AWRC NUMBER: 61602501

COMMENTS: SA

ELECTRONIC FILE NAME:

.pdf

Note: Fields marked with * must be completed.

Copy sent to WIN ☐
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WIN SITE ID:
20025333

WATER AUTHORITY of Western Australia

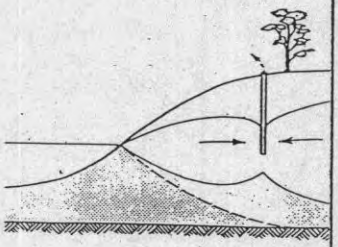
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Telephone: 096 224 888
Facsimile: 096 222 696

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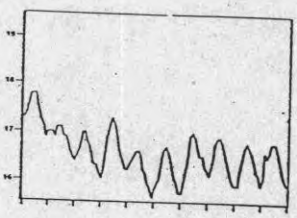
CON de BLECOURT
WATER RESOURCES OFFICER
CENTRAL REGION



TO: Groundwater & Environmental

FAX NO: 09 4203176

DATE: 30 / 7 / 93.



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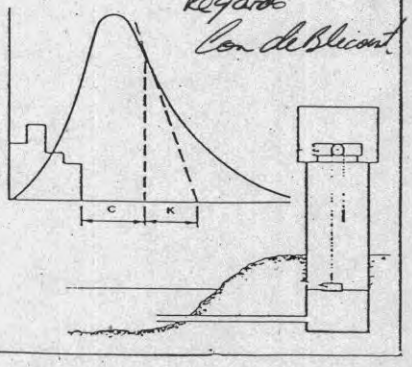
ATTENTION: ANDREW McCRAE.

MESSAGE

Attached more info on Bore 1/81 which is suppose to be located on Lot 6 GT NTH Hwy - Trading as Aust Wax Farms.

Also I have another lot 9 info on Swan Loc M1313 a Mr Feuster he has an allocation of only 6,000 KL/a. There is no info on Lot 2 Reserve Rd Mucka. Their is Two bores on the Property and I believe one is artesian, depth of 250 metes.

Regards
Con de Blecourt



WARNING

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☐ We will forward the original documents by mail for your files.

☐ We recommend you photocopy (using a plain paper copier) the following documents and place the photocopies on your files not the facsmile copies.

26

SUMMARY

Drilling Contractor: J. Weber, Muchea.

Drilling Rig: Mud rotary.

Date set up on site: [redacted].
Date test pumping completed: [redacted] Test rig removed 6 March 1981.

Test pumping: by P.W.D. driller B. Gerdai.

Test equipment supplied by P.W.D.:
22W cable tool drilling rig
Randolph deep well turbine pump Model F60.
Horsepower: 60
R.P.M.: 1760
Power unit: V-8 petrol engine.
Flow testing: Orifice tube with 64 mm orifice plate.

Procedure: Drilled pilot hole, uncased, to 216.4 m.
Electric log by Well Logging Services.

Deepened pilot hole to 259 m.
Electric log by Geological Survey of W.A.

Pilot hole reamed out for 6-1/8 inch I.D. (155.8 mm) casing having ¼-inch wall thickness. Casing was set at 12.7 cm above 228 m.

Cement grout used: 8 m^3, set overnight.
Top of plug: 225 m.

Screen: Length overall: 15.47 m.
Effective length: 15.15 m
Mesh: 30/thousands of an inch.
O.D.: 5-inch (127 mm)
Packer: Neoprene.
Top of screen: 225.70 m.
Bottom of screen: 240.97 m.

Development: by compressed air for approx. 2½ days.

Static Water Level: 86.73 m below natural surface (284.55 feet).

Pump testing: Two step drawdown tests followed by final pumping test of 6 hours duration.

Pumping delivery rates during tests:
Step 1: 369 m^3/day (4299 galls/hour)

Step 2: 836 m^3/day (7663 galls/hour)

S.W.L. recovered very rapidly.

Final: 1012 m^3/day (1010.17 galls/hour)
maximum drawdown 10.10 m below the S.W.L.
Full recovery in 30 mins.

Salinity: Approx. 280 mg/l (by conductivity). Sample submitted to [illegible]technics for analysis.

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GENERAL

The bore was initially drilled by J. Weber to 710 feet, and electrically logged by J. Hayes of Well Logging Services. Both log and mud samples indicated that the bore had not reached the bottom of the Late Cretaceous - apparently in Osborne Fm equivalent. No usable pressure water aquifer had been intersected at depth, though one layer of apparently usable water existed at about 78-81 metres in a rather more sandy sequence than elsewhere. This water, because of the thin bed and also relatively shallow depth below the static water level, was considered unlikely to provide enough water for requirement. Clients had discussed a minimum need of 6000 gallons/hour and a salinity of probably 1200 mg/l or less.

Continuation of drilling the pilot hole to 850 feet (259 metres) was agreed to, and done on 12 Feb. 1981. The logging by G.S.W.A. indicated usable water in a section between roughly 225 and 240 metres, in a more sandy section than above. The lowest salinity was estimated at about 600 mg/litre and the average for the bed at probably 1200 mg/litre.

Consultants suggested developing this level to obtain a water supply. From the nature of the mud samples and the trace of the gamma-ray log, it seems likely that the stratum is a rather gritty silt which would have to be carefully developed to obtain best results.

The driller reported bottom as being shale (not reached by the logger because of blockage), and as there is a local history of increasing salinity with depth, deeper drilling was not thought advisable, at least at the time, because further water supplies might be too saline for use.

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Approval to convert the pilot hole to a production bore was obtained by telephone on 13.2.81.

PRODUCTION BORE

Pilot bore was accordingly reamed out for 6-1/8 inch I.D. casing (¼-inch wall thickness), which was set at five inches above 228 m, and pressure-cement grouted from bottom up to natural surface level, using 8 m^3 of grout over 35 minutes. The grout was allowed to set overnight, when the top of the plug was found to be at 225 m. The plug was drilled out and the screen set in position.

SCREEN DETAILS

Length overall	- 15.27 m.
Length of mesh section	- 15.1 m.
Packer	- double neoprene rings.
Slots	- No.30 slot, 0.75 inches.
Setting	- Top of packer 225.70 m. Bottom of screen 240.97 m.

DEVELOPMENT

Development started with compressed air, the air line being placed finally at 400 feet below surface, and continued for approx. 2½ days. Water cleared on the third day and remained clear.

SALINITY

After 1½ hours of air-development, salinity by conductivity was 600 mg/litre. After 2 hours, salinity 320 mg/litre. After 2 days, salinity 230 mg/litre. Final pumped sample approx. 280 mg/litre (by conductivity).

WATER LEVEL

At conclusion of development, static water level below natural surface was 86.73 metres (284.55 feet).

aR3

, BORE NO. 1, MUCHEA 12 Feb. 1981

DRILLER: J. WEBER. Mud-rotary Rig.

Geophysical Logs: J. Hayes. Also G.S.W.A.

Geological Log

Depth (feet)	Description of Sample
0-10	Laterite, coarse quartz grit, clay. Red-brown.
10-20	As above.
20-30	As above.
30-40	As above.
40-50	Sand, coarse quartz grit, laterite fragments, very clayey, red-brown to yellow-brown.
50-60	As above, grit very rounded; with some yellow bands.
60-70	Sand and Grit, very clayey, lateritic, quartz grains well-rounded and coloured translucent, yellowish, and pale greenish. Yellowish to red-brown.
70-80	As above.
80-90	As above, with sparse dark-coloured rounded rock fragments, some pinkish quartz grains.
90-100	As for 60-70.
100-110	Quartzose grit, mainly translucent, very clayey, well-rounded, sparse hard lateritic gravel, yellowish to reddish-brown.
110-120	As for 100-110 but more lateritic; red-brown.
120-130	Grit, well-rounded and coarse, sandy, clayey, some laterite fragments, dark reddish brown.
130-140	As above.
140-150	As above.
150-160	Sand, Grit, well-rounded; and laterite, very clayey, red-brown.
160-170	As above.
170-180	As above.
180-190	As above.

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190-200	Grit, translucent, well-rounded, sandy, very clayey, red-brown.
200-210	Clay, sand, and grit, well-rounded, yellow-brown.
210-220	Clay, sand, grit, and yellow laterite, reddish to yellowish-brown.
220-230	Clayey Sand and grit, well-rounded, some dark and bottle-green fragments, some laterite particles (probably contamination); black shaley material, dark brownish-grey.
230-240	Clay, dark grey, rounded greenish or dark sand and grit, dark grey.
240-250	Grit and Sand, very clayey, well-rounded, dark brown.
250-260	As for 240-250, with some grit fragments, very dark-coloured.
260-270	As for 240-250, some grit grains pinkish-white. Dark grey-brown.
270-280	As for 240-250.
280-290	As for 240-250.
290-300	Grit and clay, sandy, slightly pyritic, well-rounded particles, dark brownish-grey.
300-310	Grit, subrounded, translucent to black, with black clayey material, greenish black. Sample collected for palynological examination.
310-320	As for 300-310.
320-330	As for 300-310.
330-340	Grit, well-rounded, translucent to light green, some grey-white, very clayey, dark brownish-grey.
340-350	Grit and Sand, dark with some greenish subrounded fragments; and Black Clay, dark brownish-black.
350-360	Shale, sandy, with plentiful grit, dark brownish-black.
360-370	Shale, with subrounded grit, greenish-black.
370-380	Shale, black, plentiful subrounded grit, dark greenish-grey.
380-390	Shale, probably carbonaceous, subrounded grit and sand, dark greenish-black.
390-400	As for 380-390.
400-410	Shale, carbonaceous, with subrounded grit and sand, brownish-black. Sample for palyno examination.
410-420	As for 400-410.

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420-430	Shale, finely sandy, subrounded grit, carbonaceous, black.
430-440	As above.
440-450	Shale, sandy, some transparent to slightly greenish subrounded grit, black.
450-460	As for 440-450.
460-470	As for 440-450.
470-480	Shale, sandy, some subrounded grit, black.
480-490	As for 470-480.
490-500	Shale, with sand and some subrounded grit, some greenish grains, black.
500-510	As for 490-500. Sample for palyno examination.
510-520	As for 490-500.
520-530	Shale, subrounded grit, one thin flake of limestone, dark brownish-black.
530-540	Shale, probably carbonaceous, with subrounded grit, black.
540-550	As above, slightly pyritic.
550-560	Shale, sandy, gritty, black.
560-570	As for 550-560.
570-580	Shale, gritty, sandy, slightly pyritic, black.
580-590	Shale, sandy, gritty black.
590-600	Shale, gravelly, sandy, very gritty, black.
600-610	Shale, sandy, carbonaceous, gritty, black. Sample for palyno examination.
610-620	Shale, sandy, with rounded greenish grit, sparse flakes of limestone, black.
620-630	Sand, grit, and shale, with sparse limestone fragments, dark brown.
630-640	As for 620-630.
640-650	As for 620-630.
650-660	Sand, grit, shale, and some sandstone, dark grey.
660-670	Sand, shale, and grit, dark grey.

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670-680	Sand, and grit, some small black fragments probably of shale, grey-black.
680-690	Sand, slightly, shaley, very dark grey.
690-700	Grit (subrounded), shale, and sand, very dark grey.
700-710	As for 690-700. Samples from 690-710 sent for palyno examination.
710-720	Shale, with plentiful subrounded pale greenish grit, black.
720-730	As for 710-720.
730-740	Shale, with plentiful subrounded pale green to translucent grit, some sandstone fragments, carbonaceous, black.
740-750	Silt, shaley and finely sandy, with subangular to subrounded grit, some black shale. Very dark grey.
750-760	Silt, some subangular grit, finely sandy, pyritic, some black shale fragments and small pieces of sandstone. Very dark grey.
760-770	Siltstone, finely sandy, shaley, subrounded coarse pale greenish quartz grit, slightly pyritic, dark grey.
770-780	Siltstone, finely sandy, frequent small fragments of black shale, coarse subrounded grit, dark grey.
780-790	Silt, finely sandy, very gritty (subangular to subrounded), fragments of black shale, dark grey.
790-800	Grit, subrounded to subangular, silty and finely sandy, thin bars of black shale, dark grey.
800-810	Grit, subrounded, fairly silty, sparse black shale fragments, dark grey. Sample for palyno examination.
810-820	Siltstone, soft, finely sandy, gritty. Some black shale fragments, fairly dark grey.
820-830	Silt, finely sandy, gritty, slightly pyritic, some black shale fragments, dark grey.
830-840	Silt, gritty, some black shale fragments, dark grey.
840-850	Silt, with subrounded to subangular grit, slightly pyritic, some black shale fragments, dark grey. Sample for palyno examination.

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True Depth: 850 feet (259 metres).

Electric log to 831 feet. 253m

Water recorded:

Depth (m)	Approx salinity (mg/litre) from electric log
78-84	700
228-246)	1200
234-240)	600

Comment: The water at 78-84 m is a very doubtful source of continuing supply in the amount needed.

Suggested screen placement is from 225 to 241 m.

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BORE 1/81 on Lot 2. Muchea

Test pumping by PWD. Driller Gerlai. BG.

Pump: Randolph Turbine Model F60
H.P. 60
R.P.M. 1760
Power unit V8 car engine (petrol).

Pump Setting: Total length of pump and column 136.04 m.
Top of pump set at 133.74 m.

Drawdown measured by airline and pressure gauge.

Airline setting: 133.74 m.

S.W.L. 86.73 m. Air gauge records 47.0 m.

Orifice tube: 2½ inch (64 mm) orifice plate. Set level.

For first Step Drawdown Test, pumping rate 369 m^3/day, (4299 galls/hour). Pump ran a little irregularly for 30 mins, and had to be manually adjusted throughout the test.

25 Feb. 1981

Time (mins)	Airline pressure (m)	Drawdown (m)
0	47.0	0
2	44.40	2.60
3	44.20	2.80
4	44.15	2.85
5	44.15	2.85
10	44.20	2.80
15	44.20	2.80
20	44.45	2.55
25	44.45	2.55
30	44.40	2.60
	Pump shut off. Zero flow.	
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	Level recovering. No footvalve on pump, so pump is backdraining at 31 minutes.	
31	47.40	
32	46.60	
33	47.0	Full SWL recovery after 3 minutes.
35	47.0	

Second Step Drawdown test.

Pumping rate 836 m^3/day = 7663 galls/hour.

S.W.L. 87 m.

Time (mins)	Airline pressure (m)	Drawdown (m)	
0	47.0	0	Pump was running
1	40.40	6.60	a little raggedly
2	40.35	6.65	throughout test.
3	40.30	6.70	
4	40.30	6.70	

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5	40.25	6.75
10	39.80	7.20
15	39.75	7.25
20	39.70	7.30

Pump shaft broke after 20 minutes.

Broken pump shaft was replaced, and main pumping test attempted on 26.2.81.

Pump delivery rate set at 1102 m^3/day.

S.W.L. 86.73 m below natural surface.

Airline pressure gauge 46.60 m.

Orifice tube level.

Time (mins)	Airline pressure (m)	Drawdown (m)
0	46.60	0
1	38.20	8.40
2	37.80	8.80
3	37.80	8.80
4	37.40	9.20
5	37.20	9.40
10	37.30 *	9.30
15	37.05 *	9.55
20	37.00	9.60
30	36.80	9.80
45	Pump stopped. Broken shaft.	

N.B. * These values are doubtful because pump was running raggedly and the pumping rate varied.

27.2.81

Broken pump shaft replaced, and airline reset at 103.30 m below natural surface.

S.W.L. now 85.9 m.

Airline pressure 17.4 m.

Pumping rate: 1102 cu. m/day.

Time (mins)	Pressure gauge (m)	Drawdown	
0	17.4	0	
1	8.30	9.1	
2	7.80	9.6	
3	8.20	9.2	
4	9.60	8.8	
5	17.10		Water ran very dirty, but stable flow.
6	20.3		?gauge sticking?
8	12.1		
9	0.8)		A hole has blown in the airline.
11	0.8)		Test abandoned.
15	0.8)		
20	0.8)		
30	0.8)		
45	0.8)		

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3 March 1981 Second (abortive) final pumping test.

S.W.L. 85.9 m.

Pumping Rate set at 1102 cu. m/day.

Airline pressure 14.80 m.

Time (mins)	Airline pressure (m)	Drawdown (m)
0	14.80	0
1	12.6	2.2
2	11.0	3.8
3	10.4	4.4
4	10.3	4.5
5	10.1	4.7
10	8.9	5.9
15	8.9	5.9
20	8.8	6.0

Pump stopped. Dirty fuel.

4 March 1981 Third (abortive) final pumping test.

S.W.L. 85.9 m below natural surface.

Pumping rate set at 1102 cu. m/day.

Pressure gauge zero was 0.8 m, so all gauge readings from here on must be reduced by 0.8.

Time (mins)	Air pressure (as recorded on gauge)	Corrected pressure	Drawdown
0	14.9	14.1	0
1	13.2	12.4	
2	12.8	12.0	
3	12.6	11.8	
4	12.5	11,7	
5	12.4	11.6	
10	10.2	9.4	
15	9.1	8.3	5.8

Engine stopped. Dirty fuel.

5 March 1981 Final (successful pump test)

S.W.L. 86.73 m below natural surface.

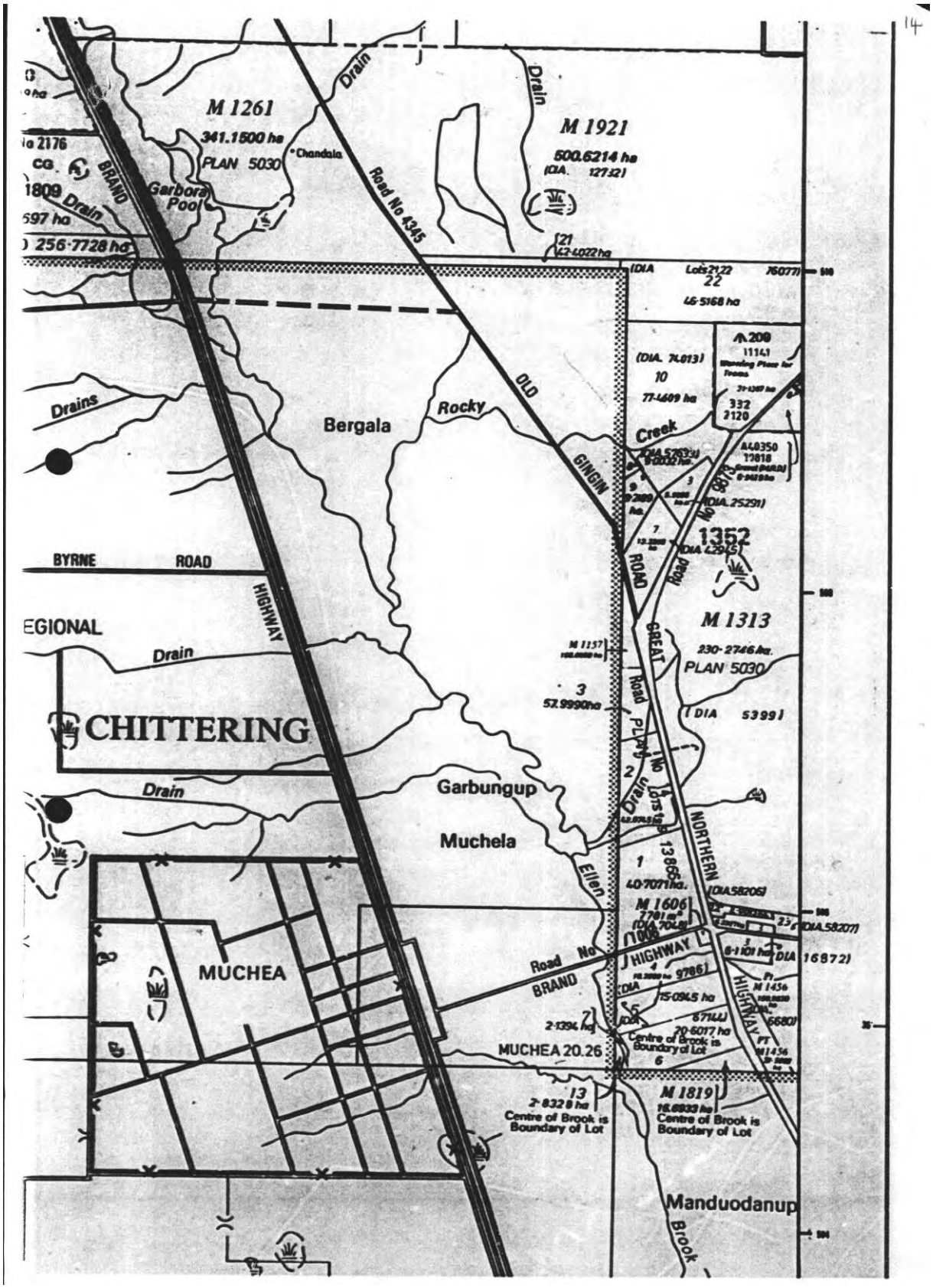
Pumping rate set as 1102 cu. m/day.

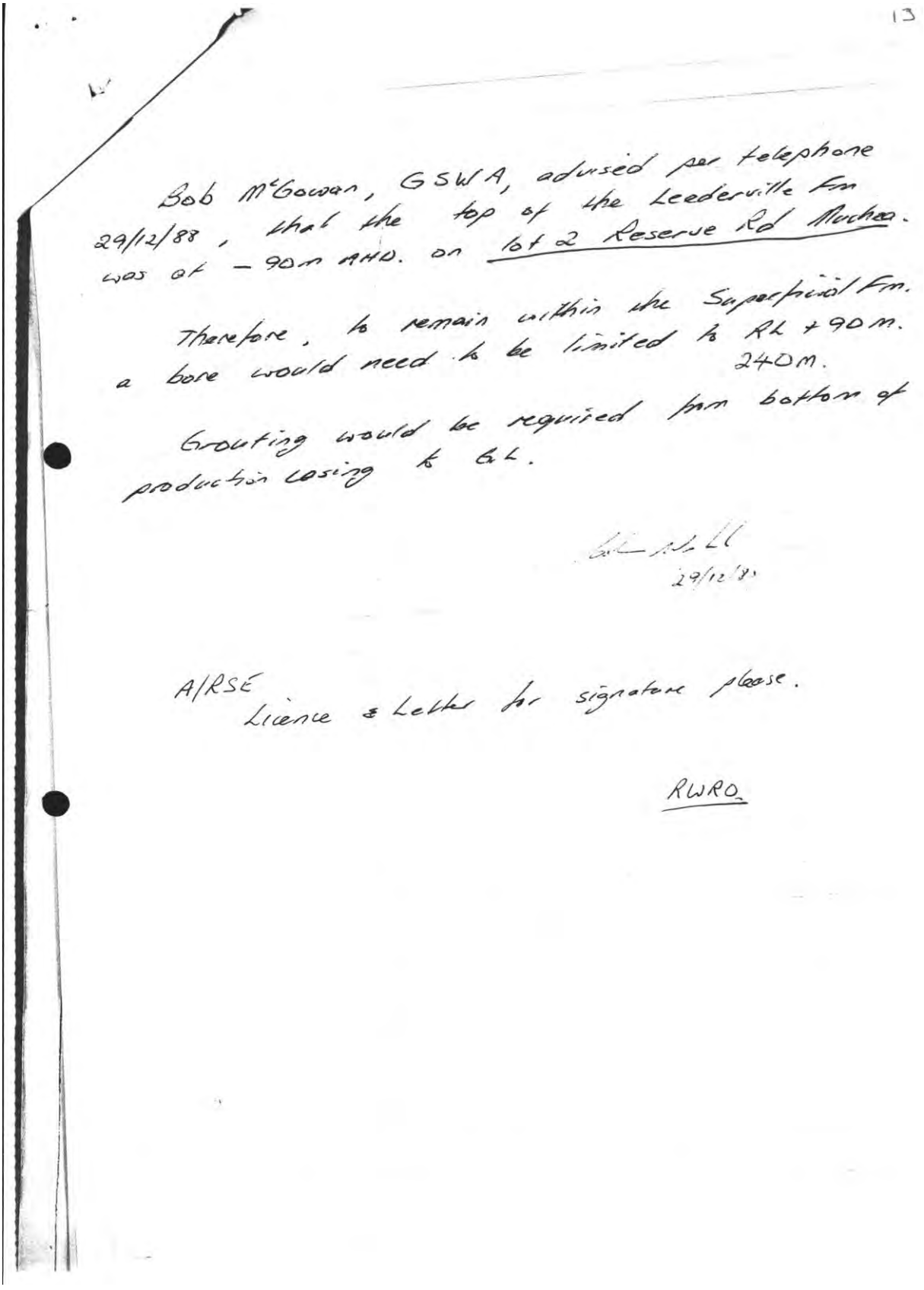
Elapsed Time	Drawdown	Elapsed Time after pumping stopped	Recovery
1 (mins)	0.90 m	1 (mins)	4.80 m
2	1.60	2	6.20
3	2.30	3	7.10
4	3.40	4	8.20
5	4.80	5	9.00
10	5.50	10	9.70
15	6.60	15	10.00
20	7.80	20	10.05
30	8.40	30	10.10

45	9.00
1 (hrs)	9.30
1¼	9.60
1½	9.80
1-3/4	9.90
2	10.00
2½	10.10
3	10.10
3½	10.10
4	10.10
5	10.10
6	10.10

Recovery complete after 30 minutes.

E.P.D. O'DRISCOLL,
Senior Consultant.


M 1261
341.1500 ha
PLAN 5030
Chandala
Garbora Pool
Drain
Road No 4345
M 1921
500.6214 ha
Drains
Bergala
Rocky
Creek
OLD
GINGIN
BYRNE ROAD
HIGHWAY
EGIONAL
Drain
CHITTERING
Garbungup
Muchela
MUCHEA
Ellen
BRAND
Road No
NORTHERN
HIGHWAY
GREAT
Road
PLAN 5030
M 1313
230-2746 ha
1352
M 1606
M 1819
MUCHEA 20.26
Centre of Brook is Boundary of Lot
Manduodanup
Brook



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Bob McGowan, GSWA, advised per telephone 29/12/88, that the top of the Leederville Fm was at −90m AHD. on lot 2 Reserve Rd Mullaloo.

Therefore, to remain within the Superficial Fm. a bore would need to be limited to RL +90m. 240m.

Grouting would be required from bottom of production casing to GL.

29/12/88

A/RSE
Licence & Letter for signature please.

RWRO

9 Appendix B – Bore Water Quality

The raw bore water is of excellent quality with low TDS of 300 mg/L. No parameters fall outside of the health requirements of the ADWG. The aesthetic levels of iron and manganese, which occur naturally in groundwater, are exceeded. Their concentrations are caused by the low oxygen content of the water. Neither of the elements causes adverse health effects and methods for iron and manganese removal that have been well established will be used on site.

Analyses of bore water taken from April to November 2015 are summarised in Table 8. It is evident that the raw water from the Leederville–Parmelia confined aquifer has an excellent quality. Most analytes are well below their respective drinking water quality criteria except for high concentrations of iron and manganese.

Table 8 Analyses of bore water sampled from April to November 2015

Bore Water Quality Analysis (GWL 59907)	Units	14 April	21 April	23 April	28 April	18 May	11 June	31 July	1 Sept	14 Oct	30 Nov	Average	Max	Min	ADWG Limits	
															Health	Aesthetic
pH in water		7.2	6.7	7	6.4	6.2	6.7	6.5	6.2	6.5	6.4	**6.6**	7.2	6.2		6.5-8.5
Electrical conductivity water	µS/cm	470	500	470	490	460	500	520	510	510	510	**490**	520	460		
TDS	mg/L	280	300	280	290	270	300	310	300	310	300	**291**	310	270		500
Chloride in water	mg/L		120	120	120	120	120	120	120	110	110	**119**	120	110		250
Fluoride in water	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.3		0.3	0.3	**0.3**	0.3	0.3	1.5	
Iodide in water	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**<1**	<2	<3	0.1	
Bromide	mg/L						<0.5	<0.5	<0.5			**<0.5**	<0.5	<0.5		
Sulphate in water	mg/L	6	12	13	13	13	14	13	13	12	12	**12**	14	6	500	250
Total Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	**<0.004**	<0.004	<0.004	0.08	
Sulphide in water	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	**<0.01**	<0.01	<0.01		
Nitrate as NO_3	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**<0.05**	<0.05	<0.05	50	
Nitrite as NO_2	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**<0.06**	<0.06	<0.06	3	
Ammonia as N	mg/L	0.15	0.02	0.03	0.05	0.04	0.05	0.055	0.044	0.019	0.051	**0.056**	0.15	0.02		0.5
Dissolved CrVI	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	N/A	N/A				**<0.005**	<0.005	<0.005	0.05	
Hardness as $CaCO_3$	mg/L	58	50	46	46	46	50	49	49	52	51	**50**	58	46		200
Sodium - Dissolved	mg/L	72	74	69	68	70	68	66	69	78	74	**70**	74	66		180
Aluminium-Total	mg/L	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.05**	0.05	0.05		0.2
Arsenic-Total	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.001**	0.001	0.001	0.007	
Barium – Total	mg/L	0.099	0.1	0.085	0.086	0.089	0.089	0.098	0.086	0.082	0.089	**0.092**	0.1	0.085	0.7	

Bore Water Quality Analysis (GWL 59907)	Units	14 April	21 April	23 April	28 April	18 May	11 June	31 July	1 Sept	14 Oct	30 Nov	Average	Max	Min	ADWG Limits	
															Health	Aesthetic
Beryllium – Total	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	**<0.0005**	<0.0005	<0.0005	0.06	
Boron – Total	mg/L	0.042	0.051	0.047	0.049	0.057	0.055	0.056	0.07	0.05	0.058	**0.052**	0.058	0.042	4	
Cadmium – Total	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	**<0.0001**	<0.0001	<0.0001	0.002	
Chromium – Total	mg/L	N/A	N/A	N/A	N/A	N/A	<0.001	<0.001	<0.001	<0.001	<0.001	**<0.001**	<0.001	<0.001		
Copper – Total	mg/L	0.016	0.019	0.17	0.041	0.019	0.011	0.014	0.002	0.004	<0.001	**0.0414**	0.17	0.011	2	1
Iron – Total	mg/L	1.7	16	16	14	6.9	5.5	12	10	11	10	**10**	16	1.7		0.3
Lead – Total	mg/L	<0.001	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.004**	0.004	0.004	0.01	
Molybdenum – Total	mg/L	0.005	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.003**	0.005	0.001	0.05	
Manganese – Total	mg/L	0.027	0.49	0.33	0.31	0.18	0.23	0.33	0.23	0.25	0.23	**0.266**	0.49	0.027	0.5	0.1
Mercury – Total	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	**<0.00005**	<0.00005	<0.00005	0.001	
Nickel – Total	mg/L	0.001	0.004	0.009	0.004	0.003	0.002	0.001	<0.001	<0.001	<0.001	**0.003**	0.009	0.001	0.02	
Selenium – Total	mg/L	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.003**	0.003	0.003	0.01	
Silver – Total	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**<0.001**	<0.002	<0.003	0.1	
Antimony – Total	mg/L	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.001**	0.001	0.001	0.003	
Tin – Total	mg/L	<0.001	<0.001	0.003	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.002**	0.003	0.001		
Uranium – Total	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	**<0.0005**	<0.0005	<0.0005	0.02	
Zinc – Total	mg/L	0.013	0.1	0.19	0.084	0.035	0.025	0.024	0.016	0.015	0.014	**0.061**	0.19	0.013		3
Thermophilic Amoebae	cfu/100 mL	D	D	D	D	D	D	D	D	ND	D	**D**	D	D	95% nil	
Thermophilic Naegleria	cfu/100 mL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	ND	ND	95% nil	
Thermotolerant Coliforms	cfu/100 mL	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	**<1**	<1	<1	98% nil	
E.Coli	cfu/100 mL	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	**<1**	<1	<1	98% nil	

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APPENDIX G

Asset Management Plan

(Aqua Ferre, 2016)

AQUA FERRE PTY LIMITED
ASSET MANAGEMENT PLAN

Version	Date Approved
Version 3.2	January 2016

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Abbreviations

ADWG	Australian Drinking Water Guidelines
Aqua Ferre	Aqua Ferre Pty Limited, ACN 121 146 772
Arris	Arris Pty Ltd ACN 092 739 574
DOH	Department of Health of Western Australia
ERA	Economic Regulatory Authority Western Australia
DWSPP	Drinking Water Source Protection Plan
kL	Kilolitre (1,000 litres)
MEN	Muchea Employment Node
ML	Megalitre (1 million litres)
Riverside	Riverside Investments WA (No 2) Pty Ltd, ACN 118 963 072
Sirona	Sirona Capital Pty Ltd, ACN 145 968 896
Water Corporation	Water Corporation of Western Australia
WAPC	Western Australian Planning Commission
WTP	Water treatment plant

1 Background

Aqua Ferre is developing a potable water treatment and reticulation scheme in collaboration with Riverside Investments WA (No 2) Pty Ltd (Riverside) and Sirona Capital Pty Ltd (Sirona) which are developing residential and industrial/commercial developments in the Muchea region (Figure 1).

The Reserve Road rural living allotment development at Muchea, Western Australia is located 8 kilometres north east of the Muchea town site and 80 kilometres north of the Perth central business district. The allotments (Lot 2 and Lot 9001 Reserve Road) and the MEN are part of the Shire of Chittering. The proposed development is in accordance with the Shire's planning scheme. The development involves the creation of approximately 245 residential allotments in progressive stages.

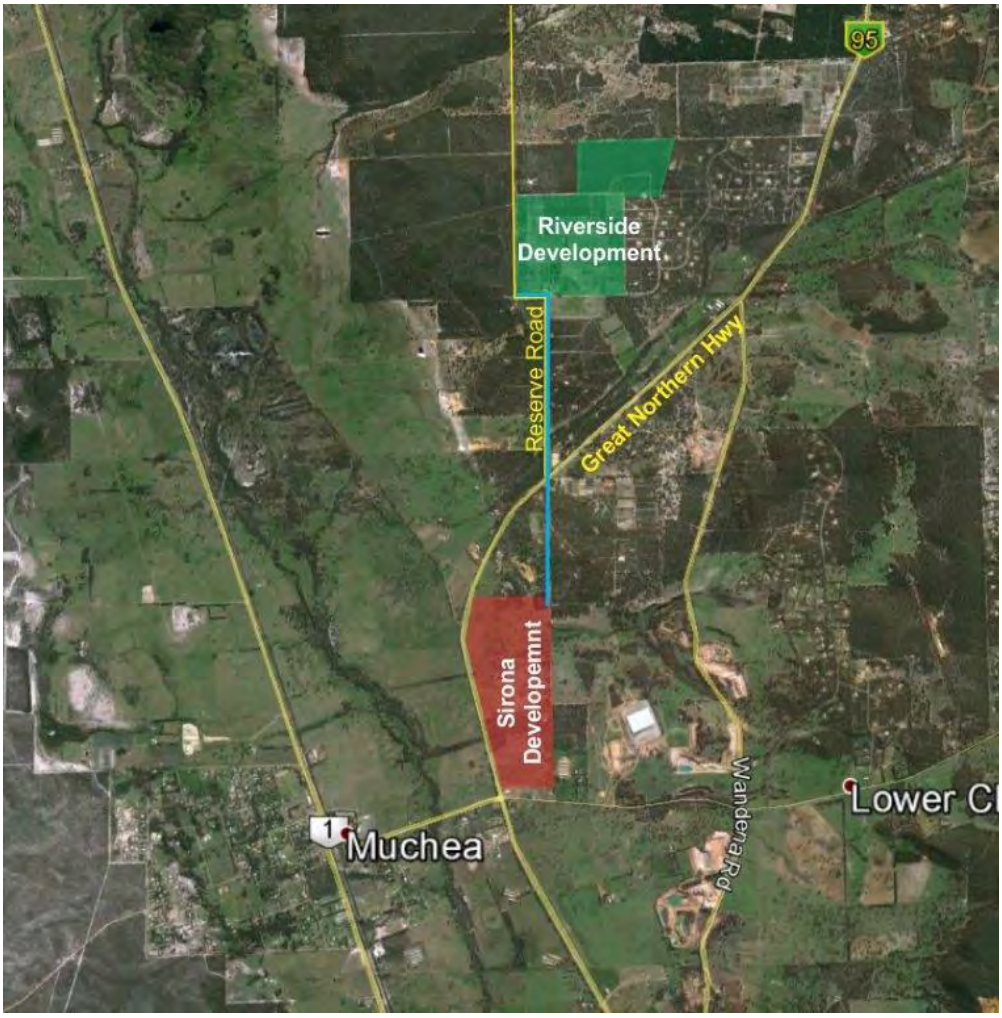


Figure 1: Location of Reserve Road residential development and water supply agreement area

The MEN development involves the creation of approximately 53 industrial/commercial lots in the first stage of an industrial development.

1.1 Aqua Ferre

Aqua Ferre is a water solutions provider focused on Western Australia. Aqua Ferre was established to supply water treatment solutions to small communities. The Company is initially working on the project in the Muchea region of Western Australia. Aqua Ferre is a private company registered with the Australian Securities and Investment Commission.

Through being "customer driven" and "asset focused", Aqua Ferre will provide quality water services as required to the Muchea region, specifically to the Riverside and Sirona residential and industrial/commercial developments.

An overview of Aqua Ferre's strategic and corporate goals include:

(a) **Customers and community**

To achieve customer satisfaction by delivering the services they value; enhancing our relationship within the community; and building strategic relationships with our key stakeholders.

(b) **Key performance outcomes**

- Sustainable water supply that meets projected budget
- Ensure safety in the workforce
- Provide a return on capital invested
- Achieve customer satisfaction
- Demonstrate regulatory compliance

(c) **Aqua Ferre values**

- Put safety above all else
- Act in the best interests of customers and the community
- Seek and apply better ways
- Respect our people
- Be trustworthy

(d) **Quality and delivery**

To deliver water and customer services that are 'fit for purpose', cost-effective and comply with regulatory requirements.

(e) **Planning for the future**

To plan for a sustainable future through integrated water planning and stewardship of our physical and natural assets.

(f) **Business success**

To ensure long-term financial success with a safe, skilled and committed workforce delivering excellence in regulatory management and governance.

Aqua Ferre is applying to Economic Regulation Authority Western Australia (ERA) to hold a water services licence under the *Water Services Act 2012* (Act). This allows it to supply potable water to a proposed residential development at Lots 2 and 9001 Reserve Road, Muchea (Riverside) and to the MEN (Sirona). As part of the licence requirements, Aqua Ferre will provide water in line with ADWG standard and test the water as per the Small Community Model Assessable Sampling Grid (DOH).

1.2 Purpose

Aqua Ferre plans to operate and maintain the water supply treatment plant and network to achieve the following strategic objectives:

1. ensure the Water Supply network is maintained at a safe and functional standard as set out in this Asset Management Plan;

2. ensure sufficient funds are raised through its fees and charges policy to provide for water asset renewal over the life of the assets;

3. meet the Australian drinking water guidelines in terms of quality and community expectations.

Further to this Aqua Ferre has produced this Asset Management Plan to meet its obligation to key stakeholders including:

- Economic Regulation Authority Western Australia;
- Departments of Health and Water;
- its customers and the greater Western Australian Community.

1.3 Key elements of the Water Supply Asset Management Plan

The goal of the Aqua Ferre Asset Management Plan is to meet a required level of service (Section 4) in the most cost effective way through the creation, acquisition, operation and maintenance, renewal and disposal of assets to provide for present and future customers/communities. To ensure sustainability of our business providing triple bottom-line benefits, we have life-cycle approach to asset management by taking account of the total cost of an asset throughout its life.

Key elements include:

- prepare a plan (Water Supply Asset Plan) demonstrating the plans, programs of work and associated budgets, processes and procedures in place to ensure the consolidated Aqua Ferre water demand forecast can be met (as described in the Reticulation System Design, Aqua Ferre 2015);
- describe the current capability of Aqua Ferre's assets (as described in the Reticulation System Design, Aqua Ferre 2015) to deliver services under a range of operating conditions; describe how existing assets will be maintained and renewed, and how decisions will be made to retire assets; and how new assets will be identified and delivered;
- where appropriate, Aqua Ferre will also demonstrate any linkages with the SEQ service providers (Council, DFES,...), Section 11;
- provide copies of any referenced documents in electronic form to accompany Aqua Ferre's respective Water Supply Asset Plans including: Drinking Water Source Protection Plan (Aqua Ferre 2015) and Reticulation System Design (Aqua Ferre 2015) Customer Service Charter (Aqua Ferre 2015).

2 System Overview

Aqua Ferre will oversee the design and build and subsequently operate the potable water supply scheme meeting the ADWG for supply of potable water to the Riverside and Sirona developments. The WTP will be located at the Riverside development. See Figure 1 for Aqua Ferre's operational areas, being the proposed Riverside and Sirona developments, covered by this Asset Management Plan with the asset schematic in Figure 2.

Service level standards have been prepared and are embedded in the customer contract and our customer charter.

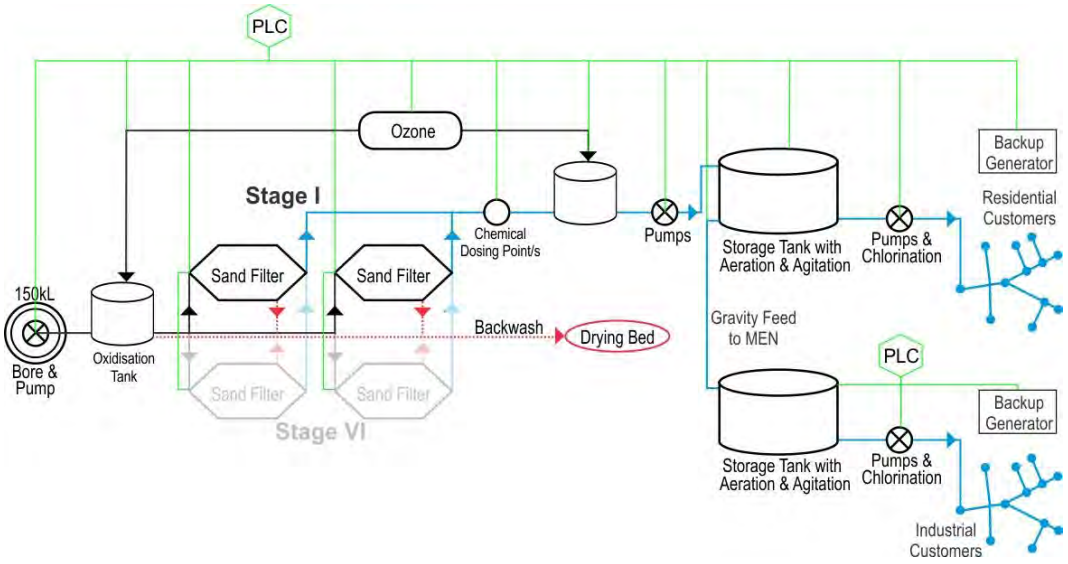


Figure 2: Water treatment and reticulation system design schematic

2.1 Reticulation System Design

The design and layout of the system is provided in the Reserve Road Reticulation System Design. It describes the following elements of the asset base:

- the methods to be applied in provision of the service (Customer Service Charter, Aqua Ferre 2015);
- the overall infrastructure of the reticulation system (Reticulation System Design, 2015);
- the construction schedule (Section 5 Development Schedule, Reticulation System Design, Aqua Ferre 2015);
- supply connection to customers (Section 6 Supply Connection to Customers, Reticulation System Design, Aqua Ferre 2015);
- details of metering arrangements (Section 7 Metering Arrangements for Water Service, Reticulation System Design, Aqua Ferre 2015);
- the materials used in the reticulation system (Section 4 Infrastructure for Providing Water Service, Reticulation System Design, Aqua Ferre 2015);
- flows and pressures in the system (Section 4 Infrastructure for Providing Water Service, Reticulation System Design, Aqua Ferre 2015);
- water demand forecasting for the next five years (Section 5 Development Schedule, Reticulation System Design, Aqua Ferre 2015);
- management of water age and disinfection residual in the reticulation system (Section 3 Methods/Principles of Service Provision, Reticulation System Design, Aqua Ferre 2015).

2.2 Drinking Water Source Protection Plan

The management and protection of the underlying ground water asset is described in the DWSPP. It describes the following elements of the asset base:

- a description of the physical environment;
- the ground water source;
- the protection of the groundwater source;
- the WTP design;
- the multi-barrier approach taken to the drinking water system design.

2.3 Water demand forecast

The WTP is designed for the total demand of the project (total of approximately 245 residential and approximately 53 industrial/commercial lots, Table 1). Due to the relatively small nature of the treatment plant, where there is little cost saving through a staged development, the plant will have base infrastructure on commencement and there are two other plant upgrades to increase water supply and filtration capacity.

Although capacity upgrade has been forecast for years 3 and 4, upgrades will be driven by demand.

