Northern Territory Government

DEPARTMENT OF LAND RESOURCE MANAGEMENT

May 2013

Katherine Tindall Limestone Aquifer

Oolloo Aquifer

WAP Measurements

Report 06/2013D
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May 2013

Bibliographic Reference
Wagenaar, D (May 2013), Katherine Tindall Limestone and Oolloo Aquifer WAP Measurements Northern Territory Government Department of Land Resource Management,
Technical Report No. 06/2013D

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Cover photo: Flow measurements in the Katharine River. Hayden Lowe \ Andy Mortimer

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1. Introduction

Water Allocation Plans (WAP's) were developed for the Tindall Limestone Aquifer (Katherine) and Oolloo Aquifer to ensure that water allocation and the management thereof is done in a sustainable manner to preserve this scarce resource for future generations. Monitoring programs were developed for each of the WAP's to ensure that all monitoring performed is done in line with Department Strategies, Water Allocation Plans and Water Resource Assessment requirements.

The Tindall Limestone Aquifer (Katherine) and Oolloo Aquifer WAP's monitoring programs are based on detailed monitoring objectives, frameworks and data requirements for each of the monitoring sites within the respective areas. The monitoring framework primarily consists of the following two categories.

- monitoring of stage and discharge for the development of stage discharge relationships. This information is used to perform flow calculations and statistical analysis of catchment characteristics.
- snap shot of water levels and discharge in the catchment at the end of the wet and dry seasons. This information is used to assist with the calibration of hydrological model.

The Katherine Daly WAP Measurements report summarises the measurements performed during the "snap shot" measurement exercise. The information collected during the measurement exercise is mainly used to assist with the calibration of the hydrological model used for the prediction of water levels and flows in the Tindall Limestone Aquifer (Katherine) and Oolloo aquifer areas.

The snap shot measurements are performed after the wet season or last flood event and at the end of the dry or before the first rainfall event, which are normally during the months of June and October respectively. The time frame of snap shot measurements are not fixed and can vary annually based on the weather conditions. The indicators that the user must take into account to determine the time for snap shot measurements can be categorised under the following points.

- measurement of water levels and flow at the end of the wet when the hydrograph recession leg approaches base flow and there are no further indication of rainfall in the catchment.
- measurement of water levels and flow at the end of dry before the first rains to ensure that measurements encompasses only base flow.

The hydrological information collected during the "snap shot" measurements is also used to compare current flow conditions against previous year runoff, which gives an approximation of what the flows would be by the end of the season.

2. Monitoring Objectives

The monitoring objectives of Tindall Limestone Aquifer (Katherine) and Oolloo Aquifer WAP's are documented in the monitoring programs under *Monitoring Objectives* as shown

in the Surface Water and Groundwater monitoring frameworks in *Diagram 1.0* and *Diagram 1.1* respectively. The monitoring objectives for the snap shot measurements are based on surface water and groundwater monitoring requirements as documented in Table 2.1.

