Groundwater and salinity study

Daisy Hill Estate
Proposed subdivision of Lot 200 DP825059, Lots 661 and 662 DP565756, Lots 64 and 65 DP754287, Lots 316 and 317 DP754308 Eulomogo Road, Dubbo NSW

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Executive summary

Background

The *Daisy Hill Estate* is a rural-residential subdivision proposed for Lot 200 DP825059, Lots 661 and 662 DP565756, Lots 64 and 65 DP754287, Lots 316 and 317 DP754308 Eulomogo Road, Dubbo NSW. Total development area is approximately 430 hectares. The conceptual plan includes 284 rural-residential lots ranging in size from a minimum lot size of 0.6ha to a minimum lot size of 3ha. A single dwelling is proposed for each lot. A salinity investigation was undertaken of a rural-residential subdivision of Lot 64 (Peachville Park) by Envirowest Consulting Pty Ltd in 2010.

A soil and water salinity assessment of the *Daisy Hill Estate* is required for the site as part of the rezoning process.

Objectives of the investigation

Undertake a groundwater and salinity study to assess the existing salinity conditions of the soil and groundwater, determine the impact of the development on groundwater and provide mitigation measures to minimise impacts on salinity.

Investigation

The groundwater and soil salinity investigation included a desktop study comprising a review of historical investigations, soil landscape maps, hydro-geological landscapes, groundwater databases and groundwater vulnerability maps. An electromagnetic induction (EM31) survey and soil investigation was undertaken to map subsurface salinity and identify the boundary between the Pilliga Sandstone and Purlewaugh Formation.

A surface inspection was undertaken for evidence of salinity from vegetation growth. Sub-surface investigations included construction of boreholes in areas based on the EM survey. Boreholes were constructed to 6m depth, profile described and soil samples collected for electrical conductivity. Soil analysis results were used to calibrate the EM survey. Simulation modelling of hydraulic and salinity flows were undertaken for pre and post development scenarios.

Assessment was undertaken of the land-use objectives of the Dubbo City Urban Salinity Management Strategy. An on-site meeting was held with Mr Allan Nicholson, Team Leader, Land Management Technical Group, Water Research Unit, Department of Primary Industries. The strategic framework, salt impacts, groundwater recharge, land-use and infrastructure of the development was assessed.

Conclusions

The *Daisy Hill Estate* is located on improved grazing and cropping land on the properties Peachville Park, Peachville Park South, Olivetti and Firgrove. The land has been extensively cleared and little deep rooted vegetation remains. Vegetation comprises native and introduced grasses, clovers, medics and broadleaved weeds. Scattered eucalypt, kurrajong and native pines are located over the site. Removal of deep rooted vegetation over the site for farming has resulted in changes in the water balance and has potential for redistribution of salt in the landscape.

No permanent waterways, poorly drained or seepage, discharge or water logged areas are located on the site. Several small farm dams are located along drainage lines. Soil on the site is brown to yellowish red sandy loam to sandy clay loam over a strong brown to yellowish red sandy clay to medium clay with sand.

Daisy Hill is located in the Richmond Estate and Firgrove Hydro-geological Landscapes (HGL) forming part of the upper Troy Gully catchment. Salinity issues within the Richmond Estate HGL indicate potential for moderate to high impact and the Firgrove HGL low to moderate potential impact. No shallow groundwater was identified on the site. Bores on the site have confined water bearing zones greater than 10m in sandstone and basalt.

Hydro-geological mapping identified a potential salinity risk at the interface between the Pilliga Sandstone and Purlewaugh Formation. The interface was identified by EM survey and confirmed by borehole construction, soil sampling and analysis. Moderate to high soil salinity was identified at the interface area. Groundwater sensitive design was undertaken to minimise the impacts on salinity of the development. The recommendations to manage salinity were undertaken after consultation with Allan Nicholson to achieve industry best practice.

High soil conductivity levels from EM31 survey was recorded in the central area of the site at in the northern section of *Peachville Park*. The high EM conductivity levels are attributed primarily to the response from clayey subsoils. Soil analysis form three boreholes identified low to moderately saline soil from 2.5m in part of the northern section of *Peachville Park*

An area of moderate salinity was also identified in a small area of west of the site from EM survey and soil borings. Impacted soil was at a depth of greater than 1.8 metres.

Simulation modelling of hydraulic and salinity balances indicated the development will result in a reduction in infiltration and groundwater recharge on the site. Reduced infiltration, recharge and salinity are achieved by planting of deep rooted vegetation along road reserves. The simulation modeling indicates the salinity status of the site and off-site will be unchanged by the development.

Recommendations

Establish deep rooted vegetation in road reserves

Deep-rooted vegetation comprising trees and shrubs planted along all road reserves and in strategic areas equivalent to 36.5 hectares. Vegetation buffers along road reserves in areas identified at the hydro-geological interface will be 30m wide on the upper side of the sealed road equivalent to 3.2 hectares. Vegetation buffers along road reserves in other areas of the site will include a 10m wide vegetated area on both sides of the road equivalent to 30ha. Other designated vegetation buffer zones in the plan will be 3.3 hectares. The vegetation buffers will contain deep-rooted vegetation to extraction of soil moisture within the profile and reduce infiltration and intercept shallow groundwater. Reducing water infiltration in to the soil will also minimise the movement of salt stores. Vegetation buffers in the Richmond Residential Estate have been effective in maintaining groundwater levels and preventing salinity impacts.

Urban sensitive design

The final subdivision plan will maintains the natural drainage pattern to ensure minimal disturbance. The plan minimises depth of cut and exposure of susceptible soils. Earthworks in areas of saline subsoil will be restricted to depths of less than 500mm reducing the risk of exposure of saline subsoils. Reversing or mixing the soil when undertaking cut and fill will be avoided. Imported fill will be tested for salinity.

The existing trees along the unformed road on the site will be maintained. Additional trees will be established be individual landholders.

The building envelope for the lot in the north eastern corner of the investigation area under the conceptual plan will be sited outside of high saline areas as identified by the EM survey.

Infrastructure including roads and buildings will be engineered with consideration of soil aggressiveness. Dwellings in area identified in areas with high salinity require BIASE consideration including high impact membranes, exposure bricks, damp course and 32 MPa concrete.

Reduce groundwater recharge
Existing dams will be filled and no new dams will be constructed in the development preventing leaking water recharging the groundwater. Runoff from roads and other hard areas will be discharges to a drainage network which is adjacent to the vegetation buffers.

Swimming pools will be regulated to utilise paper filters rather than sand filters. Paper filters do not require backwashing therefore reducing recharge to groundwater. The requirement for paper filters on pools will be enforced by a Section 88B instrument.

Rainwater reuse
All buildings will be connected to rainwater tanks to reduce groundwater recharge. The rainwater will be used for garden watering at a time when it will be utilised by plants and not infiltrate into the soil. Collection of roof water will be enforced by a Section 88B instrument.

Waterwise gardening
Waterwise gardening will be promoted to future land owners throughout the development. This promotion will be undertaken by the developer. Dubbo City Council has a waterwise promotion program. Low water use gardens are achieved by reducing areas of irrigated lawn and the use of native species. Community trends towards waterwise gardening are expected to become more common over time. Waterwise gardening will be further encouraged by enforcing restrictions on the extraction of groundwater at the site. Native species and waterwise gardening will result in minimal requirements for applications of fertilisers and herbicides.

Contents

1. Introduction

The *Daisy Hill Estate* is a rural-residential subdivision proposed for Lot 200 DP825059, Lots 661 and 662 DP565756, Lots 64 and 65 DP754287, Lots 316 and 317 DP754308 Eulomogo Road, Dubbo NSW. Total development area is approximately 430 hectares. The conceptual plan includes 284 rural-residential lots ranging in size from a minimum lot size of 0.6ha to a minimum lot size of 3ha. A single dwelling is proposed for each lot. A salinity investigation was undertaken of a rural-residential subdivision of Lot 64 by Envirowest Consulting Pty Ltd in 2010.

A soil and water salinity assessment is required for the site as part of the rezoning process.

2. Scope of work

Envirowest Consulting Pty Ltd was commissioned by Bourke Securities Pty Ltd, to undertake a groundwater investigation and salinity study of Lot 200 DP825059, Lots 661 and 662 DP565756, Lots 64 and 65 DP754287, Lots 316 and 317 DP754308 Eulomogo Road, Dubbo NSW. The objective was to assess the existing conditions and possible future impact of the proposed development on soil, groundwater and salinity. Recommended site specific works to minimise the effects of the development on groundwater quality and salinity were recommended.

3. Site identification

Address	*Daisy Hill Estate* Lot 200 DP825059, Lots 661 and 662 DP565756, Lots 64 and 65 DP754287, Lots 316 and 317 DP754308 Eulomogo Road Dubbo NSW
Client	Bourke Securities Pty Ltd *Firgrove Homestead* 30R Eulomogo Road Dubbo NSW 2830
Deposited plans	Lot 200 DP825059, Lots 661 and 662 DP565756, Lots 64 and 65 DP754287, Lots 316 and 317 DP754308
Universal grid reference	UTM Zone 55H, E659323m, N6428205m
Locality map	Figure 1
Aerial photograph	Figure 2
Photographs	Figure 12
Area	430 hectares

4. Proposed development

Daisy Hill Estate is a rural-residential subdivision. The conceptual plan includes 284 lots ranging in size from a minimum lot size of 0.6ha to a minimum lot size of 3ha (Figure 3). Building envelopes with dwellings are proposed for each lot. Four dwellings exist on the site.

Future land-use of the lots is a single dwelling with rural activities. The rural activities are expected to be cattle or horse grazing at low stocking rates. Planting of native trees will occur over the site. Extensive tree and shrub plantings will be undertaken in the road reserves across the site. Width of plantings will range from 10m up to 30m.

The building envelope will have hard surface areas comprising roofs, parking areas and driveways where rainfall will run-off and permeable areas comprising lawns, gardens and pasture where less run-off will occur. Sealed public roads will be constructed with intersections along Eulomogo Road and Pinedale Road to allow access to all lots. Gravel driveways will be constructed from the public roads to allow access to each dwelling site. The dwellings will be serviced by on-site effluent management systems.

Post-development the hard surface areas are expected to be 10.4% of the total. The hard surface areas have been estimated by assuming each dwelling and associated sheds will be 480m^2, each driveway averaging 680m^2 and 2.7% of the site will be bitumen roads.

Post-development the permeable areas comprising vegetated areas, pasture and garden are expected to be 89.6% of the total.

5. Site condition and surrounding environment

5.1 Land-use

The current land-use of the site is grazing land on the properties Peachville Park, Peachville Park South, Olivetti and Firgrove. Grazing and occasional cropping has been undertaken in the past. It is estimated grazing has been undertaken for over 100 years. The cleared areas have been cultivated, fertilised and introduced pasture species sown.

Dwellings and associated infrastructure are located on Lots 64 and 65 DP754287, Lot 662 DP565756 and Lot 200 DP825059.

5.2 Vegetation

The natural woodland has been cleared from most of the site. The site is dominated by introduced and native pasture species. Introduced species include ryegrass, lucerne, soft brome and oats. Native pasture species include weeping grass, spear grass, native medics and naturalised clovers. Weed species included saffron thistle, sheep sorrel, Paterson's curse and medic.

A small stand of remnant native trees is located in a central section of Lot 64. Tree species consisted of Inland grey box and fuzzy box. White cypress pines are located around the boundary of the site and isolated white cedar, white cypress pines and kurrajong trees occur throughout the paddocks.

5.3 Topography

The site is located on a flat within a mid-slope. A low ridge is located through the central section of Lot 200 DP825059 and extends along the eastern boundary of the investigation area. Aspect is predominantly west with a southerly aspect in the southern section of Lot 200. Slopes are very gently inclined and generally less than 1%. Elevation ranges between 311 metres on the flats to 377 metres along the crest in the eastern section.

5.4 Soils and geology

The site is within the Eulomogo Soil Landscape (Murphy and Lawrie 1998). Topsoil consists of a dark reddish brown to light reddish brown sandy loam with a gradual boundary change to a dark reddish brown to light reddish brown fine sandy clay loam to 100cm over a mottled yellow and grey clay to 150cm. Soils have a low to moderate fertility and moderate erosion hazard. Soil salinity problems are absent over the site.

The geological unit is Pilliga Sandstone and Ballimore Formation with lithology comprising massive to cross-bedded coarse pebbly lithic-quartz sandstone, minor lithic sandstone and siltstone (Colquhoun *et al.* 1997).

5.5 Surface water

An intermittent drainage line is located through the central section of the site and runs south east to north west. Surface water over the majority of the site flows into intermittent drainage lines which empty into Troy Creek located approximately 900m north west of the site.

Surface water in the southern section of the site flows south and into Eulomogo Creek approximately 1km from the site.

No dams or permanent streams are located on or near the site.

5.6 Groundwater

Bores 50, 51, 52, 53, 54, 55, 56 and 57 were identified on the NSW Natural Resource Atlas as located on the site and are licensed for stock and domestic supplies and monitoring (Figure 4). Bores 53, 55 and 46 are operational bores located on the site. Bore 46 is depicted to the south of the site. Bore 50 is a Dubbo City Council monitoring bore and is located to the south of the site, bores 51 and 52 are not known to be located on the site and bores 54, 56 and 57 are not equipped for use. Water bearing zones ranged from 14 and 90m and standing water levels of 12 to 52m. The bores were constructed between 1957 and 2012. These bores indicate shallow water does not occur on the site. Water description at the time of construction was good with water in one bore described as salty, brackish.

The Office of Environment and Heritage (OEH) NSW Natural Resource Atlas (2013b) identifies fifty seven bores within 1km of the site (Figure 4). These bores are licensed for domestic, stock and irrigation supplies (Appendix 1). Eight are Dubbo City Council groundwater monitoring bores. Depth of the bores ranged from 9 to 107m. Water bearing zones were located generally deeper than 10m in basalt and sandstone. Standing water levels at the time of construction ranged between 5 to 50m.

The site is located within the Eastern Porous Rock: Macquarie-Castlereagh Groundwater Management Unit (Murray-Darling Basin Authority 2012). Groundwater salinity ranges from 1,500-3,000mg/L.

6. Groundwater and soil salinity investigation

The groundwater and soil salinity investigation comprised a desktop study, EM survey, borehole construction and soil analysis. The desktop study included a review of previous investigations, soil landscape maps, hydro-geological landscapes and groundwater databases. Water balance modelling was also undertaken. The EM survey was undertaken to determine the Pilliga Sandstone and Purlewaugh Formation interface and areas of potential high salinity.

6.1 Review of previous investigations

A groundwater and soil salinity investigation was undertaken on Lot 64 DP754287 in 2010 by Envirowest Consulting Pty Ltd (report number R10297s). The investigation was undertaken in accordance with the requirements in Lillicrap and McGhie (2002) including initial site assessment, detailed profile description and laboratory analysis.

Lot 64 DP754287 forms the central section of the *Daisy Hill Estate* development. Land-use, site characteristics and natural resources of Lot 64 are similar to that on the remainder of the *Daisy Hill Estate* area. Lot 64 DP754287 is considered representative of the *Daisy Hill Estate* site. Results of the groundwater and soil salinity investigation conducted on Lot 64 provide indicative data for the remainder of the *Daisy Hill Estate* area.

6.2 Soil landscape maps

Soil landscape data was reviewed for information regarding soil types in the locality, occurrence of salinity, erosion and sodic soils.

6.3 Hydro-geological landscapes

Dubbo City Council (2013c) has developed hydro-geological landscapes for the locality. Hydro-geological landscape data (Figure 5) was reviewed for information regarding the groundwater aquifer including lithology, aquifer type, recharge and discharge characteristics. Management options and strategies recommended for each management areas within the landscapes were reviewed.

6.4 Groundwater databases

An investigation of registered bores in the area was undertaken to determine the depth and salinity of the groundwater. Groundwater information was found from a review of the NSW Government Natural Resource Atlas website. Groundwater information was also obtained from the Dubbo City Council Salinity Network.

The groundwater was divided into deep and shallow groundwater. Deep groundwater is located in sandstone and basalt fractures and sediments at depths greater than 10 metres. The shallow groundwater is generally confined in a local aquifer above the sandstone and basalt regolith.

Water criteria for salinity are presented in Tables 1 and 2. The conversion from EC (dS/m) to total dissolved solids or TDS (mg/L) is undertaken by applying the conversion factor of 640 for an average concentration of salts present (Lillicrap and McGhie 2002).

Table 1. Drinking water criteria for salinity (ADWG 2004)

Criteria	EC (dS/m)	Total dissolved solids -Salinity (mg/L)
Good quality drinking water	0.78	500
Acceptable based on taste	0.78-1.56	500-1000
Unsatisfactory taste	1.56	Greater than 1000
Seawater	Greater than 55	-

Table 2. Total dissolved solids of water for agricultural use (Reid 1990)

Class	Description	Total dissolved solids -Salinity (mg/L)
1	Low salinity	0-175
2	Medium salinity	175-500
3	High salinity	500-1500
4	Very high salinity	1500-3500
5	Extremely high salinity	>3500

6.5 Urban salinity management strategy

The Dubbo City Urban Salinity Management Strategy was reviewed. The strategy describes the local salinity setting and summarises historic reports into hydro-geological landscapes to enable prioritising actions for salinity management.

Strategies for managing salt impact by groundwater recharge, land-use and infrastructure contained in the report were assessed for compliance with the proposed development. The strategies to be assessed were:

- Salt impact
- Groundwater recharge
- Land-use
- Infrastructure
- Monitoring

6.6 EM survey

An electromagnetic induction (EM) survey was undertaken of the eastern section of *Daisy Hill Estate* by Terrabyte Services in May 2014 (Appendix 2). The EM31 survey was undertaken to determine changes in soil conductivity. The survey was undertaken using GPS equipment to enable a grid pattern of 50m. Depth of penetration was 6m. The scale adopted for apparent conductivity ranged from 12mS/m to 166mS/m.

EM surveys were undertaken of the central and western sections of *Daisy Hill Estate* by Department of Land and Water Conservation in 2002. The survey on the central section (Appendix 3) was undertaken using GPS equipment to enable a grid pattern of 20m. Depth of penetration was 4 to 5m. The scale adopted for apparent conductivity ranged from 0mS/m to 185mS/m.

The survey on the western section (Appendix 4) was undertaken using GPS equipment on a grid pattern of 50m. Depth of penetration was 5m. The scale adopted for apparent conductivity ranged from 38mS/m to 88mS/m.

The colour scale of individual EM data was rescaled from the 2002 sampling to enable comparison with the 2014 sampling date visually.

6.7 Detailed soil profile descriptions and laboratory analysis

The results of the EM survey were calibrated by soil testing. Fifteen boreholes were constructed to 6m with an EVH truck mounted hydraulic drilling rig with solid auger on 27 May and 28 October 2014 to provide information on the soil profiles and enable sampling. Nine boreholes (BH1, BH2, BH6, BH9, BH10, BH11, BH13, BH14 and BH15) were constructed in areas identified by the EM survey with high conductivity, five (BH3, BH4, BH5, BH8 and BH12) in areas with low conductivity and one (BH7) in moderate conductivity areas. The soil profile was described for colour, texture and moisture.

Soil samples were collected from the boreholes at 0-10, 10-20, 20-30, 40-50cm, and 0.5m intervals to the depth of the borehole and are expected to give an adequate description of subsoil salinity conditions. The samples were analysed for pH, electrical conductivity and dispersion.

Soil electrical conductivity (EC) results of the 1:5 (soil:water suspension) were converted to saturated extracts (ECe). EC values are converted to ECe by using a multiplier factor (Charman and Murphy, 1991), which is dependent on the soil texture (Table 3). Saline soils are defined as those with an electrical conductivity (ECe) greater than 4 dS/m (Charman and Murphy, 2001). Soil salinity ratings and effects on plant growth are presented in Table 4.

Table 3. ECe texture based conversion factors (Charman and Murphy 2001)

Soil texture	Conversion factor
Loamy sand, clayey sand, sand	23
Sandy loam, fine sandy loam, light sandy clay loam	14
Loam, loam fine sandy, silt loam, sandy clay loam	9.5
Clay loam, silty clay loam, fine sandy clay loam	8.6
Sandy clay, silty clay, light clay	7.5
Light medium clay, medium clay, heavy clay	5.8

Table 4. Soil salinity ratings based on ECe readings

Salinity rating	ECe (dS/m)*	Effects on Plants
Non saline (NS)	0-2	Salinity effects negligible
Slightly saline (SS)	2-4	Very salt sensitive plant growth restricted
Moderately saline (MS)	4-8	Salt sensitive plant growth restricted
Highly saline (HS)	8-16	Only salt tolerant plants unaffected
Extremely saline (ES)	>16	Only extremely tolerant plants unaffected

*ECe - Electrical conductivity of a saturated extract

Soil with ECe below 2 dS/m will have negligible effects on plant growth and soil stability. Soil with ECe of between 2 and 4 dS/m may restrict very salt sensitive plant growth. Soil with ECe between 4 and 8 dS/m will restrict the growth of salt sensitive plants.

Samples were analysed for dispersion using the Emerson aggregate test. Table 5 details the eight dispersion classes.

Table 5. Emerson dispersion classes

Class	Description
1	Highly dispersive (slakes, complete dispersion)
2	Moderately dispersive, slakes, some dispersion
3	Slightly dispersive, slakes, some dispersion after remoulding
4	Non-dispersive, slakes, carbonate or gypsum present
5	Non-dispersive, slakes, dispersion in shaken suspension
6	Non-dispersive, slakes, flocculates in shaken suspension
7	Non-dispersive, no slaking, swells in water
8	Non-dispersive, no slaking, does not swell in water

6.8 Hydraulic balance

A hydraulic balance model simulating water inputs and outputs was undertaken with pre and post development:

1. Rural - pasture with natural rainfall, four dwellings and driveways (pre development)
2. Rural-residential - with runoff from hard surfaces, 284 dwellings, driveways and sealed access roads (post development)
3. Rural-residential - with runoff from hard surfaces, 323 dwellings, driveways and sealed access roads (post development)

The model calculates groundwater recharge each month of the year. Input parameters are rainfall, infiltration from wastewater, irrigation and overflow from rainwater tanks (Table 7). Output parameters are runoff, stormwater harvesting and evaporation. Estimates were made of evaporation and other parameters based on available data. The site was partitioned into land-use units based on hydraulic factors. Conservative estimates of inputs and outputs have been made.

6.8.1 Inputs

6.8.1.1 Monthly rainfall

Monthly rainfall was obtained from the Dubbo weather station of the Bureau of Meteorology. This is the closest recording station and is considered representative of the site. The average monthly data is used in the model. The average rainfall data is appropriate as other inputs are also average in the model.

6.8.1.2 Effluent infiltration

The on-site effluent management systems recommended by Envirowest Consulting in October 2013 (Report number R13365e) were designed so as no infiltration will occur from the irrigation of treated effluent. An effluent infiltration value has been included in the water balance to provide a safety factor in the case of mismanagement of the effluent system and application of untreated effluent by homeowners. The infiltration volume has been set at 20% of total wastewater flows.

6.8.1.3 Irrigation

Irrigation rates have been set at 50mm per month above the average evapotranspiration to allow for extreme overwatering scenarios. Irrigation rates are expected to be lower during wet years and higher during dry years.

This irrigation rates based on Dubbo City Council 2011/2012 and 2012/2013 water consumption records for Firgrove Estate and Richmond Estate are presented in Table 6. Dubbo City Council have identified that rural-residential lots in Firgrove Estate and Richmond Estate consumed between 834L and 1,700L per lot per day in the 2011/2012 and 2012/2013 recording period (Table 6). Wastewater production is assumed to be 580L per dwelling per day (based on 4 people using 145L per day). It is inferred that 580L of water is consumed by each dwelling per day. The balance of between 254L and 1,120L per lot per day is therefore assumed to be utilized for irrigation.

The average irrigation lawn area was determined to be 1,300m^2 for each lot. Assuming 537m^2 is used for effluent application (Envirowest Consulting Pty Ltd report R13365e), 763m^2 is available for irrigation by town water supply. This equates to an irrigation rate of 10mm per month to 46mm per month. Monthly irrigation rates used within the hydraulic balance range from 45mm per month to 234mm per month.

The irrigation rates in the hydraulic model are averaged over the whole lot for presentation of the data.

Table 6. Summary of calculated irrigation rates per property as determined from Dubbo City Council water consumption records

Factor	Minimum	Maximum	Average
Average annual consumption (Dubbo City Council)	304,500L/year	618,037L/year	463,744L/year
Average daily consumption	834L/day	1,700L/day	1,271L/day
Daily volume consumed within the dwelling (R13365e)	725L/day	725L/day	725L/day
Daily volume used for irrigation	109L/day	975L/day	546L/day
Adopted irrigated area (Section 6.8.1.4)	1,300m^2	1,300m^2	1,300m^2
Effluent irrigation area (R13365e)	537m^2	537m^2	537m^2
Potable water irrigation area	763m^2	763m^2	763m^2
Daily irrigation rate	0.33mm/day	1.47mm/day	0.91mm/day
Monthly irrigation rate	10.2mm/month	45.6mm/month	28.2mm/month
Simulation model Monthly irrigation rate over the irrigated area (13.2% of the area)	45.5mm/month	234mm/month	131.9mm/month

6.8.1.4 Irrigation area

A review of the April 2009 aerial photograph for the Dubbo area was undertaken to determine average building (dwelling and sheds) size, driveway size and irrigated lawn area. Two rural-residential areas were selected. Buninyong Drive subdivision contained blocks ranging from 0.4 to 0.8ha with an average size of 0.5ha. The *Firgrove Estate* contained blocks ranging in size from 1.5 to 8.3ha with an average size of 2ha. A total of 127 lots were assessed (Appendix 5). The average irrigated lawn area was 1,300m^2. A conservative value of 2,000m^2 for irrigation has been used in the hydraulic balance.

6.8.1.5 Overflow from tanks

Run-off from buildings comprising dwellings and sheds will be captured in rainwater tanks (water harvesting). Some infiltration is expected to occur at times when the rainwater tanks overflow. It has been estimated that 10% of the monthly harvested volume will overflow monthly.

6.8.1.6 Surface runoff

Stormwater flows on permeable areas will result in 10% runoff. Permeable areas post development are the following:

- Pasture which comprises 68% of the site
- Irrigated lawn which comprises 13.2% of the site
- Trees and shrubs plantings comprise 8.4% of the site. Trees and shrubs will be planted in road reserves and various buffer areas.

Stormwater flows on hard (roads and driveways) areas will result in 10% runoff. Hard areas post development are the following:

- Public roads which comprise 2.7% of the site
- Driveways which comprise 4.5% of the site. Driveway area for each lot has been determined by the average driveway area identified in the review of the 2009 aerial photograph as described in Section 6.8.1.4. The average driveway area was calculated to be 680m^2.

Stormwater flows on hard (roof) areas will result in 100% runoff. The runoff will be captured in rainwater tanks. Hard (roof) areas post development comprises 3.2% of the site. Roof areas for each lot has been determined by the average roof area identified in the review of the 2009 aerial photograph as described in Section 6.8.1.4. The average roof area was calculated to be 480m^2.

6.8.2 Outputs

6.8.2.1 Monthly evaporation

Monthly evaporation was obtained from the Wellington weather station for the Bureau of Meteorology. This is the closest recording station for evaporation and is considered representative of the site.

6.8.2.2 Rainwater harvesting

Run-off from the buildings comprising dwellings and sheds will be captured in rainwater tanks (water harvesting). All buildings will be connected to rainwater tanks. Roof area post development comprises 3.2% of the site.

6.8.2.3 Evapotranspiration

Water use of pasture has been described as an empirical relationship considered to approximate water use on shallow rooted pastures.

The crop factor for lawn and trees on the site has been set at 90%.

Road reserves of 35m width will be planted with a 10m wide section of vegetation on either side of the road. Road reserves of 45m width will be planted with a 30m wide section of vegetation on one side of the road. Additional trees and shrubs will be planted at strategic locations to intercept groundwater. Vegetated areas post development will comprise 8.4% of the site.

The parameters listed in Table 7 were used in the hydraulic model.

6.9 Salinity balance

6.9.1 Groundwater salinity balance

An estimation of salinity infiltration into the groundwater was undertaken by using available data. Infiltration is expected to mobilise salt which is present in some landscapes. The parameters are described in Table 8.

6.9.1.1 Aquifer infiltration

Aquifer infiltration pre and post development was estimated using the results of the hydraulic balance model which simulated water inputs and outputs under the pre and post development. Inputs included rainfall, effluent infiltration, irrigation and overflow from tanks. Outputs included evaporation, rainwater harvesting and evapotranspiration. The parameters adopted in the hydraulic balance are described in Section 6.8.

6.9.1.2 Area

The development will be undertaken over an area of 430ha.

6.9.1.3 Groundwater EC

The groundwater electrical conductivity was estimated by calculating the average groundwater electrical conductivity for a Dubbo City Council groundwater monitoring well. The well adopted was DCC7 (Figure 6) located approximately 1km north of the investigation area.

6.9.1.4 Effluent infiltration

Effluent infiltration was assumed to be 5% of the total effluent flows applied to the site. Effluent infiltration was determined by assuming daily effluent flow rates of 725L per dwelling (Envirowest Consulting report number R13365e). Four dwellings are located on the site under the pre-development scenario and 284 dwellings on the site under the post development scenario.

6.9.1.5 Typical salinity of effluent
Typical salinity of effluent was obtained from published data.

Table 7. Hydraulic model parameters

	Pasture land-use	Rural-residential land-use
INPUTS		
Monthly rainfall	Bureau of Meteorology, Dubbo	Bureau of Meteorology, Dubbo
Effluent infiltration		
20% of total flows	0mm	0.3mm/month
Irrigation	50mm above evapotranspiration	50mm above evapotranspiration
Irrigation area (lawn)	0.97%	13.2% (2,000m^2 per lot)
Overflows from tanks	0mm	10% captured volume overflows
Surface runoff		
Permeable 10% runoff	98.86%	89.6%
Hard (Driveways and roads) 10% runoff	0.11%	7.2%
Hard (Roof) 100% runoff	0.06%	3.2%
OUTPUTS		
Monthly evaporation	Bureau of Meteorology, Wellington (nearest available data source)	Bureau of Meteorology, Wellington
Rainwater harvesting	0.06%	3.2%
Evapotranspiration		
Pasture	Evaporation$^{0.75}$	Evaporation$^{0.75}$
Crop factor	90%	90%
Trees and shrubs	0.1%	8.4%

Table 8. Groundwater salinity model parameters

Parameter	Units	Pre development	Post development	Source
Aquifer infiltration	mm	358	279	Infiltration as calculated from the hydraulic balance over the whole site
Area	ha	430	430	Subdivision area
Groundwater EC	mg/L	2,432	2,432	Average EC in DCC well 7 1km north of the site
Effluent infiltration (5% of output)	L	145	10,295	Pre 4 dwellings Post 284 dwellings 725L/dwelling 5% infiltration
Typical salinity of effluent	mg/L	940	940	Patterson (2006)

6.9.2 Surface water salinity balance
Salt in surface water moving off-site was estimated from sediment export data in each land-use type and average salt concentration of the topsoil. The parameters for the surface water salinity balance are described in Table 9.

