DEPARTMENT OF LAND RESOURCE MANAGEMENT

End of Wet Season Stream Flow Measurements, Roper River, May 2014

Report .08/2014D

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June 2014

Bibliographic Reference
Waugh, P (June 2014), End of wet season stream flow measurements, Roper River, May 2014,
Northern Territory Government Department of Land Resource Management, Technical Report No. 08/2014D

ISBN	1-74350-063-7	978-1-74350-063-7	End of wet season stream flow measurements, Roper River, May 2014

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Cover photo: Roper River downstream Mataranka Homestead (G9030176).

Table of Contents

Summary

Stream flow and water quality measurements were conducted in late May to establish early dry season baseflow conditions in the Roper River. Post wet season runoff, all flows within the Roper River discharge from the Mataranka Tindall Limestone Aquifer. Consistent with previous measurements, stream flow steadily increased as the river passes through the aquifer, with a maximum recorded flow of 7.9m^3/s on the eastern boundary. Continuing downstream, a gradual reduction in flows is observed with 4.8m^3/s measured at Red Rock, approximately 170km downstream from the aquifer boundary.

May 2014 flow measurements continue a trend of decreasing early dry season flows observed since 2011. Measured flows were below the long-term average (1967 – 2014) for the first time since 1997.

Significant variation in measured water quality parameters is representative of two distinct regional groundwater flow regimes that exist within the aquifer. A third localised flow regime also contributes its distinct water quality signature to overall riverine chemical balances. Measured parameters are generally more neutral than those collected during the October 2013 snapshot measurements, indicating dilution through aquifer recharge over the wet season and a reduced residence period within the aquifer prior to discharge. Biological as well as physical processes in the river also affect its chemistry. Overall chemical balances indicate a healthy, chemically balanced river system.

Aim

Early dry season snapshot measurements were taken on the Roper River to establish water quality and quantity conditions at commencement of baseflow conditions..
The snapshot measurements are used to:

1. Refine and calibrate the hydrological model used to assess resource availability and allocations.
2. Better define aquifer recharge/discharge zones along the river, and
3. Provide a dataset of comparable flow and water quality measurements at identical periods in the annual water cycle.

Introduction

Rising in the Mataranka area of the Northern Territory, the Roper River flows eastwards for 250 kilometres before discharging into the Gulf of Carpentaria. This study looks at the early dry season flow profile of the river with specific focus on the headwaters of the river where it passes over the carbonate rocks of the Palaeozoic aged Daly Basin. The basal formation of the basin - the Tindall Limestone - forms a regional scale fractured and karstic aquifer. The Roper River is one of several main discharge sites for the aquifer. Groundwater discharges into the river as it cuts through the unconfined aquifer and maintains stream flow throughout the dry season.

A draft Water Allocation Plan (WAP) has been developed for the Tindall Limestone (Mataranka) aquifer to ensure water allocation and management is undertaken in a sustainable manner, to ensure equitable use of increasingly scarce water resources into the future. A monitoring program developed for the WAP ensures that models used to predict the impact of future water use are developed and calibrated appropriately, providing transparency and confidence in water licensing decisions. Monitoring data is critical for accurate assessment of the plan objectives. . The monitoring framework primarily consists of the following two categories.

- continuous 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.
- snapshot monitoring of water levels and discharge at the end of the wet season when the hydrograph recession approaches base flow and the end of the dry season targeting annual minimum flow, normally May and October respectively . This information is used to calibrate the hydrological model and indicate what 'natural' end of dry season flow conditions could be.

Observations

Measurements were carried out from the 26th to 29th May 2014 as recommended in the 2014/15 WAP monitoring program. Parameters collected include surface water level, stream flow, in-situ water quality parameters and water samples for analysis of additional parameters. Measurements were conducted at nine monitoring points along the upper reaches of the Roper River and tributaries where the river intersects the Tindall Limestone aquifer, with two additional sites further downstream beyond the aquifer extent (Figure 1). Scheduled monitoring requirements are summarised in Appendix A under monitoring objectives and field measurement standards. Field measurement standards are used to quantify the influences of measuring techniques and site conditions on the accuracy of datasets collected.