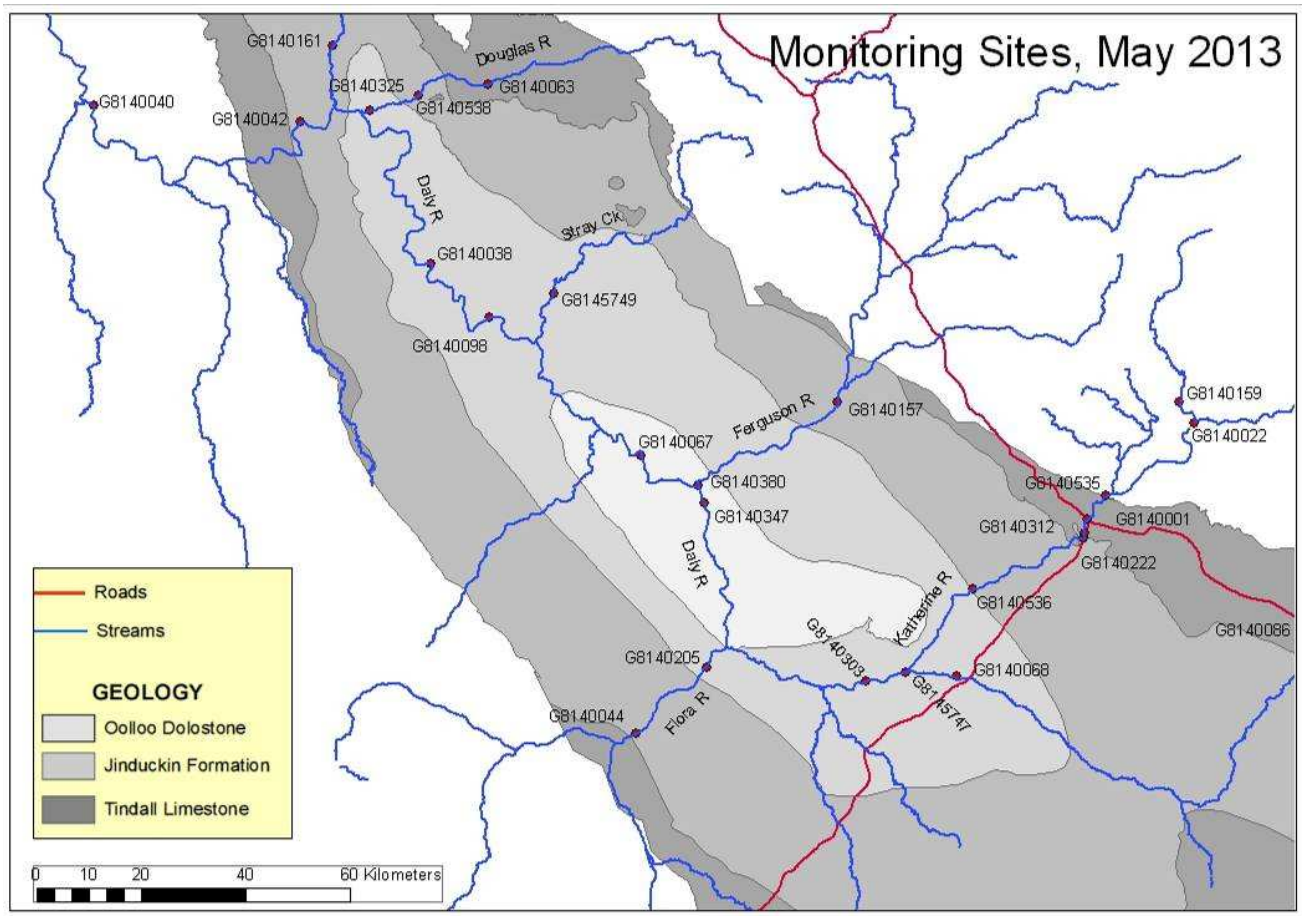
Table 2.1

Measurement	Surface Water	Groundwater
Water Level	Gauge Board \ Survey	Dip Tape
Discharge	Flow Measurement	Flow Measurement at Springs
Water Quality	Field parameters (EC, temp, pH and DO), Major Ions, Nutrients and Metals.	Field parameters (EC, temp, pH and DO), Major Ions, Nutrients and Metals.

The monitoring requirements for the snap shot measurements at each monitoring site are detailed in the *Monitoring Requirements* of Tindall Limestone Aquifer (Katherine) and Oolloo aquifer WAP's monitoring programs.

3. Monitoring Sites

The location of monitoring sites in relation to known features and monitoring sites are shown on Map 3.1.



Map 3.1: *Monitoring Sites, May 2013*

4. Field Measurements

4.1 Water Levels

4.1.1 Factors influencing accuracy

The main factors that have an influence on the accuracy of water level measurements at surface water and groundwater monitoring sites summarised in Table 4.1.

Table 4.1

Type	Conditions	Influences	Description
Surface Water	Hydraulic	Wave action	Waves created during high flows, wind and or turbulence at gauge plates
		Instrument Location	Point of measurement is a significant distance from gauge plates, especially during high flows.
		River Bend (outside)	Water level higher at the outside of the bend.
		River Bend (inside)	Water level lower at the inside of the bend.
		Velocity	High velocities creates turbulence, etc.
		Turbulence	Eddies \ turbulence created at gauge boards. Create difficulty in reading due to fluctuations in water level.
		Back Flow	Back flow creates difficulties in reading gauge plates
	Site	Sediment	Sediment deposition at gauge plates. Gauge plates can be buried under sediment.
		Debris	Debris that is collected at gauge plates. Difficult to take readings without maintenance work
	Gauge Plates	Unstable gauge posts	Gauge posts that are unstable create inaccuracies in the gauge plate heights.
		Unreadable gauge plates	Gauge plates that are in a bad condition is difficult to read and create inaccuracies in the readings
		Gauge Plate Numbers	Missing numbers create confusion and can create mistakes of up to 1m in gauge plate readings.
		Surveys	In correct surveys and adjustments on gauge plates causes error in gauge plate readings.
Ground water	Production Boreholes	Size of Well	Insufficient space to perform water level measurements with existing equipment
		Pumping	Pumping operations influences the water level measurements
	Casing Collar	Unstable casing	Unstable casing causes errors in the water level measurement
	Level Indicators	Equipment condition	Instruments with faded increments can cause errors in measurements.
		Increments	Course increments on tape measure will lead to different interpolation of values

4.1.2 Measurement Results

The water level measurements results obtained during the “snap shot” measurement exercise are summarised in **Appendix A**. There were no water level measurements taken at groundwater monitoring sites during this “snap shot” measurement exercise.

4.1.3 Measurement Accuracy

The water level measurements taken during the “snap shot” measurement exercise are within the required standards, however there are some water level measurements that were affected by site conditions as summarised in **Appendix A**.

The impact of the site conditions on the accuracy is difficult to quantify at this stage as no additional reference data was collected during the water level measurements. The single readings will have to be evaluated in conjunction with time series record and historical water level reference readings to determine if the measurements were affected.

4.2 *Discharge*

4.2.1 Factors influencing accuracy

The factors influencing the accuracy of the discharge measurements can be categorised under environmental and system influences. System influences are created by the type of instrumentation used and can be minimised if standards are followed. Environmental influences have a much greater impact as this is result of site conditions and actions by operator and for this reason will be discussed in further detail. Environmental factors that have an influence on the accuracy are the following:

- **W**: Wind: The wind causes the water level to osculate which has a large effect on the flow if the wind direction is parallel with the flow direction.

