# BORE COMPLETION REPORT: HODGSON WETLAND SUITE

# BUNTINE-MARCHAGEE NATURAL DIVERSITY RECOVERY CATCHMENT

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DEPARTMENT OF PARKS AND WILDLIFE

HYDROLOGY REPORT

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**Keywords:**

Altered hydrology, Yilgarn Craton, wetland, wheatbelt region, groundwater/surface-water interactions

**Figure 1. Photograph of wetland W023 taken by Lindsay Bourke on 17 November 2011**

**Figure 2. Photograph or wetland W024 taken by Lindsay Bourke on 14 December 2010**

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# 1 Introduction

## 1.1 Background

Groundwater inflow and outflow fluxes are especially important for wetlands located in semi-arid environments. Contributions from this water source commonly supports and sustains aquatic, riparian and terrestrial biological elements during dry seasons, or periods of extended drought. Changes to the hydrology of wetlands either through natural variation or through anthropogenic means, for example via water abstraction or changing land use, can significantly influence the biological composition, structure and function.

The Hodgson Wetland Suite (HWS) consists of 38 wetlands within a topographical catchment area of 2,390 ha (Figure 3). Within the HWS, wetlands W023 and W024 are recognised by the Department of Parks and Wildlife (DPaW) as having high conservation value due to being in relatively good condition with fresher water resulting in high aquatic biodiversity, relatively diverse waterbird populations and good riparian vegetation (Aquatic Research Laboratory, 2009).

Land use history within the HWS is similar to surrounding areas (CALM & Colmar Brunton, 2005), with a large proportion of the subcatchment being cleared last century for agricultural production. Land use changes, specifically the introduction of annual broad-acre cropping systems to the HWS last century, resulted in changes to the water, solute and nutrient status. This altered hydrology is expressed through rising groundwater levels, an altered wetland hydroperiod, rising salinity levels and nutrient enrichment. The native biota of the HWS wetland assemblage is threatened by altered hydrology and DPaW considers this area as the highest priority for management intervention within the Buntine-Marchagee Natural Diversity Recovery Catchment (BMNDRC).

In 2012, 16 groundwater monitoring bores were installed across the subcatchment of the HWS. This report describes the structure and lithology of the surficial and semi-confined saprolite aquifers intersected during this drilling program. This report also presents baseline groundwater level, water quality and hydrochemistry data (major ions and nutrients) in groundwater and wetlands occurring in the HWS. This new information builds upon the priori conceptual hydrogeological model of the catchment and its wetlands developed by Bourke (2012).

An improved knowledge of the HWS gained from this study will form the basis for the assessment of the hydrological (altered water balance) and hydrochemical (solute and nutrient concentrations) threats to the biological values of wetlands W023 and W024. This can in-turn be applied to develop and implement management actions to address these hydrological-derived threats. Fresh to brackish wetlands, which were once a common feature in the wheatbelt of Western Australia, and their associated biodiversity are now poorly represented. This improved knowledge not only has application for the HWS, but also other similar wetlands distributed throughout semi-arid Western Australia.

## 1.2 Location

The HWS is located within the western boundary of the BMNDRC, about 280 km north-east of Perth (Figure 3). The groundwater monitoring infrastructure and wetlands are all located on private property and are not accessible without explicit permission from landholders.

## 1.3 Climate

The HWS experiences warm to hot summers and cool wet winters. The long-term (1912 to 2013) average rainfall at the nearby town of Coorow (BoM site number 8037) is 378 mm. The highest monthly rainfall generally occurs in cooler months although significantly high daily rainfall totals can occur from December to March (summer to early autumn) resulting from intense thunderstorms or rain bearing depressions associated with remnants of tropical cyclones (Short, Farmer, Whale, & Coles, 2006). Since the very wet year of 1999 the area has experienced a very dry period with particularly dry years occurring in 2002 (225.5 mm) and 2010 (209.5 mm).

Average annual Class-A pan evaporation rates (based on interpolation from Three Springs, Goodlands and Wongan Hills), are approximately 2,600 mm. Average monthly potential evaporation rates vary from about 390 mm in January to 64 mm in July with rainfall deficits occurring in all but the wettest winter months.

## 1.4 Geomorphology and soil landscapes

### 1.4.1 Geomorphology

The HWS lies within the physiographical unit of the Darling Plateau (Carter & Lipple, 1982) with the Darling Scarp forming the western eroded edge. Archaean and Proterozoic crystalline basement rocks have weathered to saprock and saprolite. Cyclic periods of aridity, coinciding with glacial and interglacial periods (Commander, Schoknecht, Verboom, & Caccetta, 2001) and extended exposure of saprolite and saprock to physical and chemical weathering and erosion have created broad valleys. As the energy in these erosional systems declined these broad incised valleys were filled with transported, surficial sediments. These overlying sediments were subsequently reworked and altered through physical and biogeochemical processes.

Long-periods of relative geological stability and weathering in the HWS have resulted in little variation in relief, ranging from 342 mAHD in the western uplands and 285 mAHD in the east near wetland W118 (Figure 4). Topographic gradients are relatively uniform in the upper sandy areas, with slopes typically in the order of <5%. Marked changes in slope (breaks in slope) occur between the valley floor and flanks where slopes of <2% predominate.

### 1.4.2 Soil-landscapes

The HWS lies within the Balgerbine soil-landscape system with six subsystem phases (Griffin & Goulding, 2004). The mapped units consist of weathered granite, gravel and colluvium on the hillcrest in the west of the catchment (258Bb_6a and 258Bb_6b), which graduate eastwards downslope through deeply weathered granite, sandy duplexes, gravel and deep sand; further downslope to an undulating plain dominated by deep yellow sand

(258Bb_3). The eastern extent of the study area is dominated by sandy depressions with alluvial and lacustrine sediments associated with wetlands and wet soil (258Bb_2a and 258Bb_2b).

## 1.5 Local surface hydrology

The HWS lies within the Moore-Hill River basin (Basin 617) and the Moore River subcatchment. Topography slopes from the catchment divides towards two major drainage lines which are populated with numerous wetlands. These two drainage lines trend in an easterly and north, north-easterly direction respectively and meet proximal to wetland W118 (Figure 4). With respect to surface water the HWS is assumed to be a closed catchment and wetland W118 is considered to be a terminal wetland.

Surface water conveyance structures were constructed in subcatchment 5, which drain surface water from a number of wetlands eastwards towards Keigherly road. Little is known about their construction, although a review of historical orthophotographs (Coleman, 2013) indicates that these were constructed between the mid 1960's to late 1970's.

Surface water flow in the upper catchment occurs rarely, perhaps only during higher magnitude rainfall events (e.g. 1:10 ARI or greater), due to the dominance of deep yellow sand at the surface. Conversely surface water flows are common on hillside seeps and within drainage lines in areas where soil has limited storage capacity due to the presence of high water tables. These overland surface water flows occur over relatively small areas with local infiltration resulting in additional recharge to the surficial aquifer. Connected catchment-scale surface flow is unlikely to occur due to the discontinuous nature of surface water drainage channels, which are intersected with dunal swales. Keigherly road also forms a barrier to eastward flowing surface water flows.

## 1.6 Groundwater and surface water use

Aerial photographs, as evidenced by soil erosion and tracks worn down by stock around wetlands, indicate that numerous wetlands within the HWS were historically used as livestock watering points. The reliance of stock upon wetlands has been significantly reduced due to the construction of exclusion fences. Livestock now rely predominantly upon soaks excavated in well-drained sandy soil where fresh shallow groundwater occurs. Water is pumped from a wetland (identified as W130) to a hilltop storage tank to provide supplies for the spraying of agricultural chemicals. Agricultural water use is considered insignificant relative to water losses via evapotranspiration.

## 1.7 Landuse and vegetation

Broad-acre cropping of rain-fed wheat, canola and lupins is the predominant landuse. The grazing of sheep on fallowed stubble or volunteer pastures occurs across the remainder of available arable land. The timing of land clearing is unknown, although the majority of the perennial vegetation was cleared prior to the acquisition of the earliest aerial imagery in 1959 (Coleman, 2013). Historic aerial photographs (Coleman, 2013) show that the riparian vegetation surrounding wetland W023 consists predominantly of *Eucalyptus camaldulensis*, that colonised[1] the area in the period between 1969 and 1981.

In 2010, 15.9 ha of local provenance perennial vegetation was planted around wetland W024 by DPaW (Figure 6). In 2013, 63.2 ha of perennial native and non-native perennial species were planted in the paddock immediately to the north of wetland W023 and to the west of wetland W024 (Figure 5). The 2013 planting consisted of oil mallee eucalypts (13.4 ha), mixed local provenance native species (9.3 ha), saltbush (11.1 ha) and mixed perennial pastures (29.4 ha) plus an additional 2 ha of infill planting (Figure 6). Perennial vegetation (native and introduced species) now covers about 266 ha, or 11 % of the HWS subcatchment.

[1] It is unknown whether *Eucalyptus camaldulensis* occurring at the periphery of wetland W023 is naturally occurring (e.g. seed dispersal to the high water mark following a flood event), or was intentionally planted by the landholder. The timing of recruitment follows a particularly wet period in the mid 1960's, and given the presence of a dead tree in the wetland, the former is highly probable.

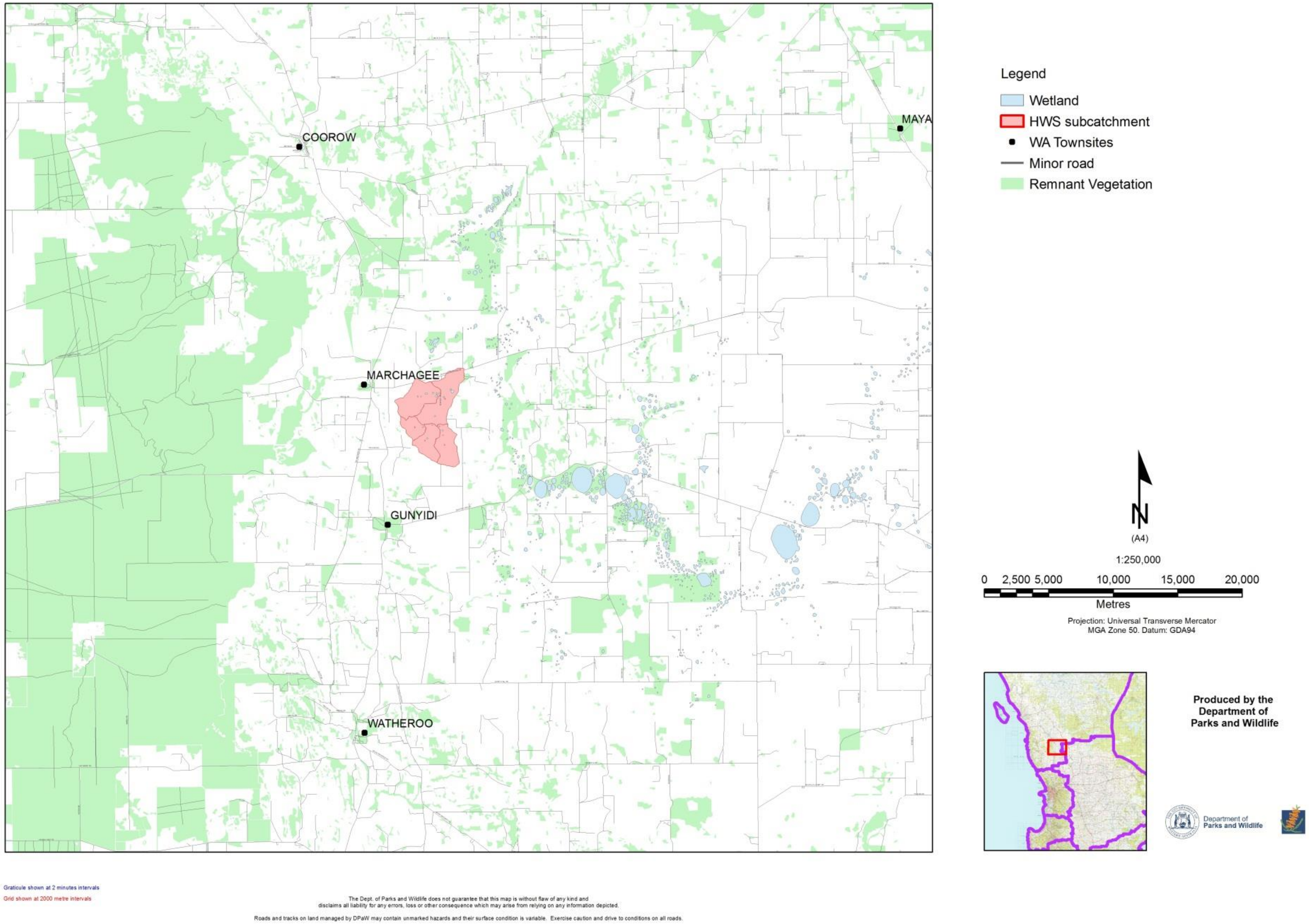


**Figure 3. Location map of the subcatchment of the Hodgson Wetland Suite (HWS)**

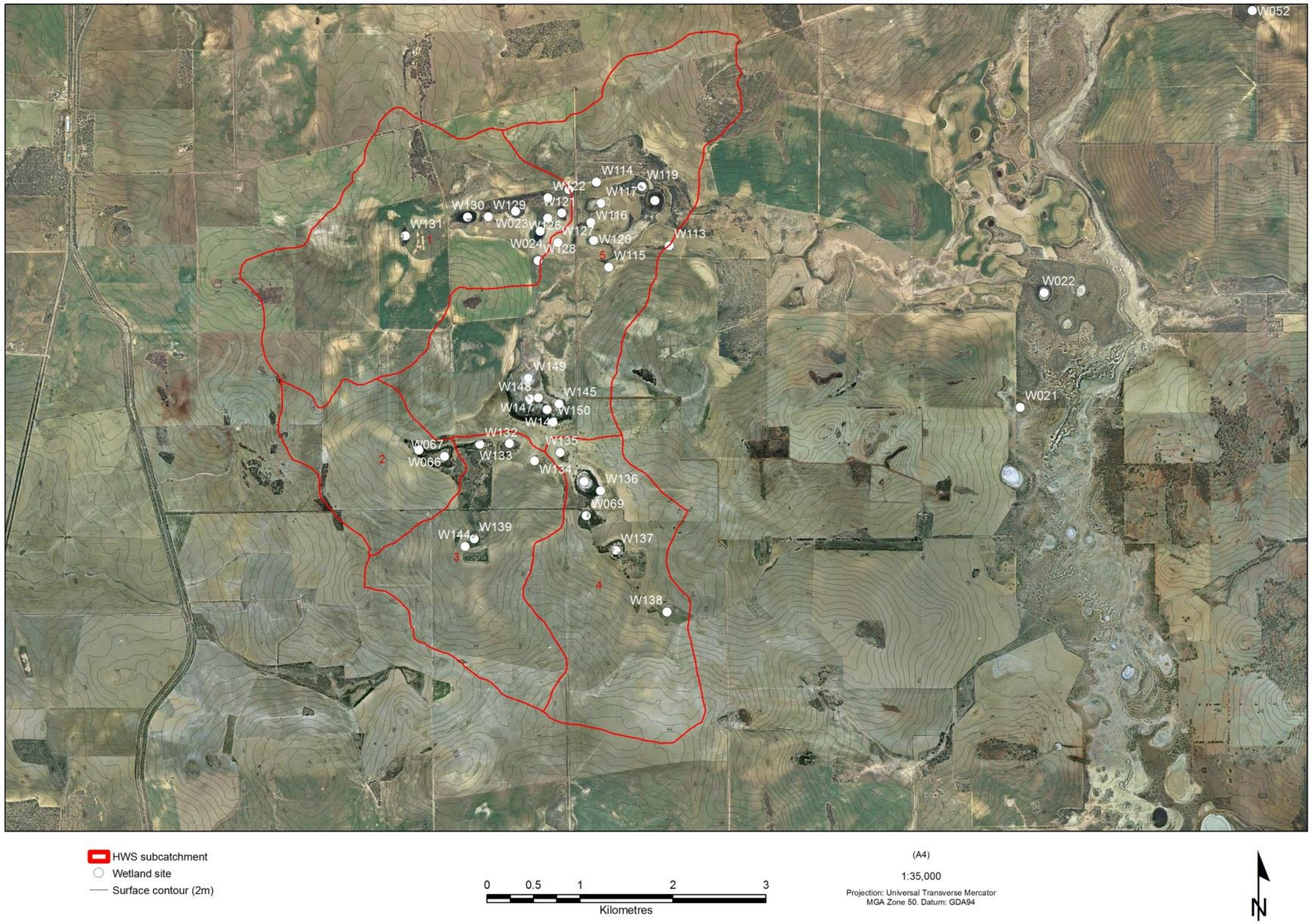


**Figure 4. Aerial photograph of the HWS with interpreted surface water subcatchment boundaries, 2.0 m elevation contours and wetlands (W*xx*) monitored by DPaW**

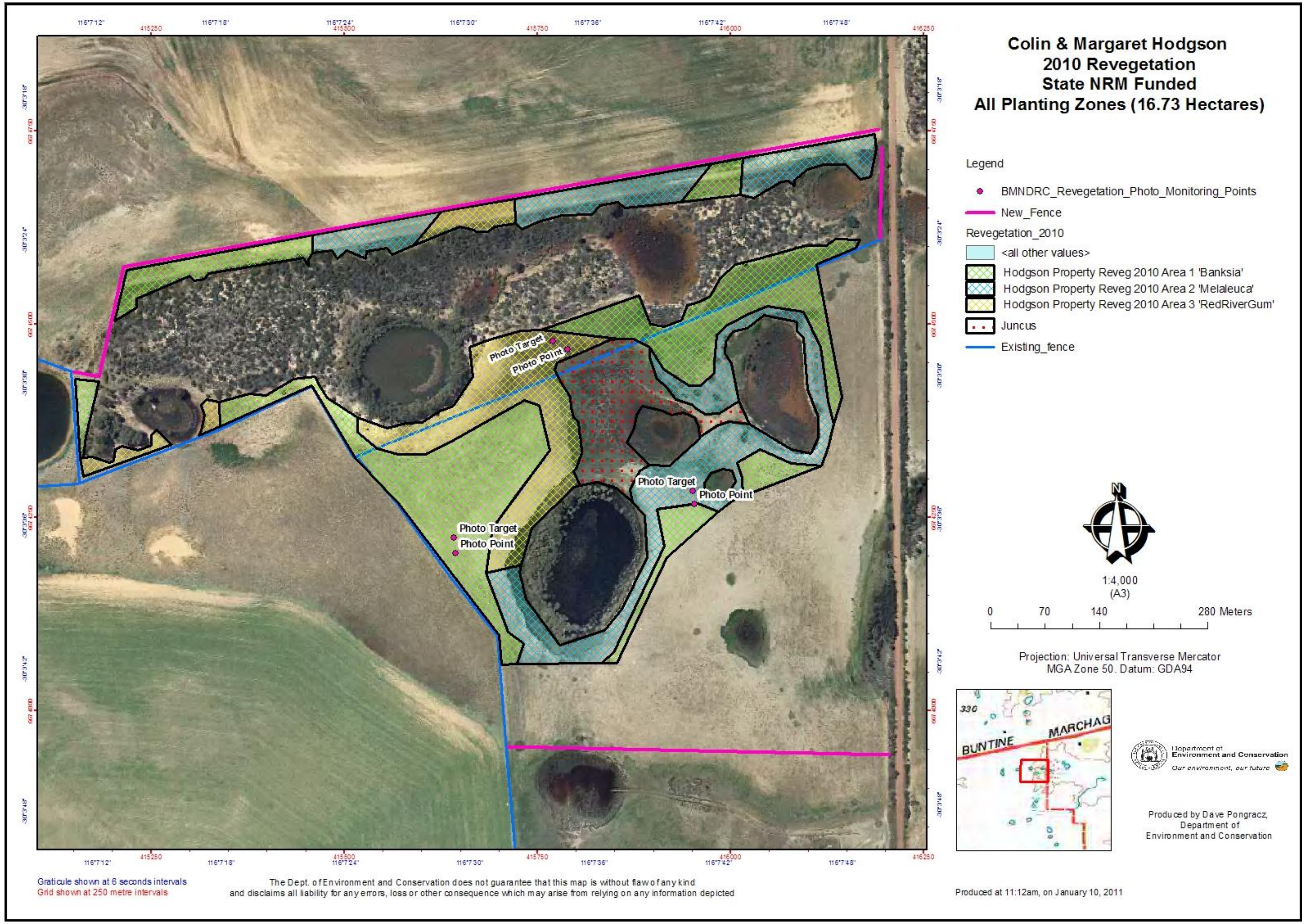


**Figure 5. The spatial extent of revegetation planted by DPaW in 2010 (figure courtesy of David Pongracz, DPaW Midwest Region)**

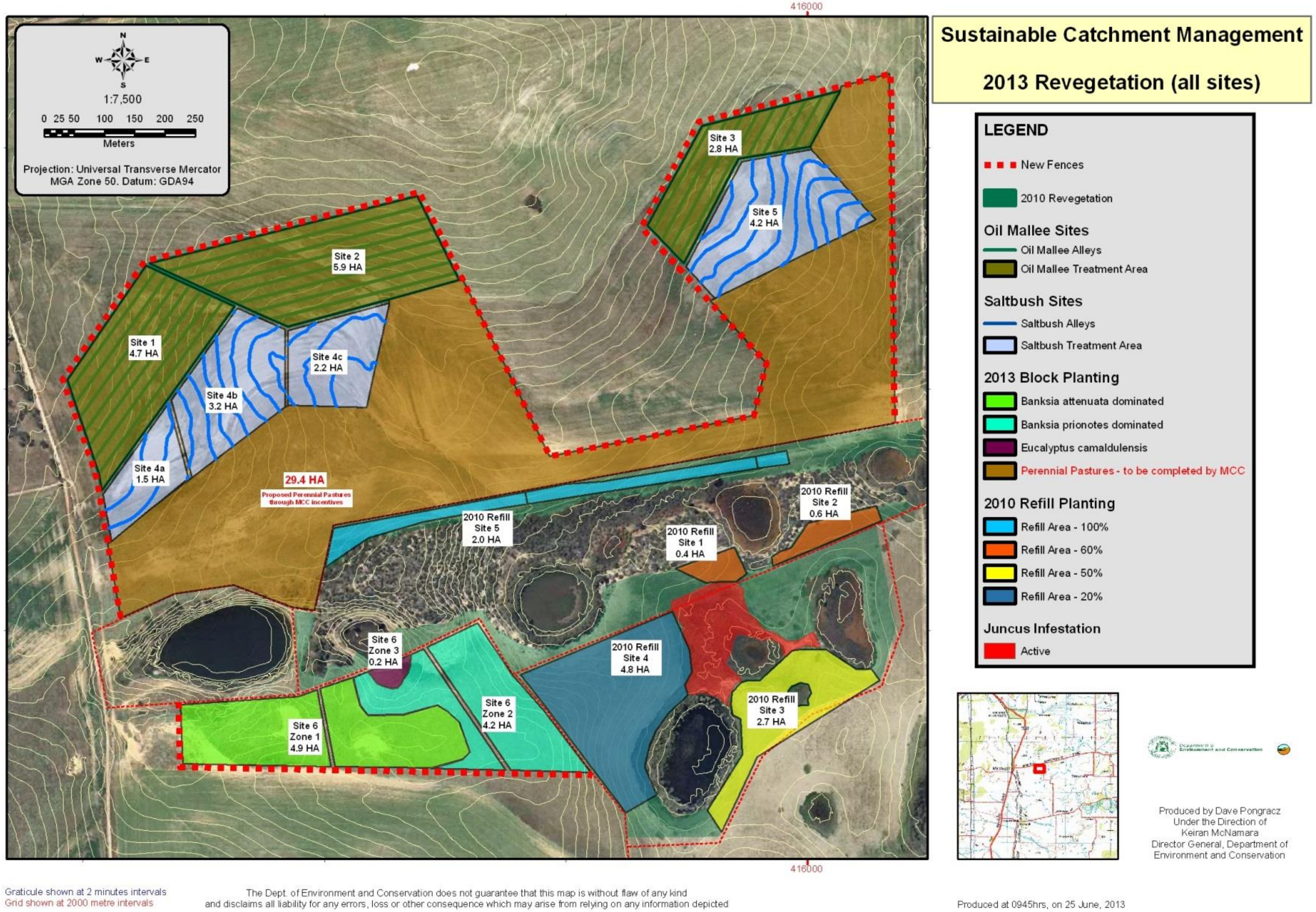


**Figure 6. The spatial extent of revegetation planted by DPaW in 2010 and 2013 (figure courtesy of David Pongracz, DPaW Midwest Region)**

# 2 Investigation

## 2.1 Previous work

A number of hydrogeological and hydro-chemical investigations have occurred within the broader BMNDRC (Bourke, 2003, 2011; Speed & Strelein, 2004; URS, 2008). A brief summary of this work is contained at the end of this document (Appendix A), or see Bourke (2014) for a detailed summary. Historical data within the HWS is limited to wetland water levels and wetland water quality collected by DPaW and the Aquatic Research Laboratory (2009) since 2008 (see Bourke, 2012).

This investigation was preceded by the development of wetland-scale and catchment-scale conceptual hydrogeochemical models for the HWS and wetlands W023 and W024 (Bourke, 2012). Given the absence of groundwater monitoring infrastructure within the HWS, these models were largely speculative, although founded on observations in similar geological and hydrological settings elsewhere in the BMNDRC (Bennett & Goodreid, 2009; Bourke, 2011; Bourke & Coleman, 2013; Speed & Strelein, 2004; URS, 2008).

## 2.2 Purpose and scope

The conceptual hydrogeochemical models described by Bourke (2012) formed the basis for the planning and design of this investigation, in terms of drill method, location, target depth and bore construction specifications. The priority was to site infrastructure in areas which would lead to an understanding of the aquifers and the groundwater/surface water interactions occurring proximal to wetlands W023 and W024, as well as the broader subcatchment (further details provided in Appendix B).

Infrastructure and baseline data discussed in this study, supported with the ongoing collection of hydrogeochemical datasets and other complimentary data, will form the basis for the assessment of the hydrological (altered water balance) and hydrochemical (solute and nutrient concentrations) threats to the biological values of wetlands W023 and W024.

## 2.3 Drilling

Piezometers were discretely screened across the surficial and semi-confined saprolite aquifers located up gradient and down-gradient of wetlands W023 and W024, within the assumed groundwater capture and release zones. Piezometers were also sited to document changes in groundwater levels and solute concentrations along a flow path from wetland W130 in the west, to wetland W118 in the east of the catchment (Figure 7). A summary of the piezometer construction details are provided in Table 1, whilst further detail regarding methods for drilling, bore construction and survey are appended (Appendix B).

## 2.4 Sampling and measurement

### 2.4.1 Groundwater levels

Water levels were manually measured following bore completion in April/May 2012. Upon commissioning all piezometers were fitted with capacitance probe-type electronic data logger (Odyssey 32k) to record water levels at half-hourly intervals. Barometric pressure

(Schlumberger Baro-diver) is measured half-hourly at the site of the automated weather station (Hobo U30) to correct water levels for barometric pressure. Water level data presented in this report were measured in October 10 and 11, 2012.

### 2.4.2 Water quality

Groundwater samples were obtained using an impeller pump or stainless-steel bailer on October 10 and 11, 2012. Water quality (EC, pH, Redox and Temperature) was measured using a portable meter (TPS, model 90-FLMV). Results were considered representative of the aquifer once key water quality parameters (pH ± 0.1, EC ± 5% and temperature ± 0.2°C) stabilised. Water samples were analysed for major ions and nutrients (see Appendix C for details). Chain of Custody (COC) documents were submitted to each laboratory along with all water samples. All samples were submitted and analysed within the appropriate holdings times (National Measurement Institute, 2007).

### 2.4.3 Regolith logging

Regolith samples were taken at one-metre intervals by the DPaW site hydrologist and described by their properties of field texture (N. Hunt & Gilkes, 1992); wetted colour (Munsell Color Company, 2000); sorting and roundness sphericity classification for soil particles (McDonald, Isbell, Speight, Walker, & Hopkins, 1998); grain size according to the Standards Association of Australia (McDonald et al., 1998); and qualitative indication of moisture (e.g. dry, damp or saturated). Bulk samples were stored in plastic bags and subsamples transferred to chip trays. All samples are stored at the DPaW Kensington.

Soil electrical conductivity (EC) and pH were analysed using the soil:water suspension method of Rayment and Higginson (1992), standardised to a 1:5 ratio. Further details regarding soil:water EC and pH methods and analysis is appended (Appendix D).

### 2.4.4 Mapping of outcrop

Field observations of bedrock outcrop were plotted with a hand-held GPS (Garmin, GPSMap 62) then boundaries qualitatively defined within the aid of a Geographical Information System (ArcGIS V10.1). It was assumed that rock exposures forms a no-flow boundary therefore were excised from water table interpretations.

### 2.4.5 Photography of chip samples

A tripod mounted SLR camera (Nikon D7000) was used to photograph dry and lightly wetted soil samples stored in chip trays (Appendix E). A colour reference chart (DataColor SpyderChekr) was photographed with samples to enable greyscale and colour calibration if required. Photographs were taken in natural light and the camera settings were ISO 400, aperture priority (F5.6) and automatic metered shutter speed with upper and lower bracketing compensation (± 0.7).

