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Daly Basin Drilling, 2010

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Cover photo: Outcrop of the basal limestone of the “Florina Formation” with seepage along bedding planes, Zone 52, East 8379986
, North 145087, Datum WGS84

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Summary

Four investigation/monitoring bores were drilled on and adjacent to Florina Station. The main findings are that the work established the presence of a newly recognised formation, the "Florina Formation" within the Daly River Group. It disconformably overlies the Oolloo Dolostone and it contains substantial aquifers that are stratigraphically controlled. Limited potential for recharge reduces the potential for significant throughflow and discharge. Minor spring discharge occurs in the Daly and Katherine Rivers. Only the basal limestone is in hydraulic connection to the Oolloo aquifer. The main body of the formation acts as a confining layer to the Oolloo.

The Oolloo aquifer formed as a result of a karstic weathering event that occurred when the formation was exposed to the atmosphere prior to the deposition of the "Florina Formation". Karstification (and so the aquifer) extends to depths as great as 80 metres below the top of the formation. Two styles of solution cavities are developed in the Oolloo, localised centimeter to decimetre scale cavities along fractures and bedding planes and a more pervasive network of sub- millimetre to centimetre scale cavities.

Introduction

Four investigation / monitoring bores were drilled in the Daly Basin as part of the National Water Commission funded Oolloo Springs Project. The work took place between May and July 2010. The locations of the drill sites are shown in Figure 1. They are in the south central part of the Daly Basin, an early Palaeozoic aged basin containing mainly carbonate rocks. It contains three formations. From oldest to youngest they comprise; the Tindall Limestone, the Jinduckin Formation (siltstone with minor limestone beds) and the Oolloo Dolostone. The Oolloo Dolostone, the focus of the current study is a major aquifer which supplies the bulk of the base flow of the Daly River. It is also utilised as a source of groundwater for irrigation and stock.

This work has two main aims:

1. Improve the coverage of regional water level monitoring bores in the Oolloo aquifer.

2. Establish the nature and stratigraphic relationships of a newly recognised formation that is thought to overlie the Oolloo Dolostone. RN36812 was drilled in 2009 for this purpose but drilling problems caused it to be stopped short of its target depth.

Graphic logs that summarise the geologists description of the cuttings, water intersections, gamma log and construction of each hole are included in Appendix 1. The formation boundaries were derived from all these sources as well as from the drillers log. Formation tops and thicknesses; and water levels for each bore are summarised in Table 1. The drillers "Final Statement of Bore" sheets are in Appendix 2, while geologists descriptions of cuttings are in Appendix 3. Plates 1 to 7 are selected images taken by a down-hole optical scanner. They give a 360^0 view of the inside of the borehole walls. The boreholes were 149mm diameter in the sections that

were imaged. The images are oriented relative to magnetic north, with the left hand margin facing 0^0, the centre facing 180^0 and the right hand margin facing 360^0. The left and right margins are therefore the same point on the borehole wall.

Observations

Drilling

RN37041: This was the first hole drilled and is situated on Florina Station, adjacent to the Daly River. It was drilled using an air hammer to a depth of 162m, where circulation was lost. Mud drilling was then tried but circulation could not be regained. Another problem with the hole was that the upper 50 metres was in soft unstable formation. This resulted in the formation outside of the surface casing and its cement seal being breached by the air stream moving up the hole. There was potential for the ground surrounding the hole to become unstable so drilling was discontinued. The target formation, the Oolloo Dolostone was not reached.

Thin sandy soil overlies Cretaceous aged clayey sand, sandstone and sandy clay which extend to a depth of 25 metres. The Cretaceous strata in turn overlie a sequence of fine grained glauconitic sandstone and limestone. The sandstone contains thin shale and limestone beds. A prominent limestone was struck between 86 and 105 metres. Aquifers were encountered at three intervals between 61 and 117 metres in both sandstone and limestone. Note that drill chips were highly contaminated by caving from the upper part of the hole. Formation depths were taken from the nearby hole RN37043. The hole was completed as a monitoring bore with 100mm PVC slotted between 59.9 and 64.9 metres adjacent to an aquifer in glauconitic sandstone.

RN37042: This hole is situated 10 kilometres south east of RN37041 where it was hoped that the Oolloo Dolostone would be shallower. It was drilled with an air hammer and Oolloo was struck at 92 metres. The hole was then cased and drilling continued to the depth of 129.3 metres. The open hole below the casing was temporally backfilled with drill cuttings and the casing cemented into place. The cement plug was later drilled and the backfill removed. The section below the casing was left uncased in order to run a down-hole optical scanner.

An aquifer was encountered in glauconitic sandstone at 45 to 48.6 metres. The sandstone in that interval is medium grained and has visible intergranular porosity. No water was encountered in the gray finely crystalline limestone that directly overlies the Oolloo Dolostone. The main water intersection was in the Oolloo Dolostone with an airlift yield in excess of 20 L/sec over the whole of the section exposed in the borehole.

RN37043: After proving the presence of Oolloo Dolostone in RN37042 it was decided to have another attempt to reach that formation at the first site (RN37041). RN37043 is located 37 metres north east of RN37041. In order to avoid the problems encountered in the first hole several strings of progressively narrower diameter casing were telescoped as the hole was deepened. The main stages involved in drilling the hole are listed in Table 2.

The Oolloo Dolostone was struck at 192 metres. It is directly overlain by a gray medium to coarsely crystalline limestone, which in turn is overlain by the glauconitic sandstone that RN37041 finished in. The clayey interval at the top of the formation from 25 to 39 metres represents decomposed glauconitic sandstone and shale. The hole was completed in a similar manner to RN37042 with steel casing run to the top of the Oolloo Dolostone and a cement plug installed. The plug was drilled and the hole beneath was also left uncased in the Oolloo Dolostone in order to run a down-hole optical scanner.

RN37044: This site was drilled to fill a gap in the regional monitoring network for the Oolloo aquifer. It encountered 18 metres of Cretaceous clay and sandstone and then passed into the bedded unit of the Oolloo Dolostone and struck Jinduckin Formation at 124.5 metres. The hole was continued to a depth of 215.5 metres in order to obtain a sufficient depth of gamma log and so establish the precise stratigraphic position of the strata. The Oolloo Dolostone only encountered seepage but minor water intersections were found in the Jindickin Formation. The hole was left uncased below 49.6 metres to enable a down-hole optical scanner to be run at a later date.

Aquifers

Aquifers were encountered in all of the units within the “Florina formation” (see “Discussion” below) with the exception of the uppermost limestone. That unit has yet to be been drilled.

The “Florina formation” sandstones have airlift yields up to 10 Litres/sec even at depths as great as 150m. Water intersections occur at specific levels within the formation. These aquifers are most likely fractured rock types but primary porosity is occasionally present. Some sandstone is calcareous and the drill chips also show rare examples of secondary porosity where calcium carbonate has been removed by solution.

The limestone units of the “Florina formation” have airlift yields up to 15 Litres/sec. No water was encountered in the basal limestone in RN37042. The aquifers are developed in fractures enlarged by solution. No significant cavities were struck. Tickell (2008) noted numerous springs in the Daly River adjacent to the outcrop zone of the lower limestone suggesting that it hosts a significant aquifer.

The Oolloo Dolostone hosts a major karstic aquifer. Airlift yields were in excess of 10 Litres/sec. Note that the boreholes were only 149mm diameter through the aquifer so yields could be potentially much higher through a larger diameter borehole. The down-hole optical images indicate that the aquifer comprises localised, moderate sized solution cavities (centimeter to decimetre) and a more pervasive set of fine scale cavities (sub-millimetre to centimetre). The larger cavities were all present in the upper 25 metres of the formation. Ones with sharp, straight edges are dominantly vertical and appear to be formed on fractures (Plates 6 and 7). Some fractures show only minor enlargement by solution (Plate 8). Cavities with smoother curved edges appear to have formed preferentially along bedding planes (Plate 1). Caliper logs run in the holes detected the main cavernous zones seen on the down-hole images.

The finer scale cavities (Plates 2, 3 and 5) occur throughout the drilled section of the Oolloo Dolostone but are more common in the upper 25 metres of the formation. Outcrops and drill cuttings suggest that they are interconnected to some degree, contributing to the permeability and storage of the aquifer. They are partly controlled by lithology because in places they are more common along particular beds (Plate 3). As well as dissolution of dolomite some deposition of secondary calcite and dolomite has taken place as veins (Plate 7), as stockworks (Plate 8) and as crystals lining cavities and fractures.

Shale beds up to 0.25 metres thick were intersected in RN37042. In some cases they are undisturbed (Plate 2) while in others they have been disrupted by solution and collapse in the underlying dolostone (Plate 4), creating pathways for the vertical movement of groundwater through the shales.

The bores were all constructed as water level monitoring bores but as yet have not been levelled to AHD. In the case of RN37042 and RN37043 the standing water levels in the Oolloo aquifer are close to or above the adjacent river bed. Detailed analysis of the water levels must await levelling of the bores.

Groundwater Chemistry

The water analyses listed in Table 3 were taken during the drilling operations and were all airlifted. The bores were typically airlifted for about 10 minutes before the sample was taken. The samples taken after the bores were constructed were airlifted until the water cleared noticeably. These include the samples from 59.9m in RN37041, 101.5 metres in RN37042, 230m in RN37043 and 205m in RN37044. The lower turbidity of these samples reflects the longer airlift time. The two main aquifers sampled were the “Florina formation” and the underlying Oolloo Dolostone. Two of the “Florina formation” samples were a mixture of waters from limestone and sandstone units.

Analyses of four groundwaters from the “Florina formation” sampled prior to the current drilling program are also included in Table 3 for comparison.

Discussion

Geology

Reconnaissance geological mapping along the Katherine and Daly Rivers (Tickell, 2008) identified a sequence of three limestones separated by two glauconitic sandstone units. At that time it was tentatively assigned to the Jinduckin Formation because the limestone resembled the well bedded limestones found in that formation. The glauconitic sandstone is however uncharacteristic of the Jinduckin Formation. The rocks are marine in origin and the uppermost limestone contains Palaeozoic fossils. This suggests that the sequence is related to the Cambro-Ordovician aged Daly River Group.

RN37043 was sited adjacent to the stratigraphically highest part of the sequence exposed in the Daly River. The name “Florina formation” is used here informally to

describe the sequence in RN37043 in the interval 25 to 192 metres. The unit will be formalised in the near future in conjunction with the Northern Territory Geological Survey. Both RN37042 and RN37043 passed through the "Florina formation" into Oolloo Dolostone proving that it is a new formation within the Daly Basin sequence and that it is younger than the Oolloo Dolostone (Figure 2). A similar sequence to the Daly River outcrops was encountered in RN37043. An exception was that the uppermost limestone unit of the "Florina formation" was not intersected by RN37043 despite being only 0.5 km east of the outcrop. Cretaceous clay and sand are present down to 25 metres depth, the level at which the limestone was expected.

The "Florina formation" shows a pattern of cyclic sedimentation. Each cycle begins with limestone which passes abruptly upwards into a thicker sequence of glauconitic sandstone with minor shale interbeds. Two complete cycles are present but only the limestone of the third and youngest cycle is preserved. Details of lithologies, sedimentary structures and fossils are not visible in the drill chips but were observed in nearby outcrops.

The limestones are predominantly very well bedded calcilutites and minor calcarenite and intraclast conglomerates (breccia). Beds appear to be laterally continuous over distances of ten's of metres. Some sections contain up to 20% detrital quartz and minor glauconite pellets. Trace fossils including horizontal feeding trails and vertical burrows are common but macro-fossils including brachiopods, gasteropods, hyoliths and nauteloids were only observed in outcrops of the uppermost limestone.

The sandstones are fine to medium grained, typically with around 5% glauconite pellets. Shaley laminae and thin shale interbeds are common. Some of the sandstones are slightly calcareous. They are well bedded with beds ranging in thicknesss up to 0.5 metres and some are laterally discontinuous. Horizontal feeding trails are common. The sandstones show broad trough type current bedding and wave ripple marks.

Reconnaissance geological mapping together with borehole data were used to interpret the extent of the "Florina formation", including the constituent limestone and sandstone units. From oldest to youngest the units are informally referred to as "Limestone 1", "Sandstone 1", "Limestone 2", Sandstone 2" and "Limestone 3". Figure 3 shows the extent of the "Florina formation" with the overlying Cretaceous strata removed. Note that there are large gaps in the data used to make the map and so it is highly speculative in most areas. Figure 4 includes the Cretaceous strata and shows that the outcrop of the "Florina formation" is limited to a relatively small area.

RN37043 encountered 165 meters of the "Florina formation" but in RN37042 which is located 10 km to the south and up dip of RN37043, only 92 metres is present (Figure 2). The base of the formation dips at about 0.5^0 to the north between the two boreholes. The "Florina formation" and the underlying Oolloo Dolostone appear to be conformable but the highly karstified and dolomitised nature of the upper section of the Oolloo suggests that it was subjected to a weathering event prior to the deposition of the "Florina formation". The two formations are therefore most likely disconformable.

In the upper section of the Oolloo Dolostone which was the part drilled in RN37042 and RN37043, finer scale bedding has been largely destroyed by recrystallisation of the dolomite. Bedding can only be seen where a contrasting lithology such as the thin shales are present. The limestone has been homogenised to a coarsely crystalline dolostone. The rock is a moderate red, coarsly crystalline dolostone which grades downward to a pale red, medium crystalline dolostone. Outcrops of deeper sections of the formation are well bedded with a variety of sedimentary structures visible. Two units; the “massive” and “bedded” units recognised in outcrops by Tickell (2001) represent respectively the recrystallised and karstified rock and the less altered rock beneath. The contact between the two is likely to be transitional. The section drilled in RN37042 and RN37043 represent the “massive” unit, while the section drilled in RN37044 belongs to the “bedded” unit.