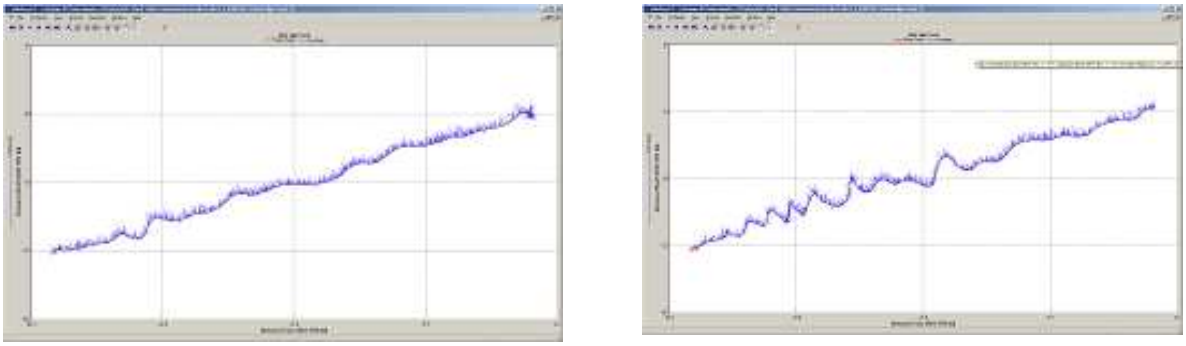


Image 4.6 *Wind effect on tagline*

- **LP**: Large pools: Reduce velocity drastically
- **WG**: Water grass: Influences the flow measurements, very high inaccuracies with depth and velocity measurements.
- **A**: Algae growth: Algae that floats in the water influence the signal strength of the ADCP.

The Hydraulic (**H**) requirements of a monitoring section are essential for accurate discharge measurements. The monitoring site needs to comply with the following hydraulic requirements during the gauging section selection process:

- Uniform cross section
- Flow in the stream should be confined to a single well-defined channel with stable banks.
- Bends upstream of site must be avoided if possible
- Steep slopes upstream should be avoided if possible.
- Avoid deep pools that can influence the flow
- Avoid prominent obstructions in a pool or excessive plant growth that can affect the flow pattern.
- Turbulence \ eddies must be avoided if possible.
- Negative \ back flow must be avoided at all times.

The abbreviations for the various factors as indicated in the above information (highlighted in bold) is shown in the gauging result tables indicating the various influences encountered at each site.

4.2.2 Measurement Results

The discharge measurement results obtained during the “snap shot” measurement exercise are summarised in **Appendix B**. Monitoring sites are listed from the most upstream monitoring site in the catchment to the lowest monitoring site in the catchment with increasing in flow.

4.2.3 Measurement Accuracy

The discharge measurements performed during the “snap shot” measurement exercise comply with all the requirements as stipulated in the Department standards. A quality matrix is completed for each measurement for the purposes of assigning a quality code to the measurements. The measurements performed in the Katherine and Daly River catchments complies with the continuity principle and are consistent with increase in flow as you move towards the lower catchment.

There are some cases where major discrepancies exist between measured flow and latest rating curve values in Hydstra. This is described to the following aspects that have an influence on the relationship between measured flow and current rating curve.

- unstable low flow stage discharge relationship
- the control is not dominant feature and is affected by changes down stream
- the low flow stage discharge relationship not sufficiently developed.

Monitoring sites that does not have a stage discharge relationship in Hydstra are flagged with a 9999.99 code.

4.3 Water Quality

4.3.1 Factors influencing accuracy

- Instrument \ Sensor calibration.
- Compliance of water sampling procedure.
- The measurement location should be as close as practical to the mid-point of the stream.
- The sensors should be as close to the surface as possible.
- Turbulence (waves, eddies) at the surface should be avoided; the measurement point should be moved away from these areas as physical-chemical parameters will be affected.
- Standing water at the edges of streams should be avoided, as these are not representative of the stream.
- Deep pools with very low flow should be sampled as close as possible to the centre of the main pool.

4.3.2 Measurement Results

The water quality measurement results obtained during the “snap shot” measurement exercise are summarised in **Appendix C**.

4.3.3 Measurement Accuracy

The water quality measurements performed during the “snap shot” exercise comply with all the requirements as stipulated in the Department standards. Hydrolab instruments were calibrated before and after the “snap shot” measurement exercise to ensure that instrumentation complied with the required accuracy during measurements. The water quality data collected during the measurements were adjusted based on the pre and post calibration results for sensor drift.