Monitoring Sites

Selection of monitoring sites is focussed on locations of major recharge from the aquifer to the Roper River. Currently only two of the snapshot measurement sites, G9030176 and G9030250, correlate with the broader NT hydrographic network collecting continuous river level and corresponding flow data.

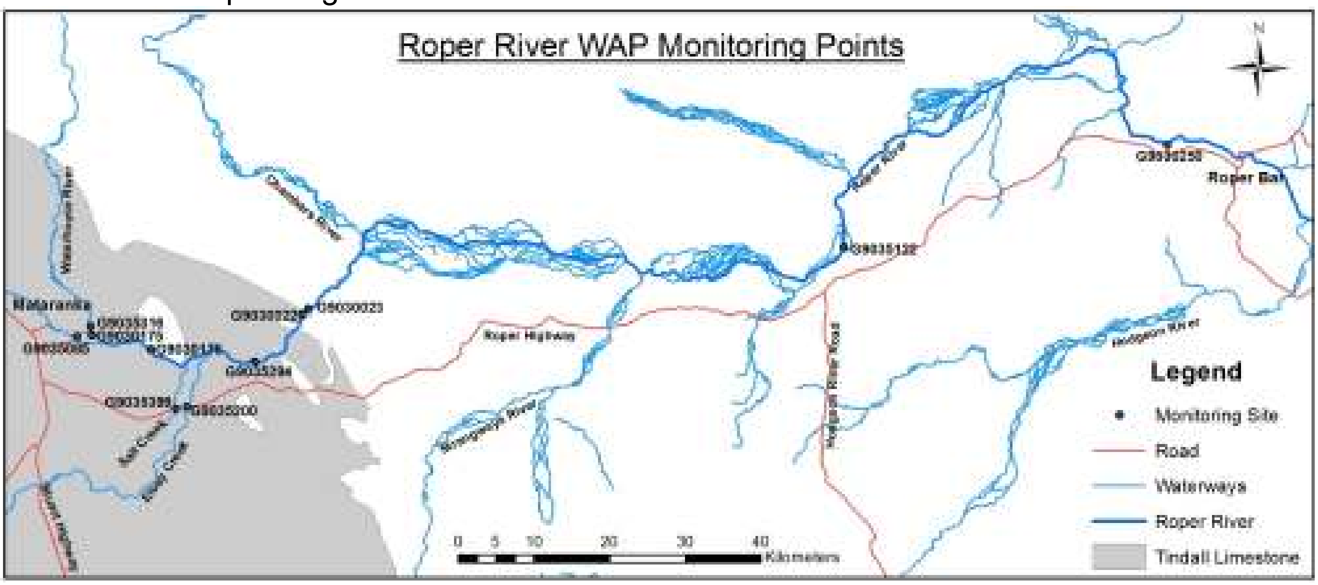

Figure 1: *Monitoring Sites, May 2014*

G9035085 – Little Roper River at Homestead Road Bridge
Located on the Little Roper River approximately 4km downstream of Bitter Springs, and 3.9km upstream of the confluence with the Waterhouse River, where the Roper River commences. Dry season flow is entirely comprised of groundwater discharge from the Tindall aquifer, predominantly Bitter Springs.

G9030175 – Mataranka Homestead at Hot Springs
Located at the Mataranka Hot Springs immediately upstream of the Waterhouse River confluence. The thermal springs discharge a relatively constant rate from the aquifer year round and are a significant point source contributor to overall flows in the Roper River.

G9035316 – Waterhouse River Upstream of Thermal Springs
Located on the Waterhouse River approximately 1km upstream from the Thermal Springs.

G9030176 – Roper River Downstream of Mataranka Homestead
Located approximately 9km downstream from the Mataranka Homestead. G9030176 is part of the broader NT Hydrographic Network collecting real time stream level and flow data since 1961. This site is rated with continuous stream level and flow data collected.

G9030399 – Salt Creek at Roper Highway
Salt Creek is a minor tributary draining a localised area of groundwater fed wetland, along John Hauser Drive.

G9035200 – Elsey Creek at Roper Highway
Elsey Creek is the major tributary that receives significant groundwater discharge upstream of the Roper Hwy.