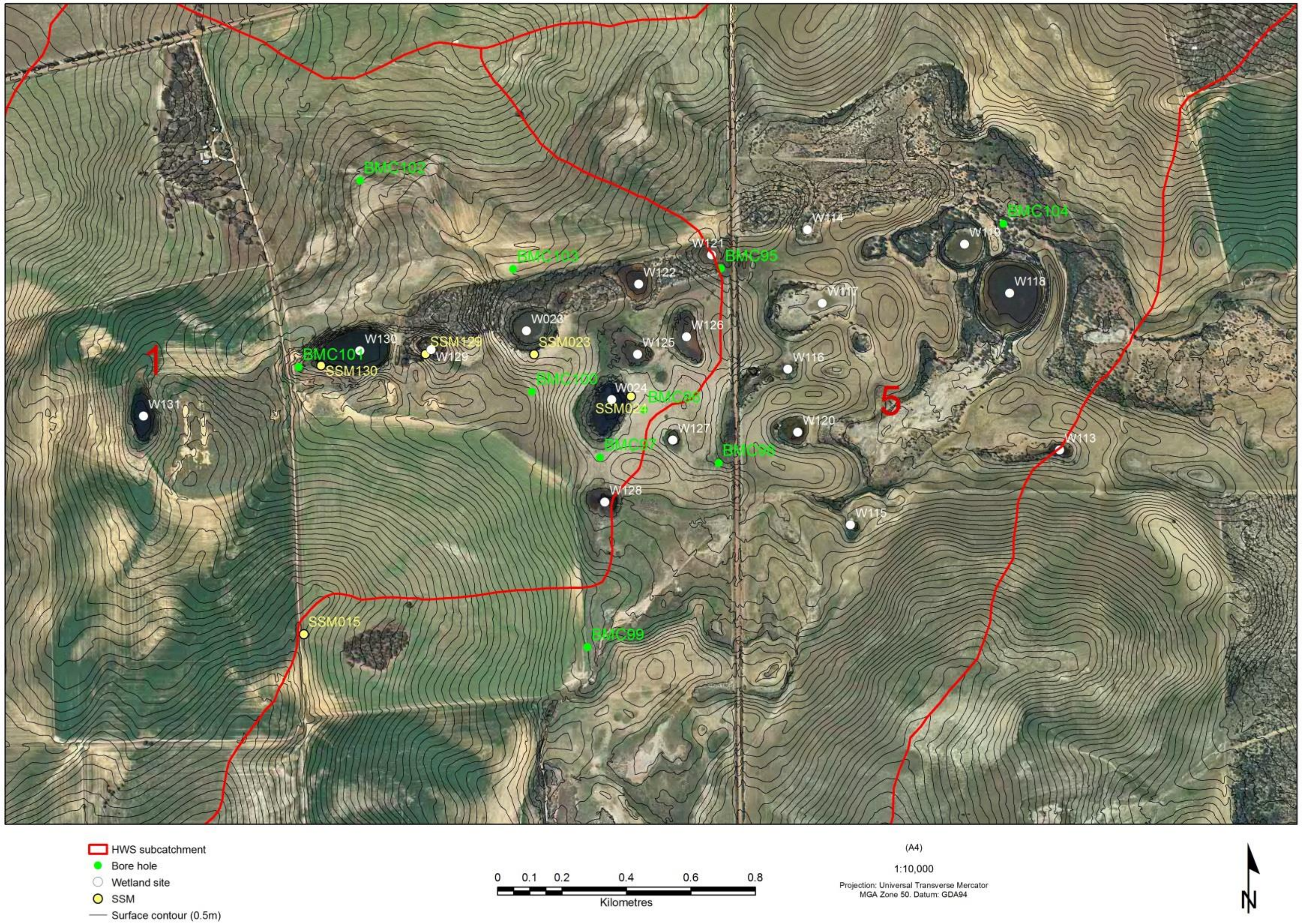


**Figure 7. Plan view of study area subcatchment with locations of wetlands (W*xx*) and piezometers (BMC*xx*)**

**Table 1. Groundwater monitoring bore coordinates (MGA-94 Zone 50J, AusGeod98) and piezometer construction summary**

| Site ID | Date completed | MGA-94 East | MGA-94 North | Surface elevation (mAHD) | TOC[2] (magl) | TOC[2] (mAHD) | Concrete collar (magl) | Concrete collar (mAHD) | Headworks (magl) | Drilled depth (m) | Casing depth (mbgl) | Screen interval | Drilling method | Aquifer | Status | Filter sock | Closest wetland |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC95D | 02/05/2012 | | | 290.79 | 0.82 | 291.61 | 0.13 | 290.92 | 0.76 | 32.0 | 30.2 | 28.2 – 30.2 | Air core | Saprolite | Monitoring | Yes | W121 |
| BMC95OB | 02/05/2012 | | | 290.83 | 0.54 | 291.37 | 0.11 | 290.94 | 0.46 | 6.0 | 3.9 | 1.1 – 3.9 | Air core | Surficial | Monitoring | No | W121 |
| BMC96D | 18/04/2012 | | | 293.08 | 0.62 | 293.70 | 0.12 | 293.19 | 0.48 | 36.0 | 31.3 | 27.3 – 31.3 | Air core | Saprolite | Monitoring | No | W024 |
| BMC96OB | 27/11/2012 | | | 293.24 | 0.48 | 293.72 | 0.10 | 293.34 | 0.41 | 6.0 | 3.8 | 1.0 – 3.8 | Hand auger | Surficial | Monitoring | Yes | W024 |
| BMC97D | 20/05/2012 | | | 293.51 | 0.65 | 294.16 | 0.16 | 293.67 | 0.53 | 27.0 | 26.1 | 24.1 – 26.1 | Air core | Saprolite | Monitoring | No | W024 |
| BMC97I | 20/05/2012 | | | 293.53 | 0.60 | 294.13 | 0.13 | 293.66 | 0.47 | 12.0 | 11.2 | 9.2 – 11.2 | Air core | Surficial | Monitoring | No | W024 |
| BMC98D | 23/05/2013 | | | 291.76 | 1.77 | 293.52 | 0.16 | 291.92 | 0.48 | 31.0 | 29.7 | 27.7 – 29.7 | Mud rotary | Saprolite | Monitoring | Yes | W127 |
| BMC98OB | 23/05/2013 | | | 291.74 | 0.57 | 292.30 | 0.14 | 291.88 | 0.45 | 6.0 | 5.5 | 1.5 – 5.5 | Air core | Surficial | Monitoring | Yes | W127 |
| BMC99OB | 27/04/2012 | | | 296.41 | 0.82 | 297.23 | 0.12 | 296.53 | 0.72 | 9.0 | 7.0 | 4.0 – 7.0 | Mud rotary | Surficial | Monitoring | Yes | W128 |
| BMC100D | 27/04/2012 | | | 298.27 | 0.77 | 299.03 | 0.11 | 298.38 | 0.75 | 39.0 | 38.5 | 36.5 – 38.5 | Mud rotary | Saprolite | Monitoring | Yes | W023/W024 |
| BMC100OB | 27/04/2012 | | | 298.31 | 0.80 | 299.11 | 0.13 | 298.44 | 0.74 | 12.0 | 6.0 | 2.0 – 6.0 | Air core | Surficial | Monitoring | Yes | W023/W024 |
| BMC101OB | 28/04/2012 | | | 299.84 | 0.83 | 300.67 | 0.17 | 300.01 | 0.86 | 12.0 | 11.5 | 7.5 – 11.5 | Air core | Surficial | Monitoring | Yes | W130 |
| BMC102OB | 28/04/2012 | | | 300.62 | 0.85 | 301.47 | 0.18 | 300.80 | 0.80 | 7.0 | 5.7 | 1.7 – 5.7 | Air core | Surficial | Monitoring | Yes | W130 |
| BMC103OB | 28/04/2012 | | | 296.15 | 0.82 | 296.96 | 0.13 | 296.28 | 0.79 | 6.0 | 5.4 | 1.4 – 5.4 | Air core | Surficial | Monitoring | Yes | W023 |
| BMC104D | 01/05/2012 | | | 286.66 | 0.81 | 287.47 | 0.12 | 286.78 | 0.79 | 36.0 | 28.1 | 22.1 – 28.1 | Mud rotary | Saprolite | Monitoring | Yes | W119/W118 |
| BMC104OB | 01/05/2012 | | | 286.67 | 0.85 | 287.51 | 0.12 | 286.79 | 0.83 | 6.0 | 5.7 | 1.7 – 5.7 | Mud rotary | Surficial/ sedimentary | Monitoring | Yes | W119/W118 |

[1] Units are in metres above ground level (magl) and metres Australian Height Datum (mAHD)
[2] Top of casing (TOC)

# 3 Geology and Regolith

## 3.1 Setting

The HWS lies within the zone of ancient drainage where Archaean (3,084 ± 191 my) granites and gneisses of the Yilgarn Craton predominate (Carter & Lipple, 1982). The Darling Fault, which marks the western edge of the Yilgarn Craton, is about 17 kilometres west of the BMNDRC boundary (Speed & Strelein, 2004).

## 3.2 Geology

The Yilgarn Craton contains series of Proterozoic (2,500 to 543 Ma) dolerite dykes that intrude the Archaean basement and increase in abundance westwards towards the Darling fault (McConnell & Pillai, 1995; Speed & Strelein, 2004). These dykes range in thickness between 1 and 10 m and are oriented in a general north to north-westerly direction, the same as the prevailing fracture/joint pattern (Carter & Lipple, 1982). The perpendicular E-W trending dykes of the Widgiemooltha dyke swarm are less prominent.

North, northwest trending mafic dolerite dykes are mapped (Carter & Lipple, 1982) in the western boundary of HWS subcatchment 2. A north, northeast trending fault is mapped immediately west of these dykes (Carter & Lipple, 1982). Outcrops of Archaean crystalline bedrock occur at the boundary between HWS subcatchments 1 and 5 within an area of remnant 'York Gum' vegetation. Younger sedimentary rocks, consisting of chert, siltstone and carbonates, typical of the Middle Proterozoic Moora Group (Carter & Lipple, 1982) were observed at the western boundary of HWS subcatchment 2 and boundary between subcatchments 1 and 2 (sample photographs in Appendix F).

## 3.3 Regolith

### 3.3.1 Basement and saprolith

Competent crystalline basement in the HWS was intersected at depths from 27 to 39 metres below ground level (mbgl) (Table 1 and Appendix H). Immediately above the crystalline basement, within the saprolith, the weathering front consisted of saprock, typically comprising of <20 % of weatherable minerals being altered, and above this horizon lay saprolite, where >20% of weatherable minerals being altered (e.g. Anand & Paine, 2002). The proportion of clay increased towards the upper areas of the saprolite and terminated at a sharp boundary with the overlying silcrete hardpan.

### 3.3.2 Silcrete hardpans

Silcrete hardpans were intersected in all piezometers and were assumed to be the lower boundary of the pedolith. Silcrete hardpans, although differentiating in the thickness, colour and degrees of cementation appeared to have a horizontal alignment and were laterally extensive. Hardpans were typically partially cemented in upper horizons, becoming increasingly consolidated with depth. Silcrete hardpan thickness ranged from 6 m at BMC97 to 19 m at BMC100 (Appendix H and Appendix I).

### 3.3.3 Pedolith

The upper pedolith in the study area typically consisted of quartz-rich surficial sediments, underlain by a mottled zone and lateritic gravel. Sediments became increasingly cemented at depth, forming completely cemented silcrete hardpans. The exception to this pattern was site BMC104, where the regolith was more typical of a sediment-dominated regolith-landform terrain (e.g. Anand & Paine, 2002). This terrain was characterised by lacustrine, aeolian and/or fluvial sediments and variably cemented horizontal beds, underlain by a variably cemented silcrete hardpan then the saprolith as discussed above.

# 4 Hydrogeology

Two types of aquifers identified in the HWS are the shallow unconfined surficial aquifer and the deeper saprolite aquifer (Figure 8 to Figure 11). Silcrete hardpans occurred at the base of surficial sediments (e.g. Bennett & Goodreid, 2009; Bennett, Speed, A., & Taylor, 2005). There is low confidence in the defined lower boundary of the surficial aquifer due to the heterogeneous and often 'leaky' nature of these silcrete hardpans. Based on evidence elsewhere in the BMNDRC (Bourke, 2011; Speed & Strelein, 2004; URS, 2008) and presence of low permeability materials in the upper profile, it was assumed that the saprolite aquifer is semi-confined.

## 4.1 Surficial aquifer

Surficial sediments thickness averaged 8 m, ranging from 4 m at BMC102 (located in a sandplain seep), to 10 m at BMC95, BMC96, BMC97 and BMC98 (Appendix H and Appendix I). Sedimentary sequences encountered at BMC104 were 9 m thick, terminating at a partially cemented hardpan at 13 mbgl. The sedimentary sequences were assumed hydraulically connected to the overlying surficial aquifer and consequently were considered as a single hydrogeological unit.

Saturated aquifer thickness, based on water table observations in October 2012, within the surficial aquifer ranged from 3.5 m (BMC102ob) to 12 m (BMC104ob). The water table generally mimics surface topography, sloping eastwards from 304 metres Australian Height Datum (mAHD) near wetland W131 to 284 mAHD near wetland W118 (Figure 12). The water table gradient falls in a north-easterly direction from wetland W149 towards wetland W118. Depth to the water table ranged from 0.45 metres below ground level (mbgl) at bore hole BMC102ob to 4.75 mbgl at BMC100ob. Shallow depths (<1 mbgl) to the water table were interpolated proximal to all wetlands; within the valley floor east of wetlands W127 and W128; and about 900 m east of BMC102ob associated with a sandplain seep (Figure 13).

Groundwater salinity, as approximated by EC, was generally freshest in the west, increasing in an easterly direction, corresponding with interpreted groundwater flow direction (Figure 12). Salinity was freshest at borehole BMC100ob (EC 0.2 mS/cm) (Table 3), located west of wetland W023, and most saline (EC 11.4 mS/cm) at bore hole BMC104ob immediately east of wetland W118. Groundwater pH ranged from acidic (pH 5.54) to alkaline (pH 8.07) at sites BMC100ob and BMC102ob respectively; groundwater temperature ranged from 17.4 $^{o}$C to 22.5 $^{o}$C at sites BMC102ob and BMC101ob respectively (Table 3).

Recharge to the surficial aquifer is assumed to be from rainfall, from leakage via wetlands and leakage from surface water flows along drainage lines. Discharge occurs through transpiration from vegetation and evaporation from surface expressions of water (e.g. wetlands) and areas where high water tables occur (e.g. groundwater discharge areas). The consistent occurrence of upward head differentials (Table 2) indicates potential for upward leakage from the saprolite aquifer.

**Table 2. Summary of groundwater levels as metres below ground level (mbgl); and metres Australian height Datum, (mAHD), and difference between potentiometric head and water table elevation for October 2012**

| Site | Date | Water level (mbgl) | Water level (mAHD) | Head difference (m) |
|---|---|---|---|---|
| BMC95D | 10/10/2012 | 0.74 | 290.048 | +0.135 |
| BMC95OB | 10/10/2012 | 0.917 | 289.913 | |
| BMC96D | 10/10/2012 | 1.417 | 291.661 | +0.046 |
| BMC96OB | 10/10/2012 | 1.622 | 291.615 | |
| BMC97D | 11/10/2012 | 1.22 | 292.286 | +0.018 |
| BMC97I | 11/10/2012 | 1.265 | 292.268 | |
| BMC98D | 11/10/2012 | -0.885 | 292.642 | +1.828 |
| BMC98OB | 11/10/2012 | 0.923 | 290.814 | |
| BMC99OB | 11/10/2012 | 0.79 | 295.623 | N/A |
| BMC100D | 10/10/2012 | 4.732 | 293.537 | +0.024 |
| BMC100OB | 10/10/2012 | 4.75 | 293.561 | |
| BMC101OB | 10/10/2012 | 1.007 | 298.834 | N/A |
| BMC102OB | 11/10/2012 | 0.446 | 300.171 | N/A |
| BMC103OB | 11/10/2012 | 1.714 | 294.432 | N/A |
| BMC104OB | 10/10/2012 | 0.493 | 286.168 | +0.561 |
| BMC104D | 10/10/2012 | 1.06 | 285.607 | |

## 4.2 Saprolite aquifer

The saprolite aquifer thickness was observed to range from 3 m to 16 m at bore holes BMC98d and BMC96d respectively. Potentiometric head followed a similar trend to water table elevation being highest at bore hole BMC100d (293.5 mAHD), located west of wetland W024, decreasing to 286.2 mAHD immediately east of wetland W118. Artesian conditions were observed at BMC98d where potentiometric head was +0.89 m above ground surface and +1.83 m above the water table (Table 2). At all other sites potentiometric head was below ground level, ranging from 0.5 mbgl at bore hole BMC104d to 4.7 mbgl at bore hole BMC100d. Spatial distribution of groundwater salinity (approximated as EC) was similar to the water table, increasing from west to east, ranging from EC 5.5 mS/cm to 29.4 mS/cm at sites BMC100d and BMC98d respectively (Table 3); groundwater pH ranged from slightly acidic (pH 6.5) to slightly alkaline (pH 7.6) at sites BMC95d and BMC100d respectively; groundwater temperature ranged from 20.7 $^{o}$C to 23.2 $^{o}$C at sites BMC97d and BMC100d respectively.

Groundwater quality within the deeper, semi-confined saprolite aquifer was consistently more saline than the water table (Table 3). Recharge and discharge mechanisms for the saprolite aquifer are unknown although there is potential for exchange with the overlying surficial aquifer and wetlands through the ‘leaky’ silcrete hardpan. The calculated head differences between the unconfined and semi-confined aquifers are likely to be more pronounced if density-corrections are applied (Post, Kooi, & Simmons, 2007).

**Table 3. Summary of groundwater and surface water water quality measured October 10 and 11, 2012**

| Site ID | Date | Time (24hr) | EC (mS/cm) | pH | Redox (eh mV) | Temperature (°C) | Turbidity | Colour | Odour | Comment |
|---|---|---|---|---|---|---|---|---|---|---|
| BMC100D | 10/10/2012 | 12:30:00 PM | 5.54 | 7.49 | -262.00 | 23.20 | | | Strong H2S | 75 L removed. Pumping rate reduced at ~60 L |
| BMC100OB | 10/10/2012 | 11:45:00 AM | 0.20 | 5.54 | 172.00 | 21.20 | Low | Clear | None | 75 L removed. Very high pumping rate (i.e. high K value) |
| BMC101OB | 10/10/2012 | 1:00:00 PM | 4.50 | 6.95 | -13.00 | 22.50 | Low | Clear | None | 75 L removed |
| BMC102OB | 11/10/2012 | 9:00:00 AM | 4.16 | 8.07 | 96.00 | 17.40 | High | | None | 20 L removed |
| BMC103OB | 11/10/2012 | 8:20:00 AM | 2.82 | 6.10 | 157.00 | 17.80 | Low | Clear | None | 200 L removed. High production rates (i.e. high K), although took a little while for WQ to stabilise. |
| BMC104D | 10/10/2012 | 10:00:00 AM | 26.90 | 7.84 | -150.00 | 21.00 | Low | Grey/clear | Very strong H2S | 125 L removed. Still producing sufficient water @100 L (high K) |
| BMC104OB | 10/10/2012 | 9:30:00 AM | 11.43 | 7.03 | -31.00 | 19.30 | Low | Grey/clear | Slight H2S | 28 L removed. Purged dry @28 L, although appeared to recover rapidly |
| BMC95D | 10/10/2012 | 2:55:00 PM | 15.13 | 6.48 | -15.00 | 21.60 | Low | Clear | Strong H2S | 90 L removed |
| BMC95OB | 10/10/2012 | 2:25:00 PM | 7.66 | 6.76 | -43.00 | 19.60 | Low | Clear | None | 30 L removed |
| BMC96D | 10/10/2012 | 4:05:00 PM | 16.61 | 7.02 | -124.00 | 21.00 | High | Grey/black | Very strong H2S | 100 L removed |
| BMC96OB | 10/10/2012 | 3:30:00 PM | 3.29 | 6.81 | -16.00 | 18.15 | Low | Clear | None | 25 L removed. Pore bore construction has led to bore filling with over 2m of sediments |
| BMC97D | 11/10/2012 | 9:45:00 AM | 18.21 | 7.01 | -42.00 | 20.70 | Medium | Brown | None | 115 L removed. Pumping rate reduced significantly after 50 L |
| BMC98D | 11/10/2012 | 11:20:00 AM | 29.40 | 7.48 | 110.00 | 22.70 | High | Grey/black | Strong H2S | 50 L removed. Pump motor blew at 25 L and replacement pump only 13m long. May not be representative |
| BMC99OB | 11/10/2012 | 10:25:00 AM | 8.26 | 7.59 | 81.00 | 18.80 | High | Brown/red | Slight H2S | 30 L removed |
| W023 | 10/10/2012 | 1:55:00 PM | 4.57 | 8.37 | 42.00 | 22.80 | Low | Clear | None | Alkalinity 238.5mg/L using Bromophenol Blue |
| W024 | 10/10/2012 | 4:39:00 PM | 1.36 | 7.47 | -65.00 | 19.20 | High | Tannin stained | None | |
| W129 | 10/10/2012 | 1:45:00 PM | 3.28 | 7.73 | 27.00 | 20.50 | Low | Clear | None | |
| W130 | 10/10/2012 | 1:30:00 PM | 2.32 | 8.80 | -3.00 | 21.60 | High | | None | |

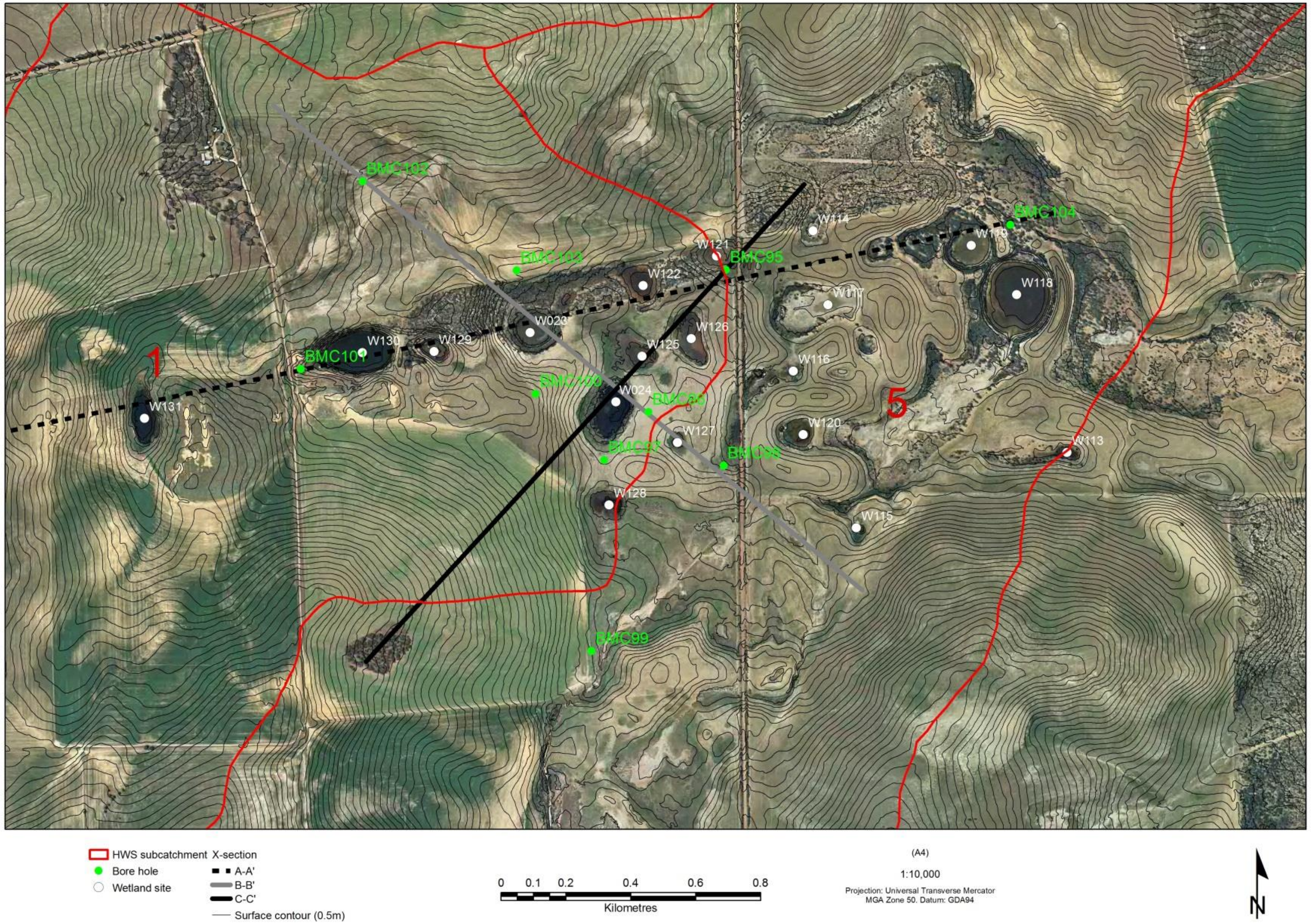


**Figure 8. Locations of cross-sections A-A', B-B' and C-C'.**

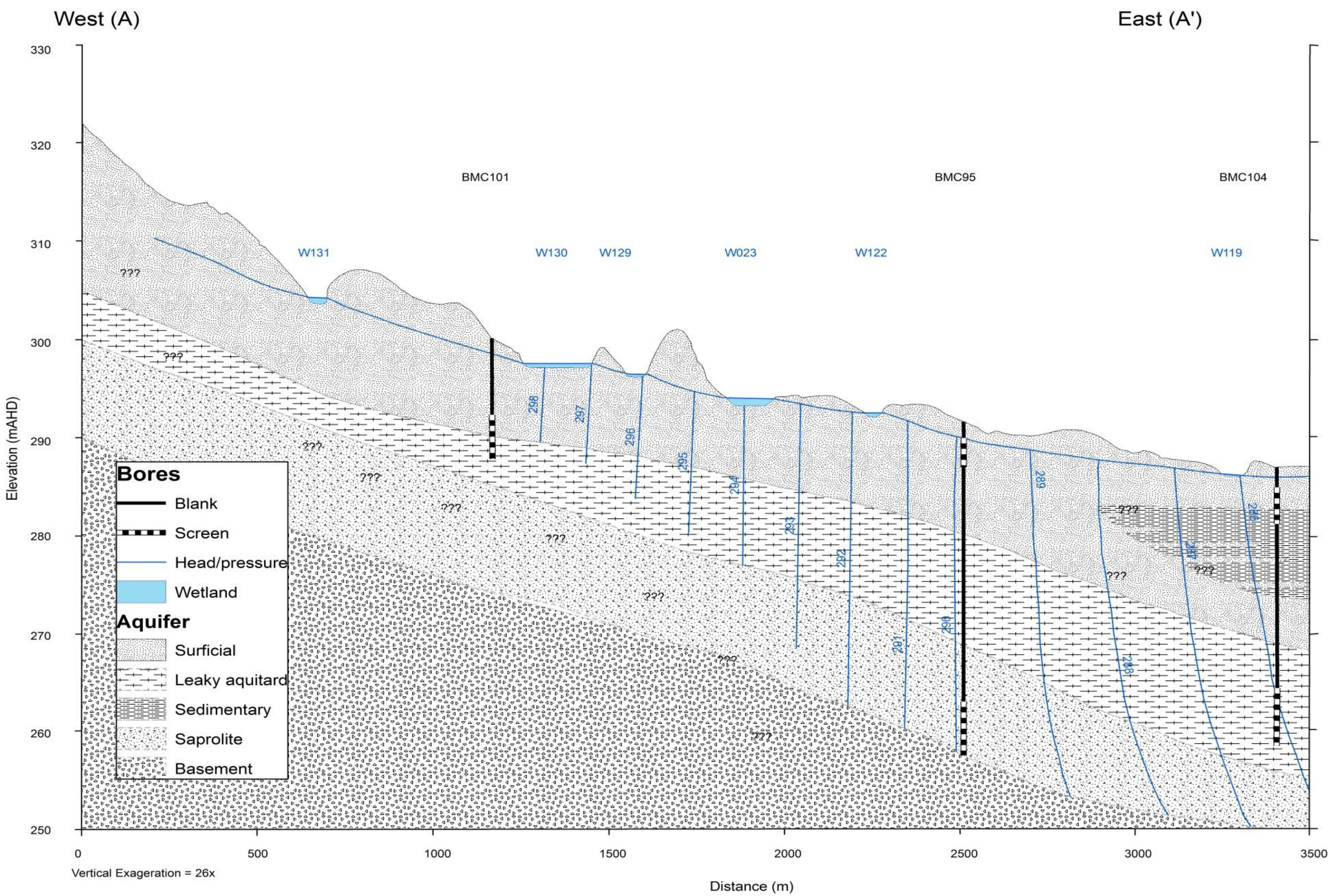


**Figure 9. Conceptual hydrogeological cross section A – A' with water table elevation, piezometric head and locations of wetlands (W*xx*) and piezometers (BMC*xx*)**

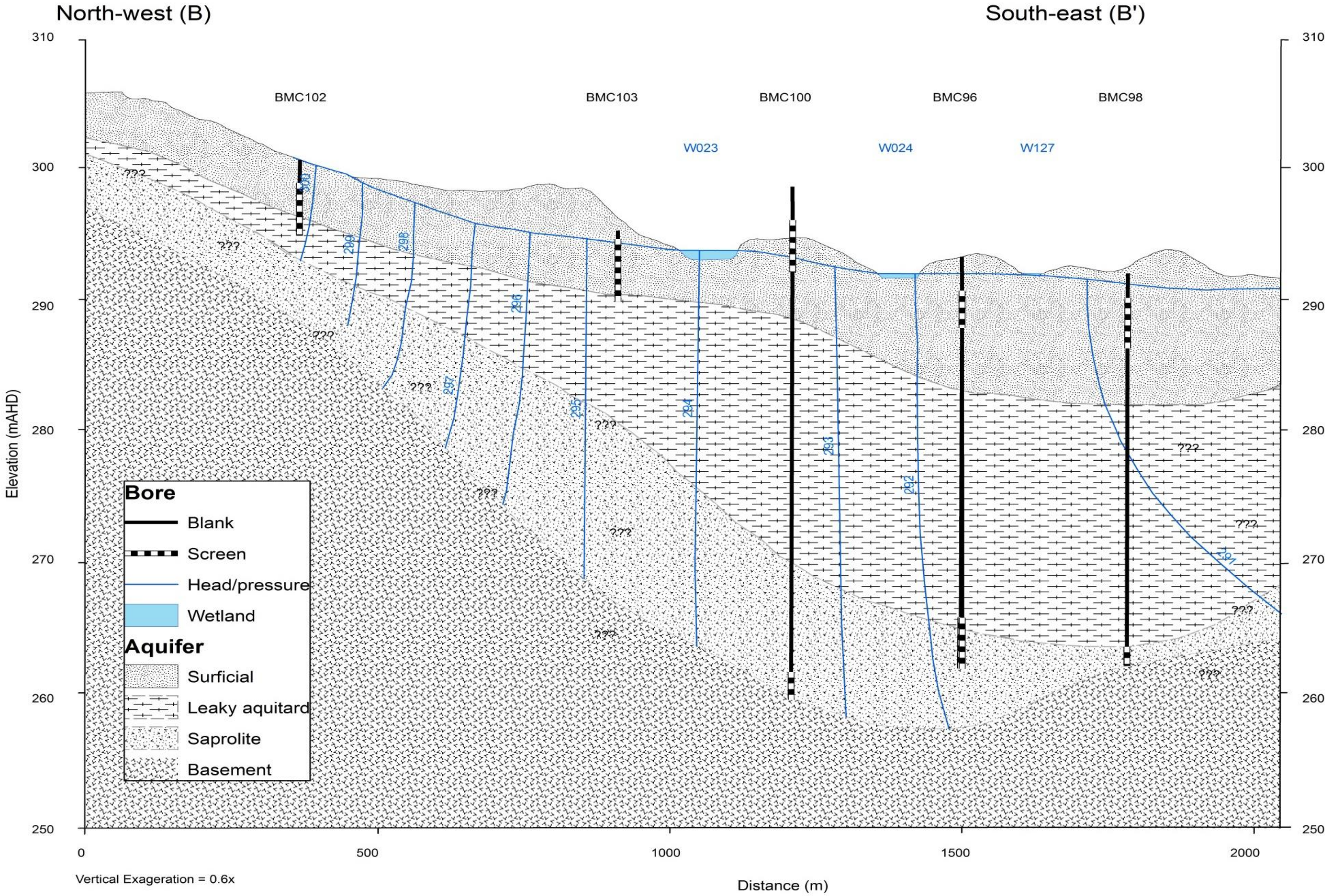


**Figure 10. Conceptual hydrogeological cross section B – B' with water table elevation, piezometric head and locations of wetlands (W*xx*) and piezometers (BMC*xx*)**

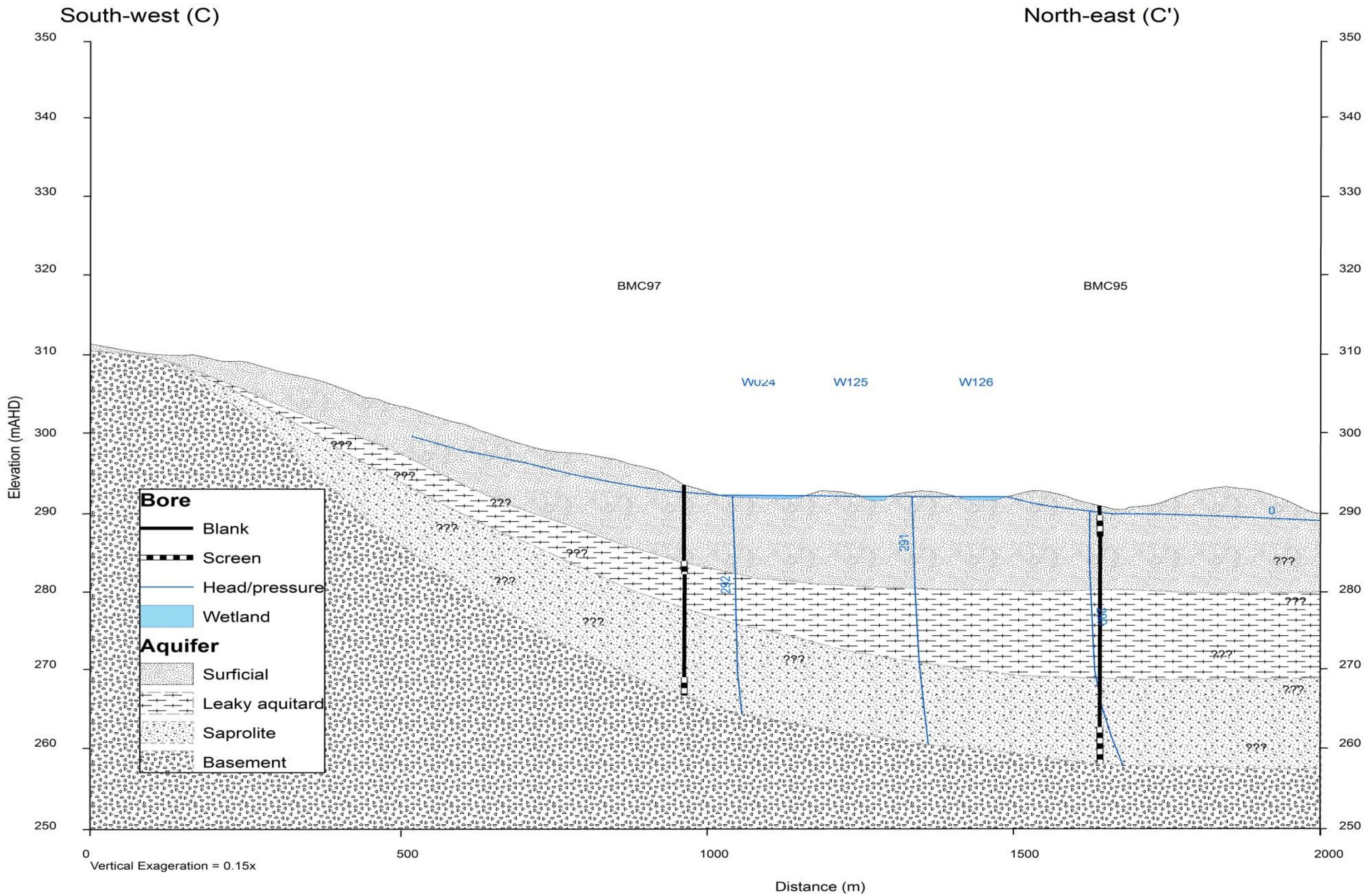


**Figure 11. Conceptual hydrogeological cross section C – C' with water table elevation, piezometric head and locations of wetlands (W*xx*) and piezometers (BMC*xx*)**

