martens

Contact
D. Martens

Our Ref
P2108371JC03V01

Pages
18

30 March 2022

Charles David Pty Ltd
c/- Morgan English
Att: Arthur Hancock

Dear Sir,

Response to Peer Review of Hydrogeological Assessment and Groundwater Management Plan prepared by Dr Robert Banks

1. Overview

I have prepared this advice in response to the above review of our report in respect of groundwater impacts (our ref: P2108371JR02V01) prepared by Dr Robert Banks of Soil Futures Pty Ltd (the **Banks Review**). This advice:

1. Summarises issues raised by Dr Banks.
2. Provides a brief response to these issues.
3. Provides further consideration of known site and off-site soil salinity affected areas as requested by Dr Banks.
4. Provides updated groundwater modelling as requested by Dr Banks.

2. Identified Issues and Responses

Issues identified as part of the Banks Review, and our responses, are summarised in Table 1.

Table 1: Summary of issues identified in the Banks Review.

Issue	Response
1. Further consideration of existing salinity at the site and downslope areas	• Historical salinity assessments, particularly the location of higher salinity risk areas, are further considered and mapped at Section 3.
2. Use of MODFLOW model to assess salinity impact	• We agree with the reviewer's comments that MODFLOW can be used for urban salinity prediction purposes. • The MODFLOW model has been updated as per the Banks Review, with results of modelling presented herein at Section 4.

Issue	Response
3. MODFLOW model extents should consider the whole catchment and include relevant urban areas	• The MODFLOW model covers the entire contributing catchment and has been extended downslope to cover an area of approximately 7.7km^2. • The model includes approximately 1.3 km^2 of existing urban area.
4. Include slope breaks and road works in MODFLOW model	• These effects are included in the MODFLOW model which has used 1 m aerial LiDAR survey as the basis of surface topography. This enables high resolution modelling of localised relief effects.
5. Inclusion of potential urban water uses (lawns and gardens) in MODFLOW model	• The effects of urban water usage, such as garden watering and run-on were considered in detail through the calibration process when determining net aerial recharge and evapotranspiration (refer to Map 4 and Map 5). • This enables aggregated effects of reduced recharge caused by impervious areas, as well as potentially increased recharge in gardens to be simulated, with calibration based on measured groundwater levels. • For the urban areas, aerial evapotranspiration rates and extinction depths were halved as part of the calibration process to represent lawns and gardens.
6. Impact of leakage from stormwater basin	• Stormwater basins can (and for this site we recommend) be designed to be impermeable. • This can be achieved using a range of standard engineering practices. Examples include: concrete lining; HDPE liners; compacted clay liners; and combinations of the like. These in practice achieve base permeabilities of < 10^{-9} m/s (or 3 cm/year) which will ensure that no material leakage occurs. • We recommend that the consent would require the basins to be designed to be impermeable and that a construction testing regime be imposed to confirm appropriate standards have been met.
7. Impact of increased runoff from the development site	• Potentially increased runoff volumes caused by the development have been further evaluated through the use of the MUSIC stormwater modelling software. • The impact of increased runoff volumes, and consequent increased recharge within drainage lines at and downslope of the site is now included as part of the revised MODFLOW model (refer to Section 4).
8. Simulation of long-term climate conditions	• Long term effects have been considered by re-running the MODFLOW model for a range of climatic scenarios based on long-term climate data (refer to Section 4).
9. Update MODFLOW based on eSPADE soil data	• Soil material properties have been updated in accordance with the latest eSPADE soil data (refer to Map 2).

Issue	Response
10. Incorporation of additional groundwater monitoring data into MODFLOW model	• 11 additional bores outside the site were included to recalibrate the MODFLOW model, this extending the calibration basis of the model and improving model accuracy (refer to Map 3).

3. Areas Affected by Salinity

3.1 Site Investigations and Mapping

Douglas Partners has conducted the following investigations into soil salinity at the site:

1. Electromagnetic Induction Survey (EM Survey) across the site. These were documented in the GHD 2020 Report.

2. Intrusive soil sample collection and laboratory testing across the site. These were documented in the Douglas Partners 2020 Report.

The following is noted and observed from these investigations:

1. In respect of the EM Survey:

    a. Results of the EM Survey are replicated at Figure 1 and Figure 2, which show apparent electrical conductivity[1] at 0.5 m and 1.5 m depths respectively.

    b. The EM Survey data indicate that there is predominantly slight to moderate salinity[2] within site surface soils, except in the lower western portion of the site (refer to Figure 1) where moderate levels occur.

    c. The EM Survey for sub-soils (at 1.5 m depth) indicates that salt levels are higher at depth, with the highest levels again found at the lower western portion of the site (refer to Figure 2) where there is a distinct area of high salinity.

2. In respect of the intrusive soil sampling:

    a. Laboratory results are summarised at Table 2 of the Douglas Partners 2020 Report.

    b. Soil testing data[3] indicated that topsoil samples (< 0.5 m) were non-saline (< 2 dS/m), this being consistent with the EM Survey findings.

    c. Sub-soil samples were on average moderately saline (4-8 dS/m), although high salinity was measured in subsoils within low lying areas at the western site boundary, this being consistent with the EM Survey findings.

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1 Electrical conductivity (EC) mapping is expressed in mS/m where 1 dS/m = 100 mS/m, or mS/m÷100 = dS/m.

2 Determined by applying a uniform spatially averaged multiplier of 7 to the field EC value to obtain a saturated extract EC (or ECe) where: Non-saline < 2 dS/m, slightly saline 2-3 dS/m, moderately saline 4-8 dS/m, highly saline 8-16 dS/m, extremely saline > 16 dS/m (in accordance with Hazelton and Murphy, 1992).

3 Douglas Partners 2020 Report expresses results in µS/cm where 1 dS/m = 1000 µS/cm, or µS/cm÷1000 = dS/m.

d. These data are consistent with eSPADE mapping (provided at Figure 11 of the Douglas Partners 2020 Report) that indicated modelled surface soil salinity for the site is generally non-saline.

3.2 Other Salinity Effected Areas

In addition to the site testing and observations, the following is noted in respect of salinity affected areas downslope of the site:

1. Existing known salinity affected areas can be found at the Scone High School, the nearby power sub-station, upslope of the New England Highway, and in the Scone Golf Course (refer to Figure 3 for approximate locations).