G9030013 – Roper River at Elsey Homestead
Located 2km downstream of the community of Jilkminggan incorporating flows from Salt Creek and Elsey Creek.

G9030022 – Roper River at WAP site 17
Located upstream of Red Lily Lagoon immediately prior to the end of the Eastern edge of the Tindall Limestone aquifer.

G9030023 – Roper River at WAP site 18
Located upstream of Red Lily Lagoon but downstream of the Eastern edge of the Tindall Limestone aquifer; identified as the location of maximum baseflow on the Roper River.

G9035122 – Roper River at Jude's Crossing
Located approximately 93km downstream of site G9030023.

G9030250 – Roper River at Red Rock
Located approximately 170km downstream of site G9030023, it is part of the broader NT Hydrographic Network collecting real time stream level and flow data since 1961. This site is rated with continuous stream level and flow data collected.

Water Levels

Where available, surface water levels have been recorded to facilitate the creation of stage discharge relationships (ratings). See Appendix B.

Stream Flows

Stream flow measurements were performed using Acoustic Doppler Current Profiler (ADCP) technology or conventional fan gauging instruments, with instrument selection at each site being dependent on water quality and/or hydraulic conditions. Discharge measurements are shown in Figure 2. The flow measurement results are tabled in **Appendix C**.
Stream flow measurements are performed within required standards and quality assurance protocols, taking into account site and hydraulic conditions present. The process is further quantified by applying a quality matrix to each individual measurement.

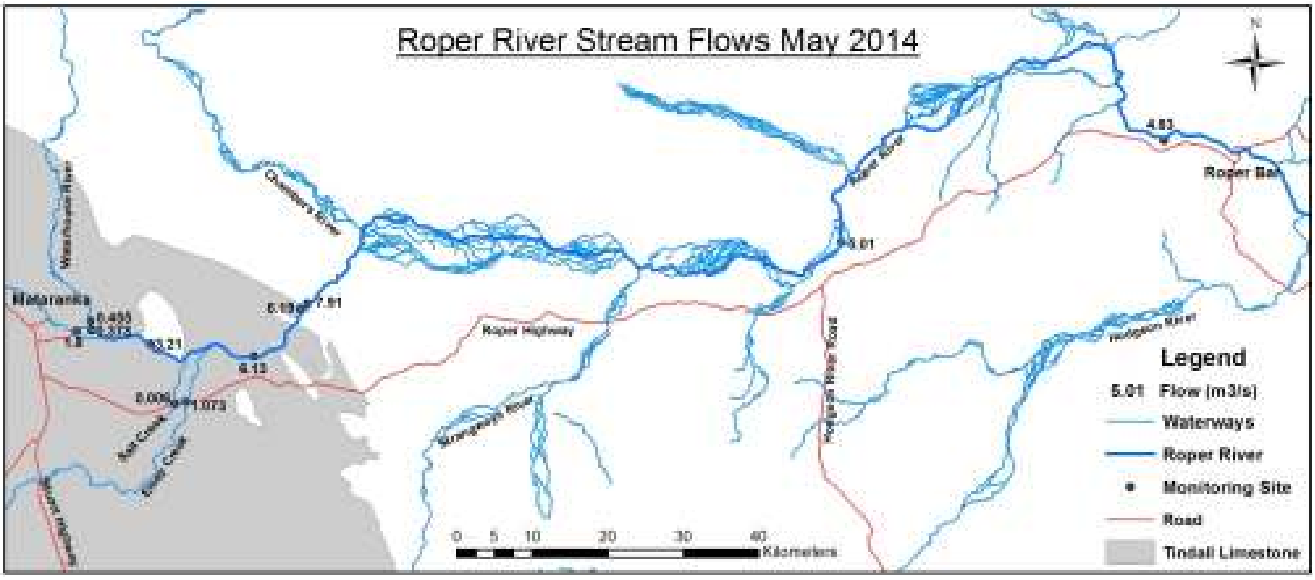

Figure 2: *Stream Flows, May 2014*

All gaugings undertaken were of good or excellent quality with the exception of site G9030250 which was downgraded to 'satisfactory' due to significant aquatic weed growth across the gauging section. The measured discharge of $4.8m^3/s$ deviates from the current rating by 6%.