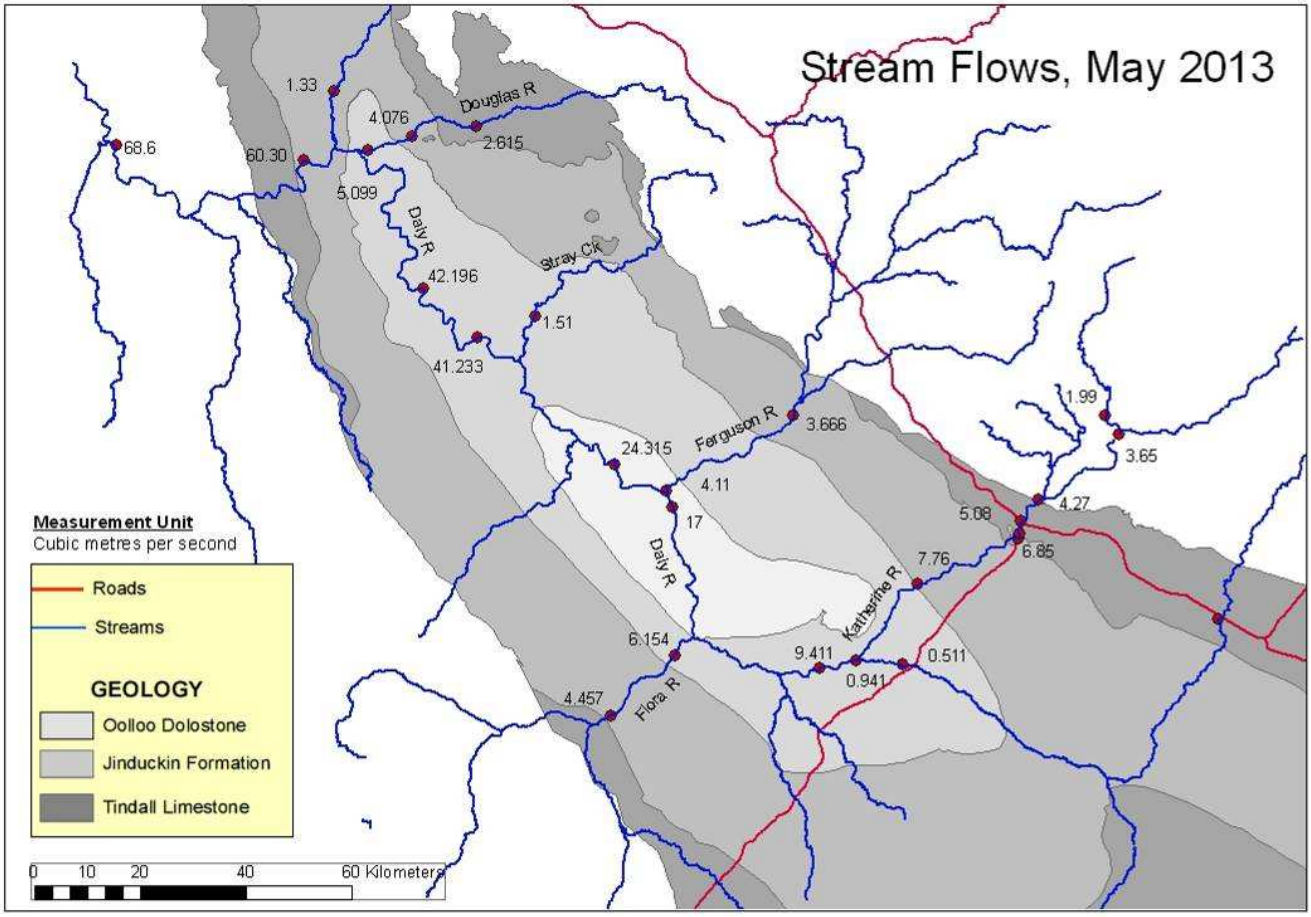
It is recommended that the Turbidity results obtained from the Hydrolab instrument is ignored based on the reliability of the Turbidity sensors.

5. Reporting

The “snap shot” measurement exercise for the Tindall Limestone Aquifer (Katherine) and Oolloo Aquifer WAP’s monitoring programs were performed from the 20 May 2013 to 31 May 2013. The period of the “snap shot” measurements were approximately two weeks earlier than recommended in the water monitoring programs due to the threat of further rainfall in the catchment necessitated an earlier response. During the field measurements groundwater recharge was noticed at various locations on the river banks throughout the catchment.