6.9.2.1 Area
The development will be undertaken over an area of 430ha.

6.9.2.2 Salinity
The average electrical conductivity for soil and water was estimated by calculating the average electrical conductivity for soil and water as determined from the groundwater and soil salinity investigation undertaken at *Peachville Park* (Lot 64 DP754287) in 2002.

Table 9. Surface water salinity parameters

Parameter	Units	Pre development	Post development	Source
Area	ha	430	430	
Average EC (1:5 soil:water)	mg/L (water) mg/kg (soil)	896 179	896 179	Average from *Peachville Park* investigations
Sediment export	kg/ha	4.2	2.2	Chafer (2003) from improved pasture and rural residential

6.10 Nitrogen
The impact from the pre development and post development nitrogen sources is described. The impacts from the nitrogen sources and potential export off site are described.

6.11 Phosphorus
Comments are made regarding phosphorus export in the groundwater. Typical soil data is used in the assessment of impacts.

6.12 Other contaminants
Comments are made on other contaminants which have potential to occur as results of the development.

7. Results and discussion
7.1 Review of previous investigations
A groundwater and soil salinity investigation was undertaken on Lot 64 DP754287 in 2010 by Envirowest Consulting Pty Ltd (report number R10297s). The investigation was undertaken in accordance with the requirements in Lillicrap and McGhie (2002) including initial site assessment, detailed profile description and laboratory analysis.

Initial investigations were undertaken at 231 locations across the site. Vegetation across the site was dominated by introduced pasture species with some native pasture species. Weed species were identified throughout the paddocks. A low density of water tolerant vegetation was identified in parts of the north east paddock indicating poorly drained soils or a high water table level.

A small stand of remnant native eucalypt trees is located in the central section of the site. Isolated kurrajong and white cedar trees are located throughout the paddocks for wind breaks and shade. Ornamental trees and shrubs have been planted around the *Peachville Park* homestead.
Slope percentage was generally less than 2% and scattered surface rocks were identified in some paddocks. Rock outcrops occur within the stand of remnant vegetation.

No bare areas or other indicators of salinity were observed.

The detailed profile description was undertaken by construction of thirty boreholes to a depth of 3m or drill refusal. Topsoil on the site was a brown to yellowish red sandy loam to sandy clay loam. Topsoil depth varied between 100 to 1100mm and was generally between 600 to 800mm. Subsoils ranged from strong brown to yellowish red sandy clay to medium clay with sand. No indicators of a shallow watertable were identified in the soil profile.

Laboratory analysis was undertaken on representative soil samples collected from the boreholes. The topsoil and majority of subsoil samples were found to be non-saline. Moderately saline soil was identified in the subsoil of two boreholes constructed in the north western paddock.

Topsoil was found to be moderately acidic with pH increasing with depth. The soil was slightly to non-dispersive and exchangeable sodium percentage indicated sodic soils. Levels of chlorides indicated non-aggressive soils.

The groundwater system is part of the upper Troy Gully catchment. No groundwater discharge areas are located on the site. Seasonally elevated groundwater occurs in the north west of the site. No evidence of groundwater was encountered to the drilling depth of 3m over the remainder of the site.

Surface runoff discharges into the existing drainage lines north and west of the site.

Assessment of hydraulic flows of the development indicated the subdivision will result in reduced infiltration and groundwater recharge on the site. This is achieved by the increase in runoff due to impermeable areas and planting of trees. The subdivision will not impact on the confined deep groundwater aquifer located at greater than 10 metres in sandstone and basalt.

7.2 Soil landscape maps

The site is located within the Eulomogo Soil Landscape (Murphy and Lawrie 1998) of which red earths are the major soil type. Parent materials include sandstone, conglomerate, siltstone and shale. Topsoils have a sandy loam texture. The boundary between the A and B horizons is gradual. Subsoils are reddish brown to dark reddish brown to light reddish brown fine sandy clay loam. The soils are well draining, some mottling may occur at depths greater than 1m.

Erodibility is moderate in the topsoil and subsoil of red earths and a sodic lower subsoil is common within the landscape. Murphy and Lawrie (1998) indicate red earths within the Eulomogo Soil Landscape are non-saline but potential exists for soil salinity issues to develop in the medium to long term.

7.3 Groundwater databases

7.3.1 Confined (deep) groundwater

Fifty seven registered water abstraction bores were identified within a 1km radius of the site on the NSW Government Natural Resource Atlas website (2013) (Figure 4). Bores 50, 51, 52, 53, 54, 55, 56 and 57 were identified on the NSW Natural Resource Atlas as located on the site and are licensed for stock and domestic supplies and monitoring. Bores 53, 55 and 46 are operational bores located on the site. Bore 46 is depicted to the south of the site. Bore 50 is a Dubbo City Council monitoring bore and is located to the south of the site, bores 51 and 52 are not known to be located on the site and bores 54, 56 and 57 are not equipped for use. Off-site bores were generally to the north and south.

Water-bearing zones (WBZ's) were recorded for 48 bores and standing water level (SWL) was recorded for 39 bores at the time of drilling or water testing. Data known about each bore from the Natural Resource Atlas website is summarised in Appendix 1.

The Natural Resource Atlas website shows that SWL's and WBZ's in bores (for which data was recorded) were at depths greater than 10m (Appendix 1 and Figure 4). The water bearing zones are located in sandstone and basalt.

A salinity description was recorded for twenty bores. Six were considered to contain saline water, with descriptions of '1001-3000ppm', '3001-7000ppm', '7001-10000ppm', 'salty' or 'brackish'. The remainder of the bores has descriptions of 'fresh', 'stock', 'fair', good stock' and '0-500ppm'.

7.3.2 Unconfined (shallow) groundwater

Four Dubbo City Council (DCC) monitoring bores are located at less than 1km from the site and seven are located between 1 and 2km from the site either to the north west and north or to the south east (Figure 6 and Appendix 6). Bore depths ranged from 3m to 12m with water bearing zones located in unconfined regolith comprising clay.

The closest bore to the site is identified as DCC4 (Figure 6) which has a depth of 9m. DCC4 has generally been too shallow to bail since monitoring began in March 2005 indicating groundwater on the site is located at depths greater than 9m.

The depth to groundwater in DCC monitoring bores within 2km of the site in May and June 2013 ranged between 0.73m and 6.95 and some were dry (Table 10). The two bores constructed adjacent to Eulomogo Creek (DCC 114 and DCC 128) had standing water levels of less than 1m and are expected to be influenced by flows in Eulomogo Creek.

Most bores sampled recorded very high to extremely high levels of total dissolved solids with levels ranging between 461mg/L to 11,053mg/L (Table 10).

The DCC monitoring data is not considered to be representative of the site due to distance downslope or location in a different sub-catchment. Previous drilling on the site identified groundwater at depths greater than 10m below the surface.

7.4 Hydro-geological landscapes

The majority of the site is located within the Richmond Estate Hydro-geological Landscape with that part of the site located on the southern side of Eulomogo Road located within the Firgrove Hydro-geological Landscape (DCC 2013c). The site and associated hydro-geological landscapes are depicted in Figure 7.

Lithology of the Richmond Estate Hydro-geological Landscape is dominated by the Purlewaugh Formation comprising siltstone, mudstone, sandstone, ironstone with small amounts of coal (DCC 2013a). The ridges of the landscape are overlain by Pilliga Sandstone comprising sandstone and siltstone. Groundwater is unconfined to semi-confined in consolidated fractured rock. Lateral flow occurs through colluvial sediments. Recharge occurs in discrete elements of the landscape including on Pilliga Sandstone. Discharge sites resulting in saline sites occur across specific contours in the landscape including the lower slopes of Management Area 2 and Management Area 5. The landscape shape and high salt store may result in high salt loads from the landscape.

Lithology of the Firgrove Hydro-geological Landscape is Pilliga Sandstone comprising sandstone and siltstone (DCC 2013b). Groundwater is unconfined in consolidated fractured rock. Lateral flow and vertical flow occurs through fractured rock and colluvium. Discharge sites resulting in saline sites occur in the mid and lower landscape including Management Area 5.

The Dubbo 1:250,000 Geological Series map depicts the Pilliga Sandstone is located in the eastern section of the site in the area proposed to be rezoned to a minimum lot size of 1.5ha to a minimum lot size of 3ha.

It is considered that the minimum lot size of 1.5ha and minimum lot size of 3ha are located within Management Areas 1 and 2 for both the Richmond Estate Hydro-geological Landscape and the Firgrove Hydro-geological Landscape and Management Area 3 for the Richmond Estate Hydro-geological Landscape. The remainder of the site comprising the 6,000m^2 lots are located within Management Area 3 of the Richmond Estate Hydro-geological Landscape.

Table 10. Shallow groundwater results for Dubbo City Council groundwater monitoring bores (DCC 2013)

Sampling location (see Figure 4)	Depth (m)	Date sampled	Standing water level (m)	EC dS/m	Total dissolved solids (EC x 640) mg/L
DCC1	12	May 13	5.69	17.27	11,053
DCC4	9	May 13	Dry	-	-
DCC5	8	May 13	2.93	6.39	4,090
DCC7	9	May 13	2.99	3.20	2,048
DCC8	15	May 13	4.75	9.27	5,933
DCC17	6	May 13	2.81	0.74	474
DCC25	12	May 13	2.98	1.99	1,274
DCC26	6	May 13	Dry	-	-
DCC27	5	May 13	Dry	-	-
DCC101	3	May 13	Dry	-	-
DCC114	4.5	May 13	0.73	7.29	4,666
DCC128	5.5	May 13	0.85	7.96	5,094
DCC1	12	Jun 13	6.95	0.72	461
DCC4	9	Jun 13	Dry	-	-
DCC5	8	Jun 13	3.05	7.10	4,544
DCC7	9	Jun 13	3.50	5.30	3,392
DCC8	15	Jun 13	4.75	11.20	7,168
DCC17	6	Jun 13	Dry	-	-
DCC25	12	Jun 13	4.60	3.90	2,496
DCC26	6	Jun 13	Dry	-	-
DCC27	5	Jun 13	Dry	-	-
DCC101	3	Jun 13	Dry	-	-
DCC114	4.5	Jun 13	0.79	6.58	4,211
DCC128	5.5	Jun 13	0.92	7.04	4,506

7.5 Urban Salinity Management strategy

The Dubbo Urban Landscape Interpretation Project has reviewed soil and geology data and produced Hydro-geological landscapes for the local area. The hydro-geological landscapes were developed to prioritise action for salinity management. Salinity hazard for each landscape was assessed based on salt impact, salt load export impact and impact on water quality.

The *Daisy Hill Estate* development is contained in the Richmond Estate Hydro-geological Landscape with a small area in the Firgrove Hydro-geological Landscape (Figure 7). A summary of the salinity context is presented in Table 11.

Table 11. Salinity context of the Richmond Estate and Firgrove Hydro-geological Landscapes

Hydro-geological landscape	Land impact	Salt load export impact	Impact on water quality	Overall hazard
Richmond Estate	Moderate	High	High	High
Firgrove	Low	Moderate	Low	Medium

The management recommends implementation of strategies to manage salinity in the landscape. The measures to be implemented are dependent on the landscape salinity hazard.

7.5.1 Salt impact

The impact of salt on the landscape will be minimised. Where salinity is present in the landscape the strategic outcomes to reduce salt impact are:

- Minimise the discharge of salt into the groundwater system and streams
- Limit the interaction of salt stores with shallow groundwater

The implementation plan for salt impact is provided as Appendix 7.

7.5.2 Groundwater recharge

The volume of water with potential to enter the natural system will be minimised. Significant impacts on the groundwater system will be minimised by mitigation measures. Evaporation reductions on hard surfaces will be offset by deep rooted vegetation planting resulting in an overall increase in evaporation. Vegetation growth will be maximised in the residential lots which are active all year. The current grazing system has periods of dormancy and low evaporation due to species characteristics and climatic conditions. The new vegetation regime will minimize lateral flows of shallow groundwater and utilise subsurface moisture within the landscape.

The subdivision will be designed to prevent ponding and waterlogged areas.

The implementation plan for groundwater recharge is provided as Appendix 7.

7.5.3 Land-use

The subdivision will be designed to minimise impacts on the natural movement of water above and through the soil. The design will consider the local geology and potential salt loads of the lithology. The use of salinity affected land will be undertaken in accordance with best practice management principles. The extent and impact of land-use activities and practices will not result in an increase in off-site movement of salt.
The implementation plan for land-use is provided as Appendix 7.

7.5.4 Infrastructure

Potential hazardous area will be identified in the detailed investigation. Construction techniques will be appropriate for the salinity risk. Engineering solutions will be implemented to minimise impacts on infrastructure and buildings.

The implementation plan for infrastructure is provided as Appendix 7.

7.5.5 Monitoring

Installation of groundwater monitoring wells will form part of the detailed soil and groundwater salinity assessment. The wells will be placed in areas of proposed road reserves. The wells will be suitable for inclusion to the Dubbo Salinity Network which is monitored by Dubbo City Council on a monthly basis.

The implementation plan for monitoring is provided as Appendix 7.

7.6 EM survey

The EM surveys identified variations in sub-surface conductivity over the eastern part of the development (Figure 8). Areas of high conductivity were identified at the hydro-geological interface between the Pilliga Sandstone and Purlewaugh Formation in the eastern section of the site. The interface was not continuous, present in several discrete areas. The surface inspection undertaken

with Mr Alan Nicholson in June 2014 identified bare areas located at the high salinity areas in the eastern area of the development.
An area of high conductivity was identified in the central northern section of the development area (Figure 8). The surface inspection identified bare areas to the east of the remnant vegetation. Other bare areas were attributed to stock tracks.

Areas of moderate apparent conductivity were identified in the western section (Figure 8). Surface inspections identified bare areas in the central section and extending to the south east.

7.7 Detailed profile description and laboratory analysis

Boreholes were constructed in areas of various levels of conductivity as interpreted from the EM survey (Figures 9 and 10). Boreholes constructed in the eastern and higher elevation areas of the site (BH1, BH2, BH3, BH4, BH5, BH6 and BH7) comprised topsoils of dark brown to dark reddish brown fine sandy loam to fine sandy clay loam. Subsoils were generally a strong brown to dark red sandy clay. Subsoils in boreholes BH1 and BH2 constructed in areas of high apparent conductivity were brownish yellow to red silty clay.

Boreholes constructed in the central and western sections of the site (BH8, BH9, BH10, BH11, BH12, BH13, BH4 and BH15) comprised topsoils of sandy loam to sandy clay loam. Subsoils were generally light to medium clay with layers of sandy clay.

Highly saline soils were identified in borehole BH2 from depths of 1m. The soil was non-saline from 0m to 1m in borehole BH2. Moderately saline soils were identified in borehole BH6 from 1m, boreholes BH13 and BH15 from 2,500mm and boreholes BH8 and BH14 from 5,000mm. Non-saline to slightly saline soils were identified to 6m in boreholes BH1, BH7, BH9, BH10 and BH11. Non-saline soils were identified to 6m in boreholes BH3, BH4, BH5 and BH12. The saturated conductivity results are described in Figure 11.

Boreholes BH9, BH10 and BH11 were constructed in areas of where the EM survey identified high apparent conductivity. The boreholes BH9, BH10, BH11 indicate the soil profile has a high clay content. The soil analysis results indicate non-saline to slightly saline soils. The moderate conductivity response obtained from the EM survey is from of the high clay content of the soil (medium clay) rather than salinity.

Moderate salinity was identified in borehole BH15 at depths from 1.8m. The moderate consistency of an area around BH15 was indicated in the EM survey.

Soil in other boreholes contained low levels of soil salinity to the drilling depth. Borelogs and laboratory analysis results are presented in Appendix 8.

7.8 Hydraulic balance

7.8.1 Rural-residential – 284 lots

The hydraulic simulation model of the 284 lot subdivision (Appendix 9) indicates that infiltration will decrease under the post development scenario by 79mm per year over the site. The decrease is a result of the increase in soil moisture extraction by the planned planting of trees and shrubs across the site. The water balance provided in Appendix 10 demonstrates the change in infiltration without the uptake of soil moisture by trees and shrubs.

7.8.2 Rural-residential – 323 lots

The hydraulic simulation model (Appendix 11) indicates that infiltration will decrease under the post development scenario by 74mm per year. The decrease is a result of the increase in soil moisture extraction by the planned planting of trees and shrubs across the site. The water balance provided in Appendix 12 demonstrates the change in infiltration without the uptake of soil moisture by trees and shrubs.

7.9 Salinity balance

7.9.1 Groundwater

The level of salt mobilised in the landscape and from on-site effluent systems will be reduced by 817 tonnes after the development (Table 12). The contribution from infiltration in the general site area is less post development due to the evaporation from deep rooted vegetation planted. The levels estimated to not include the impact of the reduction in dams on the site which are concentrated recharge locations that will not be present after the development.

Table 12. Groundwater salinity model

Parameter	Units	Pre development	Post development
Infiltration (from hydraulic balance table)	mm	358	279
Area	ha	430	430
Volume	ML	1,539,400	1,199,700
Groundwater EC	mg/L	2,432	2,432
Salt potentially mobilized from infiltration	t	3,744	2,918
Effluent infiltration (5% of output)	L	145	10,295
Typical salinity of effluent	mg/L	940	940
Salt from effluent systems	t	0.136	9.677
Total salt mobilized	t	3,744	2,927

7.9.2 Surface water

The salt export off-site via surface water flows will decrease post development by 154kg (Table 13). The export of salts is primarily in sediment exports which are higher in the grazing land-use than rural-residential land-use.

Table 13. Surface water salinity model

Parameter	Units	Pre development	Post development
Sediment export	kg/ha	4.2	2.2
Area	ha	430	430
Average EC (soil)	mg/kg	179	179
Total sediment runoff	kg	1,806	946
Salt in sediment	kg	323	169

7.10 Nitrogen

Nitrogen soil levels in the grazing system are typically low with concentrated areas around animal wastes. Nitrogen fertilisers are also used in cropping operations and biological synthesis occurs in legumes. Off-site movement occurs from sediment loss. Water soluble nitrogen has potential to leach into the groundwater.

Post development sources of nitrogen are from fertilisers and effluent application systems. Post development fertilisation will only occur in lawns and gardens and this will be minimised for native gardens. The areas fertilised pre development will be more than post development.

The nitrogen impact from effluent systems will not impact on the environment. The sizing of the effluent irrigation system was undertaken after calculating the Nitrogen balance. A neutral impact on leaching is calculated by allowing for vegetation usage and denitrification.

7.11 Phosphorus

The main phosphorus sources pre-development are from animal waste and fertilisers. Off-site movement of phosphorus will occur in sediments and susceptible times are when vegetation cover is low.

Post development phosphorus sources are from animals, fertilisers and on site effluent application systems. Fewer animals and fertilisers will be occupying the site in the post development land-use. Vegetation cover is also expected to be higher resulting in reduced sediment loads exported and consequently lower phosphorus impact.

The on-site effluent management system was sized in accordance with site and soil limitations. Phosphorus is considered in the irrigation area sizing. The phosphorus budget is based on a moderate range of phosphorus sorption capacity to the one metre soil depth and loading period of 50 years. The depth of the soil which is able to absorb phosphorus is greater than 5 metres and the data used in the phosphorus balance are considered very conservative.

7.12 Other contaminants

Minor usage of non-residual herbicides may occur post development. All agricultural chemicals are expected to be utilised in accordance with the recommended rates and no impact on surface water or groundwater will occur.

No industrial activities will occur in the development and bulk storage of chemical.

8. Soil and water impact assessment

8.1 Soil

Areas of saline soil were identified in the eastern section of the investigation area. The saline soils indicate the hydro-geological interface between the Pilliga Sandstone and Purlewaugh Formation. During an on-site meeting with Mr Alan Nicholson, Team Leader, Land Management Technical Group, Water Research Unit, Department of Primary Industries, it was proposed the site layout include extensive tree and shrub plantings at the interface as well as other areas across the site to intercept groundwater and maintain existing groundwater conditions. The tree and shrub plantings will aid in reducing the likelihood of salt mobilisation and saline impacts on the soil.

Soil from the central to western sections of the investigation area was generally non-saline to slightly saline. Moderately saline soils were identified in two boreholes from 2,500mm and in two boreholes from 5,000mm. The road reserves in these areas are 35m wide and will include a 10m wide vegetated area on either side of the road. Road reserves located within and upslope of the moderately saline subsoils will aid in reducing the likelihood of salt mobilisation and saline impacts on the soil.

8.2 Water

8.2.1 Surface water

Stormwater runoff will flow to roadside culverts and downslope lower in the landscape (MA3). The road drains and outlets will be designed to avoid large volumes of runoff infiltrating the ground at any one location. During low rainfall events infiltration will occur which will be largely used by vegetation. At times of high rainfall the surface drains will enable water to be moved off-site by the intermittent drainage lines across the site. These drainage lines will follow the existing surface water flows.

8.2.2 Groundwater

8.2.2.1 Recharge

Recharge occurs in discrete elements of the landscape including on the Pilliga Sandstone (Richmond Estate Hydro-geological Landscape, Management Areas 1 and 2). The minimum 1.5ha and minimum 3ha lots will be located within this area. Groundwater recharge has potential to increase as a result of irrigation of lawns, concentrated overflows from tanks and effluent irrigation. Hydraulic modelling predicts the infiltration will be reduced under the rural-residential land-use scenario. The proposed planting of deep-rooted vegetation in the road reserves of the site will aid in the extraction of soil moisture within the profile and reduce the occurrence of deep infiltration which may result from the additional inputs.

Filling of existing dams and prohibition of new dams will prevent recharge from leaking surface water bodies.

Pools will be regulated to utilise paper filters rather than sand filters. Paper filters do not require backwashing therefore minimising recharge to groundwater. The requirement for paper filters on pools will be enforced by a Section 88B instrument.

No additional infiltration and therefore no additional groundwater recharge will occur. Groundwater levels are not expected to rise as a result of the development.

8.2.2.2 Discharge

No discharge areas were identified on the site. Discharge has potential to occur at the boundary between the Pilliga Sandstone and Purlewaugh Formation. The extensive planting of deep-rooted trees and shrubs in these areas will intercept groundwater and maintain groundwater conditions therefore reducing the likelihood of groundwater discharges occurring.

The occurrence of discharge areas on and off site is not expected to increase as infiltration has been demonstrated to decrease post development. The construction of roads will include defined drainage channels which will increase runoff rates and prevent the occurrence of poorly drained areas.

8.3 Vegetation

The site currently contains grasses and weeds, isolated paddock trees, a small remnant woodland and landscaped areas around two dwellings. Existing annual vegetation contributes to water extraction from the upper 0.5 metres of soil depth. Areas vegetared with native deep rooted trees will be 36.5 hectares (Figure 3).

The EM surveys, detailed profile descriptions and laboratory analysis identified a non-continuous boundary between the Pilliga Sandstone and Purlewaugh Formation. The subdivision has been designed to plant native trees in the road reserves. The tree planting will be strategically located at the hydro-geological interface. Deep-rooted vegetation buffers comprising native species selected from the species list provided in DCC (no date) will be planted within all road reserves. Vegetation buffers in road reserves identified at the hydro-geological interface areas will be 30m wide on the upper side of the sealed road (Figure 8). The area of vegetation in the geological boundary will be 3.2ha.

Additional areas of vegetation will be established on several lots where high salinity was located at the geological boundary. The area of vegetation will be 3.3 hectares.

Vegetation buffers along road reserves in other areas of the site will include a 10m wide vegetated area on both sides of the pavement. The tree and shrub planting along the road reserve will comprise an area of 30ha.

Future land owners are expected to revegetate with trees which will further reduce infiltration. Evidence of revegetation activities on rural-residential lots can be observed by review of similar developments in the locality such as *Firgrove Estate*. The planting of trees by individual owners has not been included in the hydraulic balance.

Dwellings will be constructed and are expected to include irrigated landscaping. It is expected most future owners will minimize amount and extent of water use in gardens in accordance with the community attitude of water use. Many gardens are expected to be native and utilise waterwise gardens. This will be further enforced by promotions undertaken by the developer and by Dubbo City Council. Resulting fertilizer inputs are expected to be minimal. The use of fertiliser and herbicides on lawn will be utilised by plants and will not move out of the rooting zone.

8.4 Infrastructure

Saline soils were identified at the boundary of the Pilliga Sandstone and Purlewaugh Formation at depths greater than 1m. Other areas of saline soils were identified in the central and western sections of the site at depths greater than 2.5m. Earthworks in areas of saline subsoil will be restricted to depths of less than 500mm and not intercept saline subsoils or interfere with natural groundwater flows. The bbuilding envelope for the lot located in the north eastern corner of the investigation area under the conceptual plan will be sited outside of high saline areas as identified by the EM survey.

Infrastructure including roads and buildings should be engineered with consideration of soil aggressiveness.

Stormwater runoff from buildings will be captured in tanks. The requirement for rainwater tanks will be implemented by a Section 88B instrument. Other stormwater runoff will flow to roadside culverts and downslope lower in the landscape. The road drains and outlets will be designed to avoid large volumes of runoff infiltrating the ground at any one location. During low rainfall events infiltration will occur which will be largely used by vegetation. At times of high rainfall the surface drain will enable water to be moved off-site. No stormwater detention basins or ponds which may result in deep drainage are proposed.

8.5 Pollution Risk Control

The subsoil is clay with depth of greater than 9 metres to groundwater. This soil layer provides significant filtration and absorption capacity to reduce contamination loading.

Minimal chemical use is expected from the rural-residential land-use. The expected adoption of native landscaping and waterwise gardens will result in minimal application of chemicals to landscaped areas.

On-site effluent management systems will be constructed on each lot. The on-site effluent is described in a separate report (R13365e). The recommended systems are surface irrigation from aerated wastewater treatment systems (AWTS). The irrigation area of the system is sized according to the limiting factor of hydraulic, nitrogen or phosphorus to ensure no impact on the environment.

The site currently has a grazing land-use. Waste from the animals contains significant nutrients and pathogens. Nutrient and pathogens are expected to migrate less than 100mm in the soil. In overland flow, greater distances may be achieved. The proposed land-use is expected to create a neutral effect or lead to a reduction in nitrogen, phosphorus and pathogens in the groundwater and catchment. The stocking rate of animals will be reduced under the rural residential land-use. Reduced stocking rate will result in additional groundcover and establishment of other vegetation.

The site area is considered important as it forms part of the Macquarie River catchment. ANZECC (2000) has determined water quality indicators for river systems in regard to various environmental values (Table 14). The environmental values relate to the protection of:

- aquatic ecosystems
- aquatic foods
- primary contact recreation
- secondary contact recreation
- drinking water
- visual amenity
- irrigation water supplies
- homestead water supplies
- livestock water supplies
- human consumption of fish

The irrigation water quality indicators are considered appropriate for the catchment. The potential impact of the development on each water quality indicator has been assessed (Table 14). Potential issues relate to on-site application of effluent, buffer distance between effluent application areas and first and second order streams, current and future land-use and management of the site.

The impact of the development on each water quality indicator will be negligible.

8.6 Earthworks

The final subdivision plan which will form part of the development application will maintain the natural drainage pattern to ensure minimal disturbance. The plan will ensure depth of cut and exposure of susceptible soils is minimised. Reversing or mixing the soil when undertaking cut and fill will be avoided. Imported fill will be tested for salinity.

Table 14. Impacts of development on water quality (Environmental objectives)

Indicator	Objective	Impact of development
Nitrogen	5 mg/L	AWTS systems produce effluent with significant nitrogen concentration. The on-site application area is designed to apply the effluent over a sufficient area to prevent off-site movement. Nitrogen will be used by plants, digested by microbes or volatilised into the atmosphere. Infiltration for nitrogen into the subsoil and impact on groundwater systems will not occur. Maintenance of groundcover by minimal cultivation and future light grazing are important factors in reducing nitrogen export.
Phosphorus	0.05mg/L	AWTS systems produce effluent with significant phosphorus concentration. The on-site application area is designed to apply the effluent over a sufficient area to prevent off-site movement. Phosphorus will be used by plants and absorbed in the soil. Groundcover will be enhanced in the development resulting in reduced sediment and phosphorus export. Post development fertiliser application rates will be reduced and the effect on phosphorus less.
Faecal coliform	<10 cfu/100mL to 10,000cfu/100mL	Effluent treatment from AWTS includes disinfection and impact will be negligible. Maintenance of good groundcover by minimal cultivation and future light grazing are important factors to assist in reducing faecal coliform export.
Aluminium	5 mg/L	Trace in effluent. No impact.
Iron	0.2 mg/L	Trace in effluent. No impact.
Manganese	0.2 mg/L	Trace in effluent. No impact.
Dissolved oxygen	>6.5 mg/L	Organic matter in effluent may result in reducing the dissolved oxygen content in water. The application area is considered adequate to prevent impacts on waterways. Impact may increase on poorly managed pasture.
pH	between 6.0 and 8.5	Treated effluent is within this range and designed to be contained within the application area. Fertilisers have a declining influence on pH and effects off-site will be negligible.
Cyanobacteria	-	Cyanobacteria are dependent on the levels of nitrogen, phosphorus and water temperature. The development will not increase nitrogen and phosphorus outside the recommended application area, therefore will have negligible impact. Water will remain within the application area therefore no conduit exists for movement of cyanobacteria. No cyanobacteria are present in fertilisers.
Conductivity	-	Domestic effluent has a salinity of approximately 1000 µS/cm and will remain within application area.
Turbidity	-	Negligible impact due to small size of the development and the absence of any disturbed areas on site. Effluent from AWTS is typically low in suspended solids.

9. Salinity management options

Saline management options have been provided for each hydro-geological landscape. A discussion of the management options and implementation as part of the *Daisy Hill Estate* development is provided in the following paragraphs.

- *Land managers should clearly demonstrate what measures will be employed to ensure the salinity hazard does not increase (both on site and on adjoining land) as a result of a development.*

A number of measures will be employed to ensure the salinity hazard does not increase. Planting of deep-rooted vegetation will form the main part of the measures employed. The vegetation buffers will intercept groundwater and reduce the on and off-site salinity hazards which may occur as a result of the development (Figure 8). The proposed planting design as a management option for reducing the salinity hazard has been endorsed by Mr Alan Nicholson, Team Leader, Land Management Technical Group, Water Research Unit, Department of Primary Industries.