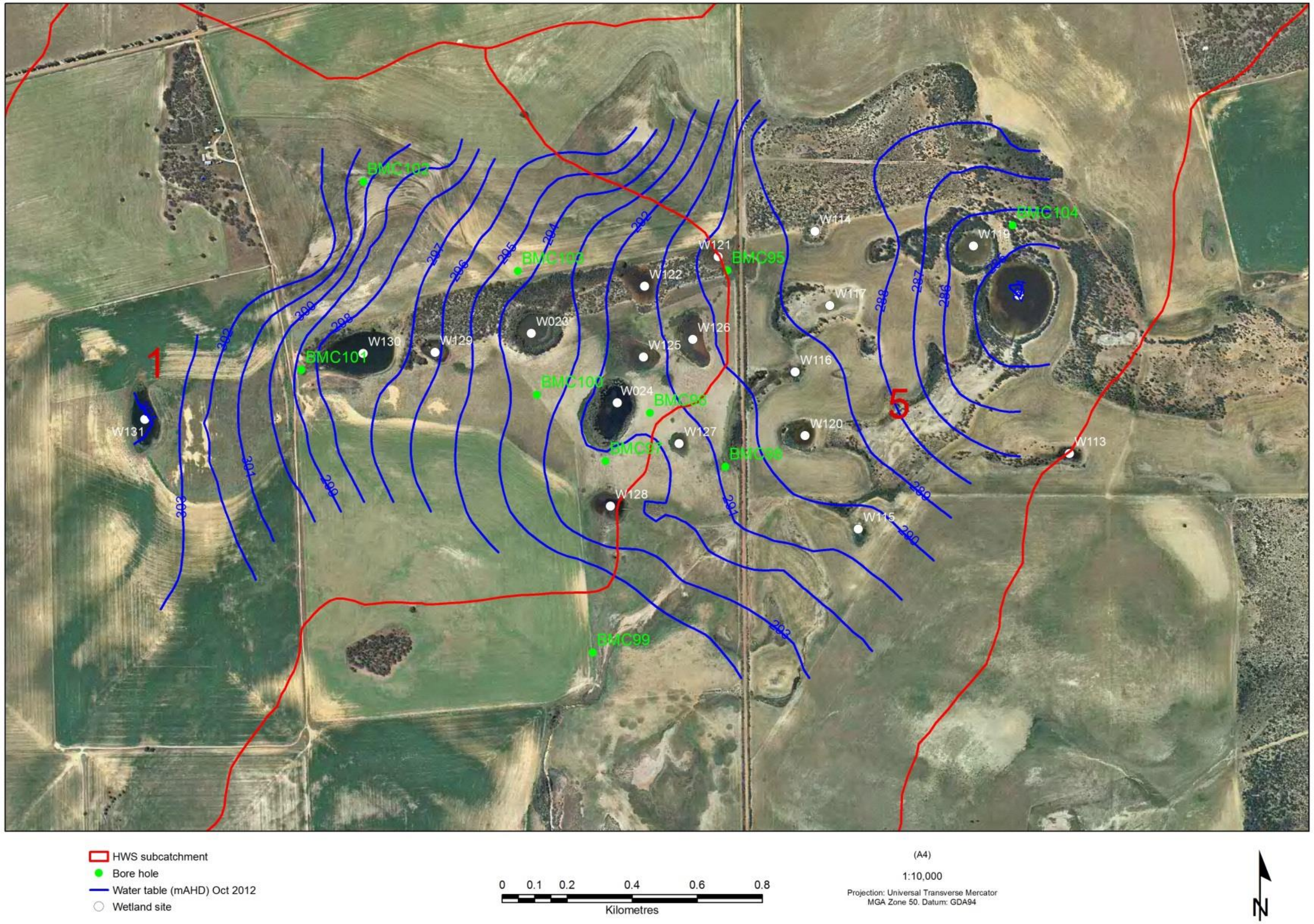


**Figure 12. Interpolated water table elevation (mAHD) based on water levels observed in October 2012**

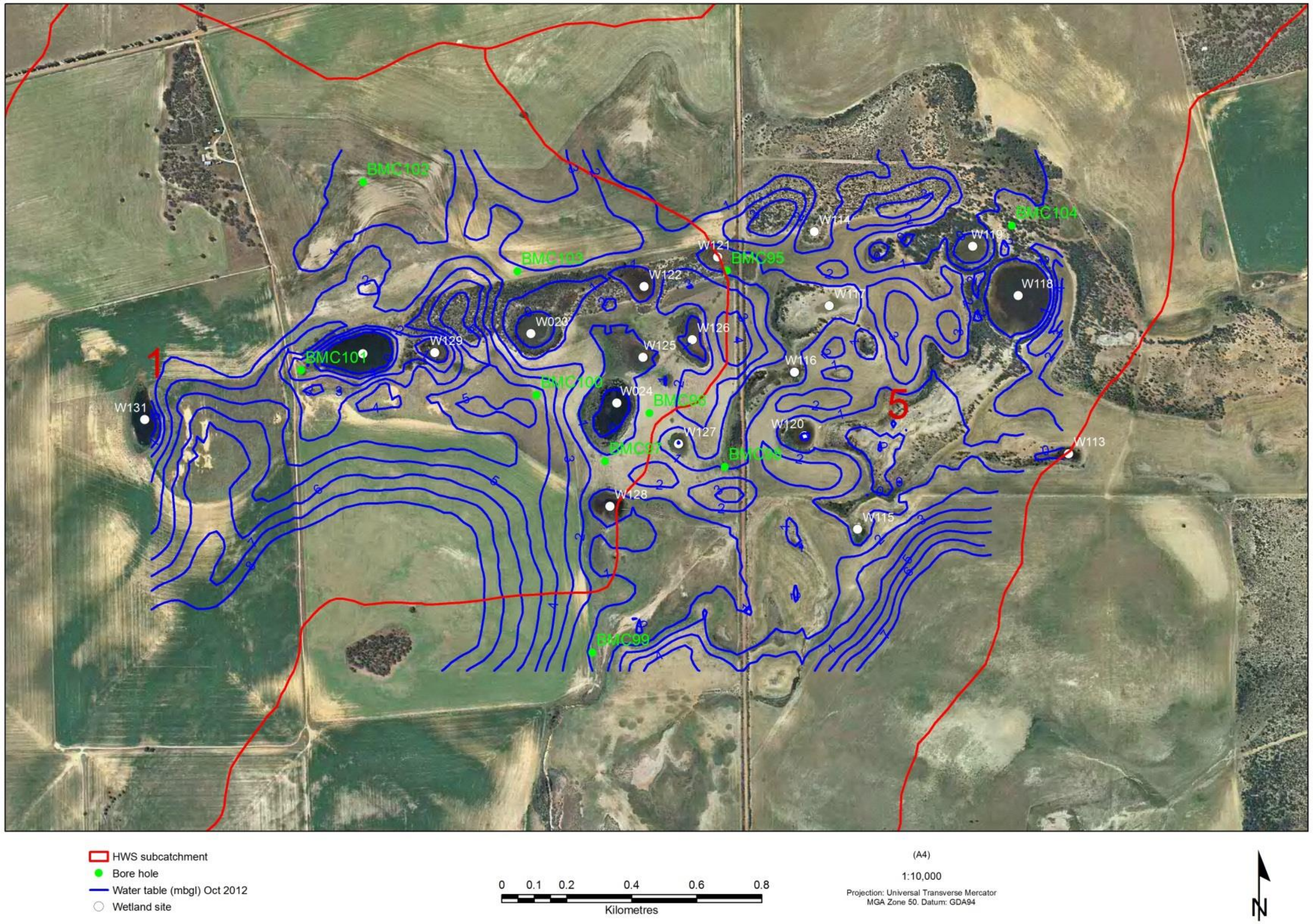


**Figure 13. Interpolated depth to water table (mbgl) based on water levels observed in October 2012**

# 5 Hydrochemistry

## 5.1 Major ions and nutrients

Chemical analysis indicated that groundwater and surface water composition is dominated by $Cl^-$ and $Na^+$ (average 82%) (Figure 14, Table 7 and Appendix K). A strong correlation between EC and calculated Total Dissolved Solids (TDS) ($y$ = 614.14$x$–145.83, $r^2$ 0.9992) (Figure 16, Appendix K) was observed. Ratios of $Cl^-/Br^-$ ranged from 150 at freshest site BMC100ob to 360 at BMC96ob, with an average of 298.5 (Appendix K). The lowest observed $Cl^-/Br^-$ ratio is likely due to high analytical error for analysis of $Br^-$ at low concentrations (Cartwright, Weaver, & Fifield, 2006). The average is a signature typical of rainfall (Cartwright et al., 2006; Davis, Whittemore, & Fabryka-Marton. J., 1998; Mazor & George, 1992).

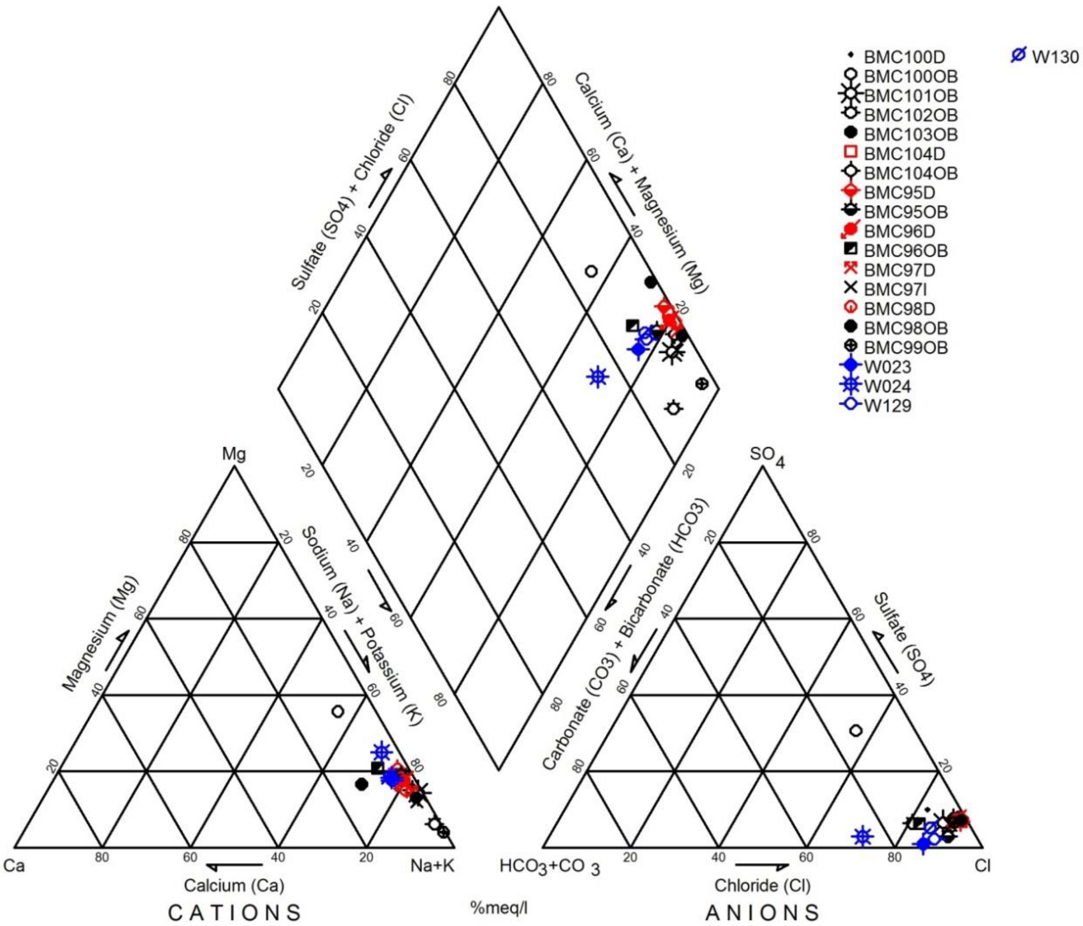


**Figure 14. Piper trilinear plot of major ions in groundwater and wetlands sampled in October 2012.**

Major ion ratios were observed to differ from seawater (Hingston & Gailitis, 1976). Ratios of $K^+$ and $SO_4^{2-}$ to $Cl^-$ were depleted relative to seawater (Figure 18 and Figure 19, Appendix K); $Cl^-/Mg^{2+}$ ratios were either equivalent to seawater or depleted relative to seawater; whilst both enrichment and depletion of $Cl^-/Ca^{2+}$ ratios was observed relative to seawater (Figure 20 and Figure 21, Appendix K).

Total Nitrogen (TN) ranged from 0.2 mg/L at BMC104ob to 11 mg/L at BMC103ob (Table 7, Appendix J). Total Phosphorous (TP) ranged from below detection limits (<0.005 mg/L) to 0.34 mg/L at BMC97d (Table 7, Appendix J). The ANZECC/ARMCANZ (2000) default physico-chemical trigger values for slightly disturbed Western Australian ecosystems are 0.35 mg/L for TN and 0.01 mg/L for TP (Aquatic Research Laboratory, 2009). Of the 20 groundwater and wetland sites sampled, 16 sites exceeded the TN threshold, and 15 were equal to or exceeded the TP threshold.

# 6 Discussion

## 6.1 Regolith

The regolith of the HWS intersected during the 2012 drilling campaign was typical of a deep-weathering profile in the Yilgarn Craton (Anand & Paine, 2002). The observed profile consisted of crystalline bedrock, overlain by the saprolith and quartz-rich pedolith. Silcrete hardpans which are a common feature of the Yilgarn Craton and the BMNDRC (e.g. Bennett & Goodreid, 2009; Speed & Strelein, 2004; URS, 2008) were intersected at all bore holes drilled to crystalline basement. These hardpans appeared to have a horizontal alignment and be laterally extensive which may suggest some water table control over silification (Anand & Paine, 2002). This hardpan was assumed to be the lower boundary of the pedolith.

## 6.2 Aquifers

Two aquifers were identified in the HWS, which are the shallow surficial aquifer and deeper semi-confined saprolite aquifer. Sedimentary sequences were identified near wetland W118, but were not extensive. The occurrence of these sediments appears to be associated with the lacustrine setting. The shallow unconfined surficial aquifer of the HWS, comprised of sandy quartz-rich sediments, is formed through secondary physical and biogeochemical processes. This aquifer ranged from very fresh to hyposaline (<10,000 mg/L) and is considerably fresher than the aquifers associated with many other wetlands of the BMNDRC (Bourke, 2011; URS, 2008). Hydraulic conductivity of the surficial aquifer was not tested, however in the nearby Nabappie Wetland Suite (NWS), horizontal hydraulic conductivity ($K_{hoz}$) of 0.15 m/day was adopted for this aquifer (Bourke, 2011). Elsewhere in the BMNDRC $K_{hoz}$ has been found to be considerably higher (URS, 2008).

The saprolite aquifer was assumed to be semi-confined and occurred within the saprock and saprolite immediately above crystalline bedrock. The proportion of clay increased in the upper areas of the weathered profile, terminating at a sharp boundary with the overlying silcrete hardpan. The consistent occurrence of upward heads indicates potential for upward leakage of more saline water from the saprolite aquifer to the surficial aquifer and wetlands. Hydraulic conductivity ($K_{hoz}$) of this aquifer was not tested within the HWS. Throughout the wheatbelt region $K_{hoz}$ of the saprolite aquifer has been found to be highly variable (Bennett & Goodreid, 2009; George, 1992a, 1992b) and within the BMNDRC $K_{hoz}$ has been found to range from 0.003 m/day (Bourke, 2011) to 2.2 m/day (URS, 2008).

The hydraulic properties of silcrete hardpans is unknown, therefore there is low confidence in interpretations of surficial aquifer thickness. Silcrete hardpans are generally less permeable than the overlying surficial sediments. This decrease in permeability leads to reduced vertical hydraulic conductivity, enhanced lateral interflow and groundwater flow within the surficial aquifer (e.g. Clarke, George, Bennett, & Bell, 2000; George, 1992b). Although fractures and other preferential flow paths, such as root channels, result in hardpans behaving like 'leaky aquitards' enabling vertical exchange of groundwater between the surficial aquifer and the underlying semi-confined saprolite aquifer (Bennett et al., 2005; Wildy, Pate, & Bartle, 2004).

The HWS is considered to be a closed catchment with respect to surface water and wetland W118 is considered to be a terminal wetland. With respect to groundwater, wetland W118 occurs at the catchment outlet and groundwater flow is assumed to continue in an easterly direction towards the main braided drainage line of the BMNDRC. The presence of hypersaline water in this wetland and the likely occurrence of very low hydraulic gradients and low hydraulic conductivities, suggests that groundwater outflow rates are likely to be a minor component of the water balance of the HWS. Further work will be required, particularly with respect to determining the hydraulic conductivity of the aquifers, to validate these assumptions.

### 6.3 Hydrochemistry

Ion concentrations were observed to increase in a general easterly direction, conforming to groundwater flow direction. This trend may be due to a combination of processes such as the mobilisation of salts stored in the soil profile, evaporation occurring in wetlands (Rich, 2004) or from shallow water tables (e.g. Chen, 1992), dissolution and precipitation of evaporates (Salama, Farrington, Bartle, & Watson, 1993) and the exclusion of $Cl^-$ by roots during plant water uptake (Bennetts, Webb, Stone, & Hill, 2006). The climate of the area is typical of the semi-arid environments with very high evaporation rates (see Section 1.3) and rainfall deficits occurring throughout most months of the year. Evaporation is therefore a significant component of the water balance and therefore likely to be a major contributor to the elevation of salinity along the flow path.

The observed $Cl^-/Br^-$ ratio in groundwater and surface water in the HWS is typical of the signature of rainfall observed in the central wheatbelt (Mazor & George, 1992) and elsewhere in Australia (Cartwright et al., 2006). The dissolution of halite significantly increases this ratio by a number of orders of magnitude (1,000 – 10,000) (e.g. Cartwright et al., 2006; Davis et al., 1998), therefore indicating that halite is not a major source of salts in the HWS. Conversely other $Cl^-$/ion ratios, particularly $Ca^-$, $SO_4^{2+}$, $K^+$ and $Mg^{2+}$, in groundwater and wetlands in the HWS deviated from those of seawater, indicating the importance of mineral-water interactions (e.g. Cartwright et al., 2004; Herczeg, Dogramaci, & Leaney, 2001). Further work is required to characterise regolith mineralogy in order to better understand the evolution of water fluxes in the HWS.

Elevated concentrations of both nitrogen and phosphorous, above likely background levels, were observed in groundwater and wetlands. This is consistent with previous studies both within the HWS and other wetlands of the BMNDRC (Aquatic Research Laboratory, 2009; Bourke, 2011). Nutrient concentrations predominantly exceeded the ANZECC/ARMCANZ (2000) physico-chemical trigger values for slightly disturbed Western Australian ecosystems. Observations of suspended algae in wetland W130 during this study indicate that phosphorous may not be a limiting nutrient, with potential for eutrophication, particularly at the end of spring as wetland levels recede and water temperature rises (Aquatic Research Laboratory, 2009). The spatial and temporal distribution of nutrients in groundwater and wetlands is unknown. The source of nutrients requires further investigation.

# 7 Conclusion

This study described the structure and lithology of the surficial and semi-confined saprolite aquifers intersected during the drilling and construction of 16 groundwater monitoring bores in the subcatchment of the HWS. The collection of water level, water quality and hydrochemistry data (major ions and nutrients) in groundwater and wetlands occurring in the HWS provides a baseline of current conditions. This new information further advances the initial conceptual hydrogeological model of the catchment and its wetlands developed by Bourke (2012).

The observed regolith and aquifer characteristics are similar to other areas within the BMNDRC, particularly those of the Balgerbine soil system. Groundwater and surface water salinity was observed to increase along a flow path from areas of recharge to discharge. This is due to the combination of a number of processes, although long-term accumulation of salts from rainfall and subsequent evaporation from open water bodies and shallow water tables are the major contributors. $Cl^-/Br^-$ ratios indicated that the precipitation and dissolution of halite was unlikely to be a major source of solutes. Ratios of other major ions indicated the importance of mineral-water interactions to the hydrochemistry of groundwater and surface water, particularly in proximity to wetland W024. Further work is required to characterise regolith mineralogy in order to better understand the evolution of these water fluxes in the HWS.

Nutrient (N and P) concentrations in most cases were observed to exceed the ANZECC/ARMCANZ (2000) trigger values for slightly disturbed Western Australian ecosystems. The presence of suspended algae in one wetland indicates that P may not be a limiting nutrient therefore eutrophication is a potential threat to the biological values of wetlands W023 and W024. Further investigations are therefore recommended to better understand the spatial and temporal distribution of nutrients and their interaction with aquatic and terrestrial biota.

Wetlands W023 and W024 within the HWS are considered by DPaW to be the highest priority area for management intervention within the BMNDRC. The establishment of infrastructure and the interpretation of baseline data derived from this study form the framework for future hydrogeochemical investigations and ongoing monitoring required to assess the risk and likelihood of altered hydrology, resultant from historical land use changes, to these wetlands and their associated biodiversity values.

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# Appendix A

**Synthesis of previous hydrogeological investigations**

In 1999 approximately 62 groundwater monitoring bores were drilled throughout the western portion of the BMNDRC (Bourke, 2003). These bore were installed on properties of farmers participating in the Marchagee Catchment "Bushcare" Group (MCG), which was supported by funds from the National Heritage Trust. Of these bores, ten were installed nearby the HWS, comprising seven shallow monitoring bores drilled up to seven metres deep and three deep monitoring bores drilled to a maximum depth of 20 m. Groundwater levels were measured monthly by landholders from mid-1999, but largely ceased by late 2002. Groundwater levels and water quality (pH and EC) were measured in April 2003 (Bourke, 2003). DPaW has since collected water level data from these bores on an ad-hoc basis.

In 2002, the DPaW installed 89 groundwater monitoring bores across the BMNDRC as part of a regional-scale hydrogeological investigation (Speed & Strelein, 2004). This investigation included interpretations of the hydrostratigraphy across seven transects. Ongoing monitoring of groundwater levels by DPaW since 2002 provides a historical context to groundwater trends within the HWS.

In 2003, the Department of Agriculture and Food (DAFWA) installed groundwater monitoring bores at 11 sites on the Calecono farm, located ~ 8.5 km east of the HWS (Bennett & Goodreid, 2009). This study consisted of a drilling program, establishment of a piezometer network, ground-based geophysics surveying, silcrete hardpan investigation and preliminary groundwater modelling using Flowtube. Analysis was undertaken to assess the influence of oil mallee plantings upon the hydrology and agricultural productivity of the property.

In 2006, 45 groundwater monitoring bores were installed across five representative wetland areas within the BMNDRC (URS, 2008). Seven bores were installed in a subcatchment located to the immediate north of the HWS containing wetlands W011 and W012. This investigation included hydrostatigraphic interpretations across a number of cross-sections; analysis of major ion chemistry in groundwater; aquifer testing (slug tests and laboratory falling head measurements); and completion of preliminary catchment-scale water balances. DPaW has continued to collect regular 6-hourly water levels from this network of groundwater monitoring bores as well as hourly surface water levels from a number of wetlands, including two wetlands (W011 and W012) within the subcatchment adjacent to the HWS since 2006. Logged data is verified against regular manual measurement of water levels.

A detailed hydrogeochemical investigation was conducted on a subset of bore holes and wetlands at the Nabappie wetland suite (Bourke, 2011), located approximately 10 km north of the HWS. Groundwater chemistry (major ions, stable isotopes ($\delta^{18}O$ and $\delta^{2}H$) and nutrient analysis), repeated aquifer testing (slug tests) and measurement of high resolution (hourly) groundwater and surface water levels occurred over a nine month period in 2009.

# Appendix B

## Drilling and bore construction

*Drilling and bore construction*
All bore holes were drilled and constructed to meet the minimum requirements for the construction of water bores (National Uniform Drillers Licensing Committee, 2012). Drilling within the study area occurred from April 16 to May 3, 2012. Austral Drilling Services deployed a truck mounted Schramm drilling rig with an on-board 900 cfm x 350 psi compressor using a specially designed ARDLL 114 mm air core system. Air core was the dominant drilling system used. The presence of unstable sand in the upper soil horizons required the use of mud rotary drilling methods. Mud rotary drilling first required a pilot hole (114 mm air core, 8 ½" spade bit or 9 $^{7}/_{8}$" spade bit) and emplacement of a 150 mm PVC collar. The PVC collar was cement grouted and allowed to cure overnight. Air-core was again engaged to drill through the cement collar to the end of hole. The drilling fluid "Liqui-Pol" was used as the drilling mud to stabilise the annulus.

Upon reaching the target depth, 50 mm Class 9 uPVC casing was run to the bottom of hole inside the centre of the 68 mm inside diameter (ID) drilling rods. The drill string was then removed leaving the PVC in place. Slotted sections consisted of 50 mm Class 9 uPVC with 1 mm wide machined slots. A 40 mm end cap was glued inside the bottom of each bore casing and a 50 mm cap fitted to the top. Slots were cut in bottom caps of bores installed in the surficial aquifer to permit drainage should the water table fall below the bottom of casing. A geofabric filter-sock was fitted to the slotted section of most bores to prevent ingress of fine sand into the PVC casing (Table 1).

The PVC casing at site BMC96ob was removed and reinstalled by DPaW on 27 November 2012 using hand auger methods. A section of 90 mm storm pipe was augered to the bottom of hole then 50 mm uPVC casing was run inside the outer casing to the bottom of hole. The outer 90 mm casing was removed, leaving the bore casing in place at the target depth.

*Bore completion*
Sixteen (16) groundwater monitoring bores were installed across the HWS (Table 1 and Figure 7). Six deep bores were drilled to crystalline basement and screened across a discrete portion of the saprolite aquifer. Graded gravel (1.6 – 3.2 mm) was run to the bottom of hole to cover at least 0.5 m above the slotted sections and sealed above with a bentonite plug. An extension was fitted to the casing of site BMC98d due to the occurrence of artesian conditions.

Each deep bore was paired with a shallow piezometer screened across the surficial aquifer immediately above the consolidated, silcrete hardpan. Shallow piezometers were installed in the unconfined surficial aquifer at four additional sites, bringing the total to ten shallow piezometers. Nine shallow piezometers were screened throughout the profile to ~1 m below surface, whilst bore BMC97i was screened at a discrete interval and sealed above with a bentonite plug. The annulus of all piezometers were backfilled with graded gravel (1.6 – 3.2 mm) and natural fill to the surface.

Piezometers were developed using compressed air and completed with lockable galvanised steel headworks (0.1 m x 0.1 m x 1.0 m or 1.3 m high), installed at least 0.4 m into the ground with a cement collar constructed to ensure top tube stability and to prevent surface water inflow down the bore annulus.

*Survey*

Concrete standard survey markers (SSM's) were installed adjacent to wetlands W023, W024, W125, W129 and W130 and next to an automated weather station (Figure 7). All SSM's, groundwater monitoring bores and graduated marker boards within wetlands were surveyed and projected to Map Grid of Australia (MGA-94, AusGeod98) and levelled relative to Australian Height Datum (AHD) (Bourke, 2013). The accuracy of surveyed elevation is ±0.02 m or better.

# Appendix C

## Hydrochemistry sampling and analysis

### Major ions

Major Anions ($Cl^-$, $Br^-$ and $SO_4^{2-}$) and Cations ($Li^+$, $Na^+$, $K^+$, $Mg^{2+}$ and $Ca^{2+}$) were analysed by the Department of Parks and Wildlife, Kensington Western Australia. Anions were determined by High Performance Ion Chromatography (HPIC) using a Dionex® ICS-1000 ion chromatograph equipped with Dionex AS-14, 4 x250 mm anion column and AG-14 guard column. The isocratic run used an eluent of 3.5 mM $NaCO_3$ and 1.0 mM $NaHCO_3$ at a flow rate of 1.5 ml /min. The HPIC method employed electronic suppression and conductivity detection. The instrument was calibrated with anion standards made from commercially available 1000 ppm standard solutions (ARC). Sample duplicates were run and reproducibility was better than 3%. Given the high dilutions involved in this analysis a confidence level of 0.1 mg/L is stated (Table 4).

### Laboratory EC and pH

EC was determined using a Schott® Handylab LF 11 conductivity meter with calibrated probe. Acidity was determined using a TPS pH meter equipped with a glass Schott® IoLine glass electrode with integrated temperature sensor.

**Table 4. Summary of hydrochemical analytes, relevant laboratories and their level of reporting (LOR)**

| Analyte | LOR (mg/L or ‰) | Field filtered (yes/no) | Laboratory |
|---|---|---|---|
| $Cl^-$ | 0.1 | Yes | DEC |
| $Br^-$ | 0.1 | Yes | DEC |
| $SO_4^{2-}$ | 0.1 | Yes | DEC |
| $Li^+$ | 0.1 | Yes | DEC |
| $Na^+$ | 0.1 | Yes | DEC |
| $K^+$ | 0.1 | Yes | DEC |
| $Mg^{2+}$ | 0.1 | Yes | DEC |
| $Ca^{2+}$ | 0.1 | Yes | DEC |
| TN | 0.025 | No | NMI |
| TKN (calc) | 0.025 | No | NMI |
| $NO_3^-$ (calc) | 0.010 | No | NMI |
| $NO_2$ | 0.010 | No | NMI |
| $NH_3$-N | 0.010 | No | NMI |
| TP | 0.005 | No | NMI |
| $PO_4$-P and SRP | 0.005 | No | NMI |

### Nutrients

Nutrients, consisting of Total Nitrogen (TN), Nitrite ($NO_2$), Ammonia ($NH_3$-N), Total Phosphorus (TP) and soluble/reactive P ($PO_4$-P and SRP) were analysed by the National Measurement Institute (NMI), Bentley Western Australia, according to their WL239 methods using a SKALAR autoanalyser, QuAAtro auto analyser and TUTTNAUER 2340 EK Autoclave. Three samples were selected by NMI as quality control replicate samples to validate their analysis methods (samples QC37 to QC39). Nitrate ($NO_3$) and Total Kjeldahl Nitrogen (TKN) was calculated as the residuals using the following equations:

**Equation 1**

$$NO_3 = TON - NO_2$$

**Equation 2**

$$TKN = TN - (NO_3 + NO_2)$$

Where *TN* is total nitrogen; *TON* is total organic nitrogen; and TKN is total Kjeldahl nitrogen.

# Appendix D

## Regolith profile EC and pH

*Methods*

Approximately 40 g soil samples were sieved (< 2 mm) and transferred to 120 mL polypropylene containers (Sarstedt part #75.9922.420) then oven dried ~40$^{o}$C for a minimum of 24 hr until a constant weight was achieved. A 10 g (± 0.2 g) subsample of dry soil was then weighed on an analytical balance (Mettler AE100 ± 0.1 mg) and 50 ml of de-ionised water added. Samples were shaken using a SP Tektator variable speed rocker and by hand for a minimum of one hour. Soil EC and pH were determined on the soil:water suspension with hand-held meters (EC with WTW LF318; and pH with Metrohm 744), calibrated twice daily. Eight blind replicate samples (samples QC33 to QC36) were prepared at a rate of 1:20 to test the repeatability of the laboratory analysis. The relative per cent difference (RPD) between the parent sample and blind replicate was calculated using Equation 3 (APHA, 2005).

**Equation 3**

$$RPD = \left(\frac{sample\ result - duplicate\ result}{(sample\ result + duplicate\ result) \div 2}\right) \times 100$$

*Quality Control*

The RPD measures of uncertainty for blind replicate samples ranged from 3.3% to 47.7% for soil $EC_{1:5}$ and 0.5% to 9.7% for soil $pH_{1:5}$ (Table 5). An uncertainty measure <10% is typically considered within acceptable limits, which was the case for pH results, however EC RPD exceeded this tolerance. This large range in error can be attributed to inherent regolith heterogeneity as well as errors associated with the analysis methodology, particularly peptization[2], hydrolysis[3], cation exchange and mineral dissolution (Rhoades, Chanduvi, & Lesch, 1999). Other potential contributors may include the adopted drilling methods, where water and drilling fluids were frequently introduced to the drill string. Therefore the large observed uncertainty in $EC_{1:5}$ means that this dataset and the following section should be considered as qualitative until further validation is undertaken.