Aquifers

Aquifers in the “Florina formation” are separated by thick sections with no water intersections. The aquifers may be laterally extensive and are confined. Groundwater movement is governed by bedding so there is little opportunity for groundwater to move vertically through the formation. Cretaceous sediments, including a basal shale layer overlie and confine most of the “Florina formation”. Recharge is limited to the few areas where the aquifers intersect the surface, especially those away from the rivers with higher elevation. Discharge occurs in the Katherine and Daly Rivers as reflected by the distribution of springs (Figure 4).

The Oolloo Dolostone is overlain by the basal limestone unit of the “Florina formation”. Both units are aquifers and are in direct hydraulic connection with each other. The presence of abundant springs and seepages in the Daly River where it crosses the outcrop zone of the basal limestone suggests that that unit hosts a significant aquifer. Stream flow measurements in that area in October 2009 indicated that the springs contributed about 0.3 cumecs to the Daly River (Wagenaar and others, 2009) Downstream of there only isolated springs are associated with higher units of the formation. The main body of the “Florina formation” acts as a confining layer for the Oolloo aquifer.

The Oolloo itself is a much more substantial aquifer because it was formed as a result of the dolomite being exposed to weathering not long after its deposition. The weathering and dissolution associated with this event extends to considerable depth and occurred over the present extent of the formation. The current drilling (RN37042 and RN37043) only penetrated less than 40 metres below the top of the formation but water bores on Taylors Park (NT Portion 1349), located 20 km to the east encountered significant aquifers at up to twice that depth below the top of the formation.

Groundwater Chemistry

Groundwaters from the Oolloo Dolostone, the Jinduckin Formation and from limestone units of the “Florina formation” have chemical compositions typical of those from carbonate rocks. TDS ranges from 300 to 400mg/L, they are alkaline and they have high hardness. Calcium and magnesium are the dominant cations while bicarbonate is the dominant anion. Chloride, sulphate, sodium and potassium

concentrations are all relatively low. Groundwaters from the sandstone units of the "Florina formation" are also calcium/magnesium bicarbonate type waters but they show a lesser and a more variable degree of influence from carbonate rocks. Hardness ranges from 60 to 255mg/L, compared to 293 to 368 in the limestones and dolostones. The degree of hardness is presumably related to the carbonate content of the sandstone which is seen from the drill chips to vary considerably. The sample of water from the Jinduckin Formation in RN37044 has a slightly elevated sulphate concentration (38 mg/L) which is characteristic of that aquifer and is related to the presence of primary anhydrite in the rock.

One water analysis is significantly different from the others. The sample from 24.6 to 25.8 metres in RN37041, from a Cretaceous aquifer has a higher TDS (680 mg/L), a lower pH (6.9), low bicarbonate (22mg/L) and a high chloride (302mg/L). Similar waters were encountered in Cretaceous aquifers in the Stray Creek area (Tickell, 2009). The elevated chloride and TDS in that case was attributed to evaporative concentration associated with a low recharge rate. The same mechanism

References

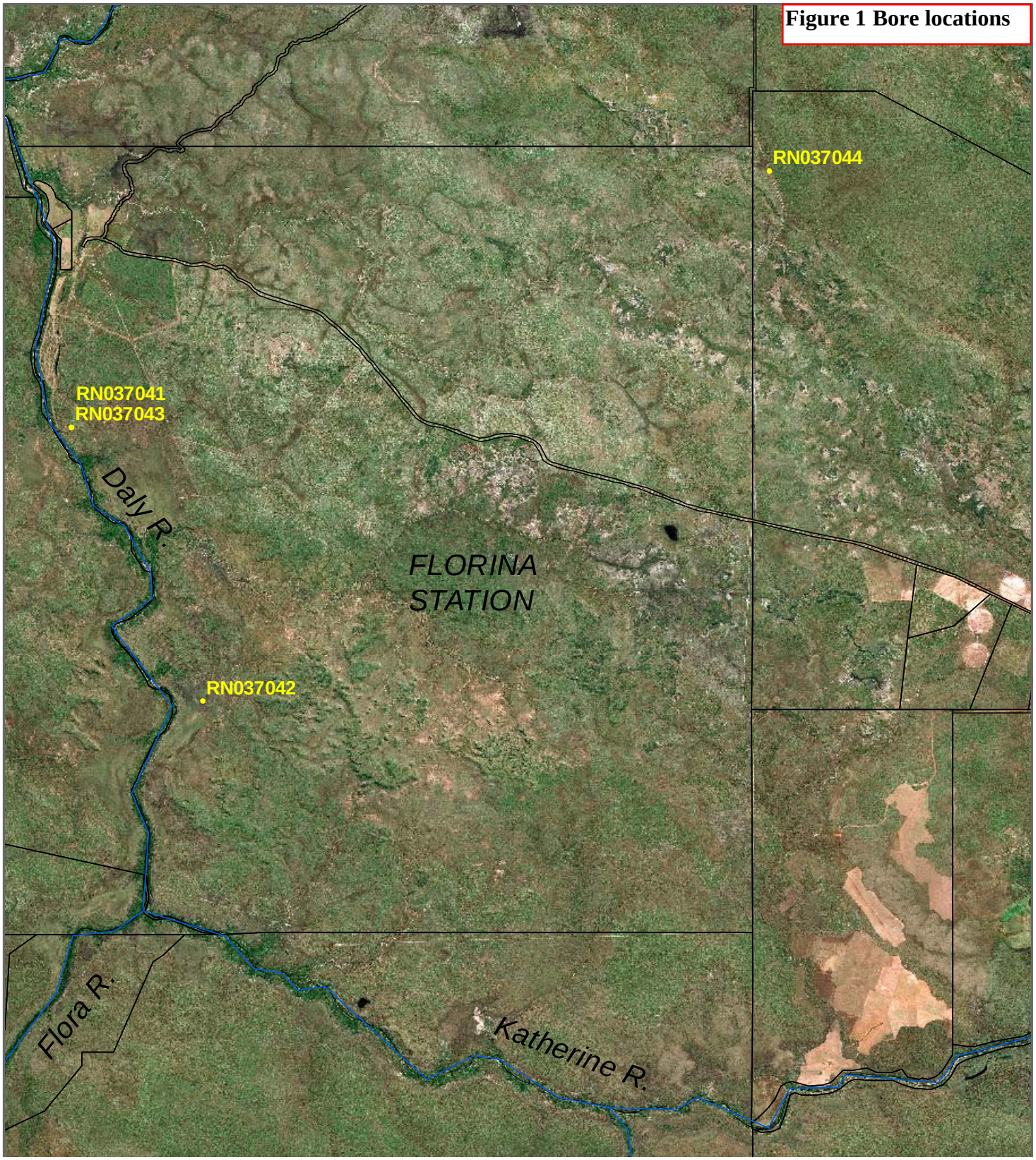
Tickell, S.J., 2001 Groundwater resources of the Oolloo Dolostone. Report 17/2002. Natural Resources Division, Northern Territory Department of Infrastructure, Planning and Environment.

Tickell, S.J., 2008 A survey of springs and rapids along the Katherine and Daly Rivers. Report 4/2008. Water Resources Division, Northern Territory Department of Natural Resources Environment the Arts and Sport

Tickell, S.J., 2009 Daly basin Drilling, 2009. Report 8/2009. Water Resources Division, Northern Territory Department of Natural Resources Environment the Arts and Sport

Wagenaar, D., Ahern, J., Lowe, H. and Boland, T., 2009 Daly low flow gaugings Report 21/2009. Water Resources Division, Northern Territory Department of Natural Resources Environment the Arts and Sport

Figure 1 Bore locations



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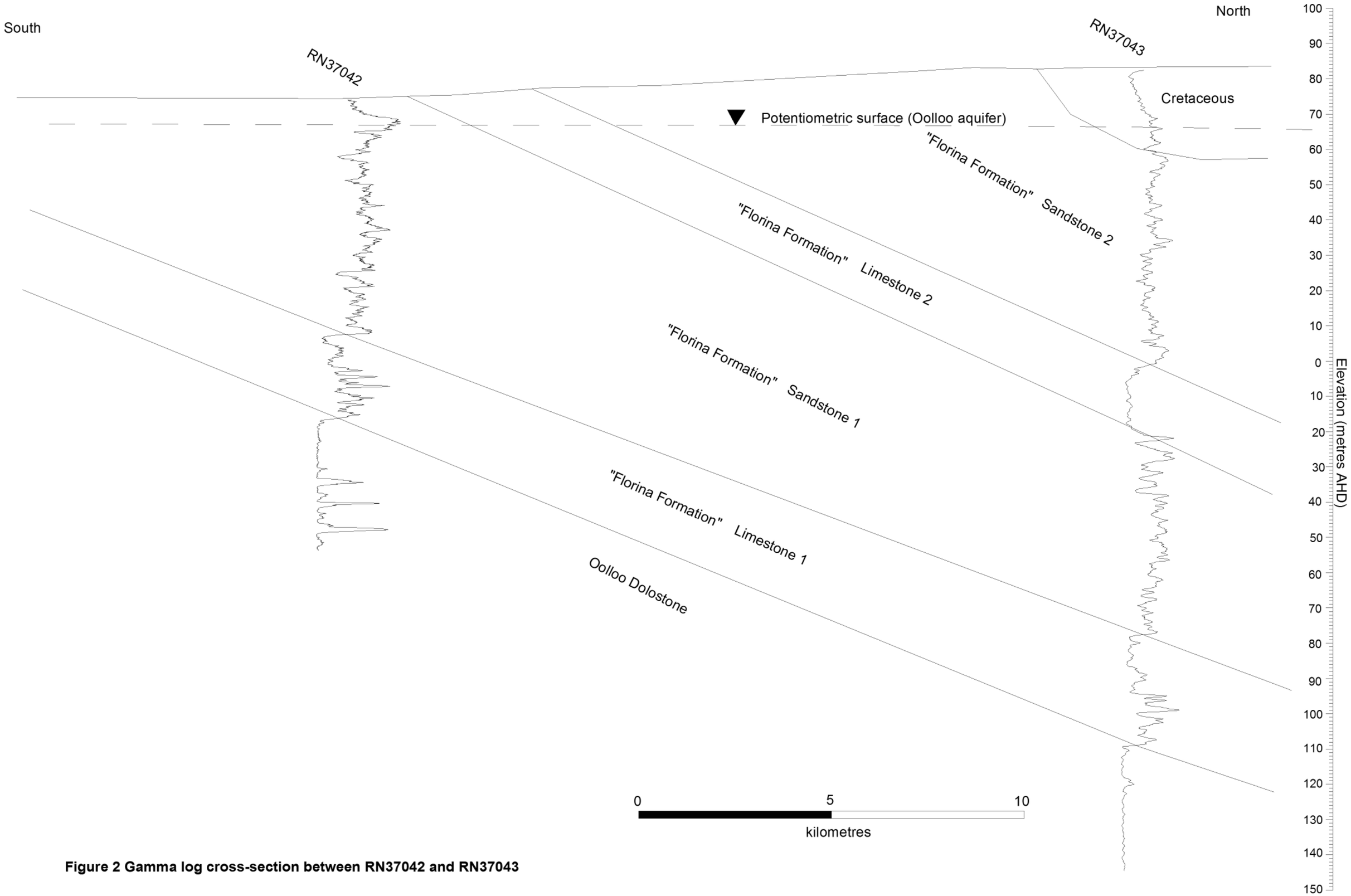

Figure 2 Gamma log cross-section between RN37042 and RN37043

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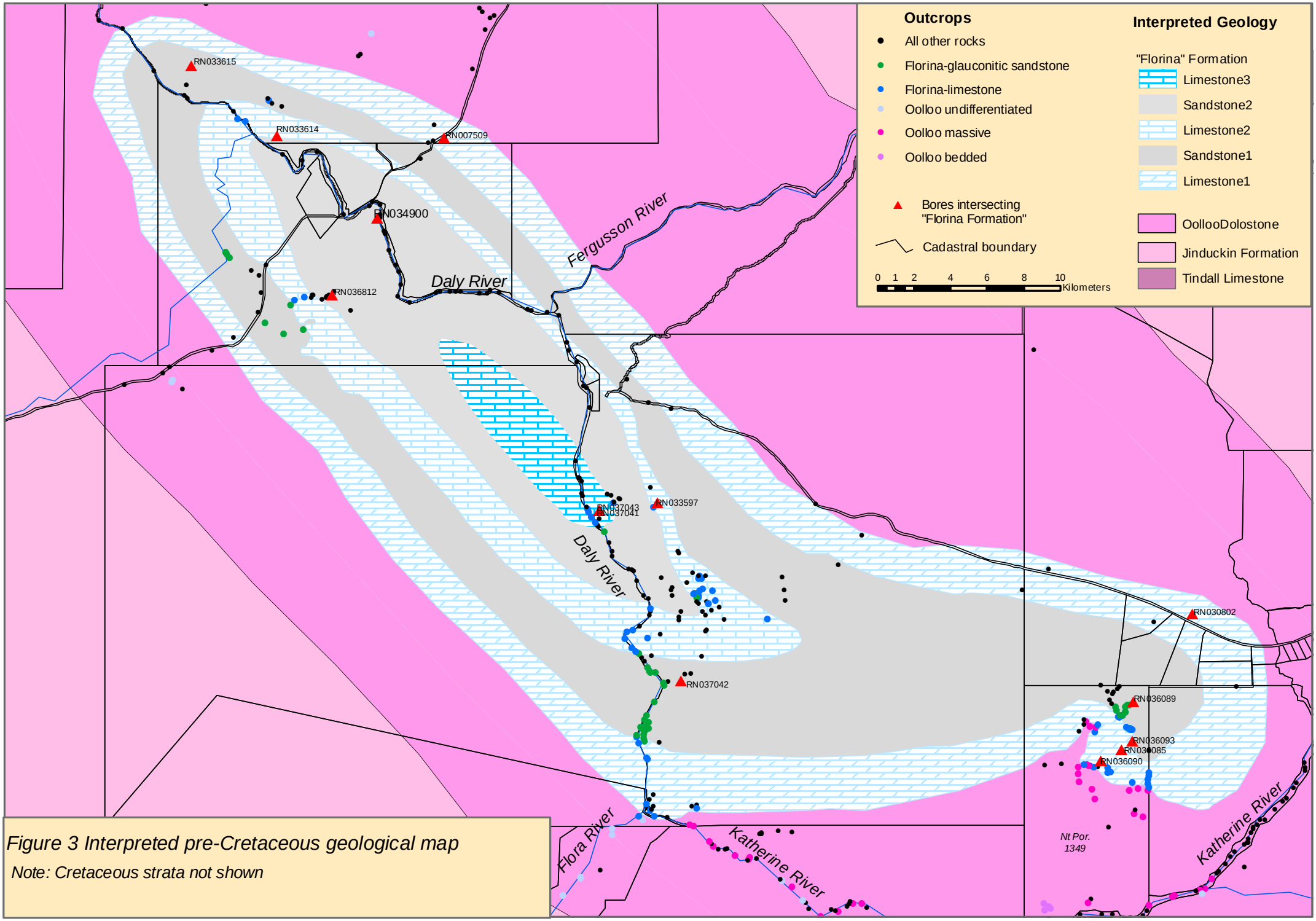