2. These areas are generally located below the 205 mAHD contour, in low lying areas of relatively poor drainage where there is an increased risk of groundwater, at least intermittently, coming close to the surface.

3. It is possible that the construction of the New England Highway may have contributed somewhat to local upslope salinity effects by impeding or locally slowing the flow of groundwater. However, the effect of this does not appear to have reached the site which is elevated at least 5 m higher than these salt-affected areas.

3.3 Conclusions About Salinity Risk

The following conclusions are made in respect of salinity risk at the site and in the local area proximate to the proposed development:

1. Site surface soils are at present not considered significantly affected by soil salinity.

2. Site sub-soils within the lower lying western parts of the site present the highest vulnerability to changes in soil groundwater levels and moisture levels due to capillary rise.

3. The primary implication of these data is that the key salinity management requirement for the site is to ensure that groundwater within low lying western portions of the site, and similar areas west of the site, is not increased, this ensuring that salt is not brought closer to the surface either by way of rising groundwater or through increased capillary rise.

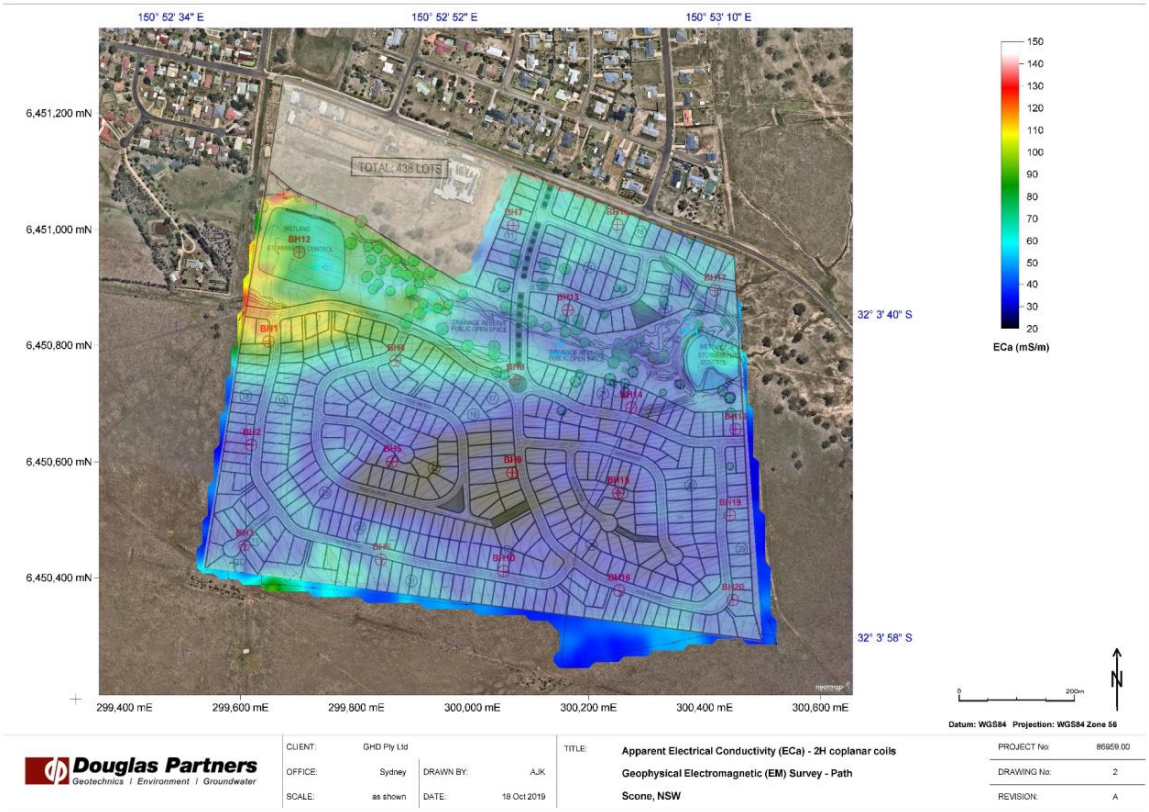


Figure 1: Soil salinity mapping at 0.5 m depth (source: Figure 3-2 GHD 2020 Report).