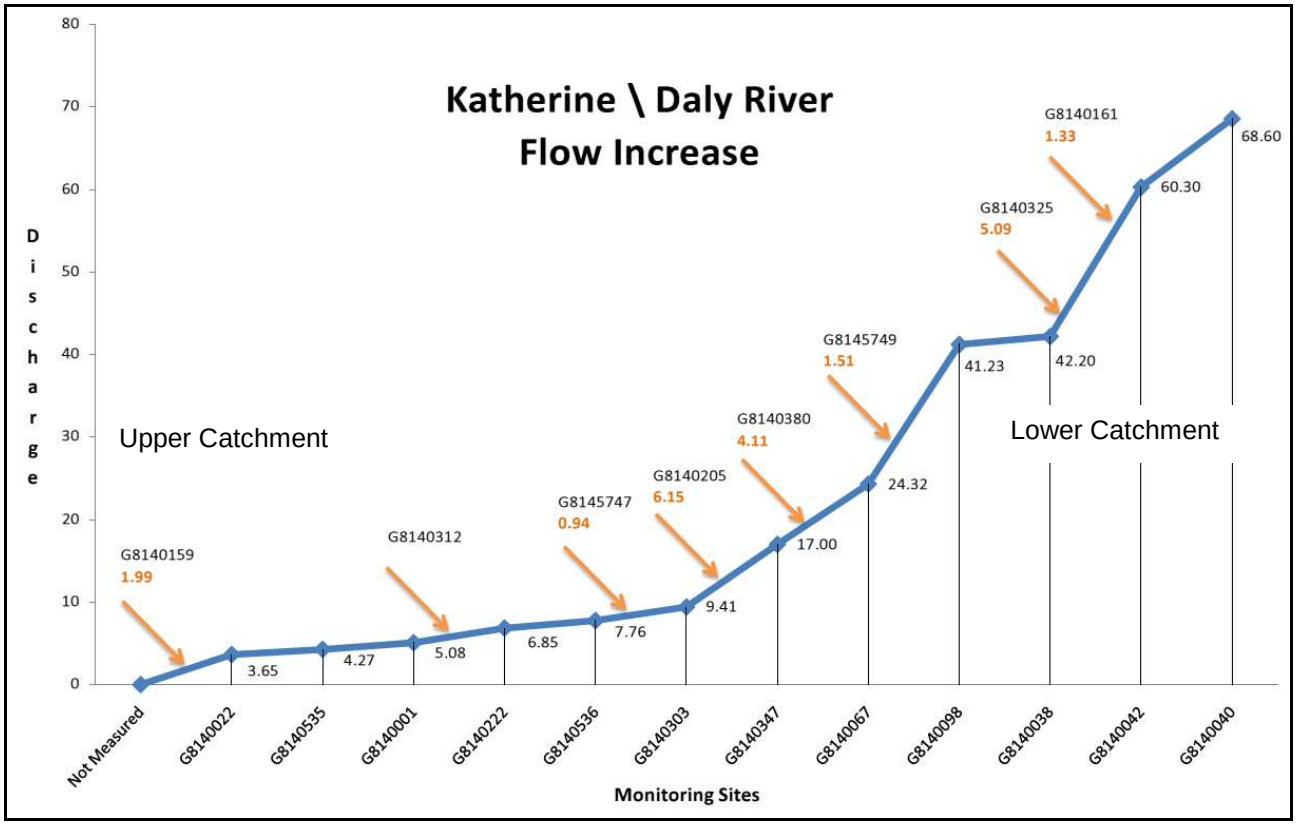
The interpretation of the data in this section is based on visual evaluation of the results and therefore must be used within that context. Performing a desktop study to determine hydrological characteristics of the catchment is not within the scope of this report.

The discharge data collected during the “snap shot” measurement exercise is spatially represented on Map 5.1, illustrating the increase in flows as we move from the upper catchment downstream to the lower catchment.