*Regolith $EC_{1:5}$ and $pH_{1:5}$ summary*

Soil $EC_{1:5}$ was observed to range from 11 µS/cm to 2,380 µS/cm with a mean of 494 µS/cm. There was a general trend of lower salinities associated with sand, particularly shallow surficial sediments encountered at sites BMC96, BMC100, BMC101 and BMC103, and higher salinities associated with elevated clay content, cemented horizons which occurred at increased depth. The soil EC trend at site BMC104 differed from other sites with both high and low salinities being observed at a range of depths (refer to Table 6). The observed soil EC trend at this site is likely due to the occurrence of sedimentary sequences of sand, silt and clay, typical of the lacustrine/fluvial setting. Although high measurement uncertainty

[2] To disperse (a precipitate) to form a colloid
[3] Decomposition of a chemical compound by reaction with water

observed for samples taken at BMC104 (up to 43.7%) means that soil EC results be considered as indicative.

Soil $pH_{1:5}$ was observed to be highly variable, ranging from acidic at pH 4.85 to alkaline (pH 10.43) with the mean being slightly alkaline at pH 7.95. Variability was evident across many sites with few consistent relationships evident in the data. A depth versus pH relationship however was evident at site BMC103 where soil pH was most acidic at the surface (pH 5.52), becoming more alkaline with increasing depth. This trend is consistent with surface soil acidification which can be induced through agricultural landuse, resulting from changes to the nitrogen and carbon cycles (L. Hunt & Patterson, 2004).

**Table 5. Summary of relative precent difference (RPD) between parent and blind replicate (QC26-QC33) samples for soil $EC_{1:5}$ and $pH_{1:5}$.**

| Site | ID | Sample depth (mbgl) | Paired sample | Colour name | Texture | Sorting | Grain size | Dominant grain roundness/sphericity | $EC_{1:5}$ (µS/cm) | pH | RPD of EC (%) | RPD of pH (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC95 | BMC95_01 | 1 | QC26 | Yellow | Sand | Well sorted | Very fine to coarse sand | Subangular/low to Rounded/low | 59 | 5.65 | -3.33 | -9.71 |
| QC26 | QC26 | 1 | BMC95_01 | | | | | | 61 | 6.223 | | |
| BMC95 | BMC95_28 | 28 | QC27 | Yellow | Clay with quartz | Poorly sorted | Clay to cobble | Very angular/low to subangular/low | 510 | 7.96 | 4.00 | -2.70 |
| QC27 | QC27 | 28 | BMC95_28 | | | | | | 490 | 8.18 | | |
| BMC96 | BMC96_31 | 31 | QC28 | Light greenish grey | Clay with quartz | Poorly sorted | Clay to pebble | Angular/low to Rounded/low | 439 | 8.83 | -47.70 | 3.64 |
| QC28 | QC28 | 31 | BMC96_31 | | | | | | 714 | 8.514 | | |
| BMC98 | BMC98_01 | 1 | QC29 | Light grey | Sand | Well sorted | Very fine to coarse sand | Subangular/low to Subrounded/High | 230 | 7.13 | -15.63 | -3.72 |
| QC29 | QC29 | 1 | BMC98_01 | | | | | | 269 | 7.4 | | |
| BMC100 | BMC100_02 | 2 | QC30 | Yellow | Sand | Well sorted | Very fine to very coarse sand | Very angular/high to Rounded/high | 45 | 7.95 | 2.25 | 0.50 |
| QC30 | QC30 | 2 | BMC100_02 | | | | | | 44 | 7.91 | | |
| BMC101 | BMC101_01 | 1 | QC33 | Yellow | Sand | Well sorted | Very fine to very coarse sand | Subangular/low to Rounded/high | 38 | 6.66 | 8.22 | -1.34 |
| QC33 | QC33 | 1 | BMC101_01 | | | | | | 35 | 6.75 | | |
| BMC104 | BMC104_06 | 6 | QC31 | Light grey | Light sandy clay | Well sorted | Clay to medium sand | Subangular/high to Rounded/high | 313 | 8.03 | -43.70 | -2.34 |
| QC31 | QC31 | 6 | BMC104_06 | | | | | | 488 | 8.22 | | |
| BMC104 | BMC104_26 | 26 | QC32 | Light grey | Partially cemented duricrust | Poorly sorted | Clay to very coarse sand | Angular/low to Rounded/low | 1001 | 8.87 | -23.30 | 0.23 |
| QC32 | QC32 | 26 | BMC104_26 | | | | | | 1265 | 8.85 | | |

**Table 6. Regolith soil:water (1:5) EC and pH**

| Site | ID | Depth (m) | $EC_{1:5}$ (μS/cm) | pH |
|---|---|---|---|---|
| BMC95 | BMC95_01 | 00 - 01m | 59 | 5.65 |
| BMC95 | BMC95_02 | 01 - 02m | 49 | 5.57 |
| BMC95 | BMC95_03 | 02 - 03m | 116 | 7.44 |
| BMC95 | BMC95_04 | 03 - 04m | 239 | 7.00 |
| BMC95 | BMC95_05 | 04 - 05m | 339 | 7.79 |
| BMC95 | BMC95_06 | 05 - 06m | 423 | 4.85 |
| BMC95 | BMC95_07 | 06 - 07m | 236 | 6.20 |
| BMC95 | BMC95_08 | 07 - 08m | 412 | 7.72 |
| BMC95 | BMC95_09 | 08 - 09m | 272 | 7.60 |
| BMC95 | BMC95_10 | 09 - 10m | 322 | 7.67 |
| BMC95 | BMC95_11 | 10 - 11m | 249 | 9.41 |
| BMC95 | BMC95_12 | 11 - 12m | | |
| BMC95 | BMC95_13 | 12 - 13m | | |
| BMC95 | BMC95_14 | 13 - 14m | | |
| BMC95 | BMC95_15 | 14 - 15m | 332 | 8.22 |
| BMC95 | BMC95_16 | 15 - 16m | | |
| BMC95 | BMC95_17 | 16 - 17m | | |
| BMC95 | BMC95_18 | 17 - 18m | | |
| BMC95 | BMC95_19 | 18 - 19m | | |
| BMC95 | BMC95_20 | 19 - 20m | | |
| BMC95 | BMC95_21 | 20 - 21m | | |
| BMC95 | BMC95_22 | 21 - 22m | 616 | 10.43 |
| BMC95 | BMC95_23 | 22 - 23m | 606 | 7.81 |
| BMC95 | BMC95_24 | 23 - 24m | 1549 | 7.42 |
| BMC95 | BMC95_25 | 24 - 25m | 570 | 7.34 |
| BMC95 | BMC95_26 | 25 - 26m | 601 | 7.44 |
| BMC95 | BMC95_27 | 26 - 27m | 689 | 8.23 |
| BMC95 | BMC95_28 | 27 - 28m | 510 | 7.96 |
| BMC95 | BMC95_29 | 28 - 29m | 741 | 7.26 |
| BMC95 | BMC95_30 | 29 - 30m | 1042 | 6.52 |
| BMC95 | BMC95_31 | 30 - 31m | | |
| BMC95 | BMC95_32 | 31 - 32m | | |
| BMC96 | BMC96_01 | 00 - 01m | 87 | 7.34 |
| BMC96 | BMC96_02 | 01 - 02m | 90 | 5.17 |
| BMC96 | BMC96_03 | 02 - 03m | 11 | 6.66 |
| BMC96 | BMC96_04 | 03 - 04m | 62 | 6.17 |
| BMC96 | BMC96_05 | 04 - 05m | 400 | 6.41 |
| BMC96 | BMC96_06 | 05 - 06m | 159 | 7.91 |
| BMC96 | BMC96_07 | 06 - 07m | 237 | 7.38 |
| BMC96 | BMC96_08 | 07 - 08m | 176 | 6.43 |
| BMC96 | BMC96_09 | 08 - 09m | 402 | 7.45 |
| BMC96 | BMC96_10 | 09 - 10m | 196 | 7.12 |
| BMC96 | BMC96_11 | 10 - 11m | 162 | 7.58 |
| BMC96 | BMC96_12 | 11 - 12m | 191 | 7.40 |
| BMC96 | BMC96_13 | 12 - 13m | 880 | 7.16 |
| BMC96 | BMC96_14 | 13 - 14m | 65 | 8.37 |
| BMC96 | BMC96_15 | 14 - 15m | 145 | 8.42 |
| BMC96 | BMC96_16 | 15 - 16m | | |

| Site | ID | Depth (m) | $EC_{1:5}$ (µS/cm) | pH |
|---|---|---|---|---|
| BMC96 | BMC96_17 | 16 - 17m | | |
| BMC96 | BMC96_18 | 17 - 18m | | |
| BMC96 | BMC96_19 | 18 - 19m | | |
| BMC96 | BMC96_20 | 19 - 20m | | |
| BMC96 | BMC96_21 | 20 - 21m | 323 | 7.86 |
| BMC96 | BMC96_22 | 21 - 22m | 2200 | 8.13 |
| BMC96 | BMC96_23 | 22 - 23m | 2070 | 8.47 |
| BMC96 | BMC96_24 | 23 - 24m | 1067 | 7.95 |
| BMC96 | BMC96_25 | 24 - 25m | 1339 | 8.16 |
| BMC96 | BMC96_26 | 25 - 26m | 1056 | 9.07 |
| BMC96 | BMC96_27 | 26 - 27m | 117 | 8.48 |
| BMC96 | BMC96_28 | 27 - 28m | 579 | 8.58 |
| BMC96 | BMC96_29 | 28 - 29m | 350 | 8.68 |
| BMC96 | BMC96_30 | 29 - 30m | | |
| BMC96 | BMC96_31 | 30 - 31m | 439 | 8.83 |
| BMC96 | BMC96_32 | 31 - 32m | 37 | 8.16 |
| BMC96 | BMC96_33 | 32 - 33m | 159 | 8.56 |
| BMC96 | BMC96_34 | 33 - 34m | 82 | 8.08 |
| BMC96 | BMC96_35 | 34 - 35m | | |
| BMC96 | BMC96_36 | 35 - 36m | | |
| BMC97 | BMC97_01 | 00 - 01m | 135 | 7.33 |
| BMC97 | BMC97_02 | 01 - 02m | 76 | 7.2 |
| BMC97 | BMC97_03 | 02 - 03m | 91 | 7.37 |
| BMC97 | BMC97_04 | 03 - 04m | 139 | 6.91 |
| BMC97 | BMC97_05 | 04 - 05m | | |
| BMC97 | BMC97_06 | 05 - 06m | 213 | 7.74 |
| BMC97 | BMC97_07 | 06 - 07m | | |
| BMC97 | BMC97_08 | 07 - 08m | 123 | 7.93 |
| BMC97 | BMC97_09 | 08 - 09m | 213 | 7.63 |
| BMC97 | BMC97_10 | 09 - 10m | 139 | 6.692 |
| BMC97 | BMC97_11 | 10 - 11m | 105 | 7.531 |
| BMC97 | BMC97_12 | 11 - 12m | | |
| BMC97 | BMC97_13 | 12 - 13m | | |
| BMC97 | BMC97_14 | 13 - 14m | | |
| BMC97 | BMC97_15 | 14 - 15m | | |
| BMC97 | BMC97_16 | 15 - 16m | 280 | 7.46 |
| BMC97 | BMC97_17 | 16 - 17m | | |
| BMC97 | BMC97_18 | 17 - 18m | 368 | 8.31 |
| BMC97 | BMC97_19 | 18 - 19m | | |
| BMC97 | BMC97_20 | 19 - 20m | 806 | 8.36 |
| BMC97 | BMC97_21 | 20 - 21m | 979 | 8.34 |
| BMC97 | BMC97_22 | 21 - 22m | 625 | 8.83 |
| BMC97 | BMC97_23 | 22 - 23m | 935 | 7.08 |
| BMC97 | BMC97_24 | 23 - 24m | 666 | 8.42 |
| BMC97 | BMC97_25 | 24 - 25m | | |
| BMC97 | BMC97_26 | 25 - 26m | | |
| BMC97 | BMC97_27 | 26 - 27m | | |
| BMC98 | BMC98_01 | 00 - 01m | 230 | 7.13 |
| BMC98 | BMC98_02 | 01 - 02m | 228 | 7.4 |

| Site | ID | Depth (m) | $EC_{1:5}$ (µS/cm) | pH |
|---|---|---|---|---|
| BMC98 | BMC98_03 | 02 - 03m | | |
| BMC98 | BMC98_04 | 03 - 04m | | |
| BMC98 | BMC98_05 | 04 - 05m | | |
| BMC98 | BMC98_06 | 05 - 06m | | |
| BMC98 | BMC98_07 | 06 - 07m | 1428 | 7.94 |
| BMC98 | BMC98_08 | 07 - 08m | 1131 | 7.82 |
| BMC98 | BMC98_09 | 08 - 09m | | |
| BMC98 | BMC98_10 | 09 - 10m | 1244 | 8.39 |
| BMC98 | BMC98_11 | 10 - 11m | 1256 | 8.58 |
| BMC98 | BMC98_12 | 11 - 12m | 830 | 8.67 |
| BMC98 | BMC98_13 | 12 - 13m | 1092 | 8.66 |
| BMC98 | BMC98_14 | 13 - 14m | 1366 | 8.28 |
| BMC98 | BMC98_15 | 14 - 15m | 857 | 8.77 |
| BMC98 | BMC98_16 | 15 - 16m | 589 | |
| BMC98 | BMC98_17 | 16 - 17m | | |
| BMC98 | BMC98_18 | 17 - 18m | | |
| BMC98 | BMC98_19 | 18 - 19m | | |
| BMC98 | BMC98_20 | 19 - 20m | | |
| BMC98 | BMC98_21 | 20 - 21m | | |
| BMC98 | BMC98_22 | 21 - 22m | | |
| BMC98 | BMC98_23 | 22 - 23m | 1125 | 8.48 |
| BMC98 | BMC98_24 | 23 - 24m | | |
| BMC98 | BMC98_25 | 24 - 25m | 888 | 8.18 |
| BMC98 | BMC98_26 | 25 - 26m | 585 | 8.24 |
| BMC98 | BMC98_27 | 26 - 27m | 594 | 8.55 |
| BMC98 | BMC98_28 | 27 - 28m | 966 | 9.41 |
| BMC98 | BMC98_29 | 28 - 29m | 941 | 9.53 |
| BMC98 | BMC98_30 | 29 - 30m | | |
| BMC98 | BMC98_31 | 30 - 31m | | |
| BMC99 | BMC99_01 | 00 - 01m | 241 | 6.51 |
| BMC99 | BMC99_02 | 01 - 02m | | |
| BMC99 | BMC99_03 | 02 - 03m | | |
| BMC99 | BMC99_04 | 03 - 04m | | |
| BMC99 | BMC99_05 | 04 - 05m | | |
| BMC99 | BMC99_06 | 05 - 06m | | |
| BMC99 | BMC99_07 | 06 - 07m | | |
| BMC99 | BMC99_08 | 07 - 08m | | |
| BMC99 | BMC99_09 | 08 - 09m | | |
| BMC99 | BMC99_10 | 09 - 10m | | |
| BMC99 | BMC99_11 | 10 - 11m | | |
| BMC99 | BMC99_12 | 11 - 12m | | |
| BMC99 | BMC99_13 | 12 - 13m | 2380 | 9.36 |
| BMC99 | BMC99_14 | 13 - 14m | 1577 | 9.47 |
| BMC99 | BMC99_15 | 14 - 15m | | |
| BMC99 | BMC99_16 | 15 - 16m | | |
| BMC99 | BMC99_17 | 16 - 17m | | |
| BMC100 | BMC100_01 | 00 - 01m | 214 | 9.48 |
| BMC100 | BMC100_02 | 01 - 02m | 45 | 7.95 |
| BMC100 | BMC100_03 | 02 - 03m | 43 | 7.72 |

| Site | ID | Depth (m) | $EC_{1:5}$ (μS/cm) | pH |
|---|---|---|---|---|
| BMC100 | BMC100_04 | 03 - 04m | 33 | 7.35 |
| BMC100 | BMC100_05 | 04 - 05m | 33 | 6.91 |
| BMC100 | BMC100_06 | 05 - 06m | 314 | 7.34 |
| BMC100 | BMC100_07 | 06 - 07m | 193 | 9.17 |
| BMC100 | BMC100_08 | 07 - 08m | 79 | 7.83 |
| BMC100 | BMC100_09 | 08 - 09m | 44 | 7.43 |
| BMC100 | BMC100_10 | 09 - 10m | 181 | 7.96 |
| BMC100 | BMC100_11 | 10 - 11m | 133 | 8.38 |
| BMC100 | BMC100_12 | 11 - 12m | 116 | 8.06 |
| BMC100 | BMC100_13 | 12 - 13m | 1224 | 7.96 |
| BMC100 | BMC100_14 | 13 - 14m | 505 | 8.99 |
| BMC100 | BMC100_15 | 14 - 15m | 569 | 8.9 |
| BMC100 | BMC100_16 | 15 - 16m | 245 | 9.24 |
| BMC100 | BMC100_17 | 16 - 17m | 387 | 8.89 |
| BMC100 | BMC100_18 | 17 - 18m | 709 | 9.1 |
| BMC100 | BMC100_19 | 18 - 19m | 434 | 9.11 |
| BMC100 | BMC100_20 | 19 - 20m | 394 | 9.06 |
| BMC100 | BMC100_21 | 20 - 21m | | |
| BMC100 | BMC100_22 | 21 - 22m | | |
| BMC100 | BMC100_23 | 22 - 23m | | |
| BMC100 | BMC100_24 | 23 - 24m | | |
| BMC100 | BMC100_25 | 24 - 25m | 177 | 8.28 |
| BMC100 | BMC100_26 | 25 - 26m | 454 | 8.53 |
| BMC100 | BMC100_27 | 26 - 27m | 99 | 8.66 |
| BMC100 | BMC100_28 | 27 - 28m | 254 | 8.9 |
| BMC100 | BMC100_29 | 28 - 29m | 432 | 7.6 |
| BMC100 | BMC100_30 | 29 - 30m | 321 | 8.11 |
| BMC100 | BMC100_31 | 30 - 31m | | |
| BMC100 | BMC100_32 | 31 - 32m | 639 | 8.45 |
| BMC100 | BMC100_33 | 32 - 33m | | |
| BMC100 | BMC100_34 | 33 - 34m | | |
| BMC100 | BMC100_35 | 34 - 35m | | |
| BMC100 | BMC100_36 | 35 - 36m | | |
| BMC100 | BMC100_37 | 36 - 37m | | |
| BMC100 | BMC100_38 | 37 - 38m | | |
| BMC100 | BMC100_39 | 38 - 39m | | |
| BMC101 | BMC101_01 | 00 - 01m | 38 | 6.66 |
| BMC101 | BMC101_02 | 01 - 02m | 61 | 8.14 |
| BMC101 | BMC101_03 | 02 - 03m | 44 | 7.15 |
| BMC101 | BMC101_04 | 03 - 04m | 19 | 8.05 |
| BMC101 | BMC101_05 | 04 - 05m | 59 | 5.57 |
| BMC101 | BMC101_06 | 05 - 06m | 32 | 7.65 |
| BMC101 | BMC101_07 | 06 - 07m | 17 | 7.94 |
| BMC101 | BMC101_08 | 07 - 08m | 144 | 7.17 |
| BMC101 | BMC101_09 | 08 - 09m | 254 | 7.6 |
| BMC101 | BMC101_10 | 09 - 10m | 259 | 7.46 |
| BMC101 | BMC101_11 | 10 - 11m | 122 | 8.04 |
| BMC101 | BMC101_12 | 11 - 12m | | |
| BMC102 | BMC102_01 | 00 - 01m | 244 | 6.58 |

| Site | ID | Depth (m) | $EC_{1:5}$ (µS/cm) | pH |
|---|---|---|---|---|
| BMC102 | BMC102_02 | 01 - 02m | 94 | 8.01 |
| BMC102 | BMC102_03 | 02 - 03m | 423 | 6.81 |
| BMC102 | BMC102_04 | 03 - 04m | | 8.62 |
| BMC102 | BMC102_05 | 04 - 05m | 130 | 7.99 |
| BMC102 | BMC102_06 | 05 - 06m | 125 | 8.71 |
| BMC102 | BMC102_07 | 06 - 07m | | |
| BMC103 | BMC103_01 | 00 - 01m | 19 | 5.52 |
| BMC103 | BMC103_02 | 01 - 02m | 11 | 6.32 |
| BMC103 | BMC103_03 | 02 - 03m | 12 | 6.85 |
| BMC103 | BMC103_04 | 03 - 04m | 19 | 7.31 |
| BMC103 | BMC103_05 | 04 - 05m | 41 | 7.05 |
| BMC103 | BMC103_06 | 05 - 06m | | |
| BMC104 | BMC104_01 | 00 - 01m | 297 | 7.67 |
| BMC104 | BMC104_02 | 01 - 02m | 1698 | 8.14 |
| BMC104 | BMC104_03 | 02 - 03m | 454 | 7.94 |
| BMC104 | BMC104_04 | 03 - 04m | 379 | 8.03 |
| BMC104 | BMC104_05 | 04 - 05m | 158 | 8.45 |
| BMC104 | BMC104_06 | 05 - 06m | 313 | 8.03 |
| BMC104 | BMC104_07 | 06 - 07m | 624 | 8.09 |
| BMC104 | BMC104_08 | 07 - 08m | 554 | 8.46 |
| BMC104 | BMC104_09 | 08 - 09m | 345 | 8.68 |
| BMC104 | BMC104_10 | 09 - 10m | 587 | 8.92 |
| BMC104 | BMC104_11 | 10 - 11m | 694 | 9.17 |
| BMC104 | BMC104_12 | 11 - 12m | 643 | 8.95 |
| BMC104 | BMC104_13 | 12 - 13m | | |
| BMC104 | BMC104_14 | 13 - 14m | 1187 | 9.08 |
| BMC104 | BMC104_15 | 14 - 15m | 2000 | 9.27 |
| BMC104 | BMC104_16 | 15 - 16m | 1011 | 9.32 |
| BMC104 | BMC104_17 | 16 - 17m | | |
| BMC104 | BMC104_18 | 17 - 18m | 776 | 9.27 |
| BMC104 | BMC104_19 | 18 - 19m | 1349 | 9.14 |
| BMC104 | BMC104_20 | 19 - 20m | 893 | 9.16 |
| BMC104 | BMC104_21 | 20 - 21m | 252 | 8.28 |
| BMC104 | BMC104_22 | 21 - 22m | | |
| BMC104 | BMC104_23 | 22 - 23m | 568 | 7.57 |
| BMC104 | BMC104_24 | 23 - 24m | 951 | 8.37 |
| BMC104 | BMC104_25 | 24 - 25m | 1556 | 8.68 |
| BMC104 | BMC104_26 | 25 - 26m | 1001 | 8.87 |
| BMC104 | BMC104_27 | 26 - 27m | 516 | 8.98 |
| BMC104 | BMC104_28 | 27 - 28m | 877 | 9.05 |
| BMC104 | BMC104_29 | 28 - 29m | 599 | 9.35 |
| BMC104 | BMC104_30 | 29 - 30m | | |
| BMC104 | BMC104_31 | 30 - 31m | | |
| BMC104 | BMC104_32 | 31 - 32m | | |
| BMC104 | BMC104_33 | 32 - 33m | | |
| BMC104 | BMC104_34 | 33 - 34m | | |
| BMC104 | BMC104_35 | 34 - 35m | | |
| BMC104 | BMC104_36 | 35 - 36m | | |
| QC26 | QC26 | | 61 | 6.223 |

| Site | ID | Depth (m) | $EC_{1:5}$ (µS/cm) | pH |
|---|---|---|---|---|
| QC27 | QC27 | | 490 | 8.18 |
| QC28 | QC28 | | 714 | 8.514 |
| QC29 | QC29 | | 269 | 7.4 |
| QC30 | QC30 | | 44 | 7.91 |
| QC31 | QC31 | | 488 | 8.22 |
| QC32 | QC32 | | 1265 | 8.85 |
| QC33 | QC33 | | 35 | 6.75 |

# Appendix E

## Chip sample photographs


Bore: BMC 95
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SpyderCHECKR
datacolor


Bore: BMC 96
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SpyderCHECKR
FadeCheckr
datacolor


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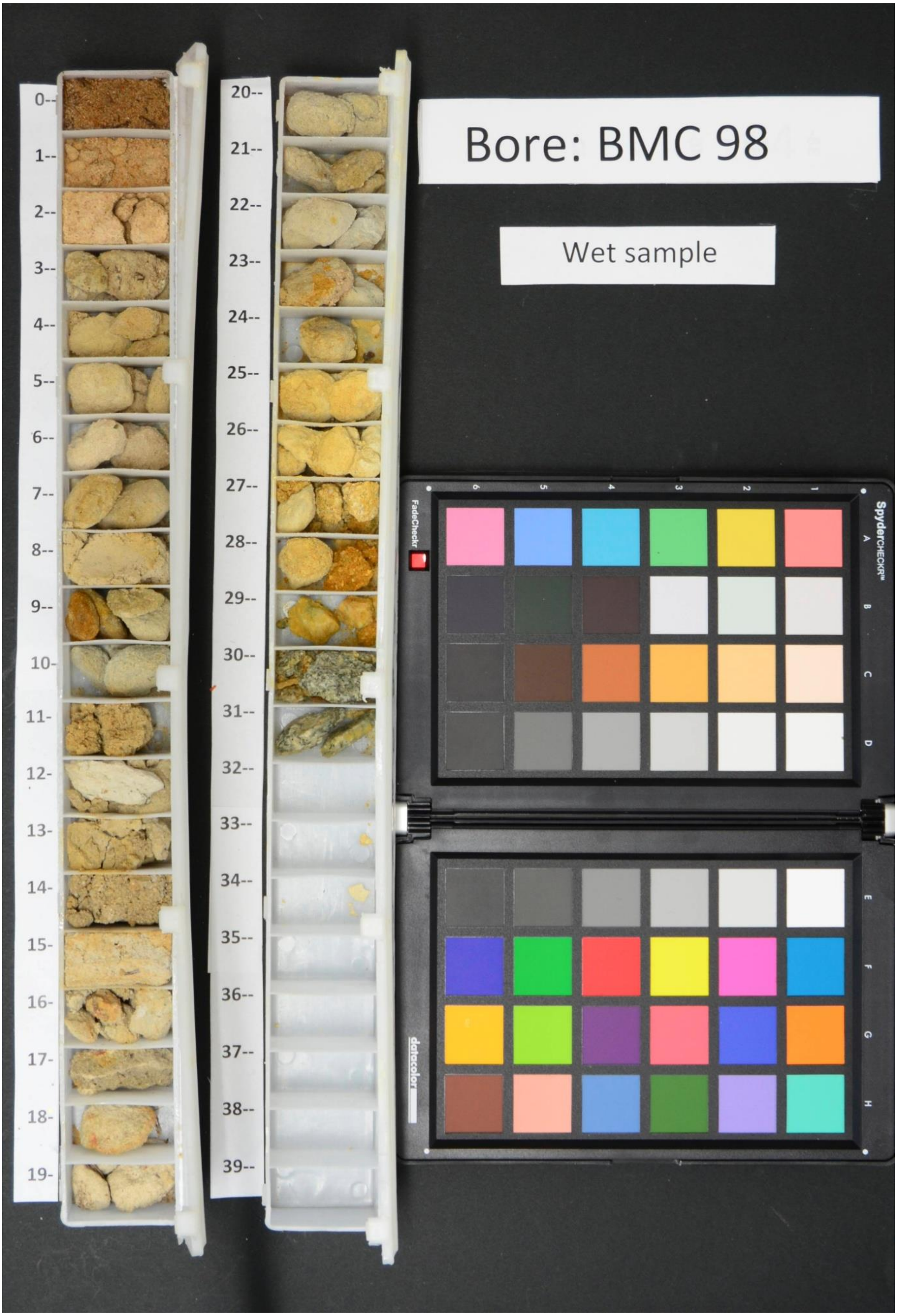
SpyderCHECKR
FadeCheckr
datacolor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Bore: BMC 99
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SpyderCHECKR
FadeCheckr
datacolor

Bore: BMC 102
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SpyderCHECKR
FadeCheckr
datacolor


Bore: BMC 103
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Bore: BMC 104
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SpyderCHECKR
datacolor

# Appendix F

## Outcrop photographs


**Figure 15. Photographs of sedimentary bedrock exposures, observed in the western extent of the study area.**

## Appendix G

**Legend - Lithology**

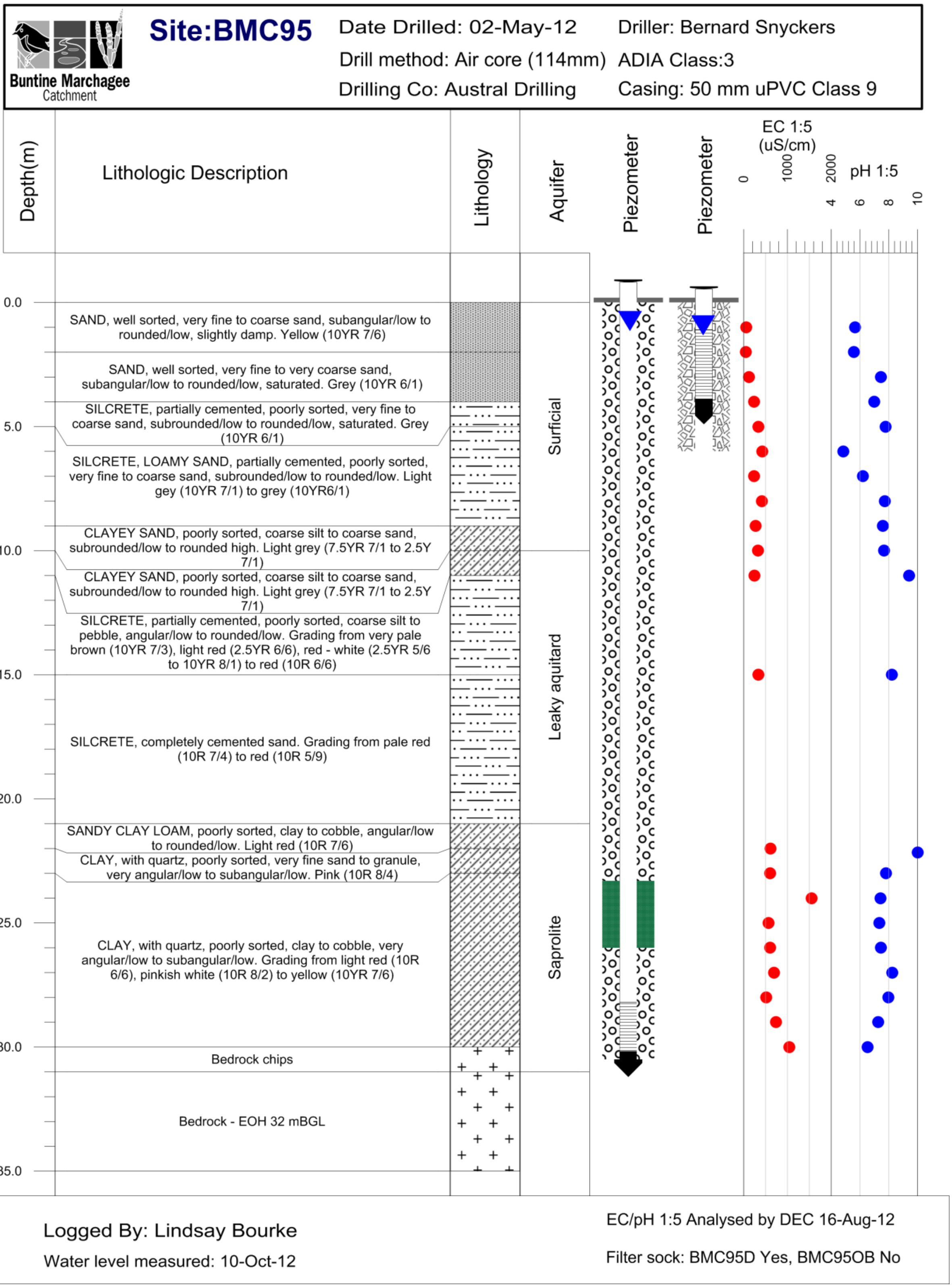
- Sand
- Sandy loam
- Sand/clay
- Sandy clay
- Clayey sand
- Clay
- Hardpan
- Granite