Deep-rooted vegetation comprising native species selected from the species list provided in DCC (no date) will be planted within all road reserves. Vegetation buffers along road reserves in areas identified at the hydro-geological interface areas will be 30m wide on the upper side of the sealed road. Vegetation buffers along road reserves in other areas of the site will include a 10m wide vegetated area on both sides of the pavement. The tree and shrub planting is expected to occur over approximately 34ha of the site under the current subdivision plan.

The impact on infiltration from the proposed planting of deep-rooted vegetation has been included in the revised water balance (Appendix 9). The revised water balance indicates plantings will reduce infiltration by approximately 47mm per annum.

In addition to the proposed plantings, future land owners are expected to revegetate with trees and shrubs which will further reduce infiltration. Evidence of revegetation activities on rural-residential lots can be observed by review of similar developments in the locality such as *Firgrove Estate*. The planting of trees by individual owners has not been included in the hydraulic balance.

Rainwater tanks connected to all buildings will be enforced by a Section 88B instrument. Rainwater harvesting will reduce the volume of infiltration resulting from stormwater flows. Rainwater tanks will be utilised for toilet flushing and garden watering. Tank overflows may occur at times of storm rain and the overflow volume is not expected to be significant. Tank overflows have been included in the hydraulic balance.

Existing dams on the site will be filled. New dams will be prohibited and enforced by a Section 88B instrument. No recharge will occur from leaking water bodies.

Swimming pools will be regulated to utilise paper filters rather than sand filters. Paper filters do not require backwashing therefore reducing recharge to groundwater. The requirement for paper filters on pools will be enforced by a Section 88B instrument.

- *Identify and manage sensitive soils (e.g. sodic soils, reactive soils, type of salts, salt loads).*

The EM survey identified the Pilliga Sandstone and Purlewaugh Formation interface to enable design of the conceptual plan to be sensitive to groundwater conditions in this location. The preliminary soil and groundwater salinity assessment undertaken over the site identified saline impacted soils at the Pilliga Sandstone and Purlewaugh Formation interface with minor areas of moderately saline soils at depths greater than 2.5m in the central and eastern sections of the site. Recommendations to manage areas of sensitive soils include strategic revegetation along road reserves, subdivision design, restrictions on the construction of dams and requirements for rainwater harvesting and pool filter management.

- *New houses, buildings or infrastructure (including roads, pathways and retaining walls) in current or potentially salt affected areas may need to be built to withstand the effects of salinity (including the establishment of good drainage prior to construction).*

The building envelope for the lot located in the north eastern corner of the investigation area under the current subdivision plan will be sited outside of high saline areas as identified by the EM survey. This management option to reduce salinity impact on the dwelling on this lot has been endorsed by Mr Alan Nicholson, Team Leader, Land Management Technical Group, Water Research Unit, Department of Primary Industries.

Houses, buildings and infrastructure (roads and services) in areas identified on the EM surveys as moderately to highly saline and where soil has potential to impact on structures will be designed in accordance with building in saline areas.

- *Employ deficit irrigation principles to prevent overwatering of sports grounds, golf courses, parks, private gardens and lawns and limit the application of extra salt through water recycling programs or irrigation of saline groundwater.*

No public open space areas or golf courses are proposed as part of the development. It is expected future owners of the site will minimise amount and extent of water use in gardens. Many gardens are expected to be native and utilise waterwise gardens. This will further be enforced by promotions undertaken by the developer and by Dubbo City Council. Restrictions on extraction of saline groundwater will be implemented.

- *Implement a monitoring program (where deemed necessary) including a clear identification of responsibilities.*

Installation of groundwater monitoring wells will form part of the detailed soil and groundwater salinity assessment. The wells will be placed in areas of proposed road reserves. The wells will be suitable for inclusion to the Dubbo Salinity Network which is monitored by Dubbo City Council on a monthly basis.

10. Salinity management strategies

Saline management strategies and associated actions have been developed for each management area. Tables 15 to 20 detail the actions applicable for the site and implementation of the actions as part of the development.

Table 15. Actions for Management Area 1 (MA1) – Richmond Estate Hydro-geological Landscape

Action	Response
Urban investigations	
• Investigate concentration and composition of salts in the soil profile, groundwater and surface waters during initial site assessment to determine salinity hazard (UI1)	A soil and groundwater salinity assessment was undertaken over the site. Fifteen boreholes were constructed to 6m and soil samples collected and analysed to calibrate the EM survey.

• Use geophysical techniques to define geological contact (EM survey) (UI2)	EM surveys were undertaken to define the contact between the Pilliga Sandstone and Purlewaugh Formation. The contact was identified by high conductivity as well as soil analysis results. EM surveys were also undertaken to indicate possible areas of high soil salinity. These areas were confirmed by soils analysis results.
Urban construction	
• Deep drainage should be minimised by maximising surface water runoff and drainage (UC2)	Stormwater runoff from buildings will be captured in tanks. The requirement for rainwater tanks will be implemented by a Section 88B instrument. Other stormwater runoff will flow to roadside culverts and downslope lower in the landscape (MA3). The road drains and outlets will be designed to avoid large volumes of runoff infiltrating the ground at any one location. During low rainfall events infiltration will occur which will be largely used by vegetation. At times of high rainfall the surface drain will enable water to be moved off-site. No stormwater detention basins or ponds which may result in deep drainage are proposed. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument. Pools will utilise paper filters rather than sand filters as implemented by a Section 88B instrument.
Urban planning	
• Implementation of WSUD techniques considers the potential impact on the local salinity hazard. Revised principles of WSUD where salinity affects are an issue (UP5)	Stormwater runoff from buildings will be captured in tanks. The requirement for rainwater tanks will be implemented by a Section 88B instrument. Other stormwater runoff will flow to roadside culverts and downslope lower in the landscape (MA3). Planting of deep rooted vegetation will utilise subsoil moisture and will reduce the occurrence of deep drainage.
Urban management	
• Minimise leakage of standing water bodies, lakes and service pipes (UM1)	Standing water bodies and lakes are not proposed as part of the development. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument.
Urban vegetation	
• Promote the retention and establishment of deep-rooted vegetation that maximises water use in new urban development areas (UV2)	Deep-rooted vegetation comprising trees will be planted along road reserves. Species will be selected from the Dubbo City Council *Water Wise and Salt Tolerant Plants* list (DCC no date). Tree plantings will also be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation. Promotion of deep-rooted vegetation plantings will also be undertaken to future owners of the site.
• Develop native landscaping and "waterwise" gardens to reduce over-irrigation and water usage (UV3)	Native landscaping will be undertaken within the road reserves using species recommended by DCC (no date). No public open space areas are proposed as part of the development. It is expected future owners of the site will minimise amount and extent of water use in gardens. Many gardens are expected to be native and utilise waterwise gardens. This will further be enforced by promotions undertaken by the developer and by Dubbo City Council.

• Locate strategic plantings of deep-rooted perennial vegetation to manage discharge areas (UV5)	No salinity impacted discharge areas have been observed on the site. The EM survey and soil analysis identified the boundary between the Pilliga Sandstone and Purlewaugh Formation as an area of potential discharge. Vegetated buffers will be established at this boundary. Plantings of deep-rooted perennial vegetation will be undertaken to reduce the risk of discharge areas developing. Plantings of deep-rooted vegetation comprising trees will be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation.

Table 16. Actions for Management Area 2 (MA2) – Richmond Estate Hydro-geological Landscape

Action	Response
Urban investigations	
• Investigate concentration and composition of salts in the soil profile, groundwater and surface waters during initial site assessment to determine salinity hazard (UI1)	A soil and groundwater salinity assessment was undertaken over the site. Fifteen boreholes were constructed to 6m and soil samples collected and analysed to calibrate the EM survey.
• Use geophysical techniques to define geological contact (EM survey) (UI2)	EM surveys were undertaken to define the contact between the Pilliga Sandstone and Purlewaugh Formation. The contact was identified by high conductivity as well as soil analysis results. EM surveys were also undertaken to indicate possible areas of high soil salinity. These areas were confirmed by soils analysis results.
Urban construction	
• Deep drainage should be minimised by maximising surface water runoff and drainage (UC2)	Stormwater runoff from buildings will be captured in tanks. The requirement for rainwater tanks will be implemented by a Section 88B instrument. Other stormwater runoff will flow to roadside culverts and downslope lower in the landscape (MA3). The road drains and outlets will be designed to avoid large volumes of runoff infiltrating the ground at any one location. During low rainfall events infiltration will occur which will be largely used by vegetation. At times of high rainfall the surface drain will enable water to be moved off-site. No stormwater detention basins or ponds which may result in deep drainage are proposed. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument. Pools will utilise paper filters rather than sand filters as implemented by a Section 88B instrument.
• Consider the use of salt protected materials for services, e.g. salt resistant drainage pipes, casing of underground services (UC7)	Houses, buildings and infrastructure (roads and services) in areas identified on the EM surveys as moderately to highly saline and where soil has potential to impact on structures will be designed in accordance with building in saline areas.
• Minimise the alteration of natural drainage patterns through construction of houses, roads, railways, channels etc. (UC8)	The final subdivision plan which will form part of the development application will maintain the natural drainage pattern to ensure minimal disturbance.
• Minimise depth of cut and exposure of susceptible soils during development. Ensure fill material is not saline (UC1)	Saline soils have been identified by the EM survey. Earthworks in areas of saline subsoil as identified by the EM survey should be restricted to depths of less than 500mm reducing the risk of exposure of saline subsoils. The final subdivision design will ensure depth of cut and exposure of susceptible soils is minimised. Reversing or mixing the soil when undertaking cut and fill will be avoided. Imported fill will be tested for salinity.

Urban planning	
• Implementation of WSUD techniques considers the potential impact on the local salinity hazard. Revised principles of WSUD where salinity affects are an issue (UP5)	Stormwater runoff from buildings will be captured in tanks. The requirement for rainwater tanks will be implemented by a Section 88B instrument. Other stormwater runoff will flow to roadside culverts and downslope lower in the landscape (MA3). Planting of deep rooted vegetation along the road reserves will utilise subsoil moisture and will reduce the occurrence of deep drainage.
• Maximise the size of impervious surfaces to prevent recharge of (perched) groundwater table. Constructed pervious surfaces may need to be lined and drained to stormwater outlets (UP4)	The area containing MA2 is proposed to be rezoned as minimum 1.5ha and minimum 3ha blocks which will contain impervious areas comprising dwellings, driveways and public roads. Stormwater runoff from the roads will be directed to roadside drains. The subdivision layout will be designed to allow the roadside drains in MA2 to discharge into areas downslope (MA3). The road drains will be designed to avoid large volumes of runoff infiltrating the ground at any one location.
• Identification of discharge sites should influence the size of the area to be developed (UP3)	No salinity impacted discharge areas have been observed on the site. The EM survey and soil analysis identified the boundary between the Pilliga Sandstone and Purlewaugh Formation as an area of potential discharge. Vegetated buffers will be established at this boundary. Plantings of deep-rooted perennial vegetation will be undertaken to reduce the risk of discharge areas developing. Plantings of deep-rooted vegetation comprising trees will be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation.
• Prior to commencement of earthworks sodic/saline soils should be identified (UP1)	Identification of sodic/saline soils was undertaken by EM survey and soil sampling and analysis.
Urban management	
• Minimise leakage of standing water bodies, lakes and service pipes (UM1)	Standing water bodies and lakes are not proposed as part of the development. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument.
Urban vegetation	
• Promote the retention and establishment of deep-rooted vegetation that maximises water use in new urban development areas (UV2)	Deep-rooted vegetation comprising trees will be planted along road reserves. Species will be selected from the Dubbo City Council *Water Wise and Salt Tolerant Plants* list (DCC no date). Tree plantings will also be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation. Promotion of deep-rooted vegetation plantings will also be undertaken to future owners of the site.
• Develop native landscaping and "waterwise" gardens to reduce over-irrigation and water usage (UV3)	Native landscaping will be undertaken within the road reserves using species recommended by DCC (no date). No public open space areas are proposed as part of the development. It is expected future owners of the site will minimise amount and extent of water use in gardens. Many gardens are expected to be native and utilise waterwise gardens. This will further be enforced by promotions undertaken by the developer and by Dubbo City Council.

• Locate strategic plantings of deep-rooted perennial vegetation to manage discharge areas (UV5)	No salinity impacted discharge areas have been observed on the site. The EM survey and soil analysis identified the boundary between the Pilliga Sandstone and Purlewaugh Formation as an area of potential discharge. Vegetated buffers will be established at this boundary. Plantings of deep-rooted perennial vegetation will be undertaken to reduce the risk of discharge areas developing. Plantings of deep-rooted vegetation comprising trees will be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation.
• Retain or establish areas of deep-rooted salt tolerant indigenous vegetation to manage recharge or discharge site (UV1)	The majority of the site has been cleared. No additional tree clearing is expected to be undertaken. Deep-rooted vegetation comprising trees will be planted along road reserves using species recommended by DCC (no date). Tree plantings will also be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation and areas of moderately saline soils in the central and western sections of the site. Promotion of deep-rooted vegetation plantings will also be undertaken to future owners of the site.

Table 17. Actions for Management Area 3 (MA3) – Richmond Estate Hydro-geological Landscape

Action	Response
Urban investigations	
• Investigate concentration and composition of salts in the soil profile, groundwater and surface waters during initial site assessment to determine salinity hazard (UI1)	A soil and groundwater salinity assessment was undertaken over the site. Fifteen boreholes were constructed to 6m and soil samples collected and analysed to calibrate the EM survey.
• Use geophysical techniques to define geological contact (EM survey) (UI2)	EM surveys were undertaken to indicate possible areas of high soil salinity. These areas were confirmed by soils analysis results.
Urban construction	
• Deep drainage should be minimised by maximising surface water runoff and drainage (UC2)	Stormwater runoff from buildings will be captured in tanks. The requirement for rainwater tanks will be implemented by a Section 88B instrument. The road drains and outlets will be designed to avoid large volumes of runoff infiltrating the ground at any one location. During low rainfall events infiltration will occur which will be largely used by vegetation. At times of high rainfall the surface drain will enable water to be moved off-site. No stormwater detention basins or ponds which may result in deep drainage are proposed. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument. Pools will utilise paper filters rather than sand filters as implemented by a Section 88B instrument.
• Minimise the alteration of natural drainage patterns through construction of houses, roads, railways, channels etc. (UC8)	The final subdivision plan which will form part of the development application will maintain the natural drainage pattern to ensure minimal disturbance.
Urban planning	
• Implementation of WSUD techniques considers the potential impact on the local salinity hazard. Revised principles of WSUD where salinity affects are an issue (UP5)	Stormwater runoff from buildings will be captured in tanks. The requirement for rainwater tanks will be implemented by a Section 88B instrument. Planting of deep rooted vegetation will utilise subsoil moisture and will reduce the occurrence of deep drainage.
• Minimise use of infiltration and detention of stormwater in hazard areas, consider lining of detention systems to prevent infiltration (i.e. reconsider WSUD implications in relation to salinity management (UP2)	Standing water bodies are not proposed as part of the development. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument.

Urban management	
• Minimise leakage of standing water bodies, lakes and service pipes (UM1)	Standing water bodies and lakes are not proposed as part of the development. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument.
Urban vegetation	
• Promote the retention and establishment of deep-rooted vegetation that maximises water use in new urban development areas (UV2)	Deep-rooted vegetation comprising trees will be planted along road reserves. Species will be selected from the Dubbo City Council *Water Wise and Salt Tolerant Plants* list (DCC no date). Promotion of deep-rooted vegetation plantings will also be undertaken to future owners of the site.
• Develop native landscaping and "waterwise" gardens to reduce over-irrigation and water usage (UV3)	Native landscaping will be undertaken within the road reserves using species recommended by DCC (no date). No public open space areas are proposed as part of the development. It is expected future owners of the site will minimise amount and extent of water use in gardens. Many gardens are expected to be native and utilise waterwise gardens. This will further be enforced by promotions undertaken by the developer and by Dubbo City Council.
• Locate strategic plantings of deep-rooted perennial vegetation to manage discharge areas (UV5)	No salinity impacted discharge areas have been observed on the site. The EM survey and soil analysis identified the boundary between the Pilliga Sandstone and Purlewaugh Formation as an area of potential discharge. Vegetated buffers will be established at this boundary. Plantings of deep-rooted perennial vegetation will be undertaken to reduce the risk of discharge areas developing. Plantings of deep-rooted vegetation comprising trees will be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation.
• Retain or establish areas of deep-rooted salt tolerant indigenous vegetation to manage recharge or discharge site (UV1)	The majority of the site has been cleared. No additional tree clearing is expected to be undertaken. Deep-rooted vegetation comprising trees will be planted along road reserves using species recommended by DCC (no date). Promotion of deep-rooted vegetation plantings will also be undertaken to future owners of the site.

Table 18. Actions for Management Area 1 (MA1) – Firgrove Hydro-geological Landscape

Action	Response
Urban investigations	
• Use geophysical techniques to define geological contact (EM survey) (UI2)	EM surveys were undertaken to indicate possible areas of high soil salinity. These areas were confirmed by soils analysis results.
Urban construction	
• Deep drainage should be minimised by maximising surface water runoff and drainage (UC2)	Stormwater runoff from buildings will be captured in tanks. The requirement for rainwater tanks will be implemented by a Section 88B instrument. Other stormwater runoff will flow to roadside culverts and downslope lower in the landscape (MA3). The road drains and outlets will be designed to avoid large volumes of runoff infiltrating the ground at any one location. During low rainfall events infiltration will occur which will be largely used by vegetation. At times of high rainfall the surface drain will enable water to be moved off-site. No stormwater detention basins or ponds which may result in deep drainage are proposed. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument. Pools will utilise paper filters rather than sand filters as implemented by a Section 88B instrument.

Urban planning	
• Minimise use of infiltration and detention of stormwater in hazard areas, consider lining of detention systems to prevent infiltration (i.e. reconsider WSUD implications in relation to salinity management (UP2)	Standing water bodies are not proposed as part of the development. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument.
• Implementation of WSUD techniques considers the potential impact on the local salinity hazard. Revised principles of WSUD where salinity affects are an issue (UP5)	Stormwater runoff from buildings will be captured in tanks. The requirement for rainwater tanks will be implemented by a Section 88B instrument. Planting of deep rooted vegetation will utilise subsoil moisture and will reduce the occurrence of deep drainage.
Urban management	
• Minimise leakage of standing water bodies, lakes and service pipes (UM1)	Standing water bodies and lakes are not proposed as part of the development. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument.
Urban vegetation	
• Promote the retention and establishment of deep-rooted vegetation that maximises water use in new urban development areas (UV2)	Deep-rooted vegetation comprising trees will be planted along road reserves. Species will be selected from the Dubbo City Council *Water Wise and Salt Tolerant Plants* list (DCC no date). Tree plantings will also be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation. Promotion of deep-rooted vegetation plantings will also be undertaken to future owners of the site.

Table 19. Actions for Management Area 2 (MA2) – Firgrove Hydro-geological Landscape

Action	Response
Urban investigations	
• Use geophysical techniques to define geological contact (EM survey) (UI2)	EM surveys were undertaken to indicate possible areas of high soil salinity. These areas were confirmed by soils analysis results.
Urban construction	
• Minimise depth of cut and exposure of susceptible soils during development. Ensure fill material is not saline (UC1)	The final subdivision design will ensure depth of cut and exposure of susceptible soils is minimised. Reversing or mixing the soil when undertaking cut and fill will be avoided. Imported fill will be tested for salinity.
• Deep drainage should be minimised by maximising surface water runoff and drainage (UC2)	Stormwater runoff from buildings will be captured in tanks. The requirement for rainwater tanks will be implemented by a Section 88B instrument. The road drains and outlets will be designed to avoid large volumes of runoff infiltrating the ground at any one location. During low rainfall events infiltration will occur which will be largely used by vegetation. At times of high rainfall the surface drain will enable water to be moved off-site. No stormwater detention basins or ponds which may result in deep drainage are proposed. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument. Pools will utilise paper filters rather than sand filters as implemented by a Section 88B instrument.
• Minimise the alteration of natural drainage patterns through construction of houses, roads, railways, channels etc. (UC8)	The final subdivision plan which will form part of the development application will maintain the natural drainage pattern to ensure minimal disturbance.
Urban planning	
• Minimise use of infiltration and detention of stormwater in hazard areas, consider lining of detention systems to prevent infiltration (i.e. reconsider WSUD implications in relation to salinity management (UP2)	Standing water bodies are not proposed as part of the development. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument.

Urban management	
• Minimise leakage of standing water bodies, lakes and service pipes (UM1)	Standing water bodies and lakes are not proposed as part of the development. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument.
Urban vegetation	
• Promote the retention and establishment of deep-rooted vegetation that maximises water use in new urban development areas (UV2)	Deep-rooted vegetation comprising trees will be planted along road reserves. Species will be selected from the Dubbo City Council *Water Wise and Salt Tolerant Plants* list (DCC no date). Tree plantings will also be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation. Promotion of deep-rooted vegetation plantings will also be undertaken to future owners of the site.
• Locate strategic plantings of deep-rooted perennial vegetation to manage discharge areas (UV5)	No salinity impacted discharge areas have been observed on the site. The EM survey and soil analysis identified the boundary between the Pilliga Sandstone and Purlewaugh Formation as an area of potential discharge. Vegetated buffers will be established at this boundary. Plantings of deep-rooted perennial vegetation will be undertaken to reduce the risk of discharge areas developing. Plantings of deep-rooted vegetation comprising trees will be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation.
• Retain or establish areas of deep-rooted salt tolerant indigenous vegetation to manage recharge or discharge site (UV1)	The majority of the site has been cleared. No additional tree clearing is expected to be undertaken. Deep-rooted vegetation comprising trees will be planted along road reserves using species recommended by DCC (no date). Tree plantings will also be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation. Promotion of deep-rooted vegetation plantings will also be undertaken to future owners of the site.

Table 20. Actions for Management Area 3 (MA3) – Firgrove Hydro-geological Landscape

Action	Response
Urban investigations	
• Investigate concentration and composition of salts in the soil profile, groundwater and surface waters during initial site assessment to determine salinity hazard (UI1)	A soil and groundwater salinity assessment was undertaken over the site. Fifteen boreholes were constructed to 6m and soil samples collected and analysed to calibrate the EM survey.
• Use geophysical techniques to define geological contact (EM survey) (UI2)	EM surveys were undertaken to indicate possible areas of high soil salinity. These areas were confirmed by soils analysis results.
Urban construction	
• Deep drainage should be minimised by maximising surface water runoff and drainage (UC2)	Stormwater runoff from buildings will be captured in tanks. The requirement for rainwater tanks will be implemented by a Section 88B instrument. The road drains and outlets will be designed to avoid large volumes of runoff infiltrating the ground at any one location. During low rainfall events infiltration will occur which will be largely used by vegetation. At times of high rainfall the surface drain will enable water to be moved off-site. No stormwater detention basins or ponds which may result in deep drainage are proposed. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument. Pools will utilise paper filters rather than sand filters as implemented by a Section 88B instrument.

• Minimise the alteration of natural drainage patterns through construction of houses, roads, railways, channels etc. (UC8)	The final subdivision plan which will form part of the development application will maintain the natural drainage pattern to ensure minimal disturbance.
• Minimise depth of cut and exposure of susceptible soils during development. Ensure fill material is not saline (UC1)	The final subdivision design will ensure depth of cut and exposure of susceptible soils is minimised. Reversing or mixing the soil when undertaking cut and fill will be avoided. Imported fill will be tested for salinity.
Urban planning	
• Identification of discharge sites should influence the size of the area to be developed (UP3)	Discharge sites were not identified in the soil and groundwater salinity assessment. Plantings of deep-rooted perennial vegetation will be undertaken to reduce the risk of discharge areas developing.
• Minimise use of infiltration and detention of stormwater in hazard areas, consider lining of detention systems to prevent infiltration (i.e. reconsider WSUD implications in relation to salinity management (UP2)	Standing water bodies are not proposed as part of the development. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument.
Urban management	
• Minimise leakage of standing water bodies, lakes and service pipes (UM1)	Standing water bodies and lakes are not proposed as part of the development. Existing farm dams will be filled. No farm dams will be constructed as implemented by a Section 88B instrument.
• Employ deficit irrigation principles to prevent over-irrigation of sports grounds, golf courses, parks, private gardens and lawns (UM2)	No public open space areas or golf courses are proposed as part of the development. It is expected future owners of the site will minimise amount and extent of water use in gardens. Many gardens are expected to be native and utilise waterwise gardens. This will further be enforced by promotions undertaken by the developer and by Dubbo City Council.
• Manage plant growth to maximise water usage. Consider harvesting mature zones of vegetation and replanting for ongoing water use efficiency (UM3)	Management of plant growth will be controlled by individual lot owners. Dubbo City Council will be responsible for the management of vegetation along the road reserves.
Urban vegetation	
• Promote the retention and establishment of deep-rooted vegetation that maximises water use in new urban development areas (UV2)	Deep-rooted vegetation comprising trees will be planted along road reserves. Species will be selected from the Dubbo City Council *Water Wise and Salt Tolerant Plants* list (DCC no date). Tree plantings will also be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation. Promotion of deep-rooted vegetation plantings will also be undertaken to future owners of the site.
• Develop native landscaping and "waterwise" gardens to reduce over-irrigation and water usage (UV3)	Native landscaping will be undertaken within the road reserves using species recommended by DCC (no date). No public open space areas are proposed as part of the development. It is expected future owners of the site will minimise amount and extent of water use in gardens. Many gardens are expected to be native and utilise waterwise gardens. This will further be enforced by promotions undertaken by the developer and by Dubbo City Council as part of the Dubbo Urban Salinity Management Plan.

• Locate strategic plantings of deep-rooted perennial vegetation to manage discharge areas (UV5)	No salinity impacted discharge areas have been observed on the site. The EM survey and soil analysis identified the boundary between the Pilliga Sandstone and Purlewaugh Formation as an area of potential discharge. Vegetated buffers will be established at this boundary. Plantings of deep-rooted perennial vegetation will be undertaken to reduce the risk of discharge areas developing. Plantings of deep-rooted vegetation comprising trees will be undertaken in the vicinity of the boundary between the Pilliga Sandstone and Purlewaugh Formation.
• Retain or establish areas of deep-rooted salt tolerant indigenous vegetation to manage recharge or discharge site (UV1)	The majority of the site has been cleared. No additional tree clearing is expected to be undertaken. Deep-rooted vegetation comprising trees will be planted along road reserves using species recommended by DCC (no date). Promotion of deep-rooted vegetation plantings will also be undertaken to future owners of the site.

11. Conclusions

The *Daisy Hill Estate* is located on improved grazing and cropping land. The land has been extensively cleared and little deep rooted vegetation remains. Vegetation comprises native and introduced grasses, clovers, medics and broadleaved weeds. Scattered eucalypt, kurrajong and native pines are located over the site. Removal of deep rooted vegetation over the site for farming has resulted in changes in the water balance and has potential for redistribution of salt in the landscape.

No permanent waterways, poorly drained or seepage, discharge or water logged areas are located on the site. Several small farm dams are located along drainage lines. Soil on the site is brown to yellowish red sandy loam to sandy clay loam over a strong brown to yellowish red sandy clay to medium clay with sand.

Daisy Hill is located in the Richmond Estate and Firgrove Hydro-geological Landscapes (HGL) forming part of the upper Troy Gully catchment. Salinity issues within the Richmond Estate HGL indicate potential for moderate to high impact and the Firgrove HGL low to moderate potenital impact. No shallow groundwater was identified on the site. Bores on the site have confined water bearing zones greater than 10m in sandstone and basalt.

Hydro-geological mapping identified a potential salinity risk at the interface between the Pilliga Sandstone and Purlewaugh Formation. The interface was identified by EM survey and confirmed by borehole construction, soil sampling and analysis. Moderate to high soil salinity was identified at the interface area. Groundwater sensitive design was undertaken to minimise the impacts on salinity of the development. The recommendations to manage salinity were undertaken after consultation with Allan Nicholson to achieve industry best practice.

High soil conductivity levels from EM31 survey was recorded in the central area of the site at in the northern section of *Peachville Park*. The high EM conductivity levels are attributed primarily to the response from clayey subsoils. Soil analysis form three boreholes identified low to moderately saline soil from 2.5m in part of the northern section of *Peachville Park*.

An area of moderate salinity was also identified in a small area of west of the site from EM survey and soil borings. Impacted soil was at a depth of greater than 1.8 metres.

Simulation modelling of hydraulic and salinity balances indicated the development will result in a reduction in infiltration and groundwater recharge on the site. Reduced infiltration, recharge and salinity are achieved by planting of deep rooted vegetation along road reserves. The simulation modeling indicates the salinity status of the site and off-site will be unchanged by the development.

12. Recommendations

Establish deep rooted vegetation in road reserves

Deep-rooted vegetation comprising trees and shrubs planted along all road reserves and in strategic areas equivalent to 36.5 hectares. Vegetation buffers along road reserves in areas identified at the hydro-geological interface will be 30m wide on the upper side of the sealed road equivalent to 3.2 hectares. Vegetation buffers along road reserves in other areas of the site will include a 10m wide vegetated area on both sides of the road equivalent to 30ha. Other designated vegetation buffer zones in the plan will be 3.3 hectares. The vegetation buffers will contain deep-rooted vegetation to extraction of soil moisture within the profile and reduce infiltration and intercept shallow groundwater. Reducing water infiltration in to the soil will also minimise the movement of salt stores. Vegetation buffers in the Richmond Residential Estate have been effective in maintaining groundwater levels and preventing salinity impacts.

Urban sensitive design

The final subdivision plan will maintains the natural drainage pattern to ensure minimal disturbance. The plan minimises depth of cut and exposure of susceptible soils. Earthworks in areas of saline subsoil will be restricted to depths of less than 500mm reducing the risk of exposure of saline subsoils. Reversing or mixing the soil when undertaking cut and fill will be avoided. Imported fill will be tested for salinity.

The existing trees along the unformed road on the site will be maintained. Additional trees will be established be individual landholders.

The building envelope for the lot in the north eastern corner of the investigation area under the conceptual plan will be sited outside of high saline areas as identified by the EM survey.

Infrastructure including roads and buildings will be engineered with consideration of soil aggressiveness. Dwellings in area identified in areas with high salinity require BIASE consideration including high impact membranes, exposure bricks, damp course and 32 MPa concrete.

Reduce groundwater recharge

Existing dams will be filled and no new dams will be constructed in the development preventing leaking water recharging the groundwater. Runoff from roads and other hard areas will be discharges to a drainage network which is adjacent to the vegetation buffers.