Table 1: Water balance model for the combined Riverside and Sirona developments

Water Balance							
Water per Lot		425kL	1000kL				
	Riverside		Sirona				
Year	Stages 1-8 Connections	Stages 4-8 Connections	Stages 1-11 Connections	Volume increase due to new lots (kL)	Annual Demand (kL)	Accumulated Peak Daily Volume (inc Fire Fighting) (kL/d)	Instantaneous Flow Through WTP (L/s,)
1	36		4	19300	19300	1007	11.7
2	18		4	11650	30950	1063	12.3
3	18		5	12650	43600	1127	13.0
4	18		5	12650	56250	1184	13.7
5	18	4	5	14350	70600	1253	14.5
6	18	6	5	15200	85800	1329	15.4
7	18	6	5	15200	101000	1404	16.3
8	18	6	5	15200	116200	1479	17.1
9	18	6	5	15200	131400	1555	18.0
10	18	6	5	15200	146600	1630	18.9
11	8	6	5	10950	157550	1674	19.4

Key Assumptions (see Reticulation System Design, Aqua Ferre 2015):

1 In the first year of sales 40 lots are forecast to be sold. Increased sales will be due to pricing and extensive marketing campaign.

2 Sales of approximately 18 to 22 lots per year are forecast for subsequent years.

3 In stages 4 through to 8 the larger lots will be marketed concurrently with standard lots. These lots will attract a different market segment and should not compete with standard lot sales.

4 Assumes peak daily demand is 2.7 times average daily demand and fire requirements 10L/s for 2 hours, residential and 20L/s for 4 hours industrial.

3 Asset Management

The Asset Management Plan is a comprehensive plan to ensure that the physical assets provide the services required to meet the customers' needs in an efficient and cost effective manner throughout their useful life while meeting the following regulatory requirements:

- Conditions on the water supply licence under the *Water Services Licensing Act 2012* to provide water to the ADWG standard and test the water as per the Small Community Model Assessable Sampling Grid;
- ADWG;
- Small Community Model Assessable Sampling Grid (DOH);
- Systems Compliance and Routine Reporting for Small Community Water Providers (DOH).

The *Water Services Act 2012*, Sections 24(1)(a) & 24(2):

- Clause 20.1: The licensee must have an asset management system that provides for the operation and maintenance of the water service works;
- Clause 20.2: The licensee must give details of the asset management system and any changes to it to the Authority;
- Clause 20.3: A licensee must provide the Authority with a report by an independent expert as to the effectiveness of its asset management system every 24 months, or such longer period as determined by the Authority.

3.1 Asset Management Plan

The Asset Management Plan provides Aqua Ferre with a blueprint that will enable it to cost-effectively achieve the strategic goals, while meeting its customers' expectations. The plan documents the current information for the following elements of the asset management life cycle:

- asset planning;
- asset creation and acquisition;
- asset disposal;
- environmental analysis;
- asset operations;
- asset maintenance;
- asset management information system;
- risk management;
- contingency planning;
- financial planning;
- capital expenditure planning.

3.2 Asset management objectives

Aqua Ferre's objectives for effective asset management are to:

- meet customer needs in the most effective and efficient manner;
- ensure effective, cost-efficient use of new and existing assets;
- ensure efficient and cost-effective acquisition of assets that decreases service costs and improves service delivery;

- lower service costs by minimising underperforming assets;
- schedule expenditure to meet the requirements of the scheme to ensure efficient and reliable operation (expenditure given in Table 3);
- operate assets in an environmentally sustainable manner;
- ensure asset operations are conducted according to standard operating procedures and confirm to required safety regulations;
- ensure maintenance is done on time and to cost;
- to improve efficiency of the operation and maintenance of water service assets;
- ensure the asset management information system provides complete and accurate information easily;
- develop contingency plans to minimise service disruption;
- ensure financing is available in a timely and cost-effective manner;
- ensure the assets do not become a liability to Aqua Ferre and Western Australia;
- continuous improvement of asset management.

3.3 Asset protection

The first step in asset protection is the design, installation and use of appropriate materials and equipment. The Reticulation System Design outlines the system design and materials used. Aqua Ferre recognises the value of maintenance and protection of assets to:

- minimise disruptions to supply;
- ensure the highest level of operational performance;
- maximise the life of assets;
- minimise costs associated with asset damage.

General conditions:

- only products and materials approved by Aqua Ferre can be used;
- no additional loading is to be applied to water assets (in line with asset service specification);
- only hand compaction is allowed over water mains. Vibrating rollers can be used if permission has been granted by Aqua Ferre;
- any works undertaken on water assets must be carried out by an Aqua Ferre approved contractor;
- appropriate signage will be installed to notify location of Aqua Ferre assets;
- all subterranean assets and assets in public space will be registered with Dial Before You Dig.

Aqua Ferre will become a member of Dial Before You Dig and all appropriate assets will be registered. This will enable the safe management and protection of assets and minimise the risk of accidental interference by third parties. It will also enable third parties to know they are working close to Aqua Ferre assets, what type of work will be undertaken and when the work will be undertaken.

3.4 Stakeholders

Key stakeholders in the preparation and implementation of this Asset Management Plan are:

- the Department of Water (Western Australia) with responsibility for infrastructure planning and effective asset management;
- ERA with responsibility for licensing;
- Riverside and Sirona, the developers;
- Aqua Ferre, the system operator;
- the customer;
- employees, construction, operation and administration;
- insurers, remedy providers

3.5 Changes over time

It is anticipated that there will be little change in water demand for the Riverside development over time post the planned staged development (Table 1). A detailed review of the water demand analysis has been undertaken and included in the Reticulation System Design Aqua Ferre 2015. This review also includes discussion with the Water Corporation to ascertain long term demand.

However, the Sirona development is likely to be more complex. At this point there is little information with respect to potential customers for water and their respective demand profile. However, Sirona, in consultation with its planning consultant, has allocated a 1ML allocation to each lot.

In the design of the system and Asset Management Plan the following points have been taken into consideration:

- changes in the service level to be provided;
- the impact of technical or commercial obsolescence;
- the maintenance given to the asset;
- asset lifecycle;
- improvements in the technology applied to maintain the asset;
- asset risk management.

This Asset Management Plan services capacity for supply of potable water to the Riverside and Sirona developments in the order of 157ML per annum. As the treatment plant and reticulation system only cater for the current Riverside and Sirona developments, no further contingency is required. However, due to the discrete nature of equipment sizing there is redundant capacity inbuilt into the system. Service potential describes the output or service capacity of an asset.

The treatment system has been designed around tried and proven technologies that have and are widely being used and installed by the water industry. Due to the source water quality, it is not envisaged that a change in treatment train will be required in the future. If changes are made they will be in line with scheduled upgrades to mitigate unforeseen cost implications.

Technology improvements are more likely in the monitoring and operational aspects of the system. It is therefore believed that any technological changes that could apply to this system will improve operation and cost efficiency.

3.6 Assets to be managed

The assets to be managed can be broken into four main divisions, which include:

- the Riverside reticulation system which will supply water to approximately 245 residential allotments – the system is proposed to be built, through staging, over a period up to ten years;
- the Sirona MEN reticulation system which will supply water to approximately 53 commercial/industrial allotments – the system is proposed to be built over a period up to ten years;
- the WTP will supply water to the developments and construction will be staged over six years;
- the main trunk from the WTP on Reserve Road, Muchea to the MEN.

The asset layout and design can be viewed in the Reticulation System Design document which demonstrates the system design specifications and performance requirements.

The proposed infrastructure and capital costs are shown in Table 2 for the four main system components.

Table 2: Proposed infrastructure staging and capital cost

Description	Total est ($000)
Riverside Reticulation System The reticulation system will be staged over an estimated ten years	1,111
Sirona MEN Reticulation System The reticulation system will be staged over an estimated ten years	1,211
Water Treatment Plant The WTP will be staged over six years, staging will be undertaken on demand	1,973
MEN Main Trunk The MEN main trunk will be built in year one to have the capacity for the total project demand	569
Total	**4,864**

4 Asset Planning

Objectives:

- To meet customer needs in the most effective and efficient manner.
- Effective utilisation of existing and new assets.
- Optimisation of the service potential of assets.

During the planning stage, assets will be identified that can provide the level of service specified (see Reticulation System Design) in a cost-effective manner. Alternative solutions to achieving the level of service required will be analysed with respect to performance, initial cost, efficiency, life, reliability, and the cost of operation and maintenance.

No customer growth is forecast beyond the 245 and 53 lots in the Riverside and Sirona developments respectively. Hence, all forward budget planning is based on the anticipated release dates of the lots.

4.1 Financial aspects of asset planning

Policies and procedure will be created to ensure that:

- budget planning does not become separated from asset planning and acquisition;
- the economic feasibility of several alternative solutions for each component of the treatment chain are compared;
- initial cost as well as operation and maintenance cost are included in the evaluation process;
- costs of commissioning new assets are included in budgeting;
- different funding options are considered (eg government grants, leasing, loans, non-asset options).

4.2 Asset performance levels

Performance criteria for each asset will include:

- product water quality will meet the ADWG health and aesthetic limits (NHMRC, 2011) with testing to the standard established in the Small Community Model Assessable Sampling Grid, DoH;
- breakdown and interruption response as per the levels described in the supply contract;
- performance and reliability as per the levels described in the supply contract;
- technical performance is addressed in separate sections of this plan:
    - maintenance;
    - asset renewal;
    - risk management.

Asset performance levels will be developed into policies and processes during the establishment phase of the scheme.

4.3 Service levels for water supply

Description	Level of Service	Comments
Availability of Service		
Domestic peak day	3.15kl/day/lot	Assessed annually (Reticulation System Design, Aqua Ferre 2015)
Domestic annual	425kl/lot	
Industrial peak day	7.40kL/day/llot	
Industrial annual	1000kl/lot	
Total annual demand	157ML	
Average day : peak day - consumption ratio	1:2.7	Assessed annually (Reticulation System Design, Aqua Ferre 2015)
Maximum Static Pressure	90m head	Monitored and recorded
Minimum pressure under peak demand with fire fighting	Domestic 20m head Industrial 20m head	Monitored progressively to gain better understanding of capability
Water flow rates 20mm service 50mm service	Minimum flow rates 20L/min 160L/min	Measured and recorded

Service Interruptions		
Planned: Notice given to customers Duration of interruption	7 day notification	This will be tracked by work orders
Unplanned: Total number of interruptions per year	no more than 2 per customer	Aqua Ferre will track this and report
Time to provide individual connection in serviced area	14 working days	Aqua Ferre will track this and report
Response Times		
The time to have staff on-site or to investigate a problem or answer a query (to be achieved 90% of cases)		
System Failure or complaint	*Response time*	
Priority 1 • Pump station failure • WTP malfunction • Valve failure • Major main break	2hr during business hours 4hr during after hours	Aqua Ferre will track this and report
Priority 2 • Minor main break • Leaking property connection • Telemetry Failure • Partial valve failure	4hr during business hours 8hr during after hours	Aqua Ferre will track this and report
Priority 3 • Leak from water main • Leak from hydrant • Partial failure of property connection	2 working days	Aqua Ferre will track this and report
Priority 4 • Minor problem or complaint which can be dealt in time convenient to customer and/or Aqua Ferre	2 weeks	Aqua Ferre will track this and report

4.4 Asset renewal planning

Asset renewal is planned for the scheduled asset lifespan as outlined in Table 3 and Table 4 with 40 year capital replacement in Table 4. A key feature of the design of Aqua Ferre water assets is the balance between performance, reliability of service and cost. Asset condition assessment inspections will be conducted as indicated in Table 5. Asset condition rating will be used to determine if assets require renewal or maintenance above the scheduled intervals or if their life can be extended, this will be assessed by appropriately experienced Aqua Ferre engineering and/or technical staff.

Table 4 outlines the indicators that will be used to replace system assets prior to end of lifespan above the use of asset inspection and rating.

Table 3: Forecasted asset renewal program

Asset Category	Asset Description	Location	Installation Date	Warrantee Life	Useful Life	Renewal Cost	Proposed Renewal
Water Treatment Plant							
WTP	Ozone (Fe & Mn removal)	Reserve Road	2016	2	30	201600	2046
WTP	Bore (#1)	Reserve Road	2016	na	50-100	165000	>2046
WTP	Bore (#2)	Reserve Road	2019	na	50-101	165000	>2046
WTP	Bore Equip (#1.1)	Reserve Road	2016	2	15	60720	2031
Bore Equip	Bore Equip (#1.2)	Reserve Road	2031	2	15	60720	2046
Bore Equip	Bore Equip (#2.1)	Reserve Road	2019	2	15	60720	2034
Bore Equip	Bore Equip (#2.2)	Reserve Road	2034	2	15	60720	>2046
WTP	Settling tanks 50kL	Reserve Road	2016	10	20	54720	2036
WTP	Settling tanks 50kL	Reserve Road	2036	10	20	54720	>2046
WTP	Sand Filters (#1.1)	Reserve Road	2016	10	25	72000	2041
WTP	Sand Filters (#1.2)	Reserve Road	2041	10	25	72000	2066
WTP	Sand Filters (#2.1)	Reserve Road	2019	10	25	43200	2044
WTP	Sand Filters (#2.1)	Reserve Road	2044	10	25	43200	>2046
WTP	Caustic Dosing (#1.1)	Reserve Road	2016	1	8	43200	2024
WTP	Caustic Dosing (#1.2)	Reserve Road	2024	1	8	43200	2032
WTP	Caustic Dosing (#1.3)	Reserve Road	2032	1	8	43200	2040
WTP	Caustic Dosing (#1.4)	Reserve Road	2040	1	8	43200	>2046
WTP	Electrical	Reserve Road	2016	1	50	172000	>2046
WTP	PCL Controller (#1.1)	Reserve Road	2016	1	25	115200	2041
WTP	PCL Controller (#1.2)	Reserve Road	2041	1	25	115200	>2046
WTP	PCL Controller (#2.1)	Reserve Road	2018	1	25	21600	2043
WTP	PCL Controller (#2.2)	Reserve Road	2043	1	25	21600	>2046
WTP	PCL Controller (#3.1)	Reserve Road	2019	1	25	28800	2044
WTP	PCL Controller (#3.2)	Reserve Road	2044	1	25	28800	>2046
WTP	Building & staff amenities	Reserve Road	2016	10	50	84000	>2046
WTP	Storage with Blowers (#1.1)	Reserve Road	2016	1	10	15000	2026
WTP	Storage with Blowers (#1.2)	Reserve Road	2026	1	10	15000	2036
WTP	Storage with Blowers (#1.3)	Reserve Road	2036	1	10	15000	2046
WTP	Chlorine Injector (#1.1)	Reserve Road	2018	1	10	4700	2028
WTP	Chlorine Injector (#1.2)	Reserve Road	2028	1	10	4700	2038
WTP	Chlorine Injector (#1.3)	Reserve Road	2038	1	10	4700	>2046
WTP	Generator	Reserve Road	2016	2	40	14400	>2047
WTP	1ML tank Panel	Reserve Road	2016	10	40	179400	>2046
WTP	Liner (#1.1)	Reserve Road	2016	10	20	78000	2036
WTP	Liner (#1.2)	Reserve Road	2036	10	20	78000	>2046
WTP	Pressure System	MEN Storage Site	2016	2	15	77640	2031
WTP	Chlorine Injector	MEN Storage Site	2016	1	8	12642	2024
WTP	WT Pumps	Reserve Road	2016	2	12	108000	2028
WTP	Chlorine Injector (#2.1)	Reserve Road	2018	1	10	4700	2028
WTP	Chlorine Injector (#2.2)	Reserve Road	2028	1	10	4700	2038
WTP	Chlorine Injector (#3.3)	Reserve Road	2038	1	10	4700	>2046

Asset Category	Asset Description	Location	Installation Date	Warrantee Life	Useful Life	Renewal Cost	Proposed Renewal
Trunk Main to MEN							
Riverside - MEN Trunk	110mm HDPE 4.5km	Lot 2 Reserve Road to MEN	2016	80	100	240000	>2046
Riverside - MEN Trunk	Great Northern Hwy crossing	GNH and Reserve Rd	2016	80	>100	N/A	>2046
Riverside - MEN Trunk	Panel Tank 500kL	MEN	2016	10	40	148000	>2046
Riverside - MEN Trunk	Liner (#2.1)	MEN	2016	10	20	48000	2036
Riverside - MEN Trunk	Liner (#2.2)	MEN	2036	10	20	48000	>2046
Riverside - MEN Trunk	Isolation Valves	500 metre intervals	2016	50	80	27000	>2046
Riverside - MEN Trunk	Fencing	MEN	2016	1	50	12000	>2046
Riverside - MEN Trunk	PLC Equipment (#4.1)	MEN	2016	1	15	15000	2031
Riverside - MEN Trunk	PLC Equipment (#4.2)	MEN	2031	1	15	15000	2046

Asset Category	Asset Description	Location	Installation Date	Warrantee Life	Useful Life	Renewal Cost	Proposed Renewal
Riverside Reticulation System							
Reserve Road Retic	110mm HDPE 2450m	Riverside	2016	80	100	127367	2116
Reserve Road Retic	110mm HDPE 1020m	Riverside	2017	80	100	53026	2117
Reserve Road Retic	110mm HDPE 1020m	Riverside	2018	80	100	53026	2118
Reserve Road Retic	110mm HDPE 1220m	Riverside	2019	80	100	63424	2119
Reserve Road Retic	110mm HDPE 3000m	Riverside	2020	80	100	155960	2120
Reserve Road Retic	110mm HDPE 819m	Riverside	2021	80	100	42577	2121
Reserve Road Retic	110mm HDPE 400m	Riverside	2022	80	100	20795	2122
Reserve Road Retic	200mm HDPE 520m	Riverside	2016	80	100	87057	2116
Reserve Road Retic	Isolation Valves	Riverside	2016	50	80	9176	2096
Reserve Road Retic	Isolation Valves	Riverside	2017	50	80	3820	2097
Reserve Road Retic	Isolation Valves	Riverside	2018	50	80	3820	2098
Reserve Road Retic	Isolation Valves	Riverside	2019	50	80	4569	2099
Reserve Road Retic	Isolation Valves	Riverside	2020	50	80	11236	2100
Reserve Road Retic	Isolation Valves	Riverside	2021	50	80	3068	2101
Reserve Road Retic	Isolation Valves	Riverside	2022	50	80	1498	2102
Reserve Road Retic	Hydrants	Riverside	2016	50	80	25332	2096
Reserve Road Retic	Hydrants	Riverside	2017	50	80	10546	2097
Reserve Road Retic	Hydrants	Riverside	2018	50	80	10546	2098
Reserve Road Retic	Hydrants	Riverside	2019	50	80	12614	2099
Reserve Road Retic	Hydrants	Riverside	2020	50	80	31019	2100
Reserve Road Retic	Hydrants	Riverside	2021	50	80	8468	2101
Reserve Road Retic	Hydrants	Riverside	2022	50	80	4136	2102
Reserve Road Retic	Hydrants	Riverside	2016	20	40	43153	2056
Reserve Road Retic	Hydrants	Riverside	2017	20	40	17966	2057
Reserve Road Retic	Hydrants	Riverside	2018	20	40	17966	2058
Reserve Road Retic	Meters	Riverside	2019	20	40	21488	2059
Reserve Road Retic	Meters	Riverside	2020	20	40	52841	2060
Reserve Road Retic	Meters	Riverside	2021	20	40	14425	2061
Reserve Road Retic	Meters	Riverside	2022	20	40	7045	2062

Asset Category	Asset Description	Location	Installation Date	Warrantee Life	Useful Life	Renewal Cost	Proposed Renewal
Westbridge Reticulation System							
MEN Reticulation	Pressure System	MEN Storage Site	2016	2	15	77640	2031
MEN Reticulation	Pressure System	MEN Storage Site	2031	2	15	77640	2046
MEN Reticulation	Chlorine Injector (#3.1)	MEN Storage Site	2016	1	10	4700	2026
MEN Reticulation	Chlorine Injector (#3.2)	MEN Storage Site	2026	1	10	4700	2036
MEN Reticulation	Chlorine Injector (#3.3)	MEN Storage Site	2036	1	10	4700	2046
Riverside - MEN Trunk	Generator (#2)	MEN Storage Site	2016	1	30	15000	2046
MEN Reticulation	160mm HDPE (480m)	MEN	2016	80	100	44900	2116
MEN Reticulation	160mm HDPE (1300m)	MEN	2017	80	100	121400	2117
MEN Reticulation	160mm HDPE (840m)	MEN	2020	80	100	78500	2120
MEN Reticulation	160mm HDPE (3020m)	MEN	2022	80	100	282000	2122
MEN Reticulation	200mm HDPE(1220m)	MEN	2016	80	100	322900	2116
MEN Reticulation	200mm HDPE (450m)	MEN	2017	80	100	115300	2117
MEN Reticulation	Hydrants	MEN	2016	50	80	44900	2096
MEN Reticulation	Hydrants	MEN	2017	50	80	46100	2097
MEN Reticulation	Hydrants	MEN	2020	50	80	22200	2100
MEN Reticulation	Hydrants	MEN	2022	50	80	75900	2102
MEN Reticulation	Isolation Valves	MEN	2016	50	80	17900	2096
MEN Reticulation	Isolation Valves	MEN	2017	50	80	18300	2097
MEN Reticulation	Isolation Valves	MEN	2020	50	80	8900	2100
MEN Reticulation	Isolation Valves	MEN	2022	50	80	30100	2102
MEN Reticulation	Meters	MEN	2016	20	40	18795	2056
MEN Reticulation	Meters	MEN	2017	20	40	48330	2057
MEN Reticulation	Meters	MEN	2020	20	40	26850	2060
MEN Reticulation	Meters	MEN	2022	20	40	48330	2062

Table 4: Indicators for replacement of assets

Asset	Lifespan (years)	Replacement Strategy
Reticulation and Main Trunk		
Pipelines	>1,000	Replace at over 3 failures per 1 kilometre of length over life
Valves	80	Replace on failure
Meters	40	Replace on failure
Hydrant	80	Replace on failure
Tank poly	10	Inspect annually and replace when degraded or leaking
Tank panel	10	Inspect annually and replace on structural strength and/or serviceability after corrosion
Tank liner	10	Inspect annually and replace when degraded or leaking
Telemetry	15	Routine servicing and attendance replace, >1 outage per month
System pumps	12	Replace on failure; as duty standby, low risk
Treatment Plant		
Building	40	Maintain as required, keep water tight
Dosing systems	8	Replace on failure, keep spares available
Electrical and control	25	Replace components as needed
Filters	25	replacement on failure
Filter media	5	Media replacement is included in the O&M budget
Ozone	30	Replace on failure
Treatment pumps	12	Replace on failure; as duty standby, low risk
Blower	10	Usually very reliable and low maintenance
Aeration equipment	10	Replace on performance drop-off to 75% of specification (to be finalised)
Borehole	15	The existing borehole and pump may need to be refurbished upon pressure drop-off to 60%
Backup generator	30	Replace only when unserviceable; it is not expected to be used often

4.5 Measuring performance

Quality

Water supply assets will be maintained in a manner to achieve the required level of service. Defects found or reported that are outside our service standard will be programmed for repair. See the maintenance response service levels for details of defect response (Table 4).

Function

The aim is that a fit for purpose water supply network is constructed, operated, maintained and renewed in partnership with other levels of government and stakeholders to provide drinking water to the National Health & Medical Research Council standards to residences and businesses.

Water supply asset attributes will be maintained at a safe level and associated signage and equipment be provided as needed to ensure public safety.

Safety

We inspect all water supply assets regularly and prioritise and repair defects and OH&S issues in accordance with our inspection schedule to maintain safety levels.

5 Asset Creation and Acquisition

Objective

- Provide or improve assets such that the cost can be expected to provide benefits beyond the year of acquisition.

Policies and procedures will be in place to ensure an economic and efficient asset acquisition framework leads to a decrease in service costs and improves service delivery. Projects will be evaluated to ensure the most appropriate solution is chosen and the most efficient assets are acquired to achieve the desired solution.

Each new asset will be commissioned appropriately and testing results documented. The legal, environmental and safety requirements for each new asset will be identified and assigned.

6 Asset Operations

Objective

- Achieve consistent customer service levels through appropriate use of assets.

Policies and procedures for asset operations will be created in relation to the level of service required. The procedures will include the following:

- adequately documenting the detail of processes required to operate assets so that a consistent level of service is achieved;
- tasks will be prioritised according to risk management implications;
- creation of an asset register (see section 9.1 for details);
- operational costs will be monitored, recorded and analysed;
- staff will be trained in the safe operation of the assets according to their responsibilities.

6.1 Routine asset monitoring and recording

Regular monitoring and recording will be undertaken in accordance with the Asset Monitoring schedule shown in Table 5.

Table 5: Asset monitoring and recording

Monitoring	Recording	Assessment interval (years)	Comment
Pipeline			
Pipeline	Annual number of bursts Annual number of leaks	10	Need to divide between aging and external influence (ie digging up pipe)
Valve	Annual number of failures	5	Need to identify if failures are within expectation

Monitoring	Recording	Assessment interval (years)	Comment
Meter	Annual number of failures	1	Need to identify if failures are within expectation Only need to be replaced on failure
Bore water	Record all water quality results	NA	Graph turbidity, bore head, flow as asset indicators
Treated water	Record all water quality results	NA	Graph turbidity, coliform counts, total suspended solids as asset indicators
Water tanks exterior	Annual inspection	5	
Water tank liner	Annual inspection	5	
Pumps	Record energy consumption (kilowatt) versus flow and pressure annually Check for leaks visually during routine maintenance	3	Graph performance annually Manually test operation of backup pumps monthly
Treatment Plant			
Building	Inspect for water tightness and security regularly	5	
Dosing systems	Record replacement parts	5	
Electrical and control	Note call outs	3	Highlight any consistent faults Annual testing of all electrical equipment
Filters	Record head-loss monthly	5	Graph deterioration
Ozone	Inspect for external corrosion annually	3	Replace at end of life – no extension allowed
Blower	Record pressure and oil consumption six monthly	3	Usually very reliable and low maintenance
Aeration equipment	Record pressure	3	Replace on performance drop off
Borehole/s	Record pump flow and pressure monthly	5	Graph and monitor ongoing changes Water quality changes will be recorded in line with DOH requirements

7 Asset Maintenance

Objective

- Maintain customer level of service through appropriate asset maintenance.

Once operation commences, annual asset maintenance policies and procedures will be prepared, as well as a maintenance plan for the coming year. Asset maintenance schedules and procedures will be in line with manufacturer and supplier warranty and operational requirements for safe and efficient use.

The objective of each plan will be to maintain the required service levels on time and on cost. As the plan will be impacted by unplanned maintenance events, it will not be publicly available.

Maintenance includes reactive, planned and specific maintenance work activities. Reactive maintenance is unplanned repair work carried out in response to service requests and

management / supervisory directions. The causes of unplanned repair work will be analysed and maintenance plans will be adjusted if necessary.

Planned maintenance is repair work that is identified and managed through a maintenance management system. The system activities include inspection, assessing the condition against failure/breakdown experience, prioritising, scheduling, actioning the work and reporting what was done to develop a maintenance history and improve maintenance and service delivery performance. Reporting will include costs.

Planned interruptions for major maintenance and replacement work will be notified two weeks in advance via Aqua Ferre's website and in writing to affected customers.

7.1 Preventative asset condition assessment

Regular inspections of asset condition and performance will be made. Asset condition assessment will be determined using:

- inspection schedule;
- age of asset;
- outcome of asset inspections;
- maintenance records;
- manufacturer's advice.

Above-ground assets will be physically inspected, which will occur as part of routine maintenance or, where not regularly maintained (eg liners), on an inspection schedule per Table 5, as modified from time to time. The rating of below-ground assets will depend on failure rate (bursts and leaks). A five-tier condition assessment will be utilised as shown in Table 6.

Table 6: Asset condition rating

Condition	Description	Action
1	Excellent	Continue planned maintenance regime
2	Very good	Additional unplanned maintenance – minor
3	Good	Additional unplanned maintenance – moderate
4	Fair	Replacement/major repair to be prioritised – serviceable
5	Poor	Replacement/major repair immediate – unserviceable

At their scheduled condition assessment, assets will also be evaluated for rehabilitation/ refurbishment for asset life extension. Asset replacement with more cost-effective assets prior to end of life will also be reviewed.

Financial asset management will be kept under annual review and cost effectiveness will be reviewed in modifying the useful life of any assets in order to keep costs of operation minimised.

Asset condition will be routinely recorded in the Asset Register (below).

7.2 Emergency and corrective maintenance plans

Emergency and corrective maintenance plans will also be developed to ensure prompt and safe action when maintenance needs are identified and prioritised (refer to Section 11.1).

7.3 Asset maintenance standards

Maintenance will be carried out in accordance with:

- AS/NZS 3500.1:2003 Plumbing and Drainage, Part 1: Water Services;
- Water Supply Code of Australia WSA 03–2002;
- manufacturers recommendations/specifications;
- project specific technical specifications.

Guidance will also be taken from:

- NAMS.PLUS2/NAMS.*lite* Asset Management Institute of Public Works Engineering Australia;
- Preventive maintenance program: Guide for small public water systems using groundwater (Washington State Department of Health, 2011).

8 Asset Disposal

Objective

- Maintain customer service levels by developing an asset disposal strategy that ensures disposal occurs in a timely manner and minimises holdings of surplus and underperforming assets.

The policies and procedures will lead to:

- regular, systematic reviews to identify underutilised and underperforming assets;
- critical evaluation of reasons for under utilisation or poor performance;
- timely response to identification of poorly performing assets;
- assessment of alternative disposal opportunities;
- a replacement strategy.

Otherwise, assets will be decommissioned at end-of-life, which is defined as condition 5 in Table 6 at any stage of their planned life, or at condition 4 or 5 at the end of their planned life. Any assets that are in condition 1, 2 or 3 at the end of their planned life will be re-assessed and continue in service for their reassessed asset life.

When required, assets may be disposed of for a number of reasons including:

- surplus to requirements;
- under-utilised;
- malfunction.

A number of alternatives exist when an asset is no longer required or is being underutilised, and these may include a range of options. These are:

- transfer assets to another project;
- kept on stock;
- sold.

The first strategy for asset disposal will be to recycle where possible.

Before final disposal, Aqua Ferre's planning includes:

- rationale for disposal;
- the proper costing and evaluation of disposal alternatives;
- engagement of experts to assist in professional valuation and disposal.

Estimates for capital cost and timing of replacement are given in Table 3 and are inclusive of disposal costs. In reality, some assets will fail earlier than the standard life and some assets will remain useful beyond the standard replacement life.

9 Asset Management Information System

Objective

- Maintain customer service levels by supporting asset management through adequate documentation.

An asset management information system will be developed in house or purchased as required, complete and accurate information for the daily running of the asset management system. Management reports will be generated from the information system to aid in efficient asset management and ensure we meet our regulatory obligations.

The Company is in the process of identifying the appropriate software for the project, thus an internally developed database will be utilised initially.

9.1 The asset register

The asset register will include:

(a) **Identification information**

Type

Name

Description

Location

Photograph

Model Name

Model Number

Serial Number

(b) **Financial information**

Asset value (purchase price)

Asset replacement value (cost to replace/replicate the asset based on current market values)

Written down value, depreciation methods and accumulated assets

Supplier

Purchase date

Installation date

Financing method (if any)

Encumbrances

(c) **Risk management**

Insurance policy

Redundancy

Backup systems

(d) **Condition information**

Date of last condition assessment

Condition at last assessment

Notes on condition

Date of next condition assessment

Asset life and any extensions

Maintenance schedule and repair history

Maintenance manuals

Performance requirements

(e) **Disposal information**

Date disposed

Disposal method

Sale price/disposal cost

9.2 Accuracy

Policies and procedures will be put in place to minimise errors in data entry and ensure information is updated in a timely fashion. Input controls will include verification and validation of data entered into the system.

9.3 Interface and support

Criteria for the software chosen for the information system will include a user friendly interface and technical support. Industry specific asset management software will be used and staff, trades and technical technicians will be inducted into the use and requirements of the asset management register to ensure information is maintained and up to date.

9.4 Security

Security access controls will be in place and policies and procedures will be created for adequate backup of data.

Asset financial information will be contained within company financial accounts retained separately from condition data.

10 Risk Management

Risk Management is an integral part of managing the lifecycle of major infrastructure assets. Aqua Ferre has developed a risk management framework consistent with the joint Australian New Zealand Standard – AS/NZS 31000, in order to ensure that risks throughout the business are managed and that risk management is performed on a consistent basis.

Aqua Ferre's risk management framework enables the likelihood and consequences of the failure of assets and systems to be evaluated. It identifies the need to review existing controls, develop contingency plans and, where appropriate, to define replacement or improvement programmes.

This process involves the systematic identification, analysis and evaluation of risks across all assets, from the wastewater treatment plants to the distribution system. The key risk criteria adopted for Aqua Ferre's networks for assessing the consequences of identified risks are: Environmental and legal compliance; Service Delivery – Loss of service (extent/duration); Financial Community health and safety.

Risk action plans will continually be developed, with the priority being based on the likelihood and consequences of individual risks. These risks include events such as natural hazards, product risks, and asset risks.

Risk management will be undertaken in accordance with AS/NZS ISO 31000:2009 Risk Management—Principles and Guidelines. A risk management plan will be developed in accordance with this Standard.

10.1 Quantitative risk assessment

Risk assessment deals with the probability (likelihood) of an event causing an undesirable effect (impact). The risk assessment is used to assess the impact to business, people and the environment. This risk assessment will lead to the development of a management system for the safe and sustainable operation of Aqua Ferre's business. This assessment will be undertaken using a risk framework, including:

- concerns;
- consequences;
- certainties and uncertainties;
- criteria analysis;
- control;
- communication.

AS/NZS ISO 31000:2009 Risk Management—Principles and Guidelines will be the guiding process where risk will be quantified using the measures below.

Environmental risk management will be undertaken in line with the requirements of the Aqua Ferre Environmental Management System (Appendix B).

(a) Occurrence assessment

For each risk identified, the likelihood of occurrence will be assessed and weighted using the quantitative measures outlined in Table 7.

Table 7: Quantitative measures of likelihood of an event occurring

Likelihood	Ranking	Interpretation
Rare	A	May occur in 100 years
Unlikely	B	Could occur within 20 years
Possible	C	Might occur in 5–10 years
Likelihood	D	Will occur in 1–5 years

Almost Certain	E	Multiple occurrences in a year

(b) **Consequence assessment**

For each risk identified the impact will be assessed and weighted using the quantitative measures outlined in Table 8.

Table 8: Quantitative measures of the impact of an event

Likelihood	Ranking	Interpretation
Insignificant	1	No impact or not detectable
Minor	2	Potentially harmful to local ecosystem
Moderate	3	Potential harmful to regional ecosystem
Major	4	Potentially lethal to local ecosystem
Catastrophic	5	Potentially lethal to regional ecosystem or threatened species

(c) **Risk exposure assessment**

Risk exposure assessment is the evaluation process of combining the likelihood and consequence assessment to provide a quantitative assessment of the severity of the risk event and consequently the action required to manage the risk exposure (Table 9).

Table 9: Quantitative risk matrix

	Impact				
	1	2	3	4	5
Risk	Insignificant	Minor	Moderate	Major	Catastrophic
A (rare)	Low	Low	Low	Low	High
B (unlikely)	Low	Low	Moderate	High	Very high
C (possible)	Low	Moderate	High	Very high	Very high
D (likely)	Low	Moderate	High	Very high	Very high
E (almost certain)	Low	Moderate	High	Very high	Very high

10.2 Identified risks

Risk identification is the process of identifying what, where, when, why and how something could happen.

The major risks to the level of service (consistent with Section 4.3) have been identified as:

- breakdown of plant and equipment, electrical supply failure or natural disaster;
- premature ageing of pipeline or other fixed assets;
- vandalism/sabotage of plant and equipment;
- environmental harm or external groundwater contamination;
- customer relationship breakdown;
- variation in cash flows;
- staff/contractor attraction and retention.
- public health

- Operation health and safety

10.3 Risk treatments

Several risk treatments are built into the system design and operating practices:

- bore water source protection plan;
- regular water quality testing;
- multiple barrier approach to maintenance of water quality;
- robust treatment train, with built-in redundancy;
- emergency response procedure:
  - 24 hour manned number for emergencies;
  - identified response team and responsibilities;
  - auto-dialling systems based on pressure to identify a catastrophic failure;
  - response times within storage available;
  - backup generation;
  - notification to customers by text and email of the issue and expected time to respond;
- supply system storage capacity within the time allowed by the storage to ensure that water supply is continuous and to meet the fire fighting demand (see Reticulation System Design);
- asset replacement plan and asset management system;
- public health and operational health and safety risk assessments;
- selection of robust assets;
- customer charter;
- take-or-pay customer contracting;
- maintenance of pressure below pipeline rating with no temperature shock;
- robust asset management practices.

Ongoing risk assessment and treatment will be utilised throughout the life of the project to identify risks and develop new or enhance existing risk treatments as required.

11 Contingency Planning

Objective

- Maintain customer service levels by adequate contingency planning for unexpected failure of an asset or process.

These plans summarise the rationale and approach to be undertaken by Aqua Ferre to manage any incidents involving its assets and/or operations in order to minimise impact to customers, the community and environment.

Aqua Ferre will meet any legislative requirements that may influence the design and operation of contingency plans. These may include, but are not limited to:

- environmental legislation;
- water quality as required by DOH and the ADWG;
- requirements as established in the ERA licence conditions.

Once the infrastructure is constructed and operational, the contingency plan will be tested and the plans reviewed according to the outcome of the test.

11.1 Emergency management process

Aqua Ferre will provide a lifeline community function, the provision of potable water services on which health, safety, comfort and economic activity depend. Aqua Ferre therefore plays an important role within local emergency management arrangements.

Aqua Ferre recognises four elements of emergency management:

- prevention and/or mitigation of hazards to the community and environment;
- preparation for emergencies;
- response to emergencies;
- recovery to normal operations subsequent to emergencies.

Examples of how Aqua Ferre's various business activities and controls relate to each of the key emergency management elements are set out in Table 10.

Table 10: Emergency management elements and examples

Element	Management Examples
Prevention and/or mitigation of hazards to the community and environment	• Asset management framework • Robust design codes and practices • Reliability and redundancy design and strategy • Water main replacement programs • Preventative maintenance strategies and activities
Prepare for emergencies	Before they start working for Aqua Ferre and as part of their induction, all staff members will be made aware of on-site hazards, and the potential risks and impacts they pose. Hazard management will be mitigated by: • employee and contractor training and induction • Job Safety Analysis (Appendix D) • OHS policy (Appendix C) • emergency response strategies and management exercises • vulnerability and risk assessment processes • networks established with emergency service organisations • operating policies and procedures • hazard, injury and incident reporting.
Response to emergencies	• 24 hour Operational Control Centre • Highly trained staff • Containment • Emergency management plans, guidelines, procedures and networks • Contingency plan:

Element	Management Examples
	emergency generators provision of potable (bottled) water for drinking external augmentation of supply.
Recovery to normal operations for emergencies	Emergency management plans, guidelines, procedures and networks: • highly trained staff • contingency plans • post incident debriefs • review of the emergency management plans
Emergency spill response plan	In the event of a chemical spill, the following steps must be taken: • recognition and assessment of incidents • immediate response to incidents; clean the area, wash up any body part in contact with the chemical, etc • follow up response/actions protocols (reporting, investigation and corrective or preventive actions). • detailed response actions to be identified in operational documentation and manuals.
Recovery to normal operations for emergencies	Emergency management plans, guidelines, procedures and networks: • highly trained staff • contingency plans • post Incident debriefs • review of the emergency management plans.

11.2 Incident reporting

For any operational faults or incidents involving Aqua Ferre's assets, contact will be made through the 24 hour emergency fault hotline.

If an incident has occurred involving an Aqua Ferre asset and/or activity and the situation is potentially life threatening a call would be made to '000' in the first instance.

Any persons wishing to report an incident involving an Aqua Ferre asset and or activity must call the 24 hour emergency fault hotline.

An Aqua Ferre Control Centre Operator will:

- assess the situation and potential consequences;
- prioritise the response based on intelligence gathered;
- contact/dispatch designated operational staff to attend the incident or advise of a course of action based on the prioritisation assessment;
- advise of any specific hazards which may be present at the location of the incident.

Aqua Ferre will escalate the incident accordingly and notify relevant stakeholders based on information received from field staff. All incidents will be recorded and include response actions and outcomes.

Aqua Ferre will adhere to Western Australian emergency management arrangements meaning that key emergency service organisations such as police, fire and rescue, the rural fire service and the State Emergency Services may be the controlling authority of a particular incident depending on the nature of the incident.

11.3 Incident management

(a) **Types of Aqua Ferre water assets**

Aqua Ferre owns and operates various assets across its area of operation including:

- bores;
- WTPs;
- water pump stations;
- water supply networks (storages, pipelines, valves, hydrants).

(b) **Examples of incidents**

Examples of potential incidents involving Aqua Ferre assets include:

- damage to third-party property caused by system failures;
- system disruption caused by asset failure or service provider outages (eg power and telecommunication outages);
- chemical spill or leak;
- damage to, or inability to access Aqua Ferre's infrastructure caused by natural hazards, or proximity hazards (bush fires etc).

Aqua Ferre will have various types of plans and procedures in place to effectively manage incidents:

- Health and Safety Policies and Procedures;
- Corporate Emergency Management Framework / Guidelines;
- Corporate Business Continuity Plans;
- Corporate Communications Plans;
- DWSPP (bore/groundwater);
- Operational Contingency Plans;
- Site Based Emergency Evacuation Plans;
- Dangerous Goods and Hazardous Substances Emergency Plans;
- Bush Fire Management Plans;
- Operating Policies and Procedures;
- Pollution Incident Response Procedures.

In the event of an incident, Aqua Ferre will assess the situation and prioritise the response using information it receives from its field and operations staff and/or contractors. Aqua Ferre will also categorise and escalate the incident as required, delivering a proportionate response ranging from dispatch of field resources for routine and minor incidents, through to whole of business response (with integrated agency support where required) for significant incidents.

11.4 Communication during incidents

Aqua Ferre will have established points of contact with its key stakeholders and notify relevant stakeholders of incidents as required.

Once an incident has been categorised, Aqua Ferre will identify all relevant stakeholders and update identified stakeholders with any changing circumstances. Stakeholders will be contacted through various means depending on the nature of the incident:

Customers will be contacted through:

- telecommunication;
- on-line communication tools (email and web);
- door knocking;
- warning signs.

Emergency services will be contacted through normal channels, eg external communication and media channels.

11.5 Communication with relevant authorities and stakeholders

Aqua Ferre will establish relationships with key emergency service organisations and Western Australian Government agencies.

In the event of a pollution incident, all relevant authorities must be advised immediately. The authorities may advise that they will not be required to attend; however, the appropriate level of information will be provided to them so an informed decision on their response can be made. The nature and location of the incident will determine whether stakeholders may also need notification.

Table 11: Relevant authority contact details

Authority	Contact details
Emergency Services, life threatening situations	000
Fire, Muchea Volunteer Bush Fire Brigade	(08) 9571 4465 or 000
Report faults or emergencies for Aqua Ferre assets and/or operations, eg pipe leaks, pipe breaks, vandalism incidents, theft, unauthorised access, etc	TBD
To receive current information relating to incidents or service disruptions	http://www.aquaferre.com.au
Department of Fire and Emergency Services:	
• State Emergency Services • Department of Fire and Emergency Services	132 500 13 3337
WorkCover	1300 794 744
Shire of Chittering	(08) 9576 4600
Food Safety:	
• Dept of Primary Industries • DOH	(08) 9368 3382 (08) 9222 4222
Poisons Emergency Hotline	131 126
Roads	8

11.6 Hazards to human and environmental health

Aqua Ferre is focused on sustainable practice and good environmental management. As part of its strategic plan Aqua Ferre will monitor and review its environmental performance and also continue to develop new ways of reducing the impact of its work. Aqua Ferre's Environmental Policy (Appendix A) guides all of its activities.

Aqua Ferre's vision is to meet all challenges to deliver safe, sustainable and affordable water services for its customers. This culture is part of everything Aqua Ferre does, from significant projects to sustainable management practices.

Some of the key objectives are to:

- minimise waste discharges from WTPs;
- use environment and user friendly products where possible;
- minimise carbon footprint.

Objectives and targets are derived from Aqua Ferre's Environmental and Safety Policies and from the basis of the management of human and environmental health.

Continual improvement in environmental and operational performance is facilitated through measuring performance against the objectives and targets and making the necessary adjustments to relevant policies and operational and work plans.

It is Aqua Ferre's responsibility to initiate, facilitate and direct the process of formulation and periodic review of the objectives and targets. This will be achieved through:

- continuous improvement;
- compliance with regulations and demonstration of leadership;
- minimisation of energy, water and waste.

(a) **Potential hazards**

There are a number of potential hazards to human and the environmental health associated with Aqua Ferre's operations. Potential hazards include: physical, electrical mechanical, biological, chemical, and toxic material hazards .

Aqua Ferre uses various chemicals to treat water and wastewater throughout its systems. Appropriate warning signage will be provided at each asset where hazardous materials are stored and/or used. MSDS for any chemical used or stored at Aqua Ferre's locations will also be kept.

Each Aqua Ferre facility (Riverside and Sirona) where hazardous materials are stored or utilised will have site-specific emergency response procedures relating to the facility and types of products used.

Note: The treatment train that Aqua Ferre proposes minimises the transport, use and storage of hazardous chemicals.