The gauging conducted at G9030176 was of good quality, however the discharge of $3.2m^3/s$ deviates from the rating by 14%. This measurement follows a series of gaugings since 2008 that sit just below the rating curve, and suggest a review and possible adjustment to the rating may be required.

Water Quality

Water quality monitoring involved taking in-situ measurements with a Hydrolab Quanta multi-parameter sonde and collection of water samples see Table 1.1.

Table 1.1

Hydrolab Quanta	Water Samples
• Electrical Conductivity (EC) • pH • Dissolved Oxygen (DO) • Temperature	• Turbidity • General Parameters • Total Nutrients • Filtered Nutrients

Water quality measurements were performed to the required standards and quality assurance protocol, taking into account site conditions. Probes were calibrated prior to and after the snapshot measurement exercise and results adjusted for sensor drift. In-situ field results are presented in Appendix D.

Nutrients.

Nutrients occur naturally in rivers, but can also originate from human activities such as fertilizer application, storm runoff from pastoral and agricultural land, and wastewater.

Water samples were collected for analysis of soluble (nitrite (NO2), nitrate (NO3), filterable reactive phosphorus(FRP)) and total nutrients (total nitrogen (TN), total phosphorus (TN)), Soluble nutrient samples were filtered through a 0.45 µm filter in the field. All samples were refrigerated immediately after collection and frozen prior to sending to the laboratory. Samples were analysed according to APHA standard methods. The results are presented in Appendix E.

Rainfall

Telemetry rainfall data was collected from monitoring sites in the catchment over the same period as the snapshot exercise to identify if local runoff affected any field measurements.

Discussion

Commencing in October 2013, the snapshot measurement program represents the first series of programmed, time-specific measurements taken in the Roper catchment. The May 2014 snapshot measurements are the first undertaken specifically at the commencement of the dry season. With the WAP snapshot program still in its infancy, little data exists to adequately compare past early dry season measurements. Ongoing snapshot measurement programs conducted at the same time of year will complement the current assessment of resource availability and provide essential information to support future management objectives.

Rainfall

Rainfall recorded in the Roper River region in the weeks prior to and during the snapshot measurements was insufficient to cause a rise in river levels therefore measurements conducted as part of the snapshot program are considered to represent baseflow only.

Rainfall totals recorded for the 2013/14 wet season (December – May) were slightly below average when compared to the long term rainfall records for each site. It is noted that the length of rainfall records vary from 3-years for G9030514 to 45-years for R8140021. As such, average wet season rainfall is observational only as no statistically relevant trend can be derived from the length of record at most sites.