Swimming pools will be regulated to utilise paper filters rather than sand filters. Paper filters do not require backwashing therefore reducing recharge to groundwater. The requirement for paper filters on pools will be enforced by a Section 88B instrument.

Rainwater reuse

All buildings will be connected to rainwater tanks to reduce groundwater recharge. The rainwater will be used for garden watering at a time when it will be utilised by plants and not infiltrate into the soil. Collection of roof water will be enforced by a Section 88B instrument.

Waterwise gardening

Waterwise gardening will be promoted to future land owners throughout the development. This promotion will be undertaken by the developer. Dubbo City Council has a waterwise promotion program. Low water use gardens are achieved by reducing areas of irrigated lawn and the use of native species. Community trends towards waterwise gardening are expected to become more common over time. Waterwise gardening will be further encouraged by enforcing restrictions on the extraction of groundwater at the site. Native species and waterwise gardening will result in minimal requirements for applications of fertilisers and herbicides.

13. Report limitations and intellectual property

This report has been prepared for the use of the client to achieve the objectives given the clients requirements. The level of confidence of the conclusion reached is governed by the scope of the investigation and the availability and quality of existing data. Where limitations or uncertainties are known, they are identified in the report. No liability can be accepted for failure to identify conditions or issues which arise in the future and which could not reasonably have been predicted using the scope of the investigation and the information obtained.

The investigation identifies the actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing is interpreted by geologists, engineers or scientists who then render an opinion about overall conditions, the nature and extent of likely impacts of the proposed development, and appropriate remediation measures. Actual conditions may differ from those inferred to exist, because no professional, no matter how well qualified, and no sub surface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock or time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions. It is thus import to understand the limitations of the investigation and recognise that we are not responsible for these limitations.

This report, including data contained, its findings and conclusions, remain the intellectual property of Envirowest Consulting Pty Ltd. A licence to use the report for the specific purpose identified is granted for the persons identified in that section after full payment for the services involved in preparation of the report. This report should not be used by persons or for purposes other than those stated, and not reproduced without the permission of Envirowest Consulting Pty Ltd.

14. References

Allan Nicholson (personal communication) Team Leader-Land Management Technical Group, Water Research Unit, Department of Primary Industries, 30 Warne Street, Wellington, NSW.

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DCC (2013b) *Firgrove hydro-geological landscape* (Dubbo City Council)

DCC (2013c) *Dubbo City Urban Salinity Management Strategy* (Dubbo City Council)

DCC (2013d) *Dubbo City Urban Salinity Implementation Plan* (Dubbo City Council)

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Figures

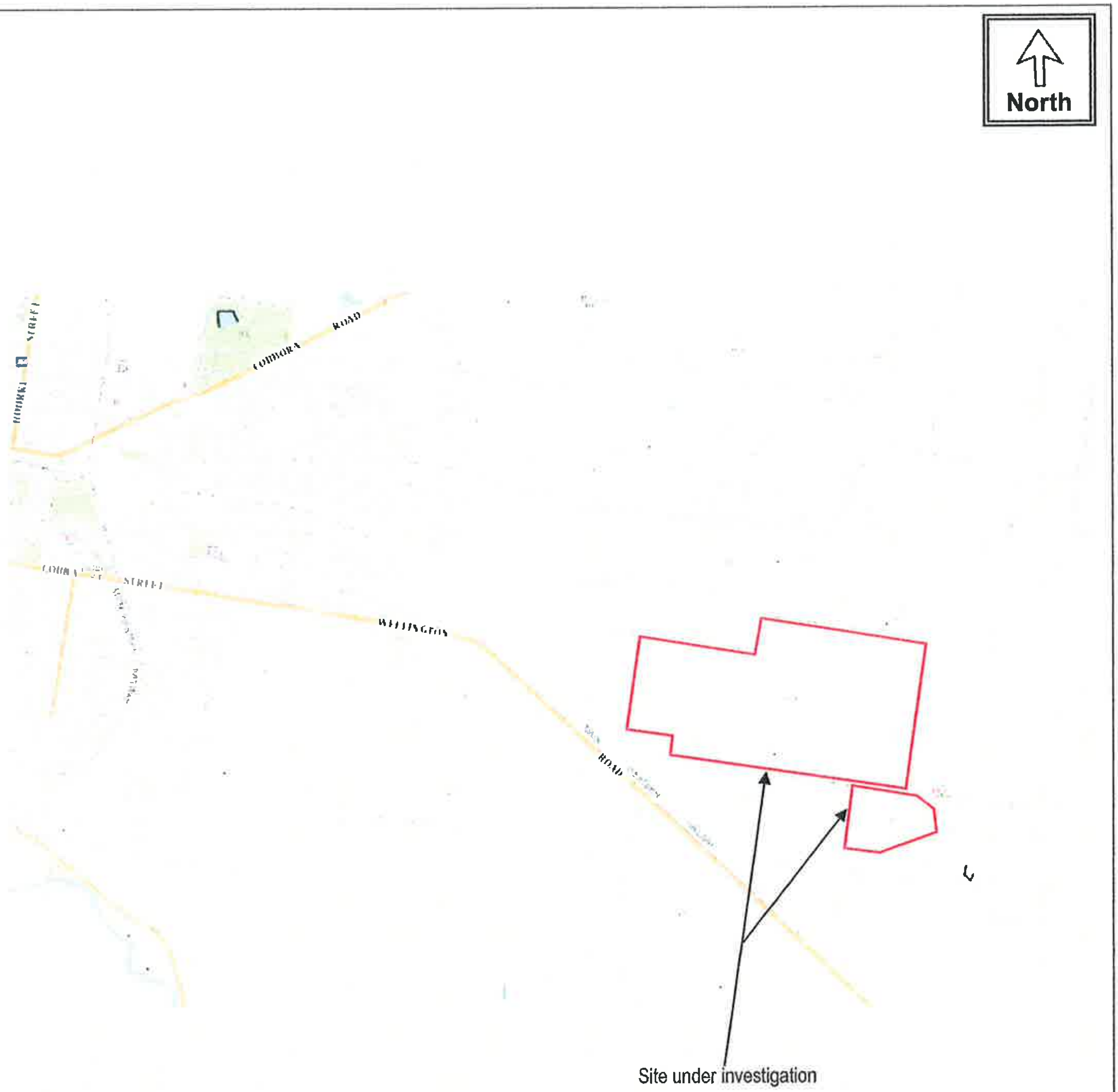


Figure 1. Locality map

Daisy Hill Estate, Eulomogo Road, Dubbo NSW

Envirowest Consulting Pty Ltd

Job – R13365s.5	Drawn by: LD	Date: 28/8/2013

Legend

Lot boundary

Approximate Scale 1: 16,000

0 160 320 640m

Figure 2. Aerial photograph of the site		
Daisy Hill Estate, Eulomogo Road, Dubbo NSW		
Envirowest Consulting Pty Ltd		
Job – R13365s.5	Drawn by: LD	Date: 29/8/2013

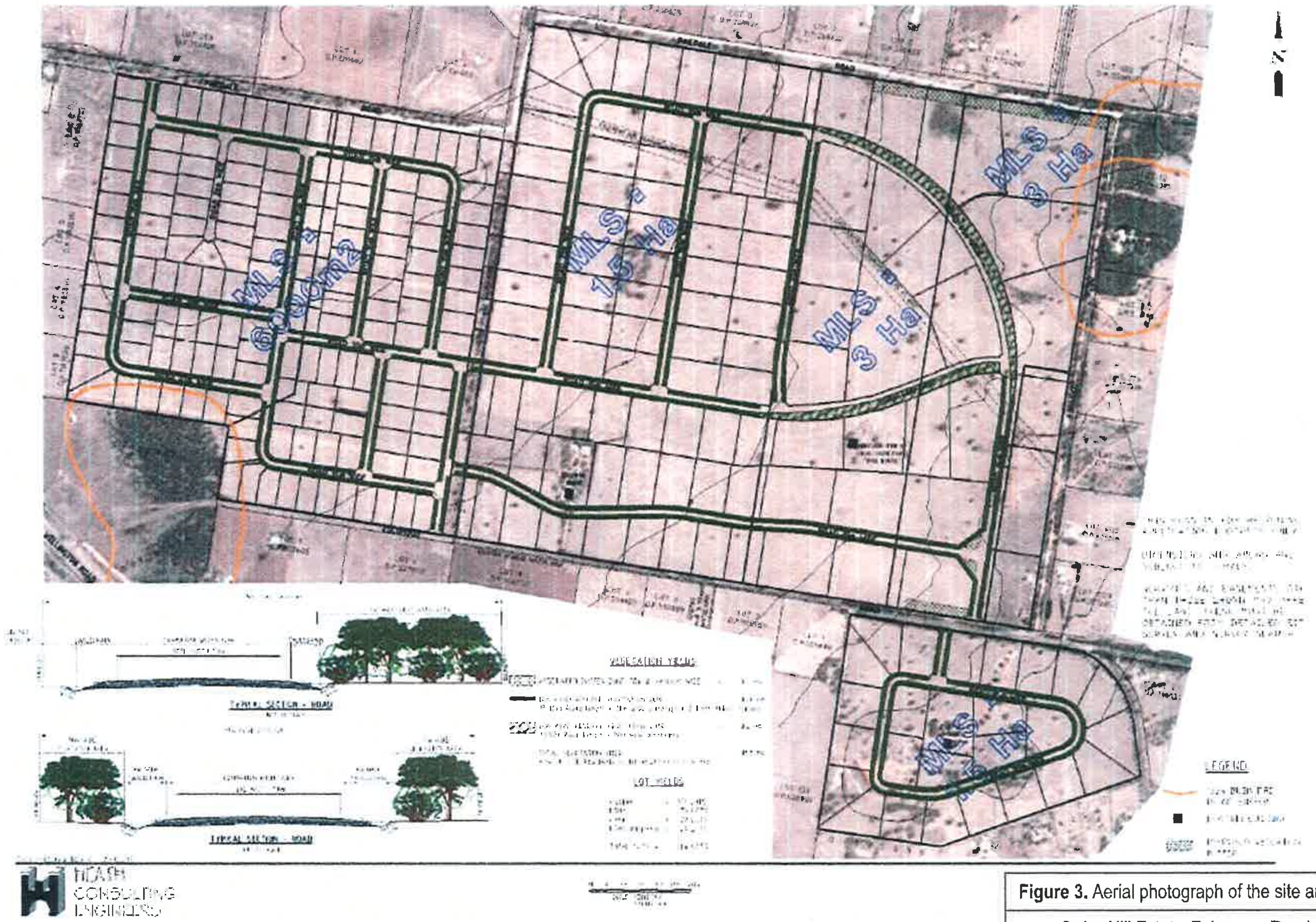
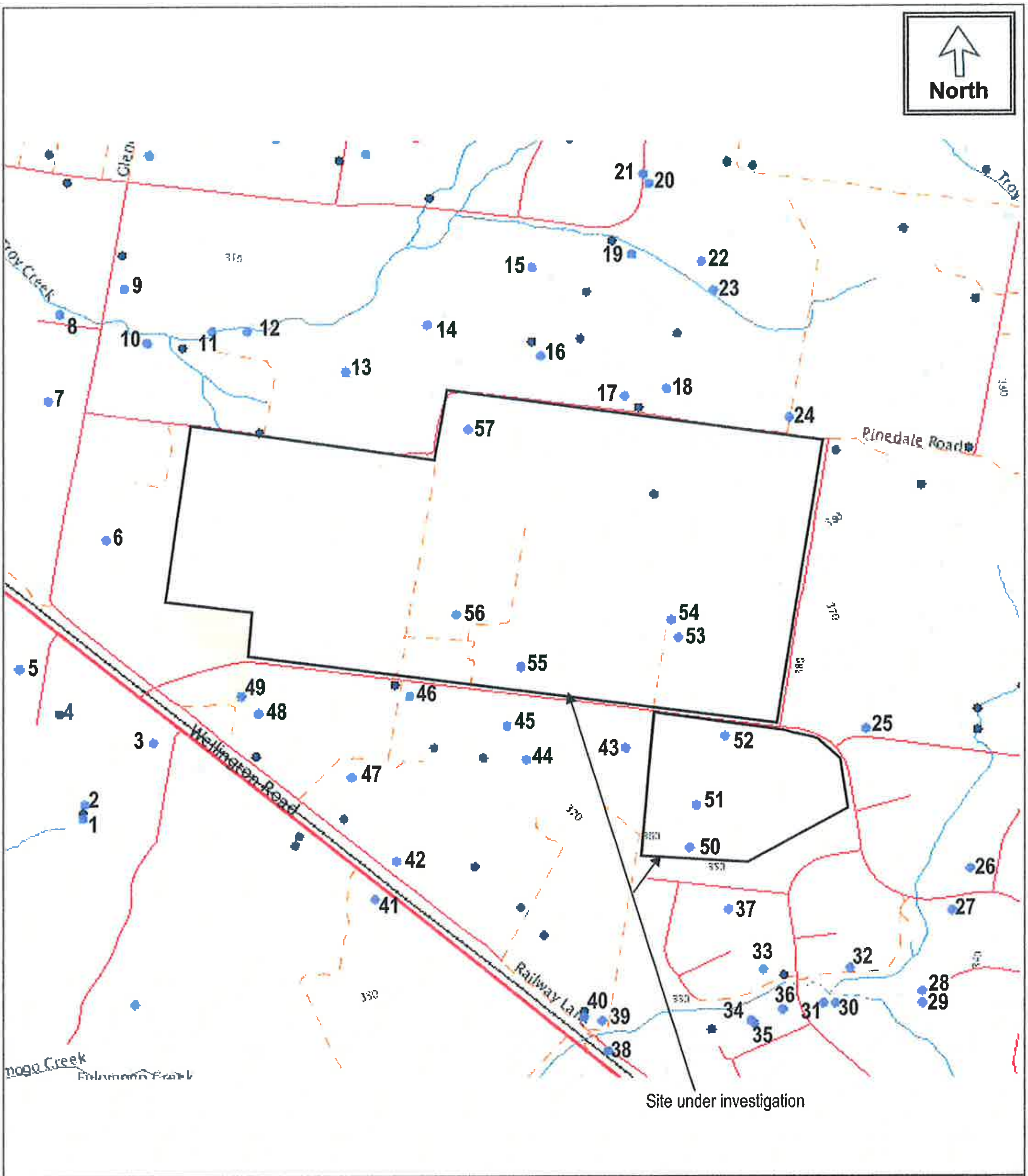


Figure 3. Aerial photograph of the site and conceptual plan		
Daisy Hill Estate, Eulomogo Road, Dubbo NSW		
Envirowest Consulting Pty Ltd		
Job – R13365s.5	Drawn by: -	Date: 25/11/2013



Legend

● Groundwater bore location (Appendix 1)

Approximate Scale 1: 3 27500

0 275 550 1100m

Figure 4. Location of groundwater bores within 1km of the site		
Daisy Hill Estate, Eulomogo Road, Dubbo NSW		
	Envirowest Consulting Pty Ltd	
Job – R13365s.5	Drawn by: LD	Date: 29/6/2013

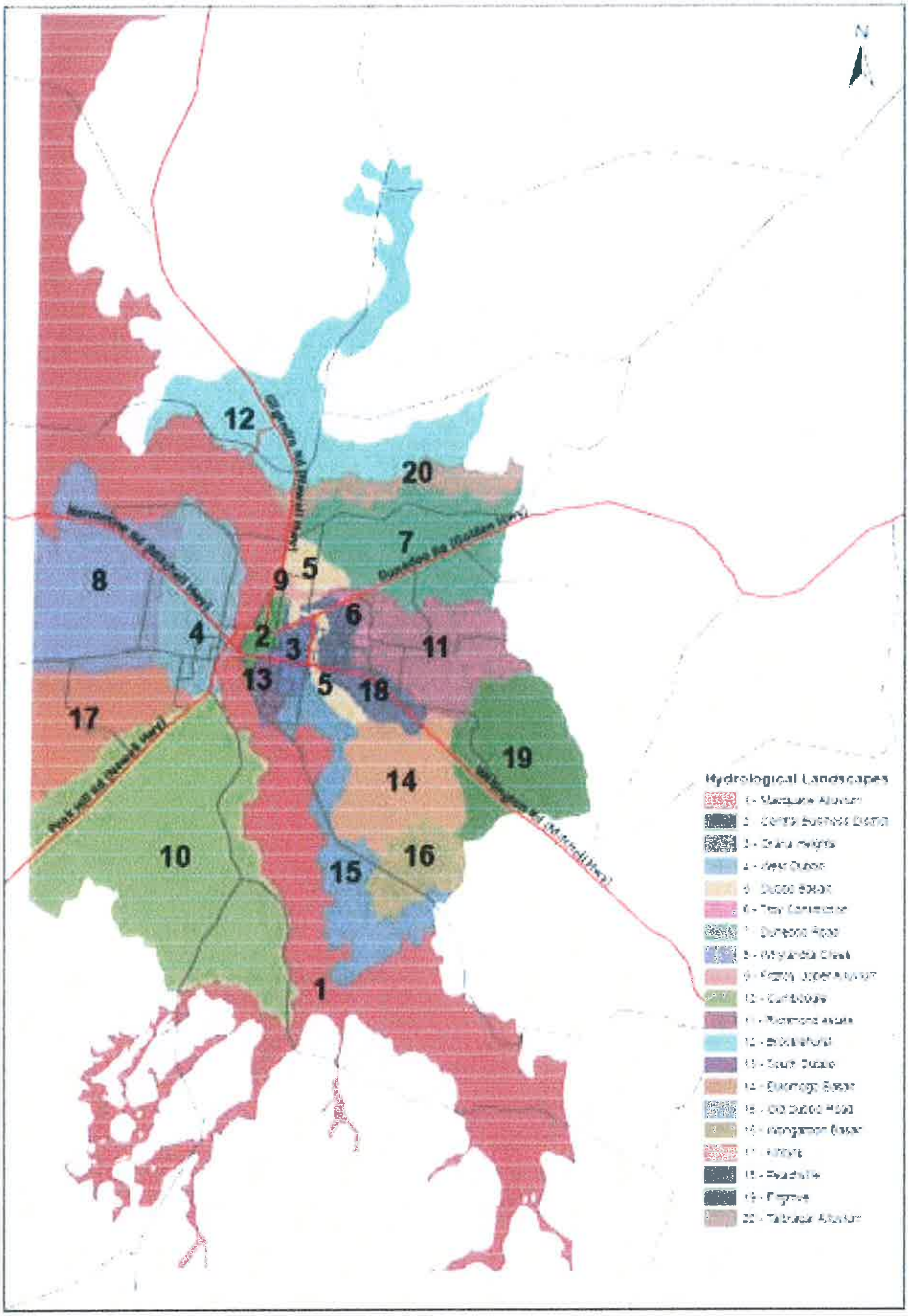
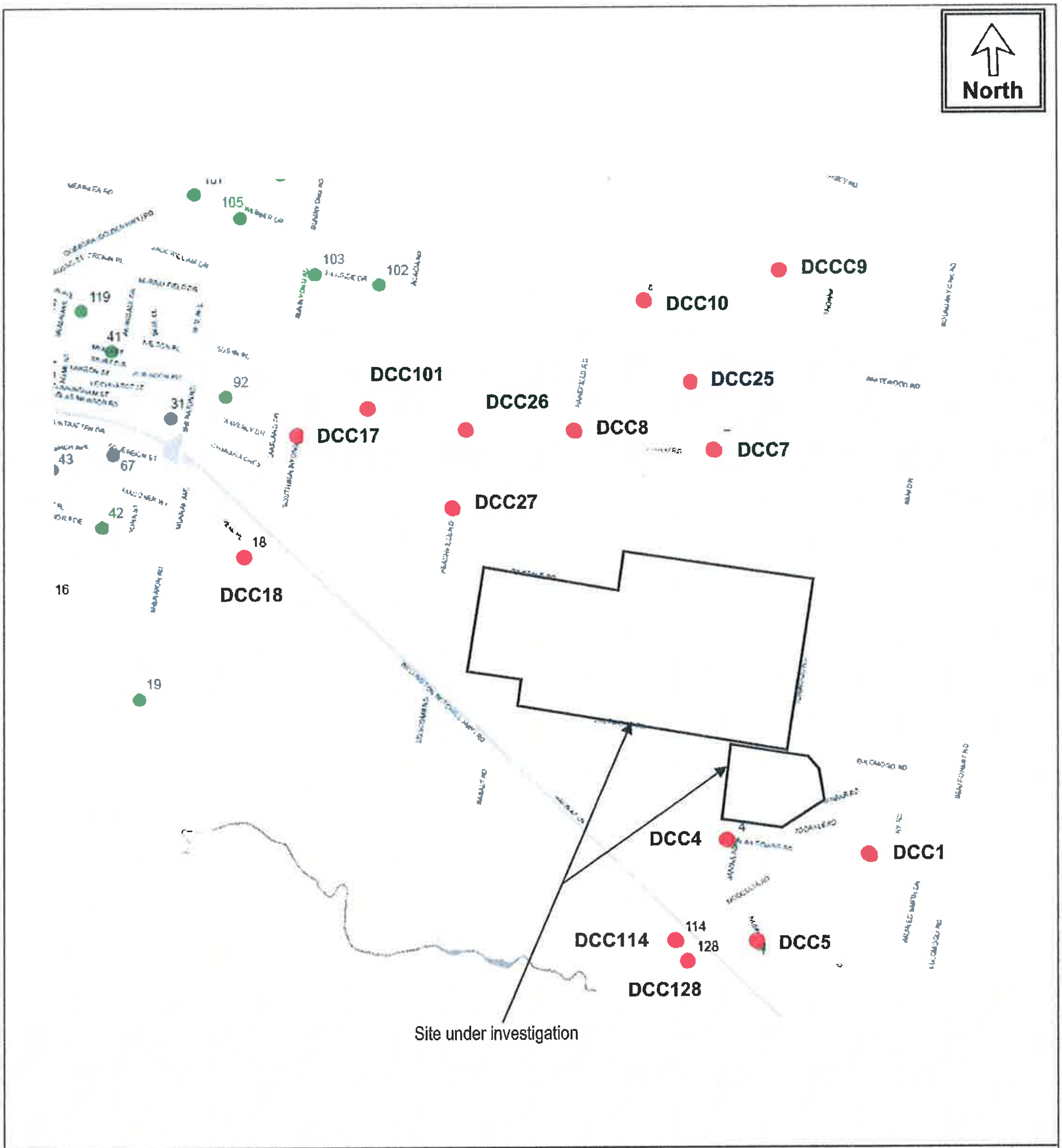


Figure 5. Hydro-geological landscapes of the Dubbo area		
Daisy Hill Estate, Eulomogo Road, Dubbo NSW		
	Envirowest Consulting Pty Ltd	
Job – R13365s.5	Drawn by: -	Date: 29/1/2014



Legend

- Dubbo City Council Salinity Network bore
- Dubbo City Council Salinity Network bore – information obtained (Appendix 6)

Approximate Scale 1: 49 100

0 491 982 1,964m

Figure 6. Dubbo City Council Salinity Network		
Daisy Hill Estate, Eulomogo Road, Dubbo NSW		
	Envirowest Consulting Pty Ltd	
Job – R13365s.5	Drawn by: LD	Date: 28/8/2013

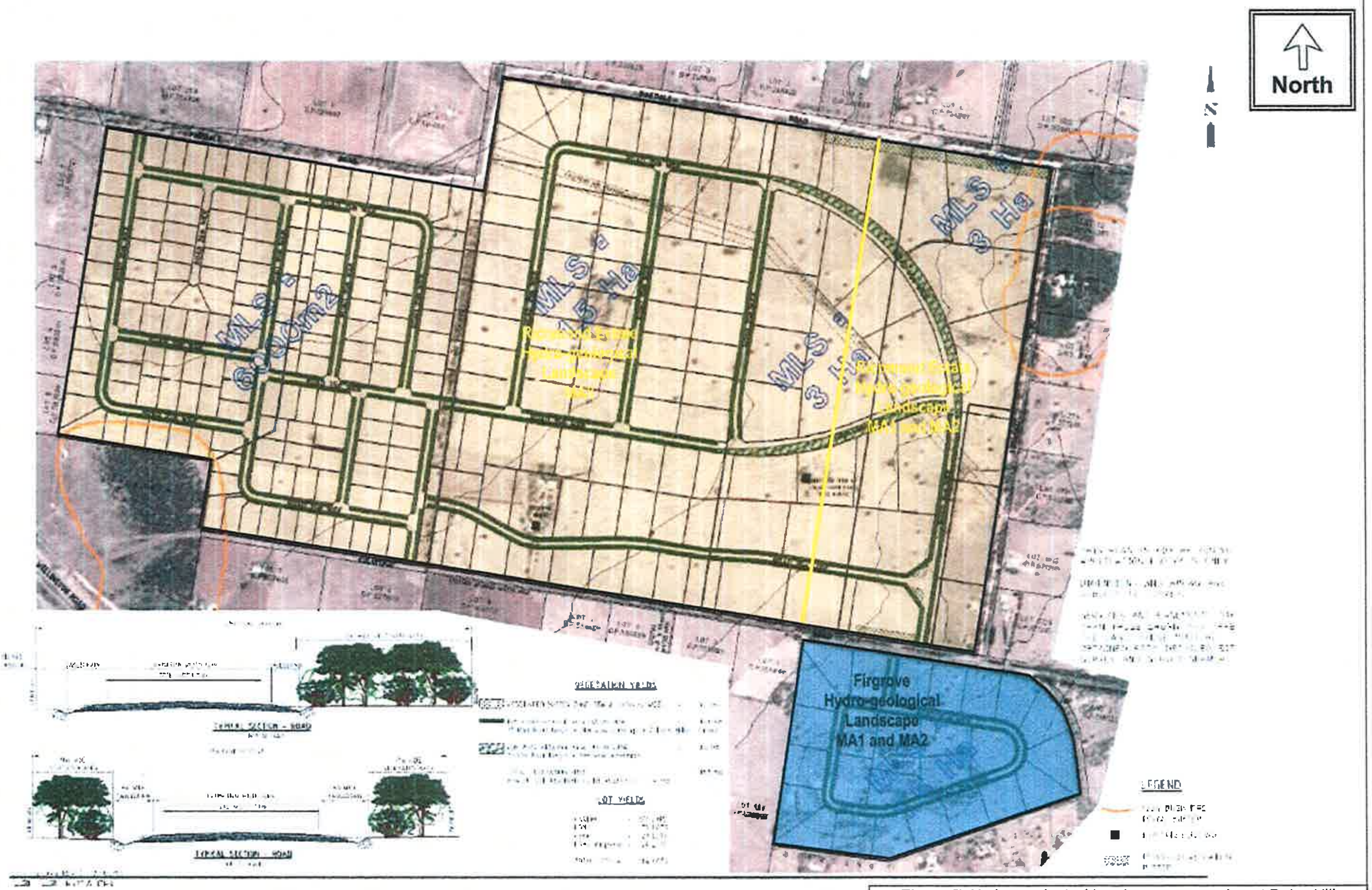
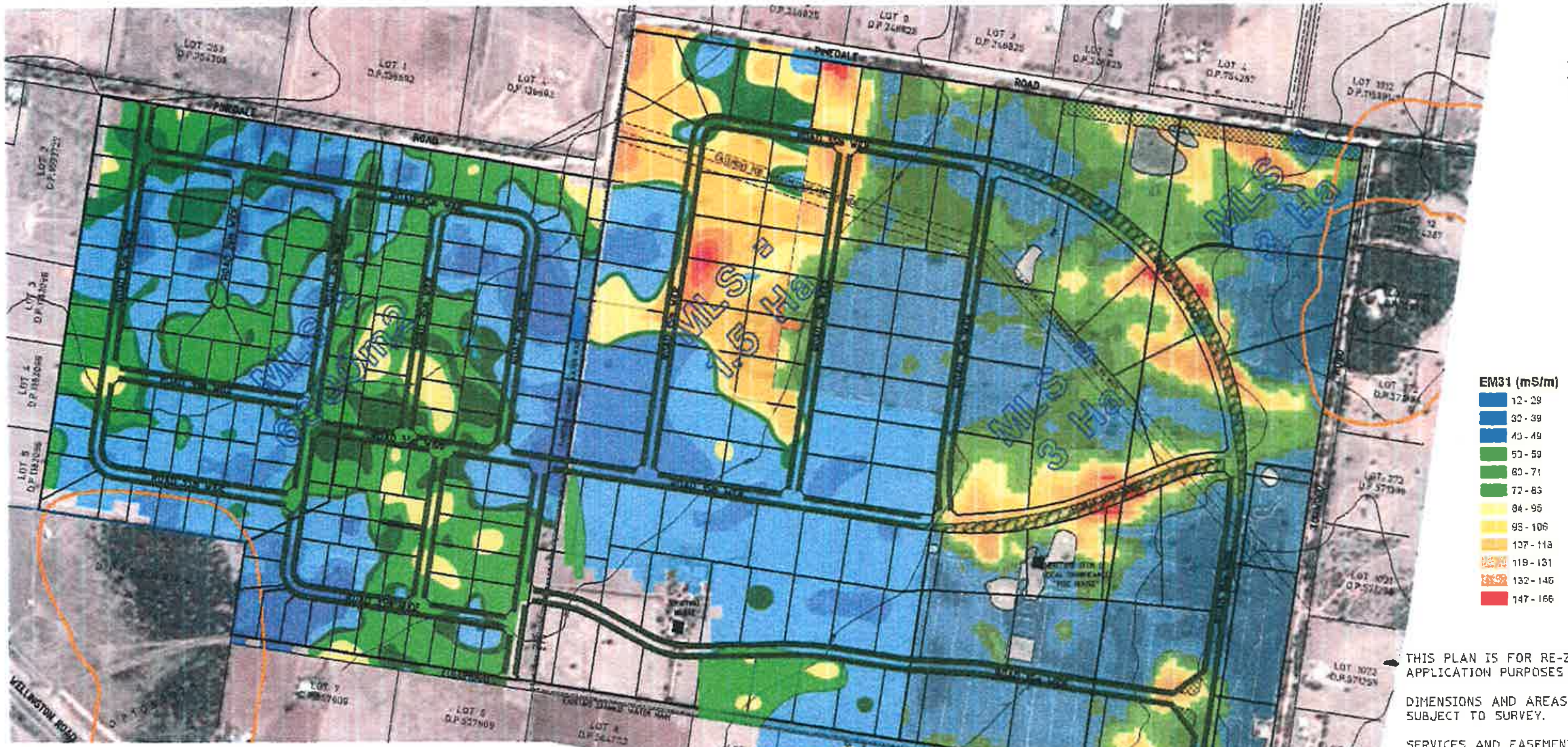


Figure 7. Hydro-geological Landscapes occurring at Daisy Hill Estate	
Daisy Hill Estate, Eulomogo Road, Dubbo NSW	
	Envirowest Consulting Pty Ltd
Job – R13365s.5	Drawn by: LD / Date: 15/8/2014

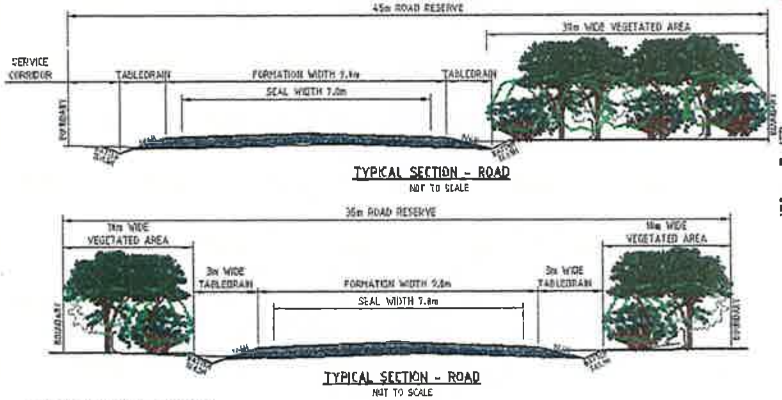
Figure 8. EM survey and conceptual site plan



THIS PLAN IS FOR RE-ZONING APPLICATION PURPOSES ONLY.