(b) **Situations which could cause hazards to human health and the environment**

There are a number of situations and threats which could potentially increase the likelihood of hazards impacting upon human health and the environment including:

- vandalism and theft;

- arson;
- terrorism;
- natural disasters;
- power failure;
- telecommunications outages;
- prolonged wet or dry weather;
- fire;
- system or equipment failure;
- operating error;
- civil works on infrastructure.

(c) **Safeguards to prevent hazards impacting human health and the environment**

Aqua Ferre will utilise many safeguards to protect people and assets and to minimise the likelihood of hazards impacting upon human health and/or the environment as follows:

- employee training;
- emergency management training and evacuation drills;
- asset protection measures including security, fencing, intruder alarms, closed circuit TV equipment, fire alarms and fire breaks;
- safety protection measures including policies, safe work methodology, procedures and risk assessment processes;
- physical protection measures such as chemical storage bunds, field safety equipment and emergency storage facilities;
- system design to include multi-barrier risk mitigation, inbuilt redundancy, system control alarms to notify operators when a fault in the system has occurred;
- equipment maintenance;
- asset monitoring and maintenance.

(d) **Water management**

The objectives of Aqua Ferre's management plan are to:

- protect the environment;
- protect the health and safety of members of the public and Aqua Ferre's employees;
- protect the Aqua Ferre's water operations and associated assets;
- promote water conservation;
- encourage compliance with Aqua Ferre's ERA water services licence conditions and other regulatory requirements.

12 Environmental Analysis

Objective

- Maintain customer service levels by taking corrective action after regularly assessing external threats and opportunities.

Aqua Ferre will assess the environment of the asset system regularly to identify and mitigate external factors that impact customer service by:

- regularly assessing threats and opportunities in the system environment;
- monitor performance standards for:
    - service availability;
    - service capacity and continuity;
    - emergency response;
- checking compliance with statutory and regulatory requirements;
- Reviewing and documenting monitoring outcomes and responses.

13 Financial Planning

Objective

Maintain customer service levels by creating a reliable financial plan that provides for the long term financial viability of the service.

13.1 Introduction

Aqua Ferre will be the water services provider to approximately 245 residential allotments and approximately 53 industrial/commercial lots.

Aqua Ferre will oversee the design and then manage and operate the potable water supply scheme for supply of potable water to the Riverside and Sirona developments. The WTP will be located at the Riverside development on two specially designated lots of land owned by Aqua Ferre.

The reticulation system will be built by Riverside, to a specification agreed with Aqua Ferre, as part of the Riverside development. Riverside will fund the construction of both the WTP and the residential reticulation system as part of its project development costs. As such, Aqua Ferre will not bear any financial risk in relation to the build cost or funding requirements of the WTP or reticulation system.

The pipeline from the WTP to the Sirona development will be designed, built and operated by Aqua Ferre. Aqua Ferre will fund the construction and associated works via upfront development charges to Sirona. As is the case for the residential development, the reticulation system will be built by Sirona, to a specification agreed with Aqua Ferre, as part of the Sirona development. Aqua Ferre will not bear any financial risk in relation to the build cost or funding requirements of the reticulation system.

Aqua Ferre will enter long-term agreements with Riverside and Sirona to ensure access to the reticulation systems with step-in rights at any time if necessary. At the expiry of the agreements Aqua Ferre will have the right to acquire the reticulation systems and the WTP.

13.2 Pricing

Aqua Ferre's financial forecast has adopted the published Water Corporation charges for the nearby regions (ie Bindoon–Chittering and Gingin). It is intended that the charges move in line with Water Corporation's published charges in the future. However, if at any time the financial forecasts indicate that costs or revenues will vary materially from the initial forecasts, Aqua Ferre may look to adjust prices to the extent reasonably required. The risk to usage charges will be mitigated by Aqua Ferre entering into minimum water volumes with lot owners. It is

intended that this be set at 425kL per annum for residential owners at the Riverside development and 1,000kL per annum for commercial users at the Sirona development.

Prices will be reviewed each financial year. Every two months Aqua Ferre will send customers a bill for water use and service charges.

The financial forecast includes the following charges:

- Service charges – applies to all properties with access to our water main. Service charges are yearly charges which are spread out over the customer's two-monthly bills.
- Water use charges – applies based on the quantity of water consumed, with a defined base usage. The price of water per kilolitre increases as customers use more water across the billing year. Water use charges will be billed to customers on a two-monthly cycle.
- Water infrastructure contribution or headworks charge – payable when subdividing land or creating survey strata lots that require our services. Payment of infrastructure contributions is the land owner's responsibility.
- Water service connection charge – payable when a meter is requested for a new house or building.

(a) Residential customers (Riverside development)

Annual water service charge – the current annual water service charge is $226.05. (This charge is for the current financial year, July 2015 to June 2016).

(i) Water use charges

For residential customers at the Riverside development, the pricing structure is tiered as follows:

Table 12: Water use charges (Riverside)

Volume kL	Pricing per kL[1]
0 –150	$1.518
151–300	$2.023
301–550	$4.138
550+	$7.114

[1] Referenced to Water Corporation published rates for Bindoon–Chittering and Gingin for 2015–16.

The minimum water charge for 425kL is the equivalent of $2.467 per kL or $1,048.40 per annum. Where a lot has been connected to the water main, water usage charges will commence on the earlier of twelve months after the purchase of the lot from the developer or the approval of a building permit.

(ii) Other charges

Infrastructure contributions are payable when subdividing land or creating survey strata lots that require our services. Payment of infrastructure contributions is the land owner's responsibility.

Table 13: Other Charges (Riverside)

Infrastructure Contribution	Cost
Water Infrastructure contribution	$4, 064.00
Cost for a new standard 20mm water connection	$1,189.48

(b) **Commercial customers (Sirona development)**

(i) **Annual water service charge**

The service charge for water is based on the size and number of meters servicing each property:

Table 14: Annual water charges (Sirona)

Size of meter	Cost
Up to 20mm	$226.05
25mm	$353.22
Up to 40mm	$904.24
50mm	$1,412.86
70, 75, 80mm	$3,616.92
100mm	$5,651.44
Up to 150mm	$12,715.74

(ii) **Water use charges**

For commercial customers at the Riverside development, the pricing structure is tiered as follows:

Table 15: Water use charges (Sirona)

Volume kL	Pricing per kL
0– 550	$3.500
550+	$7.114

(iii) **Other charges**

Table 16: Other Charges (Sirona)

Charge	Cost
Headworks charge	$8,000.00
Cost for a new water connection	Varies dependent on size of connection

13.3 Capital works and funding

Riverside, as developer of the residential subdivision, is to build and fund the WTP and the reticulation system to a design specification agreed with Aqua Ferre. The WTP is budgeted at $1.973 million and the reticulation system at $1.111 million. Aqua Ferre carries no financial risk in relation to the build of these assets.

Following the build, Aqua Ferre will assume management and operational control over the assets. Following the sale of the residential lots, the developer will transfer ownership in the assets to Aqua Ferre. Until that time Aqua Ferre will hold step-in ownership rights to protect control of the assets.

Aqua Ferre will be responsible for the design, build and management of the pipeline from the WTP to the MEN development and the related storage infrastructure. The capital costs will be fully met by upfront payments from Sirona, and work will not commence until payment is received. As such Aqua Ferre will not require additional funding to meet the forecast build costs.

Similar to the arrangements for the residential development, Sirona will be responsible for the build and funding of the reticulation through its development, which will be to the specification agreed with Aqua Ferre. Aqua Ferre will then operate and manage the infrastructure.

Aqua Ferre has developed a future capital works and replacement program. Expenditures under this program are forecast at over $0.2 million over the first 15 years of operation and more than $0.6 million in total over the first 25 years of operation. The funding for these works can be comfortably met through forecast operating cash flows.

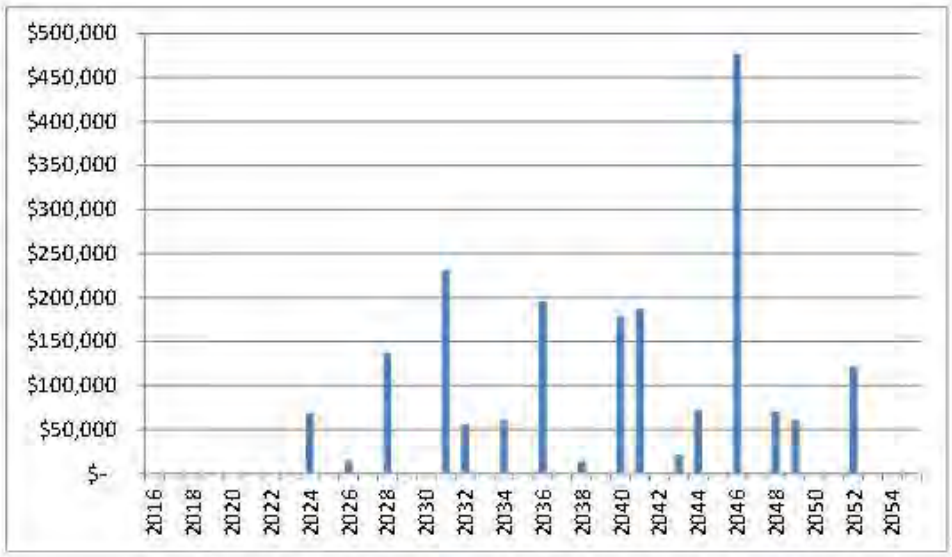


Figure 3: Programmed asset expenditure

13.4 Financial Position

Aqua Ferre's assets include significant water licence rights that were transferred into the company by its major shareholders. These water rights total 651,700kL and have been reflected on the balance sheet at $1/kL. The marketable value for potable water exceeds this carrying value.

Aqua Ferre also holds rights to two lots within the Riverside development, upon which the WTP will be located. These lots are carried on the balance sheet at $200,000 each. The marketed value of equivalent lots is from $220,000 to $250,000 each.

Aqua Ferre's total assets are in excess of $1.05 million.

Aqua Ferre does not carry any debt.

13.5 Forecasts

Aqua Ferre has developed detailed long-term financial forecasts for this project. Forecast profit and loss statements, balance sheets and cash flows covering 15 years of operation are attached as Appendix D.

The forecasts have been prepared in conjunction with Aqua Ferre's corporate advisors, Pendulum Capital Pty Limited, and with Aqua Ferre's water and environmental advisors, Arris.

13.6 Review of asset management system

The asset management system will be regularly reviewed to ensure the effectiveness of the integration of its components, particularly with reference to the effect of changing market conditions and growth on the ability to maintain the required service conditions and levels.

An internal audit will also be performed on the Asset Management Plan yearly.

13.7 Future funding strategy

Projected expenditure identified in Section 5.1 is to be funded from Aqua Ferre's operating and capital budgets. The funding strategy is detailed in Aqua Ferre's long term financial plan.

Aqua Ferre will fund the expenditure outlined in the financial forecast from the following funding sources.

Category	Definition	Funding Sources
Maintenance	The investment in an existing asset related to the ongoing up-keep to ensure it meets its useful life.	Water Charges
Operations	The investment on day to day activities of business operations. Eg power costs, chemicals, licencing charges.	Water Charges
Existing Asset Rehabilitation / Renewal	The investment of maintaining the current level of service by reinstating the original life of the asset.	Reserves Water Charges
New Assets to improve Level Of Service to existing customers	The investment in a new asset to increase a level of service to existing customers and to meet legislative requirements. Eg. Electrical control equipment such as SCADA.	State & Federal Grants Loans Water Charges
New Acquired Assets	New assets constructed by developers for future customers at the developers own cost and handed over to Council for ongoing operation, management and renewal.	Contributed assets
New or Augmented Assets for Growth	Major new assets needed to service growth	Developer Charges : Development Servicing Plan - DSP State & Federal Grants Water Charges (Reduction Amount)
Disposal	Costs associated with the decommissioning and disposal of an asset.	Water Charges

.

14 References

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WA Department of Health: Systems Compliance and Routine Reporting Requirements for Small Community Water Providers. http://ww2.health.wa.gov.au/~/media/Files/Corporate/general%20documents/water/PDF/Systems_compliance_routine_reporting_small_community.ashx

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Appendix B
Landscaping Plans

Legend	
Symbol	material
	existing mature tree
	lawn area
	vegetation retention / replanting area

Revegetation

Trees - Banksia attenuata
Banksia illicifolia
Banksia menziesli
Banksia prionotes
Eucalyptus todtiana
Eucalyptus marginata
Ssp thalasicca

Shrubs - Grevillea curviloba
Melaleuca laterita
Melaleuca seriata
Verticordia densiflora
Xanthorrhoea preissi

Low shrubs - Acacia lasiocarpa
Acacia pulchella
Schoitzia involucrata
Verticordia acerosa
Verticordia densiflora
Hibbertia hypericoides
Hovea trisperma

Ground cover - grass type plants -
Conostylis juncea
Lepidosperma viscidum
Microlaena stipoides
Nuerachne alopecuroides
Stipa compressa

car parking

gravel paths

car parking

267.9

POS 1
2.7907ha

298.3

2

155

153

bin area

2 / double bbq

shade shelter
with picnic tables

adventure
playground

toilet block

car parking

gravel paths

car parking

lawn
(5006 m²)

ROAD 9 (20m ROAD RESERVE)

N

CONCEPT PLAN
WILDFLOWER RIDGE PUBLIC OPEN SPACE

Z:\Landscapes WA\Jobs LWA\General public\W\Wildflower ridge estate

1:1000 @ a3

LANDSCAPES W.A.

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CLIENT INFORMATION:

Address :lot 2 & LOT 9001 ROSEWOOD DRIVE, CHITTERING

Client name :WILDFLOWER RIDGE

Phone no :

E-mail :

Landscape design 1:1000 scale	15/4/2020	MG
Landscape design 1:1000 scale (R1)	24/5/2020	MG
Landscape design 1:1000 scale (R2)	22/9/2020	MG

Client Approval :

Approval Date:

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Measurements - All measurements and levels to be confirmed on site prior to commencement of any works. Levels may require adjusting on site.

Reticulation Note - Gardens to be irrigated by automatic reticulation system with drip lines and drippers. all reticulation to comply with watering guidelines.

DS01-12/20

Attachment 1

Legend	
Symbol	material
	existing mature tree
	lawn area
	vegetation retention / replanting area



1 - CENTRAL PARK

The central park are is to make use of the existing mature stand of eucalypts as a backdrop to nestle in resident park amenity such as ,shade structures, play equipment focusing on adventure play, a large lawn area for picnicking ,bbq facilities, toilet and water fountain conveniences, lighting as a contrast to the more endemic vegetation.
The central park will be organised spatially though the use of desire lines that cross the park providing not only cross access however a circuitous route within the park. The larger areas encourage local planting as a strong suggestion of the sites original landscape woodlands.

2 - VEGETATION MANAGEMENT STRATEGY

The landscape architectural recommendation for residential lots is primarily influenced by maintaining 'a sense of place'. However this is conversely and equally strongly influenced by fire management regulations. the approach taken here is to limit bushland planting to no closer than 20m from residences with the areas of remnant or re-planting vegetation to be no more than 2500sq/m in size. guided by the simplified description of the fire management regulations, the masterplan, detail plans and elevations indicate planting opportunities for residences for lots 2 and lot 9001

3 - LANDSCAPE INTENT

The lot reserve road and lot 9001 Rosewood Drive landscape masterplan borrows cues from the sites unique woodlands ecology and recent use as a native flower farm.

Revegetation	
Trees -	Banksia attenuata
	Banksia illicifolia
	Banksia menziesli
	Banksia prionotes
	Eucalyptus todtiana
	Eucalyptus marginata
	Ssp thalasicca
Shrubs -	Grevillea curviloba
	Melaleuca laterita
	Melaleuca seriata
	Verticordia densiflora
	Xanthorrhoea preissi
Low shrubs -	Acacia lasiocarpa
	Acacia pulchella
	Schoitzia involucrata
	Verticordia acerosa
	Verticordia densiflora
	Hibbertia hypericoides
	Hovea trisperma
Ground cover -	grass type plants -
	Conostylis juncea
	Lepidosperma viscidum
	Microlaena stipoides
	Nuerachne alopecuroides
	Stipa compressa

NOTE:existing trees within lot 2 and lot 9001 will be retained where possible where the trees are not required for removal for fire management, clearing for roads, building works or vehicle access requirements

Z:\Landscapes WA\Jobs LWA\General public\W\Wildflower ridge estate

1:7500 @ a3

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CLIENT INFORMATION:

Address : lot 2 & lot 9001 ROSEWOOD DRIVE, CHITTERING

Client name :WILDFLOWER RIDGE

Phone no :

E-mail :

	Landscape design 1:1000 scale	15/4/2020	MG
	Landscape design 1:7500 scale (R1)	24/5/2020	MG
	Landscape design 1:7500 scale (R2)	22/9/2020	MG

Client Approval :

Approval Date:

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Measurements - All measurements and levels to be confirmed on site prior to commencement of any works. Levels may require adjusting on site.

Reticulation Note - Gardens to be irrigated by automatic reticulation system with drip lines and drippers. all reticulation to comply with watering guidelines.

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people • planet • professional

APPENDIX D

Bushfire Management Plan

FPA AUSTRALIA Fire Protection Association Australia Life. Property. Environment.

BPAD Bushfire Planning & Design

Bushfire Management Plan Coversheet

This Coversheet and accompanying Bushfire Management Plan has been prepared and issued by a person accredited by Fire Protection Association Australia under the Bushfire Planning and Design (BPAD) Accreditation Scheme.

Bushfire Management Plan and Site Details

Site Address / Plan Reference: Wildflower Ridge Estate, Lot 9002 Reserve Road and Lot 9001Rosewood Drive

Suburb: Chittering **State:** WA **P/code:** 6501

Local government area: Shire of Chittering

Description of the planning proposal: Change of Structure Plan

BMP Plan / Reference Number: 200405 **Version:** v1.0 **Date of Issue:** 26/08/2020

Client / Business Name: Riverside Investments (WA) No 2 Pty Ltd

Reason for referral to DFES	Yes	No
Has the BAL been calculated by a method other than method 1 as outlined in AS3959 (tick no if AS3959 method 1 has been used to calculate the BAL)?	☐	☒
Have any of the bushfire protection criteria elements been addressed through the use of a performance principle (tick no if only acceptable solutions have been used to address all of the BPC elements)?	☐	☒
Is the proposal any of the following special development types (see SPP 3.7 for definitions)?		
Unavoidable development (in BAL-40 or BAL-FZ)	☐	☒
Strategic planning proposal (including rezoning applications)	☐	☒
Minor development (in BAL-40 or BAL-FZ)	☐	☒
High risk land-use	☐	☒
Vulnerable land-use	☐	☒

If the development is a special development type as listed above, explain why the proposal is considered to be one of the above listed classifications (E.g. considered vulnerable land-use as the development is for accommodation of the elderly, etc.)?

Note: The decision maker (e.g. local government or the WAPC) should only refer the proposal to DFES for comment if one (or more) of the above answers are ticked "Yes".

BPAD Accredited Practitioner Details and Declaration

Name	Accreditation Level	Accreditation No.	Accreditation Expiry
Sean Winter	2	37118	01/04/2021
Company		**Contact No.**	
Bushfire Prone Planning		6477 1144	

I declare that the information provided within this bushfire management plan is to the best of my knowledge true and correct

S Winter 8/9/2020

Bushfire Management Plan
Wildflower Ridge Subdivision
Change to Structure Plan

Lot 2 Reserve Road, and Lot 9001 Rosewood Drive, Chittering

Shire of Chittering

Job Number:	200405
Assessment Date:	13 August 2020
Report Date:	26 August 2020

BPP Group Pty Ltd t/a Bushfire Prone Planning
ABN: 39 166 551 784

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Disclaimer

The measures contained in this Bushfire Management Plan are considered to be minimum standards and they do not guarantee that a building will not be damaged in a bushfire, persons injured, or fatalities occur either on the subject site or off the site while evacuating. This is substantially due to the unpredictable nature and behaviour of fire and extreme weather conditions. Additionally, the correct implementation of the required bushfire protection measures (and any associated response/evacuation plan if applicable) will depend, among other things, on the actions of the landowners or occupiers over which Bushfire Prone Planning has no control.

All surveys, forecasts, projections and recommendations made in this report associated with the project are made in good faith based on information available to Bushfire Prone Planning at the time.

All maps included herein are indicative in nature and are not to be used for accurate calculations.

Notwithstanding anything contained therein, Bushfire Prone Planning will not, except as the law may require, be liable for any loss or other consequences whether or not due to the negligence of their consultants, their servants or agents - arising out of the services provided by their consultants.

Document Control

Version	Version Details	Date Submitted
1.0	BMP	5-Aug-20
		-
		-

Author	Accreditation	Signature
Sean Winter	BPAD Level 2 - No. 37118	
Co-author		
-	-	-
Reviewed/Approved		
Kathy Nastov	BPAD Level 3 - No. 27794	

Document Content Compliance Statement
This Bushfire Management Plan (the Plan) provides the required information to address State Planning Policy No. 3.7: Planning in Bushfire Prone Areas - December 2015 (SPP 3.7), the associated Guidelines for Planning in Bushfire Prone Areas - WAPC 2017 v1.3 (Guidelines), and any additional information as directed by the WA Planning Commission (WA Department of Planning, Lands and Heritage). It is fit for accompanying a planning application.
BAL Contour & BPC Template v1.0

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Executive Summary

Bushfire Prone Planning (BPP Group Pty Ltd) has been commissioned by the landowner to prepare a Bushfire Management Plan, including a Bushfire Attack Level (BAL) Contour Map and an assessment against the Bushfire Protection Criteria for the Wildflower Ridge Structure Plan and Subdivision. This comprises 32 previously subdivided lots, as well as Lot 9002 Reserve Road, and Lot 9001 Rosewood Drive, Chittering, in the Shire of Chittering. Planning Permission for this rural subdivision was granted by the Commission on 23 November 2016. However, the original BMP was written in 2015 prior to the application of SPP3.7. The purpose of this BMP is to support an application for an amendment to the approved Structure Plan and a Scheme Amendment, in which it is proposed to change the zoning for Lot 9002 Reserve Road from R2 to R5. There will be no change to zoning for Lot 9001 Rosewood Drive or previously subdivided lots.

A BMP was prepared for the development in 2015 by the ICS Group. That BMP was written prior to the implementation of State Planning Policy 3.7, *Planning in Bushfire Prone Areas*, and is thus obsolete. This BMP assesses the bushfire risk under current regulation, and demonstrates that the bushfire risk at the site can be managed.

Contained within this report, contour mapping is utilised to visually show the potential radiant heat impacts (from bushfire prone vegetation), as separate Bushfire Attack Level contours across the entirety of the development. The BAL's have been derived for the proposed Lots within the assessed area. The purpose is to inform future development planning by determining or indicating the Bushfire Attack Levels (BAL's) that future buildings, within each Lot, are potentially subject to.

Given the rural nature of this subdivision it is recommended that a minimum BAL-12.5 constructions standard be adopted across the entire development.

Against the Bushfire Protection Criteria, the decision maker's assessment of a future Proposal will be on the basis of it being able to meet the Acceptable Solutions, once construction and landscaping (if applicable) is complete, as follows:

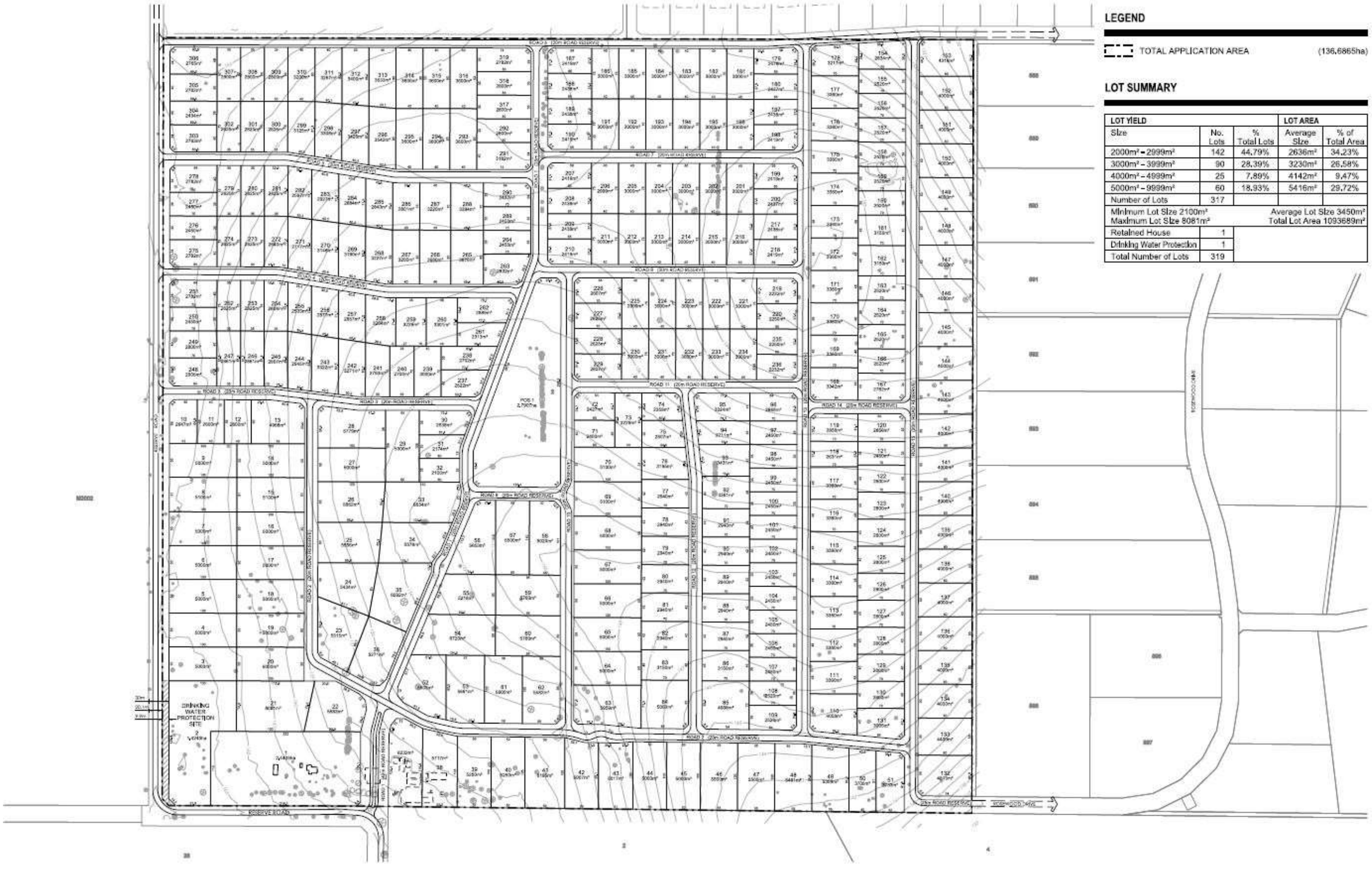
- For Element 1 'Location', all Lots are able to achieve the acceptable solution (by being located in an area that will on completion be subject to BAL-29 or less);
- For Element 2 'Siting and Design' the Proposal is able to meet the acceptable solutions by habitable buildings being able to achieve an Asset Protection Zone (APZ) of sufficient size to ensure the radiant heat impact does not exceed BAL-29. APZ's will be managed in a low-fuel state within individual lots and across the neighbouring established residential Lots;
- For Element 3 'Vehicular Access', the location of the development is able to meet the current acceptable solution A3.1 (provision of two access routes to different destinations), and A3.2 (public roads will be constructed to meet the technical requirements);
- For Element 4 'Water', the development is able to achieve the acceptable solution (it is located in reticulated water supply area for fire-fighting).

1 The Proposal and Purpose of the Plan

1.1 Details

Landowner / Proponent:	Riverside Investments (WA) No 2 Pty Ltd.
Site Address:	Wildflower Ridge Estate, Lot 9002 Reserve Road and Lot 9001Rosewood Drive, Chittering
Local Government:	Shire of Chittering
Site Area:	136.2200 ha (Lot 9002 Reserve Road and subdivided lots on Meeukany Drive, Sceptrum Avene), Karda View and Narik Grove) 58.4844 ha (Lot 9001 Rosewood Drive)
No. Of Existing Lots:	34
No. of Proposed Lots:	355 Lots
Planning Stage:	Strategic - local structure/master plan - lot layout known
Subdivision Type:	Subdivision - large number of lots
Overview of the Proposal:	Bushfire management planning assessment and report to support a Structure Plan Amendment and Scheme Amendment for Lot 9002 Reserve Road, from R2 to R5
Bushfire Prone Planning Commissioned to Produce the Plan by:	Taylor Burrell Barnett Town Planning and Design
Purpose of the Plan:	To accompany a planning application
For Submission to:	Shire of Chittering

Figure 1.1.1: Proposed Subdivision Layout for Lot 9002 and Previously Subdivided Lots



Subdivision Concept Plan

LOT 2 RESERVE ROAD, LOWER CHITTERING

A Riverside Investments (WA) No 2 Pty Ltd Project

DRAFT

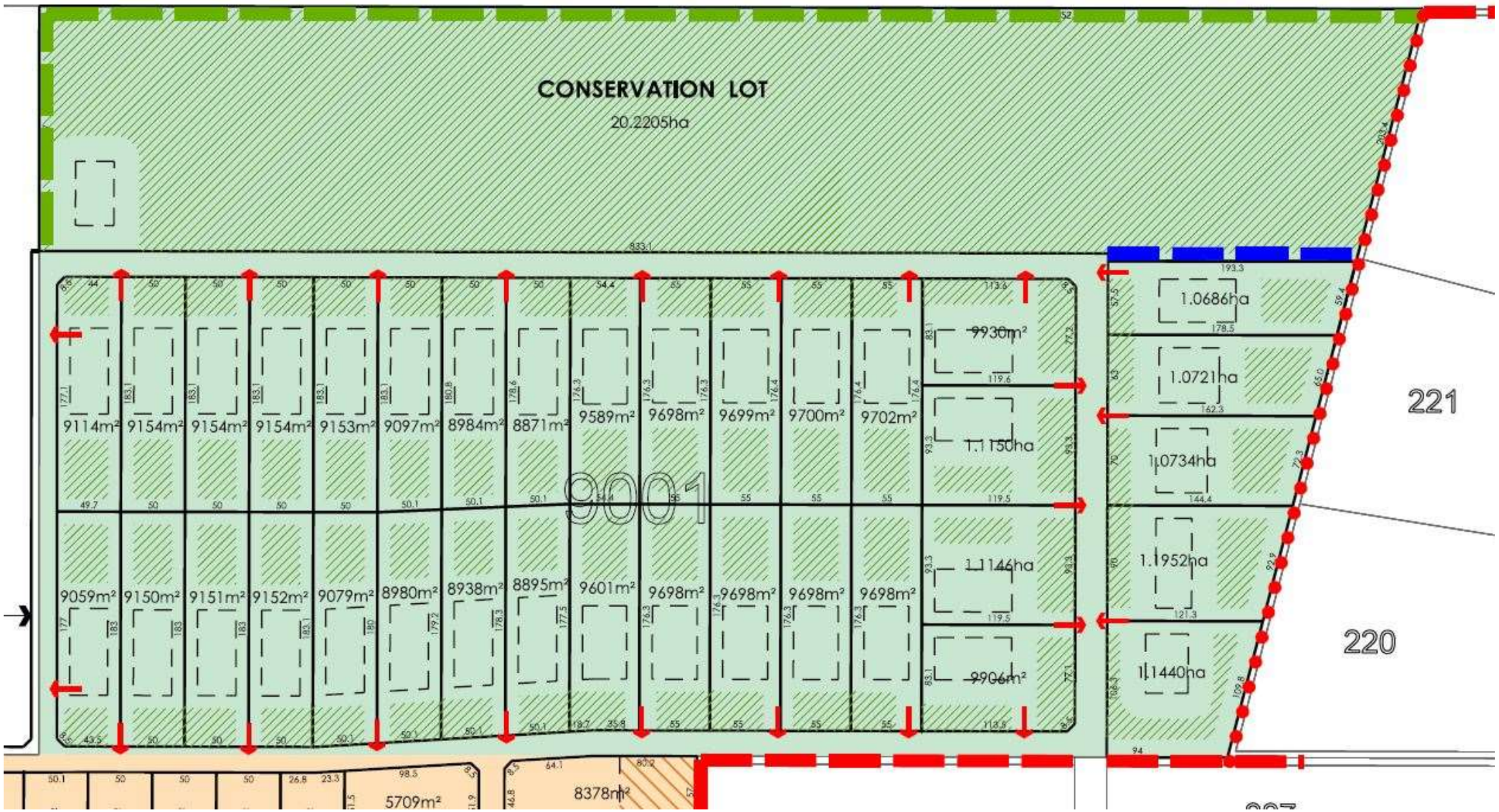
plan: 05/095/0305
date: 24/08/2020
scale: 1:5000@A3 | 1:2500@A1
grid: PCG 94
aerial: -
designed: BDM
checked: MW
drawn: BR
0 50 100m

Taylor Burrell Barnett Town Planning & Design
Level 7, 160 St Georges Terrace, Perth WA 6000
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ALL AREAS AND DIMENSIONS CONTAINED ARE SUBJECT TO DETAIL SURVEY.

Taylor Burrell Barnett

Figure 1.1.2: Proposed Subdivision Layout for Lot 9001



DSO1-12/20

Attachment 1

Figure 1.2

Location Plan

Lot 9001, Reserve Road and
Lot 9002, Reserve Road including
Previously Subdivided Lots
CHITTERING
SHIRE OF CHITTERING

SUBJECT SITE

------ LEGEND ------

- Subject Site
- Local Government Authority
- Locality / Suburb
- Reserves
- Bush Fire Brigade

Legislated Lands and Waters

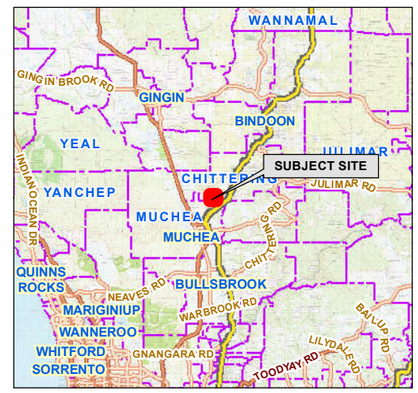
- Nature Reserve
- National Park
- Section 5(1)(g) Reserve
- Section 5(1)(h) Reserve
- State Forest

DBCA Lands of Interest

- Crown Freehold - Dept Interest

0 1 2 3 4 5
Kilometers

------ LOCALITY ------



Aerial Imagery : Landgate/SLIP
Image Date : Apr 2020

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator Units: Metre
Map compiled by: Ian Ross 24/08/2020
Map udated by: Ian Ross 24/08/2020

BUSHFIRE PRONE PLANNING

Disclaimer and Limitation: This map has been prepared for bushfire management planning purposes only. All depicted areas, contours and any dimensions shown are subject to survey. Bushfire Prone Planning does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence arising from relying on any information depicted.
Map Document Path / Name: F:\Projects\Sean\200405_Lot2 Reserve Rd_Lot9001 Rosewood Dv Chittering\Mapping\MXD\200405_Fig1-2_LOC_Reserve Rd_Chittering.mxd

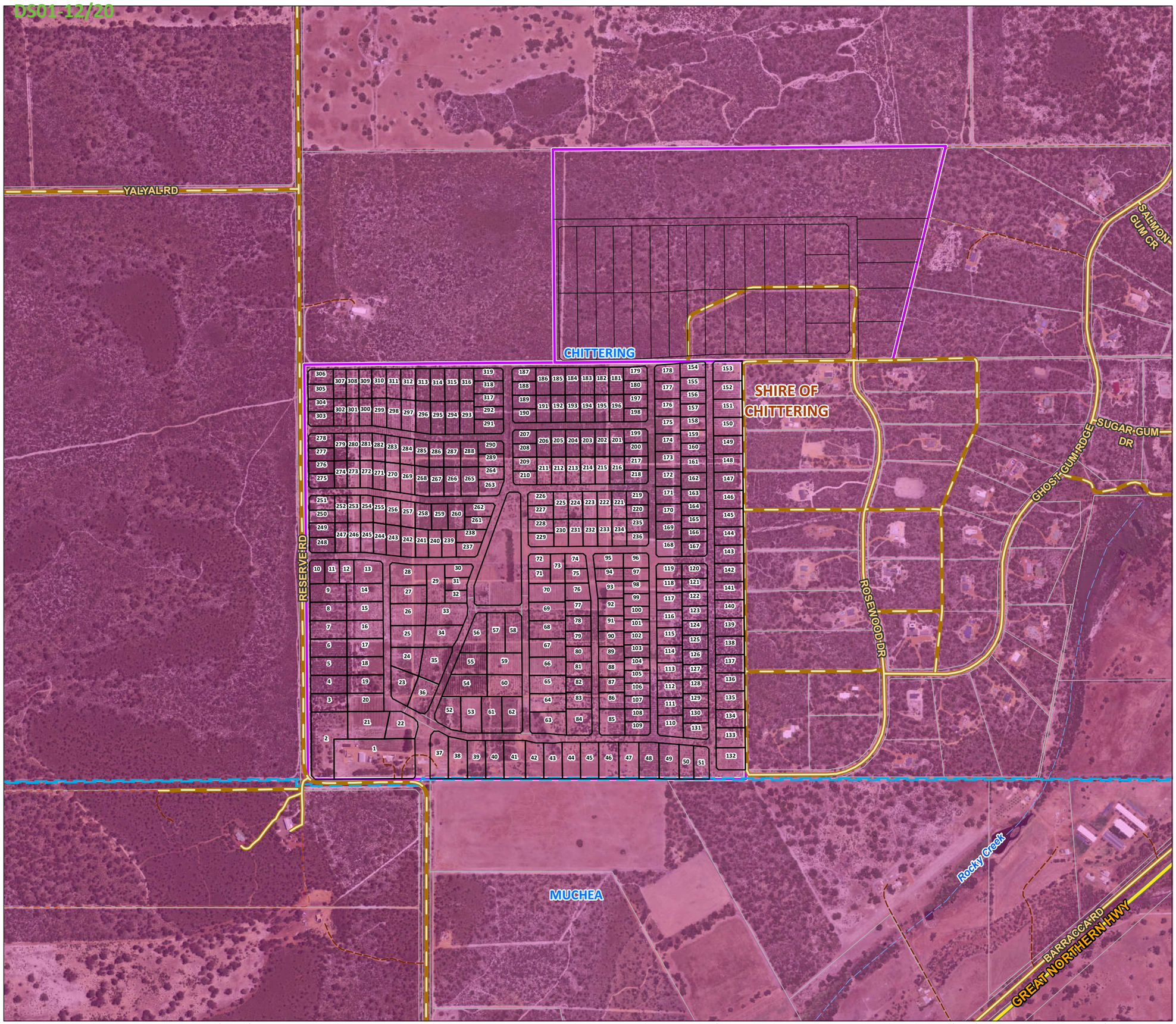
DS01-12/20

Attachment 1

Figure 1.3

Bushfire Prone Area

Lot 9001, Reserve Road and
Lot 9002, Reserve Road including
Previously Subdivided Lots
CHITTERING
SHIRE OF CHITTERING

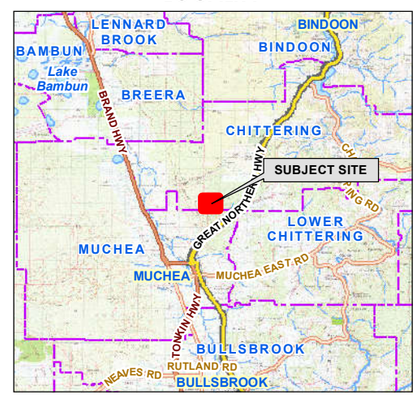


------ LEGEND ------

- Subject Site
- Other Lots
- Local Government Authority
- Locality / Suburb
- Proposed Subdivision
- Bushfire Prone Areas (2019)

0 100 200 300 400
Metres

------ LOCALITY ------



Aerial Imagery : Landgate/SLIP
Image Date : Apr 2020

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator Units: Metre
Map compiled by: Ian Ross 25/08/2020
Map udated by: Ian Ross 25/08/2020

BUSHFIRE PRONE PLANNING

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Map Document Path / Name: F:\Projects\Sean\200405_Lot2 Reserve Rd_Lot9001 Rosewood Dv Chittering\Mapping\MXD\200405_Fig1-3_BPA_Reserve Rd_Chittering.mxd

1.2 Existing Documentation Relevant to the Construction of this Plan

This section acknowledges any known reports or plans that have been prepared for previous planning stages, that refer to the subject area and that may or will impact upon the assessment of bushfire risk and/or the implementation of bushfire protection measures and will be referenced in this Bushfire Management Plan.

RELEVANT DOCUMENTS		
Existing Document	Copy Provided by Client	Title
Structure Plan	Yes	Lot 2 Reserve Road and Lot 9001 Rosewood Drive Structure Plan
Environmental Report	Yes	Lot 9001 Reserve Road, Chittering: Level 2 Flora and Vegetation Assessment
Landscaping (Revegetation) Plan	N/A	-
Bushfire Risk Assessments	Yes	Bushfire Management Plan Lot 2 Reserve Road & Lot 9001 Rosewood Drive, Shire of Chittering, 28 July 2015.

1.3 Subdivision Details

The development is subject to an approved structure plan and approved plan of subdivision granted by the WAPC. The proponents seek to change the zoning for part of the subdivision, from R2 to R5. Details of that proposed change are as shown in the Table below.

Table 1.1.1: Details of Lots

ZONING DETAILS OF LOTS			
Lot No.	Street Number	Current Zoning	Proposed Rezoning
9002 Reserve Road	N/A	Residential R2	Residential R5
9001 Reserve Road	356	Rural Conservation	No Change
132-134, 145-148 Meeukany Drive	20, 26, 31-32, 41-42, 47	Residential R2	No Change
104, 135, 142-144, 153-159, 166 Sceptrum Avenue	35-36, 45-46, 51-52, 55-56, 59, 63, 72-73	Residential R2	No Change
149 Karda View	6	Residential R2	No Change
150-152, 167-1721 Narik Grove	6, 13-14, 18-19, 24, 27-28, 34	Residential R2	No Change

2 Environmental Considerations

2.1 Native Vegetation – Modification and Clearing

'Guidelines' s2.3: "Many bushfire prone areas also have high biodiversity values. SPP 3.7 policy objective 5.4 recognises the need to consider bushfire risk management measures alongside environmental, biodiversity and conservation values."

Existing conservation areas that are potentially affected by the development proposal are required to be identified. This may result in vegetation removal/modification prohibition or limitations. These areas include National Parks, Nature Reserves, Wetlands and Bush Forever sites.

Environmental Protection Act 1986: "Clearing of native vegetation in Western Australia requires a clearing permit under Part V, Division 2 of the Act unless clearing is for an exempt purpose. Exemptions from requiring a clearing permit are contained in Schedule 6 of the Act or are prescribed in the Environmental Protection Regulations" ('Guidelines' s2.3).

The Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act): This Act administered by the Australian Government Department of Environment, provides a national scheme of environment and heritage protection and biodiversity conservation. Nationally threatened species and ecological communities are a specific matter of significance. Areas of vegetation can be classified as a Threatened Ecological Community (TEC) under the EPBC Act and consequently have removal restrictions imposed.

VEGETATION MODIFICATION AND CLEARING ASSESSMENT	
Will on-site clearing of native vegetation be required?	Yes, for lot 9001 Rosewood Drive only
Does this have the potential to trigger environmental impact/referral requirements under State and Federal environmental legislation?	Yes
Identified environmental legislation applicable to the Proposal site - No.1:	Threatened Ecological Communities (TEC)
Identified environmental legislation applicable to the Proposal site - No.2:	N/A
For the proposed development site, have any areas of native vegetation been identified as species that might result in the classification of the area as a Threatened Ecological Community (TEC)?	Yes
Potential TEC species identified:	Banksia Woodlands of the Swan Coastal Plain

Lot 9002 Reserve Road has been cleared numerous times in the past and has been used as a wildflower nursery site for the past decades. It has no specific environmental values and it is proposed to clear the entirety of this lot for the implementation of Stage One of the development.

Lot 9001 is zoned as Rural Residential with conservation values. The environmental survey conducted in 2015 identified no significant environmental issues for the lot. However, in 2018 the vegetation regime "Banksia Woodland of the Swan Coastal Plain" was listed as a Threatened Ecological Community under the EPBC Act 1999. Lot 9001 is mapped in state level broad scale mapping as potentially containing

Banksia Woodland of the Swan Coastal Plain, an issue which should be considered before any clearing is undertaken, as subdivision permission for Lot 9001 was granted prior to Banksia Woodland of the Swan Coastal Plain being declared a TEC. The proponent should ensure that all environmental considerations have been dealt with, including the potential for environmental survey, prior to any land clearing or development taking place within Lot 9001.

The bushfire assessment and management strategies contained in this report, assume that environmental approval will be achieved or clearing permit exemptions will apply prior to the development being undertaken.

Development Design Options

Establishing development in bushfire prone areas can adversely affect the retention of native vegetation through clearing associated with the creation Lots and/or Asset Protection Zones. Where loss of vegetation is not acceptable or causes conflict with landscape or environmental objectives, it will be necessary to consider available design options to minimise the removal of native vegetation.