Figure 3 Interpreted pre-Cretaceous geological map

Note: Cretaceous strata not shown

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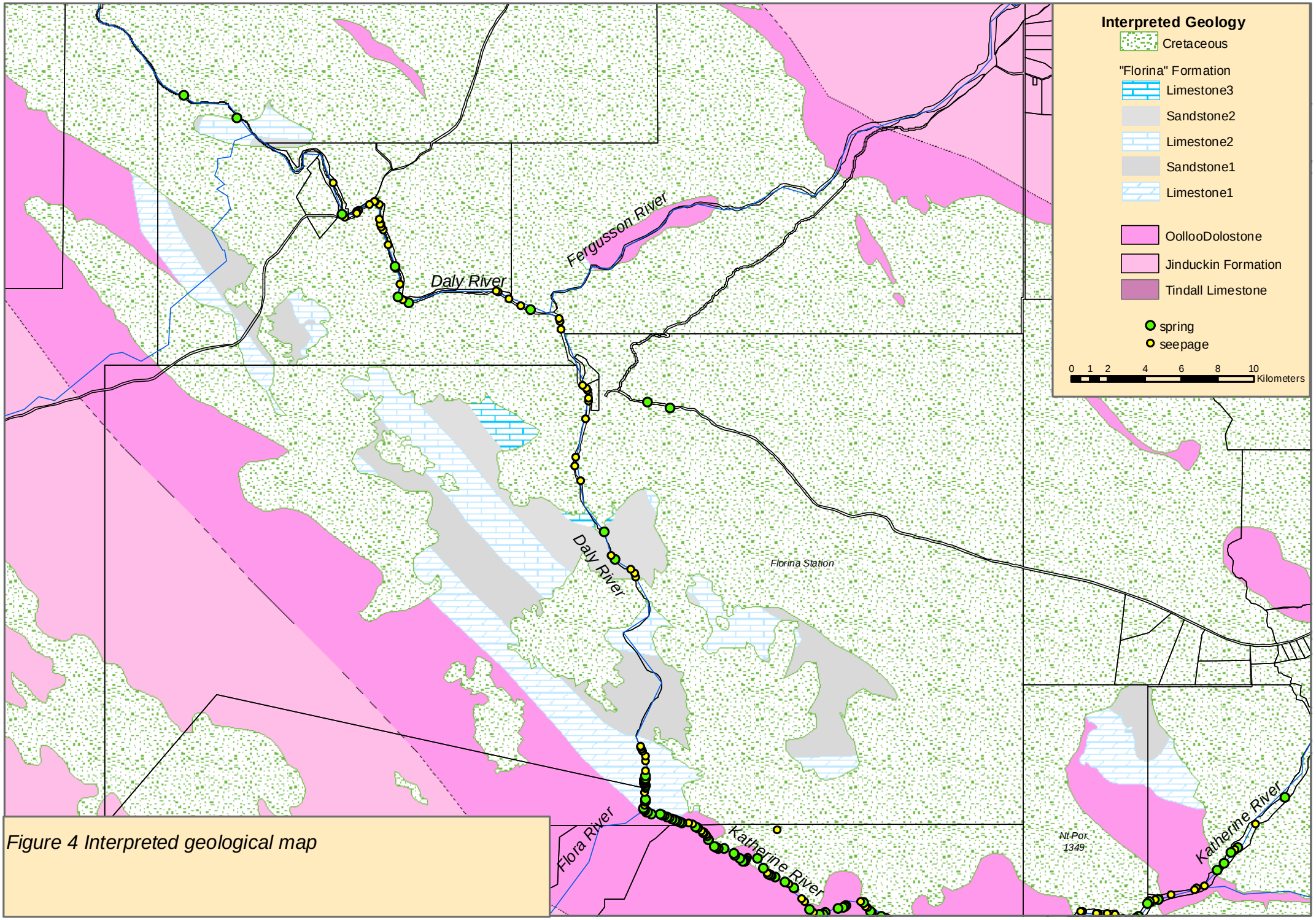

Figure 4 Interpreted geological map

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PLATES

Down-hole optical scanner images

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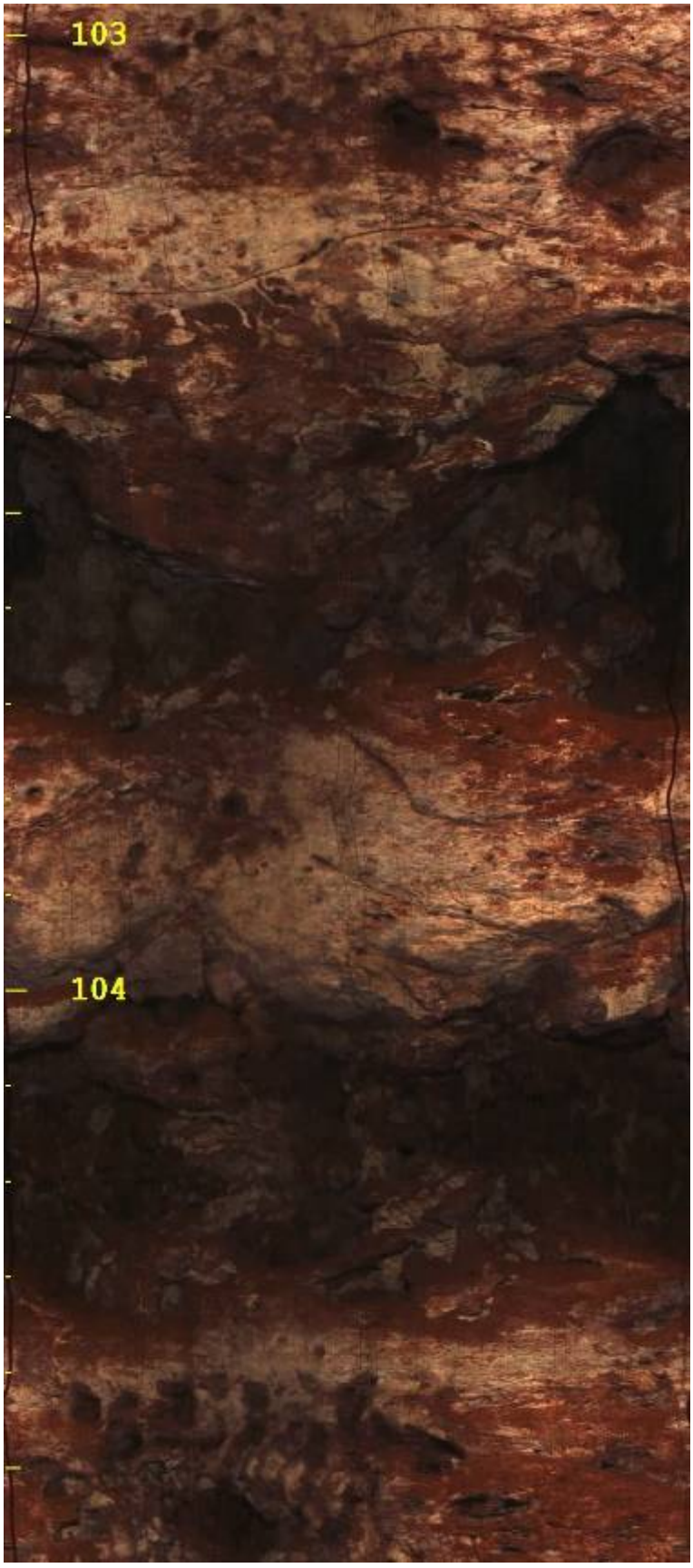

Plate 1 RN37042, 103 – 104.6m, down-hole optical scanner image

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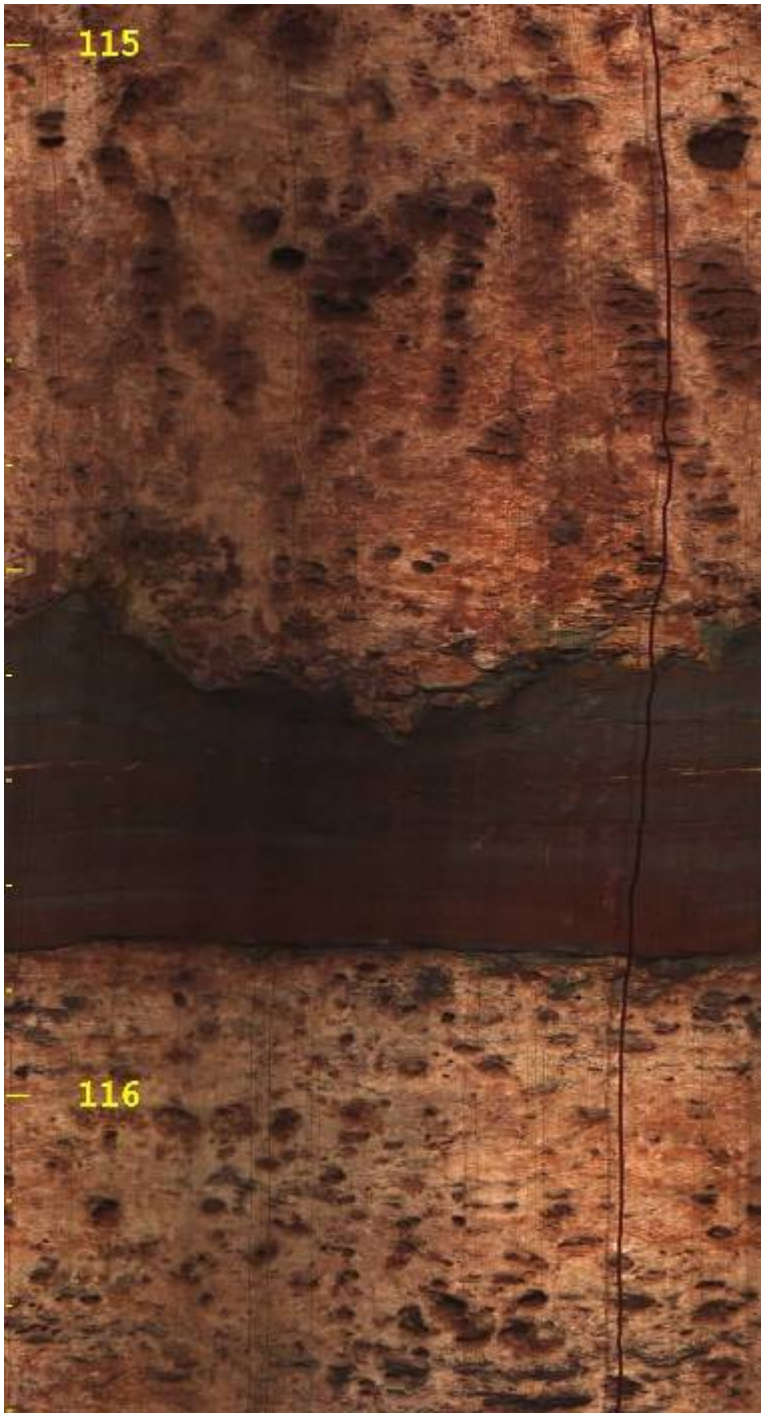