DIMENSIONS AND AREAS ARE SUBJECT TO SURVEY.

SERVICES AND EASEMENTS OTH THAN THOSE SHOWN MAY AFFE THE LAND. THESE MUST BE OBTAINED FROM DETAILED SIT SURVEY AND SURVEY SEARCH.



VEGETATION YIELDS

VEGETATED BUFFER ZONE (35m & VARIOUS WIDE)	=	3.3 Ha	
35m ROAD RESERVE VEGETATION ZONE (15,166m Road length x 10m wide plantings x 2 (both sides of road)	=	30.0 Ha	
45m ROAD RESERVE VEGETATION ZONE (1,097m Road length x 30m wide plantings)	=	3.2 Ha	
TOTAL VEGETATION YIELD (8% OF SITE REQUIRED TO BE VEGETATED = 34 Ha)	=	36.5 Ha	

LOT YIELDS

6,000m²	=	157 LOTS
1.5Ha	=	74 LOTS
>3Ha	=	27 LOTS
1.5Ha (Firgrove)	=	26 LOTS
TOTAL LOTS =		284 LOTS

LEGEND

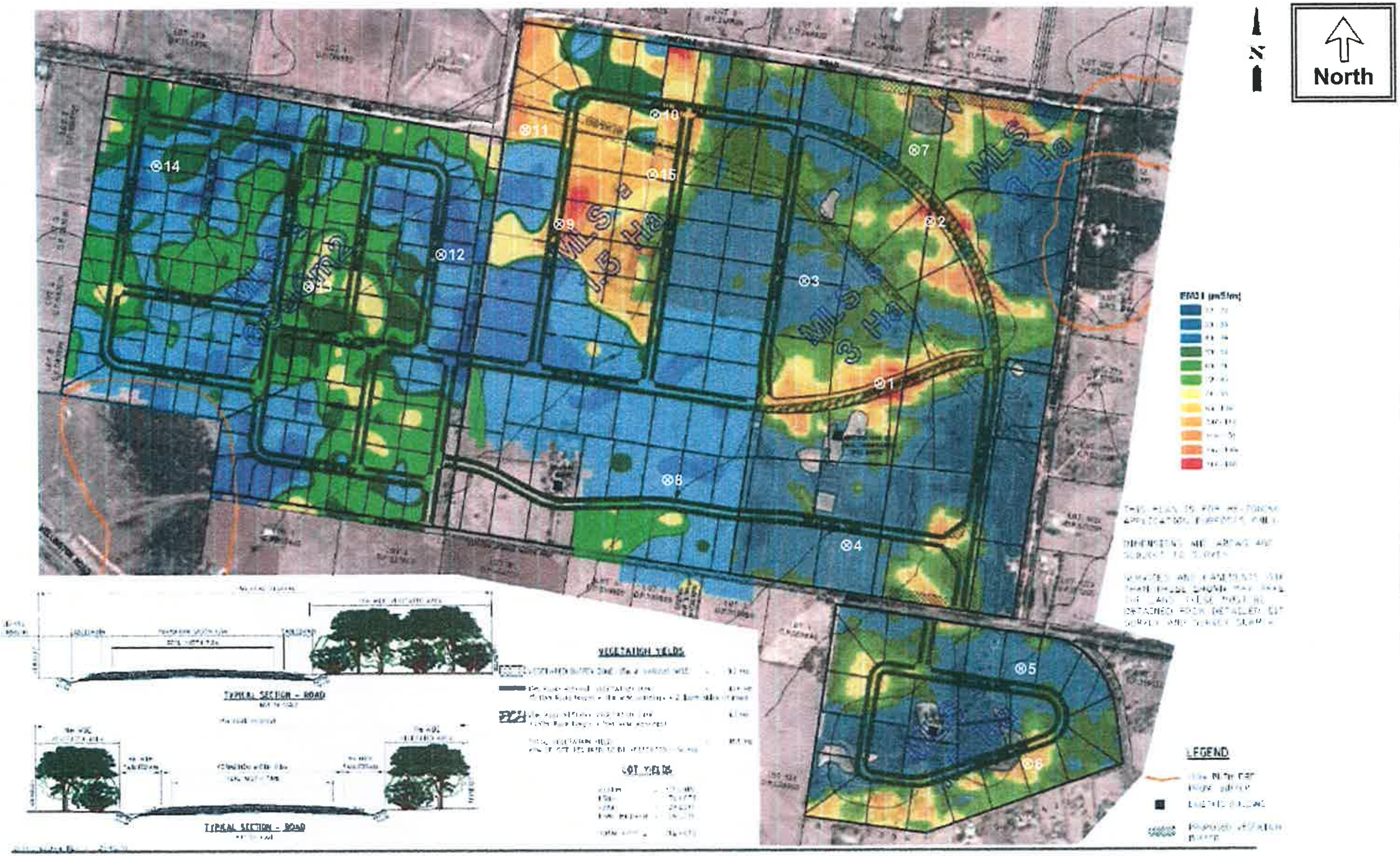
- 100m BUSH FIRE PRONE BUFFER
- EXISTING BUILDING
- PROPOSED VEGEATION BUFFER

SCALE 1:5000 (A1) 1:10,000 (A3)

13854 PHS.DWG REV 0 - 20/02/19

HEATH CONSULTING ENGINEERS

FIGURE 3
CONCEPTUAL LOT LAYOUT



Legend

⊗ Boreholes

Figure 9. EM survey and borehole locations		
Daisy Hill Estate, Eulomogo Road, Dubbo NSW		
	Envirowest Consulting Pty Ltd	
Job – R13365s.5	Drawn by: LD	Date: 15/8/2014

Legend

Lot boundary

⊗ Boreholes

Approximate Scale 1: 16,000

0 160 320 640m

Figure 10. Aerial photograph and borehole locations		
Daisy Hill Estate, Eulomogo Road, Dubbo NSW		
	Envirowest Consulting Pty Ltd	
Job – R13365s.5	Drawn by: LD	Date: 18/11/2014

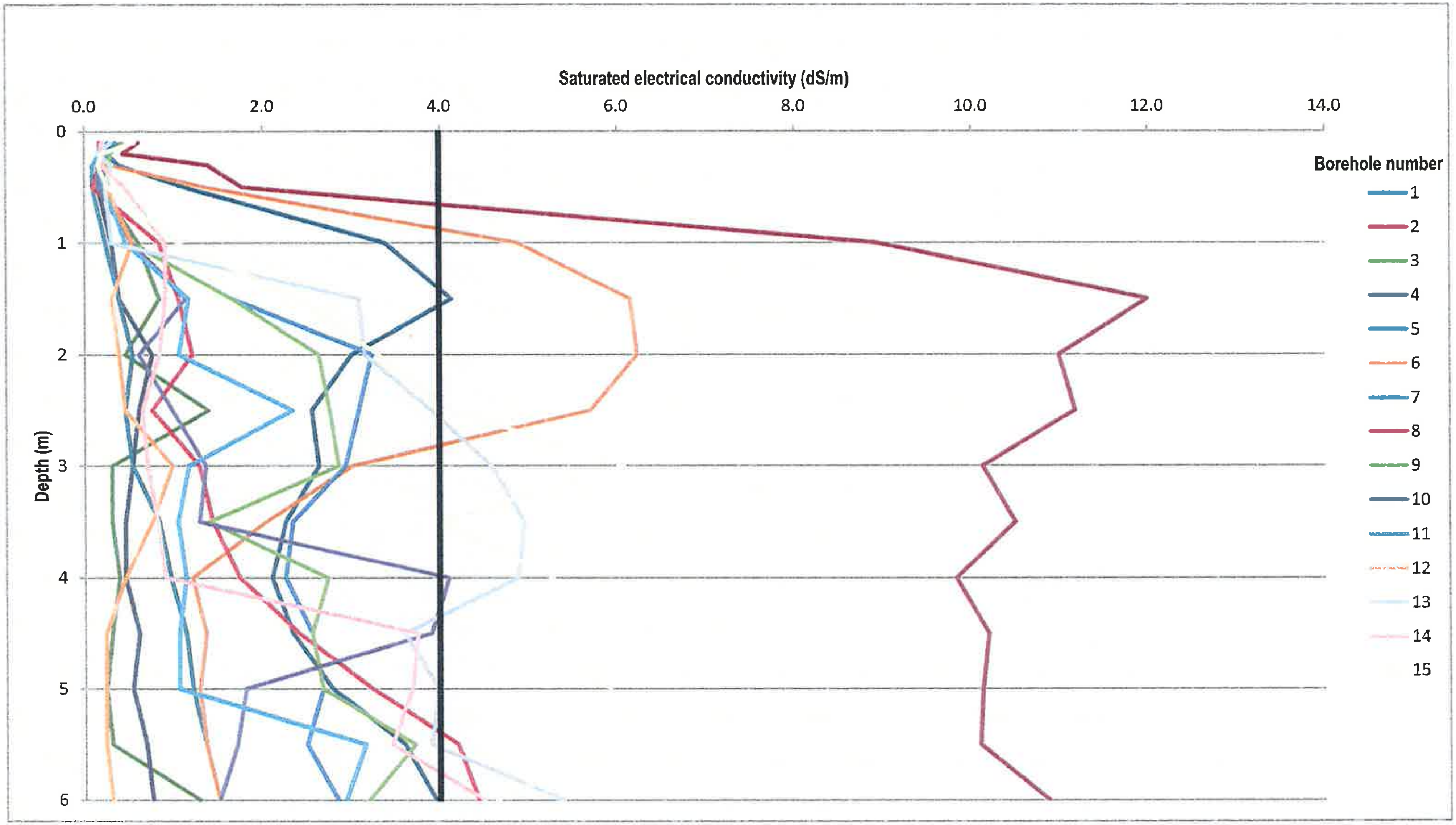


Figure 11. Electrical conductivity of boreholes

Daisy Hill Estate, Eulomogo Road, Dubbo NSW

Envirowest Consulting Pty Ltd

Job – R13365s.5	Drawn by: LD	Date: 18/11/2014

Figure 12. Photographs of the site

Photo taken looking south east over the southern section of the site

Photo taken looking north west over the site

Appendices

Appendix 1. Details of registered bores within 1km of the site – NSW Government Natural Resource Atlas
Appendix 2. EM survey – eastern section
Appendix 3. EM survey – central section
Appendix 4. EM survey – western section
Appendix 5. Results of rural-residential lot assessment for building, driveway and irrigation area sizing from *Firgrove Estate* and Buninyong Drive subdivision
Appendix 6. Salinity results from the Dubbo City Council Salinity Network
Appendix 7. Dubbo City Urban Implementation Plan
Appendix 8. Borelogs and laboratory analysis results
Appendix 9. Hydraulic balance – *Daisy Hill Estate* with road reserve vegetation (284 lots)
Appendix 10. Hydraulic balance – *Daisy Hill Estate* without road reserve vegetation (284 lots)
Appendix 11. Hydraulic balance – *Daisy Hill Estate* with road reserve vegetation (323 lots)
Appendix 12. Hydraulic balance – *Daisy Hill Estate* without road reserve vegetation (323 lots)

Appendix 1. Details of registered bores within 1km of the site – NSW Government Natural Resource Atlas.

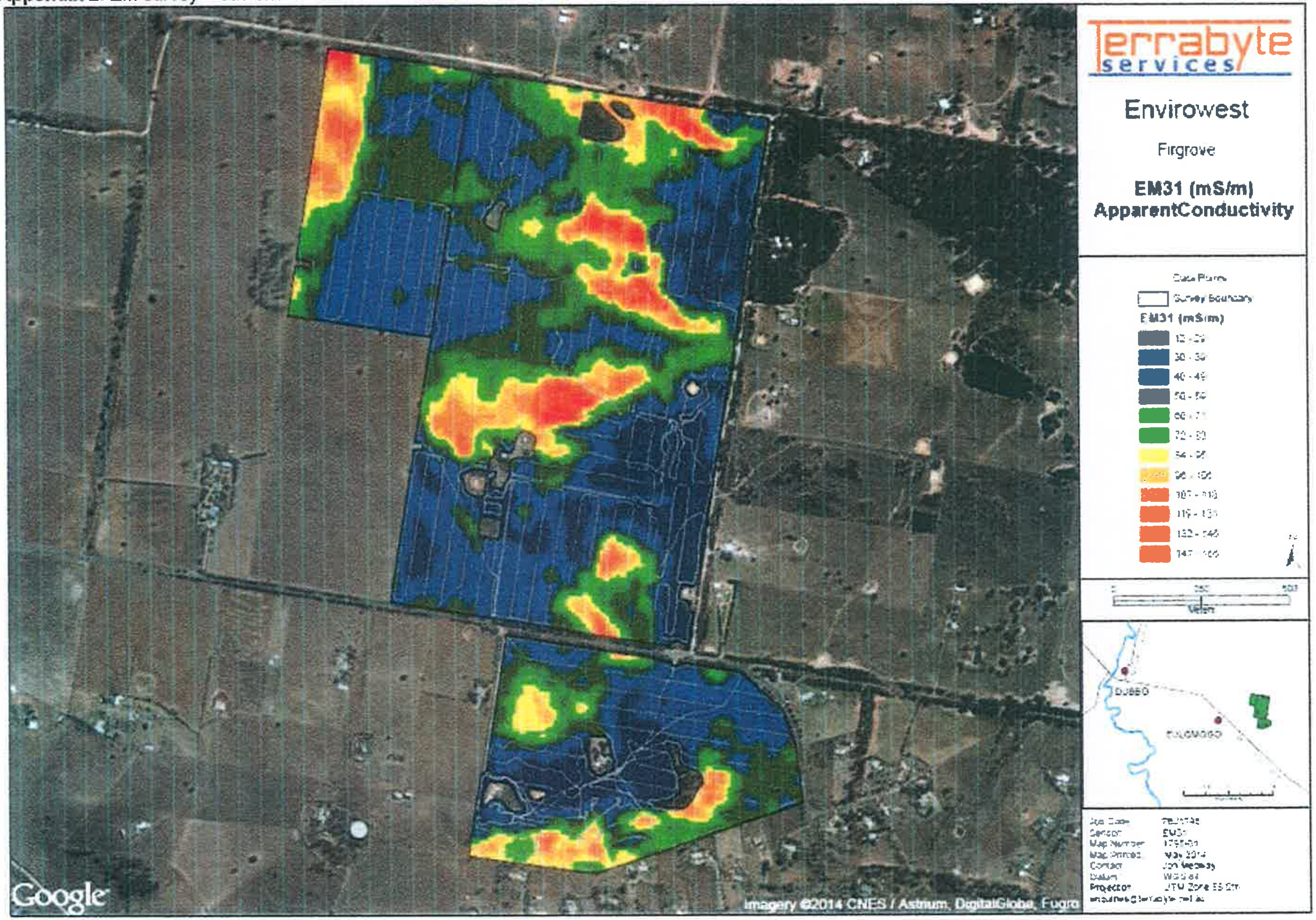
Bore ID (Figure 4)	Bore record No.	Eastings	Northings	Drilled / Completed depth (m)	Salinity description	Water bearing zones (m)	Standing water level (m)	Date drilled and or tested	Purpose
1	GW054532	657537	6427288	33	Fresh -	11.5-12 25.5-26	11.5 14.5	1981	Domestic, farming, irrigation, stock
2	GW803858	657546	6427362	50	-	30-33	13	2009	Domestic, stock
3	GW054272	657857	6427683	61.6	Stock	56.1-58.8	21.3	1980	Domestic, stock
4	GW066584	657441	6427844	62	Fresh	53-57	19	1991	Domestic, stock
5	GW803277	657263	6428087	50	-	45-46	31	2006	Domestic, stock
6	GW009169	657664	6428764	27.4	-	-	-	-	-
7	GW013539	657414	6429508	24.7	Good stock	23.8-24.7	2.4	1957	Stock
8	GW051540	657474	6429969	33.5	Brackish	27.7-30.1	4.3	1979	Domestic, stock
9	GW802536	657767	6430099	5	-	4.25-5	5	2004	Monitoring
10	GW028069	657864	6429809	39.9	Slightly salty Fair	11.6-11.6 33.8-33.8	6.1 6.1	1967	Domestic, stock
11	GW068522	658153	6429866	33	-	24-30	-	1990	Domestic, stock
12	GW045695	658310	6429863	25	-	13.4-13.4 16.8-25	- 7.2	1975	Domestic, stock
13	GW068675	658751	6429641	64	-	16-20 40-42 52-54 54-57	18	1991	Domestic, stock
14	GW800044	659121	6429881	48	-	37-39	6	1991	Domestic, stock
15	GW000203	659597	6430182	70.1	S. brackish 7001-10000ppm	54.9 64	18.3 42.1	1918	Stock
16	GW050243	659627	6429709	50.3	Fresh	44.2-45.7	27.4	1979	Domestic, stock
17	GW803995	660000	6429490	15	-	-	-	2009	Stock

Bore ID (Figure 4)	Bore record No.	Eastings	Northings	Drilled / Completed depth (m)	Salinity description	Water bearing zones (m)	Standing water level (m)	Date drilled and or tested	Purpose
18	GW050660	660189	6429526	54.5	Salty Brackish	22.9 44-44.3	8.5 14.5	-	Domestic, stock
19	GW065187	660043	6430242	40.6	-	21.8-22 25-25.1 35.9-36	-	1988	Domestic, stock
20	GW802516	660127	6430617	9	-	7-8	4.51	2004	Monitoring
21	GW008026	660102	6430667	79.2	3001-7000ppm	76.2-79.2	50.3	1947	Domestic, stock
22	GW068437	660357	6430201	24	-	-	-	1990	Stock
23	GW800042	660407	6430046	96	-	-	-	1991	Stock
24	GW002027	660736	6429363	34.1	-	-	-	1927	-
25	GW802515	661056	6427705	3	-	-	-	2004	Monitoring, abandoned
26	GW802510	661512	6426955	12	-	8-9	5.2	2004	Monitoring
27	GW001954	661427	6426734	53.6	-	-	-	1927	-
28	GW803088	661289	6426306	42	- -	14-17 38-40	6 6	2006	Domestic, stock
29	GW009146	661288	6426243	41.1	Brackish	41.1-41.1	12.2	-	-
30	GW00200	660896	6426249	43	Fresh	41.8-41.8	24.4	1927	-
31	GW049441	660844	6426250	53.3	Fresh Fresh	33.5-33.5 44.2-44.2	- -	1967	Stock
32	GW801090	660965	6426435	10	-	-	-	-	Domestic, stock
33	GW804981	660575	6426435	66	1600ppm 1600ppm	56.0-56.5 57-57.3	20 20	2012	Domestic
34	GW802514	660515	6426162	8	-	4.5-6	3.52	2004	Monitoring
35	GW804234	660530	6426145	72	-	62-63	48	2010	Domestic, stock

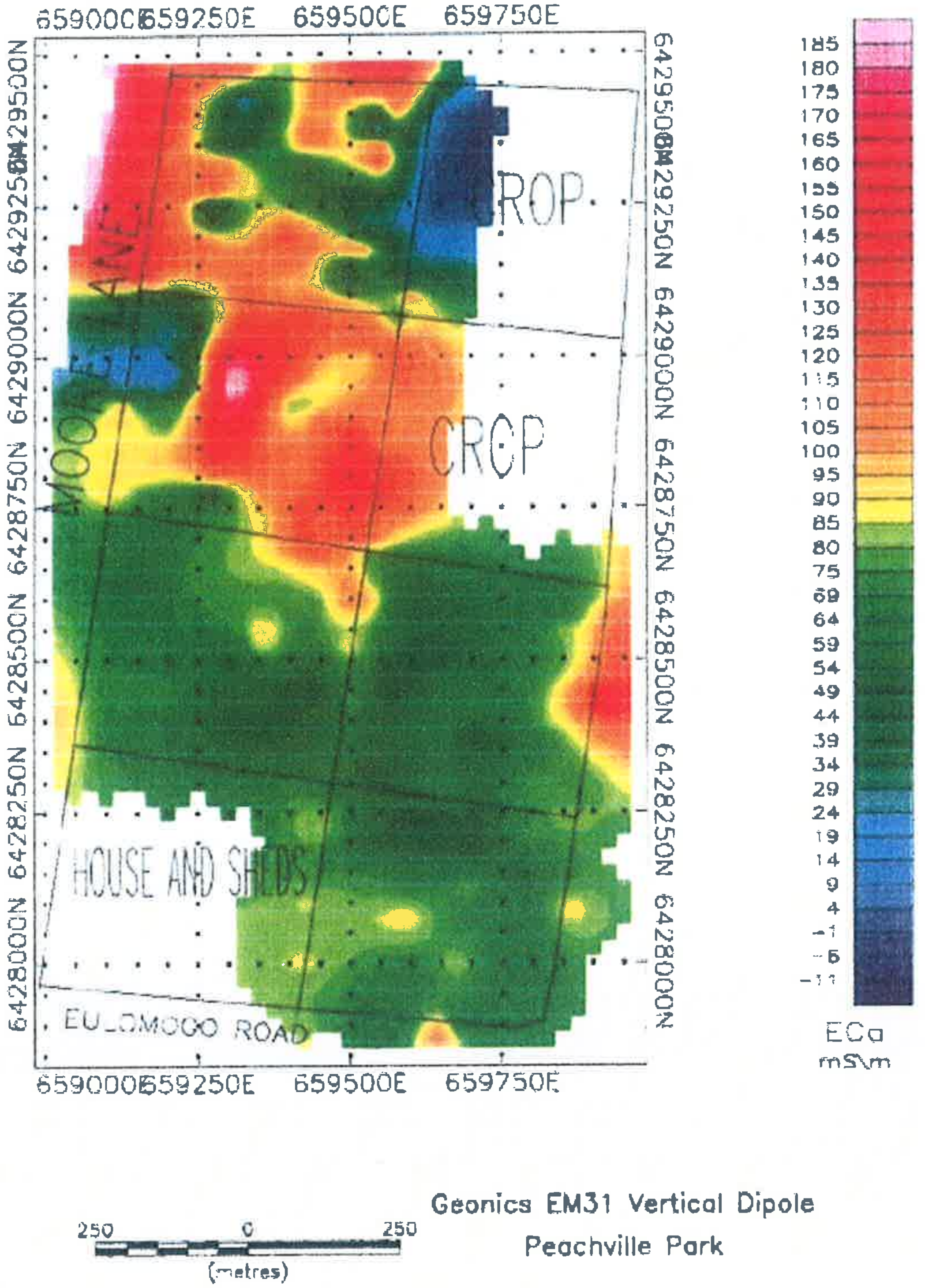
Bore ID (Figure 4)	Bore record No.	Eastings	Northings	Drilled / Completed depth (m)	Salinity description	Water bearing zones (m)	Standing water level (m)	Date drilled and or tested	Purpose
36	GW804035	660658	6426220	60	good	50-52	18	2009	Domestic
37	GW803029	660424	6426755	44.6	-	16-18	11.8	2005	Domestic, stock
38	GW802637	659871	6426011	5.5	-	4.75-5.5	1.74	2005	Monitoring
39	GW023043	659848	6426173	14.9	1001-3000ppm 1001-3000ppm	8.8-9.1 13.1-13.7	4.3 4.3	1965	Stock
40	GW802623	659768	6426194	4.5	-	3.25-4	-	2005	Monitoring
41	GW008365	658838	6426836	81.4	0-500ppm	20.1-22.5 78.3-79.2	18 -	1953	Domestic, stock
42	GW802789	658939	6427035	104	-	26-26.5 32-32.5 95-96	26 - -	2004	Domestic, stock
43	GW056365	659976	6427619	64	-	59-60	24	1982	Domestic, stock
44	GW008443	659530	6427565	106.7	Good	55.5-55.8	34.4	1953	Stock
45	GW803659	659447	6427744	60	-	50-51 53-54	-	2008	Domestic, stock
46	GW068447	659012	6427912	78	-	53-54 66-72	47.8	1990	Domestic, stock
47	GW070936	658743	6427485	67.06	-	-	-	1993	Domestic, stock
48	GW800112	658330	6427830	61	-	50-55	-	1996	Domestic, farming, irrigation, stock
49	GW068570	658253	6427924	60	-	52-55	-	1990	Domestic, stock
50	GW802513	660253	6427086	9	-	4-6	-	2004	Monitoring
51	GW800976	660288	6427309	32	-	14-26.3	12.55	1994	Domestic
52	GW800043	660421	6427674	120	-	86-90	25	1991	Stock
53	GW016645	660220	6428201	70.7	Salty Brackish	35.4-37.2 68.6-70.7	26.5 45.1	1959	Stock

Bore ID (Figure 4)	Bore record No.	Eastings	Northings	Drilled / Completed depth (m)	Salinity description	Water bearing zones (m)	Standing water level (m)	Date drilled and or tested	Purpose
54	GW805018	660190	6428295	72	-	67-69	52	2012	Stock
55	GW035529	659511	6428058	65.2	Good	47.2-50.2	30.4	1972	Stock
56	GW005199	659228	6428340	48	-	28-30.7 43.6-45.5	22.6	1959	Stock
57	GW016151	659296	6429324	74.7	Good stock	57.6-58.5 62.5-63.1 68.3-68.9	27.1 - 22.9	1957	Domestic, stock

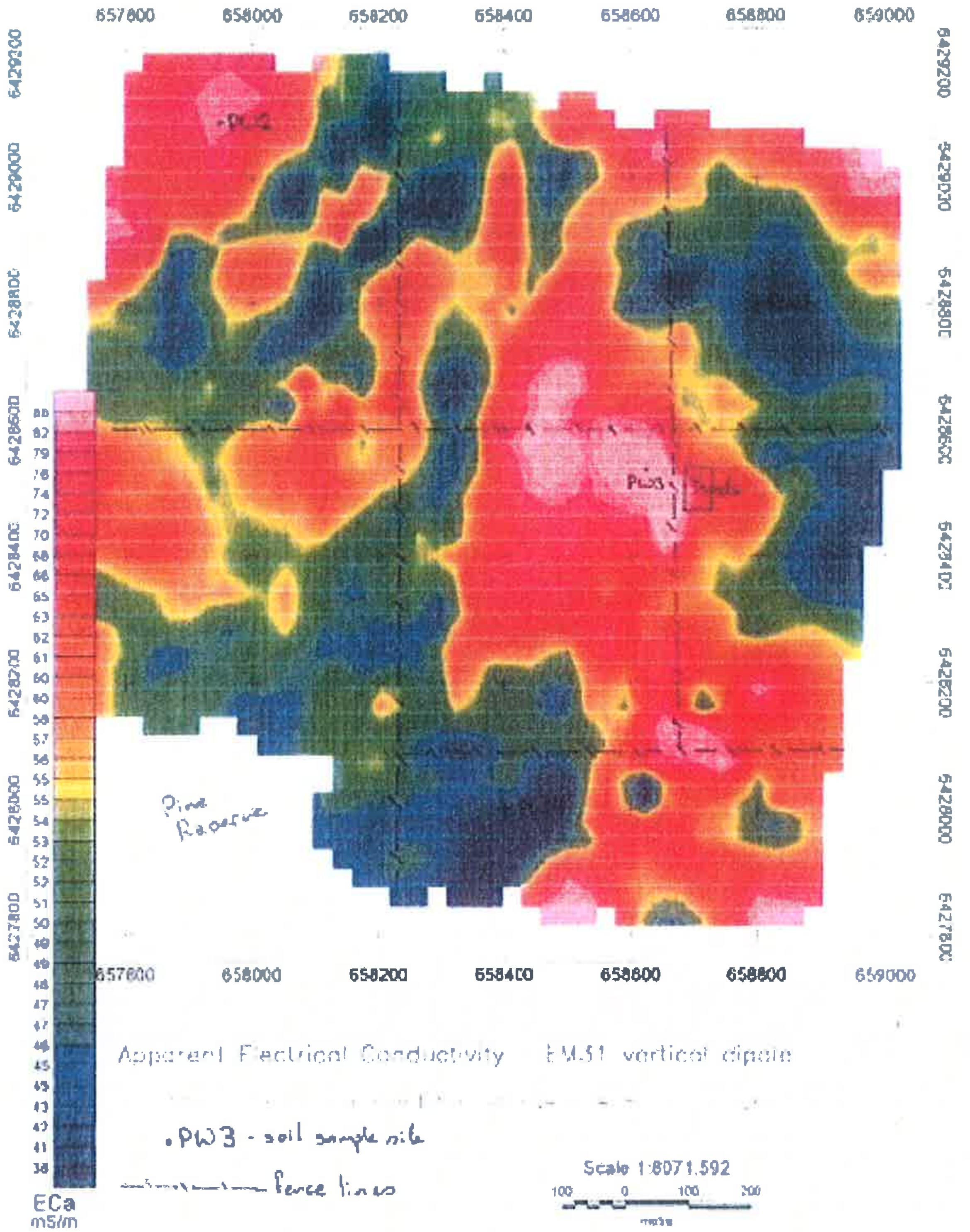
Appendix 2. EM survey – eastern section



Appendix 3. EM survey – central section



Appendix 4. EM survey – western section



EM31 survey – Apparent electrical Conductivity

Appendix 5. Results of rural-residential lot assessment for building, driveway and irrigation area sizing from *Firgrove Estate* and Buninyong Drive subdivision