MINIMISING THE REMOVAL OF NATIVE VEGETATION FOR LOT 9001		
Design Option	Identified	Adopted
Reduction of lot yield	Yes	Yes
Cluster development	Yes	Yes
Construct building to a standard corresponding to a higher BAL rating as per BCA (AS 3959-2018 and/or NASH Standard)	Yes	Yes
Modify the development location	N/A	N/A

The conservation values for Lot 9001 have been identified and dealt with through the site design. This includes a single large Conservation Lot of over 20 ha, and for the 35 other proposed lots, the maximum of 2500 m^2 of vegetation cleared or modified to low threat within the lot boundaries. All proposed lots within Lot 9001 range between 0.8938 ha and 1.1925 ha in size. This means that greater than 75% of existing bushland on Lot 9001 will be retained after the completion of development.

Impact on Adjoining Land

Is this planning proposal able to implement the required bushfire measures within the boundaries of the land being developed so as not to impact on the bushfire and environmental management of neighbouring reserves, properties or conservation covenants?	Yes

2.2 Re-vegetation / Retained Vegetation / Landscape Plans

Is re-vegetation of riparian zones and/or wetland or foreshore buffers and/or public open space a part of this Proposal?	Yes
Is the requirement for ongoing maintenance of existing vegetation in riparian zones and/or wetland or foreshore buffers and/or public open space a part of this Proposal?	No

Public Open Space is included in the development design for Lot 9002 Reserve Road. In assessing vegetation for bushfire threat, consideration must be given to possible future vegetation changes likely on the site that is being assessed and in particular those that would have the potential to increase the bushfire risk. This may be due to growth of existing vegetation or growth of planned landscape plantings. There must be careful consideration of the creation of vegetation corridors where they join offsite vegetation, and which may provide a route for fire to enter an area of future development.

Where an environmental report or landscaping (revegetation) is required as a condition of future development, the bushfire management planning may be required to address any bushfire impacts arising from these subsequent reports or plans.

Landscaping within the site requires consideration of the bushfire management planning requirements to ensure an increase in bushfire hazards does not occur, nor alter bushfire attack levels determined for the site. Future garden landscape areas will be managed and lawn on site is able to be maintained below 100mm in height to the extent required and subsequently all on-site vegetation will rate as low threat.

3 Potential Bushfire Impact Assessment

3.1 Assessment Input

3.1.1 Fire Danger Index (FDI) Applied

AS 3959-2018 specifies the fire danger index values to apply for different regions as per Table 2.1. The values used in the model calculations are for the Forest Fire Danger Index (FFDI) and for which equivalent representative values of the Grassland Fire Danger Index (GFDI) are applied as per Appendix B. The values can be refined if appropriately justified.

Table 3.1: Applied FDI Value

FDI Value			
Vegetation Area	As per AS 3959 - 2018 Table 2.1	As per DFES for the Location	Value Applied
All	80	N/A	80

Existing Vegetation Identification, Classification and Effective Slope

Vegetation identification and classification has been conducted in accordance with AS 3959-2018 s2.2.3 and the *Visual Guide for Bushfire Risk Assessment in WA* (DoP February 2016).

When more than one vegetation type is present, each type is identified separately with the worst-case scenario being applied as the classification. The predominant vegetation is not necessarily the worst-case scenario.

The vegetation structure has been assessed as it will be in its mature state (rather than what might be observed on the day). Areas of modified vegetation are assessed as they will be in their natural unmodified state (unless maintained in a permanently low threat, minimal fuel condition, satisfying AS 3959-2018 s2.2.3.2(f) and asset protection zone standards). Vegetation destroyed or damaged by a bushfire or other natural disaster has been assessed on its revegetated mature state.

Effective Slope: Is the ground slope under the classified vegetation and is determined for each area of classified vegetation. It is the measured or determined slope which will most significantly influence the bushfire behaviour in that vegetation as it approaches a building or site. Where there is a significant change in effective ground slope under an area of classified vegetation, that will cause a change in fire behaviour, separate vegetation areas will be identified, based on the change in effective slope, to enable the correct assessment.

Table 3.2: Vegetation identification and classification

ALL VEGETATION WITHIN 150 METRES OF LOT 2 RESERVE ROAD				
Vegetation Area	Identified Classification Types [1] or Description if 'Excluded'	Applied Classification[2]	Effective Slope Under Classified Vegetation	
			degrees	description
1	Open Scrub D-14	Class D Scrub	3	Downslope
2	Low Open Forest A-04	Class A Forest	2	Downslope
3	Dense Sown Pasture G-25	Class G Grassland	0	Upslope
4	Low Open Forest A-04	Class A Forest	3	Downslope
5	Low Open Forest A-04	Class A Forest	0	Upslope
6	Low Open Forest A-04	Class A Forest	4	Downslope
7	Open Scrub D-14	Class D Scrub	0	Upslope
8	Open Scrub D-14	Class D Scrub	2	Downslope
9	Open Heath C-11	Class C Shrubland	3	Downslope
10	Open Tussock G-23	Class G Grassland	2	Downslope
11	Open Heath C-11	Class C Shrubland	0	Upslope
12	Open Heath C-11	Class C Shrubland	2	Downslope
13	Low Threat Vegetation – Cleared land with minimal remnant vegetation.	Excluded AS3959-2018 2.2.3.2 (f)	N/A	N/A

Representative photos of each vegetation area, descriptions and classification justification, are presented on the following pages. The areas of classified vegetation are defined, and the photo locations identified on the topography and classified vegetation map, Figure 3.1.

Note[1]: As per AS 3959-2018 Table 2.3 and Figure 2.4 a-h
Note[2]: As per AS 3959-2018 Table 2.3.

It is assumed for the purposes of assessment that vegetation within Area 13 will continue to be managed in a low threat state in perpetuity. This is currently cleared land but these lots are shortly to be developed and built on / landscaped with gardens etc.

Vegetation Areas 8 through 12 exist within the bounds of Lot 9002 Reserve Road and will be cleared of all vegetation as part of the development. These areas are listed here as currently comprising a bushfire threat, but are excluded from consideration in the development of the contour plan, as they will be cleared prior to development.

Vegetation Area 1	**Classification Applied or Exclusion Clause:** Class D Scrub

Vegetation Type Present: Open scrub D-14

Description / Classification Justification: Low banskia woodland. Banksia dominant, with occasional *allocasuarina*, marri or jarrah trees (less than 10% canopy cover). Middle story of woolly bush, *xanthorrhoea* and *hakea*. Average height of top vegetation strata 4m and as such effectively models as Class D scrub.



Photo ID: 1a



Photo ID: 1b

Vegetation Area 2	**Classification Applied or Exclusion Clause:** Class A Forest

Vegetation Type Present: Low open forest A-04

Description / Classification Justification: Banksia woodland with overstory of regular mature jarrah and marri trees. Middle story of scattered banksia, *xanthorrhoea*, and near surface shrubs. Contiguous with Area 1 but has a clear tiered vegetation structure and overstory canopy that retards wind penetration, and as such effectively models as Class A Forest.



Photo ID: 2a



Photo ID: 2b

Vegetation Area 3	**Classification Applied or Exclusion Clause:** Class G Grassland
Vegetation Type Present: Dense sown pasture G-25	
Description / Classification Justification: Paddock of sown grass, no overstory.	



Photo ID: 3a



Photo ID: 3b

Vegetation Area 4	**Classification Applied or Exclusion Clause:** Class A Forest
Vegetation Type Present: Low open forest A-04	
Description / Classification Justification: Mixed jarrah/marri forest, with middle story of banksia, *allocasuarina* and *xanthorrhoea* over near-surface fuels of low shrubs and grasses. Clear tiered vegetation structure.	



Photo ID: 4a



Photo ID: 4b

Vegetation Area 5	**Classification Applied or Exclusion Clause:** Class A Forest

Vegetation Type Present: Low open forest A-04

Description / Classification Justification: Mixed jarrah/marri forest, with middle story of banksia, *allocasuarina* and *xanthorrhoea* over near-surface fuels of low shrubs and grasses. Clear tiered vegetation structure.



Photo ID: 5a



Photo ID: 5b



Photo ID: 5c



Photo ID: 5d

Vegetation Area 6	**Classification Applied or Exclusion Clause:** Class A Forest

Vegetation Type Present: Low open forest A-04

Description / Classification Justification: Mixed jarrah/marri forest throughout large conservation rural residential blocks. Middle story of banksia, *allocasuarina* and *xanthorrhoea* over near-surface fuels of low shrubs and grasses. Clear tiered vegetation structure.



Photo ID: 6a



Photo ID: 6b

Vegetation Area 7	**Classification Applied or Exclusion Clause:** Class D Scrub

Vegetation Type Present: Open scrub D-14

Description / Classification Justification: Low banskia woodland. Banksia dominant, with occasional *allocasuarina*, marri or jarrah trees (less than 10% canopy cover). Middle story of woolly bush, *xanthorrhoea* and *hakea.* Average height of top vegetation strata 4m and as such effectively models as Class D scrub.



Photo ID: 7a



Photo ID: 7b

Vegetation Area 8	**Classification Applied or Exclusion Clause:** Class D Scrub
Vegetation Type Present: Open scrub D-14	
Description / Classification Justification: Regrowth area within previous wildflower nursery. Dominated by woolly bush, Geraldton Wax, low banksia, and olive trees, average height of top strata between 2-4 m. No overstory trees.	



Photo ID: 8a



Photo ID: 8b

Vegetation Area 9	**Classification Applied or Exclusion Clause:** Class C Shrubland
Vegetation Type Present: Open heath C-11	
Description / Classification Justification: Regrowth area within previous wildflower nursery. Low shrubby plants, maximum height 2m, with no overstory trees.	



Photo ID: 9a

Click here to enter text.

Vegetation Area 10	Classification Applied or Exclusion Clause: Class G Grassland

Vegetation Type Present: Open tussock G-23

Description / Classification Justification: Sparse coverage of weed grasses growing in previously cleared area. Occasional mature trees with <10% canopy cover.



Photo ID: 10a



Photo ID: 10b

Vegetation Area 11	Classification Applied or Exclusion Clause: Class C Shrubland

Vegetation Type Present: Open heath C-11

Description / Classification Justification: Regrowth area within previous wildflower nursery. Low shrubby plants, maximum height 2m, with no overstory trees.



Photo ID: 11a

Click here to enter text.

Vegetation Area 12	**Classification Applied or Exclusion Clause:** Class C Shrubland

Vegetation Type Present: Open heath C-11

Description / Classification Justification: Regrowth area within previous wildflower nursery. Low shrubby plants, maximum height 2m, with no overstory trees.



Photo ID: 12a



Photo ID: 12b

Vegetation Area 13	**Classification Applied or Exclusion Clause:** Excluded AS3959-2009 2.2.3.2 (f) Low Threat Vegetation

Vegetation Type Present: N/A

Description / Classification Justification: Cleared and developed areas within the boundary of Lot 9002 Reserve Road.



Photo ID: 13a



Photo ID: 13b

Figure 3.1

Topography & Classified Vegetation

Lot 9002, Reserve Road including Previously Subdivided Lots
CHITTERING
SHIRE OF CHITTERING

CHITTERING
MUCHEA
RESERVE RD
ROSEWOOD DR
ROSEWOOD DR
ROSEWOOD DR

AREA : 7
Class (D) Scrub
Effective slope: 0°

AREA : 5
Class (A) Forest
Effective slope: 0°

AREA : 8
Class (D) Scrub
Effective slope: >0° to 5°

AREA : 9
Class (C) Shrubland
Effective slope: >0° to 5°

AREA : 11
Class (C) Shrubland
Effective slope: 0°

AREA : 12
Class (C) Shrubland
Effective slope: >0° to 5°

AREA : 6
Class (A) Forest
Effective slope: >0° to 5°

AREA : 10
Class (G) Grassland
Effective slope: >0° to 5°

AREA : 11
Class (C) Shrubland
Effective slope: 0°

AREA : 12
Class (C) Shrubland
Effective slope: >0° to 5°

AREA : 1
Class (D) Scrub
Effective slope: >0° to 5°

AREA : 2
Class (A) Forest
Effective slope: >0° to 5°

AREA : 3
Class (G) Grassland
Effective slope: 0°

AREA : 12
Class (C) Shrubland
Effective slope: >0° to 5°

AREA : 4
Class (A) Forest
Effective slope: >0° to 5°

Excluded

------ LEGEND ------

- Subject Site
- Other Lots
- Locality / Suburb
- Photo & Direction

Vegetation Assessment Area

- 150m from Subject Site

Classified Vegetation

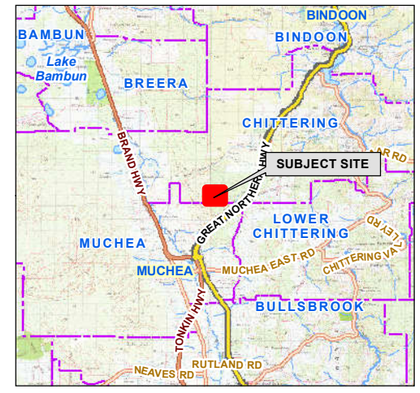
- Class (A) Forest
- Class (C) Shrubland
- Class (D) Scrub
- Class (G) Grassland
- Exclusion 2.2.3.2

Existing Building

- Class 1a
- Class 10a
- Water Tank
- Verandah / Patio

0 100 200 300 400
Metres

------ LOCALITY ------



Aerial Imagery : Landgate/SLIP
Image Date : Apr 2020

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator Units: Metre
Map compiled by: Ian Ross 26/08/2020
Map udated by: Ian Ross 26/08/2020

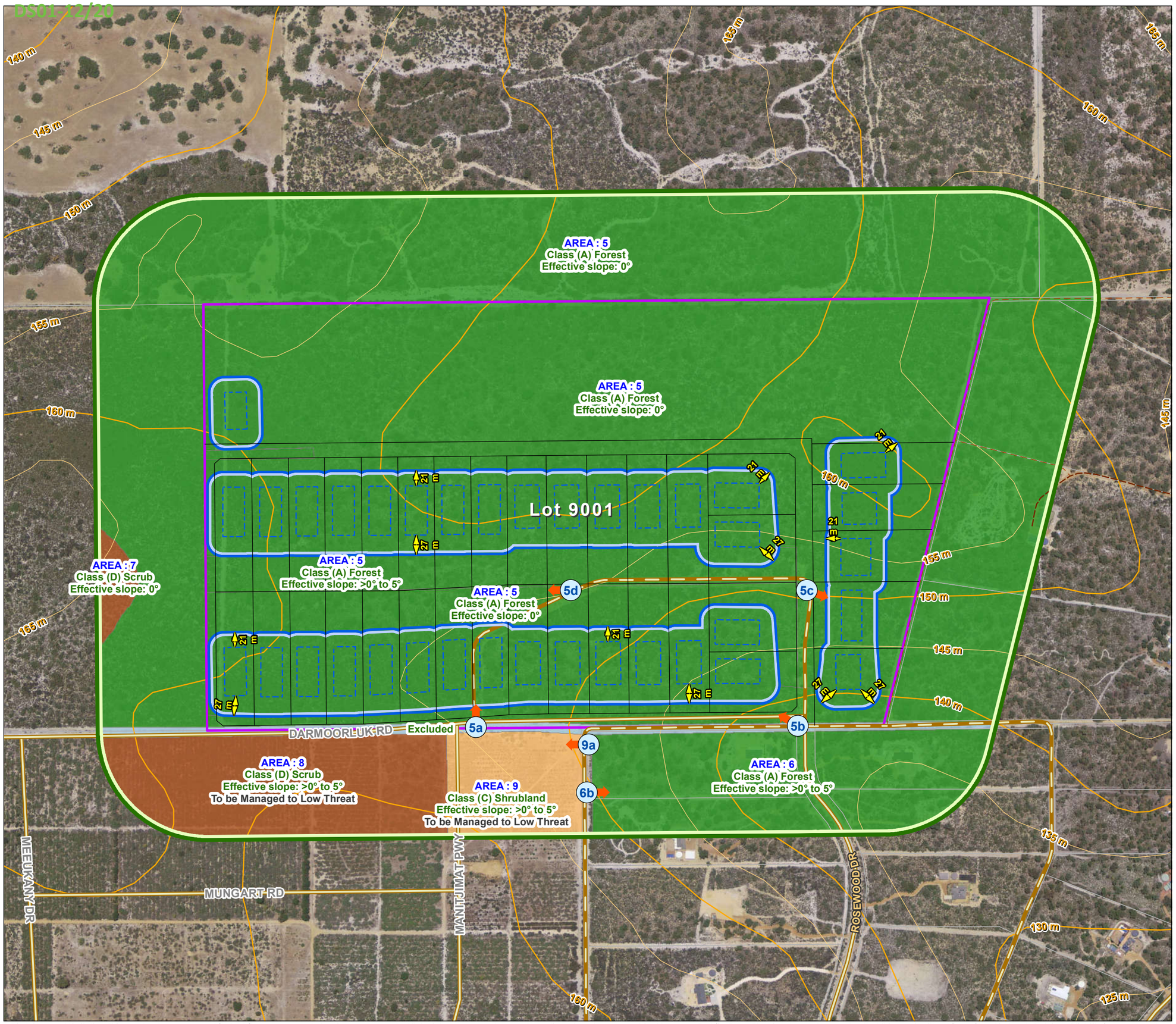
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Map Document Path / Name: F:\Projects\Sean\200405_Lot2 Reserve Rd_Lot9001 Rosewood Dv Chittering\Mapping\MXD\200405_Fig3-1_VEG_Lot9002_Reserve Rd_Chittering.mxd

Figure 3.2

Topography & Classified Vegetation

Lot 9001, Resreve Road
CHITTERING
SHIRE OF CHITTERING



------ **LEGEND** ------

- Subject Site
- Other Lots
- Photo & Direction
- Proposed Subdivision
- Proposed Building Envelope

Asset Protection

- APZ - Proposed (BAL 29)

Vegetation Assessment Area

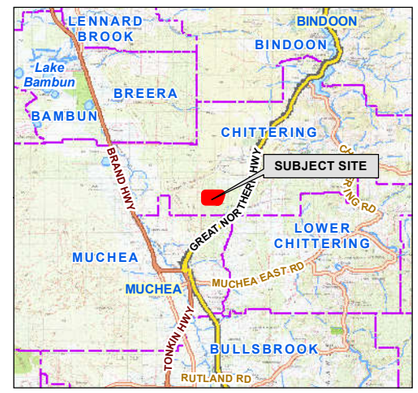
- 150m from Subject Site

Classified Vegetation

- Class (A) Forest
- Class (C) Shrubland
- Class (D) Scrub
- Exclusion 2.2.3.2
- APZ Distance

0 100 200 300
Metres

------ **LOCALITY** ------



Aerial Imagery : Landgate/SLIP
Image Date : Apr 2020

BUSHFIRE PRONE PLANNING

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator Units: Metre
Map compiled by: Ian Ross 26/08/2020
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Map Document Path / Name: F:\Projects\Sean\200405_Lot2 Reserve Rd_Lot9001 Rosewood Dv Chittering\Mapping\MXD\200405_Fig3-2_VEG_Lt9001_Rosewood_Dv_Chittering.mxd

3.2 Assessment Output

Understanding the Bushfire Assessment Results - Application of Bushfire Attack Levels (BAL)

The BAL rating has a different application in the building environment compared to the planning environment and the BAL assessment can result in a determined BAL or an indicative BAL which have different implications.

Building versus Planning Applications

In the building environment, a determined BAL rating is required (for the proposed construction) at the building application stage. This is to inform approval considerations and establish the construction standards that are to apply if approved. An indicative BAL rating is not acceptable for a building application.

In the planning environment, assessing the ability of a proposed development site to achieve BAL-29 or less is the objective (as one of the bushfire protection criteria being assessed). The 'development site' is defined by the LPS Amendment Regulations 2015 as "that part of a lot on which a building that is the subject of development stands or is to be constructed".

Therefore, being able to show that a BAL rating of BAL-29 or lower is achievable for a proposed development site (i.e. the building footprint) is an acceptable outcome for that criteria, as established by the bushfire provisions, SPP 3.7 and the associated Guidelines. For planning purposes, this BAL rating could be either indicative or determined.

Determined BAL Ratings

A determined BAL rating is to apply to an existing or proposed construction site (building) and not to a lot or envelope. Its purpose is to state the potential radiant heat flux to which the building will be exposed.

A determined BAL cannot be given for a future building whose location, elevation design and footprint (on a given lot) are unknown. It is not until these variables have been fixed that a BAL can be determined (typically at the development application or building application stage).

The one exception is when a building of ***any dimension*** can be ***positioned anywhere*** on a proposed lot or within defined limits within the lot (i.e. building setbacks or building envelope) and always remain subject to the same BAL rating. For this to be the case, there needs to be no classified vegetation either onsite or offsite that if retained could impact upon the determined BAL rating.

Indicative BAL Ratings

When this Plan presents a single indicative BAL rating for a proposed construction site (building), this will be because the construction is still subject to a location within the lot being confirmed and/or a vegetation separation distance being achieved. That is, it will be conditional upon some factor being confirmed at a later stage.

For planning applications associated with proposed lots, the building location, elevation design and footprint have typically not been established. Therefore, indicative rather than determined BAL rating/s will be presented for each lot (with the exception as noted above under 'Determined BAL Ratings').

When this Plan presents a single indicative BAL rating for a lot or building envelope (i.e. an 'area' that is not a located building footprint) it will represent the highest BAL rating affecting that 'area'. The BAL rating of a future building on that 'area' will be dependent on its eventual location.

Otherwise, this Plan will present all BAL ratings for each lot and for each BAL rating, the vegetation separation distances from each area of classified vegetation that are to apply. These distances will be presented as either figures in a table or as a BAL contour map.

From this indicative BAL information, it can be assessed if acceptable BAL ratings (≤ BAL-29) can be achieved for future buildings.

3.2.1 Bushfire Attack Level (BAL) Results Presented as a BAL Contour Map

Interpretation of the Bushfire Attack Level (BAL) Contour Map

The contour map will present different coloured contour intervals constructed around the classified bushfire prone vegetation. These represent the different Bushfire Attack Levels that exist at varying distances away from the classified vegetation. Each BAL represents a set range of radiant heat flux (as defined by AS 3959-2018) that can be generated by the bushfire in that vegetation at that location.

The width of each shaded contour (i.e. the distance interval) will vary and is determined by consideration of variables including vegetation type, fuel structure, ground slope, climatic conditions. They are unique to a site and can vary across a site. The width of each contour is a diagrammatic expression of the separation distances from the classified vegetation that apply for each BAL rating, for that site. A building (or 'area') located within any given BAL contour will be subject to that BAL rating and potentially multiple BAL ratings of which the highest rating will be applied.

Two separate contour plans are presented here, the first for Lot 9002 Reserve Road and previously subdivided lots on Meeukany Drive, Sceptrum Avenue, Karda View and Narik Grove, and the second for Lot 9001 Reserve Road. This is because the zoning for these parts of the development have different requirements related to the retention of native vegetation.

This assessment assumes that all vegetation within the boundaries of Lot 9002 is under the control of the proponent and will be cleared or modified to low threat as per AS3959-2018 c.2.2.3.2(f), as part of the development, and prior to the construction of any houses within the subdivision. As such, BAL contours are measured from vegetation external to the boundaries of Lot 9002.

The contour plan for Lot 9001 assumes that a BAL-29 sized building envelope / APZ will be installed within the boundaries of each subdivided lot. House location is clustered in order that APZs can be shared across lot boundaries to minimise the removal of native vegetation. This contour plan assumes that vegetation in Areas 8 and 9 will have already been converted to low threat at this stage of the development.

The lot layout for Lot 9001 is indicative only at this stage and the contour plan here is provided to demonstrate that it is possible to achieve BAL-29 APZs for all lots within the boundaries of the subdivision. As such while Area 5 is mapped as one contiguous block of vegetation, both the contour plan shown in Figure 3.4, and the distance used to build those contours as shown in Table 3.4, are based on the fact this lot has a gentle slope from north to south. As such, separation distances on the south side (ie downslope) of each building envelope are calculated at 0-5 degrees downslope, while all other distances are calculated as flat or upslope.

Separation Distances Calculated to Construct the BAL Contours

Table 3.3: Vegetation separation distances applied to construct the BAL contours for Lot 9002 and previously subdivided lots.

CALCULATED VEGETATION SEPARATION DISTANCES FOR LOT 9002 RESERVE ROAD										
Vegetation Area	Vegetation Classification	Effective Slope	Site Slope (Degrees)	BAL Assessment Method Applied[1]	BAL Rating and Corresponding Separation Distance [2] (metres)					
					BAL-FZ	BAL-40	BAL-29	BAL-19	BAL12.5	BAL-LOW
1	Class D Scrub	D/S	3	Method 1	<11	11-<15	15-<22	22-<31	31-<100	>100
2	Class A Forest	D/S	2	Method 1	<20	20-<27	27-<37	37-<50	50-<100	>100
3	Class G Grassland	U/S	0	Method 1	<6	6-<8	8-<12	12-<17	17-<50	>50
4	Class A Forest	D/S	3	Method 1	<20	20-<27	27-<37	37-<50	50-<100	>100
5	Class A Forest	U/S	0	Method 1	<16	16-<21	21-<31	31-<42	42-<100	>100
6	Class A Forest	D/S	4	Method 1	<20	20-<27	27-<37	37-<50	50-<100	>100
7	Class D Scrub	U/S	0	Method 1	<10	10-<13	13-<19	19-<27	27-<100	>100

[1] Method 1 as per AS 3959-2018 Table 2.5 and Method 2 as per AS 3959-2018 Appendix B. The input variables applied, other than the calculation model defaults, are presented in Section 3.1 of this Plan.
[2] Copies of the summaries of Method 2 calculation inputs and outputs are presented in the Appendices if applicable.

Note: D/S = Downslope U/S = Upslope C/S = Cross Slope

Table 3.4: Vegetation separation distances applied to construct the BAL contours for Lot 9001.

CALCULATED VEGETATION SEPARATION DISTANCES FOR LOT 9001 RESERVE ROAD										
Vegetation Area	Vegetation Classification	Effective Slope	Site Slope (Degrees)	BAL Assessment Method Applied[1]	BAL Rating and Corresponding Separation Distance [2] (metres)					
					BAL-FZ	BAL-40	BAL-29	BAL-19	BAL12.5	BAL-LOW
5	Class A Forest	U/S	0	Method 1	<16	16-<21	21-<31	31-<42	42-<100	>100
5	Class A Forest	DS	4	Method 1	<20	20-<27	27-<37	37-<50	50-<100	>100
6	Class A Forest	D/S	4	Method 1	<20	20-<27	27-<37	37-<50	50-<100	>100
7	Class D Scrub	U/S	0	Method 1	<10	10-<13	13-<19	19-<27	27-<100	>100

[1] Method 1 as per AS 3959-2018 Table 2.5 and Method 2 as per AS 3959-2018 Appendix B. The input variables applied, other than the calculation model defaults, are presented in Section 3.1 of this Plan.
[2] Copies of the summaries of Method 2 calculation inputs and outputs are presented in the Appendices if applicable.

Note: D/S = Downslope U/S = Upslope C/S = Cross Slope

DS01-12/20

Attachment 1

Figure 3.3

BAL Contour Map

Lot 9002, Reserve Road including
Previously Subdivided Lots
CHITTERING
SHIRE OF CHITTERING

AREA 7
AREA 5
AREA 1
AREA 6
AREA 2
AREA 3
AREA 4
CHITTERING
MUCHEA
RESERVE RD
ROSEWOOD DR

------ LEGEND ------

- Subject Site
- Other Lots
- Locality / Suburb

Vegetation Assessment Area

- 100m from Subject Site
- Classified Vegetation Boundary

Indicative Bushfire Attack Levels

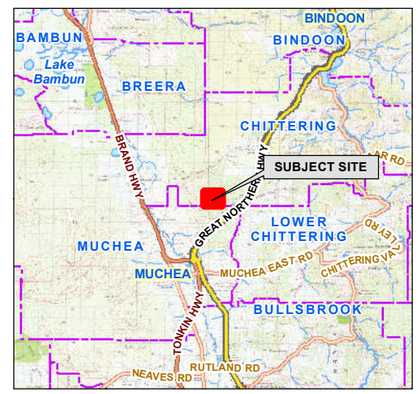
- BAL FZ
- BAL 40
- BAL 29
- BAL 19
- BAL 12.5
- BAL LOW

Existing Building

- Class 1a
- Class 10a
- Water Tank
- Verandah / Patio

0 100 200 300 400
Metres

------ LOCALITY ------



N

Aerial Imagery : Landgate/SLIP
Image Date : Apr 2020

BUSHFIRE PRONE PLANNING

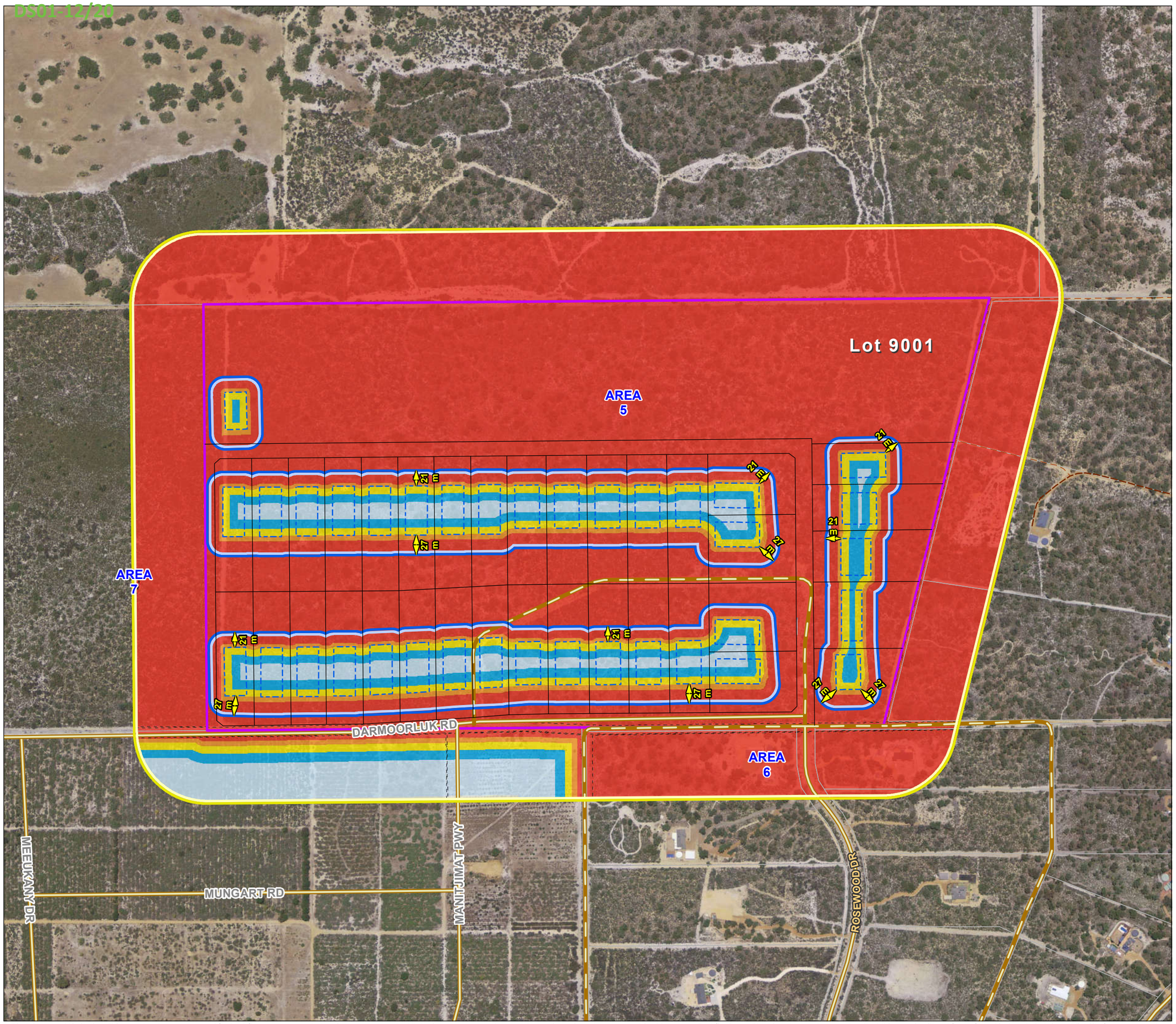
Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator Units: Metre
Map compiled by: Ian Ross 25/08/2020
Map udated by: Ian Ross 25/08/2020

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Map Document Path / Name: F:\Projects\Sean\200405_Lot2 Reserve Rd_Lot9001 Rosewood Dv Chittering\Mapping\MXD\200405_Fig3-3_BAL_Lot9002_Reserve Rd_Chittering.mxd

Figure 3.4

BAL Contour Map

Lot 9001, Reserve Road
CHITTERING
SHIRE OF CHITTERING



------ **LEGEND** ------

- Subject Site
- Other Lots
- Proposed Subdivision
- Proposed Building Envelope

Asset Protection

- APZ - Proposed (BAL 29)

Vegetation Assessment Area

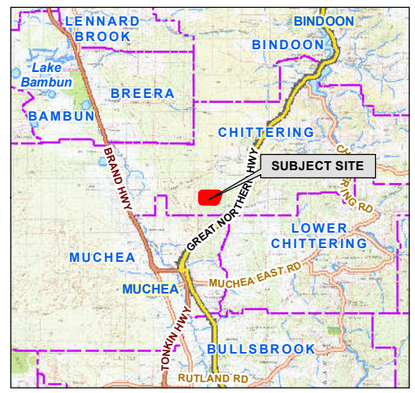
- 100m from Subject Site
- Classified Vegetation Boundary

Indicative Bushfire Attack Levels

- BAL FZ
- BAL 40
- BAL 29
- BAL 19
- BAL 12.5
- BAL LOW
- APZ Distance

0 100 200 300
Metres

------ **LOCALITY** ------



N

Aerial Imagery : Landgate/SLIP
Image Date : Apr 2020

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator Units: Metre
Map compiled by: Ian Ross 25/08/2020
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BUSHFIRE PRONE PLANNING

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3.2.2 Bushfire Attack Levels (BAL) Derived from the Contour Map

Deriving a BAL Rating for a Future Construction Site (Building) from the BAL Contour Map Data

(Capacity to Issue a BAL Certificate)

Key Assumptions: The actual location of a building within a lot or envelope (an 'area') may not have been determined at this stage of planning; and the BAL ratings represent the BAL of an 'area' not a building.

The BAL Rating is Assessed as Indicative

If the assessed BAL for the 'area' is stated as being 'indicative', it is because that 'area' is impacted by more than one BAL contour interval and/or classifiable vegetation remains on the lot, or on adjacent lots, that can influence a future building's BAL rating (and this vegetation may have been omitted from being contoured for planning purposes e.g. Grassland or when the assumption is made that all onsite vegetation can be removed and/or modified).

In this report the indicative BAL is presented as either the highest BAL impacting the site or as a range of achievable BAL's within the site – whichever is the most appropriate.

The BAL rating that will apply to any future building within that 'area' will be dependent on:

1. vegetation management onsite; and/or
2. vegetation remaining on adjacent lots; and/or
3. the actual location of the future building within that 'area'.

A BAL Certificate cannot be provided for future buildings, within a lot or envelope with an indicative BAL, until the building location and in some instances building design (elevation), have been established and any required and approved vegetation modification/removal has been confirmed. Once this has occurred a report confirming the building location and BAL rating will be required to submit with the BAL certificate.

The required confirmation of the BAL rating must be done by a bushfire practitioner with the same level of accreditation as has been required to compile this Bushfire Management Plan. This is dependent on the type of calculations utilised (e.g. if performance based solutions have been used in the Plan BPAD Level 3 accreditation is required)

The BAL Rating is Assessed as Determined

If the assessed BAL for the lot or envelope is stated as being 'determined' it is because that lot or envelope is impacted by a single BAL contour interval. This BAL has been determined by the existence (or non-existence) of classified vegetation outside the lot or envelope, and no classifiable vegetation currently exists on the lot or envelope (i.e. it has been cleared to a minimal fuel, low bushfire threat state). In the situation where the BAL Contour Map has been constructed around multiple lots, there also needs to no classifiable vegetation on an adjacent lot if this vegetation has not already been incorporated into the creation of the BAL Contour Map.

As a result, a determined BAL can be provided in this limited situation because:

1. No classified vegetation is required to be removed or modified to achieve the determined BAL, either within the lot/envelope or on adjacent lots (or if vegetation is excluded from classification, it is reasonable to assume it will be maintained in this state into the future); and
2. A future building can be located anywhere within the 'site' and be subject to the determined BAL rating; and
3. The degree of certainty is more than sufficient to allow for any small discrepancy that might occur in the mapping of the BAL contours.

For a determined BAL rating for a lot/envelope, A BAL Certificate (referring to this BMP) can be provided for a future building, if the BMP remains current.

All BAL ratings as provided in Figures 3.3 and 3.4 are Indicative. They are intended to demonstrate that it is possible to achieve BAL-29 (or lower) for every lot within the subdivision. The following tables demonstrate the achievable BAL rating applied to each lot based on the contour plan. These assume that the entirety of Lot 9002 and the previously subdivided lots have been cleared or reduced to a low threat state in perpetuity, prior to the construction of any houses. Existing roads and fire service access tracks external to the boundary of Lot 9002 have been included within the separation zone, as they will also be maintained in perpetuity.

Table 3.5: Details of bushfire exposure for Lot 9002 and previously sub-divided lots

DETAILS OF BUSHFIRE EXPOSURE FOR LOT 9002 AND PREVIOUSLY SUB-DIVIDED LOTS				
Total Number of Lots	BAL-29 Exposure	BAL-19 Exposure	BAL-12.5 Exposure	BAL-Low Exposure
319	N/A	30	65	224

Despite the majority of houses having a BAL-Low exposure, all houses will be constructed to a minimum BAL-12.5 construction standard. The rural nature of the subdivision means that a BAL-Low rating does not indicate minimal bushfire risk – rather it indicates the likely radiant heat exposure a house is likely to receive and that a structure is more than 100m away from flammable Classified vegetation. Houses built on lots rated as BAL-Low will still potentially be subject to high rates of ember attack and other fire weather impacts. There have been numerous examples in Australia of houses being destroyed as a result of ember attack up to 700m away from Classified vegetation. As such a minimum BAL-12.5 construction standard should be adopted for the entire subdivision.

Table 3.6: Details of bushfire exposure for Lot 9001

DETAILS OF BUSHFIRE EXPOSURE FOR LOT 9002				
Total Number of Lots	BAL-29 Exposure	BAL-19 Exposure	BAL-12.5 Exposure	BAL-Low Exposure
36	36	0	0	0

Due to environmental constraints, all planned lots within Lot 9001 can only achieve BAL-29.

4 Identification of Bushfire Hazard Issues

This bushfire planning assessment is required to show that the Bushfire Protection Criteria can be complied with in the future. The intent is to ensure future development is located where the bushfire hazard level is (or will on completion be) moderate or low and subject to a maximum Bushfire Attack Level of BAL-29. This can be achieved for this site due to the separation distances required for the appropriate BAL rating that considers the following:

The primary bushfire hazard issue for this site is large areas of Class A, Class B and Class D classified vegetation surrounding the site.

Onsite Vegetation

The key factor to facilitate the determining of Indicative Bushfire Attack Levels for the proposed Lots is that vegetation onsite is under the control of the landowner/s. Vegetation onsite therefore can potentially be removed or modified to lower the bushfire risk and therefore presents a low bushfire threat.

Offsite Vegetation

Areas of vegetation offsite that form part of native vegetation reserves, cannot be removed or modified and as a result the assessed BAL's determined by the proximity of this vegetation are unable to be further reduced. These areas external to the site but not part of the future development have been factored for the BAL Contour mapping.

Site Layout

This development connects two previously dead-end roads to create the possibility for access and egress to multiple destinations in the event of a fire. As such it increases safety for existing properties on Reserve Road and within the Rosewood Estate, by increasing access/egress possibilities.

5 Assessment Against the Bushfire Protection Criteria (BPC)

5.1 Bushfire Protection Criteria - Assessment Summary

Summarised Outcome of the Assessment Against the Bushfire Protection Criteria (BPC)				
Element	Basis for the Assessment of Achieving the Intent of the Element			
	Achieves compliance with the Element through meeting Acceptable Solutions		Achieves compliance with the Element by application of a Performance Based Solution	Minor or Unavoidable Development
	Meets all relevant acceptable solutions	One or more relevant Acceptable Solutions are not fully met. A variation of the solution is provided and justified.	One or more applicable Acceptable Solutions are not met. A solution is developed with the summary presented in this Plan in Section 5.5. The supporting document presenting Bushfire Prone Planning's detailed methodology is submitted separately to the decision makers.	The required supporting statements are presented in this Plan.
Location	✓			N/A
Siting and Design of Development	✓			
Vehicular Access	✓			
Water	✓			

The subject site has been assessed against:

1. The requirements established in Appendix 4 of the Guidelines for Planning in Bushfire Prone Areas, WAPC 2017 v1.3 (the 'Guidelines'). The detail, including technical construction requirements, are found at https://www.planning.wa.gov.au/8194.aspx. A summary of relevant information is provided in the appendices of this Plan; and

2. Any endorsed variations to the Guideline's acceptable solutions and associated technical requirements that have been established by the relevant local government. If known and applicable these have been stated in Section 5.2 of this Plan with the detail included as an appendix if required by the relevant local government.

5.2 Bushfire Protection Criteria – Acceptable Solutions Assessment Detail

5.2.1 Element 1: Location

Bushfire Protection Criteria Element 1: Location Assessment Statements and Bushfire Protection Measures to be Applied			
Intent: To ensure that strategic planning proposals, subdivision and development applications are located in areas with the least possible risk of bushfire to facilitate the protection of people, property and infrastructure.			
Acceptable Solution:	A1.1: Development Location	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution is fully met.

The following statements consider the requirements established in the Guidelines (v1.3) and in Position Statement: Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design (WAPC Nov 2019).

The proposed development achieves compliance by:

- By ensuring future building work on the lot/s can be located on an area that will be subject to potential radiant heat from a bushfire not exceeding 29 kW/m^2 (i.e. a BAL rating of BAL-29 or less will apply). This can be achieved by using positioning, design and appropriate vegetation removal/modification; and
- Managing the remaining bushfire risk to an acceptable level by the existence/implementation and ongoing maintenance of all required bushfire protection measures, as identified within this Plan. These measures include the requirements for vegetation management, vehicular access and firefighting water supply.

Broader Landscape Context:

Onsite: Lot 9002 Reserve Road (and the previously subdivided lots), within which the development site is located, is farming land, previously used as a wildflower nursery. It has stands of remnant vegetation throughout. However, the entire lot will be cleared and landscaped, and maintained in a low threat state in perpetuity. Lot 9001 Reserve Road is an undeveloped conservation lot entirely vegetated with mixed jarrah/marri/banksia woodland. While BAL-29 APZs are able to be achieved on each proposed lot, a lower BAL rating is not achievable due to conservation and environmental restrictions.

Offsite: The surrounding land primarily comprises jarrah/marri/banksia woodland, with some farming land and large conservation zoned residential blocks.

- To the north and west of the development site is large areas of contiguous wooded vegetation that comprise a mixture of Class A, Class B, and Class D vegetation. These comprise unbroken areas of vegetation in which a significant bushfire could occur.
- To the east and south are two conservation zoned subdivisions, that comprise a mixture of Class A, Class B, and Class D vegetation interspersed with low threat APZs, cleared areas and some farm paddocks. Land is largely residential or agricultural.

- Further afield to the south, east and west of the development site the land largely comprises farming land.

The potential exists for a landscape scale bushfire to impact on the development site. The majority of the development area is rated BAL-Low, with 95 lots around the edges of Lot 9002 and the previously subdivided lots able to achieve a BAL-19 or BAL-12.5 APZ. A minimum BAL-12.5 construction standard should be adopted for the whole subdivision (even for lots assessed as BAL-Low) based on the wider landscape fire potential.

All 36 lots within the conservation zoned Lot 9001 can achieve a BAL-29 APZ, a process that has been made possible through subdivision design and clustered building envelopes.

5.2.2 Element 2: Siting and Design of Development

Bushfire Protection Criteria Element 2: Siting and Design of Development Assessment Statements and Bushfire Protection Measures to be Applied			
Intent: To ensure that the siting and design of development (note: not building/construction design) minimises the level of bushfire impact.			
Acceptable Solution:	A2.1: Asset Protection Zone	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution is fully met.

The following statements consider the requirements established in the Guidelines (v1.3) and in Position Statement: Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design (WAPC Nov 2019).

The proposed development achieves compliance by:

- Ensuring future building work on the lot/s can have established around it an APZ of the required dimensions - to ensure that the potential radiant heat from a bushfire to impact future building/s, does not exceed 29 kW/m^2 (i.e. a BAL rating of BAL-29 or less will apply to determine building construction standards);
- Due to environmental concerns APZs are shared across lots for Lot 9001, and for some lots in Lot 9002 and the previously subdivided lots.
- The landowner/s having the responsibility of continuing to manage the required APZ as low threat vegetation in a minimal fuel state, by maintaining the APZ to the required dimensions and standard, including compliance with the local government's annual firebreak notice.

