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Groundwater investigation on Victoria location 8565, East Binnu

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GROUNDWATER INVESTIGATION

Victoria Location 8565

East Binnu

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Disclaimer

The contents of this report were based on the best available information at the time of publication. It is based in part on various assumptions and predictions. Conditions may change over time and conclusions should be interpreted in the light of the latest information available.

1. Summary

An area of native vegetation has been recently cleared within Victoria Location 8565. A drilling investigation was undertaken to assess the risk of salinity.

A total of four piezometers and five observation bores were installed at four sites in a sandplain depression. The drill sites were selected to enable construction of cross-sections east - west along the depression and north – south across the depression.

The site is underlain by Tumblagooda Sandstone which typically displays the characteristics of a high yielding aquifer. Watertable depth is less than 6 m throughout the sandplain depression. Groundwater quality typically ranges from 1550 to 2160 millisiemens per metre.

Groundwater monitoring in similar landscapes shows groundwater rise over the last decade of 4 to 5 metres.

The drilling investigation confirms that the risk of further salinity development on Victoria Location 8565 is extreme.

Contents

1. Introduction and background

In June 2003 the Department of Agriculture established groundwater monitoring bores within Victoria Location 8565. The bores were installed to assess the risk of dryland salinity developing if after clearing the native vegetation, the area is used to grow annual crops and pastures.

This report documents background information for the East Binnu area (Section 1) and details the groundwater investigations undertaken in this study (Section 2).

1.1 The East Binnu area

The Binnu townsite is located about 80 km north of Geraldton. The East Binnu area referred to in this report is an area of sandplain plateau that begins about 5 km east of the Binnu townsite and extends eastward for some 45 km to the pastoral country.

1.2 Description of the catchment

The East Binnu area is characterised by gently undulating sandplain with numerous dune ridges. It is part of the physiographic region known as the Victoria Plateau sandplain (Playford et al 1970, Playford et al 1976).

Topographic relief is subdued and ranges from about 240 m elevation in the eastern part of the area to about 290 m elevation in the central part of the area. Within the vicinity of Victoria Location 8565, topographic relief ranges from about 252 m elevation to about 276 m.

The soils are generally deep yellow sands (up to 15 m) over lateritic gravel, which becomes cemented (indurated) with depth (Rogers 1996). In topographic lows there is ~ 1 to 1.5 m of strong yellow loamy sand over clay. On the gentle rises and dune ridges the depth of sand tends to increase, it becomes paler in colour and loses its loamy texture in the top metre of the profile.

Surface drainage is rarely defined and the landscape is characterised by depressions or hollows separated by gently undulating rises. Hence, drainage is completely internal. Run-off is not generally a feature of this landscape as most of the rainfall readily infiltrates the deep sandy profile.

1.3 Geology

The East Binnu area straddles the Geraldton and Ajana 1:250,000 geological map sheet areas. The area is predominantly mapped as *Czl* (Laterite with overlying quartz sand and underlying highly weathered rock) on the Geraldton sheet (Playford et al 1970) or *Qe* (Eolian and residual sand – red-brown and yellow quartz sand) on the Ajana sheet (Hocking et al 1982).

The maps indicate some minor outcrops of Tumblagooda Sandstone and Proterozoic crystalline basement. The Tumblagooda Sandstone is a red and yellow feldspathic sandstone and conglomerate of Silurian age (Playford et al 1970). There are small outcrops of Tumblagooda Sandstone mapped in the vicinity of Victoria Location 8565.

The sandplain plateau that characterises the East Binnu area overlies a gritty clay saprolite and crystalline basement of the Northampton Block in its western part and sediments of the Coolcalalaya Sub-basin (a subdivision of the Perth Basin) in the east. The sandplain itself obscures the Northampton Block/Perth Basin contact.

The East Binnu area is bounded to the west by Proterozoic crystalline basement of the Northampton Block.

Outcrop of Proterozoic crystaline basement is known to occur north, west, south, and east of Victoria Location 8565.

1.4 Climate

The climate is typical of a semi-arid region with dominantly winter rainfall and hot, dry summers.

Annual average rainfall is less than 350 mm across most of the East Binnu area and decreases from west to east. Summer rainfall events can be significant. The highest daily rainfall on record at Binnu is 110 mm on 10 March 2000 (Bureau of Meteorology 2003).

2. Hydrogeology investigation

2.1 Previous investigations

The closest Department of Agriculture groundwater monitoring sites located on the Victoria Plateau sandplain are sites CV9 and CV13.