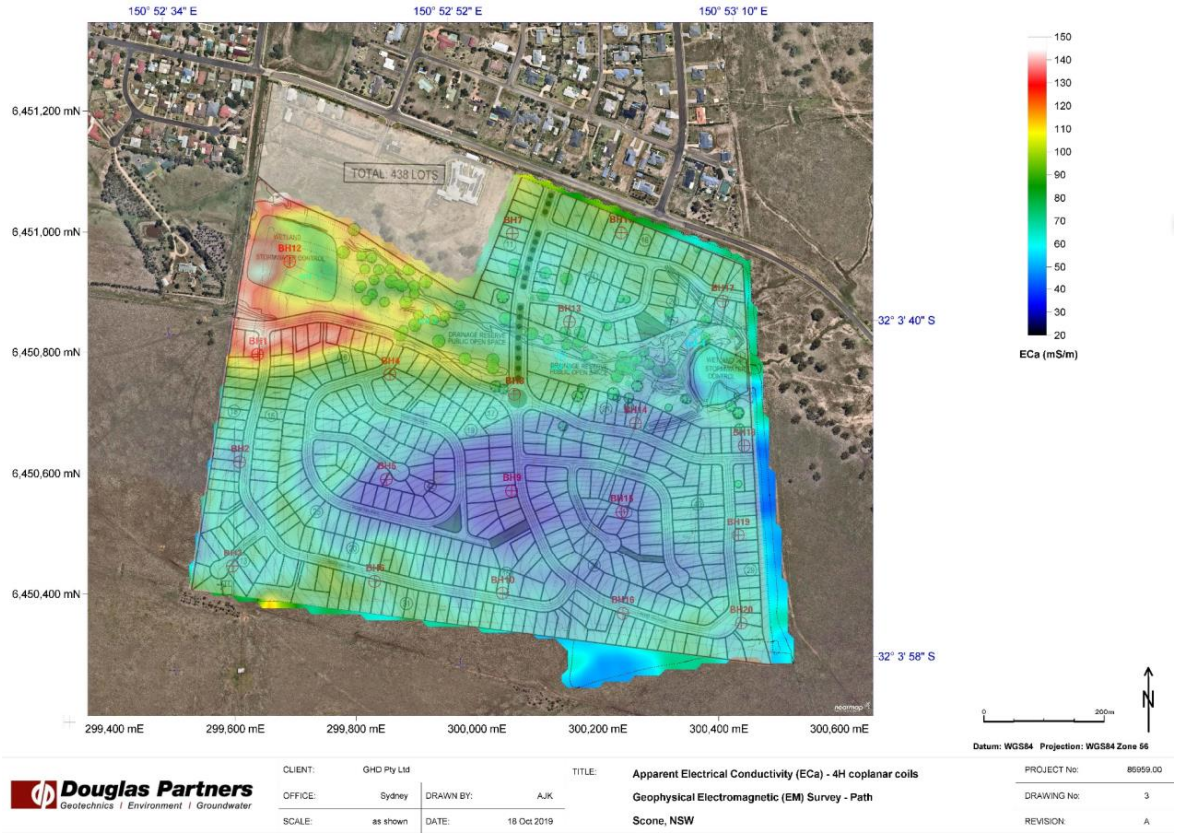


Figure 2: Soil salinity mapping at 1.5 m depth (source: Figure 3-3 GHD 2020 Report).

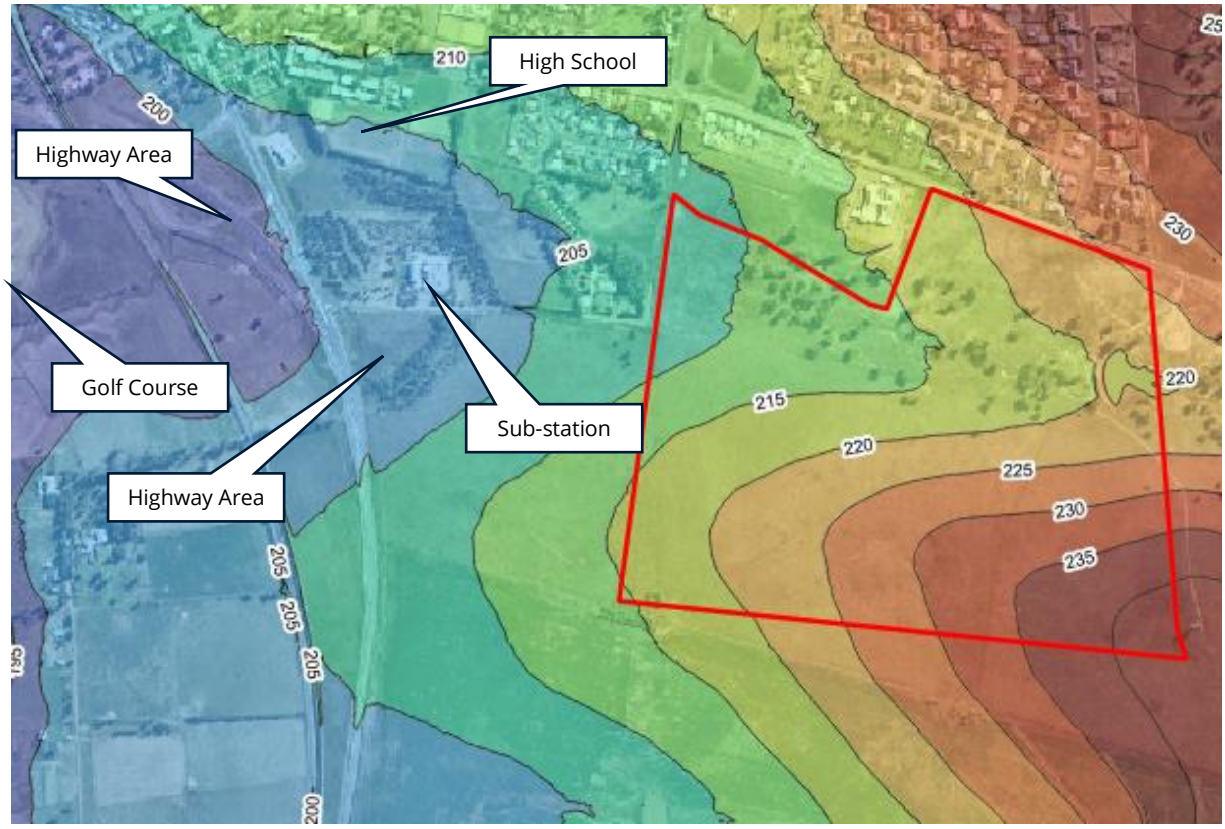


Figure 3: Other areas of known salinity (site boundary in red).

4. Updated Groundwater Modelling

4.1 Overview

The MODFLOW model was updated and recalibrated in accordance with the recommendations of Dr Banks. In summary this included:

1. Inclusion of most recent catchment soil survey data.
2. Inclusion of additional groundwater bore observational data for areas external to the site.
3. Amendments to groundwater recharge taking account of potentially increased site runoff arising from the proposed development.
4. Consideration of longer-term climate variability on modelling outcomes.

Details are provided in the following sections.

4.2 Supplementary Soil Data

The most recent soil landscape data were obtained from the eSPADE website and imported into the MODFLOW model to create updated soil material zones for the upper model layers.

Location of the soil material zones used in the modelling is provided in Map 2.

4.3 Supplementary Groundwater Data

The MODFLOW model was updated and recalibrated to include data from an additional 11 monitoring bores external to the site (data provided by Council). Location of these bores is shown on Map 3.

Inclusion of these monitoring data has improved modelling accuracy, particularly in areas down gradient of the site where there are existing known areas of soil salinity.

4.4 Amended Recharge Modelling

Recharge assumptions were amended as follows:

1. *Existing conditions*: Specific recharge zones were created for the two drainage lines receiving discharge from the site (refer to Map 4).

2. *Developed conditions*: Recharge was increased in the drainage line recharge zones where stormwater was discharged, by an amount proportional to the increased annualised flow volume (refer to Map 5) noting:

    a. Annual flow volumes were evaluated using the MUSIC stormwater modelling software, which indicated that the development would lead to a net increase from around 141 to 238 ML/year in the northern drainage line, and 52 to 84 ML/year in the southern drainage line.

    b. The effects of these increases were included at and downstream of points where site stormwater would be discharged, over an area that overland flow could reasonably be anticipated to impact.

4.5 Climate Scenarios

The MODFLOW model was re-run considering historical rainfall over the past 27 years for the Scone Airport rain gauge (station 61363). The following additional modelling scenarios were included:

1. Extended 'dry' conditions – long-term average recharge rates were scaled down by 39 % to reflect 10th percentile rainfall.