Plate 2 RN37042, 115 – 116.3m, down-hole optical scanner image

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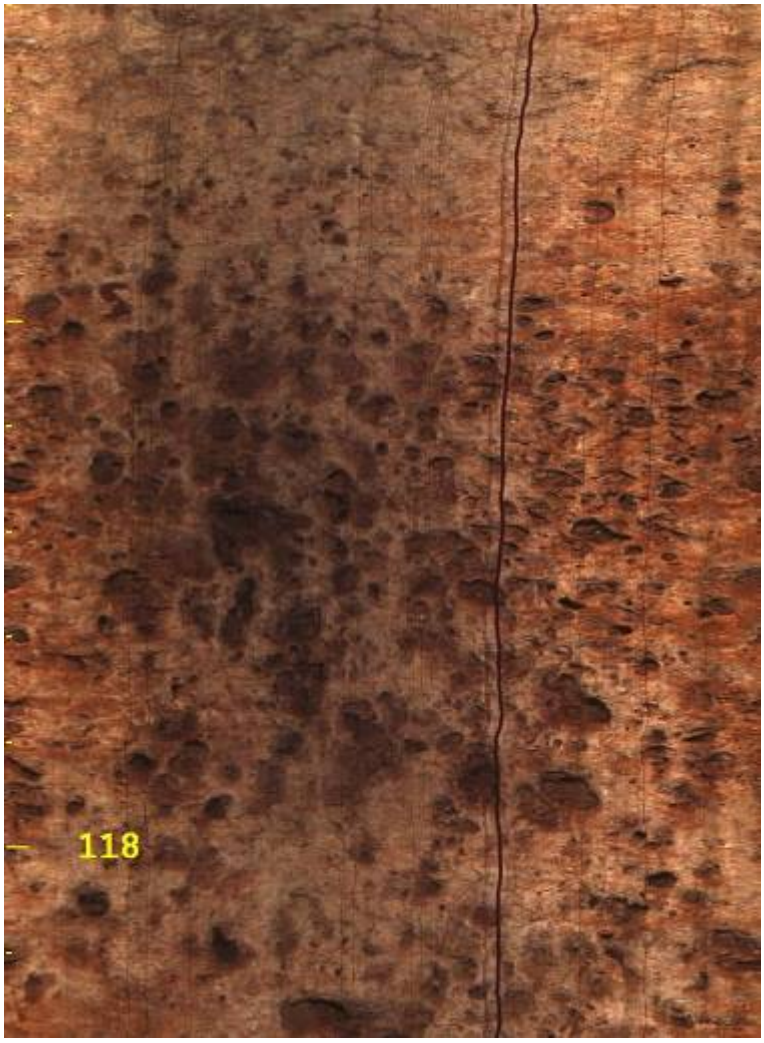

Plate 3 RN37042, 117.2 – 118.2m, down-hole optical scanner image

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Plate 4 RN37042, 122.6 – 123.9m, down-hole optical scanner image

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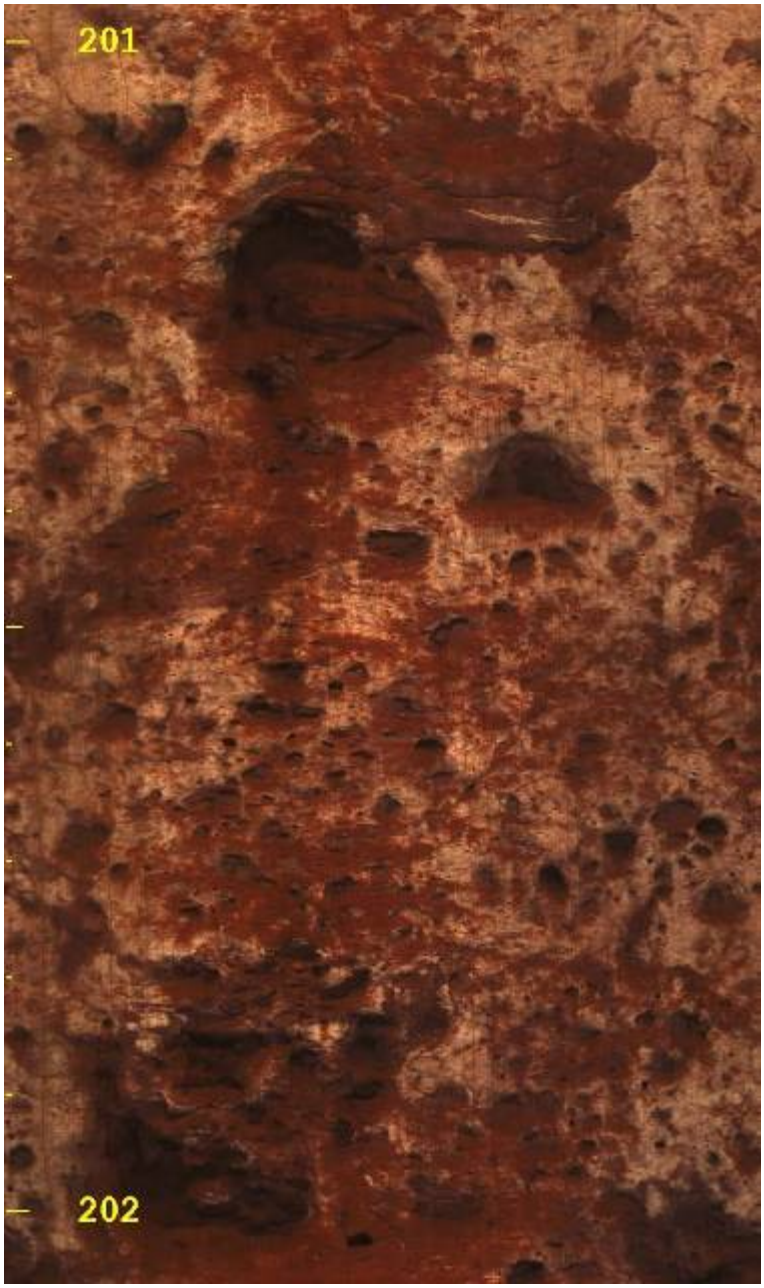

Plate 5 RN37043, 201 – 202m, down-hole optical scanner image

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Plate 6 RN37043, 208.8 – 210m, down-hole optical scanner image

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Plate 7 RN37043, 218 – 219m, down-hole optical scanner image

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Plate 8 RN37043, 230 – 230.8m, down-hole optical scanner image

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Table 1 Formation tops and water levels

Site	DateCompleted	TotalDepth (metres)	Ground Level (metres AHD)	Surveying Method	Date swl measured	Measuring point (metres above ground level)	Water level (metres below top casing)	Water level (metres AHD)	Cretaceous	Florina	Oolloo Dolostone	Jinduckin	Aquifer Screened
									(metres below ground level)				
RN037041	27/05/2010	162.9	83	GoogleEarth	2/07/2010	0.5	18.0	65.5	0	25			Florina
RN037042	4/06/2010	129.3	75	GoogleEarth	2/07/2010	0.40	8.63	66.8		0	91.5		Oolloo
RN037043	17/06/2010	230.0	83	GoogleEarth	2/07/2010	0.30	17.43	65.9	0	25	192		Oolloo
RN037044	10/07/2010	215.2	148	GoogleEarth	10/07/2010	0.55	66.5	82.1	0		18	124.5	Jinduckin/Oolloo

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Table 2 Summary of drilling operations in RN37043

From(m)	To(m)	Fluid	Bit	Casing	Remarks
0	5.6	air	330mm claw		drilling
0	5.6			258mm steel	Casing cemented back to surface
5.6	20	air	251mm blade		drilling, too hard for blade bit @20m
20	32.9	air	251mm rock roller		drilling, lost circulation 29.9-31.6m
32.9	46.6	mud	251mm rock roller		drilling
0	46.6			206mm steel	run casing
46.6	126.5	air	198mm hammer		drilling, too much water for hammer
0	127.1			150mm steel	run casing
127.1	192.8	air	150mm hammer		drilling, too much water for hammer
192.8	194.7	air	149mm rock roller		drilling
					remove 150mm casing
46.6	196.3	air	200mm rock roller		ream hole
0	197.7			150mm steel	run casing, cement base
197.7	208	air	150mm hammer		drilling, too much water for hammer
208	230	air	149mm rock roller		drilling
					remove 206mm casing

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Table 3 Groundwater chemistry, laboratory analyses

SITE	RN37041	RN37041	RN37042	RN37042	RN37043	RN37043	RN37043	RN37043	RN37043	RN37043	RN37044	RN36812	RN36812	RN36812	RN33597
Date	21/05/10	27/05/10	29/05/10	03/06/10	09/06/10	11/06/10	12/06/10	16/06/10	16/06/10	16/06/10	10/07/2010	7/10/2009	20/10/2009	21/10/2009	22/08/2003
pH	6.9	8	7.5	7.8	7.9	8	8	8.2	8.1	8.1	8.4	6.7	7.5	7.6	7.8
EC(µS/cm)	1100	477	183	676	591	614	571	516	702	632	484	183	557	583	433
Alkalinity(mg/L)	22	264	77	393	344	338	331	312	399	353	205	78	343	358	228
CO3(mg/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	5	<1	<1	<1	<1
HCO3(mg/L)	22	264	77	393	344	338	331	312	399	353	200	78	343	358	228
OH(mg/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Turbidity(NTU)	>4000	170	1650	24	350	88	83	130	56	14	130	3930	400	18	1
TSS(mg/L)	7860	110	930	<10	320	60	70	60	40	<10	250	1980	220	20	<10
TDS(mg/L)	680	270	170	380	340	340	300	300	400	340	260	150	350	350	270
NO2_N(mg/L)	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
NO2(mg/L)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.325
NO3_N(mg/L)	0.29	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	0.045	<0.005	0.005	<0.005	<0.005	0.07	
NO3(mg/L)	1.3	<0.02	<0.02	0.04	<0.02	<0.02	<0.02	<0.02	0.2	<0.02	0.04	<0.02	<0.02	0.32	0.33
Cl(mg/L)	302	8.6	10.2	5.5	6.1	9	8.6	8.4	8.2	7.9	7.9	5.4	6.5	6.7	2.5
PO4_P(mg/L)	0.02	0.005	1.19	0.01	0.01	0.01	0.01	0.01	0.01	0.01	<0.005	0.005	0.035	0.01	<0.005
NH3_N(mg/L)	0.02	0.015	0.025	<0.005	<0.005	0.01	<0.005	<0.005	0.03	<0.005	0.005	0.09	0.215	<0.005	<0.005
F(mg/L)	0.5	0.3	0.5	0.1	0.4	<0.1	0.1	0.1	0.1	0.1	2	1.1	0.8	0.2	0.2
Hardness(mg/L)	116	243	60.3	363	312	315	293	238	368	323	224	75.8	337	368	255
Na_F(mg/L)	155	6.3	10.3	5.4	5.9	8.4	7.2	11.7	7.2	7.1	7.6	18.7	69	63	3.6
Ca_F(mg/L)	13.7	46.9	11.3	64.5	57.2	59.2	51.8	25.1	74.2	58.2	41.7	10.7	5.1	3.3	58.4
K_F(mg/L)	0.7	4.2	6.6	3.1	4.7	5.1	4.9	13.1	4.1	3.9	8.1	7.1	40.1	51.1	1
Mg_F(mg/L)	19.9	30.6	7.8	49.1	41.2	40.6	39.9	42.6	44.5	43.2	29.1	7.3	6.5	5.6	26.5
SiO2(mg/L)	68.4	17.2	62.4	26	22.2	25	24.4	31.6	28.8	28.4	12.4	13.6	19.6	27.4	22.8
SO4_F(mg/L)	1	7.2	1.3	9	6.7	17.4	14.9	16.4	13.2	13.4	38.2	10.5	10.3	7.2	1.4
Ag_T(µg/L)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	<10	<10	<10
Al_T(µg/L)	>LWR	4620	>LWR	520	>LWR	>LWR	>LWR	>LWR	260	20		>LWR	700	20	80
Al_T(mg/L)	20.5	N.A.	25.4	N.A.	1.8	7.36	1.82	1.14	N.A.	N.A.		93.5	N.A.	N.A.	
As_T(µg/L)	3.5	1	4.5	<0.5	1.5	3	1.5	1.5	<0.5	<0.5		23	1	<0.5	<0.5
B_T(µg/L)	20	40	60	<20	20	40	20	20	20	20		80	20	20	20
Ba_T(µg/L)	200	300	150	<50	<50	300	<50	<50	<50	<50		1800	50	<50	<50
Be_T(µg/L)	<1	<1	3	<1	<1	<1	<1	<1	<1	<1		11	<1	<1	<1
Br_T(µg/L)	1610	56	74	36	62	52	54	54	50	48		100	34	36	40
Cd_T(µg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2		1	<0.2	<0.2	<0.2
Cr_T(µg/L)	35	<5	40	<5	<5	15	<5	5	<5	<5		105	<5	<5	<5
Cu_T(µg/L)	20	<10	20	<10	<10	10	<10	20	40	<10		170	<10	<10	<10
Fe_T(µg/L)	9400	2360	>LWR	540	>LWR	>LWR	>LWR	>LWR	700	120		>LWR	800	20	970
Fe_T(mg/L)	N.A.	N.A.	23	N.A.	1.65	6.15	1.7	1.15	N.A.	N.A.		87.4	N.A.	N.A.	
Hg_T(µg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	<0.1
I_T(µg/L)	50	10	20	<10	<10	10	<10	<10	<10	<10		80	30	10	10
Mn_T(µg/L)	50	460	355	20	70	875	35	40	70	10		3640	20	<5	10
Mo_T(µg/L)	<5	<5	<5	<5	<5	<5	<5	5	<5	<5		<5	<5	<5	<5
Ni_T(µg/L)	8	2	38	<2	4	12	4	2	<2	<2		142	<2	<2	<2
Pb_T(µg/L)	12	2	5	<1	1	11	2	3	1	<1		48	<1	<1	<1
Sb_T(µg/L)	0.8	<0.2	<0.2	<0.2	0.6	<0.2	0.2	1.2	1.6	<0.2		<0.2	<0.2	<0.2	<0.2
Se_T(µg/L)	2	<1	2	<1	1	<1	<1	<1	<1	<1		4	<1	<1	<1
Sn_T(µg/L)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	<10	<10	<10
U_T(µg/L)	10.2	5.93	1.72	0.75	2.11	1.39	1.61	0.26	0.84	0.91		16	0.8	0.7	0.18
Zn_T(µg/L)	50	20	70	10	20	30	10	60	130	10		380	<10	<10	90
Sample type	airlift	airlift	airlift	airlift	airlift	airlift	airlift	airlift	airlift	airlift	airlift	airlift	airlift	airlift	pumped
Rate(L/sec)	2.5	2.5	5	>15	15	15	15	2.5	>20	>20		1.5	20	15	1
Depth(m)	24.6-25.8	59.9-64.9	46.6-48.6	101.5-115	94.5-103	150-174	190-193	197.7-198.8	209-210.3	230	205	68.1-73.8	98-103	108-115	36-48
Details	cased to 15.7m	cased to 15.7m	cased to 5.6m	cased to 91.7m	cased to 46.6m	cased to 127m	cased to 127m	cased to 197.7m	cased to 197.7m	cased to 197.7m	cased to 49.6m	open hole	open hole	cased to 103m	slotted casing
Aquifer	Cretaceous	Florina Fm. Sandstone 2	Florina Fm. Sandstone 1	Oolloo Dolostone	Florina Fm. Sandstone 2 and limestone2	Florina Fm. Sandstone 1 and limestone1	Florina Fm. Limestone 1	Oolloo Dolostone	Oolloo Dolostone	Oolloo Dolostone	Jinduckin Fm.	Florina Fm. Sandstone 2	Florina Fm. Sandstone 2	Florina Fm. Sandstone 2 and limestone1	Florina Fm. Sandstone 2