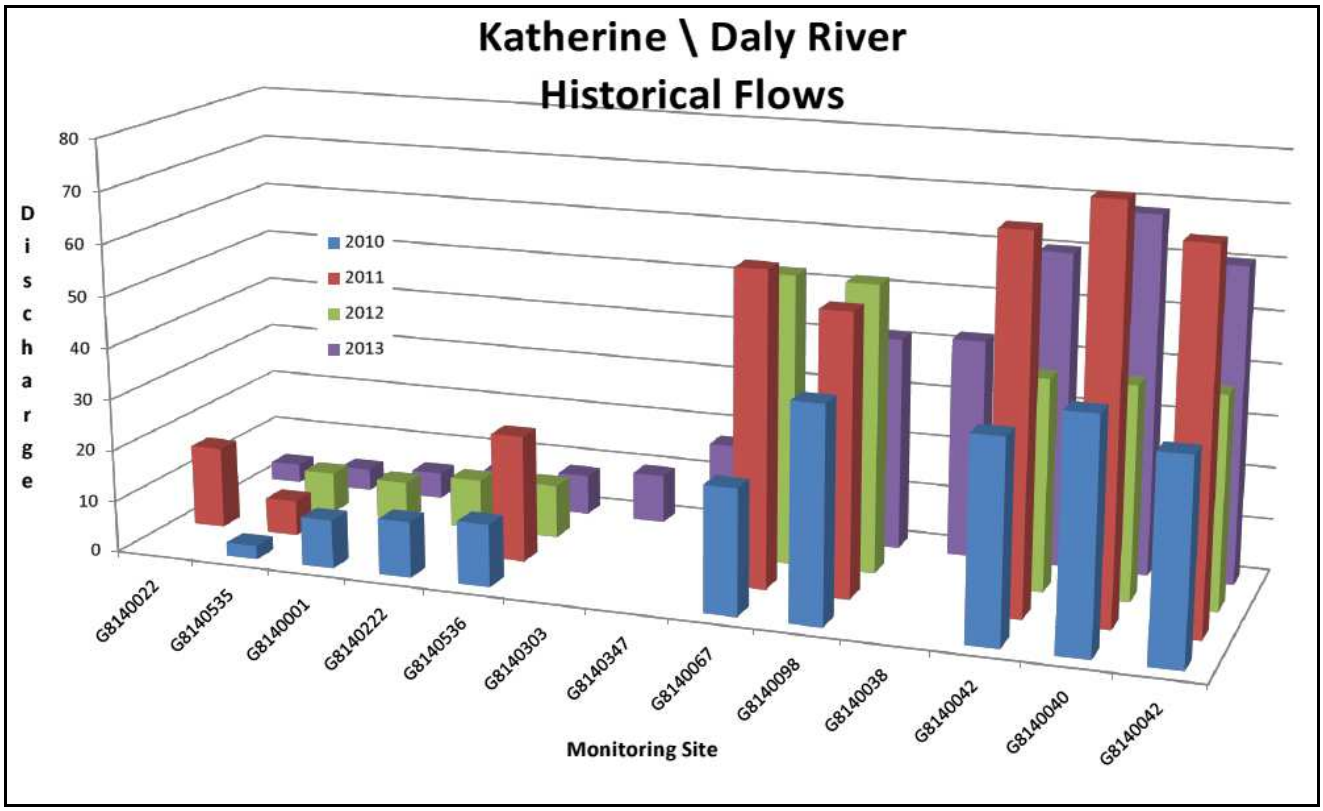
Map 5.1: *Stream Flows, May 2013*

The discharge measurements are further illustrated in Graph 5.1 showing the increase in discharge from the upper to lower catchment in the Katherine and Daly River systems. The tributaries to the main river reach are also indicated on the graph, showing the flow contribution from each tributary.



Graph 5.1 Increasing Flows

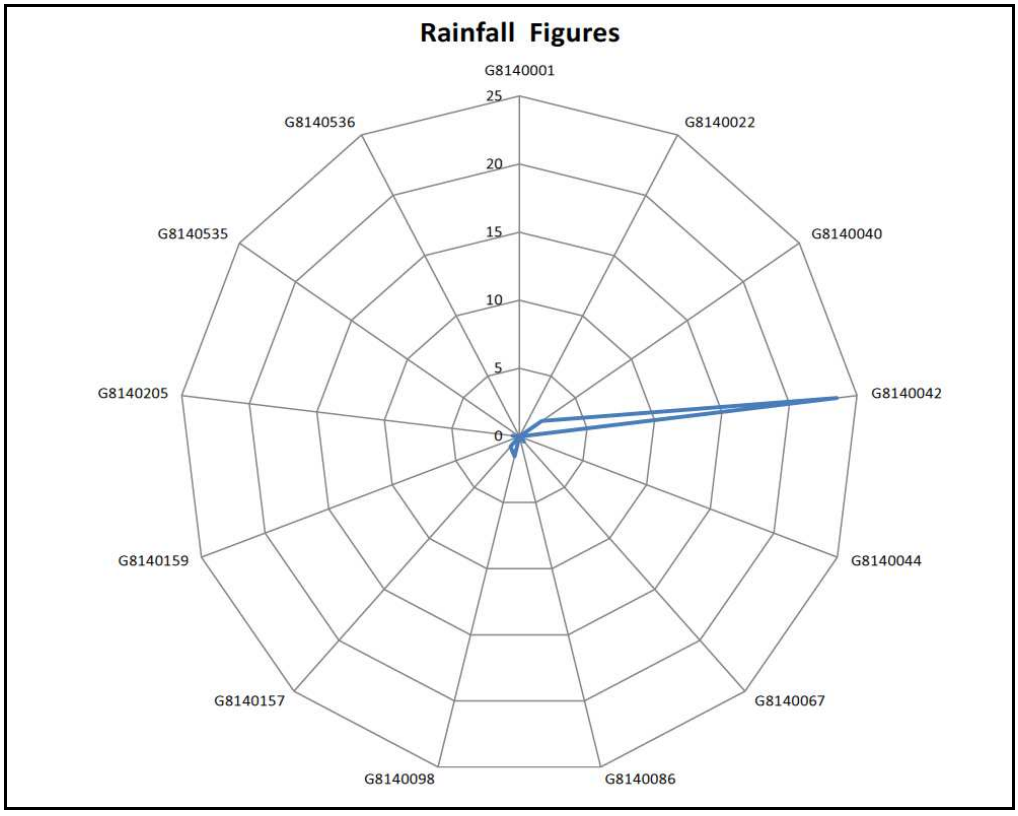
Discharge measurements during the past four years from 2010 until 2013 that were performed during the months of May, June and July in the main river reach are graphically displayed in Graph 5.2. The discharge data supplied indicates that there is variability in discharge measurements at each monitoring site.



Graph 5.2 Historical Flows

This can be attributed to annual variations in runoff due to changes in weather patterns and the actual date that measurements were undertaken. Snap shot measurements varied by up to 6 weeks between the years selected. The variation in time of measurement is not a crucial aspect in the evaluation of the field measurements, however if the measurements are performed in the same period it could be used as indicator to changes in catchment runoff.

The “snap shot” measurement exercise was not impacted by additional runoff due to rainfall in the catchment. The total rainfall figures from 7 April to 1 June 2013 at each of the monitoring sites are given in Graph 5.3. The only significant rainfall that occurred during the measurement exercise was at G8140042, which consisted of four rainfall events of 3, 10, 2.5 and 8mm respectively.



Graph 5.3 Rainfall Figures during Measurements

6. Conclusion

The measurements performed during the “snap shot” measurement exercise from the 20 May 2013 to 31 May 2013.for the Tindall Limestone Aquifer (Katherine) and Oolloo Aquifer WAP’s monitoring programs comply with Department guidelines and standards.

The synchronisation of “snap shot” measurements after the wet season would assist with comparing previous year’s data sets to give some indication if changes in annual runoff have occurred. It is identified that the time of measurement is only an indicator and that the final dates is dependent on catchment runoff, weather conditions and available resources.