Site CV9 is located at 292345 mE, 6867161 mN in Wathala Swamp about 35 km south-southeast of Victoria Location 8565. Site elevation is 256 m. This elevation was determined from contours generated from the Land Monitor Project data. The site was drilled in December 1991. The profile is about 1.5 m of predominantly sand overlying Tumblagooda Sandstone. A piezometer and observation bore were installed. The piezometer has a screened interval from 12.16 to 14.16 m below the surface with the observation bore screened from 4.09 to 8.09 m below the surface at the site.

The hydrograph for the piezometer CV9D is presented in Figure 2-1. It shows sustained groundwater rise from 3.6 m below ground to artesian conditions currently 0.6 m above the ground surface. The rate of groundwater rise was 25 cm/yr from December 1991 to December 1997. The rising trend was 83 cm/yr from December 1997 to January 2001. From January 2001 to present, the rising trend is 9 cm/yr during a particularly dry period.

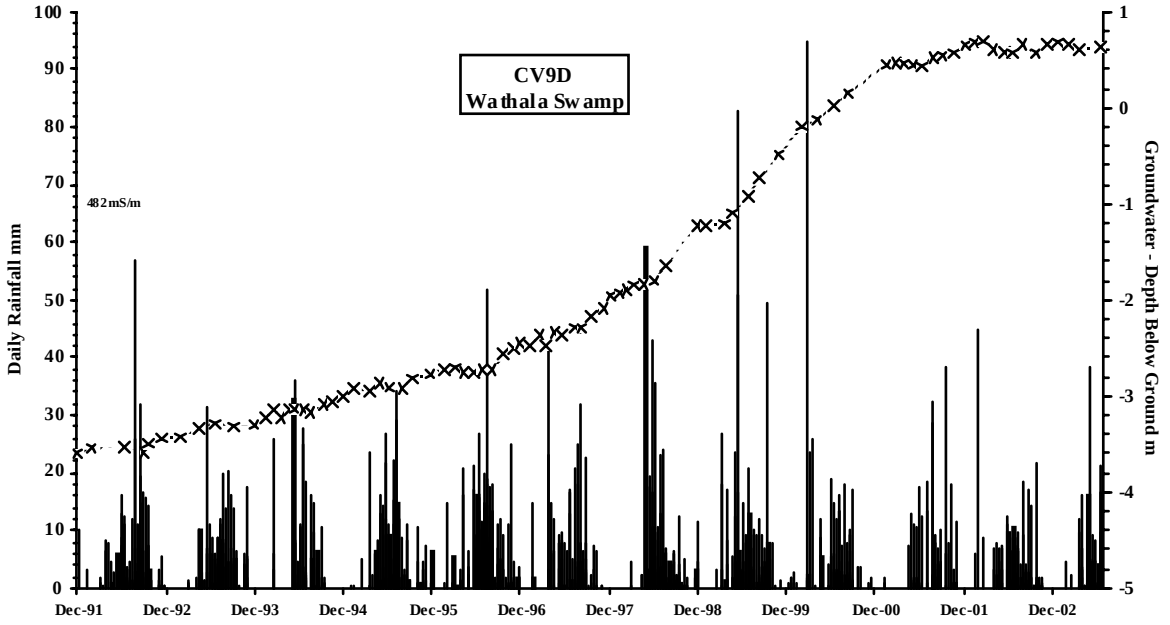

Figure 2-1. *Hydrograph for piezometer CV9D.*

Site CV13 is located at 287890 mE, 6871029 mN about 30 km south of Victoria Location 8565. Site elevation is 281 m. This elevation was determined from contours generated from the Land Monitor Project data. The site was drilled in January 1994. The profile is about 2.7 m of sand and lateritic gravel overlying sandstone with interbedded siltstone. This sandstone profile is also Tumblagooda Sandstone. Drilling was terminated at 29 m depth. An observation bore was installed with a screened interval from 26.53 m to 29.18 m below ground.

The hydrograph for bore CV13OB is presented in Figure 2-2. It shows sustained groundwater rise from 22.4 m below ground to a current depth of 17 m below ground. The rate of groundwater rise was 26 cm/yr from January 1994 to January 1996. The rising trend was 61 cm/yr from January 1996 to January 1999. The rate increased to 138 cm/yr from January 1999 to November 2000. From November 2000 to present, the rising trend is 23 cm/yr during a particularly dry period.