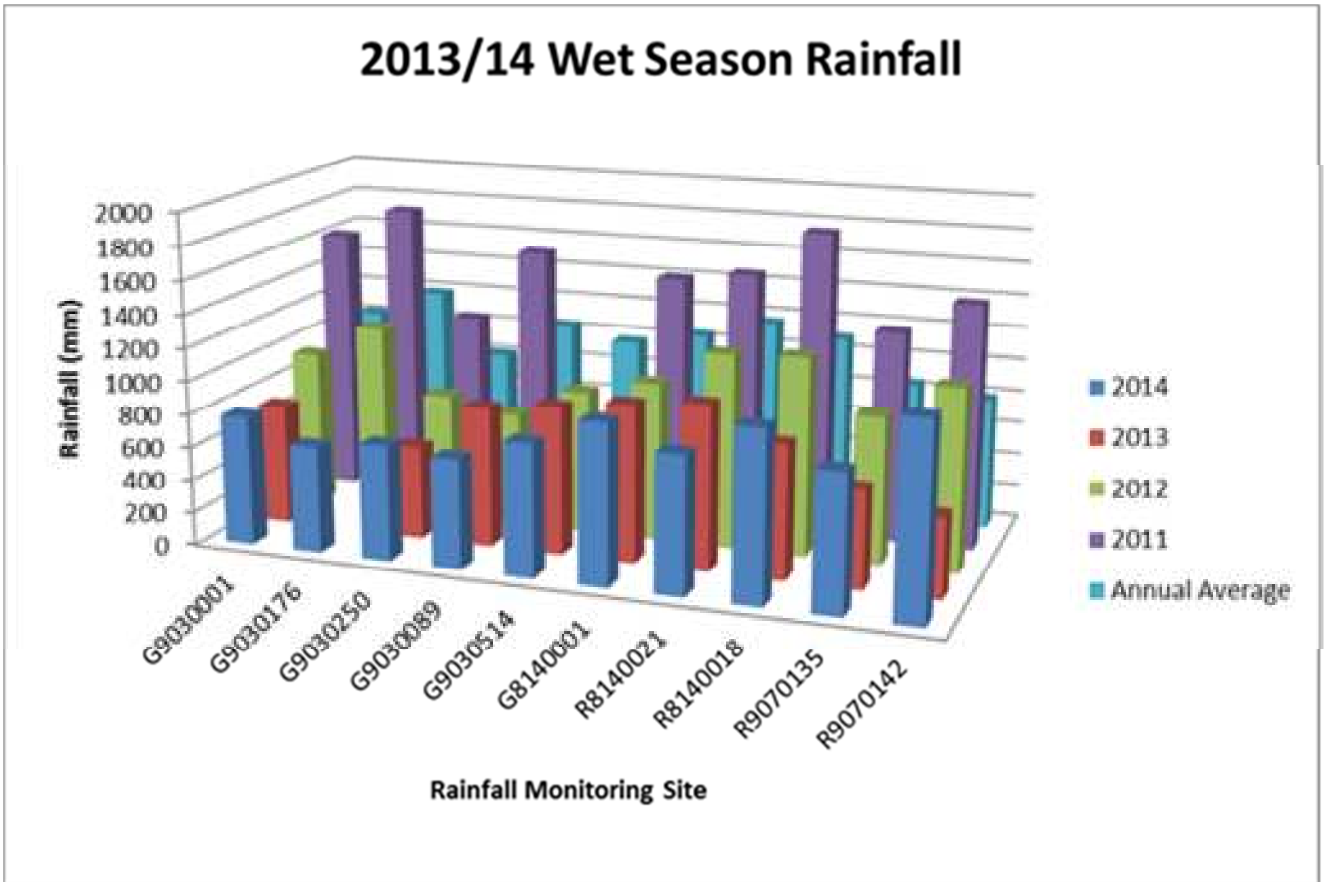

Figure 4 *Total Wet Season Rainfall (December – May)*

Figure 4 shows wet season rainfall (December – May) over the past 4-years. The set of columns at the rear of the graph show the average wet season rainfall recorded at each site for the duration of its record. We can observe that rainfall totals have been in general decline over the region since 2011, when recorded totals were about 50% above average for the region. The lowest rainfalls were recorded over the 2012/13 wet season, with 2013/14 rainfall tracking back towards average.

Stream Flows

Figure 6 shows the flow profile for the Roper River. A consistent increase in stream flow is apparent up to monitoring point G9030023 - the site located immediately downstream of the Tindall Limestone Aquifer boundary. From this point, stream flows gradually decrease through the remaining reaches of the river, indicating no further significant inflows from groundwater or tributary sources.