2. Extended 'wet' conditions – long-term average recharge were scaled up by 31 % to reflect 90th percentile rainfall.

4.6 Results

The following results were obtained:

1. Accuracy of the MODFLOW model for existing conditions was considerably improved by the inclusion of additional groundwater observations bores, soil mapping data and amendments to recharge zonation, with the model's normalised root mean square (NRMS) decreasing from 9.5 % to 7.0 %, and the mean residual head decreasing from 0.424 m to 0.072 m.

2. Impacts of the development on groundwater levels under average, dry and wet conditions were as follows:

    a. Under long-term average conditions, groundwater levels in areas of saline soils downslope of the site and within the site are either marginally lowered or remain unchanged (refer to Map 6).

    b. Under prolonged dry conditions, groundwater levels respond similarly to long-term average conditions, although the extent of lowering is reduced.

    c. Under prolonged wet conditions, groundwater levels respond similarly to long-term average conditions however drawdown is increased beneath the development footprint.

3. Modelling indicates that the development will not lead to an increase in soil salinity conditions within the site or downslope. This is because groundwater levels will not be increased and there are therefore no anticipated changes to the capillary fringe.

5. Conclusions and Recommendations

We provide the following summary conclusions and recommendations:

1. The amended groundwater modelling indicates that the proposed development is not likely to cause soil salinity impacts. This is because groundwater levels will not be increased within or downslope of the site, considering a range of long-term climatic conditions, and there are therefore no anticipated changes to the groundwater capillary fringe.

2. The potential impacts of increased urban water usage, urban gardens and lawns, and stormwater releases, are counteracted by reduced overall groundwater recharge due to urbanisation.

3. We recommend that if consent were granted, that a condition be imposed that would require the stormwater basins to be designed to be impermeable and that a construction testing regime and certification requirements be imposed to confirm appropriate standards have been met.

If you require any further information, please do not hesitate to contact our offices.

For and on behalf of

Martens & Associates Pty Ltd

Dr Daniel Martens

LLB(Hons1), BSc(Hons1), MEngSc, PhD, FIEAust, CPEng, NER, RPEQ, APEC Eng, IntPE(Aus)

Director, Principal Engineer

6. References

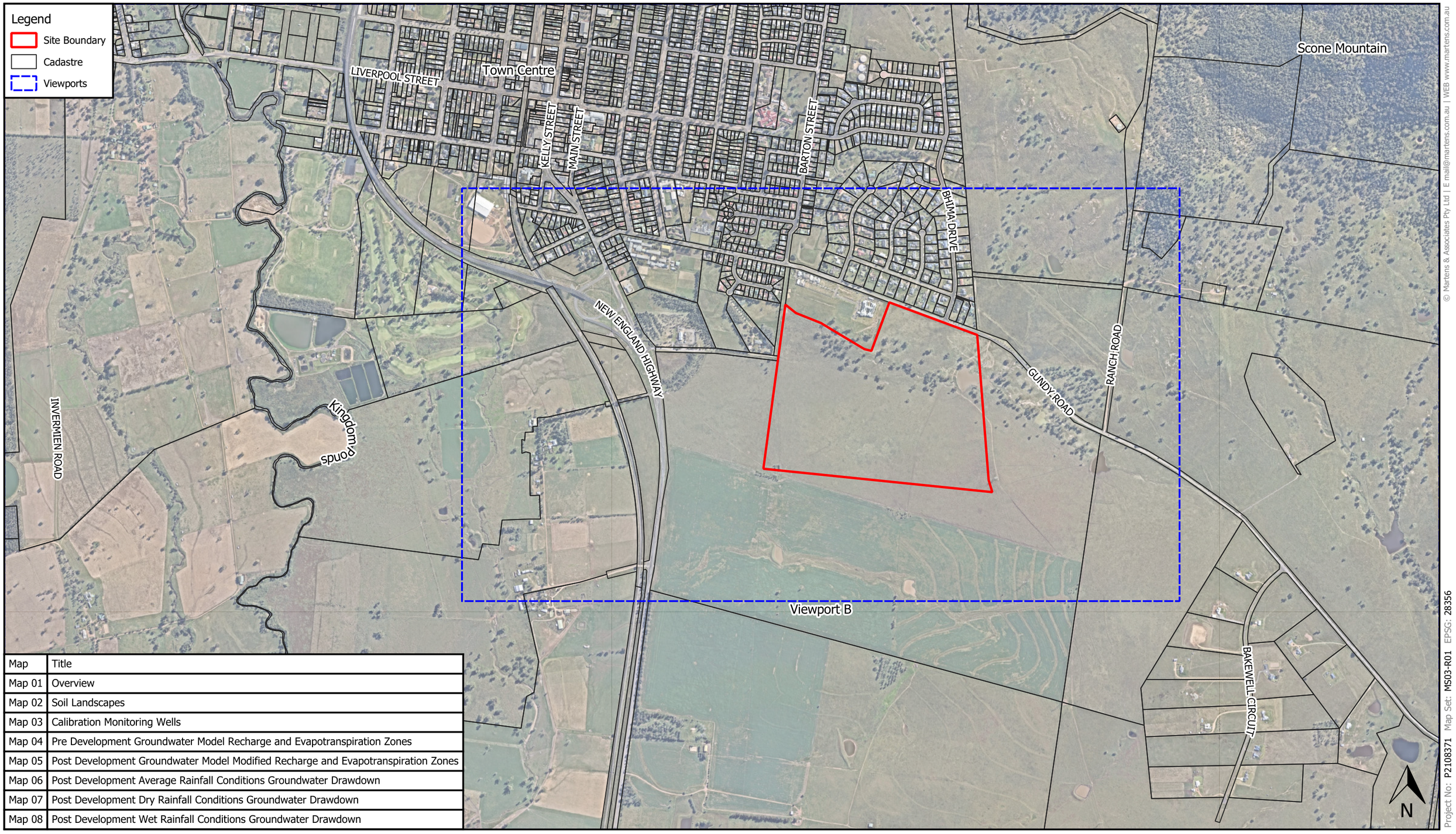
GHD (2020) *Charles Davit Pty ltd Lot 2 Gundy Road, Scone Salinity Report* (**GHD 2020 Report**).