**Legend - Bore construction**

- Casing
- Screen
- End Cap
- Collar
- Fill
- Bentonite
- Gravel Pack

# Appendix H

## Bore logs

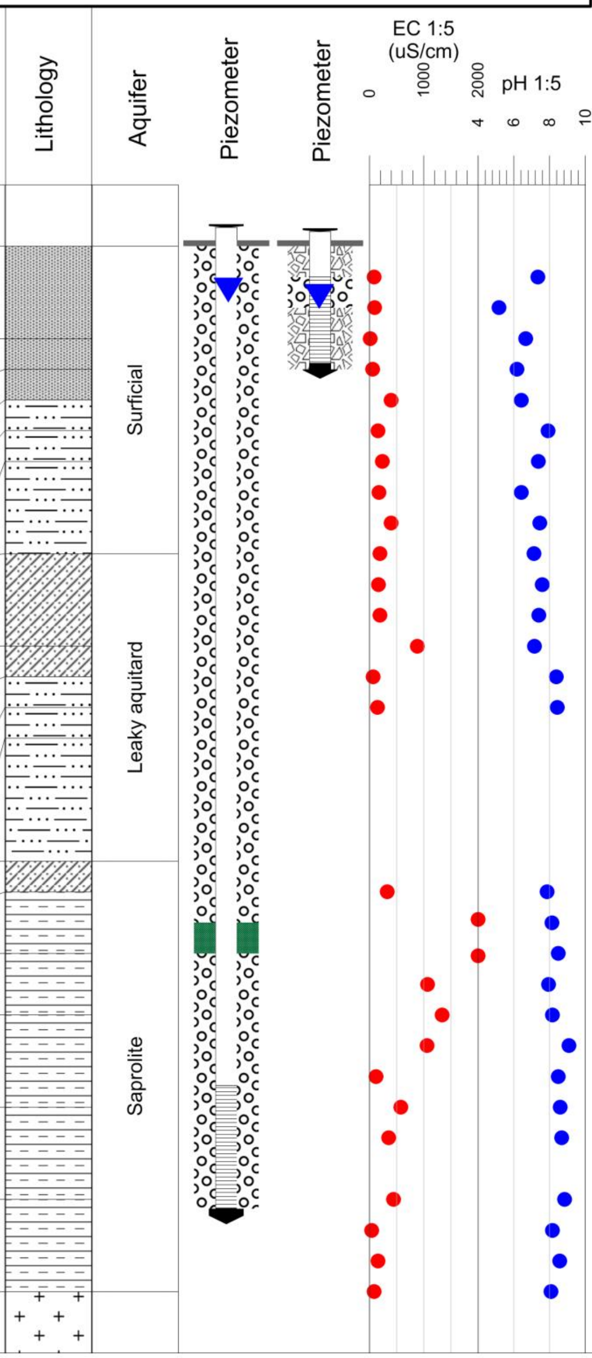


**Buntine Marchagee Catchment**

## Site:BMC96

| | |
|---|---|
| Date Drilled: 18-Apr-12 | Driller: Glenn Van Hees |
| Drill method: Air core/Hand auger | ADIA Class:1 |
| Drilling Co: Austral Drilling | Casing: 50 mm uPVC Class 9 |

| Depth(m) | Lithologic Description | Aquifer |
|---|---|---|
| 0.0 | SAND, well sorted, very fine to coarse sand, subangular/low to rounded/low, damp. Yellow (10YR 7/6 to 10YR 8/6) | Surficial |
| | SAND, well sorted, very fine to coarse sand, subangular/low to rounded/low, saturated. Grey (7.5YR 7/6) | Surficial |
| | SAND, well sorted, very fine to medium sand, subangular/low to rounded/high. Grey (7.5YR 6/1) | Surficial |
| 5.0 | SILCRETE, partially cemented, poorly sorted, very fine sand to granule, subangular/low to rounded/high. Light grey (10YR 7/2) | Surficial |
| | SILCRETE, partially cemented, well sorted, coarse silt to very coarse sand, subangular/low to rounded/high. Light grey (10YR 7/1) | Surficial |
| | SILCRETE, partially cemented, well sorted, coarse silt to very coarse sand, subangular/low to rounded/high. Very pale brown (10YR 8/2) | Surficial |
| 10.0 | SANDY LOAM, well sorted, coarse silt to very coarse sand, subangular/low to rounded/high. White (10YR 8/1) with yellow coloured nodules (mottling?) | Leaky aquitard |
| | SANDY LOAM, poorly sorted, coarse silt to very coarse sand, angular/low to rounded/high. White (10YR 8/1) | Leaky aquitard |
| 15.0 | SILCRETE, partially cemented, poorly sorted, coarse silt to granule, angular/low to rounded/low. Very pale brown (10YR 8/3) | Leaky aquitard |
| | SILCRETE, completely cemented, poorly sorted, coarse silt to very coarse sand, angular/low to rounded/low. Pale red (10R 7/3) | Leaky aquitard |
| | SILCRETE, completely cemented, poorly sorted, coarse silt to granule, angular/low to rounded/low. Pale red (10R 7/3) to white (10YR 8/1) | Leaky aquitard |
| 20.0 | CLAYEY SAND, poorly sorted, clay to very coarse sand, subrounded/low to rounded high. Pinkish white (2.5YR 8/2) | Saprolite |
| | CLAY, with quartz, poorly sorted, clay to very coarse sand, angular/low to rounded/low. Pinkish white (2.5YR 8/2) | Saprolite |
| | CLAY, with quartz, poorly sorted, clay to pebble, angular/low to rounded/low. Light grey (GLEY1 7/N) to light greenish grey (GLEY1 7/10Y) | Saprolite |
| 25.0 | CLAY, with quartz, poorly sorted, clay to very coarse sand, angular/low to rounded/low. Light greenish grey (GLEY1 8/10Y) | Saprolite |
| 30.0 | CLAY, with quartz, poorly sorted, clay to pebble, angular/low to rounded/low. Light greenish grey (GLEY1 8/10Y) | Saprolite |
| | CLAY, with bedrock, poorly sorted, clay to pebble, angular/low to rounded/low. Light greenish grey (GLEY1 8/10Y) | Saprolite |
| 35.0 | Bedrock - EOH 36 mBGL | |




Logged By: Lindsay Bourke

Water level measured: 10-Oct-12

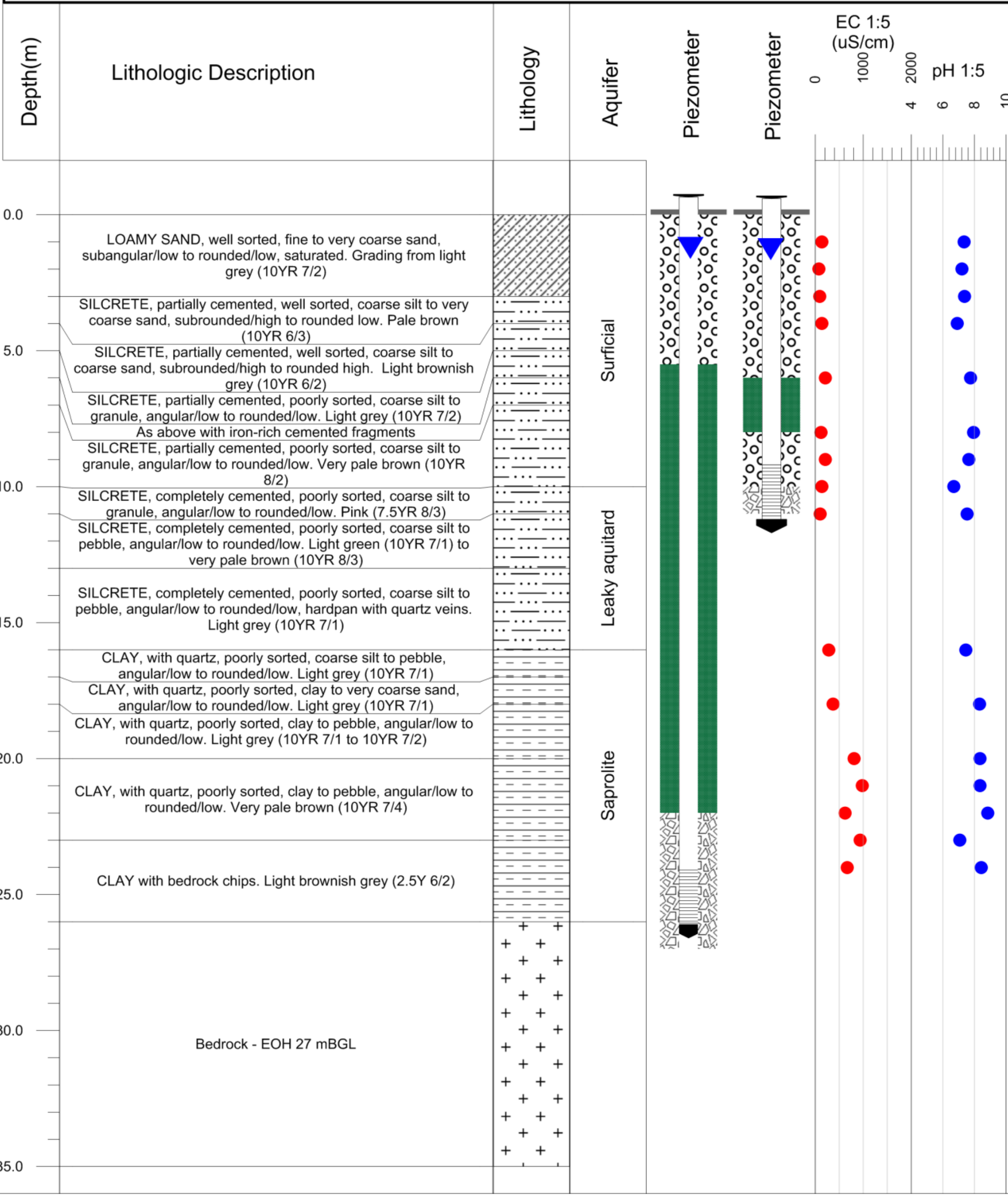
EC/pH 1:5 Analysed by DEC 16-Aug-12

Filter sock: BMC96D No, BMC96OB Yes

Buntine Marchagee Catchment

## Site:BMC97

| | |
|---|---|
| Date Drilled: 20-Apr-12 | Driller: Glenn Van Hees |
| Drill method: Air core (114mm) | ADIA Class:1 |
| Drilling Co: Austral Drilling | Casing: 50 mm uPVC Class 9 |

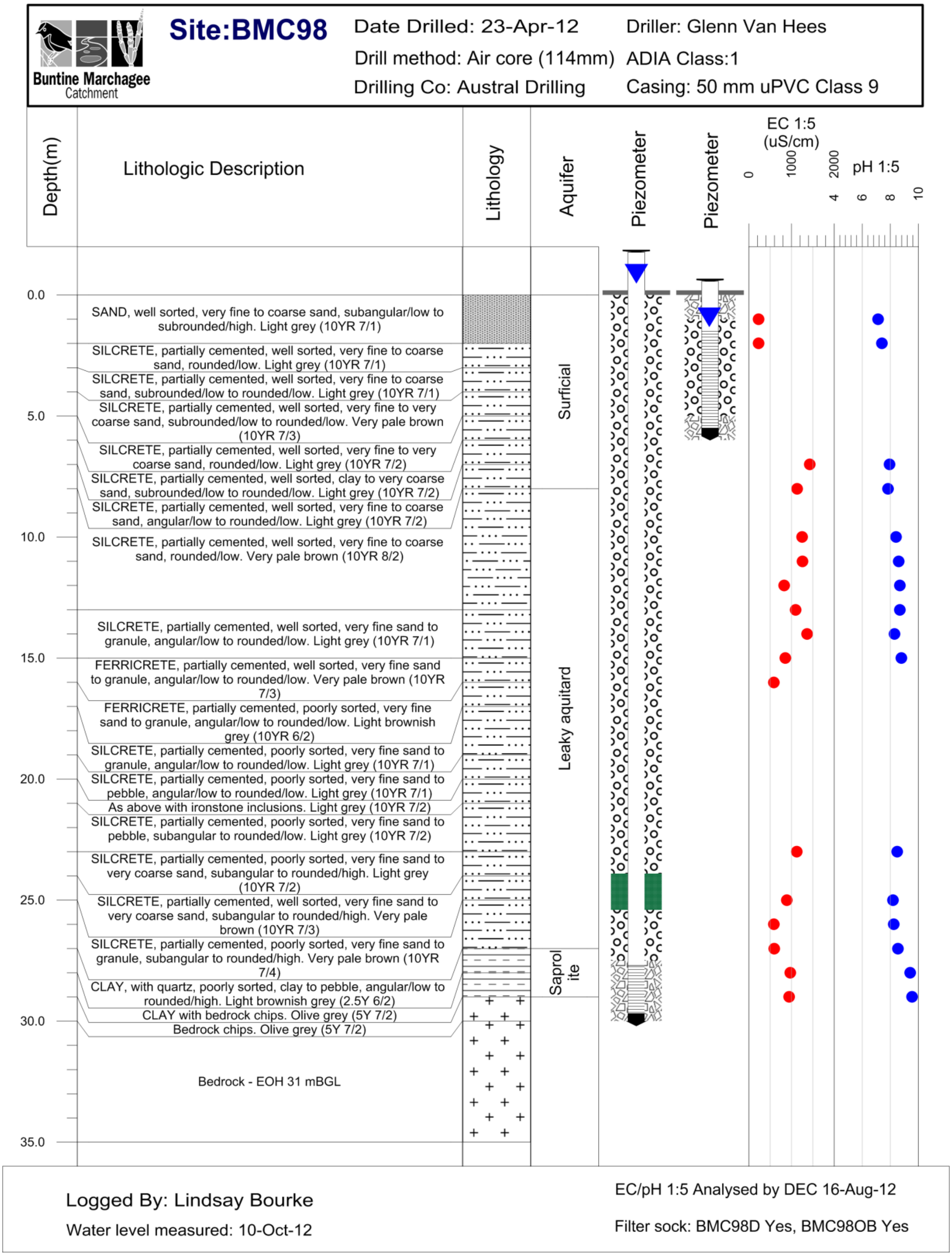



Logged By: Lindsay Bourke

Water level measured: 10-Oct-12

EC/pH 1:5 Analysed by DEC 16-Aug-12

Filter sock: BMC97D No, BMC97I No

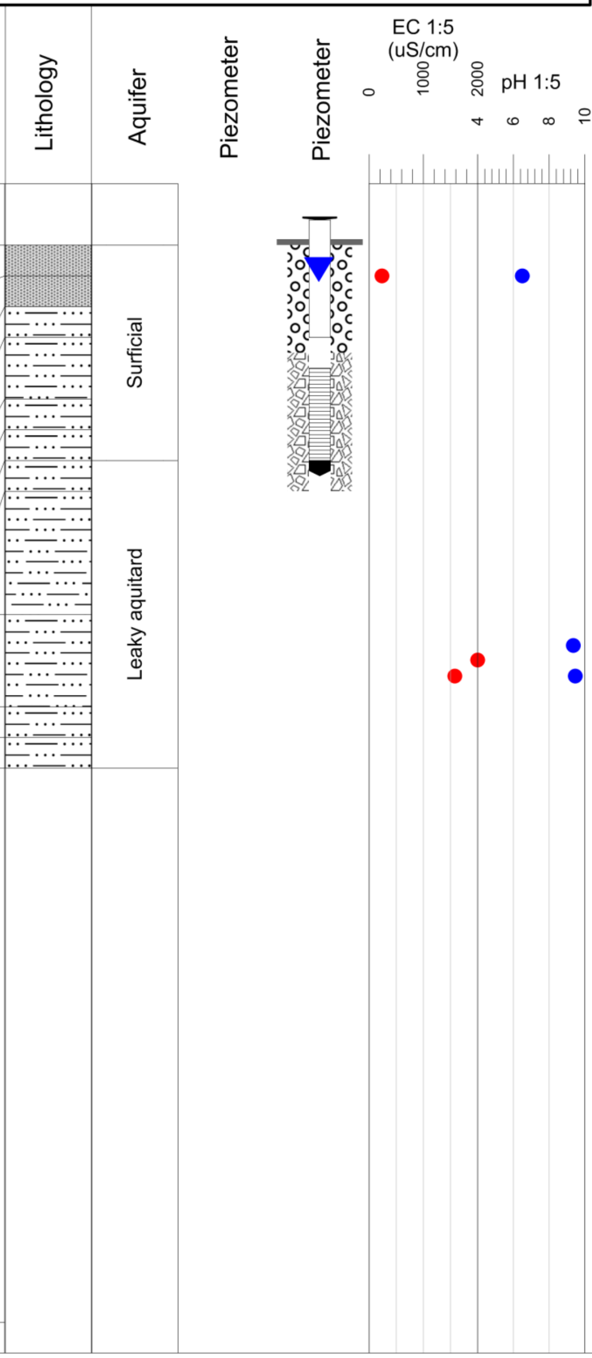

Buntine Marchagee Catchment
Site:BMC98
Date Drilled: 23-Apr-12
Driller: Glenn Van Hees
Drill method: Air core (114mm)
ADIA Class:1
Drilling Co: Austral Drilling
Casing: 50 mm uPVC Class 9
Depth(m)
Lithologic Description
Lithology
Aquifer
Piezometer
Piezometer
EC 1:5 (uS/cm)
0
1000
2000
pH 1:5
4
6
8
10
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
SAND, well sorted, very fine to coarse sand, subangular/low to subrounded/high. Light grey (10YR 7/1)
SILCRETE, partially cemented, well sorted, very fine to coarse sand, rounded/low. Light grey (10YR 7/1)
SILCRETE, partially cemented, well sorted, very fine to coarse sand, subrounded/low to rounded/low. Light grey (10YR 7/1)
SILCRETE, partially cemented, well sorted, very fine to very coarse sand, subrounded/low to rounded/low. Very pale brown (10YR 7/3)
SILCRETE, partially cemented, well sorted, very fine to very coarse sand, rounded/low. Light grey (10YR 7/2)
SILCRETE, partially cemented, well sorted, clay to very coarse sand, subrounded/low to rounded/low. Light grey (10YR 7/2)
SILCRETE, partially cemented, well sorted, very fine to coarse sand, angular/low to rounded/low. Light grey (10YR 7/2)
SILCRETE, partially cemented, well sorted, very fine to coarse sand, rounded/low. Very pale brown (10YR 8/2)
SILCRETE, partially cemented, well sorted, very fine sand to granule, angular/low to rounded/low. Light grey (10YR 7/1)
FERRICRETE, partially cemented, well sorted, very fine sand to granule, angular/low to rounded/low. Very pale brown (10YR 7/3)
FERRICRETE, partially cemented, poorly sorted, very fine sand to granule, angular/low to rounded/low. Light brownish grey (10YR 6/2)
SILCRETE, partially cemented, poorly sorted, very fine sand to granule, angular/low to rounded/low. Light grey (10YR 7/1)
SILCRETE, partially cemented, poorly sorted, very fine sand to pebble, angular/low to rounded/low. Light grey (10YR 7/1)
As above with ironstone inclusions. Light grey (10YR 7/2)
SILCRETE, partially cemented, poorly sorted, very fine sand to pebble, subangular to rounded/low. Light grey (10YR 7/2)
SILCRETE, partially cemented, poorly sorted, very fine sand to very coarse sand, subangular to rounded/high. Light grey (10YR 7/2)
SILCRETE, partially cemented, well sorted, very fine sand to very coarse sand, subangular to rounded/high. Very pale brown (10YR 7/3)
SILCRETE, partially cemented, poorly sorted, very fine sand to granule, subangular to rounded/high. Very pale brown (10YR 7/4)
CLAY, with quartz, poorly sorted, clay to pebble, angular/low to rounded/high. Light brownish grey (2.5Y 6/2)
CLAY with bedrock chips. Olive grey (5Y 7/2)
Bedrock chips. Olive grey (5Y 7/2)
Bedrock - EOH 31 mBGL
Surficial
Leaky aquitard
Saprolite
Logged By: Lindsay Bourke
Water level measured: 10-Oct-12
EC/pH 1:5 Analysed by DEC 16-Aug-12
Filter sock: BMC98D Yes, BMC98OB Yes

Buntine Marchagee Catchment

# Site:BMC99

Date Drilled: 27-Apr-12
Drill method: Air core (114mm)
Drilling Co: Austral Drilling
Driller: Bernard Snyckers
ADIA Class:3
Casing: 50 mm uPVC Class 9

| Depth(m) | Lithologic Description |
|---|---|
| 0.0 | SAND, poorly sorted, very fine sand to granule, angular/low to rounded/high. Light yellowish brown (10YR 6/4) |
| | SAND, with ironstone gravel, poorly sorted, very fine sand to cobble, angular/low to rounded/high. Light yellowish brown (10YR 6/4) |
| | FERRICRETE, completely cemented, poorly sorted, very fine sand to pebble, angular/low to rounded/low. Brown (10YR 5/3) |
| 5.0 | SILCRETE, completely cemented, well sorted, very fine to very coarse sand, subrounded/low. Holes in hardpan. Very pale brown (10YR 7/3 to 10YR 8/2) |
| | SILCRETE, completely cemented, well sorted, coarse silt to very coarse sand, subrounded/low. White (10YR 8/1) |
| | SILCRETE, moderately cemented, poorly sorted, coarse silt to cobble. Some ferricrete with iron-rich mottles. White (10YR 8/1) |
| | FERRICRETE?, completely cemented. Iron nodules with quartz grains. Redish yellow (5YR 6/6) |
| 10.0 | SILCRETE, completely cemented, poorly sorted, with iron pisoliths (gravel <5 mm). Yellowish red (5YR 5/6) |
| | SILCRETE, completely cemented, well sorted, clay to very coarse sand. Yellowish red (5YR 5/6) |
| 15.0 | SILCRETE, moderately cemented. |
| | SILCRETE, completely cemented. |
| 20.0 | |
| 25.0 | EOH 17 mBGL |
| 30.0 | |
| 35.0 | |




Logged By: Lindsay Bourke
Water level measured: 10-Oct-12

EC/pH 1:5 Analysed by DEC 16-Aug-12
Filter sock: BMC999OB Yes

Buntine Marchagee Catchment

# Site:BMC100

Date Drilled: 27-Apr-12 | Driller: Bernard Snyckers

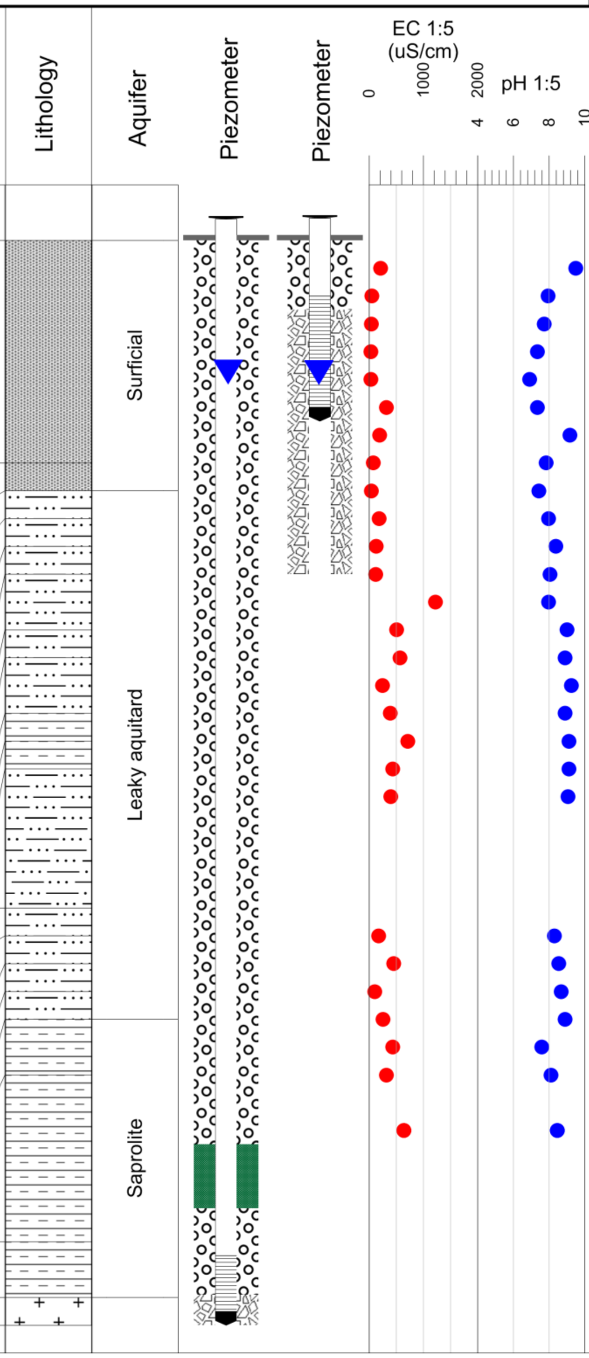
Drill method: Air core (114mm) | ADIA Class:3

Drilling Co: Austral Drilling | Casing: 50 mm uPVC Class 9

Depth(m): 0.0, 5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0

**Lithologic Description**

- SAND, well sorted, very fine to coarse sand, very angular/high to rounded/high, damp. Light grey (10YR 7/2)
- SAND, well sorted, very fine to very coarse sand, subangular/low to rounded/high, damp. Light grey (10YR 7/2)
- SILCRETE, partially cemented, poorly sorted, very fine sand to granula, angular/high to rounded/low. Light grey (10YR 7/2)
- SILCRETE, partially cemented, poorly sorted, very fine sand to granula, subangular/low to rounded/low. Hardpan with bands of sand/quartz. Light grey (10YR 7/1)
- SILCRETE, partially cemented, well sorted, coarse silt to very coarse sand, subangular/high to rounded/high. Light grey (10YR 7/1)
- SILCRETE, partially cemented, well sorted, coarse silt to coarse sand, subrounded/high to rounded high. Light grey (10YR 7/1)
- SILCRETE, partially cemented, well sorted, fine silt to coarse sand, subangular/high to rounded high. Light grey (10YR 7/1)
- As above but light grey (10YR 7/1) to very pale brown (10YR 7/3)
- CLAY, poorly sorted, clay to granule, angular/low quartz. Weak red (2.5YR 4/2)
- As above with friable weathered material. Consolidated clay with quartz. Pale red (10R 7/4)
- SILCRETE, completely cemented, poorly sorted, clay to pebble, angular/low quartz. Pale red (10R 7/4)
- SILCRETE, completely cemented, poorly sorted, clay to pebble, angular/low subangular/low quartz. White (10R 8/1)
- SILCRETE, completely cemented, poorly sorted, clay to pebble, clay to granule, subangular/low to rounded/high.White (10R 8/1)
- SILCRETE, moderately cemented, poorly sorted, coarse silt to granule, subangular/low to rounded/high.White (10R 8/1)
- SILCRETE, moderately cemented, poorly sorted, clay to very coarse sand, subangular/low to rounded/high.White (10R 8/1)
- CLAY, with quartz, poorly sorted, clay to pebble, subangular/low. Pale yellow (2.5YR 8/3)
- CLAY, with quartz, poorly sorted, clay to pebble, very angular/low. Pale yellow (2.5YR 8/3)
- As above with bedrock chips. Very pale brown (10YR 8/4)
- Bedrock - EOH 39 mBGL




Logged By: Lindsay Bourke

Water level measured: 10-Oct-12

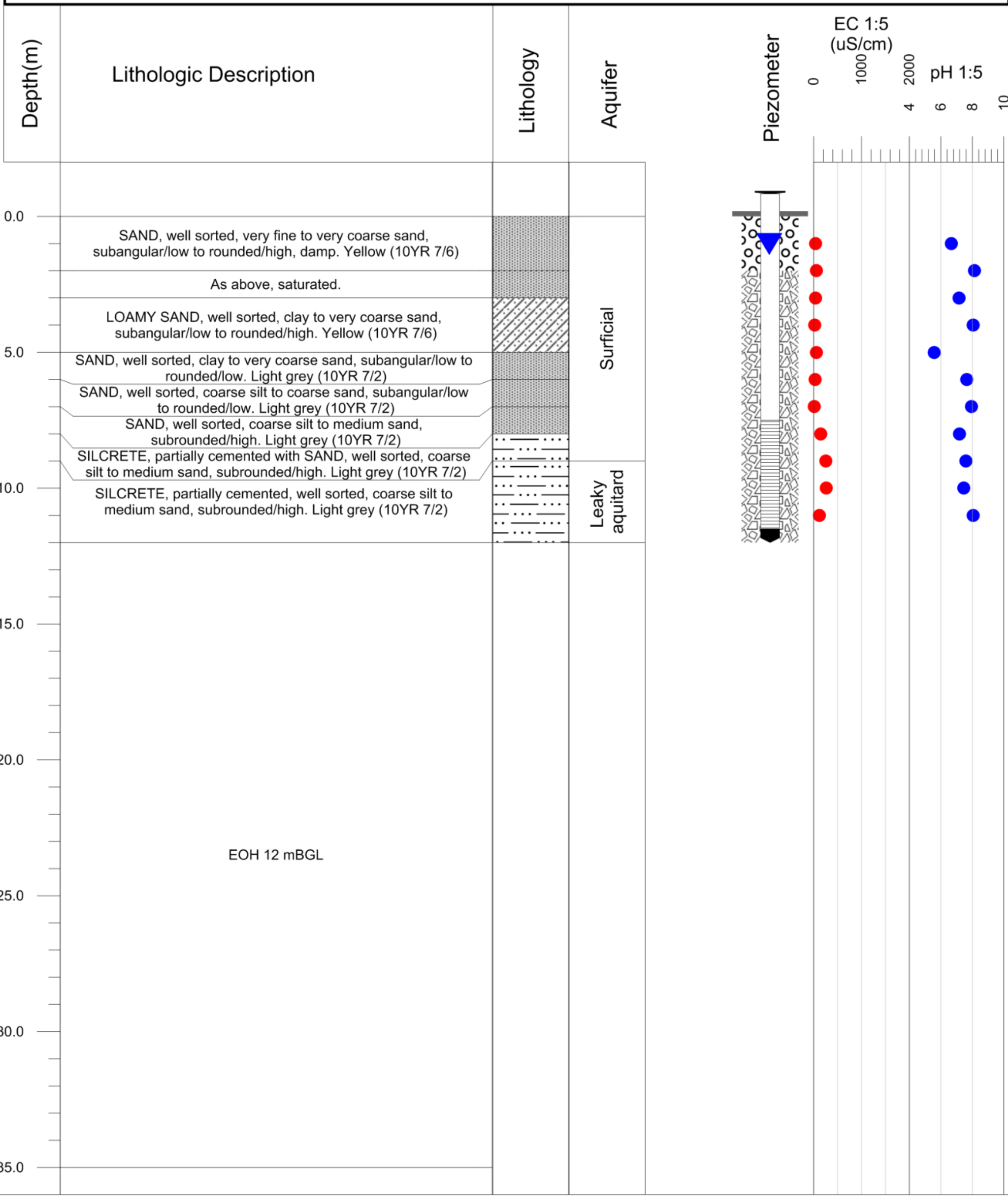
EC/pH 1:5 Analysed by DEC 16-Aug-12

Filter sock: BMC100D Yes, BMC100OB Yes

Buntine Marchagee Catchment

**Site:BMC101**

Date Drilled: 28-Apr-12 | Driller: Bernard Snyckers
Drill method: Air core (114mm) | ADIA Class:3
Drilling Co: Austral Drilling | Casing: 50 mm uPVC Class 9