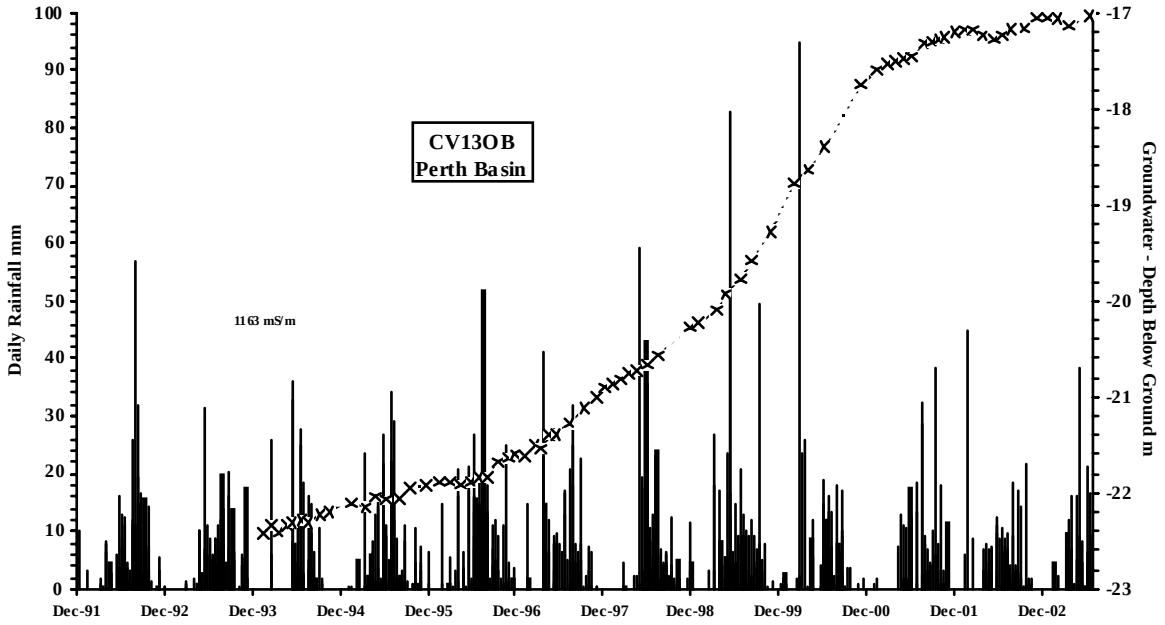

Figure 2-2. *Hydrograph for observation bore CV13OB.*

While there is considerable difference in the depth at which groundwater is monitored at sites CV9 and CV13 there is remarkable similarity in the hydrographs presented in Figures 2-1 and 2-2. Neither shows much fluctuation in response to seasonal conditions. They give the impression that groundwater is rising rapidly and uniformly in the Tumblagooda Sandstone underlying the Victoria Plateau sandplain in the Coolcalalaya Sub-basin.

Within Victoria Location 8565, an existing salt scald was observed and reported (Speed 2002). It is located at 285500 mE, 6900500 mN and is depicted on the

accompanying image as a green/brown smudge denoted S. It is bounded by the 262 m contour except in the northeast where it extends above 262 m elevation. Shallow saline groundwater is exposed in three pits excavated within the scald.

2.2 Method for this investigation

Drilling for the groundwater investigation was carried out from 16 – 19 June 2003. A total of four piezometers and five observation bores were installed at four sites. The location of these bores is listed in Table 2-1 and shown on the accompanying image.

2.2.1 Drill site selection

The aim of the drilling program was to enable construction of two cross-sections along and across a recently cleared sandplain depression on Victoria Location 8565.

At a local scale, drill site position was determined by access for the rig, long term protection of bore headworks and minimal disturbance to farming activities if the area is developed for agriculture.

2.2.2 Drilling methods

Drilling was carried out using the Department of Agriculture's Gemco HM12 Rotary Air Blast drilling rig. The first site was drilled with 4 ¾ inch chevron blades. All subsequent sites were drilled with a 4 ¾ inch Rock-Roller.

2.2.3 Bore construction

Bores were constructed with 50 mm diameter class 9 PVC casing with class 18 PVC end caps. The bottom end caps of every observation bore has five 6.5 mm diameter holes drilled through to ensure the casing and end cap completely drains if the water table recedes below the cased depth.

The casing intake sections are machine slotted. Piezometers were constructed with a 2 m slotted intake section over the lowest part of the casing. Observation bores were constructed with screened intervals ranging from 1.0 m to 3.8 m.