Appendix A

Site Number	Site Name	Date	Time	Level	Site Influences
G8140001	Katherine River at Railway Bridge	29/05/2013	1607	0.358	Possible gauge board reading error. Board is leaning on angle.
G8140022	Katherine River at Nitmiluk Centre	28/05/2013	0950	-1.416	Good gauge board reading
G8140038	Daly River at Oolloo Road Crossing	28/05/2013	1554	25.836	Water level surveyed
G8140040	Daly River at Mount Nancar	22/05/2013	1019	2.637	
G8140042	Daly River at 2km downstream of Beeboom Crossing	21/05/2013	0913	1.391	
G8140044	Flora River Upstream of Kathleen Falls	22/05/2013	1252	0.885	
G8140063	Douglas River Downstream Old Douglas Homestead	27/05/2013	1353	0.93	Gauge board reading u/s weir
G8140067	Daly River at upstream Dorisvale Crossing	20/05/2013	1546	2.195	Gauge board measured with tape measuring device
G8140068	King River D/S Victoria Highway	21/05/2013	1424	0.658	Gauge board reading
G8140086	King River D/S Stuart Highway				Gauge board reading
G8140098	Daly River @ Theyona Station	29/05/2013	1028	1.625	
G8140157	Fergusson River upstream of Bondi Creek	24/05/2013	1100	2.98	Water level taken from telemetry data as station was inaccessible
G8140159	Seventeen Mile Creek at Waterfall View	28/05/2013	1455	0.806	Good gauge board reading
G8140161	Green Ant Creek at Tipperary	20/05/2013	1355	0.777	
G8140205	Flora River @ Upstream Stoney Creek	23/05/2013	1125	1.595	
G8140222	Katherine River @ Low Level Bridge	31/05/2013	1318	0.367	Good gauge board reading
G8140303	Katherine River at D/S King River	21/05/2013	1109	0.000	No gauge board
G8140312	Katherine Hot Springs				
G8140325	Douglas River at Tipperary Crossing	30/05/2013	0945	2.263	Gauge board reading
G8140347	Daly River at Florina Homestead Crossing	30/05/2013	1531	0.000	No gauge board
G8140380	Fergusson River at Confluence Daly River	30/05/2013	1330	0.000	No gauge board
G8140535	Katherine River @ Ironwood Station	27/05/2013	1553	1.518	Good gauge board reading
G8140536	Katherine River @ Wilden Station	30/05/2013	1003	1.228	Good gauge board reading
G8140538	Douglas River @ Tippera Waterhole	30/05/2013	1345	2.228	Good gauge board reading
G8145747	King River 50 meters US from	21/05/2013	1017	0.000	No gauge board
G8145749	Stray Creek @ Fleming Road Crossing	28/05/2013	0952	2.689	Water level surveyed

Note: No water level measurements were performed at groundwater monitoring sites

Appendix B

The descriptions of “Site Influence” indicators are documented in Section 4.2.1.

Site Number	Site Name	River System	Flow m^3/s	Date	Gauging Instrument	Site Influences	Rating Deviation%	Comment
G8140159	Seventeen Mile Creek at Waterfall View	Tributary	1.99	28/05/2013	StreamPro	**H**	7.85	Large rocks/boulders u/s and d/s of gauging location
G8140022	Katherine River at Nitmiluk Centre	Main Reach	3.65	28/05/2013	StreamPro	**H**	-9.39	
G8140535	Katherine River @ Ironwood Station	Main Reach	4.27	27/05/2013	StreamPro		4.23	
G8140001	Katherine River at Railway Bridge	Main Reach	5.08	29/05/2013	StreamPro		-6.89	
G8140312	Katherine Hot Springs	Tributary						
G8140222	Katherine River @ Low Level Bridge	Main Reach	6.85	31/05/2013	StreamPro		9999.99	
G8140536	Katherine River @ Wilden Station	Main Reach	7.76	30/05/2013	StreamPro		-1.27	
G8140086	King River D/S Stuart Highway	Tributary	None					
G8140068	King River D/S Victoria Highway	Tributary	0.511	21/05/2013	StreamPro	**H**	-56.18	Inconsistent depths and velocities
G8145747	King River 50 meters US from Katherine River	Tributary	0.941	21/05/2013	StreamPro	**WG**	9999.99	
G8140303	Katherine River at D/S King River	Main Reach	9.411	21/05/2013	StreamPro		9999.99	
G8140044	Flora River Upstream of Kathleen Fall	Tributary	4.457	22/05/2013	Monitor 1200	**W**	-37.12	Wind, very low velocities
G8140205	Flora River @ Upstream Stoney Creek	Tributary	6.154	23/05/2013	StreamPro		2.17	
G8140347	Daly River at Florina Homestead Crossing	Main Reach	17.00	30/05/2013	StreamPro	**H**	9999.99	Large trees downstream of section obstructing parts of the channel flow. Deep gauging section but was the best in the area.
G8140157	Fergusson River upstream of Bondi Creek	Tributary	3.666	24/05/2013	StreamPro	**H**	-4.55	Poor gauging. Gauged 3 channels, flow from Bondi creek subtracted from total
G8140380	Fergusson River at Confluence Daly River	Tributary	4.11	30/05/2013	StreamPro		9999.99	
G8140067	Daly River at upstream Dorisvale Crossing	Main Reach	24.315	20/05/2013	Monitor 1200		-3.00	