Logged By: Lindsay Bourke

Water level measured: 10-Oct-12

EC/pH 1:5 Analysed by DEC 16-Aug-12

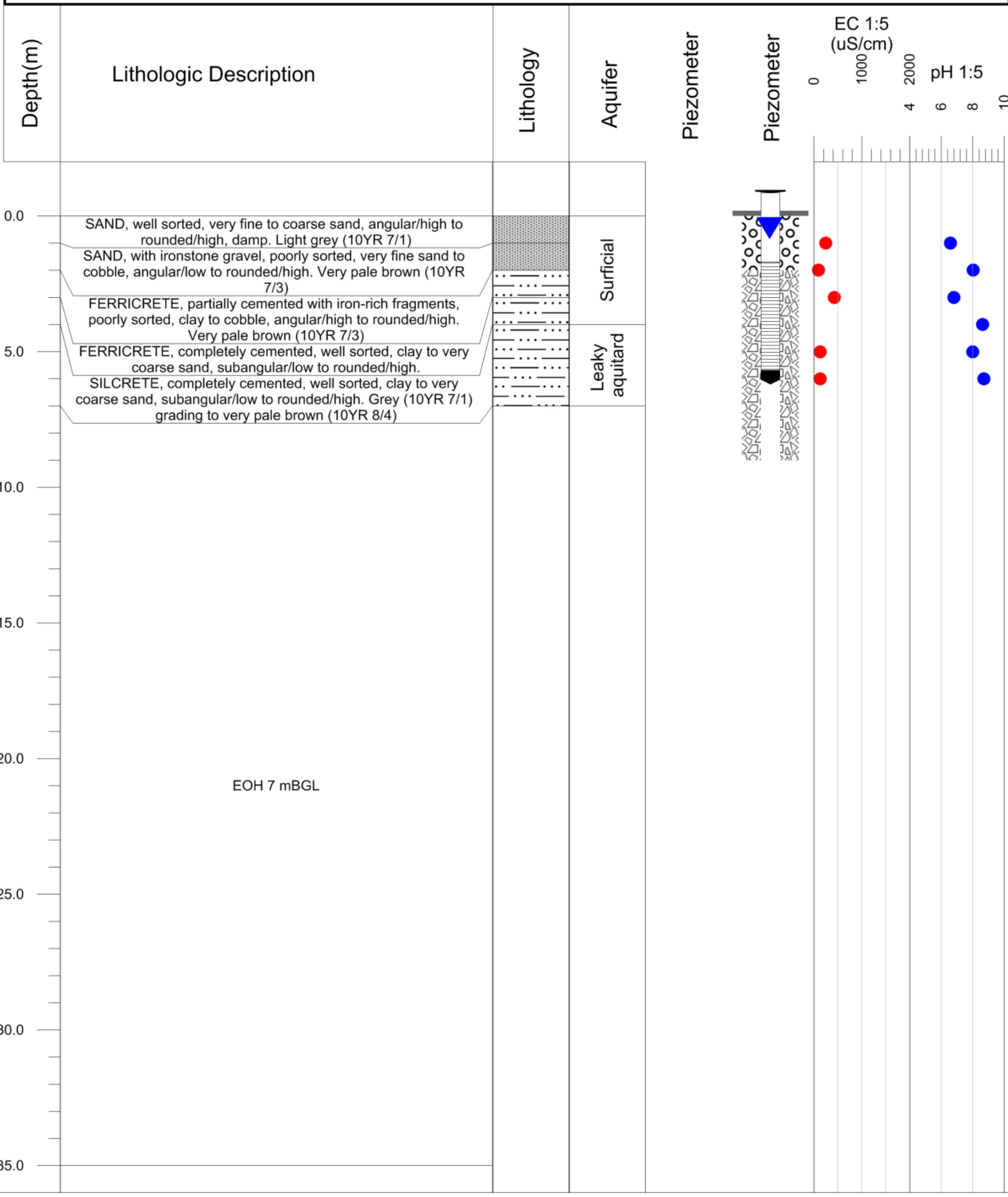
Filter sock: BMC101OB Yes

**Buntine Marchagee Catchment**

## Site:BMC102

Date Drilled: 28-Apr-12
Drill method: Air core (114mm)
Drilling Co: Austral Drilling

Driller: Bernard Snyckers
ADIA Class:3
Casing: 50 mm uPVC Class 9




Logged By: Lindsay Bourke
Water level measured: 10-Oct-12

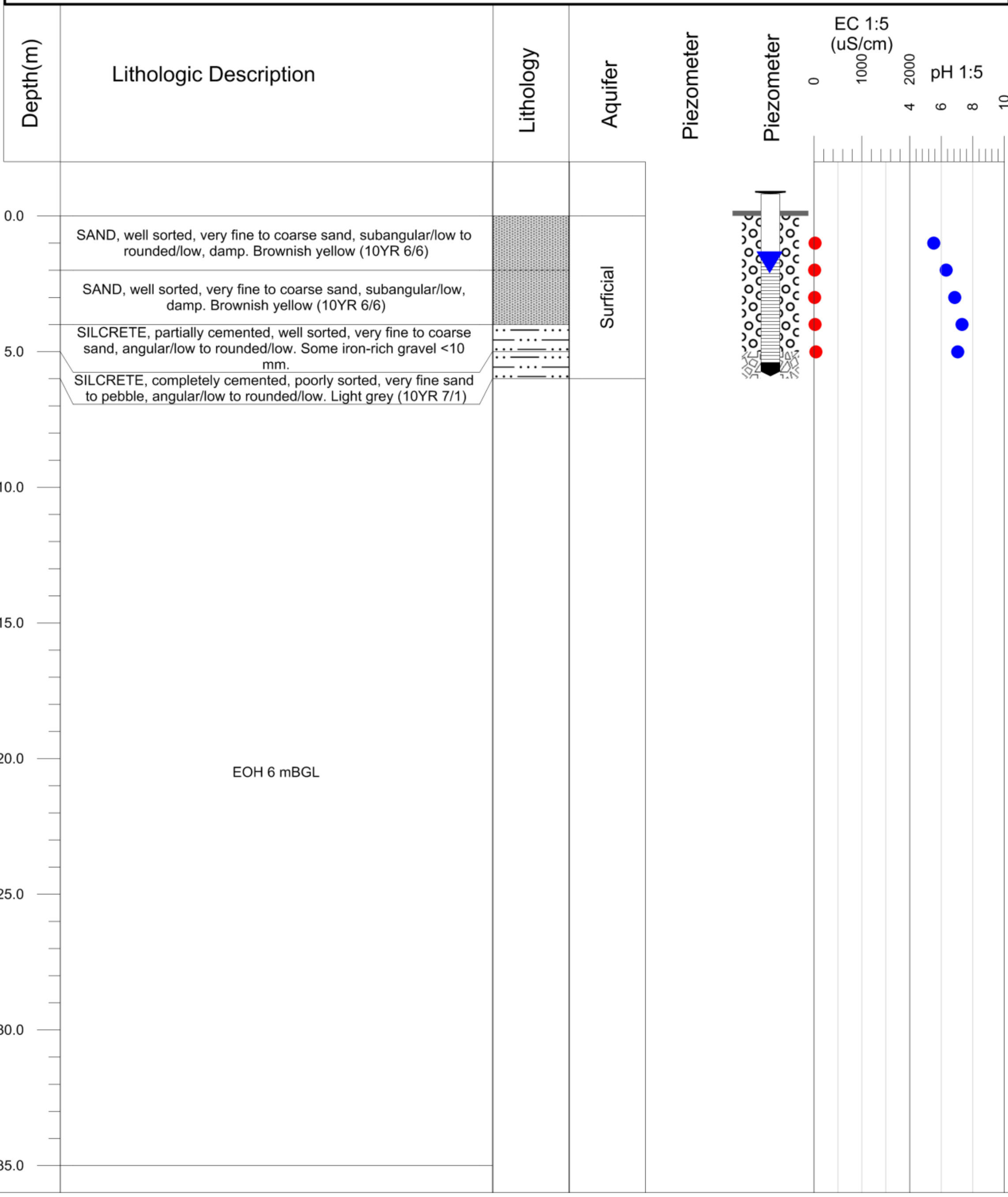
EC/pH 1:5 Analysed by DEC 16-Aug-12
Filter sock: BMC102 Yes

**Site:BMC103** Date Drilled: 28-Apr-12 Driller: Bernard Snyckers

Drill method: Air core (114mm) ADIA Class:3

Drilling Co: Austral Drilling Casing: 50 mm uPVC Class 9

Buntine Marchagee Catchment




Logged By: Lindsay Bourke

Water level measured: 10-Oct-12

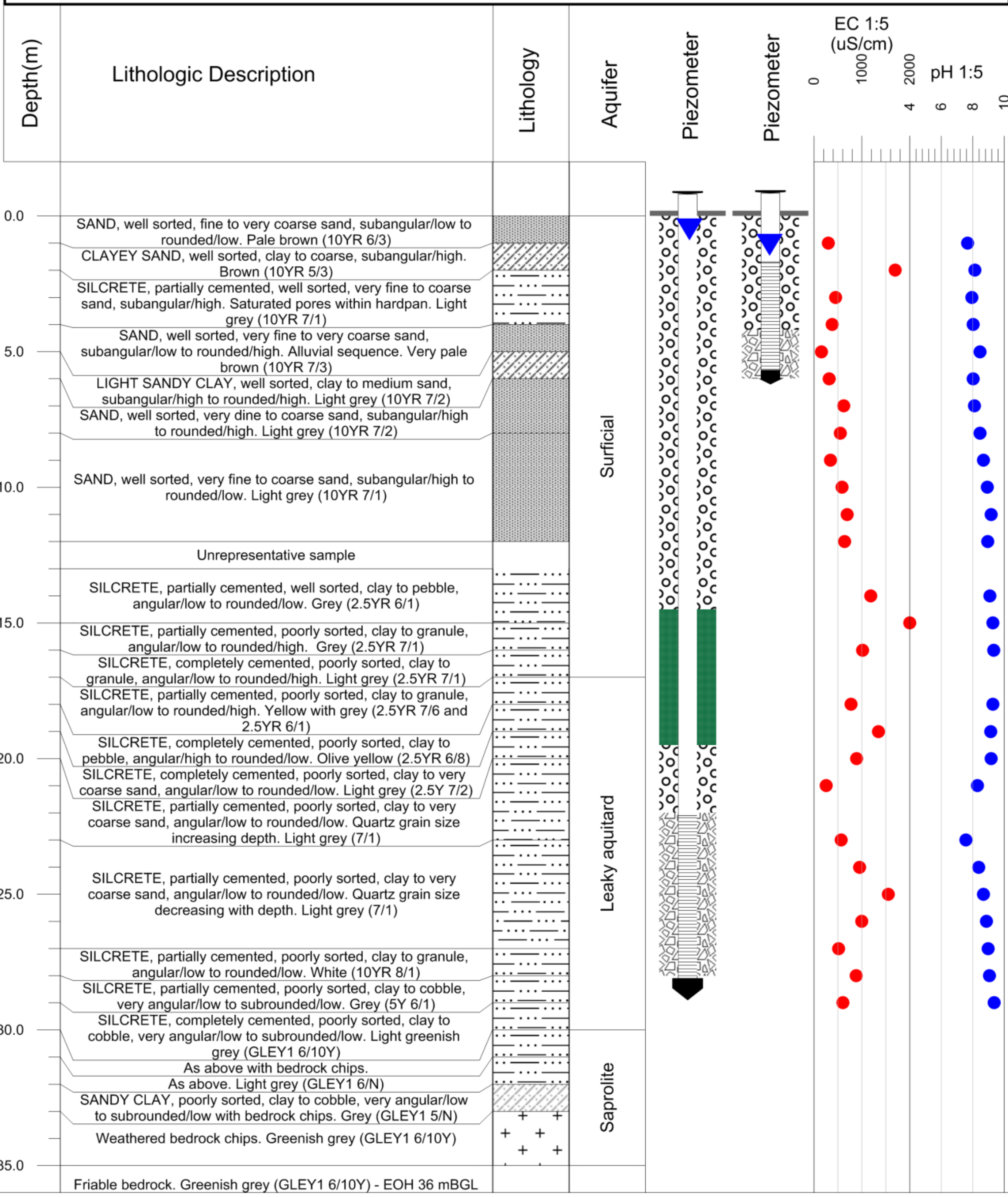
EC/pH 1:5 Analysed by DEC 16-Aug-12

Filter sock: BMC103 Yes

Buntine Marchagee Catchment

# Site:BMC104

Date Drilled: 01-May-12
Driller: Bernard Snyckers
Drill method: Air core (114mm)
ADIA Class:3
Drilling Co: Austral Drilling
Casing: 50 mm uPVC Class 9




Logged By: Lindsay Bourke

Water level measured: 10-Oct-12

EC/pH 1:5 Analysed by DEC 16-Aug-12

Filter sock: BMC104D Yes, BMC104OB Yes

## Appendix I

### Regolith description and field notes

| ID | Depth (m) | Texture | Sorting | Grain size | Dominant grain roundness/sphericity | Colour name | Munsell colour | Stratigraphy | Horizon (Anand & Paine, 2002) | DAFWA terms | Hydrostratigraphy | Field notes | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC95_01 | 00 - 01m | Sand | Well sorted | Very fine to coarse sand | Subangular/low to Rounded/low | Yellow | 10YR 7/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, fine well sorted, slightly damp | |
| BMC95_02 | 01 - 02m | Sand | Well sorted | Very fine to coarse sand | Subangular/low to Rounded/low | Yellow | 10YR 7/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, fine well sorted, slightly damp | |
| BMC95_03 | 02 - 03m | Sand | Well sorted | Very fine to very coarse sand | Subangular/low to Rounded/low | Grey | 10YR 6/1 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Start of new horizon - Sand, fine, damp, below water table? | |
| BMC95_04 | 03 - 04m | Sand | Well sorted | Very fine to coarse sand | Subangular/low to Rounded/low | Grey | 10YR 6/1 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, fine, saturated | |
| BMC95_05 | 04 - 05m | Partially cemented duricrust | Poorly sorted | Very fine sand to granule | Subrounded/low to Rounded/low | Grey | 10YR 6/1 | Pedolith | Cementation front | Silcrete | Surficial aquifer | Sand, fine to very fine (silt?), saturated. Large >8cm blocks of hardpan (silcrete?) | |
| BMC95_06 | 05 - 06m | Loamy sand - Partially cemented duricrust | Poorly sorted | Very fine to coarse sand | Subrounded/low to Rounded/low | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Clayey sand, fine to very fine with hardpan (silcrete?) blocks | |
| BMC95_07 | 06 - 07m | Loamy sand - Partially cemented duricrust | Poorly sorted | Very fine to medium sand | Subrounded/low to Rounded/low | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Clayey sand, fine to very fine with hardpan (silcrete?) blocks. Predominantly hardpan | |
| BMC95_08 | 07 - 08m | Clayey sand - Partially cemented duricrust | Poorly sorted | Very fine to coarse sand | Subrounded/low to Rounded/low | Grey | 10YR 6/1 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Clayey sand, fine to very fine with hardpan (silcrete?) blocks, saturated. Increasing clay content with larger hardpan fragments | |
| BMC95_09 | 08 - 09m | Clayey sand - Partially cemented duricrust | Poorly sorted | Coarse silt to coarse sand | Subrounded/low to Rounded/low | Grey | 10YR 6/1 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | As above | |
| BMC95_10 | 09 - 10m | Clayey sand | Poorly sorted | Coarse silt to coarse sand | Subrounded/low to Rounded/low | Light grey | 7.5YR 7/1 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Clayey sand, very fine to very coarse. Increased clay content, no hardpan (silcrete) | |
| BMC95_11 | 10 - 11m | Clayey sand | Poorly sorted | Coarse silt to pebble | Subrounded/low to Rounded/high | Light grey | 2.5Y 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Sandy clay hardpan, well sorted, very fine | |
| BMC95_12 | 11 - 12m | Partially cemented duricrust | Poorly sorted | Coarse silt to pebble | Angular/low to Rounded/low | Very pale brown | 10YR 7/3 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Friable hardpan - sandy clay, poorly sorted with quartz (<2mm) | |
| BMC95_13 | 12 - 13m | Partially cemented duricrust | Poorly sorted | Coarse silt to cobble | Angular/low to Rounded/low | Light red | 2.5YR 6/6 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Friable hardpan as above. Increasingly red (iron?) | |
| BMC95_14 | 13 - 14m | Partially cemented duricrust | Poorly sorted | Coarse silt to pebble | Angular/low to Rounded/low | Red - White | 2.5YR 5/6 - 10YR 8/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Friable hardpan as above - with white sandy clay | |

| ID | Depth (m) | Texture | Sorting | Grain size | Dominant grain roundness/sphericity | Colour name | Munsell colour | Stratigraphy | Horizon (Anand & Paine, 2002) | DAFWA terms | Hydrostratigraphy | Field notes | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC95_15 | 14 - 15m | Partially cemented duricrust | Poorly sorted | Coarse silt to pebble | Angular/low to Rounded/low | Red | 10R 6/6 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Friable hardpan as above | |
| BMC95_16 | 15 - 16m | Completely cemented duricrust | N/A | N/A | N/A | Pale red | 10R 7/4 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan (silcrete?). Very hard cores of cemented sand with variable colour (white, red and yellow) | |
| BMC95_17 | 16 - 17m | Completely cemented duricrust | N/A | N/A | N/A | Red | 10R 5/9 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan (silcrete?). Very hard cores of cemented sand with variable colour (white, red and yellow) | |
| BMC95_18 | 17 - 18m | Completely cemented duricrust | N/A | N/A | N/A | Red | 10R 5/9 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan (silcrete?). Very hard cores of cemented sand with variable colour (white, red and yellow) | |
| BMC95_19 | 18 - 19m | Completely cemented duricrust | N/A | N/A | N/A | Red | 10R 5/9 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan (silcrete?). Very hard cores of cemented sand with variable colour (white, red and yellow) | |
| BMC95_20 | 19 - 20m | Completely cemented duricrust | N/A | N/A | N/A | Red | 10R 5/9 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan (silcrete?). Very hard cores of cemented sand with variable colour (white, red and yellow) | |
| BMC95_21 | 20 - 21m | Completely cemented duricrust | N/A | N/A | N/A | Red | 10R 5/9 | Pedolith | Pedoplasmation front | Silicified weathered saprolite | Aquitard | Hardpan (silcrete?). Very hard cores of cemented sand with variable colour (white, red and yellow) | |
| BMC95_22 | 21 - 22m | Sandy clay loam | Poorly sorted | Clay to cobble | Angular/high to Rounded/low | Light red | 10R 7/6 | Pedolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | End of hardpan (silcrete?). Clay, very fine to very coarse (>5mm), some chips with quartz-rich hardpan | |
| BMC95_23 | 22 - 23m | Clay with quartz | Poorly sorted | Very fine sand to granule | Angular/low to Rounded/low | Pink | 10R 8/4 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Clay, very fine to very coarse (>5mm), some chips with quartz-rich blocks | Saprolite |
| BMC95_24 | 23 - 24m | Clay with quartz | Poorly sorted | Clay to granule | Very angular/low to subangular/low | Light red | 10R 6/6 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Clay, very fine to very coarse (>5mm), some chips with quartz-rich blocks | Saprolite |
| BMC95_25 | 24 - 25m | Clay with quartz | Poorly sorted | Clay to cobble | Very angular/low to subangular/low | Pinkish white | 10R 8/2 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Clay, very fine to very coarse (>5mm), some chips with quartz-rich blocks | Saprolite |
| BMC95_26 | 25 - 26m | Clay with quartz | Poorly sorted | Clay to cobble | Very angular/low to subangular/low | Yellow | 10YR 7/6 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Clay, very fine to very coarse (>5mm), some chips with quartz-rich blocks | Saprolite |
| BMC95_27 | 26 - 27m | Clay with quartz | Poorly sorted | Clay to cobble | Very angular/low to subangular/low | Yellow | 10YR 7/6 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Clay, very fine to very coarse (>5mm), some chips with quartz-rich blocks | Saprolite, some quartz and feldspar chips <15mm |
| BMC95_28 | 27 - 28m | Clay with quartz | Poorly sorted | Clay to cobble | Very angular/low to subangular/low | Yellow | 10YR 7/6 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Clay, very fine to very coarse (>5mm), some chips with quartz-rich blocks | Saprolite, some igneous bedrock chips <15mm |
| BMC95_29 | 28 - 29m | Clay with quartz | Poorly sorted | Clay to cobble | Very angular/low to subangular/low | Yellow | 10YR 7/6 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Clay, very fine to very coarse (>5mm), some chips with quartz-rich blocks | Saprolite, some igneous bedrock chips <30mm |
| BMC95_30 | 29 - 30m | Clay with quartz | Poorly sorted | Clay to cobble | Very angular/low to subangular/low | Yellow | 10YR 7/6 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Clay, very fine to very coarse (>5mm), some chips with quartz-rich blocks | Saprolite, some igneous bedrock chips <50mm |

| ID | Depth (m) | Texture | Sorting | Grain size | Dominant grain roundness/sphericity | Colour name | Munsell colour | Stratigraphy | Horizon (Anand & Paine, 2002) | DAFWA terms | Hydrostratigraphy | Field notes | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC95_31 | 30 - 31m | Bedrock | | | | | | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Clay, very fine to very coarse (>5mm), some chips with quartz-rich blocks | Igneous (granite?) bedrock |
| BMC95_32 | 31 - 32m | Bedrock | | | | | | Saprolith | Quartz-rich bedrock | Fresh granitoid gneiss | | EOH - competent igneous (granite?) basement | Igneous (granite?) bedrock |
| BMC96_01 | 00 - 01m | Sand | Well sorted | Very fine to coarse sand | Subangular/low to Rounded/low | Yellow | 10YR 7/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, fine, subangular to rounded, well sorted, damp | |
| BMC96_02 | 01 - 02m | Sand | Well sorted | Very fine to coarse sand | Subangular/low to Rounded/low | Yellow | 10YR 8/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, fine, subangular to rounded, well sorted, damp | |
| BMC96_03 | 02 - 03m | Sand | Well sorted | Very fine to coarse sand | Subangular/low to Rounded/low | Yellow | 10YR 8/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, fine, subangular to rounded, well sorted, damp | |
| BMC96_04 | 03 - 04m | Sand | Well sorted | Very fine to coarse sand | Subangular/low to Rounded/low | Grey | 7.5YR 6/1 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, fine, subangular to rounded, well sorted, saturated - below water table | |
| BMC96_05 | 04 - 05m | Sand | Well sorted | Very fine to medium sand | Subangular/low to Rounded/high | Grey | 7.5YR 6/1 | Pedolith | Cementation front | Tertiary sandplain | Surficial aquifer | Hardpan at 4.8m - Sand, fine, subangular to rounded, well sorted, saturated - below water table | |
| BMC96_06 | 05 - 06m | Partially cemented duricrust | Poorly sorted | Very fine sand to granule | Subangular/low to Rounded/high | Light grey | 10YR 7/2 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan with clayey sand | |
| BMC96_07 | 06 - 07m | Partially cemented duricrust | Well sorted | Coarse silt to Very coarse sand | Subangular/low to Rounded/high | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan with clayey sand, well sorted - increasing clay content | |
| BMC96_08 | 07 - 08m | Partially cemented duricrust | Well sorted | Coarse silt to Very coarse sand | Subangular/low to Rounded/high | Very pale brown | 10YR 8/2 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan with clayey sand, well sorted - increasing clay content | |
| BMC96_09 | 08 - 09m | Partially cemented duricrust | Well sorted | Coarse silt to Very coarse sand | Subangular/low to Rounded/high | Very pale brown | 10YR 8/2 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan with clayey sand, well sorted - increasing clay content | |
| BMC96_10 | 09 - 10m | Partially cemented duricrust | Well sorted | Coarse silt to Very coarse sand | Subangular/low to Rounded/high | Very pale brown | 10YR 8/2 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan with clayey sand, well sorted - increasing clay content. Reduced number of hardpan boulders | |
| BMC96_11 | 10 - 11m | Sandy loam | Well sorted | Very fine silt to Very fine sand | Subangular/low to Rounded/high | White | 10YR 8/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Sandy clay with yellow coloured nodiles (not ferricrete) | |
| BMC96_12 | 11 - 12m | Sandy loam | Well sorted | Very fine silt to Very fine sand | Subangular/low to Rounded/high | White | 10YR 8/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Sandy clay. Water added during drilling - saturated | |
| BMC96_13 | 12 - 13m | Sandy loam | Well sorted | Very fine silt to Very fine sand | Subangular/low to Rounded/high | White | 10YR 8/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Sandy clay. Water added during drilling - saturated | |
| BMC96_14 | 13 - 14m | Sandy loam | Poorly sorted | Coarse silt to Very coarse sand | Angular/low to Rounded/low | White | 10YR 8/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Sandy clay with some friable hardpan. Water added during drilling - saturated | |
| BMC96_15 | 14 - 15m | Partially cemented duricrust | Poorly sorted | Coarse silt to granule | Angular/low to Rounded/low | Very pale brown | 10YR 8/3 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Clay with Hardpan (silcrete/ferricrete?). Sandy quartz-rich conglomerate. Clay is very pale brown | |

| ID | Depth (m) | Texture | Sorting | Grain size | Dominant grain roundness/sphericity | Colour name | Munsell colour | Stratigraphy | Horizon (Anand & Paine, 2002) | DAFWA terms | Hydrostratigraphy | Field notes | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC96_16 | 15 - 16m | Completely cemented duricrust | Poorly sorted | Coarse silt to Very coarse sand | Angular/low to Rounded/low | Pale red | 10R 7/3 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Change in hardpan (ferricrete?). Some samples with saprolite? | |
| BMC96_17 | 16 - 17m | Completely cemented duricrust | Poorly sorted | Coarse silt to granule | Angular/low to Rounded/low | Pale red to White | 10R 7/3 - 10YR 8/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan as above with variable colour and structure | |
| BMC96_18 | 17 - 18m | Completely cemented duricrust | Poorly sorted | Coarse silt to granule | Angular/low to Rounded/low | Pale red | 10R 7/3 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan as above with variable colour and structure | Minimal sample return - Ferricrete? |
| BMC96_19 | 18 - 19m | Completely cemented duricrust | Poorly sorted | Coarse silt to granule | Angular/low to Rounded/low | Pale red to White | 10R 7/3 - 10YR 8/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan as above with variable colour and structure | |
| BMC96_20 | 19 - 20m | Completely cemented duricrust | Poorly sorted | Coarse silt to granule | Angular/low to Rounded/low | Pale red to White | 10R 7/3 - 10YR 8/1 | Pedolith | Pedoplasmation front | Silicified weathered saprolite | Aquitard | Very hard drilling - saprock/silcrete? | |
| BMC96_21 | 20 - 21m | Clayey sand | Well sorted | Coarse silt to pebble | Angular/low to Rounded/low | Pinkish white | 2.5YR 8/2 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | End of hardpan. Clay with quartz (>5mm), broken hardpan fragments from above. Very wet sample | |
| BMC96_22 | 21 - 22m | Clay with quartz | Poorly sorted | Clay to very coarse sand | Angular/low to Rounded/low | Pinkish white | 2.5YR 8/2 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Clay with sand, very fine to coarse (~2mm) | |
| BMC96_23 | 22 - 23m | Clay with quartz | Poorly sorted | Clay to very coarse sand | Angular/low to Rounded/low | Pinkish white | 2.5YR 8/2 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Clay with sand, very fine to coarse (~2mm) | |
| BMC96_24 | 23 - 24m | Clay with quartz | Poorly sorted | Clay to pebble | Angular/low to Rounded/low | Light grey | GLEY 1 7/N | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Sandy clay, very fine to very coarse (>2mm) | Some unweathered feldspar in sample |
| BMC96_25 | 24 - 25m | Clay with quartz | Poorly sorted | Clay to pebble | Angular/low to Rounded/low | Light greenish grey | GLEY 1 7/10Y | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Sandy clay, very fine to very coarse (>2mm) | Some unweathered feldspar in sample |
| BMC96_26 | 25 - 26m | Clay with quartz | Poorly sorted | Clay to very coarse sand | Angular/low to Rounded/low | Light greenish grey | GLEY 1 8/10Y | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Gritty clay - very wet sample | Some unweathered feldspar in sample |
| BMC96_27 | 26 - 27m | Clay with quartz | Poorly sorted | Clay to granule | Angular/low to Rounded/low | Light greenish grey | GLEY 1 8/10Y | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Gritty clay - very wet sample | Some unweathered feldspar in sample |
| BMC96_28 | 27 - 28m | Clay with quartz | Poorly sorted | Clay to granule | Angular/low to Rounded/low | Light greenish grey | GLEY 1 8/10Y | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Gritty clay - very wet sample | |
| BMC96_29 | 28 - 29m | Clay with quartz | Poorly sorted | Clay to pebble | Angular/low to Rounded/low | Light greenish grey | GLEY 1 8/10Y | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Gritty clay - very wet sample | |
| BMC96_30 | 29 - 30m | Clay with quartz | Poorly sorted | Clay to pebble | Angular/low to Rounded/low | Light greenish grey | GLEY 1 8/10Y | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Gritty clay - very wet sample | |
| BMC96_31 | 30 - 31m | Clay with quartz | Poorly sorted | Clay to pebble | Angular/low to Rounded/low | Light greenish grey | GLEY 1 8/10Y | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Gritty clay - very wet sample | |
| BMC96_32 | 31 - 32m | Clay with igneous bedrock | Poorly sorted | Clay to pebble | Angular/low to Rounded/low | Light greenish grey | GLEY 1 8/10Y | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Gritty clay - very wet sample. Some minor igneous fragments | |

| ID | Depth (m) | Texture | Sorting | Grain size | Dominant grain roundness/sphericity | Colour name | Munsell colour | Stratigraphy | Horizon (Anand & Paine, 2002) | DAFWA terms | Hydrostratigraphy | Field notes | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC96_33 | 32 - 33m | Clay with igneous bedrock | Poorly sorted | Clay to pebble | Angular/low to Rounded/low | Light greenish grey | GLEY 1 8/10Y | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Gritty clay - very wet sample. Some minor igneous fragments | |
| BMC96_34 | 33 - 34m | Clay with igneous bedrock | Poorly sorted | Clay to pebble | Angular/low to Rounded/low | | | Saprolith | Saprock | Weathered granitic saprolite | Saprolite aquifer | Weathered igneous (granite?) bedrock | Saprock |
| BMC96_35 | 34 - 35m | | | | | | | Saprolith | Saprock | Weathered granitic saprolite | | Igneous (granite?) bedrock | Igneous (granite?) bedrock |
| BMC96_36 | 35 - 36m | | | | | | | Saprolith | Quartz-rich bedrock | Fresh granitoid gneiss | | Igneous (granite?) bedrock | Igneous (granite?) bedrock |
| BMC97_01 | 00 - 01m | Loamy sand | Well sorted | Fine to very coarse sand | Subangular/low to Rounded low | Light grey | 10YR 7/2 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Clayey sand, saturated, well sorted, very fine to coarse <10% clay. Shallow water table | |
| BMC97_02 | 01 - 02m | Loamy sand | Well sorted | Fine to very coarse sand | Subangular/low to Rounded low | Light brownish grey | 10YR 6/2 | Pedolith | Cementation front | Silcrete | Surficial aquifer | Clayey sand, well sorted, very fine to coarse <10% clay, some fragments of friable hardpan | |
| BMC97_03 | 02 - 03m | Loamy sand | Well sorted | Fine to very coarse sand | Subangular/low to Rounded low | Very pale brown | 10YR 7/3 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Clayey sand, well sorted, very fine to coarse <10% clay, with hardpan blocks in sample | |
| BMC97_04 | 03 - 04m | Partially cemented duricrust | Well sorted | Coarse silt to Very coarse sand | Subangular/high to Rounded/low | Pale brown | 10YR 6/3 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Clayey sand, well sorted, very fine to coarse <10% clay, with hardpan blocks in sample. Consolidated hardpan at 4mbgl | Grain size decreasing with depth |
| BMC97_05 | 04 - 05m | Partially cemented duricrust | Well sorted | Coarse silt to coarse sand | Subrounded/high to Rounded/high | Light brownish grey | 10YR 6/2 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Liquipol and water added - Poor sample return. Clayey sand, very fine to coarse with hardpan fragments | Not representative - Liquipol added |
| BMC97_06 | 05 - 06m | Partially cemented duricrust | Poorly sorted | Coarse silt to granule | Angular/low to Rounded/low | Light grey | 10YR 7/2 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan (silcrete?). Clayey sand ~10% clay, very fine to coarse | |
| BMC97_07 | 06 - 07m | Partially cemented duricrust | Poorly sorted | Coarse silt to granule | Angular/low to Rounded/low | Light grey | 10YR 7/2 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan (silcrete?)/ Sandy clay ~10% clay, very fine to coarse with some iron-rich cemented fragments | |
| BMC97_08 | 07 - 08m | Partially cemented duricrust | Poorly sorted | Coarse silt to granule | Angular/low to Rounded/low | Very pale brown | 10YR 8/2 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan (silcrete?) Much coarser (angular?) quartz grains, quartz larger in size than above. Very fine to very coarse | |
| BMC97_09 | 08 - 09m | Partially cemented duricrust | Poorly sorted | Coarse silt to granule | Angular/low to Rounded/low | Very pale brown | 10YR 8/2 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan (silcrete?). Poor sample recovery. Some iron-staining in hardpan | |
| BMC97_10 | 09 - 10m | Partially cemented duricrust | Poorly sorted | Coarse silt to granule | Angular/low to Rounded/low | Very pale brown | 10YR 8/2 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan (silcrete?). Poor sample recovery | |
| BMC97_11 | 10 - 11m | Completely cemented duricrust | Poorly sorted | Coarse silt to granule | Angular/low to Rounded/low | Pink | 7.5YR 8/3 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan (ferricrete?) Sandy clay with hardpan, quartz >2mm, very angular, poorly sorted. High quartz content | Iron-rich ferricrete??? |