The annulus around the slotted intake section was packed with 8-16 gravel (about 1.6 to 3.2 mm diameter). Bentonite pellets were used to seal the annulus above the slotted intake section in every piezometer. The annulus of piezometers and observation bores was then back-filled to ground surface with drill cuttings if they were suitable or 8-16 gravel. All bores were then cemented at the ground surface to prevent surface water inflow down the annulus and ensure tube top stability.

All bore tube tops were cut off at 0.40 m above the ground surface. All piezometers were cleaned and developed by airlift at the completion of bore construction prior to moving the rig and compressor off-site.

Bore construction details and estimated yields by airlift are listed in Table 2-1.

2.2.4 Drill sample analyses

Drill samples were collected and described over one metre intervals during drilling. Samples were then oven dried at 60^{o} C and chip trays were prepared.

A set of drill logs was compiled by reviewing the field drill logs and chip trays. These drill logs are presented in Appendix 1.

A set of chip trays is stored at the Geraldton office of the Department of Agriculture.

2.2.5 Groundwater monitoring and sample analyses

Initial groundwater levels were measured on 27 June 2003.

Groundwater samples were retrieved from bores on 27 June 2003 and electrical conductivity was measured in the Department of Agriculture laboratories in Geraldton.

Initial groundwater levels and electrical conductivity measurements recorded in June 2003 are listed in Table 2-1.

2.2.6 Surveying

Locations (Eastings and Northings) of groundwater monitoring sites were measured with a global positioning system (GPS). The GPS receiver was placed on the bore tube top and position information was recorded by averaging 200 GPS positions into a single waypoint position. Positions are reported in the Australian Geodetic Datum of 1984 (AGD84).

Initial elevation data was derived from the Land Monitor Project. An elevation of 260.00 m was assigned to site EBH2. An automatic level, staff and roto-meter were used to measure the surface profile between bore sites and determine the relative level of bore sites to construct the cross-sections.

Bore location and elevation details are listed in Table 2-1.

Table 2-1. Drill site location and bore construction details. Groundwater depth and electrical conductivity were measured on 27 June 2003.

Bore ID	Easting (mE)	Northing (mN)	Site elevation (m)	Depth drilled (m)	Screened interval below ground (m)	Groundwater depth below surface/(elevation) (m)	Electrical conductivity (mS/m)	Est. yield by airlift (m^3/day)
03EBH1D	283693	6900646	260.70	21	19.31–21.31	5.62 (255.08)	497	7.8
03EBH1OB				7	3.35–7.15	5.78 (254.92)	2040	n/a
03EBH2D	282966	6900558	260.00	29	27.25–29.25	5.49 (254.51)	1683	7.8
03EBH2OB				7	3.58–7.22	5.57 (254.43)	1726	n/a
03EBH3D	282959	6900209	263.46	23	19.94-21.94	8.81 (254.65)	1554	57
03EBH3OB				8	4.38-8.08	Dry	n/a	n/a
03EBH4D	282957	6900756	261.56	20	18.23-20.23	7.28 (254.28)	1538	5
03EBH4OB1				8	4.41-8.21	7.30 (254.26)	2160	n/a
03EBH4OB2				4	3.21-4.21	Dry	n/a	n/a

2.3 Results

2.3.1 Profile descriptions

The profiles consist of 2 to 4.8 m of golden-yellow loamy sand overlying up to 2 m of silcrete. Below the silcrete there is 6 to 8 m of weathered regolith overlying Tumblagooda Sandstone.

The depth of yellow sand overlying silcrete is a function of landscape position with thicker profiles intersected in elevated positions.

Weathered regolith includes indurated (siliceous) and competent sandstone horizons as well as unconsolidated sand and clay horizons.

Detailed drill logs are presented in Appendix 1 and depth drilled at each site is also listed in Table 2-1.

Figures 2-3 and 2-4 show cross-sections constructed along and across the sandplain depression on Victoria Location 8565.

2.3.2 Groundwater data

2.3.2.1 Groundwater levels

The initial measurements of depth to groundwater were taken on 27 June 2003 and are listed in Table 2-1, recorded on the individual drill logs presented in Appendix 1 and shown on the cross-sections (Figures 2-3 and 2-4). Depth to the watertable ranges from 5.57 to 7.30 m below ground surface at the groundwater monitoring sites.