Douglas Partners (2020) *Report on Factual Investigation Intrusive Salinity Investigation 150 Gundy Road, Scone* (**Douglas Partners 2020 Report**).

Hazelton, P. A and Murphy, B. W. (1992) *What Do All The Numbers Mean?*, NSW Department of Conservation and Land Management (**Hazelton and Murphy 1992**).

Martens & Associates Pty Ltd (March 2022) *Hydrogeological Assessment and Groundwater Management Plan: 150 Gundy Road, Scone, NSW*, report reference P2108371JR02V01 (**Martens 2022 Report**).

Annexure A - Maps



Map	Title
Map 01	Overview
Map 02	Soil Landscapes
Map 03	Calibration Monitoring Wells
Map 04	Pre Development Groundwater Model Recharge and Evapotranspiration Zones
Map 05	Post Development Groundwater Model Modified Recharge and Evapotranspiration Zones
Map 06	Post Development Average Rainfall Conditions Groundwater Drawdown
Map 07	Post Development Dry Rainfall Conditions Groundwater Drawdown
Map 08	Post Development Wet Rainfall Conditions Groundwater Drawdown

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Viewport A

Notes:
- Aerial photo from Nearmap (2021).
- Cadastre from NSW DFSI Clip and Ship (2021).

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Map Title / Figure:
Overview

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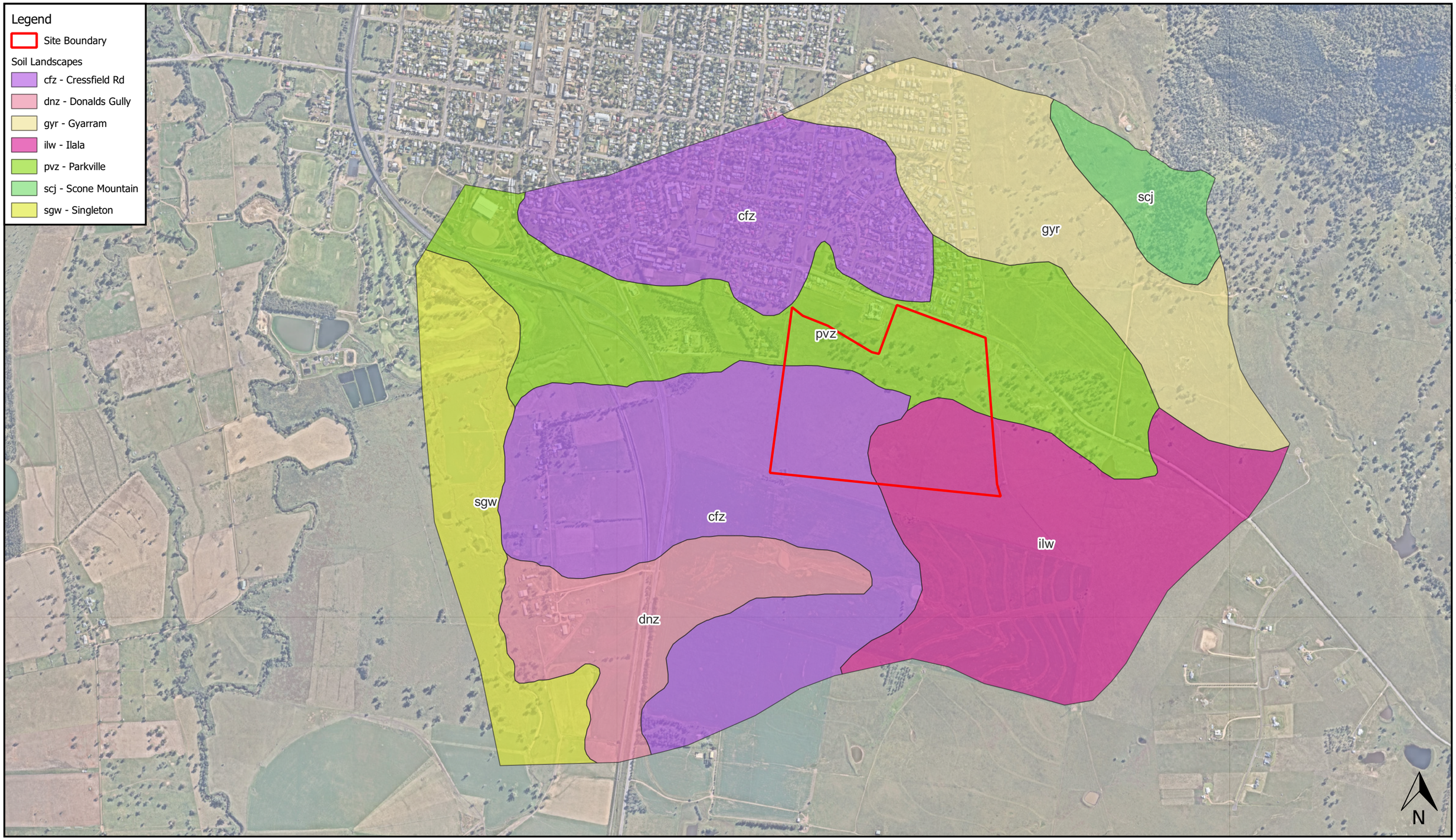
Map 01	Map
Lot 2 Gundy Rd, Scone, NSW	Site
Proposed Subdivision	Project
Groundwater Assessment Peer Review Response	Sub-Project
Charles David Pty Ltd	Client
30/03/2022	Date



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Viewport A

Notes:
- Aerial photo from Nearmap (2021).
- Soil landscapes from NSW DPIE's Soil and Land Resources of the Hunter Region (2018) (eSPADE).

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Map Title / Figure:
Soil Landscapes

Map 02	Map
Lot 2 Gundy Rd, Scone, NSW	Site
Proposed Subdivision	Project
Groundwater Assessment Peer Review Response	Sub-Project
Charles David Pty Ltd	Client
30/03/2022	Date

0 80 160 240 320 400 m

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Viewport B

Notes:
- Aerial photo from Nearmap (2021).