| ID | Depth (m) | Texture | Sorting | Grain size | Dominant grain roundness/sphericity | Colour name | Munsell colour | Stratigraphy | Horizon (Anand & Paine, 2002) | DAFWA terms | Hydrostratigraphy | Field notes | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC97_12 | 11 - 12m | Completely cemented duricrust | Poorly sorted | Coarse silt to pebble | Very angular/low to rounded/low | Light green | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan (silcrete?) with quartz >3mm in clay cement, poorly sorted, change in colour to red (iron-rich layer?), quartz very angular | |
| BMC97_13 | 12 - 13m | Completely cemented duricrust | Poorly sorted | Coarse silt to pebble | Very angular/low to rounded/low | Very pale brown | 10YR 8/3 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Poor sample recovery. Hardpan (silcrete?) with quartz >4mm, very angular with sandy clay | Veins (secondary cementation?) evident in consolidated hardpan |
| BMC97_14 | 13 - 14m | Completely cemented duricrust | Poorly sorted | Coarse silt to pebble | Very angular/low to rounded/low | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Poor sample recovery. Hardpan (silcrete?) with quartz >4mm, very angular with sandy clay. Hardpan with quartz veins | Predominantly quartz |
| BMC97_15 | 14 - 15m | | | | | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan (silcrete?) with quartz ~2mm with sandy clay | No sample |
| BMC97_16 | 15 - 16m | Completely cemented duricrust | Poorly sorted | Coarse silt to pebble | Very angular/low to rounded/low | Light grey | 10YR 7/1 | Pedolith | Pedoplasmation front | Silcrete | Leaky aquitard | Hardpan (silcrete?), quartz grains >4mm. Very poor sample recovery | |
| BMC97_17 | 16 - 17m | Clay with quartz | Poorly sorted | Clay to granule | Angular/low to Rounded/low | Light grey | 10YR 7/1 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Very poor sample return - Clay with quartz <2mm | Start of saprolite/weathering front |
| BMC97_18 | 17 - 18m | Clay with quartz | Poorly sorted | Clay to very coarse sand | Angular/low to Rounded/low | Light grey | 10YR 7/1 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Very poor sample return - Clay with quartz <2mm | Saprolite/weathering front |
| BMC97_19 | 18 - 19m | Clay with quartz | Poorly sorted | Clay to pebble | Angular/low to Rounded/low | Light grey | 10YR 7/1 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Poor sample return. Washed quartz (<4mm), poorly sorted, very angular | Saprolite/weathering front |
| BMC97_20 | 19 - 20m | Clay with quartz | Poorly sorted | Clay to pebble | Angular/low to Rounded/low | Light grey | 10YR 7/2 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Poor sample return. Washed quartz (<4mm), poorly sorted, very angular | Saprolite/weathering front |
| BMC97_21 | 20 - 21m | Clay with quartz | Poorly sorted | Clay to pebble | Angular/low to Rounded/low | Very pale brown | 10YR 7/4 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Gritty clay with quartz (<4mm), poorly sorted, very angular | Saprolite/weathering front |
| BMC97_22 | 21 - 22m | Clay with quartz | Poorly sorted | Clay to pebble | Angular/low to Rounded/low | Very pale brown | 10YR 7/4 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Gritty clay with quartz (<10mm), poorly sorted, very angular | Saprolite/weathering front |
| BMC97_23 | 22 - 23m | Clay with bedrock chips | Poorly sorted | Clay to pebble | Angular/low to Rounded/low | Very pale brown | 10YR 7/4 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Gritty clay with igneous chips (>10mm), poorly sorted, very angular | Saprock |
| BMC97_24 | 23 - 24m | Igneous (granite?) bedrock | | | | Light brownish grey | 2.5Y 6/2 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Gritty clay with igneous (granite?) chips (>10mm), poorly sorted, very angular | Saprock |
| BMC97_25 | 24 - 25m | Igneous (granite?) bedrock | | | | Light brownish grey | 2.5Y 6/2 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Igneous (granite?) bedrock chips at 25m | Saprock |
| BMC97_26 | 25 - 26m | Igneous (granite?) bedrock | | | | Light brownish grey | 2.5Y 6/2 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Igneous (granite?) bedrock chips | Igneous (granite?) bedrock |
| BMC97_27 | 26 - 27m | Igneous (granite?) bedrock | | | | Light brownish grey | 2.5Y 6/2 | Saprolith | Quartz-rich bedrock | Fresh granitoid gneiss | | EOH - Igneous (granite?) bedrock chips | Igneous (granite?) bedrock |

| ID | Depth (m) | Texture | Sorting | Grain size | Dominant grain roundness/sphericity | Colour name | Munsell colour | Stratigraphy | Horizon (Anand & Paine, 2002) | DAFWA terms | Hydrostratigraphy | Field notes | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC98_01 | 00 - 01m | Sand | Well sorted | Very fine to coarse sand | Subangular/low to Subrounded/High | Light grey | 10YR 7/1 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Liquipol contaminated sample - Sand, well sorted | |
| BMC98_02 | 01 - 02m | Sand | Well sorted | Very fine to coarse sand | Subangular/low to Subrounded/High | Light grey | 10YR 7/1 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Liquipol contaminated sample - Sand, well sorted | |
| BMC98_03 | 02 - 03m | Partially cemented duricrust | Well sorted | Very fine to coarse sand | Rounded/low | Light grey | 10YR 7/1 | Pedolith | Cementation front | Silcrete | Surficial aquifer | Liquipol contaminated sample - Hardpan, very fine to fine quartz. Water added at 3m | |
| BMC98_04 | 03 - 04m | Partially cemented duricrust | Well sorted | Very fine to coarse sand | Subrounded/low to Rounded/low | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Liquipol contaminated sample - Hardpan, very fine to fine quartz, iron-oxide nodules in sample | |
| BMC98_05 | 04 - 05m | Partially cemented duricrust | Well sorted | Very fine to very coarse sand | Subrounded/low to Rounded/low | Very pale brown | 10YR 7/3 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Liquipol contaminated sample - Hardpan with very fine to coarse quartz | |
| BMC98_06 | 05 - 06m | Partially cemented duricrust | Well sorted | Very fine to very coarse sand | Rounded/low | Light grey | 10YR 7/2 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan with very fine to coarse quartz | |
| BMC98_07 | 06 - 07m | Partially cemented duricrust | Well sorted | Clay to very coarse sand | Subrounded/low to Rounded/low | Light grey | 10YR 7/2 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan with very fine to coarse quartz | |
| BMC98_08 | 07 - 08m | Partially cemented duricrust | Well sorted | Very fine to coarse sand | Angular/low to Rounded/low | Light grey | 10YR 7/2 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Poor sample return - Hardpan absent | |
| BMC98_09 | 08 - 09m | Partially cemented duricrust | Well sorted | Very fine to coarse sand | Rounded/low | Very pale brown | 10YR 8/2 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan, quartz very fine to coarse | |
| BMC98_10 | 09 - 10m | Partially cemented duricrust | Well sorted | Very fine to coarse sand | Rounded/low | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Sandy clay, very fine to coarse | Hardpan ground-up with drilling |
| BMC98_11 | 10 - 11m | Partially cemented duricrust | Well sorted | Very fine to coarse sand | Rounded/low | Light grey | 2.5Y 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan sample ground from drilling, is very fine to coarse | Hardpan ground-up with drilling |
| BMC98_12 | 11 - 12m | Partially cemented duricrust | Well sorted | Very fine to coarse sand | Rounded/low | Light grey | 2.5Y 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan sample ground from drilling, is very fine to coarse | Hardpan ground-up with drilling |
| BMC98_13 | 12 - 13m | Partially cemented duricrust | Well sorted | Very fine to coarse sand | Rounded/low | Light grey | 5Y 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan sample ground from drilling, is very fine to coarse | Hardpan ground-up with drilling |
| BMC98_14 | 13 - 14m | Partially cemented duricrust | Well sorted | Very fine sand to granule | Angular/low to Rounded/low | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan sample ground from drilling, is very fine to coarse | Hardpan ground-up with drilling |
| BMC98_15 | 14 - 15m | Partially cemented duricrust | Well sorted | Very fine sand to granule | Angular/low to Rounded/low | Light grey | 10YR 7/2 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan sample ground from drilling, is very fine to coarse | Hardpan ground-up with drilling |
| BMC98_16 | 15 - 16m | Partially cemented duricrust | Well sorted | Very fine sand to granule | Angular/low to Rounded/low | Very pale brown | 10YR 7/3 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan sample ground from drilling, is very fine to coarse. Some iron-rich (ferricrete?) in sample | Horizon more coarse (larger quartz) than above |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC98_17 | 16 - 17m | Partially cemented duricrust | Poorly sorted | Very fine sand to granule | Angular/low to Rounded/low | Light brownish grey | 10YR 6/2 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Very hard hardpan at 17m. Hardpan sample ground from drilling, is very fine to coarse. Some iron-rich (ferricrete?) in sample | |
| BMC98_18 | 17 - 18m | Partially cemented duricrust | Poorly sorted | Very fine sand to granule | Angular/low to Rounded/low | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan (silcrete?) - as above | |
| BMC98_19 | 18 - 19m | Partially cemented duricrust | Poorly sorted | Very fine sand to granule | Subangular/low Rounded/low | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan (silcrete?) - as above | |
| BMC98_20 | 19 - 20m | Partially cemented duricrust | Poorly sorted | Very fine sand to pebble | Subangular/low Rounded/low | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan (silcrete?), very fine to very coarse. Very angular quartz | Some feldspar in sample also |
| BMC98_21 | 20 - 21m | Partially cemented duricrust | Poorly sorted | Very fine sand to pebble | Subangular/low Rounded/low | Light grey | 10YR 7/2 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan with much more quartz than above, some ironstone inclusions | |
| BMC98_22 | 21 - 22m | Partially cemented duricrust | Poorly sorted | Very fine sand to pebble | Subangular/low Rounded/low | Light grey | 10YR 7/2 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan | |
| BMC98_23 | 22 - 23m | Partially cemented duricrust | Poorly sorted | Very fine sand to pebble | Subangular/low Rounded/low | Light grey | 10YR 7/2 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan | Hardpan ground-up with drilling |
| BMC98_24 | 23 - 24m | Partially cemented duricrust | Poorly sorted | Very fine to very coarse sand | Subangular/low to Rounded/high | Light grey | 10YR 7/2 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan | |
| BMC98_25 | 24 - 25m | Partially cemented duricrust | Well sorted | Very fine to coarse sand | Subangular/low to Rounded/high | Very pale brown | 10YR 7/3 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan | |
| BMC98_26 | 25 - 26m | Partially cemented duricrust | Poorly sorted | Very fine sand to granule | Subangular/low to Rounded/high | Very pale brown | 10YR 7/4 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan | Increased proportion of quartz |
| BMC98_27 | 26 - 27m | Partially cemented duricrust | Poorly sorted | Very fine sand to granule | Subangular/low to Rounded/high | Yellow | 10YR 7/6 | Pedolith | Pedoplasmation front | Silcrete | Leaky aquitard | Hardpan | |
| BMC98_28 | 27 - 28m | Clay with quartz | Poorly sorted | Clay to pebble | Angular/low to Rounded/high | Light brownish grey | 2.5Y 6/2 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Hardpan | Some clumps of organic material in matrix - preferential pathway? |
| BMC98_29 | 28 - 29m | Clay with igneous bedrock | Poorly sorted | Clay to pebble | Angular/low to Rounded/high | Olive grey | 5Y 7/2 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Gritty clay with igneous (granite?) chips | Saprock? |
| BMC98_30 | 29 - 30m | Igneous (granite?) bedrock | | | | Olive grey | 5Y 7/2 | Saprolith | Saprock | Weathered granitic saprolite | | Top of igneous (granite?) bedrock, bedrock fragments | |
| BMC98_31 | 30 - 31m | Igneous (granite?) bedrock | | | | | | Saprolith | Quartz-rich bedrock | Fresh granitoid gneiss | | EOH - Igneous (granite?) bedrock | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC99_01 | 00 - 01m | Sand | Poorly sorted | Very fine sand to granule | Angular/low to Subrounded/low | Light yellowish brown | 10YR 6/4 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Logs from abandoned hole - Well sorted sand | |
| BMC99_02 | 01 - 02m | Sand with ironstone gravel | Poorly sorted | Very fine sand to cobble | Angular/low to Rounded/high | Light yellowish brown | 10YR 6/4 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Logs from abandoned hole - Poorly sorted sand with ferricrete nodules <2mm to >10mm | |
| BMC99_03 | 02 - 03m | Completely cemented duricrust | Poorly sorted | Very fine sand to pebble | Angular/low to Rounded/low | Brown | 10YR 5/3 | Pedolith | Cementation front | Silcrete | Surficial aquifer | Logs from abandoned hole - poorly sorted sand with variable hardpan - ferricrete and sandstone? | |
| BMC99_04 | 03 - 04m | Completely cemented duricrust | Well sorted | Very fine to very coarse sand | Subrounded/low | Very pale brown | 10YR 7/3 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Logs from abandoned hole - sandstone hardpan. Holes in hardpan | |
| BMC99_05 | 04 - 05m | Completely cemented duricrust | Well sorted | Very fine to very coarse sand | Subrounded/low | Very pale brown | 10YR 8/2 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Logs from abandoned hole - sandstone hardpan | |
| BMC99_06 | 05 - 06m | Completely cemented duricrust | Well sorted | Coarse silt to Very coarse sand | Subrounded/low | White | 10YR 8/1 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Logs from abandoned hole - sandstone hardpan | |
| BMC99_07 | 06 - 07m | Moderately cemented duricrust | Poorly sorted | Coarse silt to cobble | | White | 10YR 8/1 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Logs from abandoned hole - sandstone hardpan with iron-rich nodules (not pisoliths). Some iron-rich mottling with ferricrete | |
| BMC99_08 | 07 - 08m | Completely cemented duricrust | | | | Redish yellow | 5YR 6/6 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Logs from abandoned hole - ferricrete hardpan, EOH @8m. Iron nodules with angular quartz grains | |
| BMC99_09 | 08 - 09m | Completely cemented duricrust | Poorly sorted | | | | | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Quartz-rich hardpan with gravel <5mm | |
| BMC99_10 | 09 - 10m | | | | | | | Pedolith | Arenose zone | Silcrete | Leaky aquitard | | |
| BMC99_11 | 10 - 11m | | Poorly sorted | | | Yellowish red | 5YR 5/6 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Log from abandoned hole - Quartz-rich hardpan with gravel <5mm. Ferricrete also? | |
| BMC99_12 | 11 - 12m | Completely cemented duricrust | | | | | | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Log from abandoned hole - Quartz-rich hardpan with gravel <5mm. Ferricrete also? | |
| BMC99_13 | 12 - 13m | Clayey sand | Well sorted | Clay to very coarse sand | Subangular/low to subrounded/low | Yellowish red | 5YR 5/6 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Log from abandoned hole - Ferricrete? | |
| BMC99_14 | 13 - 14m | Completely cemented duricrust | | | | | | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Log from abandoned hole - Ferricrete? | |
| BMC99_15 | 14 - 15m | Completely cemented duricrust | | | | | | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Log from abandoned hole - Ferricrete? | |
| BMC99_16 | 15 - 16m | Moderately cemented duricrust | | | | | | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Log from abandoned hole - Ferricrete? | |
| BMC99_17 | 16 - 17m | Completely cemented duricrust | | | | | | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Log from abandoned hole - Silcrete? | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC100_01 | 00 - 01m | Sand | Well sorted | Very fine to very coarse sand | Very angular/high to Rounded/high | Light grey | 10YR 7/2 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, well sorted, damp | |
| BMC100_02 | 01 - 02m | Sand | Well sorted | Very fine to very coarse sand | Very angular/high to Rounded/high | Yellow | 10YR 7/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, well sorted, damp | |
| BMC100_03 | 02 - 03m | Sand | Well sorted | Very fine to very coarse sand | Very angular/high to Rounded/high | Yellow | 10YR 7/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, well sorted, damp | |
| BMC100_04 | 03 - 04m | Sand | Well sorted | Very fine to very coarse sand | Very angular/high to Rounded/high | Yellow | 10YR 7/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, well sorted, damp | |
| BMC100_05 | 04 - 05m | Sand | Well sorted | Very fine to very coarse sand | Very angular/high to Rounded/high | Yellow | 10YR 7/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, well sorted, damp | |
| BMC100_06 | 05 - 06m | Sand | Well sorted | Very fine to very coarse sand | Very angular/high to Rounded/high | Yellow | 10YR 7/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, well sorted, damp | |
| BMC100_07 | 06 - 07m | Sand | Well sorted | Very fine to very coarse sand | Very angular/high to Rounded/high | Yellow | 10YR 7/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, well sorted, damp | |
| BMC100_08 | 07 - 08m | Sand | Well sorted | Very fine to very coarse sand | Very angular/high to Rounded/high | Very pale brown | 10YR 7/3 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, well sorted, damp | Sample missing |
| BMC100_09 | 08 - 09m | Partially cemented duricrust | Well sorted | Very fine to very coarse sand | Subangular/low to Rounded/high | Light grey | 10YR 7/2 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, well sorted, damp - hardpan at ~9m. Water added during drilling | Hardpan ground-up with drilling |
| BMC100_10 | 09 - 10m | Partially cemented duricrust | Poorly sorted | Very fine sand to granule | Angular/high to Rounded/low | Light grey | 10YR 7/2 | Pedolith | Cementation front | Silcrete | Leaky aquitard | Hardpan | Friable, ground-up hardpan of small quartz grains <5mm. |
| BMC100_11 | 10 - 11m | Partially cemented duricrust | Poorly sorted | Very fine sand to pebble | Subangular/low to Rounded/low | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan, with bands of sand/quartz | Friable, ground-up hardpan of small quartz grains <10mm. |
| BMC100_12 | 11 - 12m | Partially cemented duricrust | Well sorted | Coarse silt to Very coarse sand | Subangular/high to Rounded/high | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Initial hole abonadoned due to hole colapsing | Friable, ground-up hardpan of small quartz grains. |
| BMC100_13 | 12 - 13m | Partially cemented duricrust | Well sorted | Coarse silt to coarse sand | Subangular/high to Rounded/high | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Sand - Sample contaminated with liquipol | Friable, ground-up hardpan of small quartz grains. |
| BMC100_14 | 13 - 14m | Partially cemented duricrust | Well sorted | Coarse silt to coarse sand | Subangular/high to Rounded/high | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Sand - Sample contaminated with liquipol | Friable, ground-up hardpan of small quartz grains, mostly <0.5mm, and silt/clay |
| BMC100_15 | 14 - 15m | Partially cemented duricrust | Well sorted | Fine silt to Coarse sand | Subangular/high to Rounded/high | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Sand - Sample contaminated with liquipol | Friable hardpan of small quartz grains, mostly <0.5mm |
| BMC100_16 | 15 - 16m | Partially cemented duricrust | Well sorted | Fine silt to Coarse sand | Subangular/high to Rounded/high | Light grey to very pale brown | 10YR 7/1 - 10YR 7/3 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan layer, cemented sand. Rods getting stuck on return. Sandy clay with pulverised hardpan >15% clay | Clumps of clay matrix containing angular quartz <3mm |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC100_17 | 16 - 17m | Partially cemented duricrust | Well sorted | Fine silt to Coarse sand | Subangular/high to Rounded/high | Light grey to very pale brown | 10YR 7/1 - 10YR 7/3 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan as above - Sandy clay with some quartz fragments. Sample contaminated with liquipol | Clumps of clay matrix containing angular quartz <3mm |
| BMC100_18 | 17 - 18m | Clay matrix | Poorly sorted | Clay to granule | Angular/low quartz | Weak red | 2.5YR 4/2 | Pedolith | Mottled zone | Silcrete | Leaky aquitard | Sample contaminated with liquipol - sandy clay with >20% clay | |
| BMC100_19 | 18 - 19m | Clay matrix | Poorly sorted | Clay to granule | Angular/low quartz | Pale red | 10R 7/4 | Pedolith | Mottled zone | Silcrete | Leaky aquitard | Clay with some fragments of friable weathered material, consolidated clay with angular to very angular quartz | |
| BMC100_20 | 19 - 20m | Completely cemented duricrust | Poorly sorted | Clay to pebble | Angular/low quartz | Pale red | 10R 7/4 | Pedolith | Mottled zone | Silcrete | Leaky aquitard | As above - Large >5cm fragments with variable colour from white to yellow to red. Water added during drilling | |
| BMC100_21 | 20 - 21m | Completely cemented duricrust | Poorly sorted | Clay to pebble | Angular/low quartz | Pale red | 10R 7/4 | Pedolith | Mottled zone | Silcrete | Leaky aquitard | As above with hardpan (saprock??) | Red (iron-oxide?) stained hardpan |
| BMC100_22 | 21 - 22m | Completely cemented duricrust | Poorly sorted | Clay to pebble | Angular/low quartz | Pink | 10R 8/3 | Pedolith | Mottled zone | Silcrete | Leaky aquitard | As above with pink clay | Red (iron-oxide?) stained hardpan |
| BMC100_23 | 22 - 23m | Completely cemented duricrust | Poorly sorted | Clay to pebble | Angular/low quartz | Pinkish white | 10R 8/2 | Pedolith | Mottled zone | Silcrete | Leaky aquitard | As above with pinkish white clay | Red (iron-oxide?) stained hardpan |
| BMC100_24 | 23 - 24m | Completely cemented duricrust | Poorly sorted | Clay to pebble | Angular/low quartz | White | 10R 8/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | As above with white clay - less iron oxide in samples | As above, although less iron staining and Quartz <10mm - insitu formation??? |
| BMC100_25 | 24 - 25m | Completely cemented duricrust | Poorly sorted | Clay to pebble | Angular/low to Subangular/low | White | 10R 8/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan - Sandy clay, quartz <5mm grain size, very angular | Quartz <5mm |
| BMC100_26 | 25 - 26m | Completely cemented duricrust | Poorly sorted | Clay to pebble | Angular/low | White | 10R 8/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan - sandy clay, quartz <10mm, poorly sorted | Quartz <10mm |
| BMC100_27 | 26 - 27m | Moderately cemented | Poorly sorted | Clay to granule | Subangular/low to Rounded/high | White | 10R 8/1 | Pedolith | Pedoplasmation front | Silicified weathered saprolite | Aquitard | Hardpan - sandy clay, quartz <5mm, poorly sorted | Much finer and more rounded quartz than above |
| BMC100_28 | 27 - 28m | Moderately cemented | Poorly sorted | Clay to very coarse sand | Subangular/low to Rounded/high | White | 10R 8/1 | Pedolith | Pedoplasmation front | Silicified weathered saprolite | Aquitard | Hardpan - sandy clay, quartz <5mm, poorly sorted. Water added during drilling | |
| BMC100_29 | 28 - 29m | Clay with quartz | Poorly sorted | Clay to pebble | Subangular/low | Pale yellow | 2.5YR 8/3 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Sandy clay, quartz poorly sorted, very angular <2mm to >5mm | |
| BMC100_30 | 29 - 30m | Clay with quartz | Poorly sorted | Clay to pebble | Subangular/low | Pale yellow | 2.5YR 8/3 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Sandy clay, quartz poorly sorted, very angular <2mm to >5mm | |
| BMC100_31 | 30 - 31m | Clay with quartz | Poorly sorted | Clay to pebble | Very angular/low | Pale yellow | 2.5YR 8/3 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Sandy clay, quartz poorly sorted, very angular <2mm to >5mm. Quartz grains becoming larger than 5mm | |
| BMC100_32 | 31 - 32m | Clay with quartz | Poorly sorted | Clay to pebble | Very angular/low | Pale yellow | 2.5YR 8/3 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Sandy clay, quartz poorly sorted, very angular <2mm to >5mm. Quartz grains becoming larger than 5mm | |

| ID | Depth (m) | Texture | Sorting | Grain size | Dominant grain roundness/sphericity | Colour name | Munsell colour | Stratigraphy | Horizon (Anand & Paine, 2002) | DAFWA terms | Hydrostratigraphy | Field notes | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC100_33 | 32 - 33m | Clay with quartz | Poorly sorted | Clay to pebble | Very angular/low | Pale yellow | 2.5YR 8/3 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Sandy clay, quartz poorly sorted, very angular <2mm to >5mm. Quartz grains becoming larger than 5mm | |
| BMC100_34 | 33 - 34m | | | | | | | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Samples contaminated from cyclone | Insufficient sample |
| BMC100_35 | 34 - 35m | Clay with quartz | Poorly sorted | Clay to pebble | Very angular/low | | | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Samples contaminated from cyclone | |
| BMC100_36 | 35 - 36m | Clay with bedrock chips | Poorly sorted | Clay to pebble | Very angular/low | Very pale brown | 10YR 8/4 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Clay with quartz, very angular, poorly sorted <2mm to >5mm | |
| BMC100_37 | 36 - 37m | Clay with bedrock chips | | | | Very pale brown | 10YR 8/4 | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Weathering front? Clay with quartz, very angular, poorly sorted quartz fragments <1mm to >5mm | |
| BMC100_38 | 37 - 38m | Igneous (granite?) bedrock | | | | | | Saprolith | Saprock | Weathered granitic saprolite | Saprolite aquifer | Fragments of igneous (granite?) basement - quartz-rich igneous rock | |
| BMC100_39 | 38 - 39m | Igneous (granite?) bedrock | | | | | | Saprolith | Quartz-rich bedrock | Fresh granitoid gneiss | | Quartz-rich basement fragments, competant basement - EOH. Difficulties extracting rods | |
| BMC101_01 | 00 - 01m | Sand | Well sorted | Very fine to very coarse sand | Subangular/low to Rounded/high | Yellow | 10YR 7/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Well sorted sand - damp. <5% clay | |
| BMC101_02 | 01 - 02m | Sand | Well sorted | Very fine to very coarse sand | Subangular/low to Rounded/high | Yellow | 10YR 7/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Well sorted sand - damp. <5% clay | |
| BMC101_03 | 02 - 03m | Sand | Well sorted | Very fine to very coarse sand | Subangular/low to Rounded/high | Yellow | 10YR 7/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Well sorted sand - damp. <5% clay Below the water table | |
| BMC101_04 | 03 - 04m | Loamy sand | Well sorted | Clay to very coarse sand | Subangular/low to Rounded/high | Yellow | 10YR 7/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Well sorted sand - damp. <10% clay Below the water table | |
| BMC101_05 | 04 - 05m | Loamy sand | Well sorted | Clay to very coarse sand | Subangular/low to Rounded/high | Yellow | 10YR 7/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Well sorted sand - damp. <10% clay Below the water table | |
| BMC101_06 | 05 - 06m | Sand | Well sorted | Very fine to coarse sand | Subrounded/high | Light grey | 10YR 7/2 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Well sorted washed sand, no evidence of hardpan | |
| BMC101_07 | 06 - 07m | Sand | Well sorted | Coarse silt to coarse sand | Subangular/low to Rounded/low | Light grey | 10YR 7/2 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Well sorted washed sand, no evidence of hardpan | |
| BMC101_08 | 07 - 08m | Sand | Well sorted | Coarse silt to medium sand | Subrounded/high | Light grey | 10YR 7/2 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Well sorted washed sand, no evidence of hardpan | |
| BMC101_09 | 08 - 09m | Partially cemented duricrust | Well sorted | Coarse silt to medium sand | Subrounded/high | Light grey | 10YR 7/2 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Well sorted washed sand, some evidence of hardpan | |
| BMC101_10 | 09 - 10m | Partially cemented duricrust | Well sorted | Coarse silt to medium sand | Subrounded/high | Light grey | 10YR 7/2 | Pedolith | Cementation front | Silcrete | Leaky aquitard | Hardpan - sand-rich hardpan | |

| ID | Depth (m) | Texture | Sorting | Grain size | Dominant grain roundness/sphericity | Colour name | Munsell colour | Stratigraphy | Horizon (Anand & Paine, 2002) | DAFWA terms | Hydrostratigraphy | Field notes | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC101_11 | 10 - 11m | Partially cemented duricrust | Well sorted | Coarse silt to medium sand | Subrounded/high | Very pale brown | 10YR 7/3 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan with sand and clay. Clay proportion increasing with depth | |
| BMC101_12 | 11 - 12m | Partially cemented duricrust | Well sorted | Coarse silt to medium sand | Subrounded/high | Very pale brown | 10YR 7/3 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan with sand and clay. Clay proportion increasing with depth - EOH | |
| BMC102_01 | 00 - 01m | Sand | Well sorted | Very fine to coarse sand | Angular/high to Rounded/high | Light grey | 10YR 7/1 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Well sorted sand, damp | |
| BMC102_02 | 01 - 02m | Sand | Poorly sorted | Very fine sand to cobble | Angular/high to Rounded/high | Very pale brown | 10YR 7/3 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Poorly sorted sand, damp. Iron oxide gravel <20mm throughout | |
| BMC102_03 | 02 - 03m | Partially cemented duricrust | Poorly sorted | Clay to cobble | Angular/high to Rounded/high | Very pale brown | 10YR 7/3 | Pedolith | Cementation front | Silcrete | Surficial aquifer | Poorly sorted sandy clay, damp. Iron-rich fragments <5mm to >10mm throughout | |
| BMC102_04 | 03 - 04m | Completely cemented duricrust | Well sorted | Clay to very coarse sand | Subangular/low to Rounded/high | | | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Ferricrete hardpan and sand-rich hardpan | |
| BMC102_05 | 04 - 05m | Completely cemented duricrust | Well sorted | Clay to very coarse sand | Subangular/low to Rounded/high | Grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan - Sandstone-rich hardpan. Hardpan (very pale brown) ground up during drilling | |
| BMC102_06 | 05 - 06m | Completely cemented duricrust | Well sorted | Clay to very coarse sand | Subangular/low to Rounded/high | Very pale brown | 10YR 8/4 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan - sandstone hardpan | |
| BMC102_07 | 06 - 07m | Completely cemented duricrust | | | | Very pale brown | 10YR 8/4 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan - sandstone hardpan. Hole colapsing during drilling, EOH @6m | |
| BMC103_01 | 00 - 01m | Sand | Well sorted | Very fine to coarse sand | Subangular/low to Rounded/low | Brownish yellow | 10YR 6/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, well sorted, damp | |
| BMC103_02 | 01 - 02m | Sand | Well sorted | Very fine to coarse sand | Subangular/low to Rounded/low | Brownish yellow | 10YR 6/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, well sorted, damp | |
| BMC103_03 | 02 - 03m | Sand | Well sorted | Very fine to coarse sand | Subangular/low | Brownish yellow | 10YR 6/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, well sorted, damp | |
| BMC103_04 | 03 - 04m | Sand | Well sorted | Very fine to coarse sand | Subangular/low | Brownish yellow | 10YR 6/6 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Sand, well sorted, damp | |
| BMC103_05 | 04 - 05m | Partially cemented duricrust | Poorly sorted | Very fine to very coarse sand | Subangular/low | Light grey | 10YR 7/2 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Hardpan @5m - Sand, well sorted with fragments of sandstone (consolidated sand). Iron-rich gravel <10mm | |
| BMC103_06 | 05 - 06m | Completely cemented duricrust | Poorly sorted | Very fine sand to pebble | Angular/low to Rounded/low | Light grey | 10YR 7/1 | Pedolith | Cementation front | Silcrete | Surficial aquifer | Quartz-rich hardpan (silcrete?). Quartz <5mm, very angular, poorly sorted with fragments of consolidated sediments. Good core sample taken | |