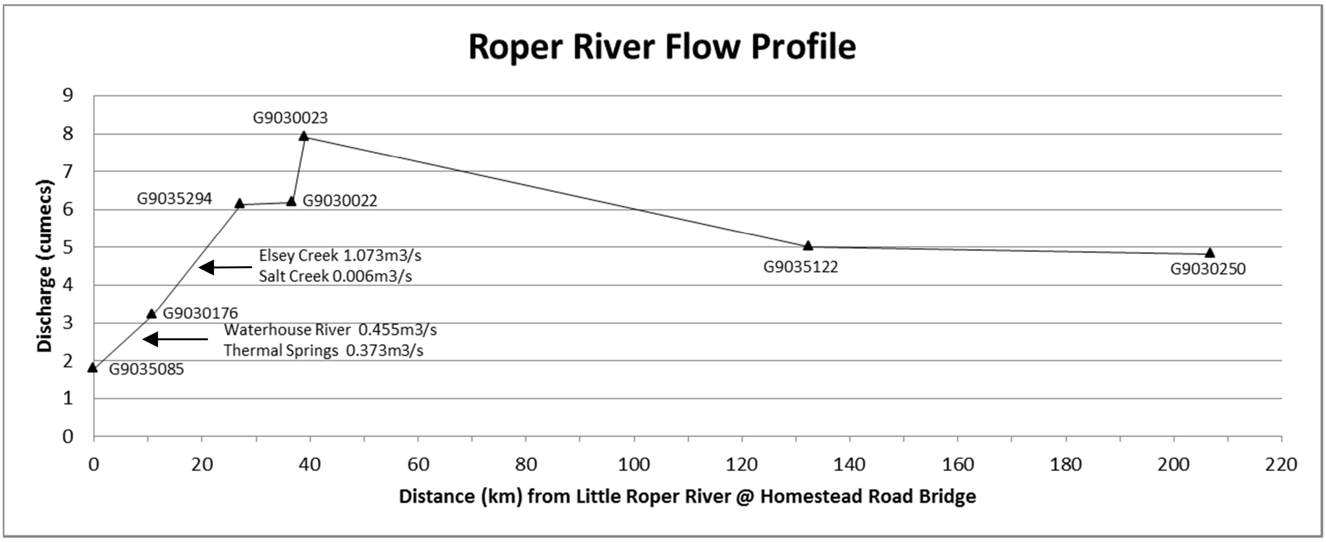

Figure 6 *Roper River Flow Profile May 2014*

This flow profile appears typical for the Roper River and replicates a pattern observed during end of dry season snapshot measurements (Wagener et al, 2013). These measurements demonstrate the high level of connectivity between the upper reaches of the Roper River and the Tindall Limestone aquifer, while indicating little if any groundwater inflow into the lower reaches.

The contribution of flows from the major tributaries and riparian springs to total catchment runoff in the Upper Roper catchment are summarised in Table 1.2. The remaining flow of 4.2m3/s in the Roper River is made up of spring inflows discharging directly into the river bed. A small flow of 0.4m3/s was recorded at Beswick on the Waterhouse River, approximately 20km upstream of the aquifer margins, during the week of snapshot measurements. Flows in the Waterhouse River upstream of the aquifer are the only known source of discharge into the Roper River external to the Tindall Limestone Aquifer. Inclusion of monitoring on the Waterhouse River upstream of the aquifer would further refine understanding of discharge sources and quantities contributing to Roper River baseflow.

Table 1.2

Aquifer	Catchment	Flows (m^3/s)	Total Flow (m^3/s)
Tindall Limestone	Little Roper	1.8	3.707
	Waterhouse	0.455	
	Thermal Springs	0.373	
	Salt Creek	0.006 (approx.)	
	Elsey Creek	1.073	
		Total Upper Catchment	7.91

A strong correlation is observed between wet season rainfall and early dry season baseflow discharging from the aquifer. High rainfall totals recorded over the 2011 wet season resulted in much higher than average stream flows throughout the 2011 dry season. Lower rainfalls since 2011 has seen a reduction in observed dry season baseflow. Very low rainfall during the 2012/13 wet season did not manifest in very low stream flow probably due to groundwater levels within the aquifer remaining high as a legacy of previous wet season rainfall recharge attenuated within the aquifer. The small amount of recharge from the 2012/13 wet season has possibly contributed to the below average stream flows observed during the May 2014 snapshot measurement, despite rainfall totals recorded over the 2013/14 wet season trending towards average.

External factors such as extraction from the aquifer and river may have contributed to the below average flows currently experienced in the Roper River, however consideration of these factors is beyond the scope of this report.

Water Quality

Electrical Conductivity (EC)

Electrical conductivity results vary significantly between discharge points in the Tindall Limestone Aquifer (Figure 6). Within the aquifer there are two main regional groundwater flow regimes that discharge to the river, low Electrical Conductivity (EC) waters (average 800 µS/cm) flowing from the North-West and higher EC waters (average 1600 µS/cm) flowing from the south. A third localised groundwater source is associated with spring waters emerging from wetland areas along John Hauser Dve, with EC in the 2000 to 5000 µS/cm range (G9035200, G9035399). These wetland areas emerge from a localised shallow watertable and groundwater salinity has probably increased due to evaporative concentration (Wagener et al, 2013).