Number	Size (ha)	Area irrigated (m^2)	Area of house and sheds (m^2)	Area of driveway (m^2)
1	2.5	745	706	663
2	2.46	814	421	1205
3	3.66	1030	492	880
4	4.03	1158	411	358
5	2.06	1265	367	289
6	1.5	1339	453	907
7	1.94	831	404	559
8	1.87	2036	553	735
9	2	928	400	708
10	2.33	1105	289	609
11	2.41	857	528	745
12	1.89	1030	521	964
13	1.78	1025	521	467
14	2.1	983	406	784
15	1.8	931	348	287
16	2.88	1577	310	282
17	1.8	1700	451	613
18	2.04	467	481	1021
19	1.86	1042	488	571
20	8.34	817	403	560
21	2.4	648	539	998
22	1.6	1717	544	884
23	2.26	1007	599	932
24	4.71	687	450	475
25	2.92	461	480	1275
26	1.96	745	317	317
27	1.84	490	442	468
28	1.79	912	339	210
29	1.91	848	479	409
30	1.9	920	530	823
31	1.88	726	386	649
32	1.9	0	154	345
33	2.37	2287	562	533
34	2.24	3234	451	677
35	3.17	2344	850	1296
36	4.78	0	0	0
37	1.72	3652	668	1424
38	1.68	891	378	358
39	1.84	3694	535	906
40	2.65	588	395	320
41	1.5	963	393	434
42	2.24	423	396	956
43	1.57	1360	408	258
44	1.74	1154	622	935
45	2.67	2192	500	366
46	2.15	1249	509	1515
47	1.7	834	492	523

48	1.52	1381	577	716
49	1.53	743	339	358
50	1.63	1463	399	439
51	1.61	1394	431	741
52	1.53	730	415	528
53	2	1431	677	885
54	1.8	1326	471	494
55	1.63	1318	441	690
56	1.72	2051	418	1233
57	2.509	1700	504	699
58	2.51	1073	656	1008
59	1.58	841	312	462
60	1.58	913	466	1198
61	1.72	979	485	312
62	1.85	1193	627	1010
63	1.63	2078	521	823
64	1.66	1121	651	983
65	1.53	1233	495	1114
66	1.51	1400	439	387
67	2.4	1368	684	576
68	2.5	2049	579	696
69	1.65	3139	443	502
70	1.8	1797	512	304
71	2.8	1443	488	1313
72	2.4	1797	489	305
73	1.99	1338	534	388
74	2.04	1418	334	641
75	2.17	1579	397	524
76	2.07	1347	436	450
77	1.69	1589	668	521
78	1.58	1553	410	536
79	1.57	1450	592	631
80	1.88	2711	464	576
81	2.1	583	642	792
82	1.88	1284	639	656
83	2.1	1718	487	1132
84	2.01	615	623	1201
85	2.16	1702	490	266
86	2.96	1686	632	1420
87	1.5	1536	346	271
88	0.59	1190	382	610
89	0.41	1044	625	431
90	0.41	823	491	702
91	0.41	1146	644	755
92	0.81	604	375	512
93	0.40	369	328	111
94	0.41	1476	348	332
95	0.46	43	334	648
96	0.39	1945	693	543

97	0.40	499	531	740
98	0.40	1823	342	391
99	0.48	1074	609	243
100	0.40	1348	470	139
101	0.62	967	306	475
102	0.50	853	499	381
103	0.41	268	532	499
104	0.65	2990	545	607
105	0.48	2160	452	578
106	0.51	994	386	217
107	0.52	2882	347	366
108	0.60	516	354	206
109	0.51	1448	357	926
110	0.44	788	480	366
111	0.52	885	379	761
112	0.51	3703	374	463
113	0.41	1549	706	437
114	0.48	897	257	507
115	0.49	1053	563	328
116	0.47	429	302	332
117	0.41	1613	405	860
118	0.40	1015	361	286
119	0.51	745	472	1165
120	0.52	320	565	919
121	0.42	501	436	445
122	0.58	1277	422	580
123	0.52	1046	395	441
124	0.48	97	373	379
125	0.46	485	495	498
126	0.39	1372	394	710
127	0.41	1115	428	631
number	127	127	127	127
median	1.72	1115	464	571
mean	1.64	1252.98	467.25	628.30
sd	1.09	718.17	120.10967	309.87
ci	0.19	124.90	20.89	53.89
upper CI	1.83	1377.88	488.14	682.19
lower CI	1.45	1128.07	446.36	574.41
mode	1.8	745	521	358
max	8.34	3703	850	1515
min	0.39	0	0	0

Appendix 6. Salinity and Standing Water Level (SWL) data from Dubbo City Council Salinity Network

Dubbo City Council Salinity Network site number (Figure 6)		DCC1	DCC4	DCC5	DCC7	DCC8	DCC9	DCC10	DCC17	DCC18	DCC25	DCC26	DCC27	DCC101	DCC114	DCC128
Sampling date	Drilled depth (m)	12	9	8	9	15	15	14.5	6	15	12	6	5	3	4.5	5.5
Mar-05	EC(dS/m)	19.8	-	0.7	0.1	16.5	63.6	0.1	-	-	51.7	-	TSTB	-	0.3	1
	SWL (m)	5.2	0	3.53	4.51	4.88	12.4	4.29	0	0	6.68	0	5	0	0.68	1.74
Apr-05	EC(dS/m)	15.8	-	3	4.7	14.4	16.3	1.3	-	-	19.7	-	-	-	1.3	1.2
	SWL (m)	5.33	0	3.62	4.67	4.95	12.44	4.45	0	5.91	6.72	0	0	0	0.9	1.74
May-05	EC(dS/m)	19.4	-	6.5	4.9	20.1	26.8	2.2	-	-	25.5	-	-	-	5.5	5.8
	SWL (m)	5.4	0	3.6	4.77	4.99	12.4	4.2	0	0	6.66	0	0	0	0.96	1.78
Jun-05	EC(dS/m)	18.90	-	5.5	7.7	19.4	24.2	1.7	-	-	23.9	-	-	-	5	6.1
	SWL (m)	5.52	0	3.65	4.82	5.09	12.46	4.6	0	0	6.75	0	0	0	0.98	1.3
Jul-05	EC(dS/m)	20.9	-	6.3	4.1	20.3	15.3	1.4	-	-	24	-	-	-	5.2	6.7
	SWL (m)	5.45	0	3.44	4.75	5.03	12.50	4.55	0	0	6.65	0	0	0	0.73	0.65
Aug-05	EC(dS/m)	19.6	-	6	4.8	20.5	17.5	1.2	-	-	25.3	-	-	-	5	7.5
	SWL (m)	5.5	0	3.4	4.89	5.09	12.4	4.6	0	0	6.73	0	0	0	0.71	0.78
Sep-05	EC(dS/m)	20	-	6.3	4.4	20.2	12.7	1.2	-	-	24.4	-	-	-	5.2	7.4
	SWL (m)	5.53	0	3.27	4.52	5.06	12.25	4.18	0	0	6.71	0	0	0	0.52	0.32
Oct-05	EC(dS/m)	19.6	TSTB	6	4.2	20	14.7	1.2	-	-	23.6	-	-	-	5.4	7.4
	SWL (m)	5.48	7.02	3.05	4.04	4.9	12.45	4.35	0	0	6.65	0	0	0	0.32	0.31
Nov-05	EC(dS/m)	19.3	TSTB	6	4.1	19.9	6.9	1.1	-	TSTB	24.2	-	-	-	5.5	7.3
	SWL (m)	5.33	6.09	2.85	3.37	4.56	12.40	4.3	0	0	6.6	0	0	0	0.25	0.3
Dec-05	EC(dS/m)	19.2	11	6.1	3.5	19.8	13.6	1	-	-	24.1	-	-	-	5.5	7.5
	SWL (m)	5.52	6.62	3.1	3.91	4.58	12.48	4.27	dry	dry	6.65	dry	dry	dry	0.6	1.09
Jan-06	EC(dS/m)	19.4	TSTB	5.5	3.3	19.6	14.6	0.7	-	TSTB	24.1	-	-	-	5.6	7.2
	SWL (m)	5.6	-	3.2	3.95	4.61	12.5	4.38	dry	-	6.25	dry	dry	dry	0.63	0.68
Feb-06	EC(dS/m)	19.6	-	6.1	3.2	19.5	16.9	0.7	-	-	23.6	-	-	-	5.8	7.2
	SWL (m)	5.7	-	3.35	4.14	4.64	12.46	4.35	dry	dry	6.45	dry	dry	dry	0.99	1.5
Mar-06	EC(dS/m)	20.6	-	6.5	3.5	20.5	18.5	0.8	-	-	24.2	-	-	-	5.8	7.3
	SWL (m)	5.88	-	3.5	4.14	4.8	12.6	4.5	dry	dry	6.5	dry	dry	dry	1.15	2.01

TSTB – Too shallow to bail

Dubbo City Council Salinity Network site number (Figure 6)		DCC1	DCC4	DCC5	DCC7	DCC8	DCC9	DCC10	DCC17	DCC18	DCC25	DCC26	DCC27	DCC101	DCC114	DCC128
Sampling date	Drilled depth (m)	12	9	8	9	15	15	14.5	6	15	12	6	5	3	4.5	5.5
Apr-06	EC(dS/m)	20.3	-	6.3	3.5	20.5	19.8	0.9	-	-	24.3	-	-	-	5.4	6.9
	SWL (m)	5.89	dry	3.49	4.56	4.8	12.5	4.53	dry	dry	6.8	dry	dry	dry	2.43	2
May-06	EC(dS/m)	20.8	-	6.7	4.2	20.5	20.7	0.9	-	-	24.8	-	-	-	6.1	6.8
	SWL (m)	6.01	dry	3.55	4.8	4.9	12.45	4.66	dry	dry	6.4	dry	dry	dry	1.49	1.88
Jun-06	EC(dS/m)	20.6	-	6.6	4.4	20.8	22.2	1.1	-	-	24.2	-	-	-	6.4	6.8
	SWL (m)	6.1	dry	3.61	4.92	5.03	12.52	4.86	dry	dry	6.49	dry	dry	dry	1.24	1.57
Jul-06	EC(dS/m)	20.6	-	6.8	4.9	20.5	7.5	1.2	-	-	25.3	-	-	-	6.4	6.6
	SWL (m)	6.1	dry	3.53	4.87	5.08	12.4	4.94	dry	dry	6.48	dry	dry	dry	1.03	1.6
Aug-06	EC(dS/m)	20.5	-	6.5	4.5	20.5	10.3	1.3	-	-	24.5	-	-	-	6.1	1.3
	SWL (m)	6.14	dry	3.52	5.06	5.11	12.52	5.05	dry	dry	6.55	dry	dry	dry	1.06	1.41
Sep-06	EC(dS/m)	20.2	-	6.7	4.8	20.2	13.9	1.4	-	-	24.7	-	-	-	6.4	6.5
	SWL (m)	6.21	dry	3.61	5.12	5.21	12.55	5.06	dry	dry	6.6	dry	dry	dry	0.86	1.3
Oct-06	EC(dS/m)	20	-	6.3	4.2	19.7	12.4	1.4	-	-	24.8	-	-	-	7.2	6.5
	SWL (m)	6.42	dry	3.65	5.74	5.29	12.48	5.1	dry	dry	6.69	dry	dry	dry	1.32	2.52
Nov-06	EC(dS/m)	20.8	-	6.4	4.1	19.9	12.8	1.4	-	-	24.8	-	-	-	7.3	6.9
	SWL (m)	6.34	dry	3.55	5.61	5.47	12.65	5.15	dry	dry	6.85	dry	dry	dry	1.55	2.08
Dec-06	EC(dS/m)	21.3	-	6.8	3.9	20.8	20.1	1.6	-	-	25.7	-	-	-	7.5	7
	SWL (m)	6.72	dry	3.95	5.59	5.53	12.69	5.24	dry	dry	6.87	dry	dry	dry	1.57	1.89
Jan-07	EC(dS/m)	19.1	-	6.6	7.8	21.1	20.8	1.4	-	-	27.9	-	-	-	4.2	7
	SWL (m)	6.79	dry	3.9	5.68	5.59	12.58	5.42	dry	dry	6.91	dry	dry	dry	1.96	2.02
Feb-07	EC(dS/m)	19	-	7	7.02	27.9	20.8	1.5	-	-	27.9	-	-	-	4.2	7.2
	SWL (m)	6.92	dry	3.99	5.62	5.53	12.53	5.48	dry	dry	6.86	dry	dry	dry	2.01	1.99
Mar-07	EC(dS/m)	20.5	-	6.8	6.9	21.5	-	1.6	-	-	27.8	-	-	-	4.3	7
	SWL (m)	7.04	dry	4.06	5.61	5.59	dry	5.4	dry	dry	6.85	dry	dry	dry	2.07	2.01
Apr-07	EC(dS/m)	22.6	-	7.4	5.4	21.1	20.8	1.4	-	-	28.8	-	-	-	7.6	6.7
	SWL (m)	7.2	dry	4.09	5.63	5.58	12.58	5.5	dry	dry	6.82	dry	dry	dry	2.06	1.96
May-07	EC(dS/m)	21.9	-	7.6	7.8	21.1	20.8	1.4	-	-	27.9	-	-	-	4.2	7.1
	SWL (m)	7.19	dry	4.01	5.68	5.61	12.63	5.44	dry	dry	6.69	dry	dry	dry	1.96	2.03

TSTB – Too shallow to bail

Dubbo City Council Salinity Network site number (Figure 6)		DCC1	DCC4	DCC5	DCC7	DCC8	DCC9	DCC10	DCC17	DCC18	DCC25	DCC26	DCC27	DCC101	DCC114	DCC128
Sampling date	Drilled depth (m)	12	9	8	9	15	15	14.5	6	15	12	6	5	3	4.5	5.5
Jun-07	EC(dS/m)	18.9	-	6.64	7.8	21.2	TSTB	1.4	TSTB	TSTB	27.8	-	-	-	4.1	7.1
	SWL (m)	6.59	dry	3.87	5.49	5.51	12.79	5.39	5.51	4.59	6.78	dry	dry	dry	1.51	1.91
Jul-07	EC(dS/m)	19	-	6.2	7.8	21.1	20.6	1.3	-	-	27.4	-	-	-	4.2	7
	SWL (m)	7.87	dry	3.88	3.89	5.1	12.3	5.11	dry	dry	6.15	dry	dry	dry	1.87	2.05
Aug-07	EC(dS/m)	13.5	-	6.9	3.4	21.1	15	1.7	-	1.7	6.4	-	-	-	7.9	7
	SWL (m)	6.48	dry	3.2	3.93	4.9	12.54	5.25	dry	4.52	5.72	dry	dry	dry	56	0.53
Sep-07	EC(dS/m)	-	-	6.9	4.6	21.4	12.7	1.7	-	TSTB	22.2	-	-	-	7.9	7.3
	SWL (m)	Dry	dry	3.3	4.07	4.94	12.54	5.14	dry	5.85	5.71	dry	dry	dry	0.93	0.97
Oct-07	EC(dS/m)	12.7	-	6.6	4.9	22.9	TSTB	1.7	-	-	25.3	-	-	-	4.2	7.1
	SWL (m)	7.18	dry	3.71	4.68	5.28	12.81	5.32	dry	dry	5.99	dry	dry	dry	1.4	1.42
Nov-07	EC(dS/m)	19.1	-	6.1	7.9	21.3	TSTB	1.6	-	-	27.5	-	-	-	4.3	7
	SWL (m)	7.01	dry	4.6	4.96	5.97	12.98	6.25	dry	dry	7.21	dry	dry	dry	2.06	1.99
Dec-07	EC(dS/m)	18	-	7.32	7.4	21.4	TSTB	1.7	-	-	27.1	-	-	-	4.2	7
	SWL (m)	7.03	dry	5.11	5.43	5.82	12.53	5.89	dry	dry	7.17	dry	dry	dry	1.87	2.04
Jan-08	EC(dS/m)	16.7	-	TSTB	7.5	21.2	20.5	1.5	-	-	27.3	-	-	-	4.3	7.1
	SWL (m)	7.06	dry	5.51	5.71	5.65	12.41	5.42	dry	dry	7.07	dry	dry	dry	2.02	2.15
Feb-08	EC(dS/m)	12.9	-	6.3	4	18.7	-	1.5	0.6	-	20.8	-	-	-	6.5	6.6
	SWL (m)	7.07	dry	3.26	4.67	5.2	dry	5.19	4.73	dry	5.23	dry	dry	dry	1.07	1.22
Mar-08	EC(dS/m)	15.5	-	6.5	4.2	19.3	7.2	1.6	-	-	21.3	-	-	-	7.7	6.9
	SWL (m)	7.1	dry	3.12	4.7	5.12	12.67	5.13	dry	dry	5.22	dry	dry	dry	1.02	1.33
Apr-08	EC(dS/m)	16.7	-	6.1	3.6	18.6	7.1	1.6	-	-	21.2	-	-	-	7.2	6.7
	SWL (m)	7.2	dry	3.27	4.9	5.15	12.6	5.19	dry	dry	5.16	dry	dry	dry	0.93	1.55
May-08	EC(dS/m)	16.3	-	6.1	4.5	18.3	8.2	1.5	-	-	20.1	-	-	-	7.2	6.6
	SWL (m)	7.42	dry	3.55	5.1	5.34	12.75	5.34	dry	dry	5.36	dry	dry	dry	0.93	1.55
Jun-08	EC(dS/m)	16.3	-	6.1	4.5	18.3	8.2	1.5	-	-	20.1	-	-	-	7.2	6.6
	SWL (m)	7.48	dry	3.56	5.15	5.38	12.7	5.6	dry	dry	5.35	dry	dry	dry	0.68	1.33
Jul-08	EC(dS/m)	16.2	-	6.1	4.5	16.3	8.9	2.1	-	-	18.1	-	-	-	7.6	6.5
	SWL (m)	7.52	dry	3.55	5.1	5.38	12.7	5.66	dry	dry	5.3	dry	dry	dry	0.68	1.33

TSTB – Too shallow to bail

Dubbo City Council Salinity Network site number (Figure 6)		DCC1	DCC4	DCC5	DCC7	DCC8	DCC9	DCC10	DCC17	DCC18	DCC25	DCC26	DCC27	DCC101	DCC114	DCC128
Sampling date	Drilled depth (m)	12	9	8	9	15	15	14.5	6	15	12	6	5	3	4.5	5.5
Aug-08	EC(dS/m)	16.2	-	6	4.5	18.2	8.2	1.4	-	-	20	-	-	-	7.1	6.5
	SWL (m)	7.38	dry	3.49	5.02	5.35	12.61	5.45	dry	dry	5.21	dry	dry	dry	0.51	1.28
Sep-08	EC(dS/m)	14.6	-	5.7	4.2	15.5	-	2	-	-	17.3	-	-	-	6	5.8
	SWL (m)	7.33	dry	3.32	4.9	5.3	dry	5.43	dry	dry	5.2	dry	dry	dry	0.33	0.62
Oct-08	EC(dS/m)	16.2	-	6.1	4.5	16.2	8.9	2.1	-	-	18.2	-	-	-	7.6	6.5
	SWL (m)	7.54	dry	3.55	5.1	5.38	12.7	5.66	dry	dry	5.31	dry	dry	dry	0.78	1.36
Nov-08	EC(dS/m)	18	-	6.1	5	18.3	-	1.7	-	-	20.2	-	-	-	5.5	6.8
	SWL (m)	7.37	dry	3.27	4.54	5.06	dry	5.24	dry	dry	4.96	dry	dry	dry	0.3	0.4
Dec-08	EC(dS/m)	18.6	-	6.6	4.8	19.3	-	1.5	-	-	14.8	-	-	-	6.1	6.8
	SWL (m)	7.33	dry	3.18	4.49	4.92	dry	5.11	dry	dry	4.63	dry	dry	dry	0.54	0.81
Jan-09	EC(dS/m)	>20	-	7	4.4	>20	-	1.6	-	-	>20	-	-	-	6.3	7.3
	SWL (m)	7.52	dry	3.35	4.91	4.76	dry	5.25	dry	dry	4.52	dry	dry	dry	1	1.27
Feb-09	EC(dS/m)	>20	-	TSTB	4.15	>20	-	TSTB	-	-	>20	-	-	-	-	-
	SWL (m)	7.69	dry	3.65	5.06	5	dry	5.44	dry	dry	4.58	dry	dry	dry	-	-
Mar-09	EC(dS/m)	1.84	-	6.2	3.71	18.76	6.18	1.39	-	TSTB	>20	-	-	-	6.51	-
	SWL (m)	7.7	dry	3.68	5.19	5.06	12.81	5.47	dry	6	4.71	dry	dry	dry	1.37	-
Apr-09	EC(dS/m)	17.4	-	6.6	3.5	17.6	5.98	1.5	-	-	>20	-	-	-	6.41	-
	SWL (m)	7.85	dry	3.56	5.05	5.21	12.93	5.39	dry	dry	5	dry	dry	dry	1.19	-
May-09	EC(dS/m)	1.94	-	7.07	3.6	19.77	1.91	1.45	-	-	>20	-	-	-	8.62	8.14
	SWL (m)	7.9	dry	3.72	5.26	5.22	12.83	5.64	dry	dry	4.86	dry	dry	dry	0.87	0.74
Jun-09	EC(dS/m)	2	-	7	4	20.1	-	1.5	-	-	19.98	-	-	-	8.71	9
	SWL (m)	7.8	dry	3.7	5.87	5.1	dry	5.6	dry	dry	4.97	dry	dry	dry	0.9	0.74
Jul-09	EC(dS/m)	2	-	6.77	3.26	18.42	6.56	1.33	-	-	>20	-	-	-	7.48	6.85
	SWL (m)	dry	dry	3.62	5.39	5.21	13	5.82	dry	dry	5.18	dry	dry	dry	0.4	0.58
Aug-09	EC(dS/m)	18.7	-	7.13	3.21	19.01	5.12	1.5	-	-	>20	-	-	-	8.3	-
	SWL (m)	7.89	dry	3.68	5.5	5.27	13	5.84	dry	dry	5.23	dry	dry	dry	0.7	dry
Sep-09	EC(dS/m)	18.56	-	7.31	3.17	>20	4.98	1.62	-	-	>20	-	-	-	8.24	7.72
	SWL (m)	8.01	dry	3.81	5.42	5.34	12.86	5.76	dry	dry	5.21	dry	dry	dry	0.58	0.96

TSTB – Too shallow to bail

Dubbo City Council Salinity Network site number (Figure 6)		DCC1	DCC4	DCC5	DCC7	DCC8	DCC9	DCC10	DCC17	DCC18	DCC25	DCC26	DCC27	DCC101	DCC114	DCC128
Sampling date	Drilled depth (m)	12	9	8	9	15	15	14.5	6	15	12	6	5	3	4.5	5.5
Oct-09	EC(dS/m)	18.01	-	6.9	3.14	17.78	5.55	1.46	-	-	>20	-	-	-	8.72	8.61
	SWL (m)	8.03	dry	3.76	5.69	5.46	12.92	6.85	dry	dry	5.44	dry	dry	dry	0.89	1.07
Nov-09	EC(dS/m)	>20	-	4.87	3.31	7.2	6.59	1.6	-	-	>20	-	-	-	8.72	7.64
	SWL (m)	8.21	dry	3.86	5.85	5.57	6	6.01	dry	dry	5.62	dry	dry	dry	1.63	1.86
Dec-09	EC(dS/m)	>20	-	4.66	3.17	7.13	6.42	1.49	-	-	7.2	-	-	-	8.61	7.55
	SWL (m)	8.03	dry	3.62	5.73	5.6	5.88	6	dry	dry	5.19	dry	dry	dry	1.52	1.71
Jan-10	EC(dS/m)	19.76	-	7.01	2.3	19.59	>20	1.49	-	-	2.3	-	-	-	7.22	6.89
	SWL (m)	8.37	dry	3.67	4.86	5.44	13	5.79	dry	dry	4.86	dry	dry	dry	1.46	1.81
Feb-10	EC(dS/m)	17.69	-	6.6	0.86	17.5	4	1.46	0.86	-	>20	-	-	-	-	-
	SWL (m)	8.24	dry	3.53	4.52	5.29	13	5.36	4.72	dry	4.57	dry	dry	dry	-	-
Mar-10	EC(dS/m)	>20	-	6.82	1.24	18.73	7.36	1.59	TSTB	-	>20	-	-	-	6.29	7.3
	SWL (m)	8.42	dry	3.78	4.63	5.56	12.59	5.62	5.86	dry	5.02	dry	dry	dry	1.48	1.09
Apr-10	EC(dS/m)	18.85	-	7.24	2.54	18.2	0.59	1.68	TSTB	-	16.58	-	-	-	7.47	7.13
	SWL (m)	7.91	dry	3.38	4.32	6.11	13.07	6.08	5.65	dry	4.12	dry	dry	dry	0.67	1.09
May-10	EC(dS/m)	19.36	-	7.86	2.39	19.06	0.69	1.53	-	-	16.87	-	-	-	7.62	7.28
	SWL (m)	8.08	dry	3.49	4.18	6.27	12.94	5.88	dry	dry	4.29	dry	dry	dry	0.79	1.21
Jun-10	EC(dS/m)	17.7	-	6.74	3.11	17.53	0.46	1.44	-	-	16.61	-	-	-	6.23	-
	SWL (m)	7.77	dry	3.43	4.12	4.95	13.04	5.7	dry	dry	3.66	dry	dry	dry	0.42	-
Jul-10	EC(dS/m)	9.72	-	6.52	2.86	17.28	1.08	1.62	-	-	16.39	-	-	-	6.09	-
	SWL (m)	7.58	dry	3.32	3.79	4.84	12.79	5.56	dry	dry	3.41	dry	dry	dry	0.53	-
Aug-10	EC(dS/m)	18.05	-	6.94	1.95	18.11	0.02	1.43	-	-	14.83	-	0.42	-	-	-
	SWL (m)	7.42	dry	2.51	2.59	4.56	13.12	5.47	dry	dry	2.36	dry	2.86	dry	dry	dry
Sep-10	EC(dS/m)	16.53	-	6.74	1.74	17.56	1.13	1.56	-	-	15.18	-	0.93	-	-	-
	SWL (m)	7.59	dry	2.67	2.88	4.31	12.91	5.21	dry	dry	2.18	dry	2.67	dry	dry	dry
Oct-10	EC(dS/m)	19.44	-	7.32	4.32	17.39	0.37	1.29	-	-	14.6	-	-	-	5.1	4.06
	SWL (m)	7.03	dry	2.67	3	4.25	13.7	5.29	dry	dry	2.88	dry	dry	dry	0.42	0.69
Nov-10	EC(dS/m)	17.99	-	7.03	3.03	17.48	0.75	1.43	-	-	14.89	-	-	-	2.55	-
	SWL (m)	7.31	dry	2.67	2.94	4.28	13.3	5.25	dry	dry	2.53	dry	-	dry	0.21	-

TSTB – Too shallow to bail

Dubbo City Council Salinity Network site number (Figure 6)		DCC1	DCC4	DCC5	DCC7	DCC8	DCC9	DCC10	DCC17	DCC18	DCC25	DCC26	DCC27	DCC101	DCC114	DCC128
Sampling date	Drilled depth (m)	12	9	8	9	15	15	14.5	6	15	12	6	5	3	4.5	5.5
Dec-10	EC(dS/m)	22.36	-	4.67	1.67	9.2	0.57	0.87	-	-	7.79	-	0.43	-	3.42	-
	SWL (m)	7.89	dry	2.54	2.55	3.49	13.32	4.95	dry	dry	2.38	dry	1.84	dry	0.39	dry
Jan-11	EC(dS/m)	18.37	-	2.3	0.3	0.92	0.39	0.32	-	-	0.69	-	0.54	-	4.28	-
	SWL (m)	7.62	dry	2.4	2.15	2.7	13.34	4.65	dry	dry	2.22	dry	4.45	dry	0.56	dry
Feb-11	EC(dS/m)	15.32	-	2.18	-	2.08	-	0.46	-	-	0.6	-	-	-	4.21	4.52
	SWL (m)	10.89	dry	5.26	dry	8.76	dry	4.79	dry	dry	2.56	dry	dry	dry	0.79	0.95
Mar-11	EC(dS/m)	-	-	-	-	TSTB	-	0.4	-	-	0.69	-	-	-	4.39	4.46
	SWL (m)	dry	dry	dry	dry	14.58	dry	4.98	dry	dry	2.9	dry	dry	dry	0.6	0.82
Apr-11	EC(dS/m)	TSTB	-	-	-	-	-	0.54	-	-	0.6	-	-	-	5.17	5.21
	SWL (m)	11.52	dry	dry	dry	dry	dry	4.12	dry	dry	2.62	dry	dry	dry	0.43	0.58
May-11	EC(dS/m)	16.85	-	-	-	3.15	-	0.79	-	-	0.89	-	-	-	4.89	4.76
	SWL (m)	8.63	dry	dry	dry	8.45	dry	4.69	dry	dry	3.1	dry	dry	dry	0.54	0.63
Jun-11	EC(dS/m)	17.65	-	0.32	0.5	6.7	0.44	0.65	-	-	1.2	-	-	-	5.27	4.45
	SWL (m)	6.08	dry	2.38	3.05	3.74	13.08	5.15	dry	dry	3.33	dry	dry	-	0.67	0.42
Jul-11	EC(dS/m)	>20	-	1.25	1.74	6.24	-	0.74	-	-	1.34	-	-	-	5.31	4.64
	SWL (m)	5.26	dry	3.87	4.2	4.09	dry	6.42	dry	dry	3.57	dry	dry	dry	0.79	0.63
Aug-11	EC(dS/m)	17.83	-	5.31	1.1	8.73	-	5.18	-	-	1.58	-	-	-	4.18	3.88
	SWL (m)	6.05	dry	2.75	3.24	4	dry	5.25	dry	dry	3.53	dry	dry	dry	0.38	0.67
Sep-11	EC(dS/m)	17.34	-	5.28	1.38	8.2	-	0.73	-	-	0.28	-	-	-	5.2	4.45
	SWL (m)	6.36	dry	2.75	3.08	4.01	dry	5.54	dry	dry	3.38	dry	dry	dry	0.59	0.4
Oct-11	EC(dS/m)	17.89	-	4.39	1.54	7.48	-	1.15	-	-	0.42	-	-	-	4.92	4.21
	SWL (m)	6.01	dry	2.59	2.91	4.14	dry	5.37	dry	dry	3.01	dry	dry	dry	0.44	0.59
Nov-11	EC(dS/m)	11.47	-	4.38	2.45	6.83	2.07	0.71	0	-	0.96	-	-	-	3.41	5.03
	SWL (m)	6.6	dry	7.47	2.3	3.73	12.84	4.96	4.81	dry	2.75	dry	dry	dry	0.34	0.51
Dec-11	EC(dS/m)	13.55	-	5.39	3.35	7.24	-	0.84	0.48	-	1.65	-	-	0.39	5.55	5.12
	SWL (m)	6.08	dry	2.7	2.93	4.8	dry	4.87	5.14	dry	3.6	dry	dry	2.31	0.53	0.42
Jan-12	EC(dS/m)	13	-	5.45	3.46	7.21	0.3	0.94	0.54	-	1.8	-	-	-	-	-
	SWL (m)	6.2	dry	2.68	2.92	3.68	12.72	4.84	5.47	dry	3.12	dry	dry	dry	dry	dry