The APZ technical requirements (Standards) are detailed in Appendix 1.

Development Design:

The development has been designed to allow a minimum BAL-29 APZ to be achieved for all lots and to use roads and fire service access ways to increase the separation distances between building envelopes and classified vegetation. The layout of the subdivision within the boundaries Lot 9001has been designed to minimise the loss of native vegetation by clustering building envelopes together and sharing APZs.

The subdivision within the boundaries of Lot 9002 and the previously subdivided lots has been designed to achieve and maintain a Low Threat state throughout the subdivision. The bushfire threat comes from outside the subdivision and only the lots around the exterior are impacted by a BAL contour.

Asset Protection Zone (APZ):

All lots within the boundaries of Lot 9001 can achieve a BAL-29 APZ. APZs are shared across lot boundaries to minimise vegetation loss.

All lots within the boundaries of Lot 9002 and the previously subdivided lots can achieve a BAL-19 APZ (or lower). The majority of lots (n=224) can achieve a BAL-Low bushfire exposure.

Management:

All areas within the bounds of within the boundaries of Lot 9002 and the previously subdivided lots, will be maintained in a low threat state in perpetuity. Where any part of the required APZ dimension is vegetated, it will be managed in accordance with the technical requirements established by the Guidelines (the technical requirements are also detailed in Appendix 1 of this Plan).

5.2.3 Element 3: Vehicular Access

Bushfire Protection Criteria Element 3: Vehicular Access Assessment Statements and Bushfire Protection Measures to be Applied			
Intent: To ensure that the vehicular access serving a subdivision/development is available and safe during a bushfire event.			
Acceptable Solution:	A3.1: Two access routes	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution is fully met.

This development connects two previously dead-end roads to create the possibility for access and egress to multiple destinations in the event of a fire.

Reserve Road to the south and Rosewood Drive to the east provide safe access and egress to two different destinations via local road networks. As sealed public roads, they are available to all residents and the public at all times and under all weather conditions.

The construction technical requirements established by the Guidelines and/or the local government can and will be complied with.

Acceptable Solution:	A3.2 Public Road	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution is fully met.

A number of new public roads will be constructed within the development. All will have two way access and provide a safe and effective road network for use by the public. No cul-de-sacs or dead end roads are included within the subdivision design.

The construction technical requirements established by the Guidelines and/or the local government can and will be complied with.

Bushfire Protection Criteria Element 3: Vehicular Access (continued) Assessment Statements and Bushfire Protection Measures to be Applied			
Acceptable Solution:	A3.3 Cul-de-sacs (including a dead-end road)	Method of achieving Element compliance and/or the Intent of the Element:	N/A
No cul-de-sacs or dead end roads will be included within the subdivision design.			
Acceptable Solution:	A3.4: Battle-axe	Method of achieving Element compliance and/or the Intent of the Element:	N/A
No battle axe lots will be included within the subdivision design.			
Acceptable Solution:	A3.5: Private Driveways	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution is fully met.
Any lot within the subdivision that requires a driveway longer than 50m from the public road will be constructed to meet the requirements of the Guidelines. The construction technical requirements established by the Guidelines and/or the local government can and will be complied with.			
Acceptable Solution:	A3.6 Emergency Access Way	Method of achieving Element compliance and/or the Intent of the Element:	N/A
No emergency access ways are necessary or will be included within the subdivision design.			
Acceptable Solution:	A3.7 Fire Service Access Routes	Method of achieving Element compliance and/or the Intent of the Element:	N/A
No fire service access routess are necessary or will be included within the subdivision design.			
Acceptable Solution:	A3.8 Firebreak Width	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution is fully met.
The subject site will comply with the requirements of the local government annual firebreak notice issued under s33 of the Bush Fires Act 1954. Firebreaks and hazard reduction, as necessary, will be installed/maintained annually and in perpetuity.			

5.2.4 Element 4: Water

Bushfire Protection Criteria Element 4: Water Assessment Statements and Bushfire Protection Measures to be Applied			
Intent: To ensure water is available to the subdivision, development or land use to enable people, property and infrastructure to be defended from bushfire.			
Acceptable Solution:	A4.1 Reticulated Areas	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution is fully met.
A reticulated water supply is available to the subject site and hydrants are installed will be installed at the required regular intervals. (State required hydrant separation distances – 100m commercial, 200m residential, 400m rural residential >1ha). The construction technical requirements established by the Guidelines and/or the local government can and will be complied with.			
Acceptable Solution:	A4.2 Non-Reticulated Areas	Method of achieving Element compliance and/or the Intent of the Element:	N/A
N/A			
Acceptable Solution:	A4.3 Non-reticulated Areas (Individual Lots)	Method of achieving Element compliance and/or the Intent of the Element:	N/A
N/A			

5.3 Additional Information for Required Bushfire Protection Measures

The subject site will be required to be maintained in accordance with the Shire of Chittering *Firebreak and Bushfire Hazard Reduction Notice*. The Notice specifies hazard reduction requirements and Asset Protection Zone detail.

Note: This Notice is updated annually and may be subject to change in the future.

5.3.1 Vegetation Management

Asset Protection Zone (APZ) Dimensions that are to Apply

The required dimensions of the APZ will vary dependent upon the purpose for which the APZ has been defined. There are effectively three APZ dimensions that can apply:

1. An application for planning approval will be required to show that an APZ can be created which is of sufficient size to ensure the potential radiant heat impact of a fire does not exceed 29kW/m² (BAL-29); and
2. If the assessment has determined a BAL rating for an existing or future building is less than BAL-29, the APZ must be of sufficient size to ensure the potential radiant heat impact of a fire does not exceed the kW/m² corresponding to the lower assessed BAL rating; or
3. Complying with the relevant local government's annual firebreak notice may require an APZ of greater size than that defined by the two previous parameters.

'Local Government Firebreak Notice APZ' Required Minimum Requirements for the Subject Site	
Requirement Set By:	Local Government (Shire of Chittering)
Minimum Standard:	Landowners and occupiers of blocks of any size or zoning are to slash/mow all grass to a height of no more than five centimetres and remove all flammable vegetation. Install an APZ of 20m radius around all habitable buildings. The roofs, gutters and walls of all buildings are free of flammable materials which can catch fire and burn. Trees over 5m high are underpruned to a clearance of 2m above the ground, and trees and shrubs within 2m of an asset may not exceed 2m in height. Perimeter firebreaks to be installed at least 5m wide with 4m height clearance.
This requirement has been established through the stated local government's annual fire break notice issued under the Bush Fires Act 1954 s33.	

6 Responsibilities for Implementation and Management of the Bushfire Protection Measures

Table 6.1: Implementation responsibilities prior to lot sale, occupancy or building for the Landowner/Developer.

LANDOWNER/DEVELOPER - PRIOR TO LOT SALE, OCCUPANCY OR BUILDING	
No.	Implementation Actions
1	The local government may condition a development application approval with a requirement for the landowner/proponent to register a notification onto the certificate of title (it may also need to be included on the deposited plan). This will be done pursuant to Section 70A Transfer of Land Act 1893 as amended ('Factors affecting use and enjoyment of land, notification on title:'). This is to give notice of the bushfire hazard and any restrictions and/or protective measures required to be maintained at the owner's cost. This condition ensures that: 1. Landowners/proponents are aware their lot is in a designated bushfire prone area and of their obligations to apply the stated bushfire risk management measures; and 2. Potential purchasers are alerted to the Bushfire Management Plan so that future landowners/proponents can continue to apply the bushfire risk management measures that have been established in the Plan.
2	Prior to sale and post planning approval, the entity responsible for having the Plan prepared should ensure that anyone listed as having responsibility under the Plan has endorsed it and is provided with a copy for their information and informed that it contains their responsibilities. This includes the landowners/proponents (including future landowners where the Plan was prepared as part of a subdivision approval), local government and any other authorities or referral agencies ('Guidelines' s4.6.3).
3	All technical requirements of the Bushfire Protection Criteria as set out in Section 5 of this BMP will be achieved.
4	Prior to sale of the subject lot/s, each individual lot is to be compliant with the local government's annual firebreak notice issued under s33 of the Bush Fires Act 1954.
5	Prior to any building work, inform the builder of the existence of this Plan and the responsibilities it contains, regarding the required construction standards. This will be: • The standard corresponding to the determined BAL rating, as per the bushfire provisions of the Building Code of Australia (BCA); and/or • A higher standard as a result of the BMP establishing that construction is required at a standard corresponding to a higher BAL rating.
6	The entirety of Lot 9002 and the previously subdivided lots will be converted to meet the definition of Low Threat as per AS3959-2018 c.2.2.3.2(f).

Table 6.3: Ongoing management responsibilities for the Landowner/Occupier.

LANDOWNER/OCCUPIER - ONGOING	
No.	Ongoing Management Actions
1	Maintain the Asset Protection Zone (APZ) to the dimensions and standard stated in the Plan.
2	Comply with the City of Stirling annual Fire Preparedness & Firebreak Requirements brochure and 'Firebreak Notice' issued under s33 of the Bush Fires Act 1954.
3	Ensure that any builders (of future structures on the lot) are aware of the existence of this Plan and the responsibilities it contains regarding the application of construction standards corresponding to a determined BAL rating.
4	Ensure all future buildings the landowner has responsibility for, are designed and constructed in full compliance with: 1. the requirements of the WA Building Act 2011 and the bushfire provisions of the Building Code of Australia (BCA); and 2. with any identified additional requirements established by this BMP or the relevant local government.

Table 6.4: Ongoing management responsibilities for the Local Government.

LOCAL GOVERNMENT - ONGOING	
No.	Ongoing Management Actions
1	Monitor landowner compliance with the annual Firebreak Notice and Fire Preparedness & Firebreak Requirements brochure.
2	Public open space is to be managed, to ensure the vegetation does not present a bushfire hazard to the residential area. Where control of an area of vegetated land is vested in the control of the local government and that area of land has influenced the assessed BAL rating/s of the subject site/s – and the BAL rating has been correctly assessed - there is an obligation to consider the impact of any changes to future vegetation management and/or revegetation plans with respect to that area.

Appendix 1 - Onsite Vegetation Management Technical Requirements

It is the responsibility of the landowner to maintain the established bushfire protection measures on their property. Not complying with these responsibilities can result in buildings being subject to a greater potential impact from bushfire than that determined by the assessed BAL rating presented in this Bushfire Management Plan.

For the management of vegetation within a lot (i.e. onsite) the following technical requirements exist:

1. **The APZ:** Installing and maintaining an asset protection zone (APZ) of the required dimensions to the standard established by the Guidelines for Planning in Bushfire Prone Areas (WA Planning Commission, as amended). When, due to the planning stage of the proposal to which this Bushfire Management Plan applies, defined APZ dimensions are known and are to be applied to existing or future buildings – then these dimensions are stated in Section 5.4.1 of this Plan.

2. **The Firebreak/Fuel Load Notice:** Complying with the requirements established by the relevant local government's annual firebreak notice issued under s33 of the Bushfires Act 1954. Note: If an APZ requirement is included in the Notice, the standards and dimensions may differ from the Guideline's APZ Standard – the larger dimension must be complied with.

3. **Changes to Vegetated/Non-Vegetated Areas:**

    a. If applicable to this Plan, the minimum separation distance from any classified vegetation, that corresponds to the determined BAL for a proposed building, must be maintained as either a non-vegetated area or as low threat vegetation managed to a minimal fuel condition as per AS 3959-2018 s2.2.3.2 (e) and (f). Refer to Part 4 of this Appendix 1.

    b. Must not alter the composition of onsite areas of classified vegetation (as assessed and presented in Section 3.1.2) to the extent that would require their classification to be changed to a higher bushfire threat classification (as per AS 3959-2018); and

    c. Must not allow areas within a lot (i.e. onsite) that have been:
        i. excluded from classification by being low threat vegetation or non-vegetated; and
        ii. form part of the assessed separation distance that is determining a BAL rating -

    …to become vegetated to the extent they no longer represent a low threat (refer to Part 4 of Appendix 1). Note: The vegetation classification exclusion specifications as established by AS 3959-2018 s2.2.3.2, are included at A1.4 below for reference.

1. Requirements Established by the Guidelines – the Asset Protection Zone (APZ) Standards

(Source: Guidelines for Planning in Bushfire Prone Areas - WAPC 2017 v1.3 Appendix 4, Element 2, Schedule 1 and Explanatory Note E2.1)

Defining the Asset Protection Zone (APZ)

Description: An APZ is an area surrounding a building that is managed to reduce the bushfire hazard to an acceptable level (by reducing fuel loads). The width of the required APZ varies with slope and vegetation. For planning applications, the minimum sized acceptable APZ is that which is of sufficient size to ensure the potential radiant heat impact of a fire does not exceed 29kW/m² (BAL-29). It will be site specific.

The APZ may include public roads, waterways, footpaths, buildings, rocky outcrops, golf courses, maintained parkland as well as cultivated gardens in an urban context, but does not include grassland or vegetation on a neighbouring rural lot, farmland, wetland reserves and unmanaged public reserves.

For subdivision planning, design elements and excluded/low threat vegetation adjacent to the lot can be utilised to achieve the required vegetation separation distances and therefore reduce the required dimensions of the APZ within the lot.

Defendable Space: The APZ includes a defendable space which is an area adjoining the asset within which firefighting operations can be undertaken to defend the structure. Vegetation within the defendable space should be kept at an absolute minimum and the area should be free from combustible items and obstructions. The width of the defendable space is dependent on the space which is available on the property, but as a minimum should be 3 metres.

Establishment: The APZ should be contained solely within the boundaries of the lot on which the building is situated, except in instances where the neighbouring lot or lots will be managed in a low-fuel state on an ongoing basis, in perpetuity.

Note: Regardless of whether an Asset Protection Zone exists in accordance with the acceptable solutions and is appropriately maintained, fire fighters are not obliged to protect an asset if they think the separation distance between the dwelling and vegetation that can be involved in a bushfire, is unsafe.

Schedule 1: Standards for APZ

Fences: within the APZ are constructed from non-combustible materials (e.g. iron, brick, limestone, metal post and wire). It is recommended that solid or slatted non-combustible perimeter fences are used.

Objects: within 10 metres of a building, combustible objects must not be located close to the vulnerable parts of the building i.e. windows and doors.

Fine Fuel Load: combustible dead vegetation matter less than 6 mm in thickness reduced to and maintained at an average of two tonnes per hectare (example below).

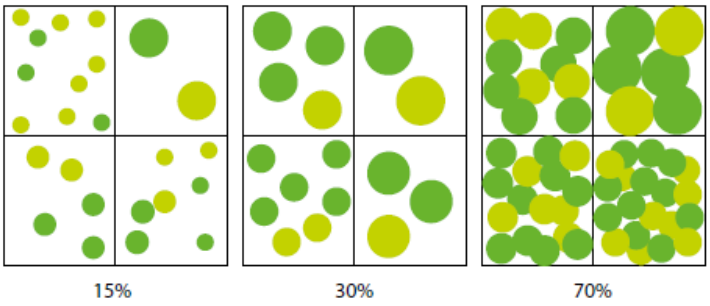
Example Fine Fuel Load of Two Tonnes per Hectare



(Image source: Shire of Augusta Margaret River's Firebreak and Fuel Reduction Hazard Notice)

Trees (> 5 metres in height): trunks at maturity should be a minimum distance of 6 metres from all elevations of the building, branches at maturity should not touch or overhang the building, lower branches should be removed to a height of 2 metres above the ground and or surface vegetation, canopy cover should be less than 15% with tree canopies at maturity well spread to at least 5 metres apart as to not form a continuous canopy. Diagram below represents tree canopy cover at maturity.

Tree canopy cover – ranging from 15 to 70 per cent at maturity



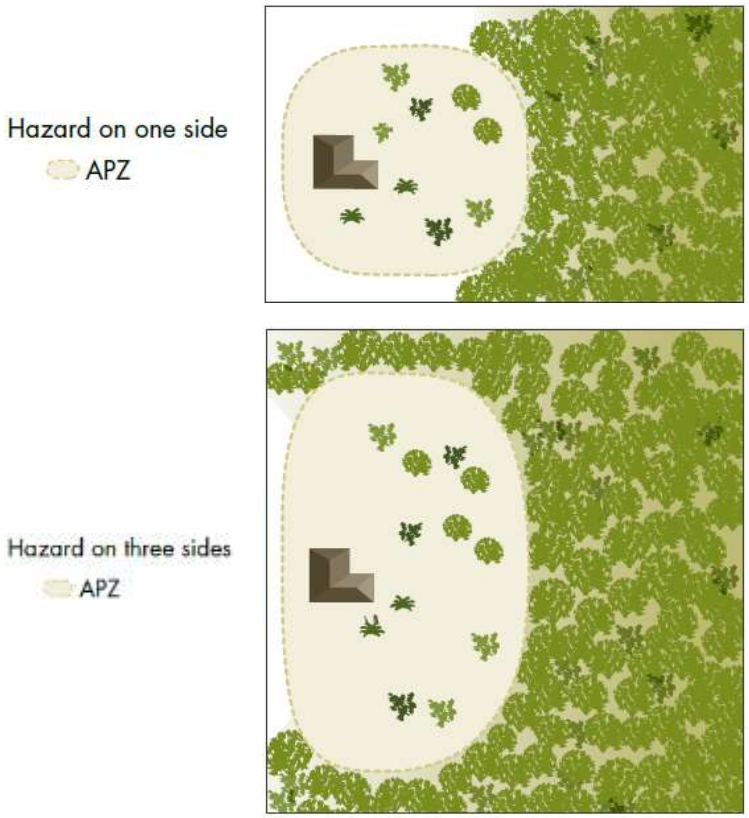
(Source: Guidelines for Planning in Bushfire Prone Areas 2017, Appendix 4)

Shrubs (0.5 metres to 5 metres in height): should not be located under trees or within 3 metres of buildings, should not be planted in clumps greater than 5m2 in area, clumps of shrubs should be separated from each other and any exposed window or door by at least 10 metres. Shrubs greater than 5 metres in height are to be treated as trees.

Ground covers (<0.5 metres in height): can be planted under trees but must be properly maintained to remove dead plant material and any parts within 2 metres of a structure, but 3 metres from windows or doors if greater than 100 mm in height. Ground covers greater than 0.5 metres in height are to be treated as shrubs.

Grass: should be managed to maintain a height of 100 mm or less.

The following example diagrams illustrate how the required dimensions of the APZ will be determined by the type and location of the vegetation.



2. Requirements Established by the Local Government – the Firebreak Notice

These requirements are established by the relevant local government's Firebreak Notice created under s33 of the Bushfires Act 1954 and issued annually (potentially with revisions). The Notice may include additional components directed at managing fuel loads, accessibility and general property management with respect to limiting potential bushfire impact.

The relevant local government's current Firebreak Notice is available on their website, at their offices and is distributed as ratepayer's information. It must be complied with.

If Asset Protection Zone technical requirements are defined in the Notice, the standards and dimensions may differ from the Guideline's APZ Standards, with the intent to better satisfy local conditions. When these are more stringent than those created by the Guidelines, or less stringent and endorsed by the WAPC and DFES, they must be complied with.
When, due to the planning stage of the proposal to which this Bushfire Management Plan applies, defined APZ dimensions are known and are to be applied to existing or future buildings – then these dimensions are stated in Section 5.4.1 of this Plan.

3. Requirements Recommended by DFES – Property Protection Checklists

Further guidance regarding ongoing/lasting property protection (from potential bushfire impact) is presented in the publication 'DFES – Fire Chat – Your Bushfire Protection Toolkit'. It is available from the Department of Fire and Emergency Services (DFES) website.

4. Requirements Established by AS 3959-2018 - Maintaining Areas within your Lot as 'Low Threat'

This information is provided for reference purposes. This knowledge will assist the landowner to comply with Management Requirement No. 3 set out in the Guidance Panel at the start of this Appendix. It identifies what is required for an area of land to be excluded from classification as a potential bushfire threat.

"Australian Standard - AS 3959-2018 Section 2.2.3.2: Exclusions - Low threat vegetation and non-vegetated areas:

The Bushfire Attack Level shall be classified BAL-LOW where the vegetation is one or a combination of the following:

a) *Vegetation of any type that is more than 100m from the site.*
b) *Single areas of vegetation less than 1ha in area and not within 100m of other areas of vegetation being classified.*
c) *Multiple area of vegetation less than 0.25ha in area and not within 20m of the site or each other.*
d) *Strips of vegetation less than 20m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20m of the site or each other, or other areas of vegetation being classified.*
e) *Non-vegetated areas, including waterways, roads, footpaths, buildings and rocky outcrops.*
f) *Vegetation regarded as low threat due to factors such as flammability, moisture content or fuel load. This includes grassland managed in a minimal fuel condition, mangroves and other saline wetlands, maintained lawns, golf courses (such as playing areas and fairways), maintained public reserves and parklands, sporting fields, vineyards, orchards, banana plantations, market gardens (and other non-curing crops) cultivated gardens, commercial nurseries, nature strips and windbreaks.*

NOTES:

1. *Minimal fuel condition means there is insufficient fuel available to significantly increase the severity of the bushfire attack (recognizable as short-cropped grass for example, to a nominal height of 100 mm).*
2. *A windbreak is considered a single row of trees used as a screen or to reduce the effect of wind on the leeward side of the trees.*

Appendix 2 - Vehicular Access Technical Requirements

Each local government may have their own standard technical requirements for emergency vehicular access and they may vary from those stated in the Guidelines.

Contact the relevant local government for the requirements that are to apply in addition to the requirements set out as an acceptable solution in the Guidelines. If the relevant local government requires that these are included in the Bushfire Management Plan, they will be included in this appendix and referenced.

Requirements Established by the Guidelines – The Acceptable Solutions

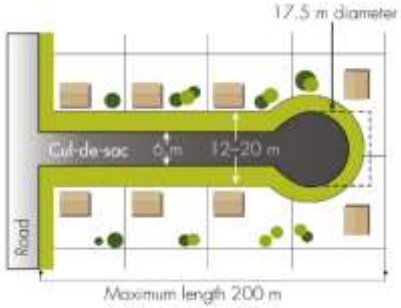
(Source: Guidelines for Planning in Bushfire Prone Areas WAPC 2017 v1.3, Appendix 4)

Vehicular Access Technical Requirements - Part 1

Acceptable Solution 3.3: Cul-de-sacs (including a dead-end road)

Their use in bushfire prone areas should be avoided. Where no alternative exists then the following requirements are to be achieved:

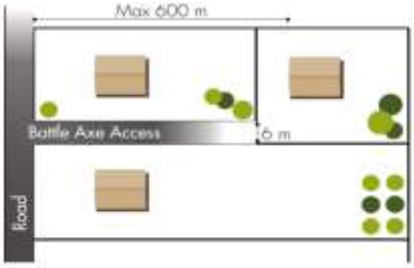
- Maximum length is 200m. If public emergency access is provided between cul-de-sac heads (as a right of way or public access easement in gross), the maximum length can be increased to 600m provided no more than 8 lots are serviced and the emergency access way is less than 600m in length;
- Turnaround area requirements, including a minimum 17.5m diameter head to allow type 3.4 fire appliances to turn around safely;
- The cul-de-sac connects to a public road that allows for travel in two directions; and
- Meet the additional design requirements set out in Part 2 of this appendix.



Acceptable Solution 3.4: Battle-axe

Their use in bushfire prone areas should be avoided. Where no alternative exists then the following requirements are to be achieved:

- Maximum length 600m and minimum width 6m; and
- Comply with minimum standards for private driveways.



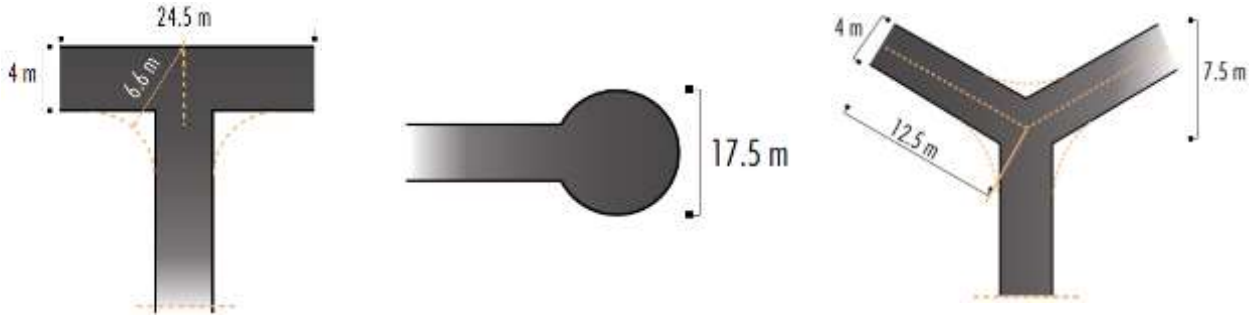
Acceptable Solution 3.5: Private Driveways

The following requirements are to be achieved:

- The design requirements set out in Part 2 of this appendix; and

Where the house site is more than 50 metres from a public road:

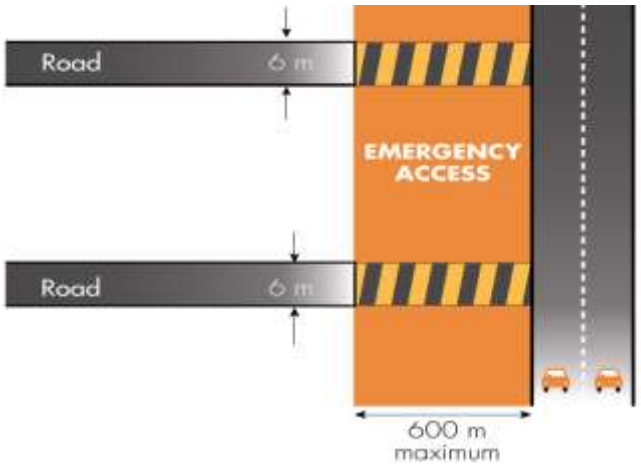
- Passing bays every 200 metres with a minimum length of 20 metres and a minimum width of two metres (ie combined width of the passing bay and constructed private driveway to be a minimum six metres);
- Turn-around areas every 500 metres and within 50 metres of a house, designed to accommodate type 3.4 fire appliances to turn around safely (ie kerb to kerb 17.5 metres);
- Any bridges or culverts are able to support a minimum weight capacity of 15 tonnes; and
- All weather surface (i.e. compacted gravel, limestone or sealed).



Acceptable Solution 3.6: Emergency Access Way

An access way that does not provide through access to a public road is to be avoided bushfire prone areas. Where no alternative exists, an emergency access way is to be provided as an alternative link to a public road during emergencies. The following requirements are to be achieved:

- No further than 600 metres from a public road;
- Must be signposted including where they ajoin public roads;
- Provided as a right of way or public access easement in gross;
- Where gates are used they must not be locked and they must be a minimum width of 3.6 metres with design and construction approved by local government (refer to the example in this appendix); and
- Meet the additional design requirements set out in Part 2 of this appendix.



Acceptable Solution 3.7: Fire Service Access Routes (Perimeter Roads)

Are to be established to provide access within and around the edge of subdivision and related development and to provide direct access to bushfire prone areas for firefighters and link between public road networks for firefighting purposes. Fire service access is used during bushfire suppression activities but can also be used for fire prevention work. The following requirements are to be achieved:

- No further than 600 metres from a public road (driveways may be used as part of the designated fire service access;
- Dead end roads not permitted;
- Allow for two-way traffic (i.e. two 3.4 fire appliances);
- Provide turn-around areas designed to accommodate 3.4 fire appliances and to enable them to turn around safely every 500m (i.e. kerb to kerb 17.5 metres);
- All weather surface (i.e. compacted gravel, limestone or sealed) and have erosion control measures in place;
- Must be adequately sign posted;
- Where gates are used they must be a minimum width of 3.6 metres with design and construction approved by local government (refer to the example in this appendix) and may be locked (use a common key system);
- Meet the additional design requirements set out in Part 2 of this appendix;
- Provided as right of ways or public access easements in gross; and
- Management and access arrangements to be documented and in place.

Acceptable Solution 3.8: Firebreak Width

Lots greater than 0.5 hectares must have an internal perimeter firebreak of a minimum width of three meters or to the level as prescribed in the local firebreak notice issued by the local government.

Vehicular Access Technical Requirements - Part 2

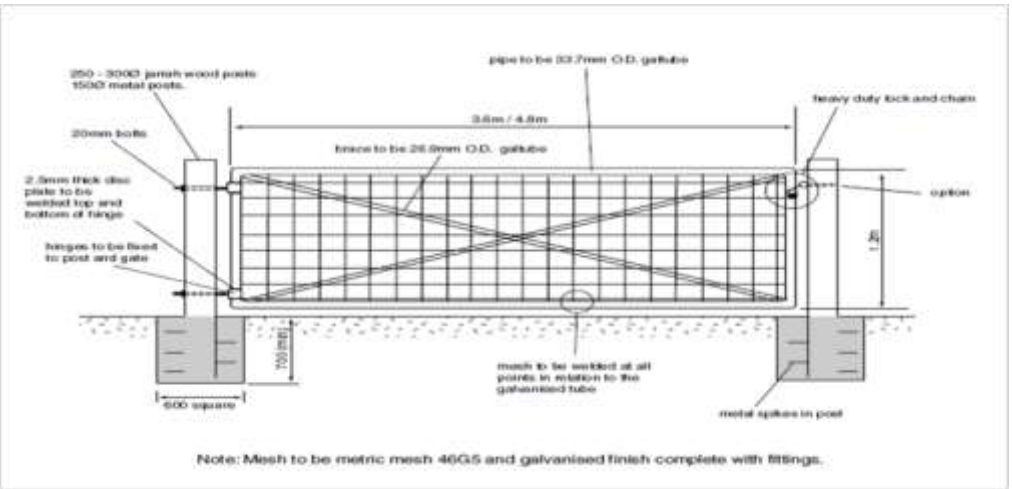
Technical Component	Vehicular Access Types				
	Public Roads	Cul-de-sacs	Private Driveways	Emergency Access Ways	Fire Service Access Routes
Minimum trafficable surface (m)	6*	6	4	6*	6*
Horizontal clearance (m)	6	6	6	6	6
Vertical clearance (m)	4.5	4.5	4.5	4.5	4.5
Maximum grade <50 metres	1 in 10	1 in 10	1 in 10	1 in 10	1 in 10
Minimum weight capacity (t)	15	15	15	15	15
Maximum cross-fall	1 in 33	1 in 33	1 in 33	1 in 33	1 in 33
Curves minimum inner radius (m)	8.5	8.5	8.5	8.5	8.5

* A six metre trafficable surface does not necessarily mean paving width. It could, for example, include four metres of paving and one metre of constructed road shoulders. In special circumstances, where 8 lots or less are being serviced, a public road with a minimum trafficable surface of four metres for a maximum distance of ninety metres may be provided subject to the approval of both the local government and DFES.

Vehicular Access Technical Requirements – Gates and Signs Examples

Gates

- ***Design and construction to be approved by relevant local government.***
- Minimum width 3.6m
- Emergency access way gates must not be locked.
- Fire service access route gates may be locked but only with a common key that is available to local fire service personnel.
- Bollards will be to the relevant local government specifications



Signs

- ***Design and construction to be approved by the relevant local government.***
- Minimum height above ground of 0.9m.
- Lettering height to be 100mm.
- To display the words (as appropriate) "Emergency Access Only" or "Fire Service Access – No Public Access".
- Size 600mm x 400mm.
- Sign colour red, base (white) area is reflective background.
- Rounded corners, radius 20mm.
- White key-line 3mm wide, 3mm from outside edge.
- Suggested mounting hole six 6mm diameter.



Appendix 3 - Water Technical Requirements

Requirements Established by the Guidelines - Acceptable Solution A4.1: Reticulated Areas

(Source: Guidelines for Planning in Bushfire Prone Areas WAPC 2017 v1.3, Appendix 4, Element 4)

The requirement is to supply a reticulated water supply and fire hydrants, in accordance with the technical requirements of the relevant water supply authority and DFES.

The Water Corporation's 'No 63 Water Reticulation Standard' is deemed to be the baseline criteria for developments and should be applied unless local water supply authority's conditions apply.

Key specifications in the most recent version/revision of the design standard include:

- ***Residential Standard*** – hydrants are to be located so that the maximum distance between the hydrants shall be no more than 200 metres.
- ***Commercial Standard*** – hydrants are to be located with a maximum of 100 metre spacing in Industrial and Commercial areas.
- ***Rural Residential Standard*** – where minimum site areas per dwelling is 10,000 m² (1ha), hydrants are to be located with a maximum 400m spacing. If the area is further subdivided to land parcels less than 1ha, then the residential standard (200m) is to be applied.

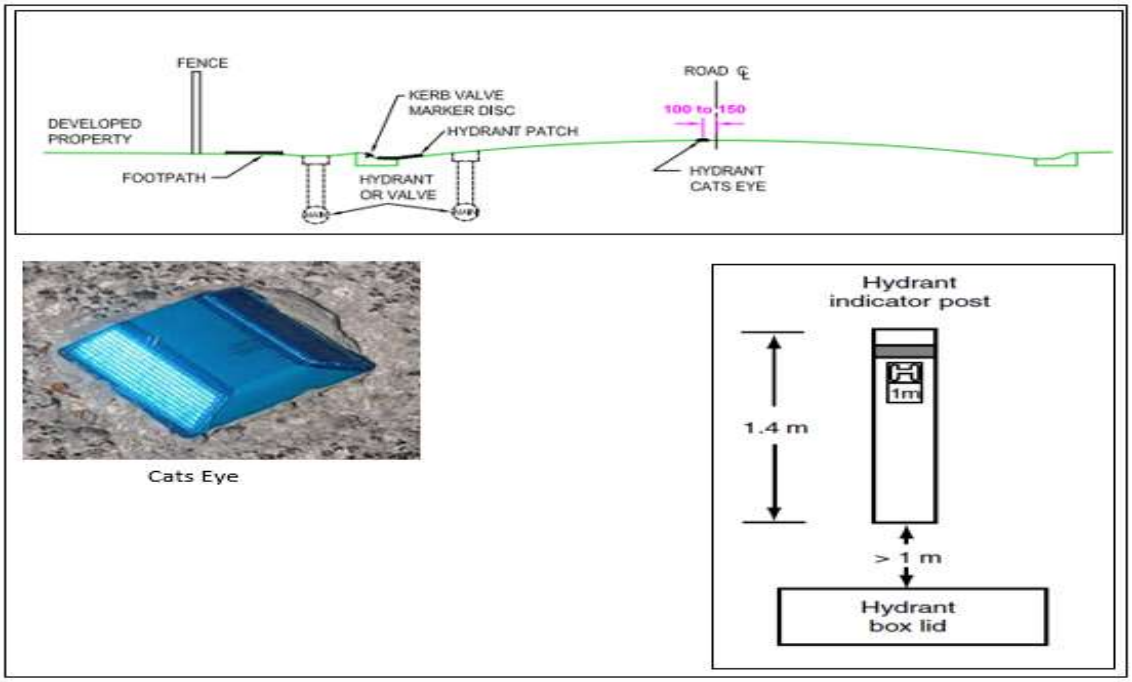


Figure A4.1: Hydrant Location and Identification Specifications

Contact the relevant water supply authority to confirm the technical requirements that are to be applied. They may differ from the minimum requirements of the 'baseline' Water Corporation's No. 63 Water Reticulation Standard.

Requirements Established by the Guidelines - Acceptable Solution A4.2: Non-Reticulated Areas

Each local government may have their own standard technical requirements for firefighting water supplies and they may vary from those stated in the Guidelines.

Contact the relevant local government for the requirements that are to apply in addition to the requirements set out as an acceptable solution in the Guidelines. If the relevant local government requires that these are included in the Bushfire Management Plan, they will be included in this appendix and referenced.

Table A4.1: The acceptable solution as contained in the Guidelines for Planning in Bushfire Prone Areas WAPC 2017 v1.3, Appendix 4, Element 4 – with example construction / coupling requirements from various sources including FESA (DFES) Operational Circular 07/2011 and Planning for Bushfire Protection Guidelines WAPC 2010.

Technical Requirements for Static Water Supply (example only – check with local government)	
Volume:	50,000 litres per tank
Ratio of tanks to lots:	1 tank per 25 lots (or part thereof)
Location:	No more than two kilometres to the furthermost house site within the residential development to allow a 2.4 fire appliance to achieve a 20-minute turnaround time at legal road speeds.
Tank Construction:	Above ground tanks constructed using concrete or metal. Stands of raised tanks are constructed using non-combustible materials and heat shielding where applicable (required for metal stands).
Pipe Construction:	Galvanised or copper (PVC if buried at least 300mm below ground).
Access:	Hardstand and turnaround areas suitable for a 3.4 appliance (i.e. kerb to kerb 17.5metres) are provided within three metres of each tank.
Couplings:	Hydrant or standpipe to be provided. Tanks can be fitted with a full flow valve gate (not ball valve) and a 100mm cam-lock coupling of metal/alloy construction (examples below).
Ownership and Responsibility:	Water tanks and associated facilities are vested in the relevant local government. A procedure must be in place to ensure that water tanks are maintained at or above designated capacity always.





Requirements Established by the Guidelines - Acceptable Solution A4.3: Non-Reticulated Areas – Single Lot

Each local government may have their own standard technical requirements for firefighting water supplies and they may vary from those stated in the Guidelines.

Contact the relevant local government for the requirements that are to apply in addition to the requirements set out as an acceptable solution in the Guidelines. If the relevant local government requires that these are included in the Bushfire Management Plan, they will be included in this appendix and referenced.

Table A4.1: The acceptable solution as contained in the Guidelines for Planning in Bushfire Prone Areas WAPC 2017 v1.3, Appendix 4, Element 4 – with example construction / coupling requirements from various sources including FESA (DFES) Operational Circular 07/2011 and Planning for Bushfire Protection Guidelines WAPC 2010.

Technical Requirements for Static Water Supply (example only – check with local government)	
Application:	Single lots above 500 m^2 need a dedicated static water supply on the lot. This solution is only for use if creating one additional lot and cannot be applied cumulatively.
Volume:	Minimum 10,000 litres per tank dedicated to firefighting purposes. The storage tank must not facilitate sharing the water for domestic use due to the danger of contamination.
Tank Construction:	Above ground tanks constructed using concrete or metal.
Pipe Construction:	Galvanised or copper (PVC if buried at least 300mm below ground).
Vehicle Access:	Hardstand and turnaround area suitable for a 3.4 appliance (i.e. kerb to kerb 17.5metres) is provided at the tank.
Couplings:	Tanks are to be fitted with a full flow gate valve (not ball valve) and a 50mm or 100mm cam-lock coupling of metal/alloy construction (example below).
Responsibility:	A procedure must be in place to ensure that water tanks are maintained at or above designated capacity always.


Static water supply tank for fire-fighting
10,000ltr minimum non-combustible tank.
Recommended coupling – 50mm Camlock with gate valve.

APPENDIX E

Landscape Masterplan

Legend	
Symbol	material
	existing mature tree
	lawn area
	vegetation retention / replanting area

Revegetation

Trees - Banksia attenuata
Banksia illicifolia
Banksia menziesli
Banksia prionotes
Eucalyptus todtiana
Eucalyptus marginata
Ssp thalasicca

Shrubs - Grevillea curviloba
Melaleuca laterita
Melaleuca seriata
Verticordia densiflora
Xanthorrhoea preissi

Low shrubs - Acacia lasiocarpa
Acacia pulchella
Schoitzia involucrata
Verticordia acerosa
Verticordia densiflora
Hibbertia hypericoides
Hovea trisperma

Ground cover - grass type plants -
Conostylis juncea
Lepidosperma viscidum
Microlaena stipoides
Nuerachne alopecuroides
Stipa compressa

car parking

gravel paths

car parking

267.9

POS 1
2.7907ha

298.3

2

155

153

bin area

2 / double bbq

shade shelter
with picnic tables

adventure
playground

toilet block

car parking

gravel paths

car parking

ROAD 9 (20m ROAD RESERVE)

lawn
(5006 m²)

N

CONCEPT PLAN
WILDFLOWER RIDGE PUBLIC OPEN SPACE

Z:\Landscapes WA\Jobs LWA\General public\W\Wildflower ridge estate

1:1000 @ a3

LANDSCAPES W.A.

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CLIENT INFORMATION:

Address :lot 2 & LOT 9001 ROSEWOOD DRIVE, CHITTERING

Client name :WILDFLOWER RIDGE

Phone no :

E-mail :

	Landscape design 1:1000 scale	15/4/2020	MG
	Landscape design 1:1000 scale (R1)	24/5/2020	MG
	Landscape design 1:1000 scale (R2)	22/9/2020	MG

Client Approval :

Approval Date:

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Measurements - All measurements and levels to be confirmed on site prior to commencement of any works. Levels may require adjusting on site.

Reticulation Note - Gardens to be irrigated by automatic reticulation system with drip lines and drippers. all reticulation to comply with watering guidelines.

DS01-12/20

Attachment 1

Legend	
Symbol	material
	existing mature tree
	lawn area
	vegetation retention / replanting area



1 - CENTRAL PARK

The central park are is to make use of the existing mature stand of eucalypts as a backdrop to nestle in resident park amenity such as ,shade structures, play equipment focusing on adventure play, a large lawn area for picnicking ,bbq facilities, toilet and water fountain conveniences, lighting as a contrast to the more endemic vegetation.
The central park will be organised spatially though the use of desire lines that cross the park providing not only cross access however a circuitous route within the park. The larger areas encourage local planting as a strong suggestion of the sites original landscape woodlands.

2 - VEGETATION MANAGEMENT STRATEGY

The landscape architectural recommendation for residential lots is primarily influenced by maintaining 'a sense of place'. However this is conversely and equally strongly influenced by fire management regulations. the approach taken here is to limit bushland planting to no closer than 20m from residences with the areas of remnant or re-planting vegetation to be no more than 2500sq/m in size. guided by the simplified description of the fire management regulations, the masterplan, detail plans and elevations indicate planting opportunities for residences for lots 2 and lot 9001

3 - LANDSCAPE INTENT

The lot reserve road and lot 9001 Rosewood Drive landscape masterplan borrows cues from the sites unique woodlands ecology and recent use as a native flower farm.

Revegetation	
Trees -	Banksia attenuata
	Banksia illicifolia
	Banksia menziesli
	Banksia prionotes
	Eucalyptus todtiana
	Eucalyptus marginata
	Ssp thalasicca
Shrubs -	Grevillea curviloba
	Melaleuca laterita
	Melaleuca seriata
	Verticordia densiflora
	Xanthorrhoea preissi
Low shrubs -	Acacia lasiocarpa
	Acacia pulchella
	Schoitzia involucrata
	Verticordia acerosa
	Verticordia densiflora
	Hibbertia hypericoides
	Hovea trisperma
Ground cover -	grass type plants -
	Conostylis juncea
	Lepidosperma viscidum
	Microlaena stipoides
	Nuerachne alopecuroides
	Stipa compressa

NOTE:existing trees within lot 2 and lot 9001 will be retained where possible where the trees are not required for removal for fire management, clearing for roads, building works or vehicle access requirements

Z:\Landscapes WA\Jobs LWA\General public\W\Wildflower ridge estate

1:7500 @ a3

LANDSCAPES W.A.

© COPYRIGHT 2019

CLIENT INFORMATION:

Address : lot 2 & lot 9001 ROSEWOOD DRIVE, CHITTERING

Client name :WILDFLOWER RIDGE

Phone no :

E-mail :

	Landscape design 1:1000 scale	15/4/2020	MG
	Landscape design 1:7500 scale (R1)	24/5/2020	MG
	Landscape design 1:7500 scale (R2)	22/9/2020	MG

Client Approval :

Approval Date:

Landscapes WA owns the copyright of this design, which includes photographs of the works,illustrating the design and planting selection . No part of this plan may be reproduced without permission.

Measurements - All measurements and levels to be confirmed on site prior to commencement of any works. Levels may require adjusting on site.

Reticulation Note - Gardens to be irrigated by automatic reticulation system with drip lines and drippers. all reticulation to comply with watering guidelines.

APPENDIX F

Traffic Report

RIVERSIDE INVESTMENTS WA No2 Pty Ltd

LOT 2 RESERVE ROAD & LOT 9001 ROSEWOOD DRIVE, CHITTERING

TRAFFIC ASSESSMENT

October 2020

Riley Consulting (WA) Pty Ltd
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Issued on	7 October 2020	Amendments
Version	V2	V2 text edits
Reference	980	

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9. PEAK HOUR IMPACTS 10
10. PUBLIC TRANSPORT ACCESS 10
11. PEDESTRIAN ACCESS 10
12. CYCLE ACCESS 11
13. SITE SPECIFIC ISSUES 11
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1. EXECUTIVE SUMMARY

1.1. Riley Consulting has been commissioned by Riverside Investments to consider the traffic and transport impacts of amending an approved structure plan on Lot 2 Reserve Road and Lot 9001 Rosewood Drive, Chittering. The key findings of the traffic review are:

1.1.1. The land has an approved structure plan for 243 residential lots. Since the structure plan Great Northern Highway has been duplicated and better access to Reserve Road is now provided. It is proposed to amend the structure plan to provide up to 318 residential lots. The structure plan also provides for 36 rural conservation zoned lots.