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APPENDIX 1

Graphic logs

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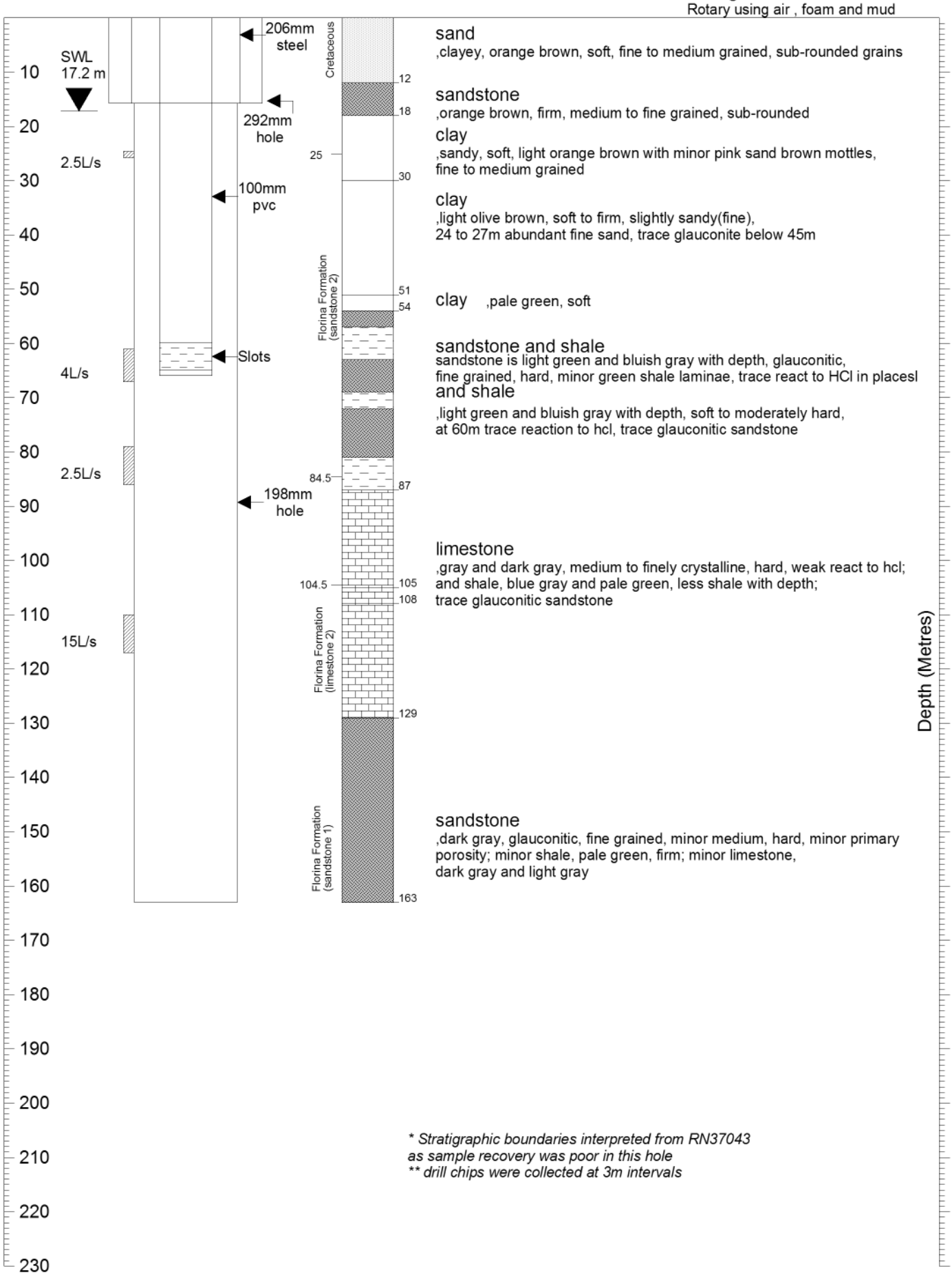
Northern Territory Government

RN37041

Purpose:
Groundwater investigation/stratigraphic
Location:
Easting 789153
Northing 8394312
MGA zone 52
Florina Station
Drilling method:
Rotary using air , foam and mud

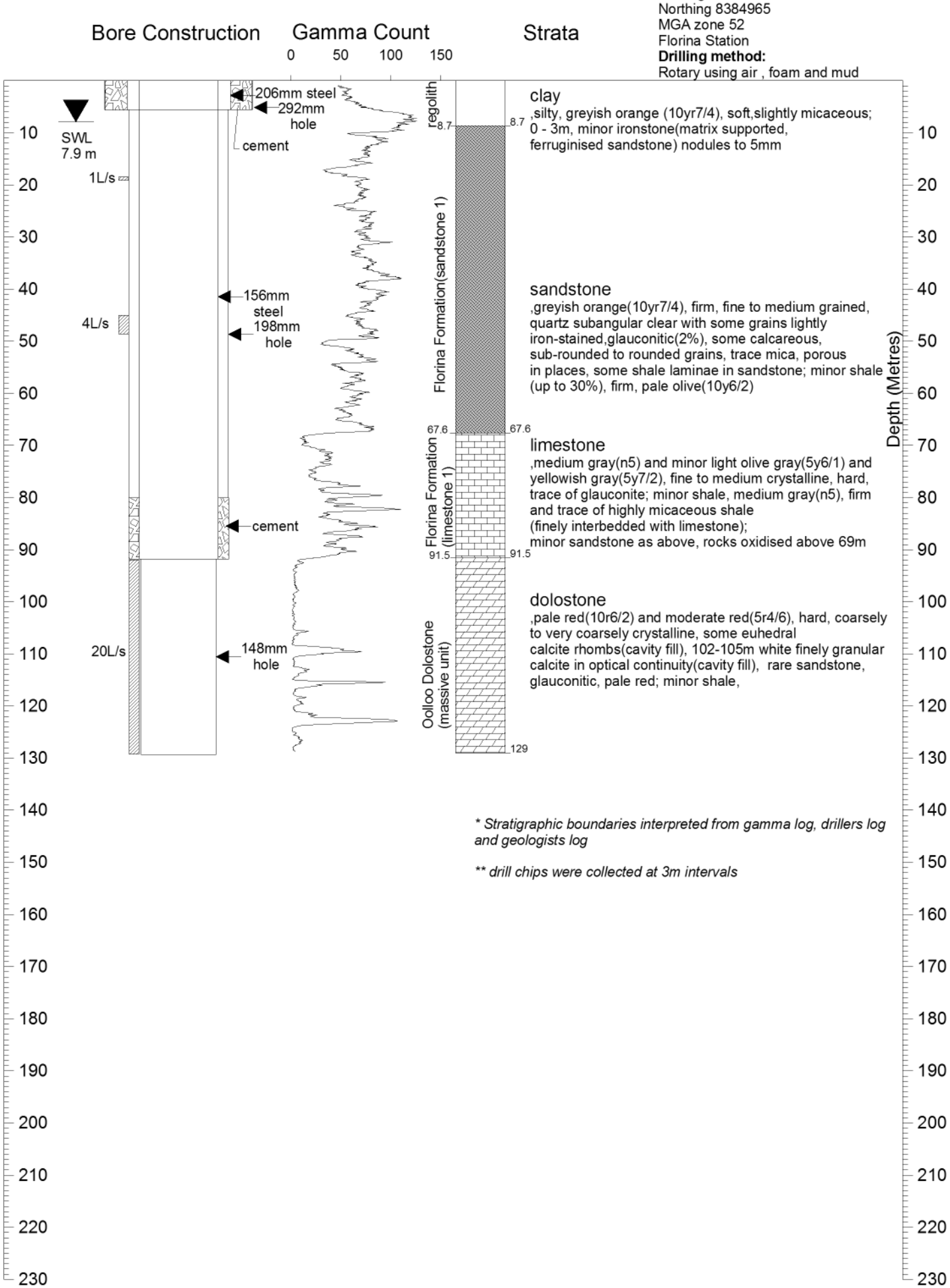


** Stratigraphic boundaries interpreted from RN37043 as sample recovery was poor in this hole*
*** drill chips were collected at 3m intervals*

Northern Territory Government

RN37042

Purpose:
Groundwater investigation/stratigraphic
Location:
Easting 793412
Northing 8384965
MGA zone 52
Florina Station
Drilling method:
Rotary using air , foam and mud



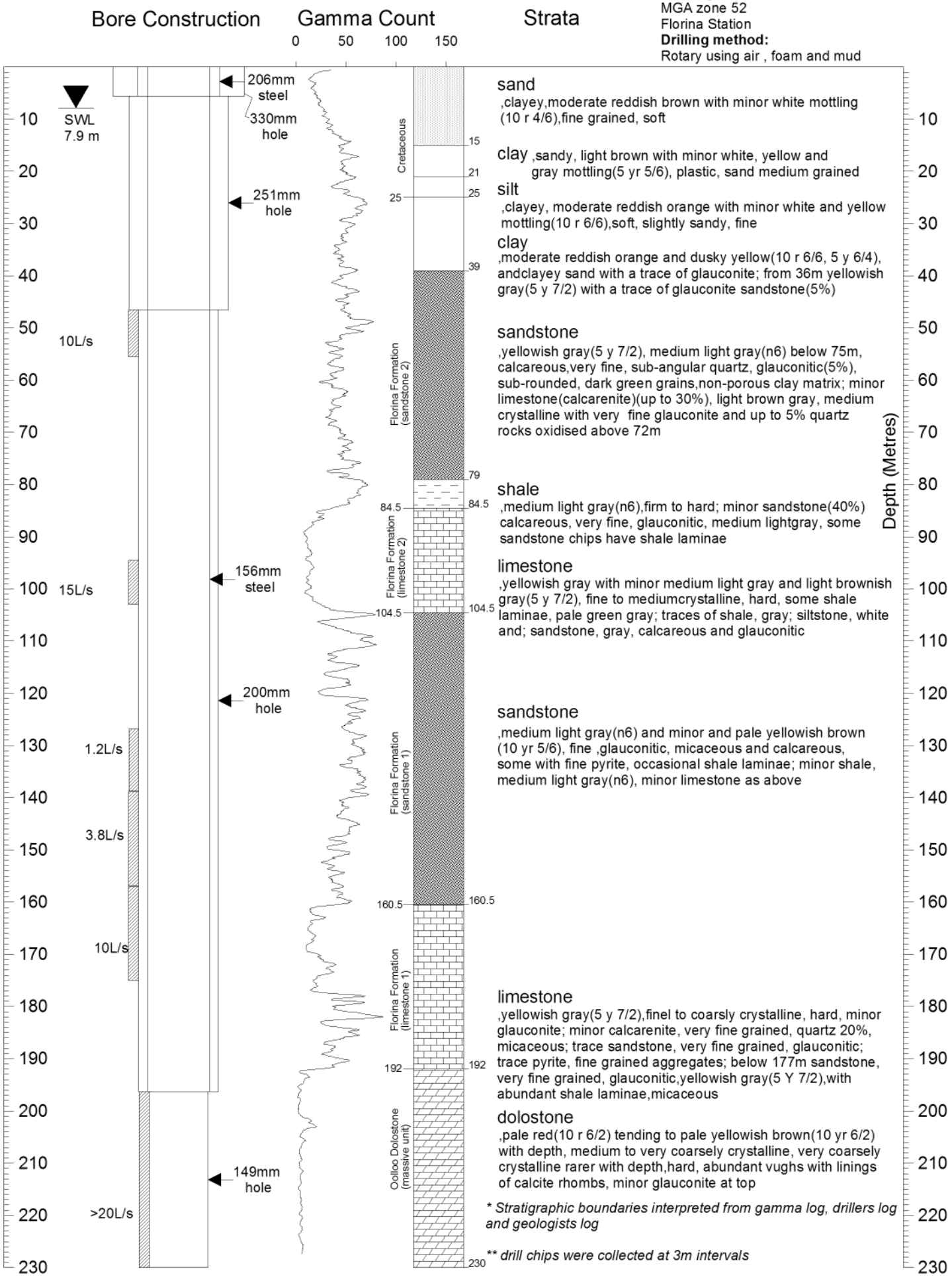
** Stratigraphic boundaries interpreted from gamma log, drillers log and geologists log*