| ID | Depth (m) | Texture | Sorting | Grain size | Dominant grain roundness/sphericity | Colour name | Munsell colour | Stratigraphy | Horizon (Anand & Paine, 2002) | DAFWA terms | Hydrostratigraphy | Field notes | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC104_01 | 00 - 01m | Sand | Well sorted | Fine to very coarse sand | Subangular/low to rounded/low | Pale brown | 10YR 6/3 | Pedolith | Soil | Tertiary sandplain | Surficial aquifer | Well sorted sand, some clay at the end of the rod | |
| BMC104_02 | 01 - 02m | Clayey sand | Well sorted | Clay to coarse | Subangular/high | Brown | 10YR 5/3 | Pedolith | Cementation front | Silcrete | Surficial aquifer | Hardpan (sandstone) - Sandy clay (<15% clay) also with cemented sand | |
| BMC104_03 | 02 - 03m | Partially cemented duricrust | Well sorted | Very fine to coarse sand | Subangular/high | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan - Hardpan of sand/clay. Broken pieces of hardpan appear wet inside | |
| BMC104_04 | 03 - 04m | Partially cemented duricrust | Well sorted | Very fine to very coarse sand | Subangular/high to Rounded/high | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan - Hardpan of sand/clay. Broken pieces of hardpan appear wet inside | |
| BMC104_05 | 04 - 05m | Sand | Well sorted | Very fine to very coarse sand | Subangular/low to Rounded/high | Very pale brown | 10YR 7/3 | Pedolith | Arenose zone | Sedimentary sequence | Surficial aquifer | Alluvial sequence - some hardpan fragmets, however mostly well sorted alluvial (well rounded) sand | |
| BMC104_06 | 05 - 06m | Light sandy clay | Well sorted | Clay to medium sand | Subangular/high to Rounded/high | Light grey | 10YR 7/2 | Pedolith | Arenose zone | Sedimentary sequence | Surficial aquifer | Sandy clay (clay >20%), saturated. Water also added during drilling. | |
| BMC104_07 | 06 - 07m | Sand | Well sorted | Very fine to coarse sand | Subangular/high to Rounded/high | Light grey | 10YR 7/2 | Pedolith | Arenose zone | Sedimentary sequence | Surficial aquifer | Sample contaminated with liquipol - well sorted sand | |
| BMC104_08 | 07 - 08m | Sand | Well sorted | Very fine to coarse sand | Subangular/high to Rounded/high | Very pale brown | 10YR 8/2 | Pedolith | Arenose zone | Sedimentary sequence | Surficial aquifer | Bulk samples only - no chip samples. Well sorted sand | |
| BMC104_09 | 08 - 09m | Sand | Well sorted | Very fine to very coarse sand | Subangular/low to rounded/low | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Sedimentary sequence | Surficial aquifer | Bulk samples only - no chip samples. Well sorted sand | |
| BMC104_10 | 09 - 10m | Sand | Well sorted | Very fine to Coarse sand | Angular/high to Rounded/low | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Sedimentary sequence | Surficial aquifer | Bulk samples only - no chip samples. Well sorted sand | |
| BMC104_11 | 10 - 11m | Sand | Well sorted | Coarse silt to coarse sand | Subangular/low to Rounded/high | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Sedimentary sequence | Surficial aquifer | Well sorted sand | |
| BMC104_12 | 11 - 12m | Sand | Well sorted | Coarse silt to coarse sand | Subangular/high to Rounded/low | Light grey | 10YR 7/1 | Pedolith | Arenose zone | Sedimentary sequence | Surficial aquifer | Well sorted sand | |
| BMC104_13 | 12 - 13m | | | | | | | Pedolith | Arenose zone | Sedimentary sequence | Surficial aquifer | Not a representative sample (cement grout contaminated sample) | |
| BMC104_14 | 13 - 14m | Partially cemented duricrust | Well sorted | Clay to medium sand | Angular/low to Rounded/low | Grey | 2.5YR 6/1 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan - Sandy clay with ground-up hardpan | |
| BMC104_15 | 14 - 15m | Partially cemented duricrust | Poorly sorted | Clay to pebble | Very angular/low to Rounded/high | Grey | 2.5YR 6/1 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan - Fragments of very hard cemented sandstone. Mixture of grey and pale yellow | |
| BMC104_16 | 15 - 16m | Partially cemented duricrust | Poorly sorted | Clay to granule | Angular/low to Rounded/high | Light grey | 2.5YR 7/1 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan - very hard drilling at 16m, no hardpan samples due to grinding of hardpan - sandy-clay samples recovered | |

| ID | Depth (m) | Texture | Sorting | Grain size | Dominant grain roundness/sphericity | Colour name | Munsell colour | Stratigraphy | Horizon (Anand & Paine, 2002) | DAFWA terms | Hydrostratigraphy | Field notes | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC104_17 | 16 - 17m | Completely cemented duricrust | Poorly sorted | Clay to granule | Angular/low to Rounded/high | Light grey | 2.5YR 7/1 | Pedolith | Arenose zone | Silcrete | Surficial aquifer | Hardpan - Numerous biscuits of hardpan in sample, sand-rich layer | |
| BMC104_18 | 17 - 18m | Partially cemented duricrust | Poorly sorted | Clay to granule | Angular/low to Rounded/high | Yellow with grey | 2.5YR 7/6 - 2.5YR 6/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Sandy-clay - Sample mostly clay/silt liquid with some balls of clay with some quartz <2mm | |
| BMC104_19 | 18 - 19m | Completely cemented duricrust | Poorly sorted | Clay to pebble | Angular/high to Rounded/low | Olive yellow | 2.5Y 6/8 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan - Bands of cemented fine sand , sandy clay hardpan | |
| BMC104_20 | 19 - 20m | Completely cemented duricrust | Poorly sorted | Clay to very coarse sand | Angular/low to Rounded/low | Light grey | 2.5Y 7/2 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan - Very fine sandy clay hardpan layers | |
| BMC104_21 | 20 - 21m | Partially cemented duricrust | Poorly sorted | Clay to very coarse sand | Angular/low to Rounded/low | Light grey | 2.5Y 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan - Very fine sandy clay hardpan layers. Sand quartz grains increasing in size with depth | |
| BMC104_22 | 21 - 22m | Partially cemented duricrust | Poorly sorted | Clay to granule | Angular/low to Subangular/high | Light grey | 2.5Y 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan - Very fine sandy clay hardpan layers. Sand quartz grains increasing in size with depth | |
| BMC104_23 | 22 - 23m | Partially cemented duricrust | Poorly sorted | Clay to pebble | Angular/low to Rounded/low | Light grey | 2.5Y 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan - Very fine sandy clay hardpan layers. Sand quartz grains increasing in size with depth | |
| BMC104_24 | 23 - 24m | Partially cemented duricrust | Poorly sorted | Clay to very coarse sand | Angular/low to Rounded/low | Light grey | 2.5Y 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan - Very fine sandy clay hardpan layers. Sand quartz grains **decreasing** in size with depth | |
| BMC104_25 | 24 - 25m | Partially cemented duricrust | Poorly sorted | Clay to very coarse sand | Angular/low to Rounded/low | Light grey | 2.5Y 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan - Very fine sandy clay hardpan layers. Sand quartz grains **decreasing** in size with depth | |
| BMC104_26 | 25 - 26m | Partially cemented duricrust | Poorly sorted | Clay to very coarse sand | Angular/low to Rounded/low | Light grey | 2.5Y 7/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan - Very fine sandy clay hardpan layers. Sand quartz grains **decreasing** in size with depth | |
| BMC104_27 | 26 - 27m | Partially cemented duricrust | Poorly sorted | Clay to very coarse sand | Angular/low to Rounded/low | White | 10YR 8/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan - Very fine sandy clay hardpan layers. Sand quartz grains <2mm, very angular, poorly sorted | |
| BMC104_28 | 27 - 28m | Partially cemented duricrust | Poorly sorted | Clay to granule | Angular/low to Rounded/low | White | 10YR 8/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan - Very fine sandy clay hardpan layers. Sand quartz grains <4mm, very angular, poorly sorted | |
| BMC104_29 | 28 - 29m | Partially cemented duricrust | Poorly sorted | Clay to cobble | Very angular/low to subrounded/low | Grey | 5Y 6/1 | Pedolith | Arenose zone | Silcrete | Leaky aquitard | Hardpan | |
| BMC104_30 | 29 - 30m | Completely cemented duricrust | Poorly sorted | Clay to cobble | Very angular/low to subrounded/low | Light greenish grey | GLEY 1 6/10Y | Pedolith | Pedoplasmation front | Silicified weathered saprolite | Aquitard | Hardpan - very hard drilling - Quartz-rich hardpan <10mm | |

| ID | Depth (m) | Texture | Sorting | Grain size | Dominant grain roundness/sphericity | Colour name | Munsell colour | Stratigraphy | Horizon (Anand & Paine, 2002) | DAFWA terms | Hydrostratigraphy | Field notes | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC104_31 | 30 - 31m | Saprolite? | Poorly sorted | Clay to cobble | Very angular/low to subrounded/low | | | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Hardpan - Hardpan ground-up in sample, quartz-rich hardpan, very angular, poorly sorted quartz <2mm to >5mm. Some unweathered basement chips | |
| BMC104_32 | 31 - 32m | Saprolite? | | | | Light grey | GLEY 1 6/N | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Insufficient bulk sample - chip sample only. Sample as above | |
| BMC104_33 | 32 - 33m | Saprock - Igneous bedrock (granite?) | Poorly sorted | Clay to cobble | Very angular/low to subrounded/low | Grey | GLEY 1 5/N | Saprolith | Saprolite | Weathered granitic saprolite | Saprolite aquifer | Weathering front - Sandy clay, poorly sorted, quartz <2mm | |
| BMC104_34 | 33 - 34m | Saprock - Igneous bedrock (granite?) | Poorly sorted | Clay to cobble | Very angular/low to subrounded/low | Greenish grey | GLEY 1 6/10Y | Saprolith | Saprock | Weathered granitic saprolite | Saprolite aquifer | Igneous (granite?) bedrock. Large biscuits of igneous basement, very fine grained, friable basement | |
| BMC104_35 | 34 - 35m | Saprock - Igneous bedrock (granite?) | | | | | | Saprolith | Saprock | Weathered granitic saprolite | Saprolite aquifer | Igneous (granite?) bedrock. Large biscuits of igneous basement, very fine grained, friable basement | |
| BMC104_36 | 35 - 36m | Saprock - Igneous bedrock (granite?) | | | | Greenish grey | GLEY 1 6/10Y | Saprolith | Quartz-rich bedrock | Fresh granitoid gneiss | | EOH 36m. Still able to penetrate basement, although still considered as competant basement. Very greenish (dolerite or granite???) | |

## Appendix J

**Table 7. Hydrochemistry data of the HWS for groundwater and wetlands collected in October 2012**

| Site ID | Date | Lab EC (mS/cm) | Cl (mg/L) | Br (mg/L) | Cl/Br | SO4 (mg/L) | Na (mg/L) | K (mg/L) | Mg (mg/L) | Ca (mg/L) | TDS sum (mg/L) | Ion balance (%) | Total Alkalinity (CaCO3 mg/L) | Lab - CO3 (mg/l) | Lab - HCO3 (mg/L) | TN (mg/L) | TP (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMC100D | 10/10/2012 | 5.6 | 1616 | 6.60 | 244.85 | 264.00 | 1018.00 | 19.80 | 106.00 | 62.70 | 3350.60 | -3.42 | 211.00 | 0.39 | 256.63 | 0.50* | 0.08* |
| BMC100OB | 10/10/2012 | 0.2 | 30 | 0.20 | 150.00 | 22.30 | 23.10 | 0.90 | 8.00 | 3.20 | 100.20 | -11.81 | 10.25 | 0.00 | 12.50 | 4.70* | 0.01 |
| BMC101OB | 10/10/2012 | 4.5 | 1307 | 4.30 | 303.95 | 131.00 | 837.00 | 16.00 | 76.00 | 9.20 | 2530.20 | -2.61 | 121.42 | 0.07 | 148.00 | 1.80* | 0.01 |
| BMC102OB | 11/10/2012 | 4 | 1138 | 3.70 | 307.57 | 121.00 | 843.00 | 10.60 | 29.90 | 11.80 | 2470.20 | -1.26 | 256.17 | 1.79 | 308.89 | 0.62* | 0.08* |
| BMC103OB | 11/10/2012 | 2.6 | 833 | 2.40 | 347.08 | 100.00 | 429.00 | 6.50 | 53.90 | 68.40 | 1516.10 | -5.41 | 18.75 | 0.00 | 22.87 | 11.00* | 0.01 |
| BMC104D | 10/10/2012 | 29.5 | 9913 | 27.70 | 357.87 | 997.00 | 5678.00 | 105.00 | 693.00 | 223.00 | 17919.60 | -3.55 | 232.17 | 0.96 | 281.29 | 0.39* | |
| BMC104OB | 10/10/2012 | 12.6 | 3833 | 11.70 | 327.61 | 443.00 | 2311.00 | 38.50 | 225.00 | 50.50 | 7125.70 | -3.88 | 174.08 | 0.11 | 212.15 | 0.20 | 0.01 |
| BMC95D | 10/10/2012 | 16.7 | 5663 | 16.10 | 351.74 | 569.00 | 2998.00 | 47.50 | 429.00 | 91.40 | 9991.90 | -7.67 | 144.75 | 0.03 | 176.54 | 0.20 | 0.02* |
| BMC95OB | 10/10/2012 | 8.5 | 2758 | 8.80 | 313.41 | 119.00 | 1535.00 | 29.00 | 199.00 | 45.80 | 5034.60 | -5.79 | 278.13 | 0.10 | 339.12 | 1.60* | 0.02* |
| BMC96D | 10/10/2012 | 18 | 6117 | 21.00 | 291.29 | 680.00 | 3408.00 | 51.20 | 400.00 | 100.00 | 11036.80 | -6.56 | 212.67 | 0.13 | 259.18 | 1.10* | |
| BMC96OB | 10/10/2012 | 2.7 | 829 | 2.30 | 360.43 | 86.00 | 460.00 | 15.20 | 71.60 | 39.80 | 1699.00 | -6.19 | 160.00 | 0.06 | 195.07 | 1.20* | 0.04* |
| BMC97D | 11/10/2012 | 18.9 | 6287 | 21.80 | 288.39 | 676.00 | 3833.00 | 58.50 | 360.00 | 94.80 | 11556.70 | -2.63 | 182.83 | 0.11 | 222.83 | 0.30 | 0.34* |
| BMC97I | 11/10/2012 | 3.6 | 1121 | 3.60 | 311.39 | 99.10 | 689.00 | 17.40 | 52.00 | 18.10 | 2094.90 | -2.44 | 76.67 | 0.02 | 93.49 | 0.34 | 0.08* |
| BMC98D | 11/10/2012 | 30.2 | 10335 | 34.50 | 299.57 | 1112.00 | 6011.00 | 97.40 | 587.00 | 230.00 | 18598.00 | -3.64 | 155.92 | 0.28 | 189.64 | 0.46* | 0.05* |
| BMC98OB | 11/10/2012 | 14.4 | 4866 | 16.20 | 300.37 | 513.00 | 2836.00 | 41.00 | 234.00 | 63.50 | 8694.40 | -5.00 | 101.92 | 0.03 | 124.27 | 0.54* | |
| BMC99OB | 11/10/2012 | 8.2 | 2581 | 8.60 | 300.12 | 258.00 | 1758.00 | 31.10 | 39.50 | 7.50 | 4839.70 | -0.33 | 126.58 | 0.30 | 153.83 | 0.79* | 0.05* |
| W023 | 10/10/2012 | 5 | 1366 | 4.80 | 284.58 | 20.50 | 820.00 | 18.90 | 105.00 | 48.40 | 2737.60 | -2.95 | 293.25 | 4.04 | 349.55 | 1.30* | 0.02* |
| W024 | 10/10/2012 | 1.3 | 296 | 1.20 | 246.67 | 16.20 | 195.00 | 7.30 | 37.10 | 9.90 | 748.10 | -5.57 | 151.67 | 0.27 | 184.49 | 1.40* | 0.04* |
| W129 | 10/10/2012 | 3.5 | 1000 | 3.50 | 285.71 | 34.60 | 563.00 | 15.50 | 68.90 | 34.70 | 1914.40 | -4.74 | 159.33 | 0.51 | 193.35 | 0.89* | 0.02* |
| W130 | 10/10/2012 | 2.5 | 686 | 2.30 | 298.26 | 56.30 | 389.00 | 11.20 | 51.40 | 24.80 | 1347.00 | -5.39 | 106.42 | 3.80 | 122.11 | 2.10* | 0.02* |

*exceeding ANZECC/ARMCANZ (2000) default physico-chemical trigger values, for slightly disturbed Western Australian ecosystems (0.35 mg/L for TN and 0.01 mg/L for TP)

# Appendix K

## Ion ratios

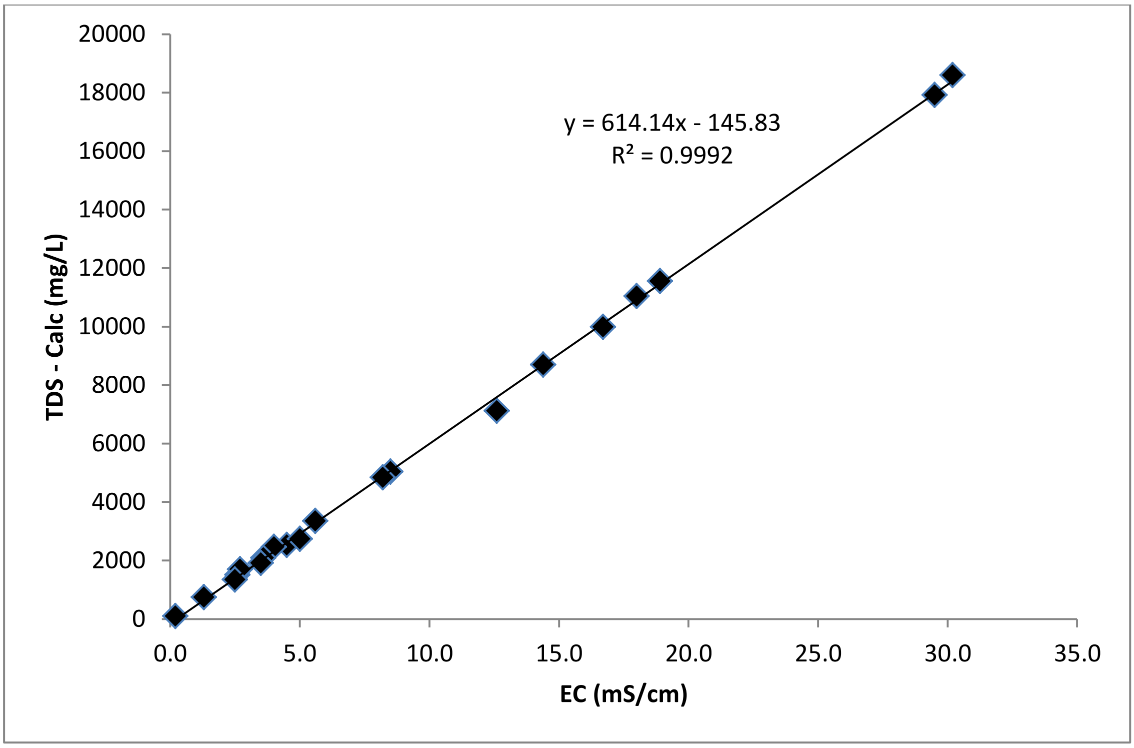


**Figure 16. Laboratory EC versus calculated TDS relationship for groundwater and surface water sampled in October 2012. Seawater ratio from Hingston and Gailitis (1976).**

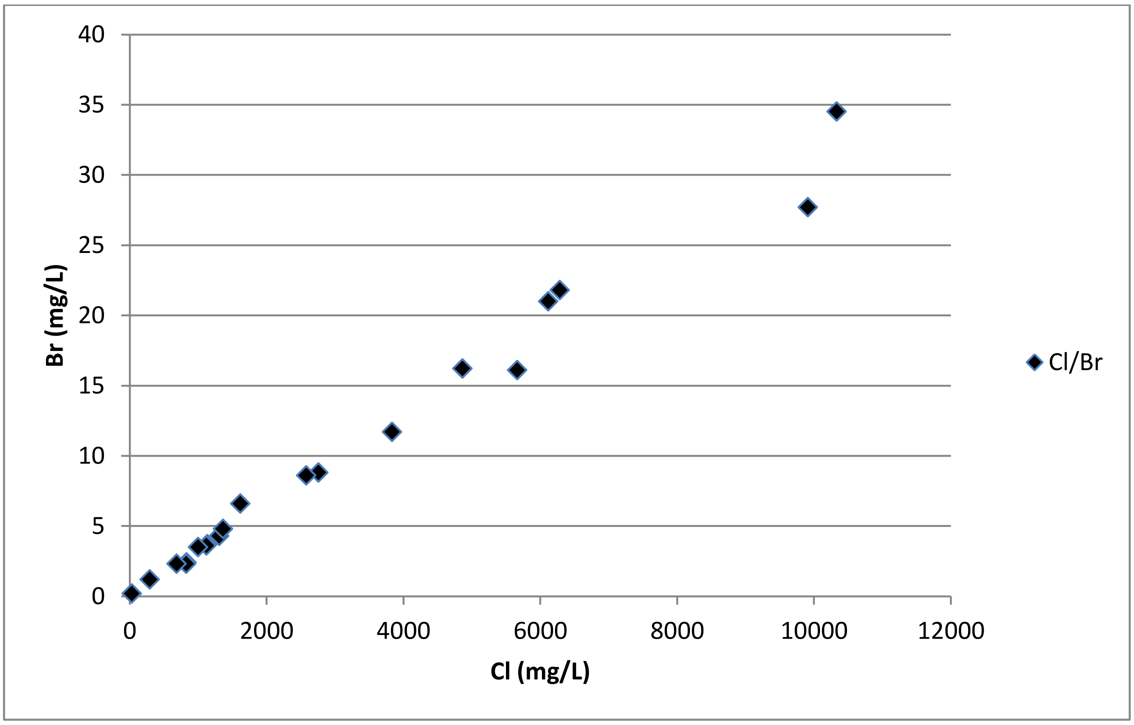


**Figure 17. Cl versus Br for groundwater and surface water sampled in October 2012.**

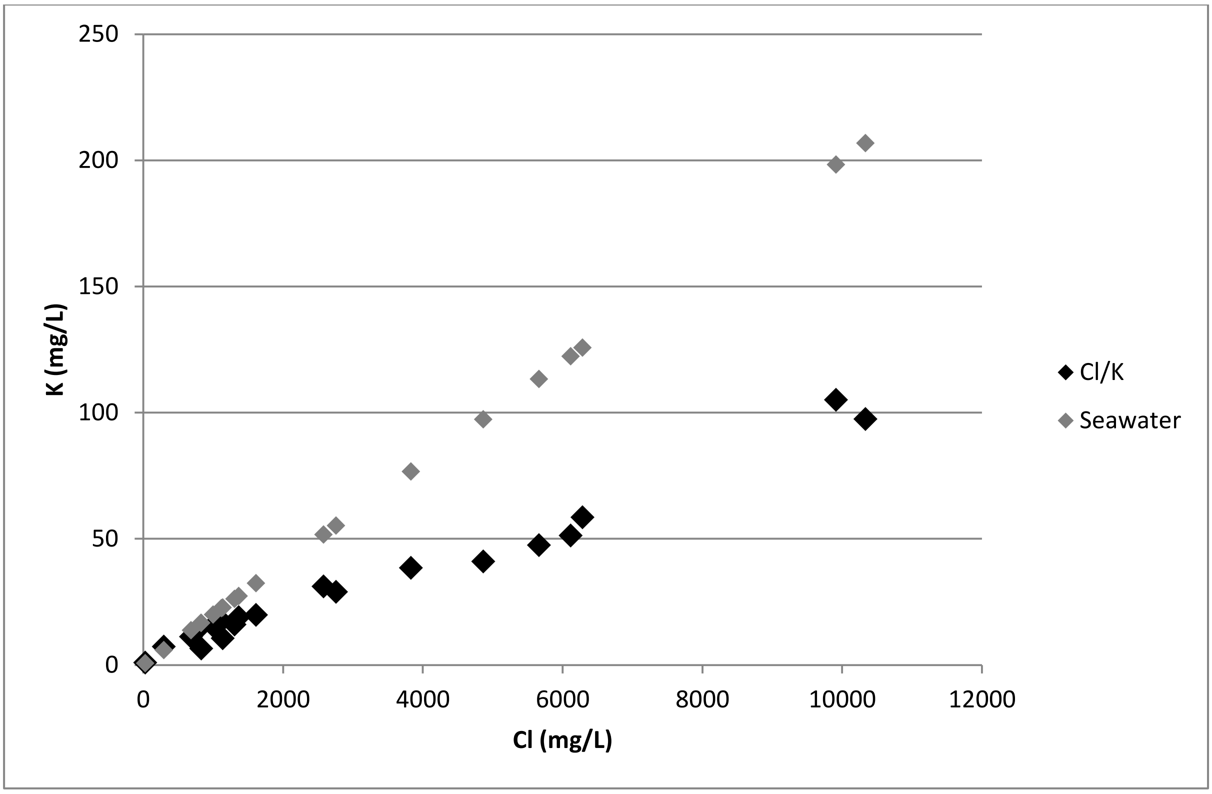


**Figure 18. Cl versus K for groundwater and surface water sampled in October 2012. Seawater ratio from Hingston and Gailitis (1976).**

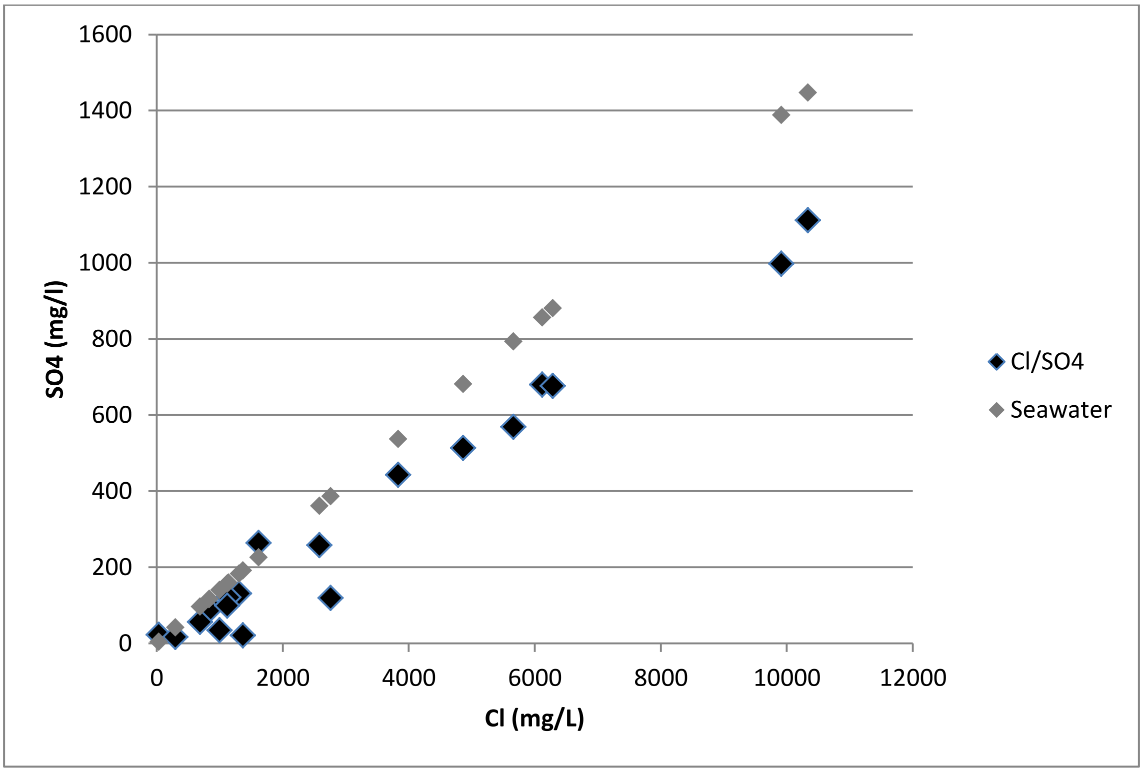


**Figure 19. Cl versus $SO_4$ for groundwater and surface water sampled in October 2012. Seawater ratio from Hingston and Gailitis (1976).**

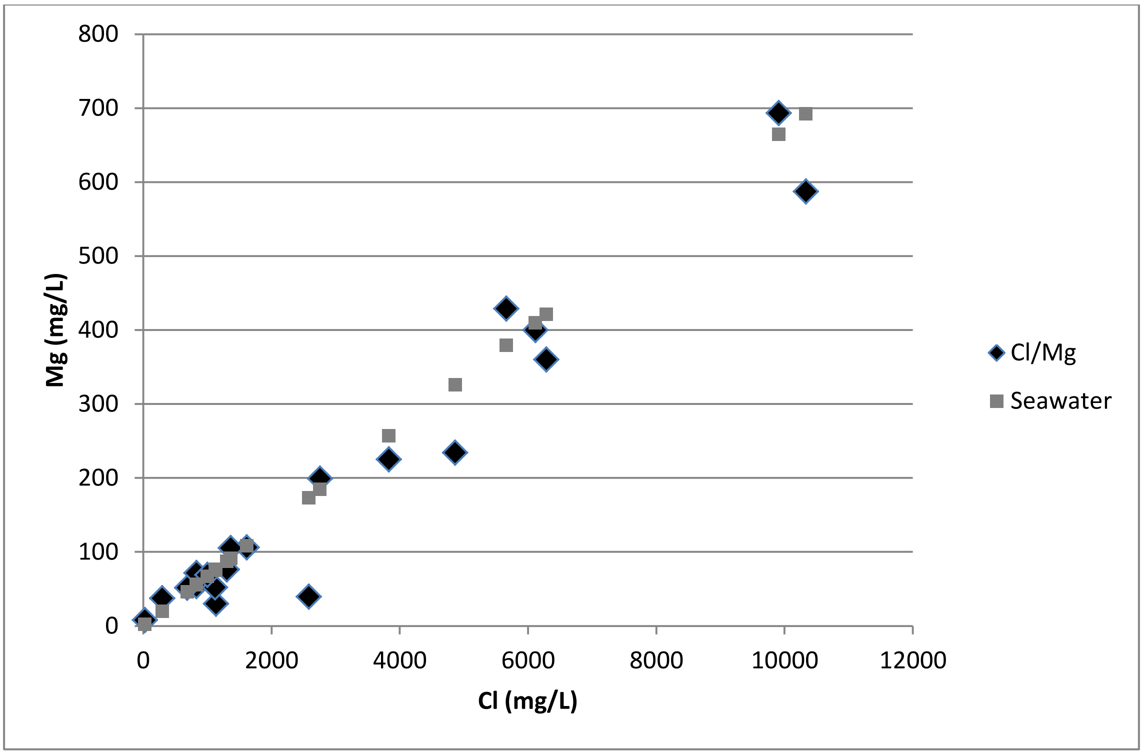


**Figure 20. Cl versus Mg for groundwater and surface water sampled in October 2012. Seawater ratio from Hingston and Gailitis (1976).**

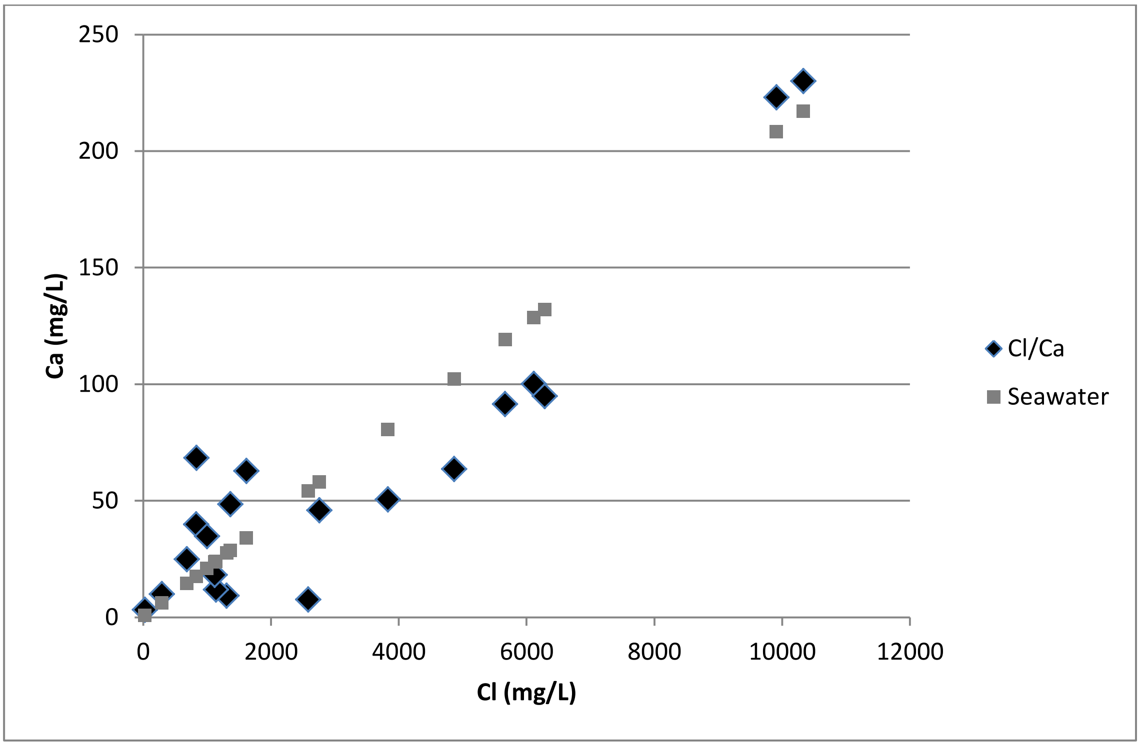


**Figure 21. Cl versus Ca for groundwater and surface water sampled in October 2012. Seawater ratio from Hingston and Gailitis (1976).**