1.1.2. The traffic assessment of the proposed changes to the structure plan indicates an ultimate potential traffic generation of 2,832 vehicle movements per day. The forecast demand is below 3,000vpd and would not be expected to result in any planed street operating in a manner contrary to its classification.

1.1.3. Assessment was undertaken of the Reserve Road / Great Northern Highway intersection for the long-term indicates Level of Service A for the Highway and Level of Service B for Reserve Road. Excellent operation is forecast. As a new intersection, visibility meets current standards and all approaches are to optimum design requirements.

2. CHECKLIST

Item	Comments/Proposals
Proposed development	
proposed land uses	Residential
existing land uses	Green field
context with surrounds	Adjacent to existing residential
Vehicular access and parking	
access arrangements	From Reserve Road
public, private, disabled parking set down / pick up	
Service vehicles	
access arrangements	From Reserve Road
rubbish collection and emergency vehicle access	As above – on street provision
Hours of operation (non-residential only)	
Traffic volumes	
daily or peak traffic volumes	2,832 movements per day
type of vehicles (eg cars, trucks)	Predominantly cars
Traffic management on frontage streets	
Public transport access	
nearest bus stops/train stations	N/A
pedestrian/cycle links to bus stops/train station	N/A
Pedestrian access/facilities	
existing pedestrian facilities within the development (if any)	None
proposed pedestrian facilities within development	Footpaths and on-street
existing pedestrian facilities on surrounding roads	Rural area
proposals to improve pedestrian access	N/A
Cycle access/facilities	
existing cycle facilities within the development (if any)	N/A
proposed cycle facilities within development	On-street
existing cycle facilities on surrounding roads	Minimal
proposals to improve cycle access	N/A
Site specific issues	None
Safety issues	None

3. INTRODUCTION

3.1. Riley Consulting has been commissioned by Riverside Investments to assess the traffic issues associated with the proposed development of 318 residential lots.

3.2. The subject site is located on Lot 2 Reserve Road and Lot 9001 Rosewood Drive, Chittering. It is located to the north side of the Great Northern Highway.

3.3. Figure 1 shows the location of the subject site

3.4. Roads of importance are discussed below.

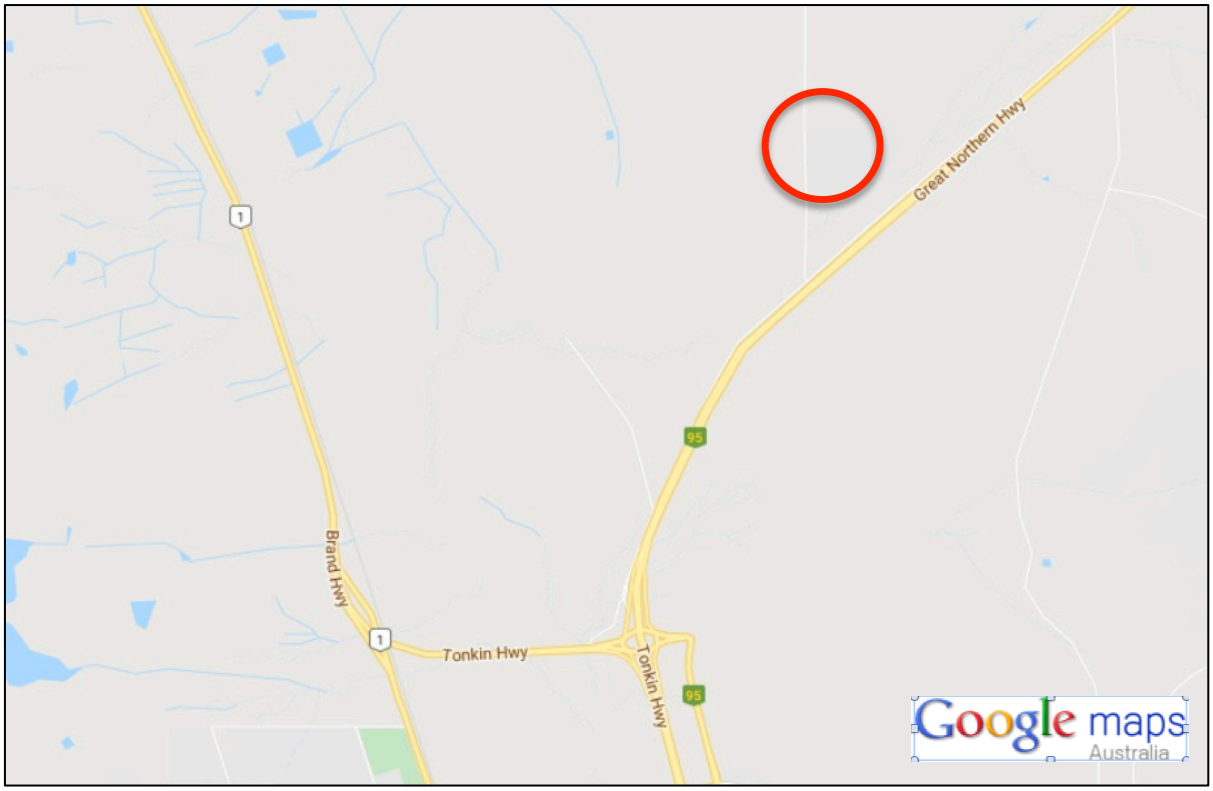


Figure 1 **Subject Site Location** (location indicative)

Great Northern Highway

3.5. The Great Northern Highway is a primary regional road under the control of Main Roads Western Australia (MRWA). It has recently been upgraded as part of the Northlink project to provide a four lane divided road.

3.6. Its intersection with Reserve Road has been constructed with full standard deceleration lanes and a wide median.

3.7. Traffic data retrieved from the MRWA website shows 3,729 vehicles per day (vpd) to the north of Sandalford Drive (2018/19). The data indicates 27% of vehicles are trucks. The peak period of movement occurs between 4pm and 5pm. The MRWA data is attached at Appendix A and summarised in Table 1.

Table 1 Great Northern Highway Peak Hour Traffic Demands

Direction	North	South
AM Peak (8am-9am)	125	132
PM Peak (4pm-5pm)	148	148
PM Peak (5pm-6pm)	142	125

3.8. As a four lane divided road Great Northern Highway would have capacity to carry 40,500vpd at Level of Service D. The present day traffic demands indicate it is operating at Level of Service A (refer Appendix B).

Reserve Road

3.9. Reserve Road is a local access street and is presently a cul de sac. It provides access to approximately 11 existing developed lots. Between the Great Northern Highway and the subject land, it is constructed with a standard 7m carriageway within a 30 metre road reservation.

3.10. An old traffic count supplied by the Shire of Chittering indicates a daily flow in the order of 30 vehicles. However, traffic demands may have changed since the construction of the Great Northern Highway.

3.11. With 11 lots located between the subject land and Great Northern Highway, a demand of about 100 movements per day would be expected.

3.12. As a single lane road, Reserve Road would have capacity to carry 13,500vpd at Level of Service D. The current traffic demands indicates operation at Level of Service A.

Sugargum Drive

3.13. Sugargum Drive is a local access street and is effectively a cul de sac. It provides access to approximately 71 residential lots of which 62 lots are developed. It is constructed with an 8m carriageway within a 25 metre road reservation.

3.14. An old traffic count has been sourced at the intersection of Sugargum Drive and Great Northern Highway that indicates about 300 vehicle movements per day. The count is attached at Appendix A.

3.15. As a single lane road, Sugargum Drive would have capacity to carry 13,500vpd at Level of Service D. The current traffic demands indicates operation at Level of Service A.

4. PROPOSED DEVELOPMENT

4.1. Lot 2 Reserve Road contains an existing dwelling and 30 lots have been constructed as part of a subdivision approval over part of the site. Lot 9001 Rosewood Drive is currently vacant.

4.2. There is an existing structure plan for the subject land that shows a yield of 243 lots that was approved in May 2016 (refer Appendix C).

4.3. It is proposed to expand the approved yield to provide 318 residential lots and facilitate 36 rural conservation zoned lots.

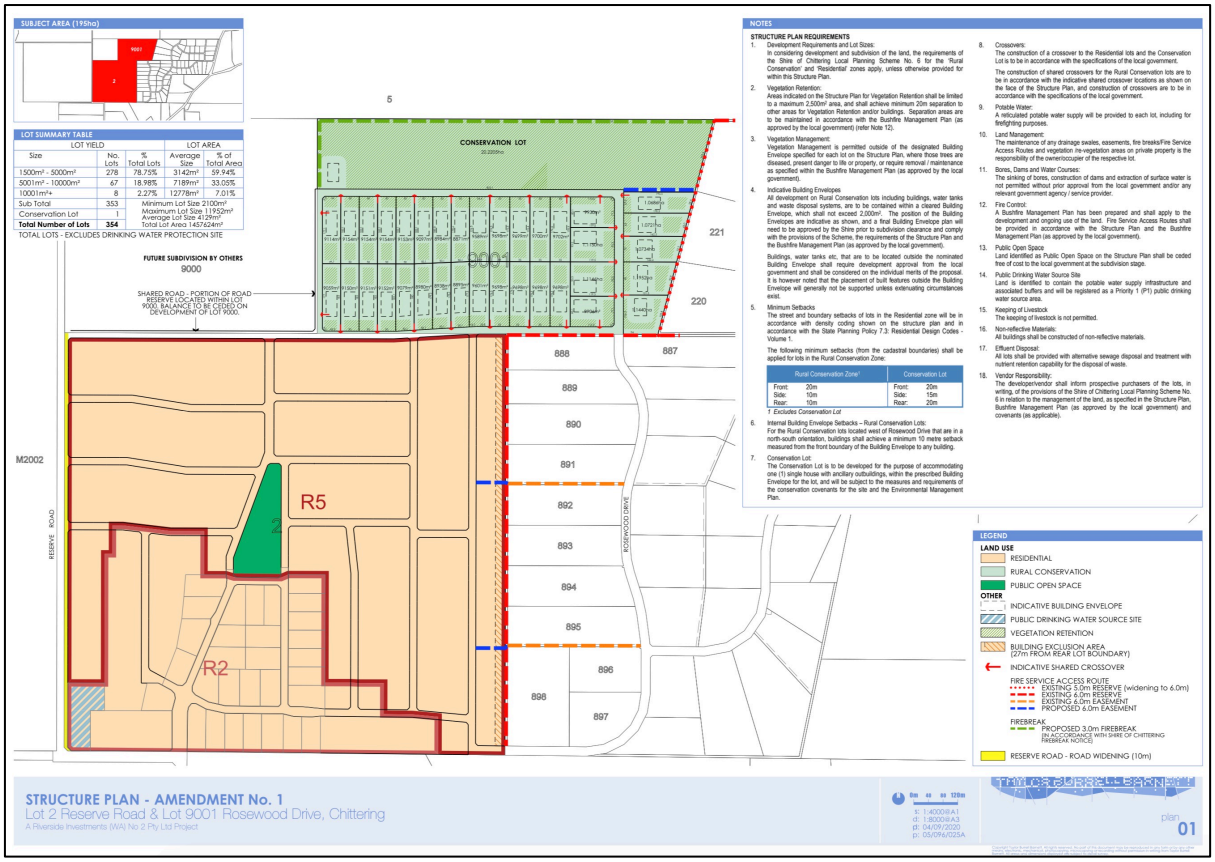


Figure 3 Indicative Site Concept Plan (refer to DA for detail)

5. VEHICLE ACCESS AND PARKING

5.1. The site has limited development and as such, has little to no associated traffic.

5.2. All traffic will access the subject land from the Great Northern Highway / Reserve Road intersection. Future road access to Rosewood Drive is not anticipated to attract significant levels of traffic.

5.3. As a residential development all parking would be provided on each lot. Limited on-street parking may be provided adjacent to the public open space.

6. PROVISION FOR SERVICE VEHICLES

6.1. All services vehicles will access the subject land from the Reserve Road / Great Northern Highway intersection.

6.2. It is expected that loading would be provided on-street.

6.3. Garbage collection would be provided on-street.

7. DAILY TRAFFIC VOLUMES AND VEHICLE TYPES

7.1. As indicated the site has little traffic movement at the present time.

7.2. Reference to the WAPC Transport Assessment Guidelines for Developments indicates a trip rate of 0.8 trips per dwelling during peak periods (split 0.6 trips in the peak direction). The trip rate is equal to 8 trips per lot per day.

7.3. Based on the WAPC trip rate the development of 318 lots and 36 rural conservation zoned lots (354 total lots) could generate up to 2,832 vehicle movements per day.

7.4. An old traffic count of Sugargum Drive recorded 30 vehicle movements during the peak period suggesting that the 62 developed lots generate (30/62) 0.48 peak movements per lot. Based on typical residential profiles, the adjacent rural residential lots are generating 4.8 trips per lot per day.

7.5. For the purpose of road network planning the higher trip generation is applied to ensure a robust assessment of future traffic impacts.

Distribution

7.6. The distribution of traffic generated by the subdivision is based on the turning movements recorded at Sugargum Drive, which showed:

- North 13%
- South 87%

7.7. The distribution indicates that the directional split is 80% in the peak direction, which is typical of residential development. Table 2 shows the forecast traffic generation.

Table 2 Forecast Traffic Movements

Use	AM	PM	Daily
Existing Site	0	0	0
354 Lots	282	282	2,832

8. TRAFFIC MANAGEMENT ON FRONTAGE STREETS

8.1. Reference to the WAPC Transport Assessment Guidelines for Developments states that:

> *"As a general guide, an increase in traffic of less than 10% of capacity would not normally be likely to have a material impact on any particular section of road, but increases over 10% may. All sections of road with an increase greater than 10% of capacity should therefore be included in the analysis. For ease of assessment, an increase of 100 vehicles per hour for any lane can be considered as equating to around 10% of capacity. Therefore any section of road where traffic would increase flows by more than 100 vehicles per hour for any lane should be included in the analysis. An intersection may be considered materially affected if flows on any leg increase by more than 10% or any individual movement by more than 20%".*

8.2. Table 3 considers the traffic impact of the development based on the generated daily traffic demands. Table 3 does not include reductions for pass-by traffic and provides a robust assessment of the maximum traffic impact.

Table 3 Daily Traffic Impacts

Approach	Flow	Capacity*	Development	% Capacity
Reserve Road	30	13,500	2,832	21%
Great Northern Highway N	3,729	40,500	368	<1%
Great Northern Highway S	3,729	40,500	2,464	6%

*Capacity is based on reaching Level of Service F or LN threshold for residential streets.

8.3. It can be seen from Table 4 that, based on the WAPC *Transport Assessment Guidelines for Developments,* the proposed development can be expected to have no material traffic impact on external roads except Reserve Road.

8.4. The impact to Reserve Road is significant due to all development taking access from this road. However, the road can be expected to operate well within capacity and the increase in daily demand would have little impact to adjacent land uses. Further, the forecast demand is less than 3,000vpd and accords with residential amenity thresholds set out in Liveable Neighbourhoods for residential street (should such thresholds be deemed to apply)/

9. PEAK HOUR IMPACTS

9.1. It has been indicated that the forecast traffic demands of the proposed structure plan area would have minimal impact to the forecast operation of the surrounding road network. However, during peak periods, the level of traffic generated is high in comparison to current base traffic demands. A Sidra assessment of the Great Northern Highway / Reserve Road intersection is undertaken to assess the operation of this access point.

9.2. The Sidra analysis is only undertaken for the full development scenario as current traffic demands are very low and uninterrupted flow conditions would be expected.

9.3. For the purpose of assessment growth on Great Northern Highway at 3% per annum is applied and the analysis undertaken for the 10 year planning horizon (circa 2031). Heavy goods vehicles are input at 30% for the Highway (daily = 27%) to reflect current haulage. Reserve Road is also modelled as a Stop control to reflect the high speed approaches of the Great Northern Highway.

9.4. Appendix D shows the forecast peak hour demands used for the Sidra analysis.

9.5. Table 4 shows a summary of the analysis and Appendix E shows the Sidra outputs.

Table 4 Great Northern Highway / Reserve Road Sidra 2031

Approach	AM Peak			PM Peak		
	V/C	Delay	Los	V/C	Delay	LoS
Great Northern Highway North	0.058	0.5s	A	0.065	1.3s	A
Reserve Road	0.549	18.5s	B	0.229	17.3s	B
Great Northern Highway South	0.055	2.1s	A	0.104	3.9s	A

9.6. Table 4 shows that the operation of the Great Northern Highway intersection with Reserve Road can be expected to operate with good Levels of Service with full development of the structure plan area.

10. PUBLIC TRANSPORT ACCESS

10.1. There are no public transport services beyond Bullsbrook, approximately 12 kilometres south of the subject land.

11. PEDESTRIAN ACCESS

11.1. Pedestrian access for the external road network would not be expected due to the isolated nature of the subject land.

11.2. With low daily traffic demands, walking on street would be considered acceptable for most internal roads. However, key roads within the structure plan area should be provided with at least one footpath.

12. CYCLE ACCESS

12.1. The structure plan area is remote form existing development and facilities and cycling is not anticipated to be a major travel mode.

12.2. Recreational cycling may occur and cycling on local streets would be safe and appropriate. Beyond the subject land, access to local facilities could only be achieved via the Great Northern Highway. Whilst a sealed shoulder is provided, cycling along the highway would not be considered safe.

13. SITE SPECIFIC ISSUES

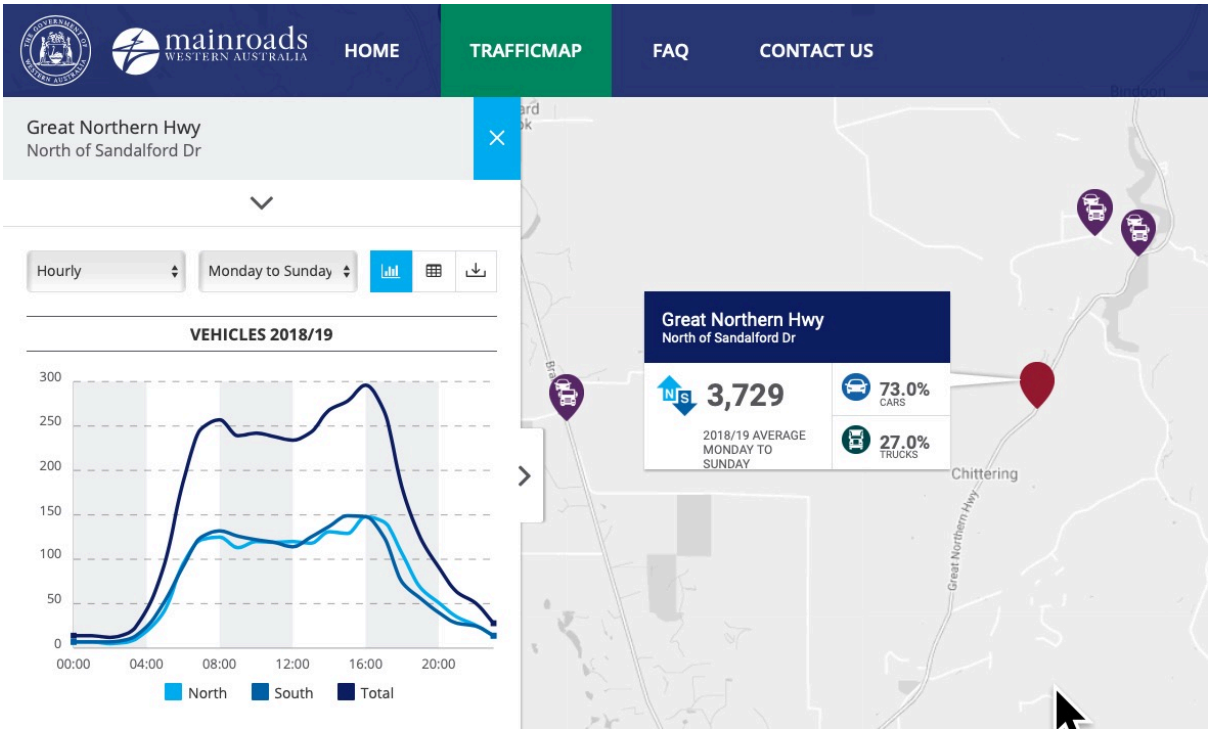
13.1. There are no issue raised as a result of the assessment of the changes to the structure plan.

14. SAFETY ISSUES

14.1. The traffic assessment has not identified any road safety issues as a result of the proposed development. It is noted that Great Northern Highway operate at 110kph adjacent to Reserve Road and thus any crashes could be serious. Analysis of the future operation of the intersection shows delays are low (Level of Service B) and therefore driver impatience should not contribute to the likelihood of crashes occurring.

14.2. With visibility provided to current standards, there are no reasons to believe the intersection would not operate in a safe and appropriate manner.

APPENDIX A



Sugargum Drive Traffic Count

Time	A	B	C	D	Total	GNH N	GNH S
3pm – 4pm	3	1	1	17	22	113	90
3:30pm – 4:30pm	3	2	1	21	27	119	94
4pm – 5pm	4	2	1	21	28	127	86
4:30pm – 5:30pm	5	2	3	20	30	149	114
5pm – 6pm	3	2	3	20	28	140	88
MRWA 4pm – 5pm						168	147

A Right turn out
B Left turn out
C Right turn in
D Left turn in

APPENDIX B

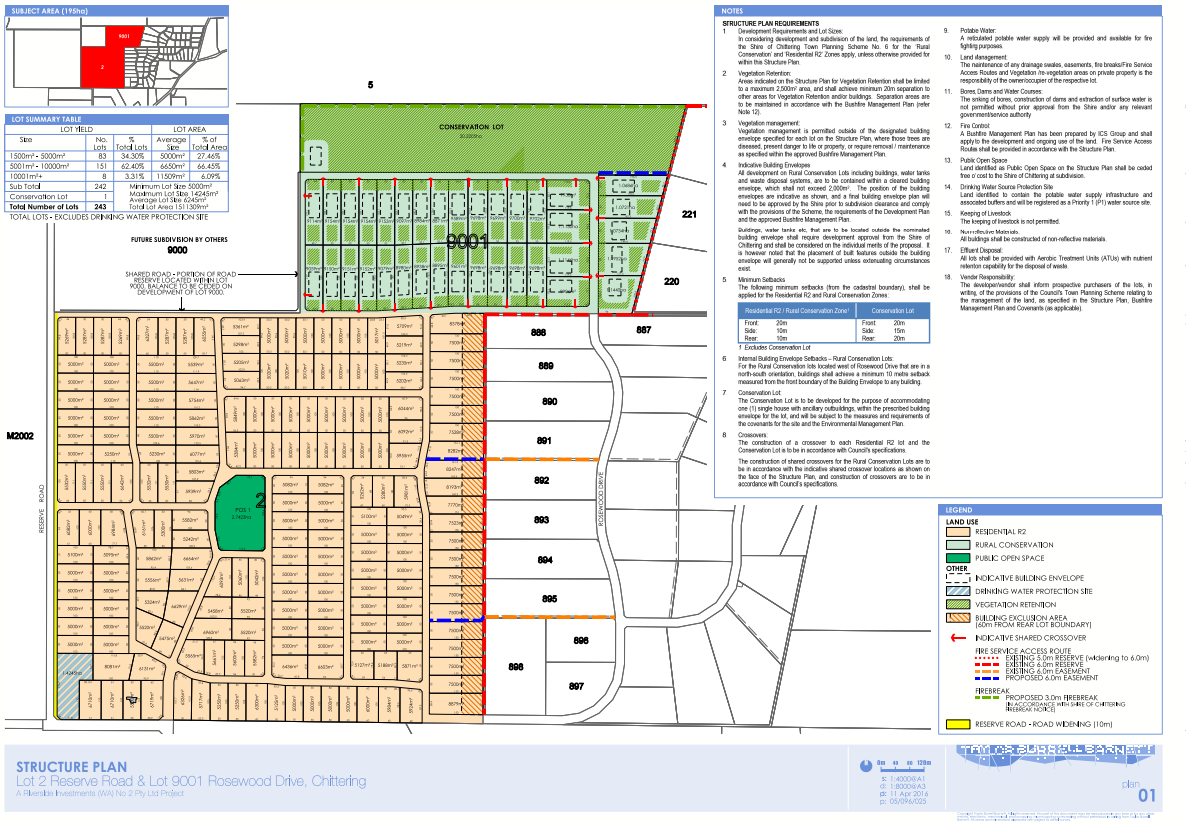
DAILY LEVELS OF SERVICE

LOS	Single Carriageway	2-Lane Boulevard	Dual Carriageway (4-Lanes)	Dual Carriageway (4-lane Clearway)
A	2,400vpd	2,600vpd	24,000vpd	27,000vpd
B	4,800vpd	5,300vpd	28,000vpd	31,500vpd
C	7,900vpd	8,700vpd	32,000vpd	36,000vpd
D	13,500vpd	15,000vpd	36,000vpd	40,500vpd
E	22,900vpd	25,200vpd[4]	40,000vpd	45,000vpd
F	>22,900vpd	>25,200vpd[4]	>40,000vpd	>45,000vpd

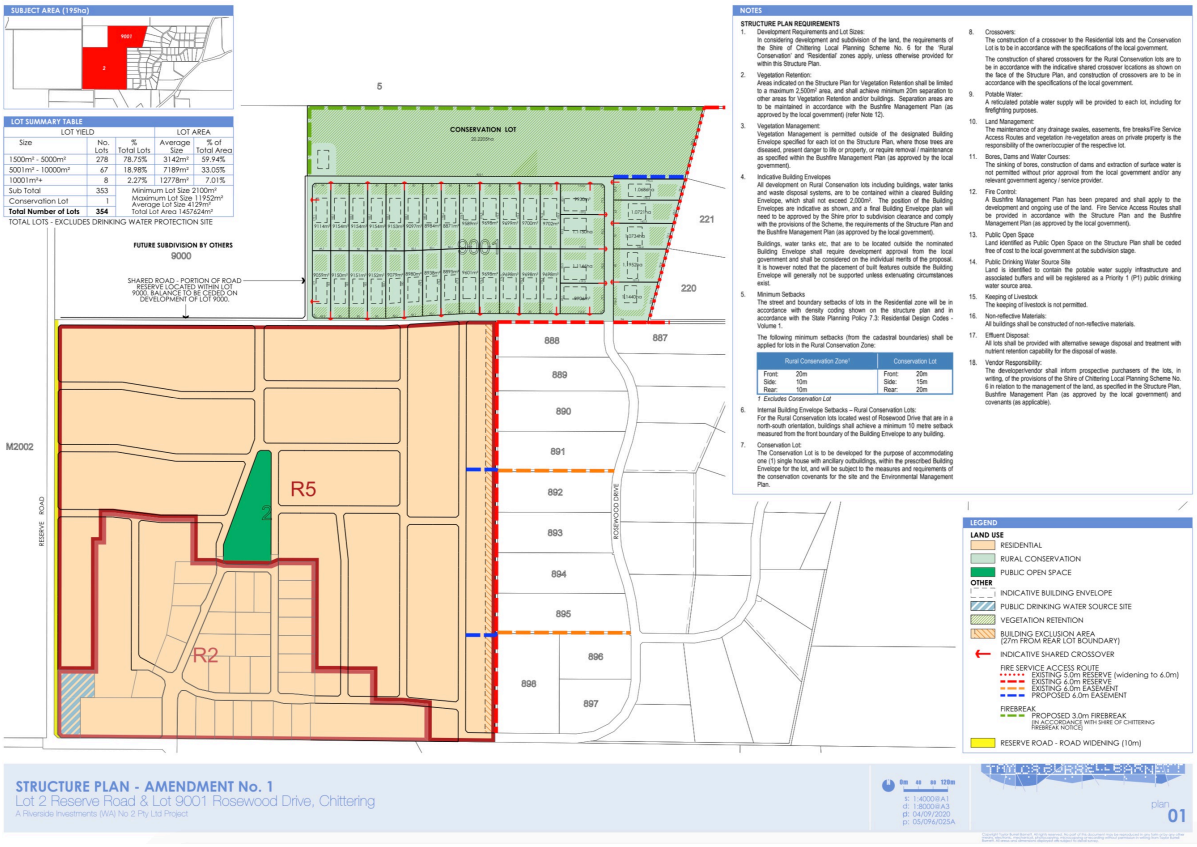
Levels of Service and Capacity are based on Austroads

The actual capacity of any road is greater than shown in the above table. However, a Level of Service D is used as the capacity to provide acceptable operating conditions.

APPENDIX C EXISTING STRUCTURE PLAN

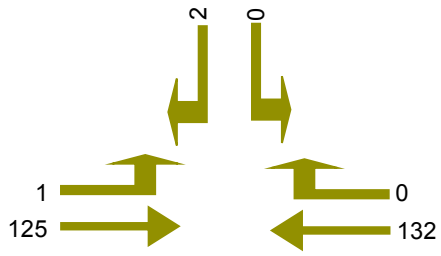
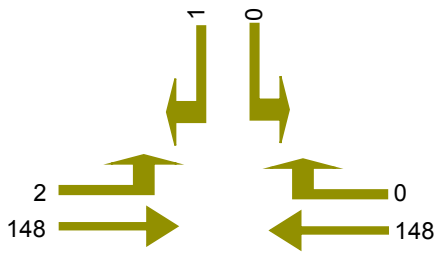


PROPOSED STRUCTURE PLAN

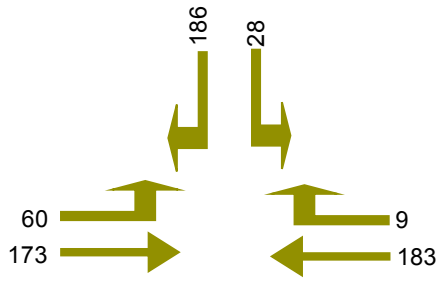
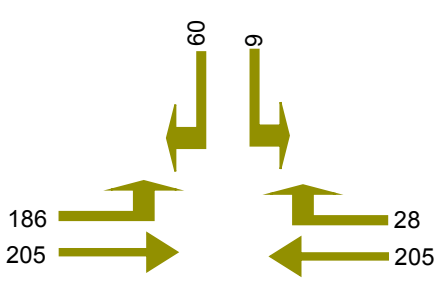


APPENDIX D FORECAST TRAFFIC DEMANDS

Existing Peak Hour Demands

	
AM Peak Demands	PM Peak Demands

Forecast Peak Hour Demands with Full Development @ 2031

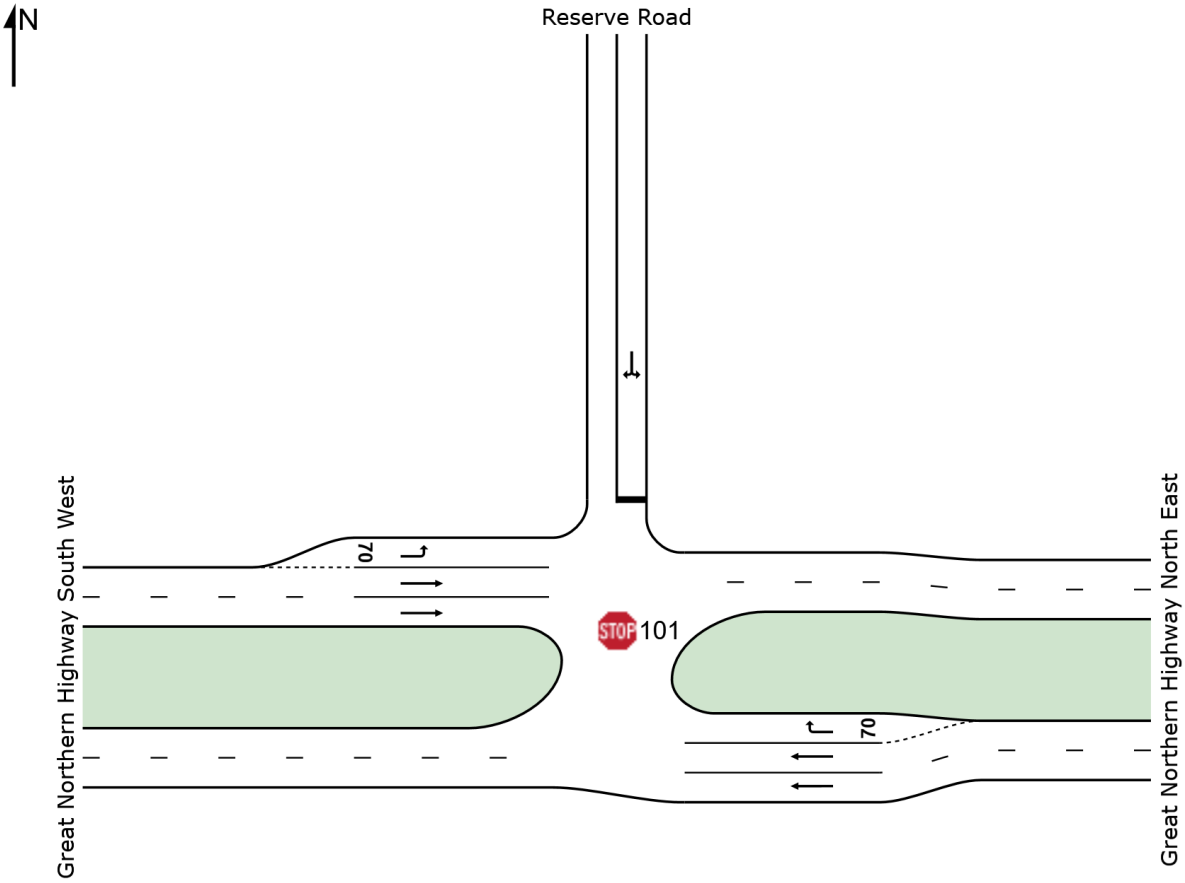
	
AM Peak Demands	PM Peak Demands

APPENDIX E
SIDRA ANALYSIS

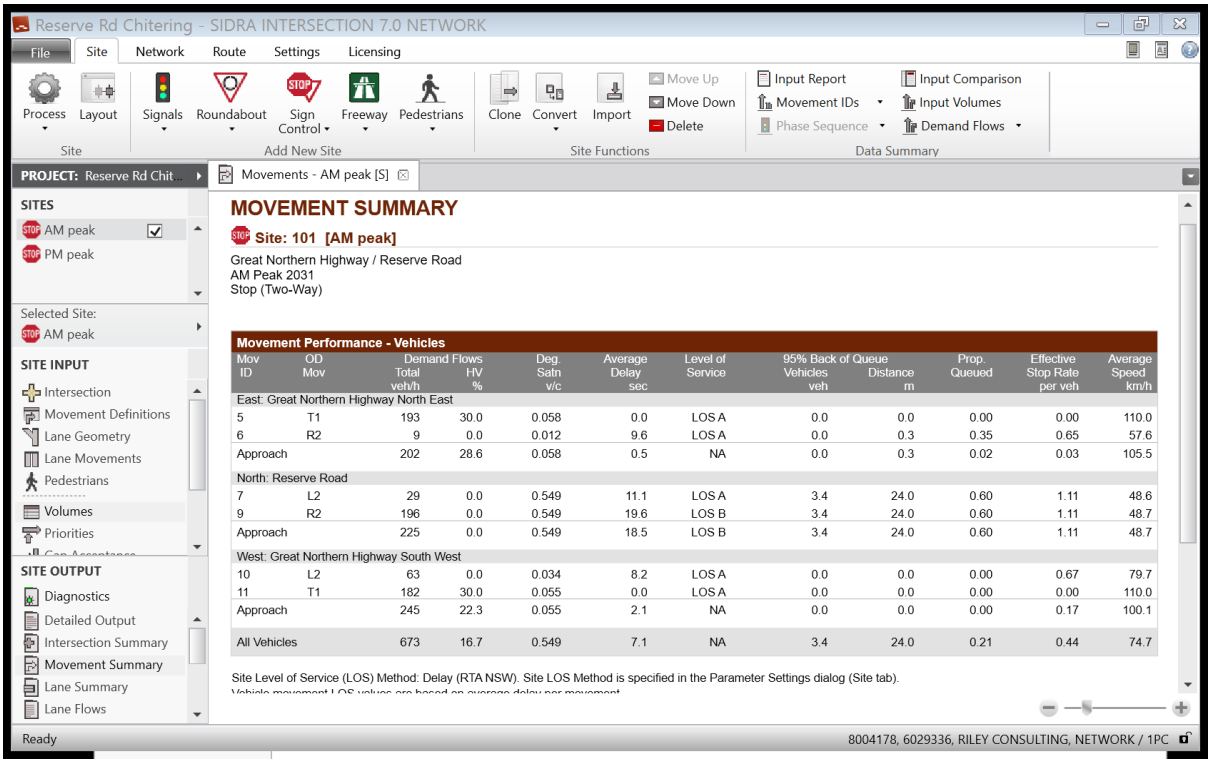
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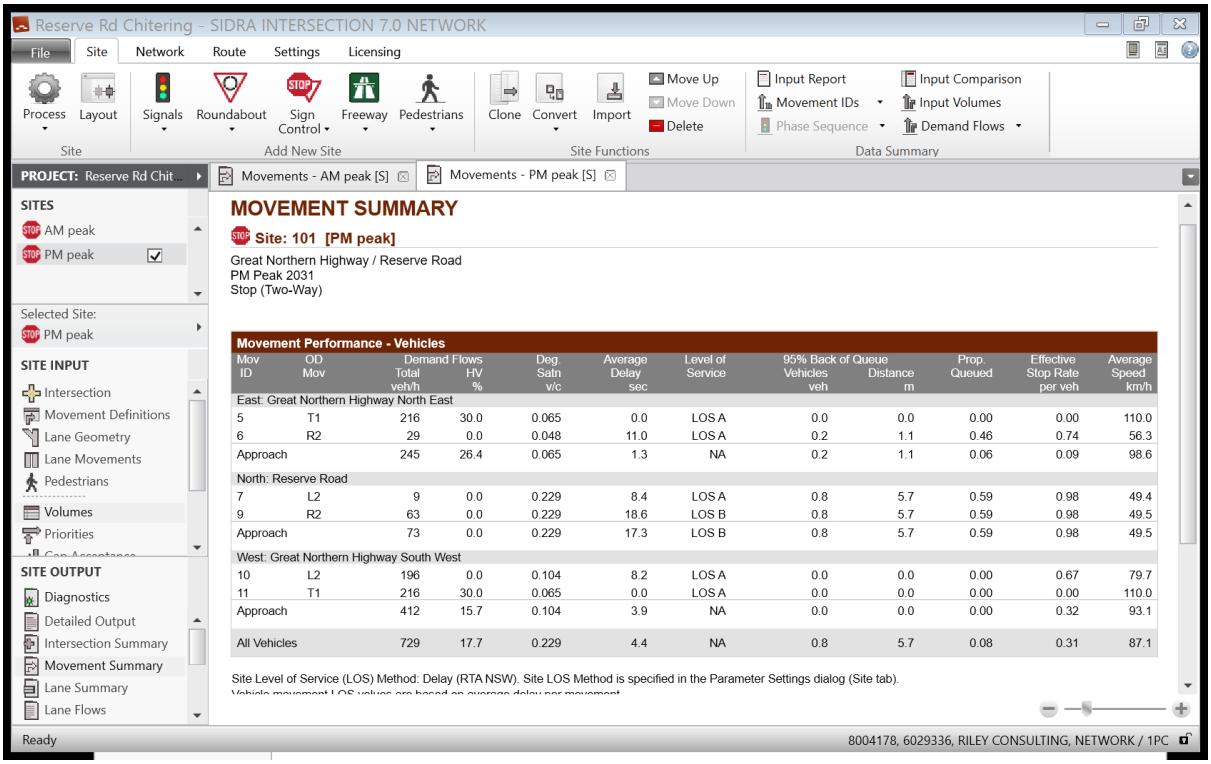
Site: 101 [AM peak]

Great Northern Highway / Reserve Road
AM Peak 2031
Stop (Two-Way)



SIDRA INTERSECTION 7.0 | Copyright © 2000-2017 Akcelik and Associates Pty Ltd | sidrasolutions.com
Organisation: RILEY CONSULTING | Created: Monday, 10 August 2020 11:43:40 AM
Project: Not Saved


Reserve Rd Chitering - SIDRA INTERSECTION 7.0 NETWORK
File Site Network Route Settings Licensing
Process Layout Signals Roundabout Sign Control Freeway Pedestrians Clone Convert Import Move Up Move Down Delete Input Report Movement IDs Phase Sequence Input Comparison Input Volumes Demand Flows
Site Add New Site Site Functions Data Summary
PROJECT: Reserve Rd Chit...
Movements - AM peak [S]
SITES
AM peak
PM peak
Selected Site:
AM peak
SITE INPUT
Intersection
Movement Definitions
Lane Geometry
Lane Movements
Pedestrians
Volumes
Priorities
SITE OUTPUT
Diagnostics
Detailed Output
Intersection Summary
Movement Summary
Lane Summary
Lane Flows
MOVEMENT SUMMARY
Site: 101 [AM peak]
Great Northern Highway / Reserve Road
AM Peak 2031
Stop (Two-Way)
Movement Performance - Vehicles
Mov ID OD Mov Demand Flows Total veh/h HV % Deg. Satn v/c Average Delay sec Level of Service 95% Back of Queue Vehicles veh Distance m Prop. Queued Effective Stop Rate per veh Average Speed km/h
East: Great Northern Highway North East
5 T1 193 30.0 0.058 0.0 LOS A 0.0 0.0 0.00 0.00 110.0
6 R2 9 0.0 0.012 9.6 LOS A 0.0 0.3 0.35 0.65 57.6
Approach 202 28.6 0.058 0.5 NA 0.0 0.3 0.02 0.03 105.5
North: Reserve Road
7 L2 29 0.0 0.549 11.1 LOS A 3.4 24.0 0.60 1.11 48.6
9 R2 196 0.0 0.549 19.6 LOS B 3.4 24.0 0.60 1.11 48.7
Approach 225 0.0 0.549 18.5 LOS B 3.4 24.0 0.60 1.11 48.7
West: Great Northern Highway South West
10 L2 63 0.0 0.034 8.2 LOS A 0.0 0.0 0.00 0.67 79.7
11 T1 182 30.0 0.055 0.0 LOS A 0.0 0.0 0.00 0.00 110.0
Approach 245 22.3 0.055 2.1 NA 0.0 0.0 0.00 0.17 100.1
All Vehicles 673 16.7 0.549 7.1 NA 3.4 24.0 0.21 0.44 74.7
Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Ready
8004178, 6029336, RILEY CONSULTING, NETWORK / 1PC


Reserve Rd Chitering - SIDRA INTERSECTION 7.0 NETWORK
File Site Network Route Settings Licensing
Process Layout Signals Roundabout Sign Control Freeway Pedestrians Clone Convert Import Move Up Move Down Delete Input Report Movement IDs Phase Sequence Input Comparison Input Volumes Demand Flows
Site Add New Site Site Functions Data Summary
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AM peak
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Movement Definitions
Lane Geometry
Lane Movements
Pedestrians
Volumes
Priorities
SITE OUTPUT
Diagnostics
Detailed Output
Intersection Summary
Movement Summary
Lane Summary
Lane Flows
MOVEMENT SUMMARY
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Great Northern Highway / Reserve Road
PM Peak 2031
Stop (Two-Way)
Movement Performance - Vehicles
Mov ID OD Mov Demand Flows Total veh/h HV % Deg Satn v/c Average Delay sec Level of Service 95% Back of Queue Vehicles veh Distance m Prop. Queued Effective Stop Rate per veh Average Speed km/h
East: Great Northern Highway North East
5 T1 216 30.0 0.065 0.0 LOS A 0.0 0.0 0.00 0.00 110.0
6 R2 29 0.0 0.048 11.0 LOS A 0.2 1.1 0.46 0.74 56.3
Approach 245 26.4 0.065 1.3 NA 0.2 1.1 0.06 0.09 98.6
North: Reserve Road
7 L2 9 0.0 0.229 8.4 LOS A 0.8 5.7 0.59 0.98 49.4
9 R2 63 0.0 0.229 18.6 LOS B 0.8 5.7 0.59 0.98 49.5
Approach 73 0.0 0.229 17.3 LOS B 0.8 5.7 0.59 0.98 49.5
West: Great Northern Highway South West
10 L2 196 0.0 0.104 8.2 LOS A 0.0 0.0 0.00 0.67 79.7
11 T1 216 30.0 0.065 0.0 LOS A 0.0 0.0 0.00 0.00 110.0
Approach 412 15.7 0.104 3.9 NA 0.0 0.0 0.00 0.32 93.1
All Vehicles 729 17.7 0.229 4.4 NA 0.8 5.7 0.08 0.31 87.1
Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Ready
8004178, 6029336, RILEY CONSULTING, NETWORK / 1PC

APPENDIX G

Environmental Assessment

Our Ref: 4010AC_Rev1

26 October 2020

Stephen Seaward
Riverside Investments (WA) No 2 Pty Ltd
Via Email: sjs@3rdwavecapital.com

Dear Stephen

Subject: Modified Structure Plan for Lot 2 Reserve Road Chittering – Environmental Assessment

360 Environmental Pty Ltd was engaged by Riverside Investments to consider the environmental implications of a modified structure plan application for Lot 2 Reserve Road, Chittering (the site). The modified structure plan proposes an increase in lot density relative to the previously obtained planning approvals. This letter considers the environmental implications of the proposed change in density.