*** drill chips were collected at 3m intervals*

Northern Territory Government

RN37043

Purpose:
Groundwater investigation/stratigraphic
Location:
Easting 789175
Northing 8394342
MGA zone 52
Florina Station
Drilling method:
Rotary using air , foam and mud



sand
,clayey,moderate reddish brown with minor white mottling (10 r 4/6),fine grained, soft

clay ,sandy, light brown with minor white, yellow and gray mottling(5 yr 5/6), plastic, sand medium grained

silt
,clayey, moderate reddish orange with minor white and yellow mottling(10 r 6/6),soft, slightly sandy, fine

clay
,moderate reddish orange and dusky yellow(10 r 6/6, 5 y 6/4), andclayey sand with a trace of glauconite; from 36m yellowish gray(5 y 7/2) with a trace of glauconite sandstone(5%)

sandstone
,yellowish gray(5 y 7/2), medium light gray(n6) below 75m, calcareous,very fine, sub-angular quartz, glauconitic(5%), sub-rounded, dark green grains,non-porous clay matrix; minor limestone(calcarenite)(up to 30%), light brown gray, medium crystalline with very fine glauconite and up to 5% quartz rocks oxidised above 72m

shale
,medium light gray(n6),firm to hard; minor sandstone(40%) calcareous, very fine, glauconitic, medium lightgray, some sandstone chips have shale laminae

limestone
,yellowish gray with minor medium light gray and light brownish gray(5 y 7/2), fine to mediumcrystalline, hard, some shale laminae, pale green gray; traces of shale, gray; siltstone, white and; sandstone, gray, calcareous and glauconitic

sandstone
,medium light gray(n6) and minor and pale yellowish brown (10 yr 5/6), fine ,glauconitic, micaceous and calcareous, some with fine pyrite, occasional shale laminae; minor shale, medium light gray(n6), minor limestone as above

limestone
,yellowish gray(5 y 7/2),finel to coarsly crystalline, hard, minor glauconite; minor calcarenite, very fine grained, quartz 20%, micaceous; trace sandstone, very fine grained, glauconitic; trace pyrite, fine grained aggregates; below 177m sandstone, very fine grained, glauconitic,yellowish gray(5 Y 7/2),with abundant shale laminae,micaceous

dolostone
,pale red(10 r 6/2) tending to pale yellowish brown(10 yr 6/2) with depth, medium to very coarsely crystalline, very coarsely crystalline rarer with depth,hard, abundant vughs with linings of calcite rhombs, minor glauconite at top

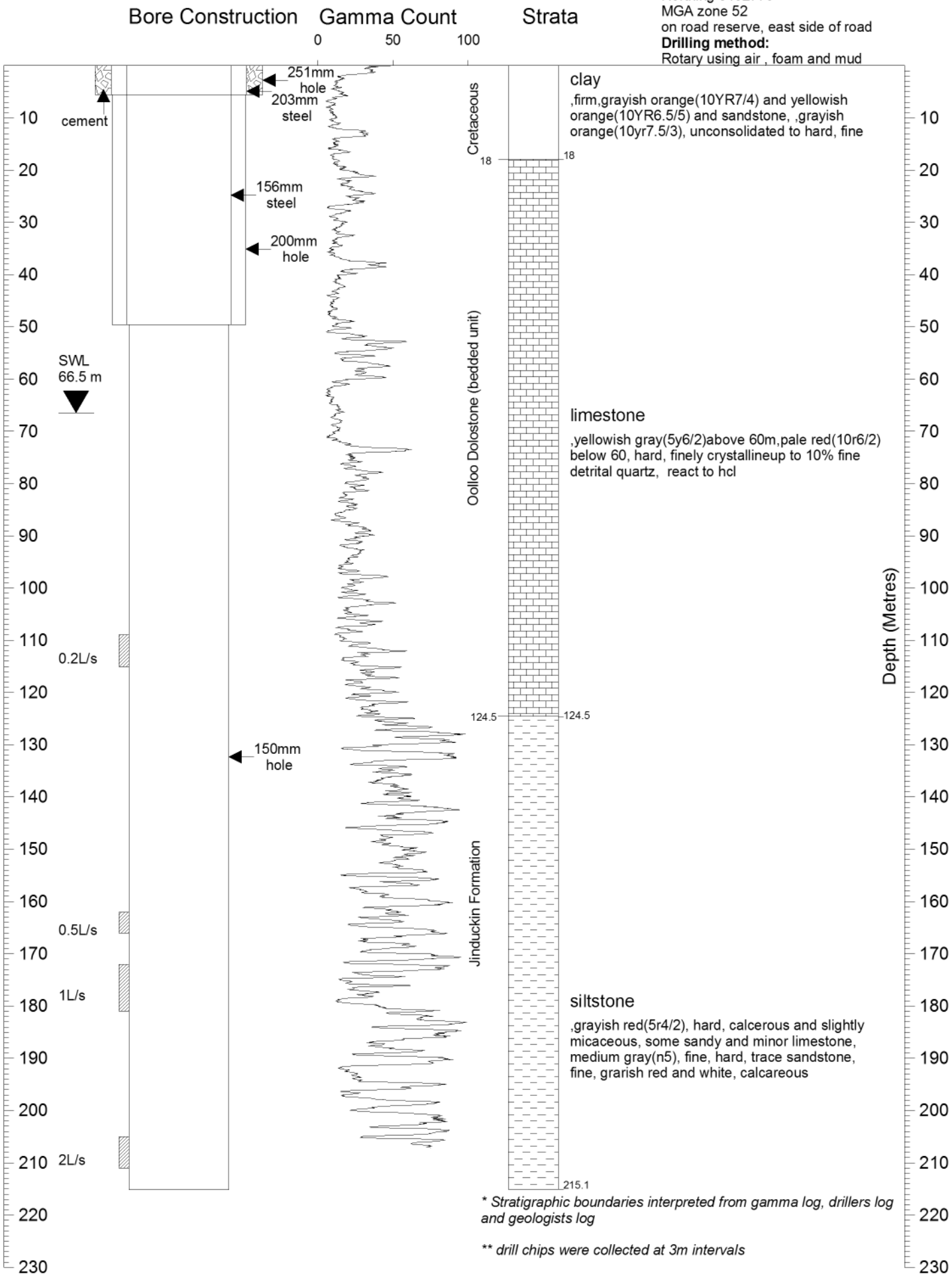
** Stratigraphic boundaries interpreted from gamma log, drillers log and geologists log*

*** drill chips were collected at 3m intervals*

Northern Territory Government

RN37044

Purpose:
Groundwater investigation/stratigraphic
Location:
Easting 812352
Northing 8402770
MGA zone 52
on road reserve, east side of road
Drilling method:
Rotary using air , foam and mud



** Stratigraphic boundaries interpreted from gamma log, drillers log and geologists log*

*** drill chips were collected at 3m intervals*

APPENDIX 2

Drillers “statement of bores” sheets

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THE NORTHERN TERRITORY OF AUSTRALIA

Water Act

FINAL STATEMENT OF BORE

Name of Owner:	NT Government	**Registration No:**	**37041**
Name of Bore:	Florina 1/10		
Intended use:	Monitoring	Index Map No:	
Location:	Florina Station Portion No. 1166	Permit No:	BCPK201

From	To (m)	
0	24.6	Sandy clays
24.6	25.8	Fractured sandstone
25.8	43.8	Sandy clays
43.8	61.8	Bands of clay and friable sandstone
61.8	67.8	Green/grey sandstone
67.8	85.8	Green/grey glauconitic sandstone
85.8	105.0	Creamy coloured limestone
105.0	162.9	Dark grey limestone and bands silicified sandstone

Name of Contractor: Water Resources
Name of Driller: C Gallagher
Date Commenced: 20-May-10
Date Completed: 27-May-10
Depth Drilled: 162.9 m
Completion Depth: 65.9 m

METHOD OF DRILLING

Rotary	Rev. Cir	Cable	Other
☑	☐	☐	

HOLE DIAMETER			Drilling Fluid
From	To (m)	Dia (mm)	Type
0	15.7	292	Air/Foam
15.7	162.9	198	Air/Foam

PARTICULARS OF CASING

From	To (m)	Dia (ID)	Type
0	15.7	206 mm	Steel
0	65.9	100 mm	PVC

PARTICULARS OF PERFORATIONS OR SCREEN STRINGS

From	To (m)	Dia (ID)	Aperture	Type
59.9	64.9	100 mm	4 mm	Slots

Casing Suspended: Yes ☑ No ☐

Top of Packer set at: N/A

Method: Annular ring between 206 mm ID Steel and 100 mm ID PVC

Length of Packer: N/A

Height of Casing above GL: 206 mm ID Steel 0.5 m
100 mm ID PVC 0.3 m

Method of Packer Connection: N/A

CEMENTING/GRAVEL PACKING

From	To (m)	Type
0	15.7	Cement

WATER BEARING BEDS

Depth (m) From	Depth (m) To	Yield L/s	SWL m	Duration hr	Quality	EC	ph	Bottle No.
24.6	25.8	2.5		Drilling	Fair	1044Us	7.15	1
61.0	67.0	4		Drilling	Fair	560 Us	9.86	2
79.0	86.0	2.5		Drilling				
110.0	117.0	15		Drilling				
59.9	64.9	2.5		1.5	Good	509Us	6.53	3

STRATA and WATER SAMPLES

Have been ☑ Will be ☐

Left at: Tannadice St Depot

Completion Yield: 2.5 L/s Method: Air Duration: 1.5 hr

Completion SWL from GL: 17.2 m Depth of lift: 38.0 m

LOCATION SKETCH OF BORE	LOCATION DESCRIPTION OF BORE		
			6.19km
	E	SE ☐	
	W ☐	NE ☐	
	N ☐	SW ☐	
	S ☑	NW ☐	
	OF: Florina Station Homestead.		

FINAL CONSTRUCTION STATUS

Capped	Casing Pulled	Left for Obs.	Abandoned	Equipped	Backfilled	Other
☐	☐	☑	☐	☐	☐	☐

GPS DATUM:	AGD66	WGS84	GDA94	Other	Easting	Northing
	☐	☑	☐	☐	52L 0789153	8394312

ADDITIONAL INFORMATION AND INTEREST ABOUT THE BORE:
PVC has cap fitted to bottom of casing and faucet on top. 206 mm Steel casing has cap welded with 50 mm socket and bung fitted. Drilled under supervision of W Cover and Peter Rees.

Signature of Licensed Driller: Date:

FOR OFFICIAL USE ONLY

How Located:	GPS	TST	Survey	Hand Plotted	other
	☐	☐	☐	☐	☐

ELEVATION OF BORE AHD: (m) from: GL ☐ TOC ☐

DESCRIPTION OF PROPERTY:

Rural	Mineral	Pastoral	Reserve	VCL	SPL	EL	Other
☐	☐	☐	☐	☐	☐	☐	☐

Lease No: Lot No: Hundred of:
Portion No: Section No: Town of:

Class of Bore:	Town	Domestic	Investigation	Agriculture	Mineral	Pastoral	Other
	☐	☐	☐	☐	☐	☐	☐

Use of Bore:	Production	Investigation	Irrigation	Observation	Monitoring	Roads	None
	☐	☐	☐	☐	☐	☐	☐

Grid Reference: AMG ☐ Clark ☐ Zone: Scale:
Easting: Lattitude: Map Name:
Northing: Longitude: Map Number:

AWRC stream Basin Number: Major Geological Units Name:

Geophysical Log Run: Yes ☐ No ☐ Date: Depth: m

Gamma	SP	Caliper	Point Res.	Density	Camera	Other ( )
☐	☐	☐	☐	☐	☐	☐

Test Pump carried out: Yes ☐ No ☐

Date Registered: Bore Plotted on the map? Yes ☐ No ☐

Officer: Signature:

Remarks:

THE NORTHERN TERRITORY OF AUSTRALIA

Water Act

FINAL STATEMENT OF BORE

Name of Owner:	NT Government	**Registration No:**	**37042**
Name of Bore:	Florina 2/10		
Intended use:	Monitoring	Index Map No:	
Location:	Florina Station Portion No.1166	Permit No:	BCPK201

From	To (m)	
0	19.1	Clays and claystone
19.1	67.7	Friable Glauconitic sandstone
67.7	88.8	Grey limestone with bands of glauconitic sandstone
88.8	129.3	Pink Oolloo limestone

Name of Contractor:	Water Resources
Name of Driller:	C Gallagher
Date Commenced:	28-May-10
Date Completed:	4-Jun-10
Depth Drilled:	129.3 m
Completion Depth:	129.3 m

METHOD OF DRILLING

Rotary	Rev. Cir	Cable	Other
☑	☐	☐	

HOLE DIAMETER			Drilling Fluid
From	To (m)	Dia (mm)	Type
0	5.6	292	Air
5.6	91.8	198	Air/Foam
91.8	129.3	148	Air/Foam

PARTICULARS OF CASING

From	To (m)	Dia (ID)	Type
0	5.6	206 mm	Steel
0	91.8	156 mm	Steel

PARTICULARS OF PERFORATIONS OR SCREEN STRINGS

From	To (m)	Dia (ID)	Aperture	Type

Casing Suspended: Yes ☐ No ☑

Method:

Height of Casing above GL: 206 mm ID Steel 0.4 m
156 mm ID Steel 0.6 m

Top of Packer set at: N/A

Length of Packer: N/A

Method of Packer Connection: N/A

CEMENTING/GRAVEL PACKING

From	To (m)	Type
0	5.6	Cement
80	91.8	Cement

WATER BEARING BEDS

Depth (m) From	Depth (m) To	Yield L/s	SWL m	Duration hr	Quality	EC	ph	Bottle No.
45	48.6	5	9.2	Drilling	Good	203Us	4.9	1
91.0	96.0	1		Drilling	Good	765Us	5.5	2
101.5	115.0	15+		Drilling	Good	786Us	7.7	3

STRATA and WATER SAMPLES

Have been ☑ Will be ☐

Left at: Tannadice St Depot

Completion Yield: 20 L/s Method: Air Duration: 0.5 hr

Completion SWL from GL: 7.9 m Depth of lift: 126.0 m

LOCATION SKETCH OF BORE	LOCATION DESCRIPTION OF BORE		
			16.04km
	E	SE ☐	
	W ☐	NE ☐	
	N ☐	SW ☐	
	S ☑	NW ☐	
	OF: Florina Station Homestead.		