TSTB – Too shallow to bail

Dubbo City Council Salinity Network site number (Figure 6)		DCC1	DCC4	DCC5	DCC7	DCC8	DCC9	DCC10	DCC17	DCC18	DCC25	DCC26	DCC27	DCC101	DCC114	DCC128
Sampling date	Drilled depth (m)	12	9	8	9	15	15	14.5	6	15	12	6	5	3	4.5	5.5
Feb-12	EC(dS/m)	15.63	-	7.03	4.87	12.68	1.15	0.98	-	-	2.04	-	-	-	7.62	8.45
	SWL (m)	6.04	dry	2.66	2.78	3.74	12.56	4.77	dry	dry	2.95	dry	dry	dry	0.89	0.74
Mar-12	EC(dS/m)	19.62	-	8.16	1.03	11.15	0.83	1.49	2.52	1.43	2.33	-	-	-	8.51	9.23
	SWL (m)	6.02	dry	2.62	1.32	3.48	12.82	4.57	5.55	3.73	2.8	dry	dry	dry	1.07	0.94
Apr-12	EC(dS/m)	18.19	-	7.92	2.25	10.64	1.03	1.26	2.34	2.01	2.51	-	-	-	8.21	8.94
	SWL (m)	5.89	dry	2.53	1.59	3.08	12.49	4.21	5.31	4.25	2.61	dry	dry	dry	0.93	0.81
May-12	EC(dS/m)	17.64	-	5.65	2.63	7.4	3.17	4.45	-	2.24	2.12	-	-	-	8.34	9.05
	SWL (m)	5.42	dry	2.65	2.24	3.6	12.45	4.91	dry	4.83	2.42	dry	dry	dry	0.69	0.68
Jun-12	EC(dS/m)	18.8	-	6.7	-	-	-	1.03	1.22	-	0.92	-	0.32	-	4.9	-
	SWL (m)	6	dry	2.55	dry	dry	dry	4.75	5.65	dry	1.8	dry	3.01	dry	0.1	-
Jul-12	EC(dS/m)	18.24	-	6.21	2.51	6.45	-	0.84	TSTB	-	1.21	-	1.21	-	6.54	7.54
	SWL (m)	5.67	dry	2.49	6.42	4.21	dry	3.41	5.84	dry	1.46	dry	3.84	dry	0.54	0.47
Aug-12	EC(dS/m)	18.42	-	6.42	2.89	6.09	-	0.93	1.39	-	1.06	-	0.77	-	5.70	6.45
	SWL (m)	5.81	dry	2.51	6.02	3.95	dry	4.07	5.71	dry	1.62	dry	3.4	dry	0.32	0.59
Sep-12	EC(dS/m)	16.21	-	5.4	2.21	8.6	-	1.45	-	-	2.36	-	-	-	4.95	5.47
	SWL (m)	5.95	dry	2.55	2.3	3.4	dry	4.61	dry	dry	2.92	dry	dry	dry	0.58	0.83
Oct-12	EC(dS/m)	13.65	-	2.3	-	8.03	-	-	-	-	2.6	-	-	-	4.29	5.12
	SWL (m)	6.21	dry	2.82	dry	3.61	dry	dry	dry	dry	3.4	dry	dry	dry	0.64	1.12
Nov-12	EC(dS/m)	12.3	-	4.9	-	5.12	-	1.12	-	-	2.71	-	-	-	3.58	4.25
	SWL (m)	6.52	dry	2.7	dry	3.75	dry	5.02	dry	dry	3.71	dry	dry	dry	0.79	1.47
Dec-12	EC(dS/m)	13.11	-	3.64	-	6.64	-	1.13	-	-	2.68	-	-	-	3.98	4.73
	SWL (m)	6.43	dry	2.79	dry	3.72	dry	5.07	dry	dry	3.59	dry	dry	dry	0.72	1.31
Jan-13	EC(dS/m)	12.6	-	5.2	2.19	7.23	-	1.1	-	-	2.39	-	-	-	3.58	4.29
	SWL (m)	6.7	dry	3.21	3.5	4.15	dry	5	dry	dry	4.03	dry	dry	dry	0.89	1.52
Feb-13	EC(dS/m)	14.87	-	5.87	3.74	8.84	TSTB	1.47	-	-	1.17	-	-	-	5.27	6.21
	SWL (m)	6.73	dry	3.18	3.55	4.21	14.21	5.63	dry	dry	3.74	dry	dry	dry	0.88	1.38
Mar-13	EC(dS/m)	16.5	-	6.9	4.5	10.2	4.28	-	-	-	0.45	-	-	-	6.83	7.19
	SWL (m)	6.84	dry	3.1	3.6	4.3	12.21	dry	dry	dry	3.5	dry	dry	dry	0.86	1.15

TSTB – Too shallow to bail

Dubbo City Council Salinity Network site number (Figure 6)		DCC1	DCC4	DCC5	DCC7	DCC8	DCC9	DCC10	DCC17	DCC18	DCC25	DCC26	DCC27	DCC101	DCC114	DCC128
Sampling date	Drilled depth (m)	12	9	8	9	15	15	14.5	6	15	12	6	5	3	4.5	5.5
Apr-13	EC(dS/m)	16.83	-	7.13	3.41	11.13	3.89	1.49	1.48	-	1.86	-	-	-	6.24	6.88
	SWL (m)	5.95	dry	3.21	3.74	4.55	12.28	5.29	5.62	dry	3.54	dry	dry	dry	0.77	1.03
May-13	EC(dS/m)	17.27	-	6.39	3.2	9.27	3.53	2.97	0.74	1.12	1.99	-	-	-	7.29	7.96
	SWL (m)	5.69	dry	2.93	2.99	4.75	12.37	5.1	2.81	2.42	2.98	dry	dry	dry	0.73	0.85
Jun-13	EC(dS/m)	0.72	-	7.1	5.3	11.2	-	1.36	-	-	3.9	-	-	-	6.58	7.04
	SWL (m)	6.95	dry	3.05	3.5	4.75	dry	6.4	dry	dry	4.6	dry	dry	dry	0.79	0.92

TSTB – Too shallow to bail

Appendix 7. Dubbo City Urban Implementation Plan

A7.1. Salt impact

To ensure the salt impact on the landscape is minimised and managed

Strategic outcome		Requirements		Action
1.1	The discharge of saline water into the groundwater system, rivers and streams is minimised	1.1.1	Rehabilitate discharge sites with the strategic planting of salt tolerant species matched to the site salt intensity	Potential discharge sites occur at the interface of the Pilliga Sandstone and Purlewaugh Formation. The interface was identified by an EM survey and soil assessment. The potential discharge sites will be managed by planting of deep-rooted vegetation which will maintain existing groundwater conditions.
		1.1.2	Vegetation management in riparian areas to minimize salt export to streams	No riparian areas are located on the site. Vegetation will be planted along road reserves.
1.2	Salt stores are buffered to limit their interaction with shallow groundwater	1.2.1	Strategic planting of vegetation to buffer the salt stores in the upper colluvial areas of the HGL	Tree planting of road reserves and the boundary between Pilliga Sandstone and Purlewaugh Formation is proposed to be undertaken by the developer as part of the development. Additional plantings of deep rooted vegetation are expected to be undertaken by future landowners.
		1.2.2	Installation of sub-surface drains where required to intercept saline water discharge into the groundwater system, rivers and streams	No shallow groundwater is expected and sub-surface interception drains are unlikely required.

A7.2. Groundwater recharge

The volume of water with the potential to enter into and contaminate the natural system is minimised

Strategic outcome		Requirements		Action
2.1	Lateral flow of shallow groundwater is intercepted and reduced	2.1.1	Strategic planting of native vegetation to intercept lateral flow of saline water and reduce volume of flow	Native trees and shrub planting of road reserves and the boundary between Pilliga Sandstone and Purlewaugh Formation will be undertaken as part of the development. Additional plantings of deep rooted vegetation are expected to be undertaken by future landowners.
2.2	Excess soil moisture within the landscape is utilised	2.2.1	Strategic planting of native vegetation within the landscape to reduce the volume of shallow groundwater and dry out the landscape	Native trees and shrub planting of road reserves and the boundary between Pilliga Sandstone and Purlewaugh Formation will be undertaken as part of the development. Additional plantings of deep rooted vegetation are expected to be undertaken by future landowners.
		2.2.2	Productive use of groundwater to dry out the landscape	Not applicable to the Richmond Estate and Firgrove HGLs

2.3	Ponding of water on discharge sites is minimised	2.3.1	Identification of discharge sites and subsequent management of water input	Potential discharge sites occur at the interface of the Pilliga Sandstone and Purlewaugh Formation. The interface was identified by an EM survey and soil assessment. The potential discharge sites will be managed by planting of deep-rooted vegetation which will maintain existing groundwater conditions.
		2.3.2	The size and location of future urban development is influenced by the location of discharge sites	Potential discharge sites occur at the interface of the Pilliga Sandstone and Purlewaugh Formation. The interface was identified by an EM survey and soil assessment. These areas have been included within road reserves which are 45m wide with a 30m vegetated buffer. No discharge sites have been identified on the site in the groundwater and salinity study. The presence of any discharge sites will be identified in the detailed soil and groundwater salinity assessment undertaken as part of the development application.
2.4	Discharge to the groundwater system is minimised	2.4.1	Protect and manage native vegetation	Minimal native vegetation occurs on the site. No existing trees are expected to require removal as part of the development. Native tree and shrub planting of road reserves and the boundary between Pilliga Sandstone and Purlewaugh Formation will be undertaken as part of the development. Additional plantings of deep rooted vegetation are expected to be undertaken by future landowners.
		2.4.2	Strategic planting of native vegetation in public open space, sites with high groundwater recharge potential and where protecting salt affected land	No public open space is proposed in the development. Native tree and shrub planting of road reserves and the boundary between Pilliga Sandstone and Purlewaugh Formation is proposed to be undertaken by the developer as part of the development. Additional plantings of deep rooted vegetation are expected to be undertaken by future landowners. The presence of other salt affected land will be identified in the detailed soil and groundwater salinity assessment undertaken as part of the development application.

		2.4.3	Elements of the landscape identified as recharge points are managed to eliminate discrete groundwater recharge	Applicable to the Richmond Estate HGL. Native trees and shrub planting of road reserves and the boundary between Pilliga Sandstone and Purlewaugh Formation will be undertaken as part of the development. Additional plantings of deep rooted vegetation are expected to be undertaken by future landowners. Rainwater flows from buildings will be captured in tanks. No dams or other standing water bodies will be located on the site. Planting of deep rooted plants will manage recharge of the site.
2.5	Discharge of water into the landscape is minimised	2.5.1	Urban management of water use (lawns, gardens, sporting fields) encourages the establishment of spaces with low water requirements	Waterwise gardening will be promoted to future land owners. Waterwise gardening is becoming the norm when managing residential yards throughout Dubbo and expected to be adopted by the future land-owners. Waterwise gardening will be further encouraged by enforcing restrictions on the extraction of groundwater. No sporting fields or public open spaces are proposed as part of the development.

A7.3. Land-use

Water usage and land-use activities area appropriate for the soil landscape in managing urban salinity and do not contribute to an increase in the assessed salinity hazard of the landscape

Strategic outcome		Requirements		Action
3.1	The use of salinity affected land is undertaken in accordance with best practice management principles	3.1.1	Best practice management principles are applied on land affected by salinity	Saline soils have been identified at the boundary between the Pilliga Sandstone and Purlewaugh Formation. Best practice management principles including subdivision design, limit of cut and planting of deep-rooted vegetation have been adopted. No other salinity affected land has been identified on the site. The presence of other saline affected land will be identified in the detailed soil and groundwater salinity assessment undertaken as part of the development application. Identified salinity affected land will be managed by best practice management including: subdivision designed to maintain natural drainage patterns, no deep cut and fill, planting of deep-rooted vegetation, rainwater tanks connected to all buildings, no dams or standing water bodies, waterwise gardening and paper filters on swimming pools to avoid the need for backwash water recharge.
3.2	Salinity risk is considered in the land-use planning process	3.2.1	Salinity risk is considered in Structure Planning of Urban Release Areas	The requirement is not considered applicable to the developer and is undertaken by Dubbo City Council.

		3.2.2	The impact of land-use on salinity is addressed in strategic planning processes within the relevant Hydro-geological Landscapes	The strategies of the Richmond Estate and Firgrove Hydro-geological Landscapes have been addressed for the development (Tables 15 to 20).
3.3	The extent to which land-use activities and practices contribute to salinity hazard is understood	3.3.1	Increase agricultural production to dry out the landscape and reduce recharge	Not applicable to the Richmond Estate and Firgrove HGLs. Planting of deep-rooted trees will increase sub-surface water use compared with the current grazing system.

A7.4. Infrastructure

Public and private infrastructure development and maintenance is consistent with the salinity hazard of the landscape

Strategic outcome		Requirements		Action
4.1	Construction techniques are responsive and appropriate for the salinity risk of the landscape	4.1.1	Design, construction materials, method, depth of cut and fill and location of roads and infrastructure including underground utilities is suited to the landscape salinity hazard	The subdivision will be designed to maintain natural drainage patterns and minimize cut and fill. The adoption of salt protected materials will be considered if saline areas are identified.
4.2	Urban development on at-risk landscapes specifically addresses the impacts of salinity	4.2.1	Site specific assessment and investigation is a part of the development assessment process	A salinity and groundwater investigation has been prepared as part of the rezoning and lot layout development.
		4.2.2	Existing salt affected areas are remediated and monitored as a condition of consent where determined as necessary in the site specific assessment and investigation	No surface salt affected areas have been identified on the site in the preliminary groundwater and salinity study. Salt impacted subsoil was identified at the hydro-geological interface. Vegetative buffers planted in this location will intercept groundwater and maintain existing groundwater conditions. No increase in surface salinity is expected. The presence of other salt affected areas will be identified in the detailed soil and groundwater salinity assessment undertaken as part of the development application.
4.3	Existing infrastructure is maintained to minimize salinity impacts on the landscape	4.3.1	Stormwater infrastructure is evaluated for contribution to groundwater recharge	Not applicable to the Richmond Estate and Firgrove HGLs
		4.3.2	A pipe replacement program is developed where necessary to reduce input of water into the landscape	All pipes installed in the development will be new and constructed in accordance with Auspec 1. A pipe replacement program is not considered required.

A7.5. Monitoring

The capacity to predict and monitor salinity impacts on land resources and biodiversity is maintained

Strategic outcome		Requirements		Action
5.1	The impacts of development on groundwater and salinity are recognized, measured and monitored	5.1.1	Urban investigation of areas with extreme salinity and areas that may impact on extreme areas	A salinity and groundwater investigation has been prepared as part of the rezoning and lot layout development.
		5.1.2	Evaluation of the Urban Salinity Network; any groundwater bores which are identified to increase salinity concern are further investigated	A salinity and groundwater investigation has been prepared as part of the rezoning and lot layout development. The assessment included a review of the data obtained in the Urban Salinity Network.
		5.1.3	Installation of additional groundwater bores suitable for incorporation into the Urban Salinity Network are considered during new developments	Applicable to the Richmond Estate HGL. Groundwater monitoring bores will be constructed as part of the detailed soil and groundwater salinity assessment. The bores will be located in road reserves to allow incorporation into the Urban Salinity Network.
5.2	The overall situation of salinity in Dubbo is understood	5.2.1	Groundwater bore sites identified in Table 3 of the Salinity Management Strategy are further evaluated	The requirement is not considered applicable to the developer and is undertaken by Dubbo City Council.
		5.2.2	Salinity trends are monitored annually	The requirement is not considered applicable to the developer and is undertaken by Dubbo City Council.
5.3	Groundwater modelling is provided in a spatial capacity	5.3.1	The groundwater modelling map is updated using the average SWL data calculated for each groundwater bore for the period 2009-2012	The requirement is not considered applicable to the developer and is undertaken by Dubbo City Council.

Appendix 8. Borelogs and soil analysis results

Salinity assessment

Client: Bourke Securities		**Job no:** 13365	**Date:** 27/5/2014
Address: *Daisy Hill Estate*, Eulomogo Road, Dubbo NSW			
Borehole: 1	**GPS:** 55H 660304E 6428458N		

Surface description

Slope:	1%	Aspect:	West
Morphological type:	Mid-slope		
Land-use:	Grazing		
Disturbance:	High		
Erosion:	Nil		
Coarse fragments:	Trace on surface		
Surface cover:	Red grass, flatweed, clover, wallaby grass, windmill grass, aster sp., height of vegetation >30cm		
% surface cover	100%		
Salinity:	Nil		

Sub-surface description

Sample method: EVH		Logged by: LD					
Depth (mm)	Soil description (texture, colour, coarse fragments, mottles, roots, structure)	Sample	M/D	pH (1:5 water)	EC (dS/m)	ECe	Emerson aggregate test
0-200	Dark brown clay loam with gravel	X	M	6.1	0.03	0.26	8
		X		6.4	0.03	0.26	5
200-900	Reddish brown silty clay	X	Wp	7.0	0.05	0.38	5
		X		7.8	0.15	1.13	5
900-1200	Reddish brown light clay with fine gravel	X	M	8.2	0.45	3.38	8
1200-2000	Strong brown silty clay with fine gravel	X	Wp	6.9	0.55	4.13	2
2000-3000	Yellowish brown light clay with calcite nodules	X	Wp	5.6	0.40	3.00	2
		X		4.9	0.34	2.55	2
3000-4600	Brownish yellow to yellow silty clay with calcite nodules	X	Wp	4.9	0.35	2.63	2
		X		4.7	0.30	2.25	2
		X		4.9	0.28	2.10	2
		X		4.6	0.31	2.33	2
4600-6000	Yellowish brown to brownish yellow silty clay	X	Wp	4.5	0.37	2.78	2
		X		4.4	0.48	3.60	2
		X		4.3	0.53	3.98	5
6000	End of hole						
Notes:							

Salinity assessment

Client: Bourke Securities		**Job no:** 13365	**Date:** 27/5/2014
Address: *Daisy Hill Estate*, Eulomogo Road, Dubbo NSW			
Borehole: 2	**GPS:** 55H 660465E 6428939N		

Surface description

Slope:	6%	Aspect:	South west
Morphological type:	Mid-slope		
Land-use:	Grazing		
Disturbance:	High		
Erosion:	Nil		
Coarse fragments:	Nil at borehole, 10m north – numerous surface rocks		
Surface cover:	Clover, wallaby grass, wild sage, height of vegetation <10cm		
% surface cover	Nil to 100%		
Salinity:	Nil		

Sub-surface description

Sample method: EVH		Logged by: LD					
Depth (mm)	Soil description (texture, colour, coarse fragments, mottles, roots, structure)	Sample	M/D	pH (1:5 water)	EC (dS/m)	ECe	Emerson aggregate test
0-400	Dark brown clay loam	X	M/D	6.1	0.07	0.60	3
		X		6.5	0.05	0.43	3
		X		7.1	0.16	1.38	5
400-1300	Reddish brown silty clay	X	M/D	7.7	0.25	1.88	5
		X		7.8	1.19	8.93	8
1300-2100	Strong brown sandy clay with fine gravel	X	M/D	7.9	1.60	12.00	5
		X		7.2	1.46	11.00	5
2100-4200	Strong brown silty clay with calcite nodules	X	M/D	7.0	1.49	11.18	5
		X		4.8	1.35	10.13	5
		X		4.1	1.40	10.50	6
		X		3.9	1.31	9.83	6
4200-6000	Red silty clay with calcite nodules	X	M/D	4.0	1.36	10.20	6
		X		3.7	1.35	10.13	6
		X		3.8	1.34	10.10	6
		X		3.7	1.45	10.88	6
6000	End of hole						
Notes:							

Salinity assessment

Client: Bourke Securities		**Job no:** 13365	**Date:** 27/5/2014
Address:	*Daisy Hill Estate*, Eulomogo Road, Dubbo NSW		
Borehole: 3	**GPS:** 55H 660071E 6428751N		

Surface description

Slope:	0-1%	Aspect:	West
Morphological type:	Mid-slope		
Land-use:	Grazing		
Disturbance:	High		
Erosion:	Nil		
Coarse fragments:	Nil		
Surface cover:	Stipa sp., red grass, Paterson's curse, wild sage, panic grass		
% surface cover	100%		
Salinity:	Nil		

Sub-surface description

Sample method: EVH		Logged by: LD					
Depth (mm)	Soil description (texture, colour, coarse fragments, mottles, roots, structure)	Sample	M/D	pH (1:5 water)	EC (dS/m)	ECe	Emerson aggregate test
0-200	Dark reddish brown fine sandy loam	X	M	5.0	0.02	0.19	3
		X		5.4	0.02	0.19	3
200-900	Dark red fine sandy clay loam	X	M	5.9	0.02	0.19	3
		X		6.0	0.02	0.19	3
900-2300	Dark red to red fine sandy clay	X	M	6.9	0.08	0.60	5
		X	Wp	7.3	0.11	0.83	5
		X	M/D	7.0	0.06	0.4	5
2300-2900	Red clayey sand with gravel	X	M/D	7.2	0.06	1.38	3
2900-5300	Red to reddish brown sandy clay	X	M/D	7.1	0.04	0.30	3
		X		6.7	0.04	0.30	3
		X		6.6	0.05	0.38	3
		X		7.0	0.04	0.30	3
		X		7.0	0.03	0.23	3
5300-6000	Strong brown sandy clay with gravel	X	M/D	7.1	0.04	0.30	3
		X		7.9	0.17	1.28	5
6000	End of hole						
Notes:							

Salinity assessment

Client: Bourke Securities		**Job no:** 13365	**Date:** 27/5/2014
Address:	*Daisy Hill Estate*, Eulomogo Road, Dubbo NSW		
Borehole: 4		**GPS:** 55H 660194E 6427945N	

Surface description

Slope:	1%	Aspect:	West
Morphological type:	Mid-slope		
Land-use:	Grazing		
Disturbance:	High		
Erosion:	Nil		
Coarse fragments:	Nil		
Surface cover:	Red grass, clover, windmill grass, wild sage, Paterson's curse		
% surface cover	100%		
Salinity:	Nil		

Sub-surface description

Sample method: EVH		Logged by: LD					
Depth (mm)	Soil description (texture, colour, coarse fragments, mottles, roots, structure)	Sample	M/D	pH (1:5 water)	EC (dS/m)	ECe	Emerson aggregate test
0-100	Dark brown sandy loam	X	M	6.0	0.03	0.42	3
100-400	Reddish brown to dark red fine sandy	X	M	5.5	0.02	0.17	3
	clay loam	X		5.7	0.02	0.17	3
400-1600	Dark red fine sandy clay	X	Wp	6.2	0.02	0.15	3
		X		6.8	0.04	0.30	3
		X		6.7	0.05	0.38	2
1600-2700	Strong brown fine sandy clay	X	Wp	7.5	0.10	0.75	2
		X		7.7	0.08	0.60	2
2700-5200	Reddish brown fine sandy clay	X	Wp	7.6	0.07	0.53	2
		X		7.5	0.06	0.45	2
		X		7.5	0.06	0.45	1
		X		7.0	0.08	0.60	1
		X		7.0	0.07	0.53	1
5200-6000	Strong brown fine sandy clay	X	Wp	5.7	0.09	0.68	2
		X		5.4	0.10	0.75	2
6000	End of hole						
Notes:							

Salinity assessment

Client: Bourke Securities	**Job no:** 13365	**Date:** 27/5/2014
Address: *Daisy Hill Estate*, Eulomogo Road, Dubbo NSW		
Borehole: 5	**GPS:** 55H 660745E 6427600N	

Surface description

Slope:	3%	Aspect:	East
Morphological type:	Mid-slope		
Land-use:	Grazing		
Disturbance:	High, trees along road reserve to north and isolated in paddocks to the south		
Erosion:	Nil		
Coarse fragments:	Nil		
Surface cover:	Clover, windmill grass, wild sage		
% surface cover	100%		
Salinity:	Nil		

Sub-surface description

Sample method: EVH | Logged by: LD

Depth (mm)	Soil description (texture, colour, coarse fragments, mottles, roots, structure)	Sample	M/D	pH (1:5 water)	EC (dS/m)	ECe	Emerson aggregate test
0-700	Reddish brown to strong brown fine sandy clay loam with gravel	X	M	5.2	0.04	0.34	3
		X		5.1	0.02	0.17	5
		X		5.4	0.01	0.09	5
		X		5.5	0.01	0.09	5
700-4100	Light olive brown to yellow fine sandy clay with gravel and calcite nodules	X	M	5.7	0.03	0.23	5
		X		6.1	0.05	0.38	2
		X		6.3	0.07	0.53	2
		X		6.2	0.06	0.45	3
		X		6.3	0.07	0.53	3
		X		6.4	0.11	0.83	2
		X		5.7	0.13	0.96	2
4100-5400	Pale brown silty clay with gravel	X	M	5.5	0.15	1.13	3
		X		4.8	0.16	1.20	5
5400-6000	Brownish yellow fine sandy clay loam with gravel	X	M	4.5	0.18	1.35	6
		X		4.3	0.20	1.50	5
6000	End of hole						

Notes:

Salinity assessment

Client: Bourke Securities		**Job no:** 13365	**Date:** 27/5/2014
Address: *Daisy Hill Estate*, Eulomogo Road, Dubbo NSW			
Borehole: 6	**GPS:** 55H 660737E 6427322N		

Surface description

Slope:	4%	Aspect:	East
Morphological type:	Mid-slope		
Land-use:	Grazing		
Disturbance:	High		
Erosion:	Nil		
Coarse fragments:	Nil. Coarse surface fragments to the west.		
Surface cover:	Clover, windmill grass, red grass, wild sage		
% surface cover	100%		
Salinity:	Nil		

Sub-surface description

Sample method: EVH		Logged by: LD					
Depth (mm)	Soil description (texture, colour, coarse fragments, mottles, roots, structure)	Sample	M/D	pH (1:5 water)	EC (dS/m)	ECe	Emerson aggregate test
0-100	Dark brown fine sandy clay loam with gravel	X	M	5.6	0.03	0.26	3
100-1400	Brown to strong brown fine sandy clay	X	Wp	6.0	0.03	0.23	6
		X		6.4	0.04	0.30	5
		X		7.9	0.18	1.35	5
		X		8.1	0.65	4.88	5
1400-1800	Yellowish brown fine sandy clay with grey mottles	X	Wp	8.1	0.82	6.15	5
1800-2200	Brownish yellow fine sandy clay	X	M	7.2	0.83	6.23	2
2200-3100	Brownish yellow sandy clay loam with gravel	X	M	4.7	0.60	5.70	2
		X		4.5	0.35	3.01	2
3100-6000	Light olive brown fine sandy clay to sandy clay	X	M	4.7	0.27	2.03	2
		X		4.8	0.16	1.20	2
		X		4.8	0.18	1.35	2
		X		4.8	0.17	1.28	2
		X		4.9	0.18	1.35	2
		X		5.3	0.20	1.50	2
6000	End of hole						
Notes:							

Salinity assessment

Client: Bourke Securities		**Job no:**	13365	**Date:**	27/5/2014
Address:	*Daisy Hill Estate*, Eulomogo Road, Dubbo NSW				
Borehole:	7	**GPS:**	55H 660403E 6429137N		

Surface description

Slope:	3%	Aspect:	South
Morphological type:	Mid-slope		
Land-use:	Grazing		
Disturbance:	High		
Erosion:	Nil		
Coarse fragments:	Nil.		
Surface cover:	Panic grass, wild sage, red grass, Paterson's grass		
% surface cover	100%		
Salinity:	Nil		

Sub-surface description

Sample method: EVH		Logged by: LD					
Depth (mm)	Soil description (texture, colour, coarse fragments, mottles, roots, structure)	Sample	M/D	pH (1:5 water)	EC (dS/m)	ECe	Emerson aggregate test
0-900	Dark reddish brown fine sandy clay loam	X	M	5.5	0.03	0.26	3
		X	Wp	5.8	0.03	0.26	3
		X		5.9	0.03	0.26	3
		X		6.1	0.02	0.17	3
900-4900	Yellowish red to reddish brown fine sandy clay with calcite nodules and gravel	X	Wp	7.1	0.07	0.53	3
		X	M/D	7.9	0.22	1.65	5
		X		8.0	0.43	3.23	5
		X		7.8	0.41	3.08	5
		X		7.7	0.39	2.93	2
		X		7.3	0.31	2.33	3
		X		7.5	0.30	2.25	3
		X		7.4	0.34	2.55	2
4900-6000	Light yellow to light reddish brown fine sandy clay loam	X	M	7.2	0.31	2.67	3
		X		7.1	0.29	2.49	3
		X		7.3	0.33	2.84	3
6000	End of hole						
Notes:							

Salinity assessment

Client: Bourke Securities		**Job no:** 13365	**Date:** 28/10/2014
Address: *Daisy Hill Estate*, Eulomogo Road, Dubbo NSW			
Borehole: 8	**GPS:** 55H 659674E 6428146N		

Surface description

Slope:	1%	Aspect:	North
Morphological type:	Mid-slope		
Land-use:	Grazing		
Disturbance:	High		
Erosion:	Nil		
Coarse fragments:	Nil		
Surface cover:	Saffron thistle, wallaby grass		
% surface cover	100%		
Salinity:	Nil		

Sub-surface description

Sample method: EVH — Logged by: LD

Depth (mm)	Soil description (texture, colour, coarse fragments, mottles, roots, structure)	Sample	M/D	pH (1:5 water)	EC (dS/m)	ECe	Emerson aggregate test
0-300	Dusky red sandy clay loam	X	M/D	5.4	0.02	0.17	5
		X		5.4	0.02	0.17	3
300-1500	Dark red sandy clay loam to sandy clay with fine gravel from 1200mm	X	M/D	5.5	0.02	0.17	3
		X		5.8	0.01	0.09	3
		X		7.3	0.11	0.83	5
		X		7.5	0.14	1.05	5
1500-3200	Strong brown to yellowish brown sandy clay to light clay with fine gravel and grey mottles	X	M/D	7.6	0.16	1.20	5
		X		7.7	0.10	0.75	3
		X		7.7	0.17	1.28	3
3200-4200	Light brown sandy clay with trace gravel	X	M/D	7.8	0.19	1.43	3
	Brownish yellow	X		7.7	0.23	1.73	3
4200-6000	Yellowish brown to strong brown sandy clay	X	M/D	7.6	0.32	2.40	3
		X		7.9	0.43	3.23	5
		X		8.1	0.56	4.20	5
		X		8.0	0.59	4.43	5
6000	End of hole						