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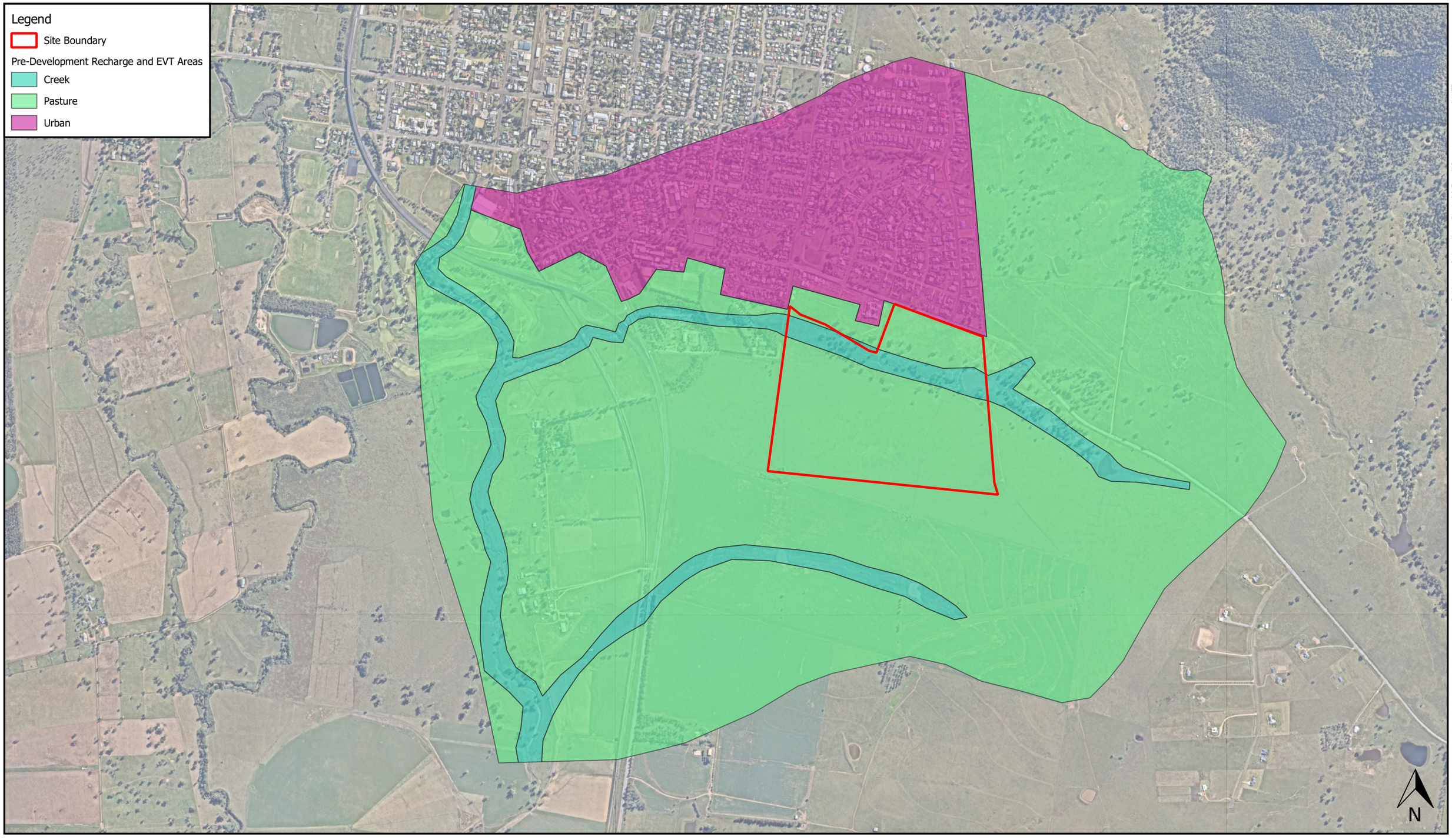
Map Title / Figure:

Calibration Monitoring Wells

Map 03	Map
Lot 2 Gundy Rd, Scone, NSW	Site
Proposed Subdivision	Project
Groundwater Assessment Peer Review Response	Sub-Project
Charles David Pty Ltd	Client
30/03/2022	Date



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Viewport A

Notes:
- Aerial photo from Nearmap (2021).

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Map Title / Figure:

Pre Development Groundwater Model Recharge and Evapotranspiration Zones

Map 04	Map
Lot 2 Gundy Rd, Scone, NSW	Site
Proposed Subdivision	Project
Groundwater Assessment Peer Review Response	Sub-Project
Charles David Pty Ltd	Client
30/03/2022	Date

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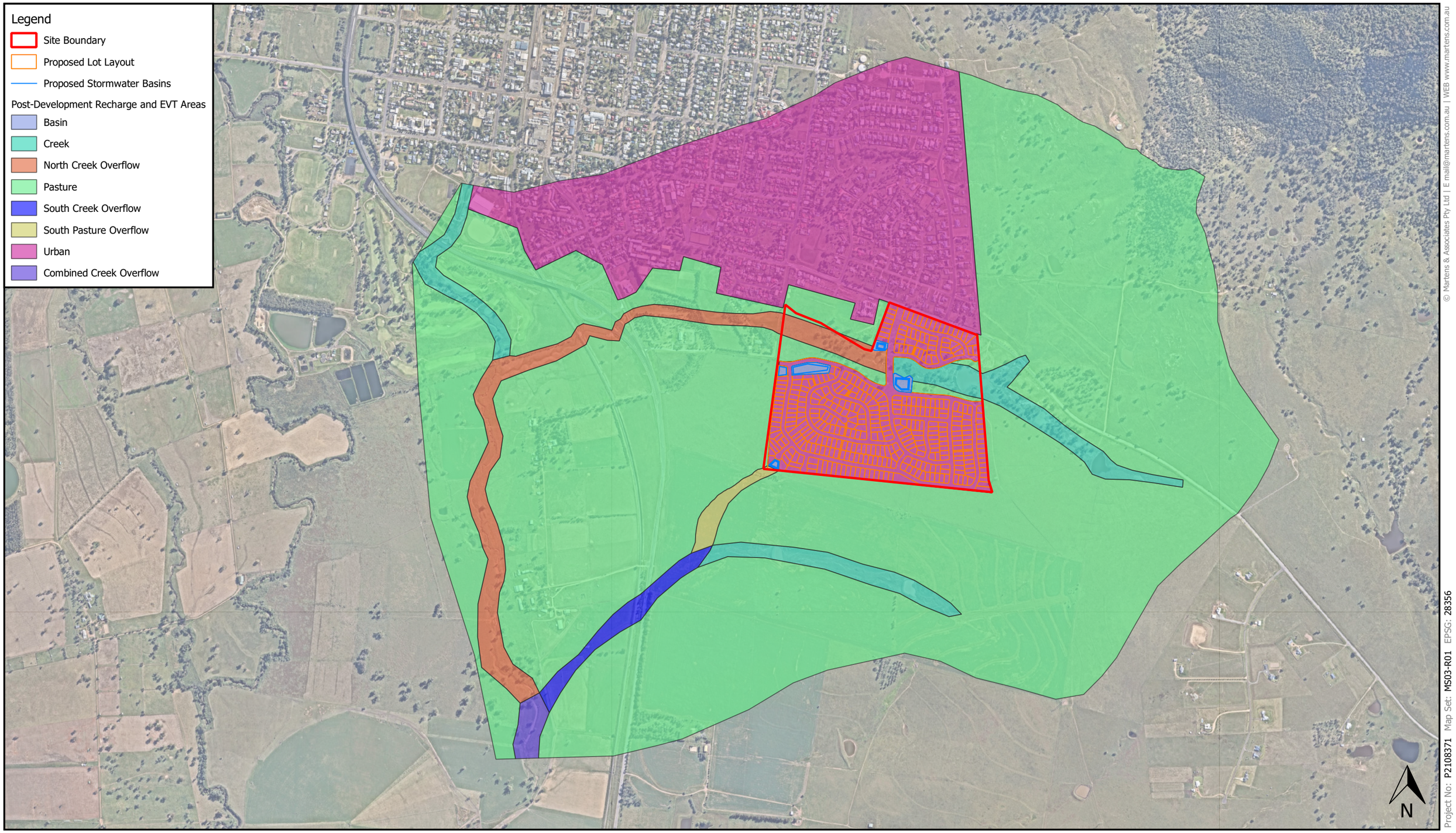

