Independent Review of Daisy Hill Groundwater and Salinity Modelling

Prepared for Department of Planning and Environment | 14 June 2018

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1 Introduction

EMM Consulting (EMM) was engaged by New South Wales Department of Planning and Environment (DPE) to carry out an independent review of groundwater and salinity modelling carried out to assess the risk of off-site salinity impacts from a proposed development at Daisy Hill, Eulomogo Road Dubbo NSW (the site).

The site is located in the Troy Gully catchment which is known to be at risk of impacts from shallow groundwater discharges, saline soil and scalding. The site is currently pasture/grazing and cropping land but is proposed to be rezoned to allow for a higher density of large lot residential development. Currently the land has a block size of 8 ha (Daisy Hill) and 1.5 ha (Firgrove) that has a potential yield of about 40 and 26 lots respectively. A proposal was put forward by the proponent to reduce block sizes such that 284 lots of varying size between 6000 m^2 (0.6ha) and 3 ha to be created. Site investigations and subsequent modelling were carried out to predict groundwater and salinity impacts of the increased lot density. Review of the initial proposal has led to revised modelling of an amended 222 lots varying in size from 6,000 m^2 (0.6 ha) to 3 ha.

1.1 Initial EMM review

EMM delivered an initial review on 8 March 2018 of previous submissions by the proponent. That review covered the following material:

1. Gateway determination dated 9 June 2016.
2. DPE – Minutes of Technical Workshop 14 March 2017.
3. DPE – 30 March 2017 – letter to Duffy Solicitors about bores and additional investigations required.
4. Proponent – 10 August 2017 – updated groundwater and salinity study.
5. DPE letter 11 October 2017 – includes 6 October 2017 Agencies response.
6. Council – 17 September 2017 response.
7. Proponent - 22 November 2017 – Heath Consulting re water use.
8. Proponent – 12 December 2017 – revised modelling and revised proposed lot layout 222 lots & staging.
9. DPE – 22 December 2017 – water usage information from Council.
10. Proponent – 15 January 2018 – water use comments.
11. Council – 17 January 2018 – response to amended modelling.

The initial review raised the following five issues to be addressed by the proponent:

1. There is insufficient information presented in the reports to support the conclusion that no off-site salinity impacts will occur. The approach taken relies on a net zero increase in recharge (deep drainage) to the underlying watertable. The earlier report provided volumes (although it was not clear if they were total aggregates). However, the second report switched to recharge rates (in

mm/yr) and provided no total recharge volumes, either by land use type or as an aggregate. In the first instance the results should be tabulated in a manner that enables the reader to identify total deep drainage/recharge below each landuse type when aggregated proportionally across the soil profiles over which that land use type occurs, as well as the total net deep drainage from the site. The full modelled water balance is to be reported, including the numerical error components. The report should clarify whether the modelled 5.1 mm/yr recharge was uniform or if it differs according to upper, mid and lower slope positions and/or with soil profile. This aspect does not require any further modelling. It is a matter of adequately reporting what has been done such that it meets industry standards consistent with guidance set out in the Australian Groundwater Modelling Guidelines (Barnett et al. 2012).

2. The approach taken assumes that deep drainage at one part of the site can be offset by net discharge at another part of the site. As a minimum, a figure illustrating the spatial distribution of modelled recharge/discharge across the site is to be provided to help identify whether this might be the case. If positive and negative recharges are evenly distributed across the site then this might support the assumption. However, should deep drainage be concentrated then that water may recharge the watertable and be at depths no longer accessible to the trees that are relied upon to remove it before it migrates off site. Should the aforementioned mapping not support the assumption that increased recharge in some areas will be accessible to be offset by increased evapotranspiration in other areas, a further step would be to model the underlying aquifer, at least in two-dimensions, to predict the mounding and movement of shallow groundwater from the site into the local shallow groundwater system such that impacts could be assessed. Two dimensional numerical groundwater flow modelling would require substantial additional effort with cost estimated to be in the tens of thousands of dollars.

3. The issue of the assumed ability of the top 200 mm of the soil profile to transmit the necessary volumes of water to avoid waterlogging and surface discharge when rainfall or irrigation exceeds 2 mm/hr should be addressed. Whilst, perhaps, not a direct salinity impact issue, it relates to the modelling in that this water is not accounted for in the one-dimensional modelling approach employed. A figure is to be prepared showing rates and spatial distribution across the site of this currently unaccounted for water. This can be done using the current model outputs and requires no further modelling to produce.

4. The modelling has no associated uncertainty analysis associated with the predictions. At the very least the results for the worst case plausible parameters should be presented. At the moment the results present one possible outcome. However, actual soil properties will vary from those modelled, land owners will apply varying rates of irrigation, and trees and pasture will transpire at variable rates and with varying rooting depths. The apparent differences between the 10 August 2017 and 12 December 2017 model results indicate that rooting depth is a key parameter. Carrying out sensitivity and uncertainty analyses will help identify factors that may aid design (e.g. tree selection) of the development and reduce the risk of off-site salinity impacts.