FINAL CONSTRUCTION STATUS

Capped	Casing Pulled	Left for Obs.	Abandoned	Equipped	Backfilled	Other
☐	☐	☑	☐	☐	☐	☐

GPS DATUM:	AGD66	WGS84	GDA94	Other	Easting	Northing
	☐	☑	☐	☐	52L 0793412	8384965

ADDITIONAL INFORMATION AND INTEREST ABOUT THE BORE:
Left open hole from 91.8 to 129.3 metres . 156 mm ID Steel casing left with lockable cap. Drilled under supervision of W Cover and Peter Rees.

Signature of Licensed Driller: Date:

FOR OFFICIAL USE ONLY

How Located:	GPS	TST	Survey	Hand Plotted	other
	☐	☐	☐	☐	☐

ELEVATION OF BORE AHD: (m) from: GL ☐ TOC ☐

DESCRIPTION OF PROPERTY:

Rural	Mineral	Pastoral	Reserve	VCL	SPL	EL	Other
☐	☐	☐	☐	☐	☐	☐	☐

Lease No: Lot No: Hundred of:
Portion No: Section No: Town of:

Class of Bore:	Town	Domestic	Investigation	Agriculture	Mineral	Pastoral	Other
	☐	☐	☐	☐	☐	☐	☐

Use of Bore:	Production	Investigation	Irrigation	Observation	Monitoring	Roads	None
	☐	☐	☐	☐	☐	☐	☐

Grid Reference: AMG ☐ Clark ☐ Zone: Scale:
Easting: Lattitude: Map Name:
Northing: Longitude: Map Number:

AWRC stream Basin Number: Major Geological Units Name:

Geophysical Log Run: Yes ☐ No ☐ Date: Depth: m

Gamma	SP	Caliper	Point Res.	Density	Camera	Other ( )
☐	☐	☐	☐	☐	☐	☐

Test Pump carried out: Yes ☐ No ☐

Date Registered: Bore Plotted on the map? Yes ☐ No ☐

Officer: Signature:

Remarks:

THE NORTHERN TERRITORY OF AUSTRALIA

Water Act

FINAL STATEMENT OF BORE

Name of Owner:	NT Government	**Registration No:**	**37043**
Name of Bore:	Florina 3/10		
Intended use:	Monitoring	Index Map No:	
Location:	Florina Station Portion No.1166	Permit No:	BCPK201

From	To (m)	
0	20.0	Sandy clays
20.0	36.9	Glauconitic Sandstone and claystone
36.9	67.5	Glauconitic Sandstone and cream limestone
67.5	88.0	Glauconitic sandstone with bands of shale
88.0	106.5	Brown/grey Limestone
106.5	159.8	Glauconitic sandstone with bands of shale
159.8	190.0	Brown/grey Limestone
190.0	194.7	Grey/pink limestone
194.7	230.0	Pink Oolloo limestone

Name of Contractor:	Water Resources
Name of Driller:	C Gallagher
Date Commenced:	5-Jun-10
Date Completed:	17-Jun-10
Depth Drilled:	230.0 m
Completion Depth:	230.0 m

METHOD OF DRILLING

Rotary	Rev. Cir	Cable	Other
☑	☐	☐	

HOLE DIAMETER			Drilling Fluid
From	To (m)	Dia (mm)	Type
0	5.6	330	Air
5.6	46.5	251	Polymer Mud
46.5	196.3	200	Air/Foam
196.3	230.0	149	Air/Foam

PARTICULARS OF CASING

From	To (m)	Dia (ID)	Type
0	5.6	258 mm	Steel
0	196.3	156 mm	Steel

PARTICULARS OF PERFORATIONS OR SCREEN STRINGS

From	To (m)	Dia (ID)	Aperture	Type

Casing Suspended: Yes ☐ No ☑

Method:

Height of Casing above GL: 258 mm ID Steel 0.3 m
156 mm ID Steel 0.8 m

Top of Packer set at:	N/A
Length of Packer:	N/A
Method of Packer Connection:	N/A

CEMENTING/GRAVEL PACKING

From	To (m)	Type
0	5.6	Cement
188	196.3	Cement

WATER BEARING BEDS

Depth (m) From	Depth (m) To	Yield L/s	SWL m	Duration hr	Quality	EC	ph	Bottle No.
46.5	55.5	10		Drilling	Good	384Us	5.69	1
94.5	103.0	15		Drilling	Good	638Us	7.15	2
150.0	174.0	15		Drilling	Good	640Us	7.5	2.1
190.0	193.0	15		Drilling	Good	620Us	8	3
210.0	230.0	20+	16.6	0.5	Good	658Us	5.4	6

Completion Yield: 20+ L/s Method: Air Duration: 0.5 hr

Completion SWL from GL: 16.6 m Depth of lift: 228.0 m

STRATA and WATER SAMPLES

Have been ☑ Will be ☐

Left at: Tannadice St Depot

LOCATION SKETCH OF BORE	LOCATION DESCRIPTION OF BORE		
	6.16		km
	E	SE ☐	
	W ☐	NE ☐	
	N ☐	SW ☐	
	S ☑	NW ☐	
	OF: Florina Station Homestead.		

FINAL CONSTRUCTION STATUS

Capped	Casing Pulled	Left for Obs.	Abandoned	Equipped	Backfilled	Other
☐	☐	☑	☐	☐	☐	☐

GPS DATUM:	AGD66	WGS84	GDA94	Other	Easting	Northing
	☐	☑	☐	☐	52L 0789175	8394342

ADDITIONAL INFORMATION AND INTEREST ABOUT THE BORE:
Left open hole from 196.3 m to 230 m . 156 mm ID Steel casing left with lockable cap. Drilled under supervision of W Cover.

Signature of Licensed Driller: Date:

FOR OFFICIAL USE ONLY

How Located:	GPS	TST	Survey	Hand Plotted	other
	☐	☐	☐	☐	☐

ELEVATION OF BORE AHD: (m) from: GL ☐ TOC ☐

DESCRIPTION OF PROPERTY:

Rural	Mineral	Pastoral	Reserve	VCL	SPL	EL	Other
☐	☐	☐	☐	☐	☐	☐	☐

Lease No: Lot No: Hundred of:
Portion No: Section No: Town of:

Class of Bore:	Town	Domestic	Investigation	Agriculture	Mineral	Pastoral	Other
	☐	☐	☐	☐	☐	☐	☐

Use of Bore:	Production	Investigation	Irrigation	Observation	Monitoring	Roads	None
	☐	☐	☐	☐	☐	☐	☐

Grid Reference: AMG ☐ Clark ☐ Zone: Scale:
Easting: Lattitude: Map Name:
Northing: Longitude: Map Number:

AWRC stream Basin Number: Major Geological Units Name:

Geophysical Log Run: Yes ☐ No ☐ Date: Depth: m

Gamma	SP	Caliper	Point Res.	Density	Camera	Other ( )
☐	☐	☐	☐	☐	☐	☐

Test Pump carried out: Yes ☐ No ☐

Date Registered: Bore Plotted on the map? Yes ☐ No ☐

Officer: Signature:

Remarks:

THE NORTHERN TERRITORY OF AUSTRALIA

Water Act

FINAL STATEMENT OF BORE

Name of Owner:	NT Government	**Registration No:**	**37044**
Name of Bore:	Florina 4/10		
Intended use:	Monitoring	Index Map No:	
Location:	Florina Station Portion No.1166	Permit No:	BCPK201

From	To (m)	
0	1.5	Top soil and laterite
1.5	4.2	Multi coloured layered clay
4.2	5.4	Loose course sand and gravel
5.4	6.8	White and brown weathered sandstone
6.8	13.5	Weathered sandstone and clay
13.5	15	Limestone and clay
15	25.56	Grey limestone
25.56	60	Tan and grey limestone
60	79	Pink and brown limestone
79	97	Pink tan and grey limestone
97	131	Brown limestone
131	215.16	Grey green and brown banded limestone

Name of Contractor: Water Resources
Name of Driller: C Gallagher
Date Commenced: 6-Jul-10
Date Completed: 10-Jul-10
Depth Drilled: 215.16 m
Completion Depth: 215.16 m

METHOD OF DRILLING

Rotary	Rev. Cir	Cable	Other
☑	☐	☐	

HOLE DIAMETER			Drilling Fluid
From	To (m)	Dia (mm)	Type
0	5.6	251	Air
5.6	49.56	200	Polymer Mud
49.56	215.16	150	Air/Foam

PARTICULARS OF CASING

From	To (m)	Dia (ID)	Type
0	5.6	203 mm	Steel
0	49.56	156 mm	Steel

PARTICULARS OF PERFORATIONS OR SCREEN STRINGS

From	To (m)	Dia (ID)	Aperture	Type
49.56	215.16	150 mm	open hole	

Casing Suspended: Yes ☐ No ☑
Method:
Height of Casing above GL: 0.55 m - 156 mm ID steel

Top of Packer set at: N/A
Length of Packer: N/A
Method of Packer Connection: N/A

CEMENTING/GRAVEL PACKING

From	To (m)	Type
0	5.6	Cement

WATER BEARING BEDS

Depth (m) From	Depth (m) To	Yield L/s	SWL m	Duration hr	Quality	EC	ph	Bottle No.
109	115	0.2				570	8.2	
162	166	0.5				700	8.5	
172	181	1				620	8.2	
205	211	2				635	8.2	

STRATA and WATER SAMPLES
Have been ☑ Will be ☐
Left at: Tannadice St Depot

Completion Yield: 2 L/s Method: Air Duration: 10 mins
Completion SWL from GL: 66.5 m Depth of lift: 215 m

LOCATION SKETCH OF BORE

LOCATION DESCRIPTION OF BORE

		12.2	km
E		SE ☐	
W ☐		NE ☐	
N ☑		SW ☐	
S ☐		NW ☐	

OF:
Florina Station Gate

FINAL CONSTRUCTION STATUS

Capped	Casing Pulled	Left for Obs.	Abandoned	Equipped	Backfilled	Other
☑	☐	☑	☐	☐	☐	☐

GPS DATUM:	AGD66	WGS84	GDA94	Other	Easting	Northing
	☐	☑	☐	☐	52L 812352	8402770

ADDITIONAL INFORMATION AND INTEREST ABOUT THE BORE:
Left open hole from bottom of 156 mm ID steel casing. 156 mm ID Steel casing left with lockable cap. Drilled under supervision of Peter Rees. Note: total depth 211.16 m (backfilled).

Signature of Licensed Driller: Date:

FOR OFFICIAL USE ONLY

How Located:	GPS	TST	Survey	Hand Plotted	other
	☐	☐	☐	☐	☐

ELEVATION OF BORE AHD: (m) from: GL ☐ TOC ☐

DESCRIPTION OF PROPERTY:

Rural	Mineral	Pastoral	Reserve	VCL	SPL	EL	Other
☐	☐	☐	☐	☐	☐	☐	☐

Lease No: Lot No: Hundred of:
Portion No: Section No: Town of:

Class of Bore:	Town	Domestic	Investigation	Agriculture	Mineral	Pastoral	Other
	☐	☐	☐	☐	☐	☐	☐

Use of Bore:	Production	Investigation	Irrigation	Observation	Monitoring	Roads	None
	☐	☐	☐	☐	☐	☐	☐

Grid Reference: AMG ☐ Clark ☐ Zone: Scale:
Easting: Lattitude: Map Name:
Northing: Longitude: Map Number:

AWRC stream Basin Number: Major Geological Units Name:

Geophysical Log Run: Yes ☑ No ☐ Date: 12/07/2010 Depth: 212 m

Gamma	SP	Caliper	Point Res.	Density	Camera	Other ( )
☑	☐	☑	☐	☐	☐	☐

Test Pump carried out: Yes ☐ No ☑

Date Registered: Bore Plotted on the map? Yes ☐ No ☐

Officer: Signature:

Remarks:

APPENDIX 3

Cuttings descriptions

Steven Tickell

Return to Contents

RN37041

From	To	Rock Type	Description
0	0.5		Soil, sandy, light yellow brown, loose, ironstone nodules to 1cm
0.5	12		Sand, clayey, orange brown, soft, fine to medium grained, sub-rounded grains
12	18		Sandstone, orange brown, firm, medium to fine grained, sub-rounded
18	30		Clay, sandy, soft, light orange brown with minor pink sand brown mottles, fine to medium grained
30	51		Clay, light olive brown, soft to firm, slightly sandy(fine), 24 to 27m abundant fine sand, trace glauconite below 45m
51	54		Clay, pale green, soft
54	57		Sandstone, clayey and clean sections, soft, light green brown, fine grained, trace glauconite; and shale, light green, hard to firm
57	63		Shale, light green, soft, at 60m trace reaction to HCl, trace glauconitic sandstone as above
63	69		Sandstone, light green, glauconitic, fine grained, hard, minor green shale laminae
69	72		Shale, pale green, soft to firmand glauconitic sandstone, fine grained, very calcareous, almost a calcarenite
72	81		Sandstone, bluish gray, glauconitic, hard, fine grained, , trace react to HCl at 78 - 81m; minor shale, bluish gray, firm to hard
81	87		Shale, bluish gray, moderately hard; trace glauconitic sandstone, fine grained
87	105		Limestone, gray, medium to finely crystalline, hard, weak react to HCl;and shale, blue gray and pale green, less shale with depth; trace sandstone
105	108		Limestone, gray, fine to medium crystalline, trace glauconite
108	129		Limestone, dark gray and gray, fine, hard, trace glauconite, minor shale as per 87 to 105m, glauconitic sandstone abundant at 117-120m and 123-128m
129	163		Sandstone, dark gray, glauconitic, fine grained, minor medium, hard, minor primary porosity; minor shale, pale green, firm; minor limestone, dark gray and light gray

RN37042

From	To	Rock Type	Description
0	9		Clay, silty, greyish orange (10YR7/4), soft,slightly micaceous; 0 - 3m, minor ironstone(matrix supported, ferruginised sandstone) nodules to 5mm
9	12		Clay, silty, greyish orange (10YR7/4), soft, slightly micaceous(highly weathered shale); trace sandstone laminations, very fine grained, glauconitic(5%)
12	18		Shale, pale olive(10Y6/2), firm; minor sandstone(very weathered) laminations, greyish orange, very fine to fine grained, slightly micaceous, glauconitic(5%)
18	42		Sandstone, greyish orange(10YR7/4), firm, fine to medium grained, quartz subangular clear with some grains lightly iron-stained, glauconitic(5%) sub-rounded to rounded grains, trace mica, fine grained sandstone tends to have clayey matrix but medium grained sandstone is porous, calcareous @ 39-42m and 45-48m; minor shale laminae, firm, pale olive(10Y6/2)"
42	45		Shale, pale olive(10Y6/2), firm, some layers micaceous; minor sandstone ,greyish orange(10YR7/4), very fine to fine grained, slightly micaceous, glauconitic(5%)

RN37042 ctd.