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Viewport A

Notes:
- Aerial photo from Nearmap (2021).
- Development Layout from MM Hyndes Bayley & Co. (2022).

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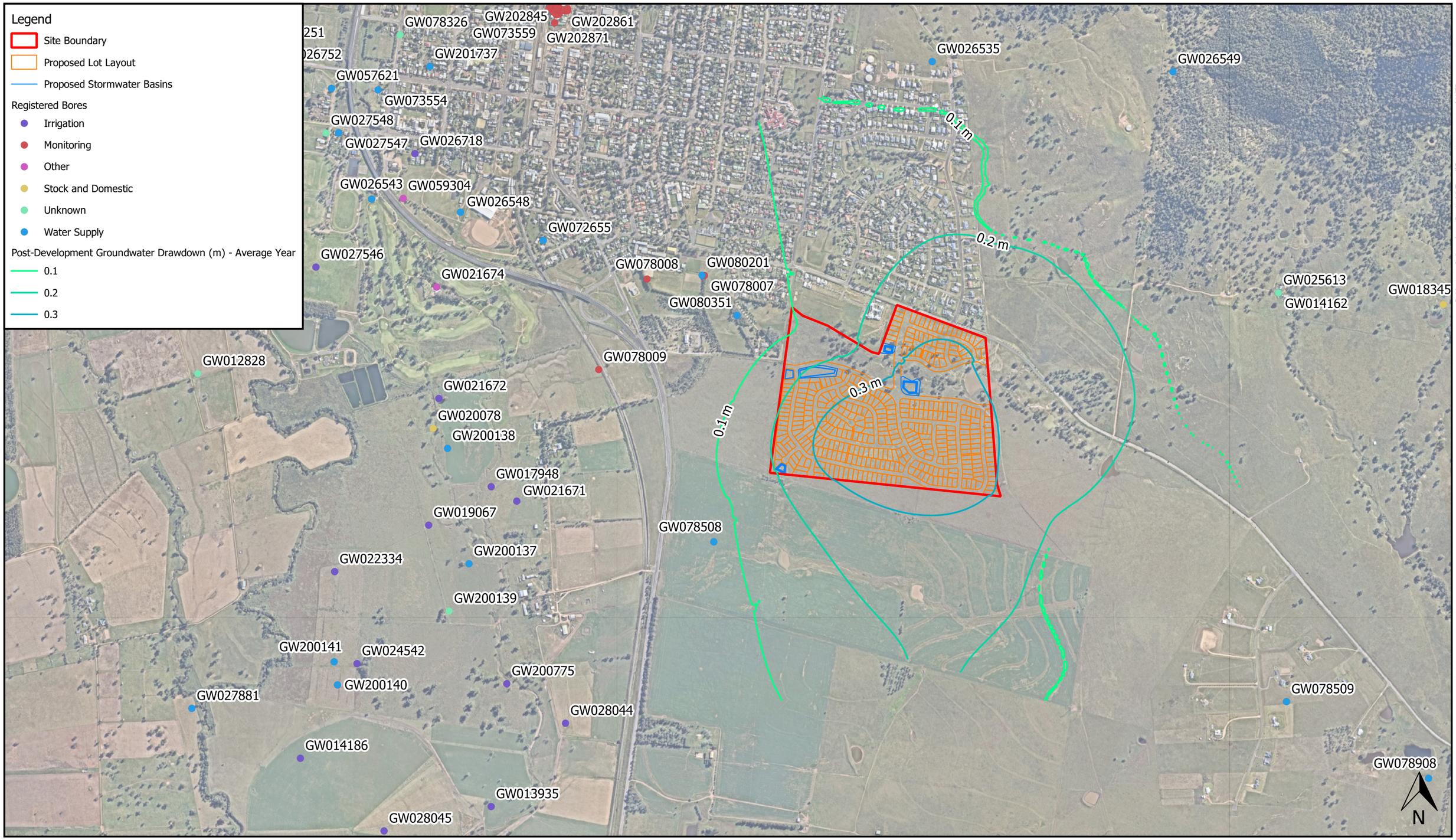
Map Title / Figure:

Post Development Groundwater Model Modified Recharge and Evapotranspiration Zones

Map 05	Map
Lot 2 Gundy Rd, Scone, NSW	Site
Proposed Subdivision	Project
Groundwater Assessment Peer Review Response	Sub-Project
Charles David Pty Ltd	Client
30/03/2022	Date



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Viewport A

Notes:
- Drawdown is calculated as pre-development groundwater level minus post-development level, hence positive drawdown is a reduction in groundwater level.
- Aerial photo from Nearmap (2021).
- Development Layout from MM Hyndes Bayley & Co. (2022).