5. Two groundwater flownets should be constructed for the June 2017 shallow groundwater level data that show current measured point values and contoured depth to water and contoured watertable elevations across the site and the surrounding area for a minimum 5 km. This should include mid 2017 data from all relevant monitoring bores maintained by Dubbo Regional Council in the Troy Gully catchment to the north and south of the proposed development. Data points should be contoured so that any local mounding can be identified and shallow groundwater flow directions can be clearly identified and articulated.

The proponent subsequently submitted three further documents in response to feedback and request for further information from DPE (i.e. the initial review conducted by EMM). DPE has requested EMM:

1. Review the three new documents submitted, by the proponent, to DPE with regard to whether they address the issues raised in the prior review; and

2. Provide a summary of recommendations, where necessary, of any modifications to the development and/or additional modelling work required to determine the risk of off-site salinity impact.

1.2 Secondary EMM review

The secondary review covers material presented in the following documents:

1. Soilwater Consultants - 16 April 2018 - letter prepared for Bourke Securities titled "Peer Review of the groundwater and salinity study for the proposed Daisy Hill development";

2. Soilwater Consultants – 16 April 2018 – Daisy Hill groundwater & salinity study peer review; and

3. Envirowest Consulting – 18 April 2018 – letter/report prepared for Bourke Securities titled "Additional groundwater information Daisy Hill"

This secondary review has been carried out with reference to the guidance, and international best practice, presented in the Australian Groundwater Modelling Guidelines (Barnett et al. 2012).

2 Summary of further documentation and modelling

The proponent commissioned a revised assessment, by Soilwater Consultants (Soilwater), of the studies and modelling conducted by Envirowest Consulting (2017a and b). Soilwater (2018a) is a letter summary, addressed to Bourke Securities, of the revised assessment and concludes that "*it is considered that the Daisy Hill development will not adversely impact the environment, and thus there is (sic) no environmental grounds for preventing this proposal going ahead.*"

Soilwater (2018b) provides details of the revised assessment, indicating that it focuses on:

1. the groundwater and salinity data; and

2. the suitability of the hydraulic parameter values adopted for modelling by Envirowest.

However, the revised assessment does also cover the modelling more generally and documents re-modelling of groundwater impacts of the proposed development, carried out using HYDRUS 1D (an alternative one dimensional unsaturated flow modelling code – Envirowest used CLASS-U3M-1D). Soilwater (2018b) documents the HYDRUS 1D modelling carried out in a much clearer manner than do Envirowest (2017a and b).

Whilst relying on the description of the soil profile provided by Envirowest (a and b), the Soilwater HYDRUS 1D modelling validates the outcomes of the Envirowest (2017a and b) work and concludes that "it is expected that the planned mitigation measures will actually reduce groundwater recharge." As with the Envirowest (2017a and b) investigation, the modelling does suggest waterlogging will occur at points and times in the soil profile. It is assumed that this can be managed by the proposed planting of vegetation in road reserves. Soilwater (2018b) makes the recommendation that "*a species mix of both shallow and deep rooting species with good drought and waterlogging tolerance be selected for water managemernt. Shallow rooted species will be able to capture low intensity events while deep rooted species will be able to capture drainage through the profile and/or generated from lateral subsurface flow from upper slopes of the site.*"

Envirowest (2018) provides further information on the modelling that was documented in Envirowest (2017a and b). This provides much greater clarity on the modelling carried out. Importantly, Table 5 and Table 6 present modelled recharge rates, application areas and resultant volumes for the different land use types across the three modelled soil profiles, thereby documenting the full modelled water balance for the site both pre- and post-development. Figures are presented for coverage of soil types across the site, proposed development layout, individual plot land use coverages including cross sections through the soil profile indicting the location of the pre-development water table, depth to water table in June/July 2017 and water table elevation in June/July 2017.

The additional information provided in the revised assessment greatly improves the documentation of the proposed development, the groundwater modelling carried out and predicted impacts.

3 Conclusions

With regard to the five issues raised in the initial review by EMM, the following respective assessments are made in this secondary EMM review:

1. Envirowest (2018) provides significant further information on predicted impacts, particularly Table 5 and Table 6, such that the predicted water balance for the site under developed conditions can now be clearly identified for each of the soil types and land uses as well as in aggregate. The modelled values suggest the development will not result in a net increase in groundwater recharge to the water table.

   It should be noted that this outcome is heavily reliant on uptake of water by proposed vegetation in roadside reserves. Appropriate vegetation selection will be required such that the lateral flow to these areas can be removed. Soilwater (2018b) makes the recommendation that "*a species mix of both shallow and deep rooting species with good drought and waterlogging tolerance be selected for water managemernt. Shallow rooted species will be able to capture low intensity events while deep rooted species will be able to capture drainage through the profile and/or generated from lateral subsurface flow from upper slopes of the site.*"

   This recommendation should be acted upon, with reference to local climate and soils, such that appropriate vegetation is identified and planted to act in the manner required.