Notes:

Salinity assessment

Client: Bourke Securities		**Job no:** 13365	**Date:** 28/10/2014
Address:	*Daisy Hill Estate*, Eulomogo Road, Dubbo NSW		
Borehole:	9	**GPS:**	55H 659354E 6428886N

Surface description

Slope:	0-1%	Aspect:	North west
Morphological type:	Mid-slope		
Land-use:	Grazing		
Disturbance:	High		
Erosion:	Nil		
Coarse fragments:	Nil		
Surface cover:	Foxtail, wild sage, saffron thistle		
% surface cover	100%		
Salinity:	Nil		

Sub-surface description

Sample method: EVH		Logged by: LD					
Depth (mm)	Soil description (texture, colour, coarse fragments, mottles, roots, structure)	Sample	M/D	pH (1:5 water)	EC (dS/m)	ECe	Emerson aggregate test
0-450	Dark red to yellowish red sandy loam	X	M/D	6.3	0.03	0.42	3
		X		6.2	0.02	0.28	3
		X		6.1	0.02	0.28	3
450-1300	Yellowish red sandy clay	X	M/D	6.4	0.03	0.23	2
		X		7.2	0.07	0.53	2
1300-2200	Reddish brown sandy clay with ironstone	X	M/D	8.1	0.22	1.65	1
	Strong brown light clay with sand	X		8.5	0.35	2.63	2
2200-3200	Strong brown light clay	X	Wp	8.6	0.37	2.78	2
	Yellowish brown	X		8.7	0.38	2.85	2
3200-6000	Brownish yellow to yellowish brown medium clay	X	Wp	8.4	0.24	1.39	2
		X		8.6	0.47	2.73	2
		X		8.8	0.44	2.55	2
		X		8.6	0.46	2.67	2
		X		8.4	0.64	3.71	2
		X		8.5	0.55	3.19	2
6000	End of hole						

Notes: Soil moisture from 2200mm was wet (plastic limit)

Salinity assessment

Client: Bourke Securities		**Job no:** 13365	**Date:** 28/10/2014
Address:	*Daisy Hill Estate*, Eulomogo Road, Dubbo NSW		
Borehole: 10		**GPS:** 55H 659636E 6429228N	

Surface description

Slope:	1%	Aspect:	North west
Morphological type:	Mid-slope		
Land-use:	Grazing		
Disturbance:	High		
Erosion:	Nil		
Coarse fragments:	Nil		
Surface cover:	Red grass, wallaby grass, saffron thistle, corkscrew grass		
% surface cover	100%		
Salinity:	Nil		

Sub-surface description

Sample method: EVH		Logged by: LD					
Depth (mm)	Soil description (texture, colour, coarse fragments, mottles, roots, structure)	Sample	M/D	pH (1:5 water)	EC (dS/m)	ECe	Emerson aggregate test
0-150	Dark reddish brown sandy clay loam	X	M/D	5.2	0.03	0.29	3
150-2400	Dark red sandy clay to light clay	X	M/D	5.4	0.02	0.15	3
		X		5.9	0.02	0.15	3
		X		6.5	0.02	0.15	3
	Yellowish red	X		7.2	0.07	0.53	3
		X		8.0	0.15	1.13	3
	Grey mottles	X		7.8	0.08	0.60	2
2400-3400	Yellowish red to strong brown light clay	X	Wp	7.9	0.13	0.98	1
	with sand and red and grey mottles	X		8.4	0.18	1.35	1
3400-6000	Yellowish brown light clay to medium clay	X	Wp	8.1	0.22	1.28	1
	with sand and red and grey mottles	X		8.7	0.54	4.05	2
		X		8.7	0.52	3.90	2
		X		8.4	0.31	1.80	2
		X		8.2	0.30	1.74	2
		X		8.0	0.25	1.45	2
		X					
6000	End of hole						
Notes: Soil moisture from 2400mm was wet (plastic limit)							

Salinity assessment

Client: Bourke Securities	**Job no:** 13365	**Date:** 28/10/2014	
Address:	*Daisy Hill Estate*, Eulomogo Road, Dubbo NSW		
Borehole:	11	**GPS:**	55H 659239E 6429183N

Surface description

Slope:	0-1%	Aspect:	North
Morphological type:	Mid-slope		
Land-use:	Grazing		
Disturbance:	High		
Erosion:	Nil		
Coarse fragments:	Trace conglomerate on surface		
Surface cover:	Red grass, saffron thistle, wild oats, rye grass		
% surface cover	100%		
Salinity:	Nil		

Sub-surface description

Sample method: EVH		Logged by: LD					
Depth (mm)	Soil description (texture, colour, coarse fragments, mottles, roots, structure)	Sample	M/D	pH (1:5 water)	EC (dS/m)	ECe	Emerson aggregate test
0-150	Reddish brown sandy clay loam	X	M/D	5.5	0.02	0.19	3
150-900	Yellowish red sandy clay with fine gravel to light clay with sand	X	M/D	5.2	0.02	0.15	3
		X		5.6	0.02	0.15	3
		X		5.9	0.03	0.23	3
900-1800	Reddish brown to strong brown medium clay with grey and red mottles and ironstone	X	M/D	7.0	0.08	0.46	5
		X		7.9	0.20	1.16	5
1800-2200	Reddish brown sandy clay with fine gravel	X	M/D	8.1	0.14	1.05	2
2200-3800	Dark yellowish brown medium clay with sand, fine gravel and grey, orange and red mottles	X	M/D	8.4	0.31	2.33	3
		X		8.2	0.20	1.16	2
		X		8.1	0.18	1.04	2
3800-5100	Yellowish brown to dark yellowish brown light clay with sand and fine gravel	X	Wp	8.0	0.15	1.13	2
		X		7.8	0.14	1.05	2
		X		7.8	0.14	1.05	2
5100-6000	Reddish brown light clay with sand and fine gravel	X	M/D	8.5	0.42	3.15	3
		X		8.5	0.39	2.93	3
6000	End of hole						
Notes: Soil moisture was wet (plastic limit) at 3800mm to 5100mm							

Salinity assessment

Client: Bourke Securities	**Job no:** 13365	**Date:** 28/10/2014
Address: *Daisy Hill Estate*, Eulomogo Road, Dubbo NSW		
Borehole: 12	**GPS:** 55H 658982E 6428802N	

Surface description

Slope:	0-1%	Aspect:	North west
Morphological type:	Mid-slope		
Land-use:	Grazing		
Disturbance:	High, tree line to east		
Erosion:	Nil		
Coarse fragments:	Nil		
Surface cover:	Wallaby grass, saffron thistle, corkscrew grass		
% surface cover	80%, bare areas along stock tracks		
Salinity:	Nil		

Sub-surface description

Sample method: EVH		Logged by: LD					
Depth (mm)	Soil description (texture, colour, coarse fragments, mottles, roots, structure)	Sample	M/D	pH (1:5 water)	EC (dS/m)	ECe	Emerson aggregate test
0-150	Reddish brown fine sandy loam	X	M/D	5.7	0.04	0.56	3
150-700	Dark red fine sandy clay loam	X	M/D	5.9	0.02	0.17	3
		X		5.9	0.03	0.26	3
		X		6.4	0.03	0.26	3
700-2700	Red to dark red sandy clay	X		7.1	0.07	0.53	5
		X		6.0	0.04	0.30	5
		X		6.2	0.05	0.38	5
		X		6.3	0.06	0.45	5
2700-3900	Yellowish red light clay with trace fine	X	M	7.2	0.13	0.98	2
	gravel from 3400mm	X		7.2	0.10	0.75	2
3900-4400	Reddish brown sandy clay with fine gravel	X	M	6.8	0.06	0.45	3
4400-6000	Reddish grey to brown fine gravelly clay	X	M	6.5	0.03	0.23	3
	with grey mottles	X		6.4	0.03	0.23	3
		X		6.1	0.03	0.23	3
		X		6.2	0.04	0.30	3
6000	End of hole						
Notes:							

Salinity assessment

Client: Bourke Securities	**Job no:** 13365	**Date:** 28/10/2014
Address: *Daisy Hill Estate*, Eulomogo Road, Dubbo NSW		
Borehole: 13	**GPS:** 55H 658583E 6428708N	

Surface description

Slope:	1%	Aspect:	North west
Morphological type:	Mid-slope		
Land-use:	Grazing		
Disturbance:	High		
Erosion:	Erosion along stock track		
Coarse fragments:	Scattered surface coarse gravel		
Surface cover:	Wallaby grass, corkscrew grass		
% surface cover	70%, bare areas along stock tracks and adjacent areas		
Salinity:	Bare areas		

Sub-surface description

Sample method: EVH		Logged by: LD					
Depth (mm)	Soil description (texture, colour, coarse fragments, mottles, roots, structure)	Sample	M/D	pH (1:5 water)	EC (dS/m)	ECe	Emerson aggregate test
0-150	Reddish brown sandy clay loam	X	M/D	5.5	0.03	0.29	3
150-250	Weak red sandy clay	X	M/D	5.6	0.02	0.15	3
250-1800	Red to dark red light clay with grey mottles from 1400mm	X	M/D	6.2	0.04	0.30	5
		X		6.3	0.03	0.23	3
		X		6.6	0.04	0.30	2
		X		8.0	0.41	3.08	3
1800-6000	Yellowish brown to brownish yellow sandy clay with grey and red mottles. Fine gravel from 4500mm.	X	M/D	7.7	0.42	3.15	5
		X		7.5	0.52	3.90	6
		X		7.4	0.61	4.58	6
		X		7.2	0.66	4.95	6
		X		7.0	0.65	4.88	6
		X		6.9	0.48	3.60	6
		X	M	6.8	0.53	3.98	6
		X		7.8	0.52	3.90	6
		X		7.4	0.72	5.40	5
6000	End of hole						
Notes:							

Salinity assessment

Client: Bourke Securities	**Job no:** 13365	**Date:** 28/10/2014
Address: *Daisy Hill Estate*, Eulomogo Road, Dubbo NSW		
Borehole: 14	**GPS:** 55H 658089E 6429071N	

Surface description

Slope:	1%	Aspect:	North east
Morphological type:	Mid-slope		
Land-use:	Grazing		
Disturbance:	High		
Erosion:	Nil		
Coarse fragments:	Nil		
Surface cover:	Red grass, wallaby grass, saffron thistle, ryegrass		
% surface cover	100%		
Salinity:	Nil		

Sub-surface description

Sample method: EVH | Logged by: LD

Depth (mm)	Soil description (texture, colour, coarse fragments, mottles, roots, structure)	Sample	M/D	pH (1:5 water)	EC (dS/m)	ECe	Emerson aggregate test
0-400	Reddish brown sandy clay loam	X	M	5.7	0.02	0.19	3
		X		5.7	0.02	0.19	3
		X		6.1	0.02	0.19	3
400-2400	Reddish brown to dark yellowish brown sandy clay to light clay with sand	X	M	6.6	0.06	0.45	5
		X		7.4	0.12	0.90	5
		X		7.6	0.12	0.90	3
		X	M	7.7	0.11	0.83	2
2400-3700	Yellowish brown to dark yellowish brown medium clay with orange and grey mottles	X		7.8	0.11	0.64	1
		X		7.7	0.12	0.70	2
		X		7.4	0.14	0.81	2
3700-4300	Strong brown light clay with grey mottles and ironstone and basalt gravel	X	M	6.9	0.12	0.90	2
4300-6000	Light yellowish brown to yellowish brown fine sandy clay	X	M	7.7	0.50	3.75	3
		X		7.7	0.49	3.68	3
		X		7.3	0.46	3.45	3
		X		7.1	0.60	4.50	3
6000	End of hole						

Notes:

Salinity assessment

Client: Bourke Securities	**Job no:** 13365	**Date:** 28/10/2014
Address: *Daisy Hill Estate*, Eulomogo Road, Dubbo NSW		
Borehole: 15	**GPS:** 55H 659324E 6429057N	

Surface description

Slope:	0-1%	Aspect:	North east
Morphological type:	Mid-slope		
Land-use:	Grazing		
Disturbance:	High		
Erosion:	Nil		
Coarse fragments:	Trace surface coarse gravel		
Surface cover:	Wallaby grass, red grass, slender rat's tail grass, corkscrew grass		
% surface cover	80%, bare areas along stock tracks and adjacent areas		
Salinity:	Bare areas		

Sub-surface description

Sample method: EVH		Logged by: LD					
Depth (mm)	Soil description (texture, colour, coarse fragments, mottles, roots, structure)	Sample	M/D	pH (1:5 water)	EC (dS/m)	ECe	Emerson aggregate test
0-250	Reddish brown to dark reddish brown fine	X	M/D	5.7	0.04	0.56	3
	sandy loam to sandy clay loam	X		5.7	0.02	0.19	3
250-3200	Yellowish red to strong brown sandy clay	X	M/D	6.1	0.02	0.15	3
	to light clay with sand	X		6.2	0.03	0.26	2
		X		7.7	0.14	1.05	2
	Trace gravel	X		8.3	0.32	2.40	5
		X		8.4	0.44	3.30	5
	Fine gravel	X		8.4	0.55	4.13	5
	Grey and red mottles	X	Wp	8.4	0.81	6.08	2
3200-6000	Brownish yellow to yellowish brown	X	Wp	7.7	0.69	4.00	2
	medium clay with sand	X		7.2	0.91	5.28	2
	Grey mottles	X		6.4	0.91	5.28	2
		X		7.3	1.02	5.92	2
		X		6.8	1.03	5.97	2
		X		6.7	0.80	4.64	2
6000	End of hole						
Notes: Soil moisture was wet (plastic limit) from 2600mm							

Appendix 9. Hydraulic balance – *Daisy Hill Estate* with road reserve vegetation (284 lots)

Rural land-use (mm) factor	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
INPUTS (mm)													
Rainfall	66	53	48	44	52	44	52	54	52	63	55	56	
Runoff	6.5	5.2	4.8	4.4	5.1	4.4	5.1	5.3	5.1	6.2	5.4	5.5	
Rainfall less runoff	59.5	47.8	43.2	39.6	46.9	39.6	46.9	48.7	46.9	56.8	49.6	50.5	
Irrigation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total inputs	**59.5**	**47.8**	**43.2**	**39.6**	**46.9**	**39.6**	**46.9**	**48.7**	**46.9**	**56.8**	**49.6**	**50.5**	
OUTPUTS (mm)													
Evaporation (pan)	273	221	195	126	78	48	53	74	102	158	207	267	
Evaporation from pasture area	21.2	18.0	16.7	15.6	17.7	15.6	17.7	18.2	17.7	20.4	18.5	18.7	
Evaporation from lawn area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Evaporation from trees	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.2	
Water harvesting	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0003	0.0003	
Total outputs	**21.4**	**18.2**	**16.8**	**15.7**	**17.8**	**15.7**	**17.8**	**18.3**	**17.8**	**20.6**	**18.7**	**19.0**	
INPUTS-OUTPUTS (mm)													
Infiltration	**38.1**	**29.6**	**26.4**	**23.9**	**29.1**	**24.0**	**29.1**	**30.4**	**29.1**	**36.2**	**30.9**	**31.5**	**358**
Rural-residential land-use (mm) 284 lots													
INPUTS (mm)													
Rainfall	66	53	48	44	52	44	52	54	52	63	55	56	639
Runoff	5.5	4.4	4.0	3.7	4.3	3.7	4.3	4.5	4.3	5.3	4.6	4.7	
Rainfall less runoff	60.5	48.6	44.0	40.3	47.7	40.3	47.7	49.5	47.7	57.7	50.4	51.3	
Effluent infiltration	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Irrigation	30.3	25.9	23.5	15.8	8.9	6.5	6.0	8.3	11.9	17.1	23.9	30.9	
Overflows from tanks	0.211	0.170	0.154	0.141	0.166	0.141	0.166	0.173	0.166	0.202	0.176	0.179	
Total inputs	**91.3**	**74.9**	**67.9**	**56.5**	**57.1**	**47.3**	**54.1**	**58.3**	**60.0**	**75.3**	**74.8**	**82.7**	
OUTPUTS (mm)													
Evaporation (pan)	273	221	195	126	78	48	53	74	102	158	207	267	
Evaporation from pasture area	14.8	12.5	11.6	10.9	12.3	10.9	12.3	12.7	12.3	14.2	12.9	13.0	
Evaporation from lawn area	32.4	26.3	23.2	15.0	9.2	5.7	6.3	8.8	12.1	18.8	24.6	31.7	
Evaporation from trees	20.6	16.7	14.8	9.5	5.9	3.6	4.0	5.6	7.7	12.0	15.6	20.2	
Water harvesting	2.112	1.696	1.536	1.408	1.664	1.408	1.664	1.728	1.664	2.016	1.760	1.792	
Total outputs	**69.9**	**57.2**	**51.1**	**36.8**	**29.1**	**21.6**	**24.2**	**28.9**	**33.8**	**47.0**	**54.9**	**66.7**	
INPUTS-OUTPUTS (mm)													
Infiltration	**21.4**	**17.7**	**16.8**	**19.7**	**28.0**	**25.6**	**29.9**	**29.4**	**26.1**	**28.3**	**19.9**	**16.0**	**279**

MODEL PARAMETERS			Runoff	**Rural land-use**	**Rural-residential land-use**
INPUTS					
Irrigation	Lawn	50 mm per month above evaporation		0.00%	13.20%
Runoff	Permeable (non-hard, pasture)		10%	98.86%	68.00%
	Permeable (non-hard, lawn)		10%	98.86%	13.20%
	Hard (driveways and roads)		10%	0.11%	7.70%
	Hard (house and shed roof)		100%	0.06%	3.20%
Rainwater harvesting	Roof area		100%	0.06%	3.20%
OUTPUTS					
Evapotranspiration	Crop factor			90%	90%
	Native pasture			Rainfall (exp 0.75)	Rainfall (exp 0.75)
	Trees and shrubs (roadside)			0.1%	8.4%

Appendix 10. Hydraulic balance – *Daisy Hill Estate* without road reserve vegetation (284 lots)

Rural land-use (mm) factor	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
INPUTS (mm)													
Rainfall	66	53	48	44	52	44	52	54	52	63	55	56	
Runoff	6.5	5.2	4.8	4.4	5.1	4.4	5.1	5.3	5.1	6.2	5.4	5.5	
Rainfall less runoff	59.5	47.8	43.2	39.6	46.9	39.6	46.9	48.7	46.9	56.8	49.6	50.5	
Irrigation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total inputs	**59.5**	**47.8**	**43.2**	**39.6**	**46.9**	**39.6**	**46.9**	**48.7**	**46.9**	**56.8**	**49.6**	**50.5**	
OUTPUTS (mm)													
Evaporation (pan)	273	221	195	126	78	48	53	74	102	158	207	267	
Evaporation from pasture area	21.2	18.0	16.7	15.6	17.7	15.6	17.7	18.2	17.7	20.4	18.5	18.7	
Evaporation from lawn area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Evaporation from trees	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.2	
Water harvesting	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0003	0.0003	
Total outputs	**21.4**	**18.2**	**16.8**	**15.7**	**17.8**	**15.7**	**17.8**	**18.3**	**17.8**	**20.6**	**18.7**	**19.0**	
INPUTS-OUTPUTS (mm)													
Infiltration	**38.1**	**29.6**	**26.4**	**23.9**	**29.1**	**24.0**	**29.1**	**30.4**	**29.1**	**36.2**	**30.9**	**31.5**	**358**
Rural-residential land-use (mm) 284 lots													
INPUTS (mm)													
Rainfall	66	53	48	44	52	44	52	54	52	63	55	56	639
Runoff	6.1	4.9	4.4	4.0	4.8	4.0	4.8	5.0	4.8	5.8	5.0	5.1	
Rainfall less runoff	59.9	48.1	43.6	40.0	47.2	40.0	47.2	49.0	47.2	57.2	50.0	50.9	
Effluent infiltration	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Irrigation	30.3	25.9	23.5	15.8	8.9	6.5	6.0	8.3	11.9	17.1	23.9	30.9	
Overflows from tanks	0.211	0.170	0.154	0.141	0.166	0.141	0.166	0.173	0.166	0.202	0.176	0.179	
Total inputs	**90.8**	**74.5**	**67.5**	**56.2**	**56.6**	**46.9**	**53.7**	**57.8**	**59.5**	**74.8**	**74.4**	**82.2**	
OUTPUTS (mm)													
Evaporation (pan)	273	221	195	126	78	48	53	74	102	158	207	267	
Evaporation from pasture area	16.4	13.9	12.9	12.1	13.7	12.1	13.7	14.1	13.7	15.9	14.3	14.5	
Evaporation from lawn area	32.4	26.3	23.2	15.0	9.2	5.7	6.3	8.8	12.1	18.8	24.6	31.7	
Evaporation from trees	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.2	
Water harvesting	2.112	1.696	1.536	1.408	1.664	1.408	1.664	1.728	1.664	2.016	1.760	1.792	
Total outputs	**51.2**	**42.1**	**37.9**	**28.6**	**24.7**	**19.3**	**21.7**	**24.8**	**27.6**	**36.8**	**40.9**	**48.2**	
INPUTS-OUTPUTS (mm)													
Infiltration	**39.5**	**32.3**	**29.7**	**27.5**	**32.0**	**27.6**	**32.0**	**33.1**	**31.9**	**38.0**	**33.5**	**34.0**	**391**

MODEL PARAMETERS		Runoff	**Rural land-use**	**Rural-residential land-use**
INPUTS				
Irrigation	Lawn 50 mm per month above evaporation		0.00%	13.20%
Runoff	Permeable (non-hard, pasture)	10%	98.86%	76.30%
	Permeable (non-hard, lawn)	10%	98.86%	13.20%
	Hard (driveways and roads)	10%	0.11%	7.70%
	Hard (house and shed roof)	100%	0.06%	3.20%
Rainwater harvesting	Roof area	100%	0.06%	3.20%
OUTPUTS				
Evapotranspiration	Crop factor		90%	90%
	Native pasture		Rainfall (exp 0.75)	Rainfall (exp 0.75)
	Trees and shrubs (roadside)		0.1%	0.1%

Appendix 11. Hydraulic balance – *Daisy Hill Estate* with road reserve vegetation (323 lots)

Rural land-use (mm)													
factor	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
INPUTS (mm)													
Rainfall	66	53	48	44	52	44	52	54	52	63	55	56	
Runoff	6.5	5.2	4.8	4.4	5.1	4.4	5.1	5.3	5.1	6.2	5.4	5.5	
Rainfall less runoff	59.5	47.8	43.2	39.6	46.9	39.6	46.9	48.7	46.9	56.8	49.6	50.5	
Irrigation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total inputs	**59.5**	**47.8**	**43.2**	**39.6**	**46.9**	**39.6**	**46.9**	**48.7**	**46.9**	**56.8**	**49.6**	**50.5**	
OUTPUTS (mm)													
Evaporation (pan)	273	221	195	126	78	48	53	74	102	158	207	267	
Evaporation from pasture area	21.2	18.0	16.7	15.6	17.7	15.6	17.7	18.2	17.7	20.4	18.5	18.7	
Evaporation from lawn area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Evaporation from trees	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.2	
Water harvesting	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0003	0.0003	
Total outputs	**21.4**	**18.2**	**16.8**	**15.7**	**17.8**	**15.7**	**17.8**	**18.3**	**17.8**	**20.6**	**18.7**	**19.0**	
INPUTS-OUTPUTS (mm)													
Infiltration	**38.1**	**29.6**	**26.4**	**23.9**	**29.1**	**24.0**	**29.1**	**30.4**	**29.1**	**36.2**	**30.9**	**31.5**	**358**
Rural-residential land-use (mm) 323 lots													
INPUTS (mm)													
Rainfall	66	53	48	44	52	44	52	54	52	63	55	56	639
Runoff	5.3	4.3	3.9	3.6	4.2	3.6	4.2	4.4	4.2	5.1	4.4	4.5	
Rainfall less runoff	60.7	48.7	44.1	40.4	47.8	40.4	47.8	49.6	47.8	57.9	50.6	51.5	
Effluent infiltration	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Irrigation	34.2	29.2	26.5	17.8	10.1	7.3	6.8	9.4	13.4	19.3	27.0	34.9	
Overflows from tanks	0.238	0.191	0.173	0.158	0.187	0.158	0.187	0.194	0.187	0.227	0.198	0.202	
Total inputs	**95.4**	**78.4**	**71.1**	**58.7**	**58.4**	**48.2**	**55.1**	**59.5**	**61.7**	**77.7**	**78.1**	**86.8**	
OUTPUTS (mm)													
Evaporation (pan)	273	221	195	126	78	48	53	74	102	158	207	267	
Evaporation from pasture area	14.2	12.0	11.2	10.5	11.9	10.5	11.9	12.2	11.9	13.7	12.4	12.5	
Evaporation from lawn area	36.6	29.7	26.2	16.9	10.4	6.4	7.1	10.0	13.7	21.2	27.8	35.8	
Evaporation from trees	20.6	16.7	14.8	9.5	5.9	3.6	4.0	5.6	7.7	12.0	15.6	20.2	
Water harvesting	2.376	1.908	1.728	1.584	1.872	1.584	1.872	1.944	1.872	2.268	1.980	2.016	
Total outputs	**73.8**	**60.3**	**53.8**	**38.5**	**30.0**	**22.1**	**24.8**	**29.7**	**35.1**	**49.1**	**57.7**	**70.5**	
INPUTS-OUTPUTS (mm)													
Infiltration	**21.6**	**18.1**	**17.2**	**20.2**	**28.4**	**26.1**	**30.3**	**29.8**	**26.5**	**28.6**	**20.3**	**16.4**	**284**

MODEL PARAMETERS		Runoff	**Rural land-use**	**Rural-residential land-use**
INPUTS				
Irrigation	Lawn 50 mm per month above evaporation		0.00%	14.90%
Runoff	Permeable (non-hard, pasture)	10%	98.86%	65.20%
	Permeable (non-hard, lawn)	10%	98.86%	14.90%
	Hard (driveways and roads)	10%	0.11%	7.80%
	Hard (house and shed roof)	100%	0.06%	3.60%
Rainwater harvesting	Roof area	100%	0.06%	3.60%
OUTPUTS				
Evapotranspiration	Crop factor		90%	90%
	Native pasture		Rainfall (exp 0.75)	Rainfall (exp 0.75)
	Trees and shrubs (roadside)		0.1%	8.4%

Appendix 12. Hydraulic balance – *Daisy Hill Estate* without road reserve vegetation (323 lots)

Rural land-use (mm)													
factor	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
INPUTS (mm)													
Rainfall	66	53	48	44	52	44	52	54	52	63	55	56	
Runoff	6.5	5.2	4.8	4.4	5.1	4.4	5.1	5.3	5.1	6.2	5.4	5.5	
Rainfall less runoff	59.5	47.8	43.2	39.6	46.9	39.6	46.9	48.7	46.9	56.8	49.6	50.5	
Irrigation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total inputs	**59.5**	**47.8**	**43.2**	**39.6**	**46.9**	**39.6**	**46.9**	**48.7**	**46.9**	**56.8**	**49.6**	**50.5**	
OUTPUTS (mm)													
Evaporation (pan)	273	221	195	126	78	48	53	74	102	158	207	267	
Evaporation from pasture area	21.2	18.0	16.7	15.6	17.7	15.6	17.7	18.2	17.7	20.4	18.5	18.7	
Evaporation from lawn area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Evaporation from trees	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.2	
Water harvesting	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0003	0.0003	
Total outputs	**21.4**	**18.2**	**16.8**	**15.7**	**17.8**	**15.7**	**17.8**	**18.3**	**17.8**	**20.6**	**18.7**	**19.0**	
INPUTS-OUTPUTS (mm)													
Infiltration	**38.1**	**29.6**	**26.4**	**23.9**	**29.1**	**24.0**	**29.1**	**30.4**	**29.1**	**36.2**	**30.9**	**31.5**	**358**
Rural-residential land-use (mm) 323 lots													
INPUTS (mm)													
Rainfall	66	53	48	44	52	44	52	54	52	63	55	56	639
Runoff	5.9	4.7	4.3	3.9	4.6	3.9	4.6	4.8	4.6	5.6	4.9	5.0	
Rainfall less runoff	60.1	48.3	43.7	40.1	47.4	40.1	47.4	49.2	47.4	57.4	50.1	51.0	
Effluent infiltration	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Irrigation	34.2	29.2	26.5	17.8	10.1	7.3	6.8	9.4	13.4	19.3	27.0	34.9	
Overflows from tanks	0.238	0.191	0.173	0.158	0.187	0.158	0.187	0.194	0.187	0.227	0.198	0.202	
Total inputs	**94.8**	**77.9**	**70.7**	**58.3**	**57.9**	**47.9**	**54.6**	**59.1**	**61.2**	**77.2**	**77.6**	**86.4**	
OUTPUTS (mm)													
Evaporation (pan)	273	221	195	126	78	48	53	74	102	158	207	267	
Evaporation from pasture area	15.9	13.5	12.5	11.7	13.3	11.7	13.3	13.7	13.3	15.3	13.9	14.0	
Evaporation from lawn area	36.6	29.7	26.2	16.9	10.4	6.4	7.1	10.0	13.7	21.2	27.8	35.8	
Evaporation from trees	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.2	
Water harvesting	2.376	1.908	1.728	1.584	1.872	1.584	1.872	1.944	1.872	2.268	1.980	2.016	
Total outputs	**55.1**	**45.2**	**40.6**	**30.3**	**25.6**	**19.8**	**22.3**	**25.7**	**28.9**	**39.0**	**43.8**	**52.1**	
INPUTS-OUTPUTS (mm)													
Infiltration	**39.8**	**32.7**	**30.1**	**28.0**	**32.3**	**28.1**	**32.3**	**33.4**	**32.3**	**38.2**	**33.8**	**34.3**	**395**

MODEL PARAMETERS			Runoff	**Rural land-use**	**Rural-residential land-use**
INPUTS					
Irrigation	Lawn	50	mm per month above evaporation	0.00%	14.90%
Runoff	Permeable (non-hard, pasture)		10%	98.86%	73.60%
	Permeable (non-hard, lawn)		10%	98.86%	14.90%
	Hard (driveways and roads)		10%	0.11%	7.80%
	Hard (house and shed roof)		100%	0.06%	3.60%
Rainwater harvesting	Roof area		100%	0.06%	3.60%
OUTPUTS					
Evapotranspiration	Crop factor			90%	90%
	Native pasture			Rainfall (exp 0.75)	Rainfall (exp 0.75)
	Trees and shrubs (roadside)			0.1%	0.1%