Site Number	Site Name	River System	Flow m^3/s	Date	Gauging Instrument	Site Influences	Rating Deviation%	Comment
G8145749	Stray Creek @ Fleming Road Crossing	Tributary	1.510	28/05/2013	Flow Tracker		9999.99	
G8140098	Daly River @ Theyona Station	Main Reach	41.233	29/05/2013	StreamPro		18.18	
G8140038	Daly River at Oolloo Road Crossing	Main Reach	42.196	28/05/2013	StreamPro		-69.43	
G8140063	Douglas River Downstream Old Douglas Homestead	Tributary	2.615	27/05/2013	StreamPro		1.82	
G8140538	Douglas River @ Tipperary Waterhole	Tributary	4.076	30/05/2013	StreamPro		-10.91	
G8140325	Douglas River at Tipperary Crossing	Tributary	5.099	30/05/2013	StreamPro		20.76	
G8140161	Green Ant Creek at Tipperary	Tributary	1.33	20/05/2013	StreamPro		3.37	
G8140042	Daly River at 2km downstream of Beeboom Crossing	Main Reach	60.30	21/05/2013	StreamPro		-17.16	
G8140040	Daly River at Mount Nancar	Main Reach	68.60	22/05/2013	StreamPro		-14.56	

Appendix C

The Turbidity measurements from the Hydrolab must be ignored based on the reliability of the sensors.

Site Number	Site Name	Date	Time	Temp	pH	D.O.	DO	E.C.	General Chemistry	Heavy Isotope
				(˚C)		(mg/L)	% sat	(µS/cm)	Sample (500mL)	Sample (50mL)
G8140001	Katherine River at Railway Bridge	29/05/2013	16:34	27.83	6.26	7.76	99	227	Not taken	Not taken
G8140022	Katherine River at Nitmiluk Centre	28/05/2013	10:17	24.56	5.75	9.14	110	43	Not taken	Not taken
G8140038	Daly River at Oolloo Road Crossing	28/05/2013	16:00	27.65	7.76	8.52	108	589	Not taken	Not taken
G8140040	Daly River at Mount Nancar	22/05/2013	08:39	29.93	7.83	6.33	84	542	Not taken	Not taken
G8140042	Daly River at 2km downstream of Beeboom Crossing	21/05/2023	10:35	29.65	7.80	7.12	94	555	Not taken	Not taken
G8140044	Flora River Upstream of Kathleen Falls	22/05/2013	14:06	31.99	6.96	6.35	87	814	Not taken	Not taken
G8140063	Douglas River Downstream Old Douglas Homestead	27/05/2013	15:00	26.17	7.08	7.71	95	327	Not taken	Not taken
G8140067	Daly River at upstream Dorisvale Crossing	20/05/2013	15:38	29.73	7.86	8.41	111	503	Not taken	Not taken
G8140068	King River D/S Victoria Highway	21/05/2013	14:54	27.96	7.20	7.44	95	74	Not taken	Not taken
G8140086	King River D/S Stuart Highway								Not taken	Not taken
G8140098	Daly River @ Theyona Station	29/05/2013	14:10	27.91	7.53	7.56	97	559	Not taken	Not taken
G8140157	Fergusson River upstream of Bondi Creek	24/05/2013	12:00	27.26	7.57	8.46	107	675	Not taken	Not taken
G8140159	Seventeen Mile Creek at Waterfall View	28/05/2013	15:18	25.93	5.62	8.98	111	34	Not taken	Not taken
G8140161	Green Ant Creek at Tipperary	20/05/2013	14:30	27.36	7.78	6.77	86	497	Not taken	Not taken
G8140205	Flora River @ Upstream Stoney Creek	23/05/2013	11:15	29.34	7.71	8.00	105	677	Not taken	Not taken
G8140222	Katherine River @ Low Level Bridge	31/05/2013	13:40	27.60	6.26	7.49	95	370	Not taken	Not taken
G8140303	Katherine River at D/S King River	21/05/2013	11:36	28.74	7.69	8.42	109	368	Not taken	Not taken
G8140312	Katherine Hot Springs								Not taken	Not taken
G8140325	Douglas River at Tipperary Crossing	30/05/2013	10:45	26.35	7.76	7.80	97	459	Not taken	Not taken
G8140347	Daly River at Florina Homestead Crossing	30/05/2013	15:50	26.78	7.73	8.63	108	613	Not taken	Not taken
G8140380	Fergusson River at Confluence Daly River	30/05/2013	14:00	26.41	7.00	8.61	107	480	Not taken	Not taken
G8140535	Katherine River @ Ironwood Station	27/05/2013	16:20	27.24	5.87	8.88	112	60	Not taken	Not taken
G8140536	Katherine River @ Wilden Station	30/05/2013	09:04	25.95	6.63	7.55	93	447	Not taken	Not taken
G8140538	Douglas River @ Tippera Waterhole	30/05/2013	14:27	27.45	7.36	6.74	85	467	Not taken	Not taken
G8145747	King River 50 meters US from	21/05/2013	10:36	27.94	7.68	8.82	113	339	Not taken	Not taken
G8145749	Stray Creek @ Fleming Road Crossing	28/05/2013	10:10	23.65	8.03	9.32	110	502	Not taken	Not taken