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Map Title / Figure:

Post Development Average Rainfall Conditions Groundwater Drawdown

Map 06	Map
Lot 2 Gundy Rd, Scone, NSW	Site
Proposed Subdivision	Project
Groundwater Assessment Peer Review Response	Sub-Project
Charles David Pty Ltd	Client
30/03/2022	Date

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Legend

- Site Boundary
- Proposed Lot Layout
- Proposed Stormwater Basins

Registered Bores

- Irrigation
- Monitoring
- Other
- Stock and Domestic
- Unknown
- Water Supply

Post-Development Groundwater Drawdown (m) - Dry Year

- 0.1
- 0.2
- 0.3

GW078326 GW073559 GW202747 GW202871 GW201737 GW026752 GW057621 GW073554 GW027548 GW027547 GW026718 GW026543 GW059304 GW026548 GW072655 GW027546 GW021674 GW078008 GW080201 GW078007 GW080351 GW012828 GW078009 GW021672 GW020078 GW200138 GW017948 GW021671 GW019067 GW078508 GW200137 GW022334 GW200139 GW200141 GW024542 GW200775 GW200140 GW027881 GW028044 GW014186 GW013935 GW028045 GW026535 GW026549 GW014162 GW025613 GW018345 GW078509 GW078908

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Viewport A

Notes:
- Drawdown is calculated as pre-development groundwater level minus post-development level, hence positive drawdown is a reduction in groundwater level.
- Aerial photo from Nearmap (2021).
- Development Layout from MM Hyndes Bayley & Co. (2022).

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Map Title / Figure:

Post Development Dry Rainfall Conditions Groundwater Drawdown

Map 07	Map
Lot 2 Gundy Rd, Scone, NSW	Site
Proposed Subdivision	Project
Groundwater Assessment Peer Review Response	Sub-Project
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30/03/2022	Date

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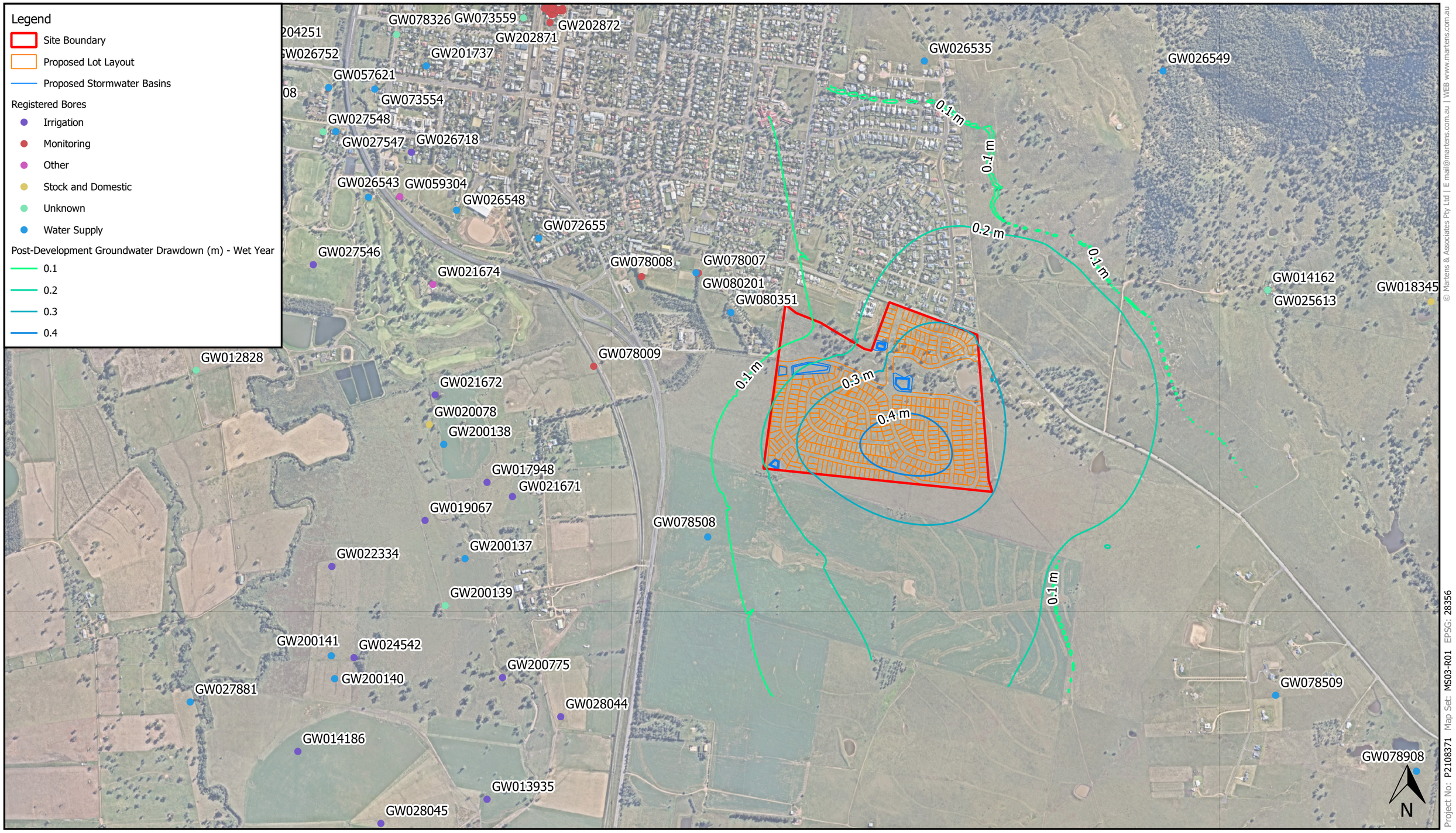

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Viewport A

Notes:
- Drawdown is calculated as pre-development groundwater level minus post-development level, hence positive drawdown is a reduction in groundwater level.
- Aerial photo from Nearmap (2021).
- Development Layout from MM Hyndes Bayley & Co. (2022).

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Map Title / Figure:

Post Development Wet Rainfall Conditions Groundwater Drawdown

Map 08	Map
Lot 2 Gundy Rd, Scone, NSW	Site
Proposed Subdivision	Project
Groundwater Assessment Peer Review Response	Sub-Project
Charles David Pty Ltd	Client
30/03/2022	Date

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