The elevation of the watertable ranges from 254.92 m to 254.26 m. In general, the surface of the watertable appears to be virtually flat and slopes downward to the north.

2.3.2.2 Groundwater electrical conductivity

The electrical conductivity of recovered groundwater samples is listed in Table 2-1, recorded on the individual drill logs presented in Appendix 1 and labeled next to the intake sections of observation bores and piezometers in Figures 2-3 and 2-4.

With one exception, the electrical conductivity of groundwater samples was reasonably uniform. The groundwater recovered from piezometer 03EBH1D had an electrical conductivity of 497 millisiemens per metre. The electrical conductivity of all other groundwater samples ranged from 1538 to 2160 millisiemens per metre.

2.4 Interpretation and discussion of results

The cross-sections presented in Figures 2-3 and 2-4 show a relatively simple and uniform profile. Each cross-section is presented at the same vertical and horizontal scale so the same vertical exaggeration is applied and they can be compared directly.

The zone of 'Weathered Regolith' shown between the silcrete (above) and Tumblagooda Sandstone (below) is interpreted to be insitu weathered Tumblagooda Sandstone.

The Tumblagooda Sandstone is a water bearing aquifer. Hocking et al (1982) note that it produces large quantities of water from nearly all wells and bores that intersect it and it is the source of supply for Kalbarri. Playford et al (1970) acknowledge that it is a good aquifer but note that much of the water is too saline for domestic use.

Tumblagooda Sandstone was not expected at Victoria Location 8565. Playford et al (1976) describe the Coolcalalaya Sub-basin as a 5000 m thick sedimentary basin occurring between the Darling Fault and Northampton Block consisting mainly of Silurian Tumblagooda Sandstone. It is known there is outcrop of Proterozoic crystalline basement and saprolite east of Victoria Location 8565 so it was anticipated the Perth Basin/Northampton Block contact was east of the site.

Clearly the Coolcalalaya Sub-basin has variable thickness. Stratigraphically, the Tumblagooda Sandstone unconformably overlies or is faulted against the Precambrian crystalline Northampton Block (Playford et al 1976).

It would appear that Tumblagooda Sandstone onlaps the Northampton Block on Victoria Location 8565. The depth to crystalline basement on Victoria Location 8565 is unknown. The only direction where the thickness of Tumblagooda Sandstone is not known to be restricted by shallow or outcropping basement is to the northeast.

The piezometers show upward vertical hydraulic gradients. In Figure 2-3 the watertable slopes downward east to west from site EBH1 to site EBH2. In Figure 2-4 the watertable slopes downward to north from site EBH3 to site EBH4. The surface of the watertable appears to be virtually flat. This may be indicative of high hydraulic conductivity and unrestricted hydraulic connection throughout the Tumblagooda Sandstone aquifer.

If so, the presence of this aquifer beneath the site serves to increase the risk of salinity because it introduces the speculation that the site may become saline regardless of on-site management. Recharge and groundwater may be able to freely flow from surrounding cleared land.

The silcrete is unlikely to be a confining layer. It is extremely common throughout the Northern Agricultural Region. While it has been found to be water bearing itself in some instances, it has never been known to mitigate or protect against salinity by confining rising groundwater. Indeed, groundwater rise per increment of recharge is expected to be much greater in the silcrete because of its extremely low porosity.

2.5 Conclusions

Tumblagooda Sandstone underlies Victoria Location 8565. Watertable depth is less than 6 m throughout the sandplain depression investigated. Groundwater quality typically ranges from 1550 to 2160 millisiemens per metre.

Hydrographs from groundwater monitoring sites in the same physiographic region (Victoria Plateau sandplain), intersecting the same aquifer (Tumblagooda Sandstone) with similar climate and average annual rainfall (< 350 mm) show sustained groundwater rise even during the particularly dry period over the last three years.

The drilling investigation confirms the previously reported conclusion (Speed 2002) that there is a risk of further salinity development on Victoria Location 8565.

The results support the estimate that all the area below 262 m elevation shown on the accompanying image is at high risk of becoming saline and the areas below 260 m elevation are at extreme risk of becoming saline.

The drilling showed the similarity between this site and others where long term bore records are available. Hence it is predicted that the areas assessed to be at risk will exhibit symptoms of saline land degradation in the short term, that is, within about a decade.

3. Acknowledgments

Richard Kelly from Moora provided willing and able assistance with the drilling for which I am most grateful.

Mike Clarke from Geraldton assisted with the surveying.

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