2. Figure 2 in Envirowest (2018) presents the proposed development layout and land use type distribution. This, combined with Figure 1 (soil type distribution) and Table 6 (modelled post-development excess soil moisture), provides the information necessary to examine the spatial distribution of areas of predicted increased and decreased soil moisture. The proposed vegetated road reserves are distributed fairly evenly across the site, likely giving them access to lateral flows predicted to occur from regions of excess soil moisture during rainfall events. Lateral flow moves water from landuse areas with excess water to the vegetated road reserves that are predicted to remove this excess water. The northernmost part of the area characterised by soil type 2, in the west of the site, overlies an area of shallow water table. Soil type 2 also corresponds with the smallest proposed lot sizes.

   Whilst the revised assessment provides evidence to suggest proposed vegetated road reserves will be able to access lateral flow during rainfall events and prolonged wet periods, it is worth noting that this area appears to be at highest risk of both a) waterlogging and b) recharge to the water table should vegetation not be capable of taking up lateral flow of excess soil moisture.

3. As mentioned in point 2, above, the combination of Figure 1, Figure 2 and Table 6 suggest a fairly even distribution of net recharge and discharge across the site. However, it would seem likely that waterlogging of shallow soils will occur at times given the stated critical rainfall or irrigation rate of only 2 mm/hr.

4. A dedicated uncertainty analysis has not been carried out. However, the modelling conducted by Soilwater (2018b), to validate the results of Envirowest (2017a and b) does provide some level of sensitivity analysis because different rainfall data sets were used between the two studies. Given that the results of both studies are similar, it suggests that rainfall variability (sampled from a historical data set) does not impact the outcomes of the assessment. As identified in the initial EMM review, plant rooting depth associated with modelled transpiration from vegetation in road reserves, appears to be a critical factor in the predicted outcome of net reduced recharge to groundwater under post-development conditions. Uncertainty associated with vegetation selection has not been addressed specifically in any of the documents provided to date. It should be noted

then that plant selection must be conducted carefully such that the modelled water uptake can be achieved.

5. Figure 9 and Figure 10 in Envirowest (2018) provide the requested information.

4 Recommendations

The further information provided by the proponent in the revised assessment, in response to issues raised by DPE, has addressed the issues raised from the initial EMM review. The soil/groundwater balance modelling is now adequately documented such that the inputs, assumptions and predicted impacts are clearly presented. Four additional recommendations are made with regard to progression of the proposed development in terms of potential impacts on the regional groundwater and salinity:

1. Given the strong reliance on vegetation in proposed roadside reserves to uptake excess soil moisture transferred laterally from other land use types, it is imperative that plant selection be made in consultation with appropriate experts such that it performs this role;

2. Modelling suggests waterlogging may occur at times. Appropriate water and landscaping engineering (e.g. roadside drains and drainage around buildings and landscaped areas such as retaining walls or excavations) will be required to ensure this does not negatively impact site access, stability or land use;

3. Staged development of the site would enable early identification, and potential mitigation, of any groundwater impacts. Development of larger blocks (with expected lower irrigation density) first would provide a precautionary approach to development. Further, a reconfiguration of smaller blocks to overly areas with greater depth to water table and larger blocks to the region of shallow water table in the west of the site, would reduce the risk of impacts in this higher risk area.

4. Ongoing monitoring of groundwater levels in existing monitoring bores on and within 1 km of the site should be maintained such that any impacts of development can be identified as soon as possible and appropriate mitigation measures implemented if necessary.

5 References

Barnett B, Townley LR, Post V, Evans RE, Hunt RJ, Peeters L, Richardson S, Werner AD, Knapton A, and Boronkay A, 2012, Australian groundwater modelling guidelines, Waterlines Report Series, Number 82, National Water Commission, Canberra.

Envirowest Consulting Pty Ltd (Envirowest) 2017a, Updated groundwater and salinity study, Daisy Hill Estate, Report prepared for Bourke Securities Pty Ltd, Ref R13365s6, dated 10 August 2017.

2017b, Hydraulic model simulations for Daisy Hill. Letter prepared for Bourke Securities Pty Ltd, Ref L13365s13, dated 12 December 2017.

2018, Additional groundwater information Daisy Hill. Letter/report prepared for Bourke Securities, dated 18 April 2018.

Soilwater Consultants 2018a, Peer review of the groundwater and salinity study for the proposed Daisy Hill development. Letter prepared for Bourke Securities, dated 16 April 2018.

2018b, Daisy Hill groundwater & salinity study peer review. Report prepared for Bourke Securities, dated 16 April 2018.