The proposed structure plan for the site includes 318 residential lots and 2.79 ha of public open space (POS) within Lot 2. The previous subdivision application was granted conditional approval on 23 November 2016 and proposed 105 residential lots, a public drinking water source site, and a POS area. The developer has acted on the subdivision approval insofar that some lots have been created. We understand that the proposed development of the adjacent Lot 9001, which was also covered by existing planning approvals, remains unchanged. Consequently, the development of Lot 9001 is not considered further here.

The original planning approvals for Lot 2 were supported by environmental survey work that included an ecological assessment prepared by Belleng VDM Pty Ltd in 2005. The report notes that at the time of reporting the site had been cleared and then used as a wildflower nursery for 20 years. Most of the site contained plantations of Banksia planted in rows. Rows of planted Wandoo, Geraldton Wax, and Kangaroo Paw, with a limited number of Blackbutt were also described. The survey did not identify any significant flora nor any significant fauna habitat. No wetlands, water bodies or drainage lines were identified. The report recommended that plantings be used to enhance the environmental values of the ultimate development.

It is concluded that the proposed increase in lot density will result in comparable environmental impacts like those that would have occurred because of the originally approved development. The opportunity to retain already planted vegetation is of little environmental consequence as while it may be desirable to retain it from an aesthetic perspective, it has no conservation value.

The increase in density will have implications with regards to water management for the development. A Site and Soil Evaluation and an addendum to the Local Water Management Strategy have been prepared by 360 Environmental to address these implications and we understand that these documents will be assessed by the Department of Health and the Department of Water and Environmental Regulation as part of the planning approval process for the modified structure plan.

We trust this meets your requirements. Should you have any questions or require further action please do not hesitate to contact the undersigned on (08) 9388 8360. We look forward to hearing from you.

For and on behalf of 360 Environmental Pty Ltd



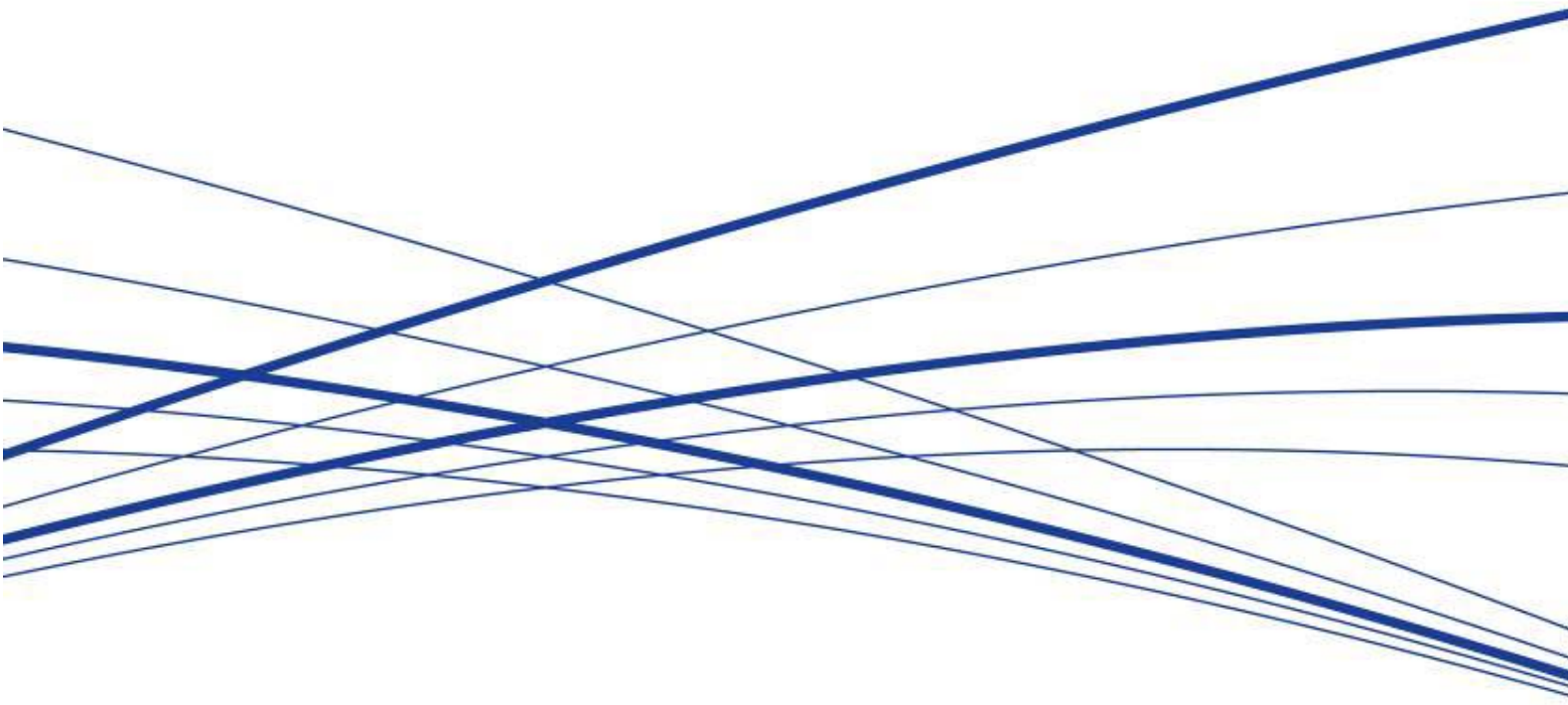
Scott Bird Director

Proposed Residential Development

LOT 7 RESERVE ROAD, MUCHEA

Vegetation Survey

Issue No. 1
January 2008



VDM Environmental

DOCUMENT CONTROL RECORD

VDM Environmental **63 Burswood Rd, Burswood WA 6100** **PO Box 186, Victoria Park WA 6979**		**Job No:**	71222
Telephone:	08 6250 9900	**File Reference:**	**W:\VDM Environmental\Projects\71222 - Lot 7 Reserve Road\Report\EDD Lot 7 Reserve RoadFINAL.doc**
Facsimile:	08 6250 9999	**Date of Issue:**	22 January 2008
Email:	**vdmenvironmental@vdmgroup.com.au**	**Project Leader:**	Carel van der Westhuizen

Report Details:

Title:	Proposed Residential Development Lot 7 Reserve Road, Muchea Vegetation Survey
Author(s):	S. Connell, R. Dawson, M.Harvey
Status:	Issue 1
Client Contact:	Mr. Andrew Van Der Meer
Synopsis:	This report presents the vegetation survey for the proposed residential development at Lot 7 Reserve Road, Muchea.

Document Distribution:

Issue No	Date	Checked By & Date		Issued By & Date		Distributed to:	No. of Copies
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- The information contained within this report is provided in good faith in the belief that no information, opinions or recommendations made are misleading.
- All comments and opinions given in this report are based on a limited survey of the study site or on information supplied by the client, his agents and third parties.
- Assessments of site and the extent and nature of impacts of and to this study site are limited within the terms of reference stated within this report, and by the limited timeframe of study. Therefore the results presented herein cannot be considered absolute or conclusive without additional long-term follow-up studies.
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- Acceptance of this document denotes acceptance of these terms.

Executive Summary

An assessment of the flora and vegetation found at Lot 7 Reserve Rd, Muchea was undertaken in September and October 2007 on behalf of Riverside Investments (WA) No.2. The field study was supported by data from CALM Herbarium, FLORABASE, an extract of the CALM rare and threatened plants and communities databases and existing mapping and literature.

Extant native vegetation consists of *Corymbia calophylla – Eucalyptus marginata – Banksia sps* dominated woodlands with a variable open to closed understorey consisting of numerous woody shrubs and herbaceous species. Stands of tall *Adenanthos cygnorum* shrubs dominate locally. Variation in plant community floristics and structure is related to soil type. Three communities were recognized and these relate to topographic features and substrate. Plant community health is good with peripheral weed invasion being the main disturbance. No threatened ecological communities are present. There is no indication of dieback.

A total of 183 vascular plant species were recorded: 161 species being native. A specific search was undertaken for rare and priority species. No rare or priority plant species were found during the site survey undertaken by Steven Connell.

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1.0 Introduction

1.1 Background

VDM Environmental was requested by Riverside Investments (WA) No.2 to undertake a Vegetation survey at Lot 7 Reserve Rd, Muchea (the subject site). The report has been prepared in accordance with the EPA Guidelines for Terrestrial Flora Surveys and Vegetation Surveys for Environmental Impact Assessment in Western Australia.

1.2 Objectives

The primary aims and objectives were to ascertain and determine:

- All plant species present.
- Determine and map plant communities present.
- Report on ecological values and protection needed.

1.3 EPA's Perspective

The EPA's objective for flora is to maintain the abundance, diversity, geographical distribution and productivity of flora at the species and ecosystem levels, through the avoidance or management of adverse impacts and through improvement in knowledge. The EPA has established broad principals to maintain these objectives:

- Avoid clearing
- Maintain biodiversity at sustainable levels
- Prepare and implement regional strategies for native vegation and biodiversity protection
- Conserver biodiversity in situ
- Reintroduce native vegetation
- Prevent loss of native biodiversity

2.0 Site Description

2.1 Location

Lot 7 Reserve Road, Muchea is approximately 50km north of the city of Perth within the Shire of Chittering Local Government Area. The site is to be subdivided into two separate portions of land, with the eastern portion to be subdivided for development. This report is an assessment of the eastern portion of the lot only. (Refer Figures 1 and 2).

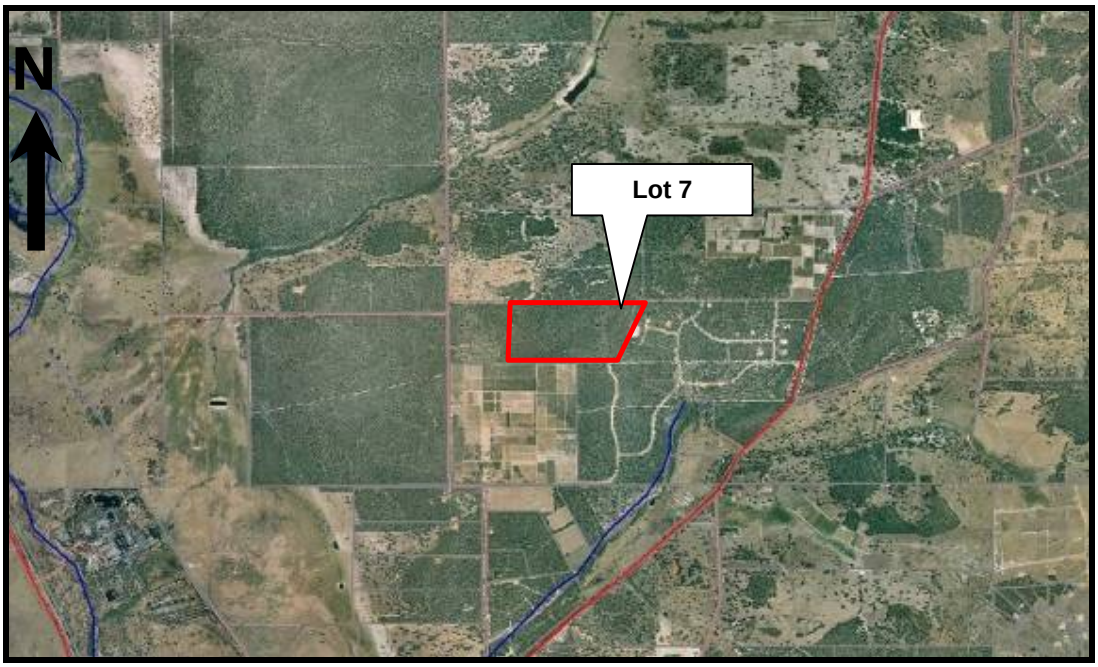


Figure 1: Aerial Photograph of Lot 7 (Wetland Base).

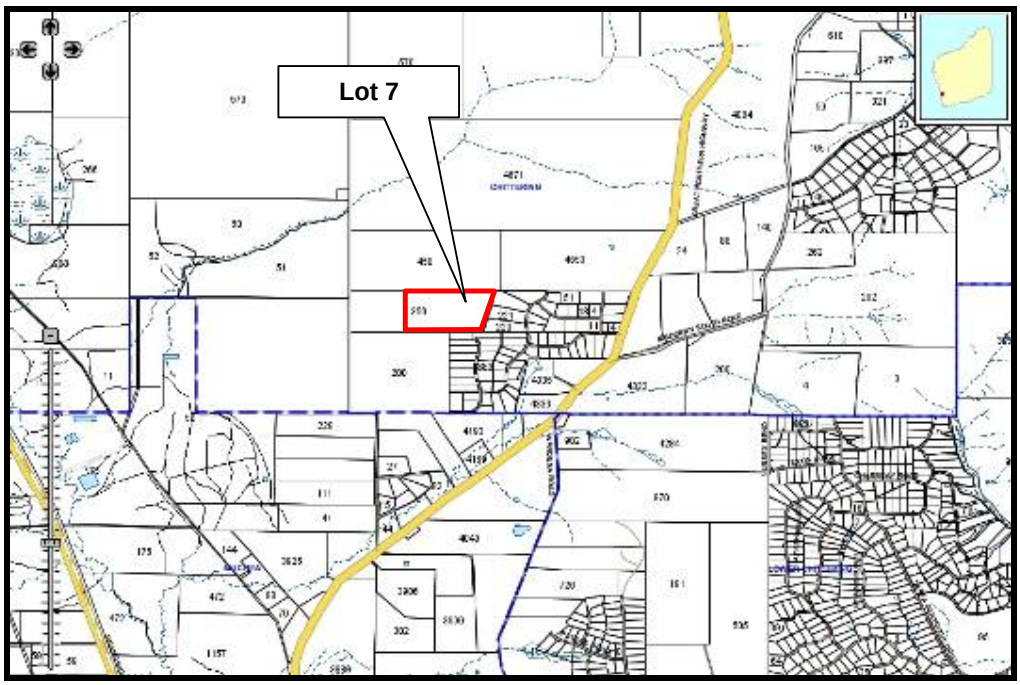


Figure 2: Cadastral Plan.

2.2 Land Use

Lot 7 occupies an area of approximately 50ha, and is classified as rural residential under the Shire of Chittering's Town Planning Scheme 8 (TPS 8). The site is densely vegetated and has no current land uses.

Surrounding land uses include a native wild flower farm to the south, rural land developments to the south and east, and semi-rural bushland to the north and west.

2.3 Landforms

Lot 7 occurs on low sand hills of the northern Swan Coastal Plain. The topography varies from approximately 140 to 165 m above sea level. A number of different soil types are mapped over the property (Table 1, Figure 3). The topographic and edaphic variation results in a mosaic of vegetation types (Refer fig 3).

2.4 Topography and Soils

Lot 7 occurs on low sand hills of the northern Swan Coastal Plain. The topography varies from approximately 140 m on the western boundary to 165 m on the eastern boundary above sea level. A number of different soil types are mapped over the property (refer Table 1).

Table 1: Land Management Units at Lot 7 Reserve Rd (Bessell-Browne unpub).

Unit	Name	Description	Soils
222Mb_1	Mogumber 1 Subsystem	Undulating broad crests and very gentle upper slopes <10% with common lateritic duricrust outcrop and shallow gravelly sands. Low woodland and shrubland of *E. todtiana* and *Acacia* spp.	Shallow gravely sands.
222Mb_4	Mogumber 4 Subsystem	Gently to moderately inclined slopes <10% with shallow gravelly sands and few areas of lateritic outcrop. Low wood-land with some *C. calophylla* and *E. marginata* also with *E. todtiana, Dryandra* spp. and *Acacia* spp..	Shallow gravelly sands.
222Mb_3	Mogumber 3 Subsystem	Gently inclined undulating slopes and minor drainage head-waters. Deep grey siliceous or bleached sands. Low wood-land and shrubland of *C. calophylla* and *Acacia* spp.	Deep grey siliceous or bleached sands.
222Mb11	Mogumber 11 Subsystem	Drainage depressions in gently sloping (<10%) plain. Duplex brown and yellow duplex soils that are often gravelly. Low woodland of *C. calophylla* and *E. wandoo* with the occasional *E.marginata, Banksia* and *Allocasuarina* spp.	Duplex brown and yellow duplex soils that are often gravelly.

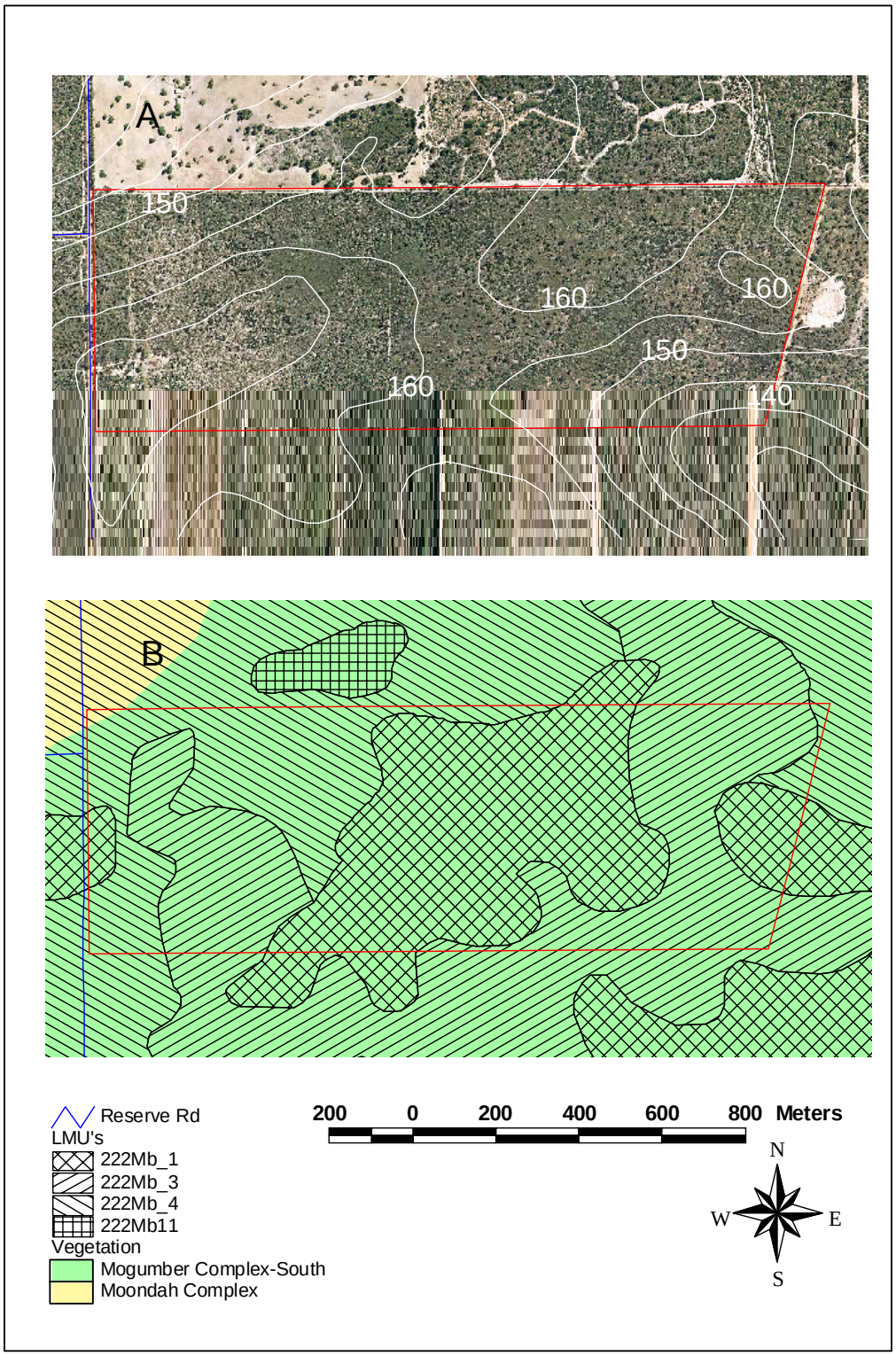


Figure 3 – Topography of Lot 7 Reserve rd

2.5 Rainfall

As part of this vegetation survey, VDM Environmental undertook a review of relevant climatic data and information obtained from the Bureau of Meteorology. Rainfall data from the climate statistics were obtained for Pearce, being 15km south and the closest measuring station to Lot 7. Most rain falls between May and September with heaviest falls during the winter months.

Relevant rainfall statistics derived for Pearce were as follows:

- Mean rainfall: 698.2 mm/year
- Dry Year (10th percentile): 498.7 mm/year
- Wet Year (90th percentile): 835.7 mm/year

3.0 Vegetation

3.1 Flora and Vegetation

Two System 6 Vegetation Complexes (Heddle *et al.* 1980) occur on the property (Table 2). Both community types are extensive in the Muchea sandplain area and neither is considered to be under immediate threat (>40% of original areas remain, del Marco *et al.* 2004, Connell 2007b). These broad complexes include a considerable variation in both structural and floristic communities (e.g. wet and dry heaths, low woodlands, outcrops etc.).

3.2 Threatened Ecological Communities

A single Threatened Ecological Community is found within a 5 kilometre search radius of the property. This community, at Iopollo Rd. Gingin Ridge, occurs on similar soil and vegetation types. It includes many species in common with those found along Reserve Rd as well as DRF and priority species. It does not occur at Lot 7 Reserve Rd.

3.3 Threatened Flora

A number of declared rare flora and conservation priority species are located in the vicinity of the property (DEC database extraction October 2007) and are found on similar landforms and vegetation complexes found on Lot 7. However there was no threatened flora identified on the site during the flora survey.

3.4 Ecological Linkages

The native vegetation present on Lot 7 forms part of an important ecological linkage between the extensive uncleared bushlands of the Gingin Ridge and the network of vegetated blocks leading to the northern Darling Scarp forests (Figure 4, Connell 2007b). The vegetation on the site is in consistently good condition with low level disturbance and is therefore a good representative of corridor number 5 (Appendix C). This ecological linkage can be maintained via the retention of vegetation outside building envelopes.

3.5 Native Flora

161 native vascular plant species were collected (Table 4). The woody plant layer was dominated by species of *Myrtaceae, Dilleniaceae* and *Proteaceae* while the ephemeral flora consisted of a range of Droseraceae, Orchidaceae and Stylidiaceae. The populations of most species were in good condition with flowering, seed set and recruitment noted.

3.6 Exotic Species

22 exotic species were identified (Table 4). Most were confined to disturbed areas and the periphery and are not threatening.

3.7 Rare and Priority Flora

A number of rare and threatened plant species are recorded for the local area and for the vegetation complex present (Connell. 2007). No priority species were detected during this flora assessment.

Table 2. Heddle et al. (1980) vegetation complexes present and their conservation status within the Shire of Chittering (Connell 2007).

Vegetation complex	Description	Pre-clearing		1999		2006	
		No. of Blocks	Area (km^2)	No. of Blocks	Area (km^2)	No. of Blocks	Area (km^2)
Mogumber South	Open woodland of *C. calophylla*, with some admixture of *E. marginata* and a second storey of *E. todtiana – Banksia attenuata – B. menziesii – B. ilicifolia*	9	130	258	58	687	52 (40%)
Moondah	Low closed and open forest of *Banksia attenuata – Banksia menziesii – Banksia prionotes – Eucalyptus todtiana* on the slopes. Open woodland of various *Banksia* spp in the valley.	6	52	92	23	227	23 (44%)

Table 3. Vegetation Community Descriptions

Name	Description	Soil
Xanthorrhoea-Eucalyptus woodland	Open woodland of *Xanthorrhoea acanthostachya – Corymbia calophylla* with occasional *Banksia sps* and *Eucalyptus marginata* above a species rich understorey.	Sandy lateritic gravel
Adenanthos shrubland	Open low woodland of *Adenanthos cygnorum* with occasional *Banksia sps., Nuytsia floribunda* and *Eucalyptus marginata/Corymbia calophylla* over a low species rich understorey.	White-grey sands.
Banksia-Eucalyptus woodland	*Banksia attenuata – Banksia menziesii – Eucalyptus marginata – Eucalyptus todtiana - Corymbia calophylla* woodland over a species rich understorey	White-grey sands

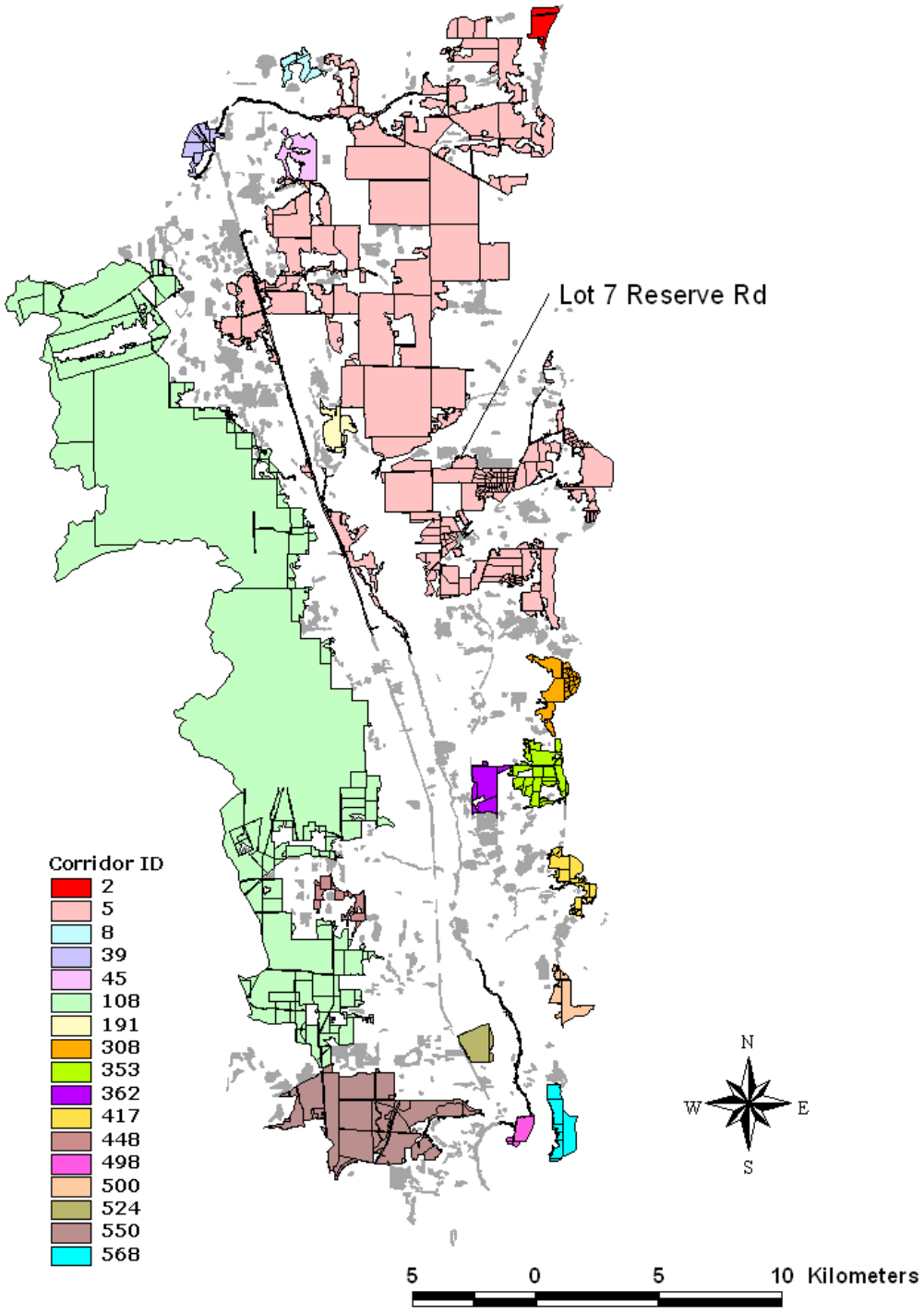


Figure 4 - Ecological linkages in the Ellen Brook Catchment

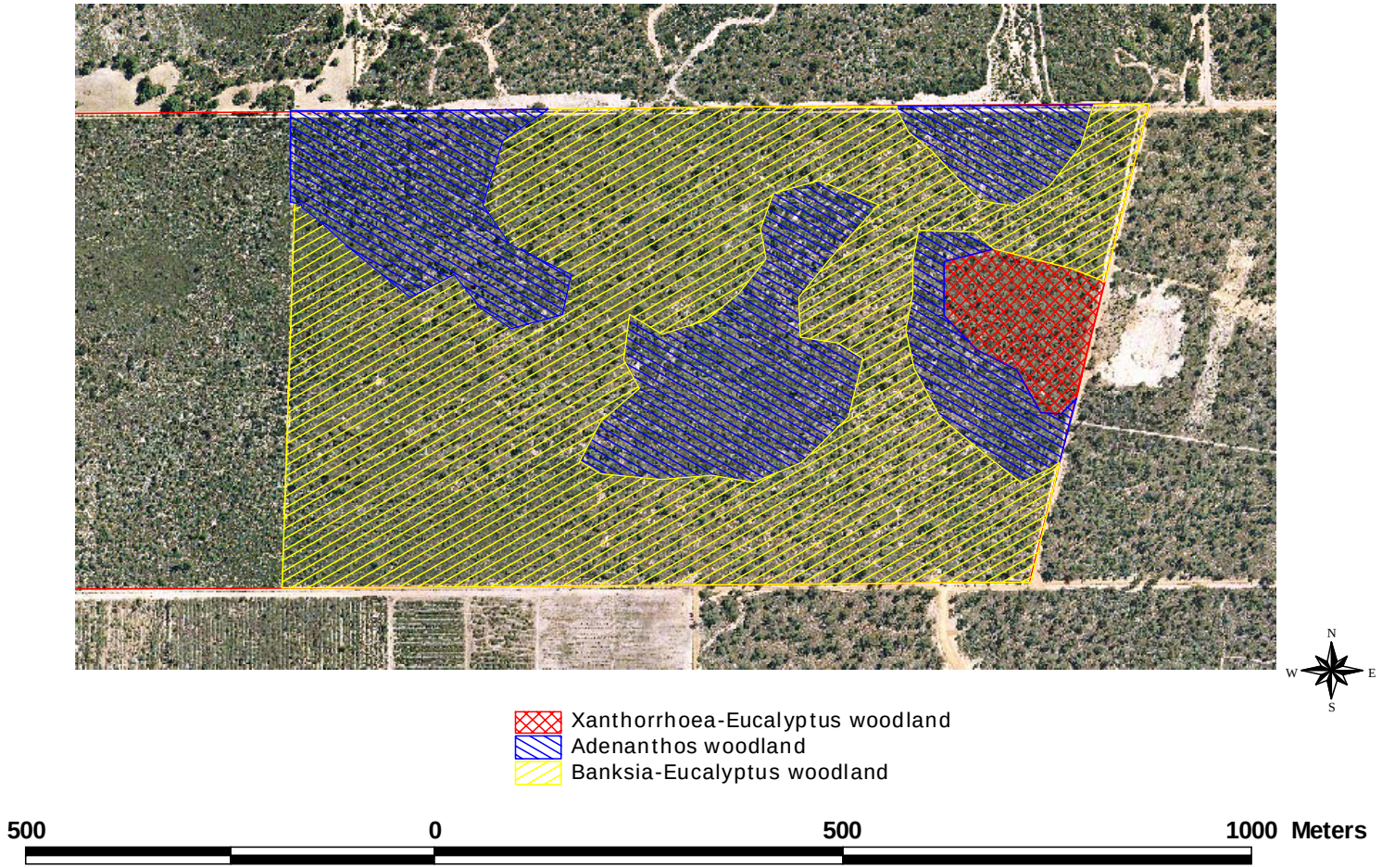


Figure 5 – Vegetation classification map

Table 4. Native plant species present, September/October 2007

Species	Author	Family
Acacia pulchella	R.Br.	Mimosaceae
Adenanthos cygnorum	Diels	Proteaceae
Agrostocrinum scabrum	(R.Br.)Baill	Antheriaceae
Allocasuarina humilis	(Otto & Dietr.) LAS.Johnson	Casuarinaceae
Andersonia lehmanniana	Sonder	Epacridaceae
Anigozanthos humilis	Lindley	Haemodoraceae
Anigozanthos manglesii	D.Don	Haemodoraceae
Aphelia brizula	F. Muell.	Centrolepidaceae
Astartea fascicularis	(Labill.)DC	Myrtaceae
Astroloma pallidum	R.Br.	Epacridaceae
Baeckea crispifolia	F.Muell	Myrtaceae
Baeckea sp. Darling Range (R.J.Cranfield 1673)		Myrtaceae
Banksia attenuata	R.Br.	Proteaceae
Banksia grandis	Willd.	Proteaceae
Banksia menziesii	R.Br.	Proteaceae
Beaufortia elegans	Schauer	Myrtaceae
Boronia ramosa	(Lind.)Benth.	Rutaceae
Bossiaea eriocarpa	Benth.	Fabaceae
Burchardia umbellata	R.Br.	Colchicaceae
Caladenia flava	R.Br.	Orchidaceae
Calandrinia linifolia	Fenzl	Portulacaceae
Calectasia cyanea	R.Br.	Dasypogonaceae
Calothamnus sanguineus	Labill.	Myrtaceae
Calytrix flavescens	Cunn.	Myrtaceae
Cartonema philydroides	F.Muell.	Commelinaceae
Cassytha flava	Nees	Lauraceae
Chamaescilla corymbosa	(R.Br.)Benth.	Antheriaceae
Conospermum stoechadis	Endl.	Proteaceae
Conostephium pendulum	Benth.	Epacridaceae
Conostephium preissii	Sonder	Epacridaceae
Conostylis juncea	Endl.	Haemodoraceae
Conostylis setigera	R.Br.	Haemodoraceae
Conostylis setosa	Lindley	Haemodoraceae
Corymbia calophylla	(Lindl.) KD Hill & L Johnson	Myrtaceae
Craspedia variabilis	Everett&Doust	Asteraceae
Crassula colorata	(Nees)Ostenf.	Crassulaceae
Cyathochaeta avenacea	Benth.	Cyperaceae
Dampiera linearis	de Vriese	Goodeniaceae
Dasypogon bromelifolius	R.Br.	Dasypogonaceae
Daviesia decurrens	Meissner	Fabaceae
Daviesia longifolia	Benth.	Fabaceae
Daviesia physodes	Cunn ex. Don	Fabaceae
Daviesia triflora	M.D. Crisp	Fabaceae
Desmocladus fasciculatus	(R.Br.)B.Briggs & L.Johnson	Restionaceae
Desmocladus flexuosa	(R.Br.)B.Briggs & L.Johnson	Restionaceae

Dianella divaricata	R.Br.	Phormiaceae
Drosera erythrorhiza	Lindley	Droseraceae
Drosera macrantha	Endl.	Droseraceae
Drosera menziesii	R. Br. ex DC	Droseraceae
Drosera paleacea	DC	Droseraceae
Dryandra bipinnatifida	R.Br.	Proteaceae
Dryandra lindleyana	Meisn.	Proteaceae
Eremaea pauciflora	(Endl.) Druce	Myrtaceae
Eucalyptus marginata	Donn ex Smith	Myrtaceae
Eucalyptus todtiana	F.Muell.	Myrtaceae
Fimbristylis velata	R.Br.	Cyperaceae
Gastrolobium spathulatum	Benth.	Fabaceae
Gompholobium confertum	(DC)Crisp	Fabaceae
Gompholobium knightianum	Lindley	Fabaceae
Gompholobium marginatum	R.Br.	Fabaceae
Gompholobium tomentosum	Labill.	Fabaceae
Grevillea pilulifera	(Lindey)Druce	Proteaceae
Grevillea synapheae	R.Br.	Proteaceae
Haemodorum paniculatum	Lindley	Haemodoraceae
Haemodorum spicatum	R.Br.	Haemodoraceae
Hakea erinacea	Meisn.	Proteaceae
Hakea ruscifolia	Labill.	Proteaceae
Hakea trifurcata	(Smith)R.Br.	Proteaceae
Hemiandra pungens	R.Br.	Lamiaceae
Hibbertia hueglii	(Endl.) F. Muell.	Dilleniaceae
Hibbertia hypericoides	(DC)Benth.	Dilleniaceae
Hibbertia subvaginata	(steudel) F. Muell.	Dilleniaceae
Hovea trisperma	Benth.	Fabaceae
Hybanthus calycinus	(DC ex Ging.) F. Muell.	Violaceae
Hypocalymma xanthopetalum	F.Muell	Myrtaceae
Hypoxis occidentalis	Benth.	Hypoxidaceae
Isopogon dubius	(R.Br.)Druce	Proteaceae
Isopogon sphaerocephalus	Lindley	Proteaceae
Isotoma hypocrateriformis	(R.Br.)Druce	Lobeliaceae
Jacksonia sternbergiana	Huegel	Fabaceae
Johnsonia lupulina	R.Br.	Antheriaceae
Kunzea ericifolia	(Smith) Heynh.	Myrtaceae
Labichea punctata	Benth.	Caesalpinaceae
Lagenophora hueglii	Benth.	Asteraceae
Lasiopetalum lineare	S. Paust	Sterculiaceae
Laxmannia squarrosa	Lindley	Antheriaceae
Lechenaultia biloba	Lindley	Goodeniaceae
Lechenaultia floribunda	Bentham	Goodeniaceae
Lepidosperma longitudinale	Labill.	Cyperaceae
Lepidosperma squamatum	Labill.	Cyperaceae
Leptomeria cunninghamii	Miq.	Santalaceae
Leucopogon glaucifolius	W.Fitz.	Epacridaceae

Leucopogon pulchellus	Sonder	Epacridaceae
Levenhookia pusilla	R.Br.	Stylidiaceae
Levenhookia stipitata	(Sonder)F.Muell.	Stylidiaceae
Lomandra micrantha	(Endl.) Ewart	Dasypogonaceae
Lomandra preisii	(Endl.) Ewart	Dasypogonaceae
Lyginia barbata	R.Br.	Restionaceae
Lysinema cilliatum	R.Br.	Epacridaceae
Macrozamia fraseri	Miq.	Zamiaceae
Melaleuca incana	R.Br.	Myrtaceae
Melaleuca seriata	Lindley	Myrtaceae
Melaleuca uncinata	R.Br.	Myrtaceae
Mesomelaena pseudostygia	(Kurek.)K.L.Wilson	Cyperaceae
Microleana stipoides	(Labill.)R.Br.	Poaceae
Millotia myosotidifolia	(Benth.)Streetz	Asteraceae
Monotaxis grandiflora	Endl.	Euphorbiaceae
Nemcia reticulata	(Mesiner)Domin.	Fabaceae
Neurachne alopecuroides	R.Br.	Poaceae
Nuytsia floribunda	(Labill.) R.Br. ex Fenzl	Loranthaceae
Orthrosanthus laxus	(Endl.) Benth.	Iridaceae
Patersonia juncea	Lindley	Iridaceae
Patersonia occidentalis	R.Br.	Iridaceae
Persoonia saccata	R.Br.	Proteaceae
Petrophile linearis	R.Br.	Proteaceae
Petrophile macrostachya	R.Br.	Proteaceae
Petrophile seminuda	Lindley	Proteaceae
Philotheca spicatus	(ARich)P.Wilson	Rutaceae
Phyllangium paradoxa	(R.Br.)Dunlop	Loganiaceae
Phyllanthus calycinus	Labill.	Euphorbiaceae
Pimelea imbricata	R.Br.	Thymeleaceae
Pimelea suaveolens	Meissner	Thymeleaceae
Podolepis gracilis	(Lehm.)R.A.Graham	Asteraceae
Podolepis lessonii	(Cass.)Benth.	Asteraceae
Podotheca angustifloia	(Labill.)Less	Asteraceae
Podotheca gnaphalioides	R.A.Graham	Asteraceae
Poranthera microphylla	Brongn	Euphorbiaceae
Pterochaeta paniculata	Streetz	Asteraceae
Ptilotus polystachyus	(Gaudich.) Muell.	Amaranthaceae
Quinetia urvillei	Cass.	Asteraceae
Rhodanthe citrina	(Benth.)Wilson	Asteraceae
Scaevola canescens	Benth.	Goodeniaceae
Scaevola fascicularis	Benth.	Goodeniaceae
Scaevola platyphylla	Lindley	Goodeniaceae
Schoenus grandiflora	(Nees) F. Muell.	Cyperaceae
Siloxeros humifusus	Labill.	Asteraceae
Sowerbaea laxiflora	Lindley	Antheriaceae
Sphaerolobium linophyllum	(Huegel) Benth.	Fabaceae
Stipa compressa	R.Br.	Poaceae

Stirlingia latifolia	(R.Br.) Steudel	Proteaceae
Stylidium adpressum	Benth.	Stylidiaceae
Stylidium amoenum	R.Br.	Stylidiaceae
Stylidium bulbiferum	Benth.	Stylidiaceae
Stylidium calcaratum	R.Br.	Stylidiaceae
Stylidium diuroides	Lindley	Stylidiaceae
Stylidium hispidum	Lindley	Stylidiaceae
Stylidium junceum	R.Br.	Stylidiaceae
Stylidium repens	R.Br.	Stylidiaceae
Stylidium schoenoides	DC	Stylidiaceae
Synaphaea gracillima	Lindley	Proteaceae
Synaphaea petiolaris	R.Br.	Proteaceae
Synaphaea spinulosa	(Burm.f.)Merr.	Proteaceae
Tetrarrhena laevis	R.Br.	Poaceae
Thysanotus manglesianus	Kunth	Antheriaceae
Trachymene pilosa	Smith	Apiaceae
Tripterococcus brunonis	Endl.	Stackhousiaceae
Velleia trinervis	Labill.	Goodeniaceae
Verticordia nitens	(Lindley)Endlicher	Myrtaceae
Verticordia densiflora var densiflora	Lindley	Myrtaceae
Xanthorrhoea preisii	Endl.	Xanthorrhoeaceae
Xanthosia pusilla	Bunge	Goodeniaceae

Table 5. Exotic plant species present, September/October 2007

Species	Author	Family
Aira cupiana	Guss.	Poaceae
Anagalis arvense	L.	Primulaceae
Arctotheca calendula	(L.) Levyns	Asteraceae
Briza maxima	L.	Poaceae
Briza minor	L.	Poaceae
Ehrarta calycina	Smith	Poaceae
Eragrostis curvula	(Schrad.) Nees	Poaceae
Erodium botrys	(Cav.)Bertol.	Geraniaceae
Gladiolus caryophyllaceus	(N.L. Burman) Poiret	Iridaceae
Hypochoeris glabra	L.	Asteraceae
Lolium perenne	L.	Poaceae
Lupinus consentinii	Guss.	Fabaceae
Narcissus tazetta	L.	Amaryllidaceae
Orobanche minor	Smith	Orobanchaceae
Oxalis corniculata	L.	Oxalidaceae
Pelargonium capitatum	(L.) L.'Her.	Geraniaceae
Petrorhagia velutina	(Guss.)Bail.&Heywood	Caryophyllaceae
Romulea rosea	(L.) Ecklon	Iridaceae
Silene gallica	L.	Caryophyllaceae
Sonchus oleraceus	L.	Asteraceae
Ursinia anthemoides	(L.) Poiret	Asteraceae
Wahlenbergia capensis	(L.)A.D.C.	Campanulaceae

4.0 CONCLUSIONS AND RECOMMENDATIONS

No declared rare flora and threatened ecological communities were found during the flora surveys conducted by Dr Steven Connell during September and October 2007. Vegetation on the site is consistently in good condition, with little evidence of weed invasion, logging and dumping of household wastes.

It is recommended that vegetation outside building envelopes is retained to maintain the ecological link mentioned in Section 3.4.

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Appendix A: Site Photographs:



South east corner of site facing north



North east corner of site facing west



North west corner of site facing south



South west corner of site facing north

Appendix B: Definition of Rare and Priority Flora Species

(Department of Conservation and Land Management, 2004)

Conservation Code	Category	Description
R	Declared Rare Flora – Extant Taxa	"Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection and have been gazetted as such."
P1	Priority One – Poorly Known Taxa	"Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey."
P2	Priority Two – Poorly Known Taxa	"Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but urgently need further survey."
P3	Priority Three – Poorly Known Taxa	"Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but need further survey."
P4	Priority Four – Rare Taxa	"Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years."

Appendix C: Criteria Used for the Field Assessment of remnant vegetation condition

Rating	Criteria
4. Very Good	Evidence of localised low level damage to otherwise healthy bush. Recruitment should be apparent. Weed and grazing damage is confined (<20% of area). Some modification to vegetation structure due to changes in fire regimes may be apparent. Little evidence of logging or fire wood collection.
3. Good	Evidence of localised high level damage to otherwise low-level damaged bush. Recruitment is localised and the populations of some species may be senescent. Weed and grazing damage is apparent in <50% of the area. Modification to vegetation structure due to changes in fire regimes may be apparent. Gall and mistletoe damage may be apparent. Evidence of logging or fire wood collection.
2. Poor	Widespread high level damage. Recruitment is disrupted and most woody species appear senescent. Weed and grazing damage may be apparent throughout the area. Modification to vegetation structure due to changes in fire regimes may be apparent. Locally some strata may be absent. Gall and mistletoe damage may be apparent. Evidence of logging or fire wood collection.
1. Very Poor	Widespread high level damage. Recruitment is disrupted and most woody species appear senescent. Weed and grazing damage may be apparent throughout the area. Modification to vegetation structure due to changes in fire regimes may be apparent. Widespread loss of vertical strata. Gall and mistletoe damage may be apparent. Evidence of logging or firewood collection.
Damage type	**Description**
High Level	Grazing (domestic and feral), logging, clearing and excavation, die-back, salinisation or other water table modification, road works, flower picking, major structures (eg. managed or fenced areas), mowing, car bodies.
Low Level	Dumping (household, garden etc.), minor structures (eg. sheds), fire wood collection, weed infestation, modified fire regime.