From	To	Rock Type	Description
45	54		Sandstone, greyish orange(10YR7/4), firm, fine to medium grained, quartz subangular clear with some grains lightly iron-stained, glauconitic(2%) sub-rounded to rounded grains, trace mica, porous in places; minor shale (up to 30%), firm, pale olive(10Y6/2), some shale laminae in sandstone"
54	63		Sandstone, greyish orange(10YR7/4), firm, fine to medium grained, quartz subangular clear with some grains lightly iron-stained, glauconitic(2%) sub-rounded to rounded grains, trace mica, porous in places; minor shale (up to 10%), firm, pale olive(10Y6/2), some shale laminae in sandstone"
63	66		Sandstone, greyish orange(10YR7/4), firm, fine to medium grained, quartz subangular clear with some grains lightly iron-stained, glauconitic(2%) sub-rounded to rounded grains, trace mica, porous in places; minor shale (up to 30%), firm, pale olive(10Y6/2), some shale laminae in sandstone"
66	69		Limestone, yellowish gray(5Y7/2), finely crystalline, trace manganese dendrites on joints, hard; minor sandstone as above
69	81		Limestone, medium gray(N5) and light olive gray(5Y6/1), fine to medium crystalline(minor coarse), hard, rare trace of glauconite; minor shale as above and trace of highly micaceous shale(interbedded with limestone); minor sandstone as above
81	87		Limestone, medium gray(N5), fine to medium crystalline, hard, some with 2% fine glauconite; shale, medium gray(N5), firm; minor sandstone, fine, glauconitic
87	90		Limestone, medium gray(N5), fine to medium crystalline, hard, some with 2% fine glauconite; minor sandstone, fine grained, glauconitic(5%), medium gray(N5); 50% of chips are the same lithology but pale red(5R6/2 and 10R6/2), in some sandstone the carbonate grains are moderate red(5R5/4), some chips are both gray and red with irregular boundaries between the colours"
90	93		Limestone, as above and limestone, coarsely crystalline, moderate red(5R4/6)(Oolloo Dolostone)
93	105		Limestone, coarse to very coarsely crystalline, pale red(10R6/2) and moderate red(5R4/6), hard, some euhedral calcite rhombs(cavity fill), rare sandstone, glauconitic, pale red, 102-105m white finely granular calcite in optical continuity(cavity fill)
105	114		Limestone, as above and shale, brownish gray(5YR4/1) and light olive gray(5Y6/1), firm, slightly calcareous
114	129		Limestone, pale red(10R6/2) and minor moderate red(5R4/6), coarsely crystalline, hard; trace shale as above

RN37043

From	To	Rock Type	Description
0	1		Sand, pale yellowish brown (10 YR 6/2), unconsolidated, fine grained, minor medium, sub-rounded grains
1	3		Sand, light brown (5 YR 6/4), unconsolidated, fine grained, minor medium, ironstone nodules to 5mm (medium sub-rounded to rounded sand in ferruginious matrix, matrix supported)
3	6		Sand, slightly clayey, unconsolidated, fine to medium grained, light brown with white specks (5 YR 6/4), minor white kaolinitic clay
6	15		Sand, clayey,moderate reddish brown with minor white mottling (10 R 4/6), soft
15	18		Clay, sandy, light brown with minor white, yellow and gray mottling(5 YR 5/6), plastic, sand medium grained
18	21		Clay, sandy, light brown with minor white, brown, yellow and gray mottling(5 YR 5/6), plastic, sand medium grained
21	24		Silt, clayey, moderate reddish orange with minor white and yellow mottling(10 R 6/6),soft, slightly sandy, fine
24	27		Silt, clayey, moderate reddish orange(10 R 6/6),soft, slightly sandy, fine
27	30		Clay, moderate reddish orange and dusky yellow(10 R 6/6, 5 Y 6/4); and clayey sand with a trace of glauconite
30	33		no sample
33	36		Clay, moderate reddish orange and dusky yellow(10 R 6/6, 5 Y 6/4), soft, with a trace of glauconite sandstone(5%), very fine, firm to hard, calcareous
36	39		Clay, yellowish gray(5 Y 7/2),soft, glauconitic sandstone, calcareous, very fine grained, quartz with 5% glauconite
39	48		Sandstone, yellowish gray(5 Y 7/2),calcareous, very fine, sub-angular quartz, glauconitic(5%), sub-rounded, dark green grains, non-porous clay matrix; minor limestone(calcarenite)(10%), light brown gray, medium crystalline with very fine glauconite and up to 5% quartz
48	60		Sandstone, yellowish gray(5 Y 7/2),calcareous, very fine, sub-angular quartz, glauconitic(5%), sub-rounded, dark green grains, non-porous clay matrix, rare sandstone chips with shaley laminae; minor siltstone(30%), light gray, shaly, micaceous
60	63		Sandstone, as above and up to 30% limestone as per 39-48m
63	66		Sandstone, as per 48-60m, one chip with a sandstone limestone contact
66	75		Sandstone, as per 39-48m but limestone up to 20%
75	78		Sandstone, as per 48-60m, medium light gray(N6)
78	81		Sandstone, as per 39-48m, medium light gray(N6) and minor shale, gray, firm
81	87		Shale, medium light gray(N6),firm to hard; minor sandstone(40%),calcareous, very fine, glauconitic, medium light gray, some sandstone chips have shale laminae
87	90		Limestone, yellowish gray with minor medium light gray and light brownish gray(5 Y 7/2), fine to medium crystalline, hard, some shale laminae, pale green gray
90	102		Limestone, as above and trace gray shale and siltstone white
102	105		Limestone, as per 87-90m and trace sandstone, very fine, gray, glauconitic, calcareous

RN37043 ctd.

From	To	Rock Type	Description
105	114		Sandstone, medium light gray(N6) fine ,glauconitic, micaceous and calcareous, some with fine pyrite and limestone as per 87-90m, some slightly glauconitic, some shale laminae, pronounced iron staining along bedding planes, and shale, medium light gray(N6)
114	117		Limestone, medium light gray(N6),hard, finely crystalline,minor medium crystalline limestone, some with medium grained glauconite; and minor shale, medium light gray(N6), firm to hard; and minor sandstone, very fine grained, calcareous, hard to firm
117	123		Sandstone, medium light gray(N6) and pale yellowish brown(10 YR 5/6), fine to medium grained, quartz, the medium grained sandstones have some intergranular porosity, glauconitic(to 30%), calcareous and minor limestone, medium light gray(N6), finely crystalline, glauconitic
123	126		Sandstone, medium light gray(N6) and pale yellowish brown(10 YR 5/6), fine to medium grained quartz, the medium grained sandstones have some intergranular porosity, glauconitic(to 30%), calcareous; and minor shale medium light gray(N6), firm,
126	150		Sandstone, medium light gray(N6), fine to medium grained quartz, quartz mostly clear 10% lightly iron stained, sub-angular, glauconitic(to 10%), glauconite sub-rounded to rounded, calcareous, firm, some intergranular porosity present in the medium grained sections;
150	156		Sandstone, sandstone as above; and limestone, medium to coarsely crystalline, medium light gray(N6),glauconitic(5%), sub-rounded, medium grained, some limestone may be veins cutting the sandstone but most probably thinly interbedded with sandstone.
156	162		Sandstone, yellowish gray with minor medium gray(5 Y 7/2),fine grained, quartz mostly clear 10% lightly iron stained, sub-angular, glauconite(5%), sub-rounded, some intergranular porosity; trace limestone, medium crystalline, glauconitic(2%)
162	165		Limestone, yellowish gray(5 Y 7/2),finely crystalline, hard; minor calcarenite, very fine grained, quartz 20%, micaceous; trace sandstone, very fine grained, glauconitic; trace pyrite, fine grained aggregates
165	174		Limestone, yellowish gray(5 Y 7/2),medium to coarsely crystalline, minor ironstaining on fractures hard, rare chips have 1% fine glauconite grains; minor calcarenite, very fine grained, quartz 20%, micaceous; trace sandstone, very fine grained, glauconitic
174	177		Limestone, medium light gray(N6) and minor(40%) yellowish gray(5 Y 7/2),medium to coarsely crystalline, minor fine, minor ironstaining on fractures, hard, rare chips have 1% fine glauconite grains; minor calcarenite, very fine grained, quartz 20%, micaceous; trace sanstone
177	180		Limestone, yellowish gray(5 Y 7/2),medium to coarsely crystalline, minor fine, hard, 10% of limestone has up to 5% fine glauconite grains,rare pyrite; and sandstone(30%), very fine grained, glauconitic, yellowish gray(5 Y 7/2),with abundant shale laminae,micaceous
180	189		Limestone, medium light gray(N6),medium to coarsely crystalline, minor fine, hard, 50% of chips have up to 5% fine glauconite grains; and sandstone(10%), very fine grained, glauconitic, medium light gray(N6),with minor shale laminae,micaceous;183-186m ironstaining on fractures

RN37043 ctd.

From	To	Rock Type	Description
189	192		Limestone, as above; 50% is pale red(5 R 6/2), a few chips contain both gray and red areas with irregular boundaries, in one instance the red colour follows a fracture in the gray fine grained glauconitic limestone
192	195		Limestone, calcarenite, grayish red(5 R 4/2),up to 20% glauconite, up to 10% quartz, hard, fine grained; and limestone, very coarsely crystalline, grayish red and minor pale red(5 R 4/2 and 10 R 6/2), abundant vughs with linings of calcite rhombs
195	210		Limestone, grayish red and minor pale red(5 R 4/2 and 10 R 6/2), very coarsely crystalline, hard; at 198-201m siltstone, white, chalky, calcerous, firm
210	231		Limestone, pale red(10 R 6/2) tending to pale yellowish brown(10 YR 6/2) with depth, medium to coarsely crystalline, hard; minor limestone, grayish red(5 R 4/2), very coarsely crystalline as above becoming rarer with depth

RN37044

From	To	Rock Type	Description
0	3		Sandstone, clayey, firm, pale yellowish brown(10YR7/2),grayish orange(10YR7/4) and moderate brown(5YR4/4)
3	6		Clay, firm, grayish orange(10YR7/4) and very pale orange(10YR8/2), minor sandstone, white, fine, slightly clayey
6	12		Sandstone, grayish orange(10YR7.5/3), unconsolidated to hard, fine
12	18		Clay, sandy, soft,dark yellowish orange(10YR6.5/5), fine at top coarse at base
18	21		Limestone, dark yellowish orange(10YR6/6) & pale olive(10Y6/2), finely crystalline, hard, react to HCl
21	36		Limestone, yellowish gray(5Y6/2), hard, finely crystalline, react to HCl
36	60		Limestone, yellowish gray(5Y6/2) & pale red(10R6/2), hard, finely crystalline, react to HCl
60	99		Limestone, pale red(10R6/2),hard, finely crystalline, react to HCl, some with up to 10% fine quartz(calcarenite)
99	117		Limestone, pale red(10R6/2 & 5R6/2)) & minor pale olive(10Y6/2),hard, finely crystalline, react to HCl, some with up to 10% fine quartz(calcarenite)
117	126		Limestone, pale red(5R6/2), hard, finely crystalline & silty limestone, fine, light brownish gray(5YR6/1), some with up to 10% fine quartz(calcarenite)
126	147		Siltstone, grayish red(5R4/2), hard, calcerous and slightly micaceous and limestone, medium gray(N5), fine, hard
147	162		Limestone, silty, medium light gray(N6), calcerous and slightly micaceous, hard
162	177		Siltstone, grayish red(5R4/2), hard, calcerous, micaceous, some sandy and limestone, medium light gray(N6), hard, fine and sandstone, grayish red and white, calcareous, fine
177	201		Siltstone, grayish red(5R4/2), hard, calcerous, micaceous, some sandy and limestone, medium light gray(N5), hard, fine(calcarenite), trace sandstone, calcareous
201	215.1		Siltstone, grayish red(5R4/2), hard, calcerous, micaceous and limestone, medium gray(N5), hard, fine