LEGEND

Good Condition Vegetation

Low Level Disturbance

NUM	NOTE	DRN	DATE
NUM	NOTE	DRN	DATE
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VERTICAL	VSCALE	DRAWN	BBB
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Riverbank Investments Pty Ltd

Proposed Rural Residential Development
Lot 2 Reserve Road, Chittering

Basic Ecological Assessment

Issue No. 1
22 December 2005

Prepared for:
Riverbank Investments Pty Ltd

Prepared By:
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Report Details:

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Author(s):	Gemma Connolly
Status:	Issue No. 1 - *Final*
Client:	Riverbank Investments Pty Ltd
Client Contact:	Andrew van der Meer
Synopsis:	This report presents the Basic Ecological Assessment for a proposed rural residential development. It has been developed in accordance with the Shire of Chittering Town Planning Scheme No. 6.

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Disclaimer and Limitations

- The information contained within this report is provided in good faith in the belief that no information, opinions or recommendations made are misleading.

- All comments and opinions given in this report are based on a limited survey of the study site or on information supplied by the client, his agents and third parties.

- Assessments of site biology, ecology and the extent and nature of impacts of and to this study site is limited within the terms of reference stated within this report, and by the limited timeframe of study. Therefore the results presented herein cannot be considered absolute or conclusive without additional long-term follow-up studies.

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1.0 INTRODUCTION

Belleng VDM Pty Ltd were commissioned by Riverbank Investments Pty Ltd to prepare a Basic Ecological Assessment for a Proposed Residential Development of Lot 2 Reserve Road, Chittering (the subject site).

1.1 Objectives

The objectives of the Basic Ecological Assessment are:

- Mapping of existing vegetation types, topographical features, existing infrastructure etcetera.
- Basic assessment of ecological features including location of expected and known significant flora, fauna and habitat, location of poorly conserved ecosystems, significant weed infestations, all water bodies and drainage lines, location and tenure of conservation reserves and location of areas subject to Voluntary Conservation Agreements.
- Basic assessment of ecological functions, including core habitat areas, ecological corridors and buffer areas.
- Basic assessment of impacts of the development on the conservation of Ecologically Significant Areas, Fauna, Buffers and Ecological Corridors.
- Provide recommendations to mitigate the impact of development on ecological features and functions.
- Propose any additional management plans required to conserve ecologically significant areas identified in the study area.

1.2 Methodology

Owing to the large area of the site, survey methodology for flora and fauna comprised a random walk over through vegetated areas. Cleared areas were not surveyed.

Vegetation communities are described in accordance with the standard descriptions listed by the Water and Rivers Commission (Natural Resource Management Plan and status as gazetted under the Wildlife Conservation Notice 2005 (*Wildlife Conservation Act 1950*)).

Fauna was identified through on-site identification and observation of scats, scratchings, burrows and vocalizations. Habitat quality was also assessed throughout the surveyed areas. The survey was performed in December 2005; conditions comprised relatively warm temperatures with no rain experienced on the day of the survey or days prior to the survey.

1.3 Site Location

The subject site is located on Lot 2 Reserve Road, Chittering. Reserve Road is situated west of Great Northern Highway, at the southern end of the Shire of Chittering (see Figure 1.1).The site is bounded to the south and west by Reserve Road and to the north by rural residential lots.

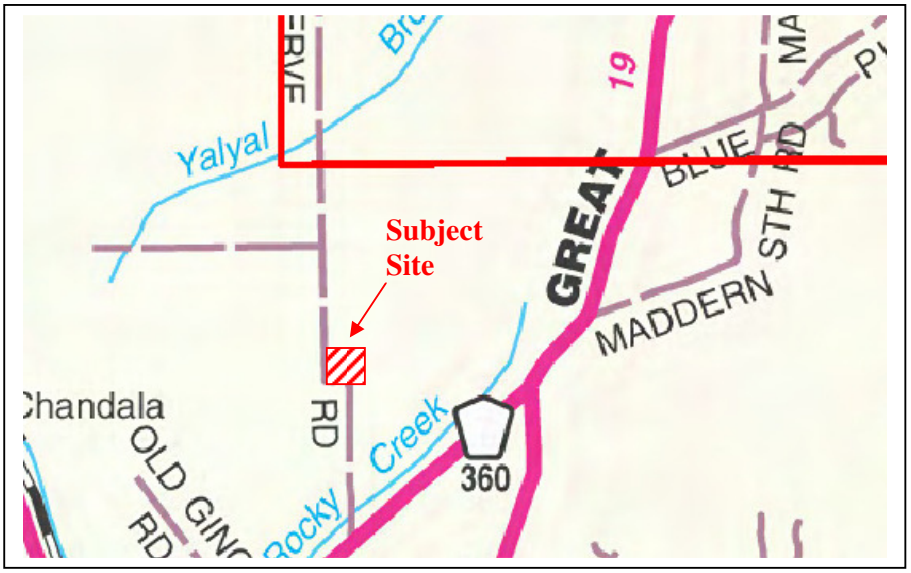


Figure 1.1: Site Locality (UBD Extract)

1.4 Proposed Development Summary

Riverbank Investments Pty Ltd propose to develop the site into 110 lots approximately 1ha in size with one area of Public Open Space (3901m^2) in the north-western corner. The housing will be low density, rural residential focusing on a rural lifestyle theme. Access to the development will be via a subdivisional loop road connecting to Reserve Road.

2.0 STAGE 1A: BASIC ASSESSMENT OF ECOLOGICAL FEATURES

2.1 Site Description

Existing vegetation communities, topographical features and infrastructure are mapped on Figure 2.1.

2.1.1 General Features

The site is situated on the Dandaragan Plateau east of the Darling Scarp, in the Brockman River Catchment, 20km south west of the Bindoon townsite. Rocky Creek is located approximately 750m south of the site flowing in a south-west direction. The site slopes gently to the east from a maximum of 165m AHD in the northwest corner to 150m AHD in the southeast corner. A gravel pit exists in the northwest corner of the site. The removed gravel from the pit has been spread over vehicle tracks.

2.1.2 Land Use

The site is currently utilised as a wildflower nursery operating for over 20 years. The site is heavily cleared and highly disturbed by weeds. The plantations include a mosaic of Geraldton wax, Kangaroo paw, Olive trees, Wandoo and Banksias. A residential home is located at the entrance of the site on the southern boundary. Large packing sheds are located to the east of the entrance and home. Firebreaks run along the perimeter of the site boundary. Surrounding landuses include rural residential lots, rural retreat (native vegetation) and limited horticulture.

2.1.3 Planning Scheme

Under the Shire of Chittering Planning Strategy the vegetation in the northern section of the site has been mapped as *Vegetation Protection Area* (Local Planning Strategy Map 2001-2015). This category aims to enhance rural amenity. The proposed management objectives for areas mapped as *Vegetation Protection* is to limit clearing, felling or removal of vegetation to:

a) vegetation that is dead, diseased or poses a danger to humans or stock,

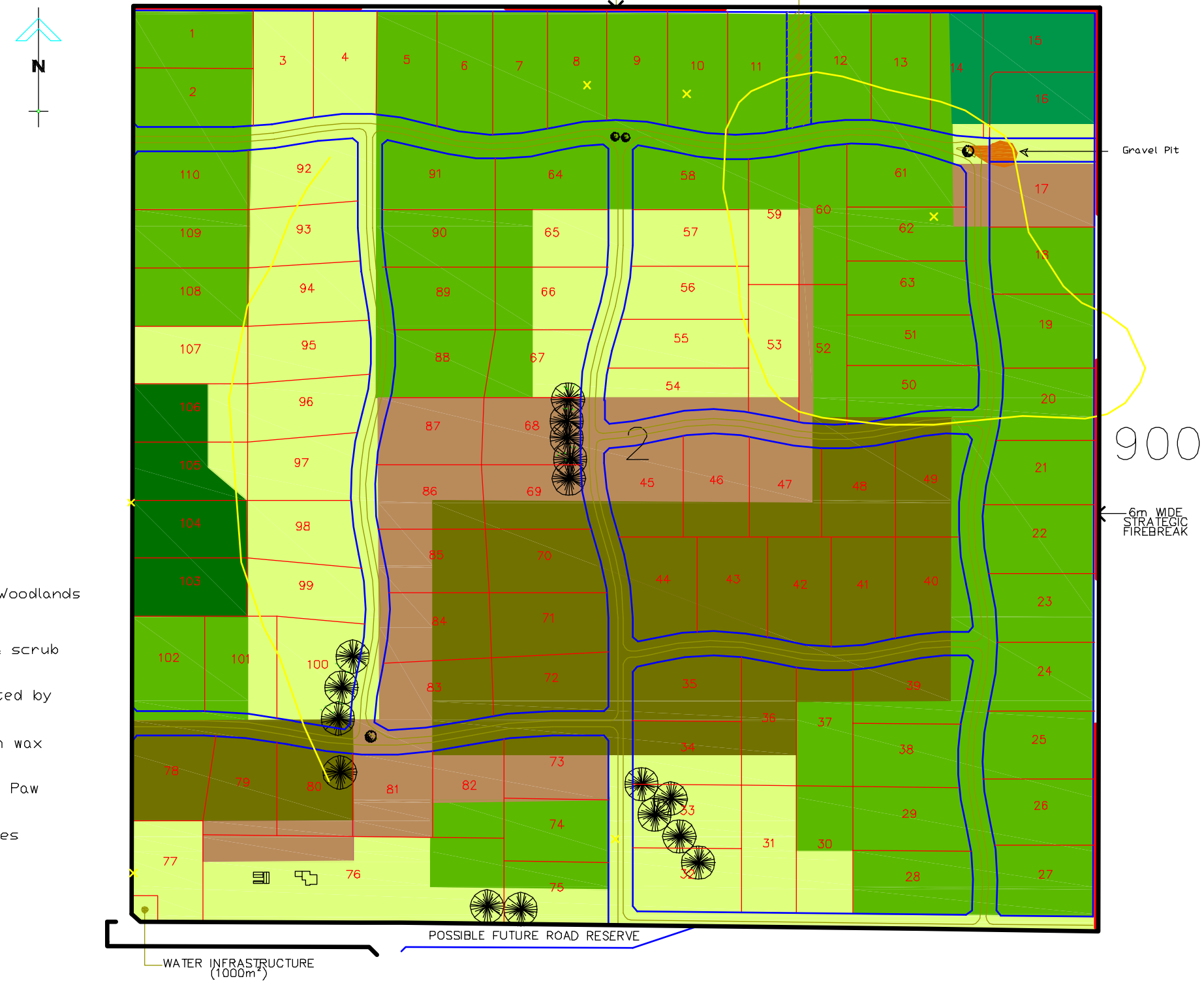
b) clearing required by law for firebreaks,

c) clearing for the purpose of access to a dwelling or outbuildings;

d) clearing within a defined building envelope and limited to that area;

e) *clearing necessary for the construction of a dwelling, outbuildings and area 20m wide surrounding the dwelling for the purpose of bush fire protection.*

Attachment 1



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2.2 Vegetation

Figure 2.1 shows vegetation communities and other ecological features and functions identified at the subject site. A full plant species list for the site is given in Appendix 1. Sections 2.2.1-2.2.3 below summarise the characteristics and structure of vegetation communities identified at the site; predominately a mosaic of planted vegetation that is highly disturbed by weedy grasses. Refer to figures 2.2-2.6.

2.2.1 Scrub-heath and Plantation Banksia Woodlands

Dense plantation Banksia woodlands up to 3m in height are growing in a mosaic across the site in between Kangaroo paw and Geraldton wax. The Banksia woodlands are situated in pockets with dense scrub-heath and a number of sparse larger Blackbutt that have Diameter at Breast Height (DBH) of 30-40cm. One Blackbutt in the southern entrance has a DBH of approximately 50cm. The mosaic of vegetation is highly disturbed by weed species.

Canopy: Scattered *Eucalyptus todtiana*, *E. macrocarpa,* common *Nuytsia floribunda*, and one *E. gomocephala*.

Understorey: Dominated by closed plantation Banksia woodland including *Banksia prionotes*, *B. sphaerocarpa*, *B. speciosa*, *B. grandis*. Frequent *Xanthorrhea priessi*. Shrubs interspersed include *Acacia saligna*, *Adenanthos cygnorum, Conospermum stoechadis, Jacksonia* sp. Dominant small shrubs include *Hemiandra linearis*, *Hibertia hypercoides*, *Thysanotus tuberosus, Verticordia picta*. Grass *Ptilotus polystachyus*. Plantations include *Anigozanthos manglesii*, *Anigozanthus flavidus*, *Chamelaucium ulcinatum*, and small section of *Olea europaea* in northwest corner. Exotic weeds of low species diversity include *Carpobrotus edulis, Chamaecytisus palmensis, Hypochaeris radicata*, *Hypochaeris radicata, Pelargonium capitatum*.

Groundcover: Ground layer covered in leaf litter, Herb *Scaveola* sp.

2.2.2 Scrub-heath and Costal Blackbutt

A section on the western boundary of the site is dominated by dense scrub heath and scattered Coastal Blackbutt up to 3m height and DBH of 20cm.

Canopy: Scattered *Eucalyptus patens* and *Nuytsia floribunda.*

Understorey: Open understorey dominated by larger shrubs *Adenanthos cygnorum, Allocasuarina* sp, *Dryandra* sp and *Xanthorrhea priessi.* Dense shrubs to 40cm with moderate species diversity including; *Conospermum stoechadis*, *Daviesia pachyphylla, Eremaea beaufortioides, Eremaea brevifolia, Isolepis* sp, *Isopogen dubias, Melaleuca gibbosa*, *Petrophiel linearis, Synaphea* sp, *Verticordia chrysantha, Verticordia picta*.

Groundcover: The ground layer is open with a dense covering of leaf litter.

2.2.3 Stand of Marri – Wandoo Plantation

Rows of 6-10 planted Wandoos running in a north south direction intersect the sections of Geraldton wax, Banksia heath and Kangaroo paw. Height 4-5m and DBH of 20cm. A small stand of large Red gum are situated in the southern section of the site near the packing shed.

Canopy: Row of *Eucalyptus wandoo*. Stand of Red Gum *E. calophylla.*

Understorey: Plantation includes *Anigozanthus flavidus, Anigozanthos manglesii* and *Chamelaucium ulcinatum.*

Groundcover: The ground layer is open with limited leaf litter or groundcover.



Figure 2.2: Plantation Banksia Woodland



Figure 2.3: Eastern section of site, Common Woolly Bush, Grass Tree and Round-leaved Eremea



Figure 2.4: Central section of site, Geraldton Wax in foreground, Blackbutt and Kangaroo Paw in background



Figure 2.5: Scrub Heath and Coastal Blackbutt



Figure 2.6: Large Blackbutt at southern entrance

2.3 Known and Expected Fauna

2.3.1 Basic Site Survey

A list of expected and known fauna identified during a basic fauna survey of the site is given in Table 2.1 below. Fauna were identified through on-site identification and observation of scats, scratchings, burrows and habitat types. The survey was conducted on the 8th December 2005, being partly cloudy, mild temperatures of 23 degrees and west- south- westerly winds.

Table 2.1: Fauna species identified at the subject site

Family	Genus and Species	Common name	Status*	Method**
Aves (Birds)				
Artamidae	*Gymnorhina tibicen*	Australian Magpie	-	O
Corvidae	*Corvus cornoides*	Australian Raven	-	O
Grallinidae	*Grallina cyanoleuca*	Magpie Lark	-	O
Meliphagidae	*Phylidonyris novaehollandiae*	New Holland Honeyeater	-	O
Meliphagidae	*Phylidonyris nigra*	White Cheeked Honeyeater	-	O
Meliphagidae	*Lichmera indistincta*	Brown Honeyeater	-	O
Psittacidae	*Barnardius zonarius*	Port Lincoln Parrot ('28')	-	O
Rhipiduridae	*Rhipidura leucophrys*	Willie Wagtail	-	O
Mammals				
Macropodidae	*Macropus fulignosus*	Western Grey Kangaroo	-	S

****Primary Method of identification**
C = Hand Caught, H = Heard, O = Observed, T = Trapped, S = Other Signs of Presence (scats, traces etc).

2.3.2 Fauna of the Brockman Catchment

A search of Western Australian Museum records and observations in the catchment area, listed 186 bird, 24 mammal, 15 amphibian, 49 reptile, 6 fish and 3 crustacean species as having been recorded in the Brockman River Catchment, covering 1520km^2, as listed in Appendix 2 of this report (Water and Rivers Commission, 2003).

2.4 Significant Species

2.4.1 Significant Flora

No species of state, federal or local significance were identified during the site survey.

2.4.2 Significant Fauna

The following significant species are known or expected in the Brockman River Catchment area, as identified in Section 2.3 above, are summarised in Table 2.2 below.

Table 2.2: Expected and Known Significant Fauna Species in the Brockman River Catchment

Scientific name	Common name	Family	Observed/ Expected	Significance	Likelihood of occurrence at the site
Bettongia penicilliata	Woylie	Potoroidae	Expected	*Schedule 4 WCA	Unlikely. Woylie are found predominantly in the shrubby understorey of dry eucalypt forest and woodlands. The site does not support any areas, which would be suitable for this species.
Dasyurus geoffroyii	Chuditch	Dasyuridae	Expected	*Schedule 1 WCA V & V IUCN	Unlikely. This species requires dense scrub/bush jarrah or mallee ecosystems (no areas of dense vegetation exist on the property). There are also few mature trees that are capable of supporting hollows for den sites.
Isooden obesulus fusciventor	Quenda	Peramelidae	Expected	*Schedule 4 WCA	Unlikely. Although this species is common in areas of banksia woodland on the Swan Coastal Plain, the banksia woodlands on site are isolated.
Macropus eugenii	Tammar Wallaby	Macropodidae	Expected	*Schedule 4 WCA	Unlikely, as this species is usually found in scrub or semi desert habitats.
Pseudemydura umbrina	Western Swamp Tortoise	Chelidae	Expected	*Schedule 1 WCA C & Endangered IUCN	Unlikely, as the site does not contain any winter wet depressions. This species has only been re-introduced in a few select locations at Mogumber.
Trichosurus vulpecula	Brush-tailed Possum	Petauridae	Expected	*Schedule 4 WCA	Unlikely. Although brush tailed possums occur in a variety of habitats, the scattered areas of wandoo occurring on the site are not capable of supporting a population of this species (due to a lack of hollows for den sites)

Significance-
WCA= As listed in the Wildlife Conservation (Specially Protected Fauna) Notice 2005 (Wildlife Conservation Act 1950).
Schedule 1= fauna that is rare or likely to become extinct- in need of special protection.
Schedule 2= fauna presumed to be extinct.
Schedule 3= birds that are subject to an agreement between the governments of Japan and Australia for the protection of migratory birds and birds in danger of extinction.
Schedule 4= fauna that is in need of special protection, otherwise than for the reasons outlined for schedules 1, 2 and 3. (Conservation dependant)

*= As listed under the Natural Resource Management Plan for the Brockman River Catchment.
EPBC =As listed in the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act).
CE*= Critically endangered, E*= Endangered, V*= Vulnerable, CD*= Conservation dependent, I = introduced species

IUCN = As listed under the International Union for Conservation of Nature and Natural Resources.
EX=Extinct, EW= Extinct in the Wild, CR=Critically Endangered, EN=Endangered, VU=Vulnerable, NT=Near Threatened, LC=Least Concern.

2.5 Significant Fauna Habitats

No significant habitat areas were identified during the basic fauna survey. One Blackbutt (*Eucalyptus todtiana)* at the southern entrance of the site had a DBH of approximately 50cm. Trees with DBH of over 50cm are considered over 100 years old and begin to hollow out forming habitats for native fauna. Due to the isolation of the tree it is unlikely to be used as habitat for the significant or other fauna identified in Sections 2.3.1 and 2.4.2.

2.6 Significant Weed Infestations

A basic ecological assessment of the site identified no weed species listed as Declared Plants of Western Australia under the *Agricultural and Related Resources Protection Act 1976.*

A number of non-declared weed species were identified during the survey as summarised in the table below (refer to Appendix 1). Non declared weed species include those that are environmental weeds not locally endemic, such as species used in agriculture and landscaping.

Table 2.3: Non declared weeds on site

Botanical Name	Family	Common Name
Carpobrotus edulis	Aizoaceae	Pigface
Chamaecytisus palmensis	Papillionaceae	Tagasaste
Hypochaeris radicata	Asteraceae	Flatweed
Pelargonium capitatum	Geraniaceae	Rose Pelargonium
Watsonia meriana	Iridaceae	Watsonia

Pigface, Watsonia and a number of exotic grasses occurred in large infestations across the site. Pigface is predominately growing in the north of the site and Watsonia in the south. The remainder of the species listed do not occur in large numbers and are present as isolated individuals scattered throughout the site.

2.7 Wetlands, Water bodies and Drainage Lines

No wetlands, water bodies or drainage lines were identified on site as indicated on Chittering Local Planning Strategy Map 2001-2015.

2.8 Conservation Reserves and Voluntary Conservation Agreements

No Conservation reserves (for example National Parks, Protected Areas or Environmental parkland) as identified on the Town Planning Scheme Map are located on or adjacent to the subject site (Town Planning Scheme Map 3). No parts of the site are subject to a Voluntary Conservation Agreement.

3.0 SUMMARY OF RELEVANT LEGISLATION

3.1 Federal Legislation – Environmental Protection and Biodiversity Conservation Act

No species listed as Endangered/Vulnerable under the Commonwealth Environmental Protection and Biodiversity Conservation Act were identified during the site survey.

3.2 Western Australian Environmental Protection Act

No species listed as Endangered/Vulnerable/Rare under the Western Australian *Environmental Protection Act* were identified during the site survey.

Under the *Environmental Protection Amendment Act 2003* new legislation relating to land clearing will require permits to remove native vegetation over 1ha or where it is not for an exempt purpose. No portions of vegetation on the subject land is mapped as *Environmentally Sensitive Area* as depicted on the Native Vegetation Map Viewer, on Department of Environment's (DoE) website dated 5th December 2005. However the removal of mature native trees on site will require a clearing permit from the DoE, unless found exempt during the application process.

3.3 Wildlife Conservation Act

No species listed as Threatened under the Wildlife Conservation (Specially Protected Fauna) Notice 2005 (*Wildlife Conservation Act 1950*) were identified during the site survey.

3.4 Shire of Chittering Council

3.4.1 Land Management

Developments in the Shire of Chittering require land management by the landowner which can be summarised as;

(a) replanting and remedial works for environmental protection and regeneration of vegetation, using endemic local species;

(b) preventing degradation of the land or vegetation;

(c) minimising vegetation disturbance during earthworks;

(d) minimising soil tillage, and controlling dust and emissions;

(e) employing stormwater management

(f) fire control; and

(g) minimising the spread of Jarrah dieback.

To address these requirements an Environmental Management Plan is recommended. The EMP will support the Outline Development Plan submitted to Council for approval.

4.0 STAGE B: BASIC ASSESSMENT OF ECOLOGICAL FUNCTIONS

Figure 2.1 provides a summary of the ecological functions of the subject site.

4.1 Core Habitat

Basic ecological assessment of the subject site indicates that existing vegetation at the site is isolated therefore unlikely to provide core habitat for the significant fauna species listed in Table 2.2.

4.2 Ecological Corridors

Due to its isolation the remaining vegetation on the subject site is unlikely, in its current state, to have any functional role as a corridor or linkage for significant flora or fauna.

4.3 Buffer Areas

The vegetation on the subject site does not function as a buffer for any larger native vegetation communities.

4.4 Other Ecological Functions

The intermittent rows of plantation Wandoo are habitat to a large variety of insects that are frequented by insectivorous birds. The Blackbutt at the southern entrance of the site is frequented by Port Lincoln Parrot who feed on the flowers and the plantation Banksia woodlands is frequented by honeyeaters; Brown Honeyeater, New Holland Honeyeater, White Cheeked Honeyeater who feed on the nectar. Once fully mature, the Wandoo and Blackbutt have the potential to bear hollows, which may be used by a variety of bird species.

5.0 STAGES 2 & 3: BASIC ASSESSMENT OF ECOLOGICALLY SIGNIFICANT AREAS AND IMPACTS

Table 5.1 summarises the ecologically significant areas identified at the subject site and lists potential impacts on these areas resulting from the proposed development in addition to requirements for maintaining ecological viability of these areas.

Table 5.1: Summary of Ecologically Significant Areas, Requirements and Impacts of Proposed Development

Location	Description	Significance	Requirements for maintaining viability	Impacts of Development
Scattered throughout the site	Mature Blackbutt, Wandoo and Red Gum	Marginal habitat for insectivorous and honey eating - nectar feeding birds. Also provides visual amenity.	Retain existing large trees where possible and incorporate into landscaping or lots.	The proposed development is still in the preliminary stages but covers the areas where Blackbutt tree(s), Wandoos and Red Gums are located. Their removal will result in the loss of a number of bird foraging trees on the site.

6.0 STAGE 4: RECOMMENDATIONS

The proposed development involves the subdivision of the site into 1 ha lots with a loop access road. Establishment of residence and roads are unlikely to further impact on the highly disturbed vegetation. However individual Blackbutt, Wandoo and Red Gum will provide future habitat and foraging for birds and arboreal mammals connecting to surrounding vegetation.

The adjacent rural retreat to the west and vegetation surrounding the north and east of the site are best served by artificial biodiversity corridors along roadsides allowing the movement of fauna through the development. To enhance the ecological viability of the corridors mature trees will be retained where possible. Retaining vegetation and creating artificial roadside corridors will also provide visual amenity to the rural lifestyle development.

Within the proposed lots, in the northeast corner of the site, an area of Public Open Space (POS), 3901m^2 has been provided as fauna habitat, drainage basin, buffer and linkage to surrounding native vegetation. The POS is included in the supplementary planting of the roadside corridors. All logs will be retained where possible to provide new fauna habitats.

Supplementary planting of the POS and roadside corridors should adhere to a Landscape Plan and as a minimum the following conditions;

- Experienced and qualified personnel with knowledge of local and exotic species identification should carry out all revegetation work.
- Plants used for revegetation must be exclusively those listed in the Landscape Plan that will be developed for the site. However not all plants may be horticulturally available at the time of planting. Despite this, every effort should be made to use a diverse mix of species and life form types.
- Supplementary planting should take into account site suitability for natural regeneration and must not be conducted in such a way as to cause damage to naturally regenerating plants.
- Supplementary planting should take into account the existing species composition, for example, in areas with good canopy cover but degraded lower strata, ground cover and understorey species are to form the predominant part of the revegetation planting. In some instances woody weeds may be retained to shade out other weeds and allow a native ground cover to establish. These species should be removed once native species are established.
- Planting should be carried out during suitable weather conditions to minimise the risk of loss of newly establishing plants through drought.
- The retained vegetation is to be weeded and revegetated
- Green plastic tree guards to be installed around seedlings where necessary

Prior to construction works, to minimise the risk of environmental damage, all personnel involved in construction activities including transient deliverers and other associated contractors and builders shall be briefed on all aspects of the environment related to their activity and their compliance to the stated protection measures is to be demanded including dust control and prevention of jarrah dieback.

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APPENDICES

APPENDIX 1: PLANT SPECIES LIST

APPENDIX 2: FAUNA LIST EXTRACTED FROM NATURAL RESOURCES MANAGEMENT PLAN

Appendix 1

Plant Species List

Flora List – Reserve Rd, Chittering

Native Plants by Genus

Botanical Name	Family	Common Name
Acacia saligna	Mimosaceae	Orange Wattle
Adenanthos cygnorum	Proteaceae	Common Woollybush
Allocasuarina sp.	Casuarinaceae	
Anigozanthus flavidus	Haemodoraceae	Tall Kangaroo Paw
Anigozanthos manglesii	Haemodoraceae	Mangles Kangaroo Paw
Anigozanthus pulcherrimus	Haemodoraceae	Yellow Kangaroo Paw
Banksia grandis	Proteacea	Bull Banksia
Banksia prionotes	Proteceae	Acorn Banksia
Banksia speciosa	Proteaceae	Showy Banksia
Banksia sphaerocarpa	Proteaceae	Round- fruit Banksia
Beaufortia squarrosa	Myrtaceae	Sand Bottlebrush
Chamelaucium ulcinatum	Myrtaceae	Geraldton Wax
Conospermum stoechadis	Proteaceae	Common Smokebush
Conostylis sp.	Haemodoraceae	
Dasypogon bromeliifolius	Dasypogonaceae	Pineapple Bush
Daviesia pachyphylla	Papillionaceae	Ouch Bush
Dryandra sp.	Proteaceae	
Eremaea beaufortioides	Myrtaceae	Round Leaved Eremea
Eremaea brevifolia	Myrtaceae	
Eucalyptus calophylla	Myrtaceae	Red Gum
Eucalyptus gomphocephla	Myrtaceae	Tuart
Eucalyptus macrocarpa	Myrtaceae	Mottlecah
Hemiandra linearis	Lamiaceae	Speckled Snakebush
Hibbertia hypericoides	Dilleniaceae	Yellow Buttercups
Isolepis sp.	Cyperaceae	
Jacksonia floribunda	Papillionaceae	Holly Pea
Melaleuca gibbosa	Myrtaceae	Slender Honey-myrtle
Nuytsia floribunda	Loranthaceae	Christmas Tree
Olea europaea	Oleaceae	Olive Tree
Patersonia occidentalis	Iridaceae	Purple Flag
Petrophile linearis	Proteaceae	Pixie Mops
Ptilotus polystachyus	Amaranthaceae	Prince of Wales Feather
Scaevola sp.	Goodeniaceae	
Synaphea sp.	Proteaceae	
Thysanotus dichotomus	Anthericaceae	Branching Fringe Lily
Verticordia chrysantha	Myrtaceae	
Verticordia picta	Myrtaceae	Painted Featherflower
Xanthorrhoea preisii	Xanthorrhoeaceae	Grass Tree

Exotic Species by Genus

Botanical Name	Family	Common Name
Watsonia meriana	Iridaceae	Watsonia
Hypochaeris radicata	Asteraceae	Flatweed
Pelargonium capitatum	Geraniaceae	Rose Pelargonium
Carpobrotus edulis	Aizoaceae	Pigface
Chamaecytisus palmensis	Papillionaceae	Tagasaste

Appendix 2

Fauna list extracted from Natural Resources Management Plan

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Priority Species	Conservation code
Persoonia sulcata	3
Petrophile plumosa	3
Synaphea grandis	3
Acacia clydonophora	4
Boronia tenuis	4
Calytrix sylvana	4
Dryandra polycephala	4
Grevillea drummondii	4
Hydrocotyle lemnoides	4
Schoenus natans	4
Verticordia lindleyi subsp. *lindleyi*	4
Verticordia paludosa	4
Lysinema elegans	C

Typical flora in the Brockman River catchment

Jarrah forest		
Botanical name	**Common name (if known)**	**Notes**
Allocasuarina fraseriana	sheoak	small tree
Banksia grandis	bull banksia	small tree
Eucalyptus accedens	powerbark wandoo	tree, some sites only
Corymbia calophylla	marri	tree, usually <50% of tree cover
Eucalyptus marginata	jarrah	dominant tree
Eucalyptus patens	blackbutt	tree, some sites
Eucalyptus wandoo	wandoo	trees, some sites
Grevillea wilsonii	native fuchsia	shrub
Personnia longifolia	snottygobble	small tree
Marri-wandoo		
Corymbia calophylla	marri	tree
Eucalyptus wandoo	wandoo	tree
Eucalyptus laeliae	Darling Range ghost gum	tree
Xanthorrhoea preissii	grasstree	small tree
Macrozamia riedlei	samia	small tree
Nuytsia floribunda	Christmas tree	small tree
Dryandra sessilis	parrot bush	tall shrub
Daviesia horrida	prickly bitter pea	tall shrub
Hakea cristata	snail hakea	tall shrub
Hakea trifurcata	two-leaf hakea	tall shrub
Acacia pulchella	prickly Moses	small shrub
Dryandra nivea	couch honeypot	small shrub
Hibbertia hpericoides	yellow buttercups	small shrub
Hibbertia montana		

Jarrah- wandoo – powerbark		
Botanical name	**Common name (if known)**	**Notes**
Acacia acuminata	jam	small tree in drier eastern areas
Acacia varia var. *affinis*		large shrub
Adenanthos cygonorum	common woollybush	large shrub
Allocasuarina fraseriana	sheoak	small tree
Allocasuarina humilis	dwarf sheoak	large shrub
Anigozanthos humilis	catspaw	herb
Anigozanthos mangelisii	Mangle's kangaroo paw	herb
Astroloma pallidum	kickbush	small shrub
Baeckea crispiflora		small shrub
Banksia grandis	bull banksia	small tree
Bossiaea armata		small shrub
Bossiaea eriocarpa	common brown pea	small shrub
Burchardia umbellata	milkmaids	herb
Calothamnus quadrifidus	one sided bottlebrush	tall shrub, drier eastern parts
Calothamnus sanguineus	pindak	large shrub
Calytrix brachyphylla		small shrub
Calytrix sappirina		small shrub
Chorizema dicksonii	yellow-eyed flame pea	small shrub
Comesperma volubile	love creeper	creeper
Conospermum densiflorum	common smokebush	small shrub
Conospermum glumaceum	hooded smokebush	small shrub
Conostylis setosa	white cottonhead	herb
Darwinia sp.		
Daviesia divaricata	marno	large shrub
Daviesia pectinata	prickly bitter pea	large shrub
Dianella revoluta	blueberry lily	herb
Dillwynia cinerascens	grey parrot-pea	small shrub
Dryandra polycephala	many-headed dryandra	large shrub
Dryandra nivea	couch honeypot	small shrub, wetter western part
Dryandra sessilis	parrot bush	tall shrub, wetter western parts
Eucalyptus accedens	powderbark wandoo	tree in drier eastern parts
Eucalyptus marginata	jarrah	occasional, western parts
Eucalyptus patens	Swan River blackbutt	tree, in some valleys
Eucalyptus wandoo	wandoo	tree, wetter western parts
Gastrologium spinosum	prickly poison	medium shrub, drier eastern parts
Gastrolobium villosum	crinkle-leaved poison	small shrub
Gompholobium knightianum		small shrub
Grevillea synapheae	catkin grevillea	small shrub
Grevillea pilulifera	woolly-flowered grevillea	large shrub
Haemodorum sp.		herb
Hakea ruscifolia	candle hakea	large shrub
Hakea lissocarpha	honey bush	large scrub
Hakea cristata	thick leaved hakea	tall shrub, wetter eastern parts
Hakea undulata	wavy-leaved hakea	tall shrub, wetter eastern parts
Hakea trifurcata	two leaved hakea	tall shrub, wetter eastern parts

Botanical name	Common name (if known)	Notes
Hibbertia hypericoides	yellow buttercups	small shrub, wetter eastern parts
Hibbertia montana	mountain primrose	small shrub, wetter eastern parts
Hibbertia lasiopus	large hibbertia	small shrub
Kennedia prostrata	scarlet runner	creeper
Lechenaultia biloba	blue lechenaultia	small shrub
Leucopogon pulchellus	beard-heath	small shrub
Leptospermum erubescens	roadside tea tree	tall shrub, drier eastern parts
Macrozamia riedlei	zamia	wetter eastern parts
Melaleuca scabra	rough honeymyrtle	large scrub
Nuytsia floribund	Christmas tree	small tree, western eastern parts
Orthrosanthus laxiflorus		herb
Oxylobium parviflorum	box poison	shrub, drier eastern parts
Patersonia occidentalis	purple flag	herb
Petrophile serruriae		large shrub
Petrophile striata		large shrub
Ptilotus mangelsii	pom poms	herb
Phyllanthus calycinus	false bornia	small shrub
Spaerolobium vimineun	leafless glove pea	small shrub
Stackhousia sp.		herb
Tetratheca sp.		herb
Xanthorrhoea prissii	grass tree	shrub
Riverine woodland		
Eucalyptus loxophleba	York gum	in drier areas on and close to drainage
Eucalyptus rudis	flooded gum	along streams in wetter areas
Melaleuca rhaphiophylla	swamp paperbark	narrow strips along streams
Melaleuca uncinata		
Melaleuca viminea		
Granite outcrops in drier areas		
Allocasuarina huegeliana	rock sheoak	small tree, peripheral groves
Borya spaerocephala	pincushions	tussocks
Grevillea bipinnatifida	Fuchsia grevillea	shrub
Hakea elliptica	two leaf hakea	shrub
Hakea undulata	wavy-leaf hakea	shrub
York gum, wandoo and salmon gum woodlands and heath		
Acacia acuminata	jam	small tree
Acacia micorbotrya	manna wattle	shrub
Acacia pulchella	prickly Moses	understorey species
Allocasuarina campestris	tamma	shrub
Allocasuarina humilis	dwarf sheoak	shrub
Allocasuarina huegeliana	rock sheoak	medium tree
Casuarina obesa	swamp sheoak	small tree, along streams
Eucalyptus accedens	powerbark wandoo	tree, associated with breakaways

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Botanical name	Common name (if known)	Notes
Eucalyptus loxophleba	York gum	tree
Eucalyptus rudis	flooded gum	tree, along stream
Eucalyptus salmonophloia	salmon gum	tree
Eucalyptus wandoo	wandoo	tree
Adenanthos cygnorum	common wollybush	heath species
Banksia attenuata	slender banksia	heath species
Calathamnus quadrifidus	one-sided bottlebrush	understorey species
Conospermum sp.	smoke bush	heath species
Dryandra nivea	couch honey pot	heath species
Eucalyptus drummondii	Drummond's mallee	heath species/mallee
Eucalyptus macrocarpa	mottlecah	heath species/mallee
Leptospermum erubescens	roadside tea-tree	heath species
Isopogon dubius	pin custion cornflower	heath species
Jackson sp.		heath species
Stirling latifolia	blueboy	heath species
Nuytsia floribunda	Christmas tree	heath species
Pericalymma ellipticum		understorey species
Gastrolobium spinosum	prickly poison	shrub
Hakea priessi	needle tree	small tree
Pericalymma ellipticum	swamp tea-tree	shrub
Xanthorrhoea preissi	grass tree	understory species
Scrub-heath and banksia low woodland		
Actinostrobus arearius	sandplain cypress	shrub
Adnanthos cygnorum	common woollybush	tall shrub
Adenanthos drummondii		
Allocasuarina campestris		shrub
Allocasuarina humilis	dwarf sheoak	shrub
Astroloma sp.		shrub
Banksia attenuata	slender banksia	small tree
Banksia menziesii	firewood banksia	small tree
Banksia prionotes	acorn banksia	medium tree
Comesperma volubile	love creeper	low shrub
Chorizema dicksonii	Flame pea	low shrub
Diannella revoluta	blueberry lily	herb
Dryandra sp.		shrub
Eremaea sp.		
Gastrolobium spinosum	prickly poison	medium shrub
Grevillea eriostachya	flame grevillea	shrub
Grevillea integrifolia	entire-leaved grevillea	shrub
Hakea trifurcata	tow-leaf hakea	shrub
Isopogon dubius	pincushion coneflower	small shrub
Leptospermum ellipticum	swamp tea tree	shrub
Melaleuca radula	graceful honeymyrtle	shrub
Melaleuca scabra	rough honeymyrtle	large shrub
Nuytsia floribunda	Christmas tree	small tree, parastici

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Botanical name	Common name (if known)	Notes
Petrophile sp.		shrub
Verticordia chrysantha		low shrub
Verticordia picta	painted featherflower	low shrub
Xanthorrhoea preissii	grasstree	shrub
Salt flats		
Halosarcia sp	samphire	small tree, adjacent salt flats
Casuarina obesa	swamp sheoak	medium to large shrub
Melaleuca thyoides		medium shrub
Melaleuca uncinata	broombrush	

This list was modified from list published in the Weaving, S. (1999). Native vegetation handbook for the Shire of Toodyay.

APPENDIX H

Lots Created on Lot 2 Reserve Road

Table 3 Lots created on Lot 2 Reserve Road

Lot Address Details	Volume / Folio	Area (square metres)	Registered Proprietor
Lot 101 (No. 200) Reserve Road, Chittering	2983/949	24,342	L & S A Carbone
Lot 102 (No. 240) Reserve Road, Chittering	2983/950	14,341	Riverside Investments (WA) No 2 Pty Ltd
Lot 104 (No. 73) Sceptrum Avenue, Chittering	2983/951	5,540	Riverside Investments (WA) No 2 Pty Ltd
Lot 132 (No. 47) Meeukany Drive, Chittering	2983/952	6,778	Riverside Investments (WA) No 2 Pty Ltd
Lot 133 (No. 41) Meeukany Drive, Chittering	2983/953	5,503	Riverside Investments (WA) No 2 Pty Ltd
Lot 134 (No. 31) Meeukany Drive, Chittering	2983/954	6,810	Riverside Investments (WA) No 2 Pty Ltd
Lot 135 (No. 72) Sceptrum Avenue, Chittering	2983/955	5,141	Riverside Investments (WA) No 2 Pty Ltd
Lot 142 (No. 46) Sceptrum Avenue, Chittering	2983/956	5,567	Riverside Investments (WA) No 2 Pty Ltd
Lot 143 (No. 52) Sceptrum Avenue, Chittering	2983/957	5,555	Riverside Investments (WA) No 2 Pty Ltd
Lot 144 (No. 56) Sceptrum Avenue, Chittering	2983/958	5,585	Riverside Investments (WA) No 2 Pty Ltd
Lot 145 (No. 20) Meeukany Drive, Chittering	2983/959	5,451	Riverside Investments (WA) No 2 Pty Ltd
Lot 146 (No. 26) Meeukany Drive, Chittering	2983/960	6,758	Riverside Investments (WA) No 2 Pty Ltd
Lot 147 (No. 32) Meeukany Drive, Chittering	2983/961	5,245	Riverside Investments (WA) No 2 Pty Ltd
Lot 148 (No. 42) Meeukany Drive, Chittering	2938/962	5,673	L K Cleghorn & A Kamboj
Lot 149 (No. 6) Karda View. Chittering	2983/963	5,500	K P & R P Ward
Lot 150 (No. 27) Narik Grove, Chittering	2983/964	5,019	Riverside Investments (WA) No 2 Pty Ltd
Lot 151 (No. 19) Narik Grove, Chittering	2983/965	5,760	Riverside Investments (WA) No 2 Pty Ltd
Lot 152 (No. 13) Narik Grove, Chittering	2983/966	5,760	Riverside Investments (WA) No 2 Pty Ltd
Lot 153 (No. 63) Sceptrum Avenue, Chittering	2983/967	6,193	Riverside Investments (WA) No 2 Pty Ltd
Lot 154 (No. 59) Sceptrum Avenue, Chittering	2983/968	5,766	Riverside Investments (WA) No 2 Pty Ltd
Lot 155 (No. 55) Sceptrum Avenue, Chittering	2983/969	5,250	Riverside Investments (WA) No 2 Pty Ltd
Lot 156 (No. 51) Sceptrum Avenue, Chittering	2983/970	5,250	Riverside Investments (WA) No 2 Pty Ltd
Lot 157 (No. 45) Sceptrum Avenue, Chittering	2983/971	6,195	Riverside Investments (WA) No 2 Pty Ltd
Lot 158 (No. 39) Sceptrum Avenue, Chittering	2983/972	5,002	Riverside Investments (WA) No 2 Pty Ltd
Lot 159 (No. 35) Sceptrum Avenue, Chittering	2983/973	5,015	Riverside Investments (WA) No 2 Pty Ltd
Lot 166 (No. 36) Sceptrum Avenue, Chittering	2983/974	5,950	Riverside Investments (WA) No 2 Pty Ltd
Lot 167 (No. 8) Narik Grove, Chittering	2983/975	5,000	Riverside Investments (WA) No 2 Pty Ltd

Lot Address Details	Volume / Folio	Area (square metres)	Registered Proprietor
Lot 168 (No. 14) Narik Grove, Chittering	2983/976	5,000	Riverside Investments (WA) No 2 Pty Ltd
Lot 169 (No. 18) Narik Grove, Chittering	2983/977	5,000	Riverside Investments (WA) No 2 Pty Ltd
Lot 170 (No. 24) Narik Grove, Chittering	2983/978	5,000	Riverside Investments (WA) No 2 Pty Ltd
Lot 171 (No. 28) Narik Grove, Chittering	2983/979	5,000	Riverside Investments (WA) No 2 Pty Ltd
Lot 172 (No. 34) Narik Grove, Chittering	2983/980	5,100	Riverside Investments (WA) No 2 Pty Ltd
Lot 9002 on Deposited Plan 415968	2983/981	1,126,245	Riverside Investments (WA) No 2 Pty Ltd