As with the October 2013 snapshot measurements, conductivity increased gradually downstream as discharge from the north-west diminishes, and discharge from the South becomes progressively dominant. Also common to the October 2013 measurements, EC peaked around site G9035294 before gradually dropping off throughout the rest of the catchment. Mapping of the aquifer indicates discharge in the vicinity of Red Lily Lagoon (G9030022, G9030023), the last part of the river to receive groundwater discharge from the aquifer, is again from the north-west. This is supported by a dilution of EC levels observed at these points.

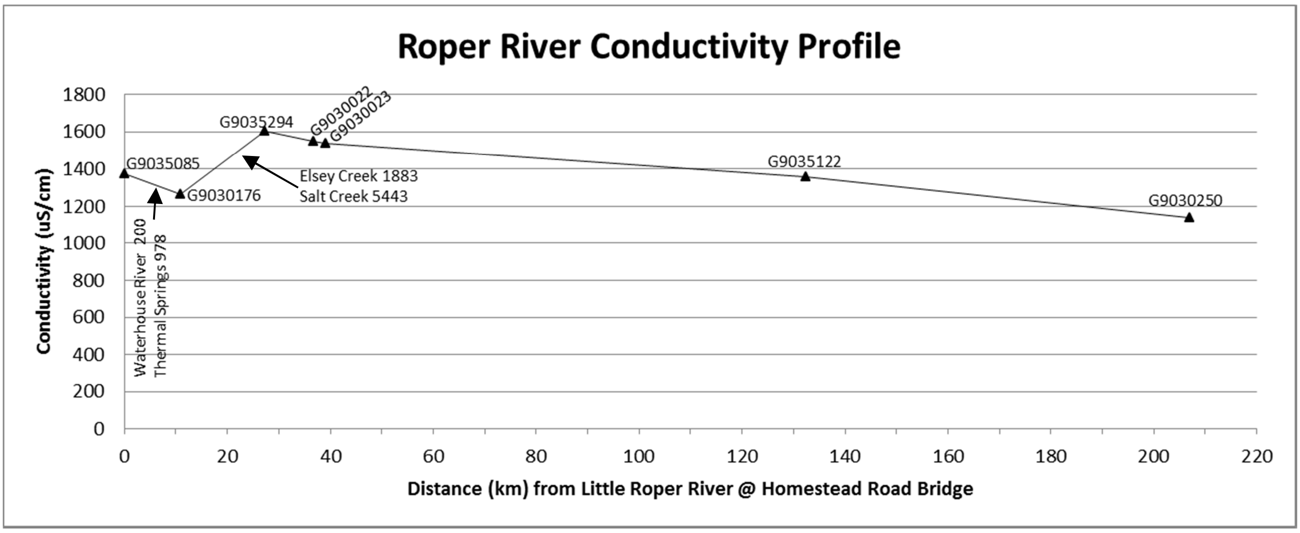

Figure 7 *Roper River Conductivity Profile May 2014*

pH

All headwater sources (Little Roper River, Waterhouse River and Thermal Springs) have slightly acidic water's with pH between 6.3 and 6.9. Downstream from the confluence of Little Roper and Waterhouse Rivers, pH rises to a slightly alkaline 7.08 at G9030176. Despite higher alkalinity inflows from Elsey and Salt Creeks (7.4 and 7.3 respectively), overall pH falls back to 6.9 at G9035294 before rising steadily as the river continues downstream.

Overall, pH measurements conducted in May 2014 were lower than those collected in the October 2013 snapshot measurements, probably due to dilution from wet season recharge and reduced retention period of water within the aquifer immediately after the wet season. Interestingly, pH levels in discharges from the North-West are significantly less than those collected in October, while those flowing from the South show much smaller variation. This is possibly due to higher rainfall totals to the north and shorter retention periods in the aquifer for water flowing from the north-west.

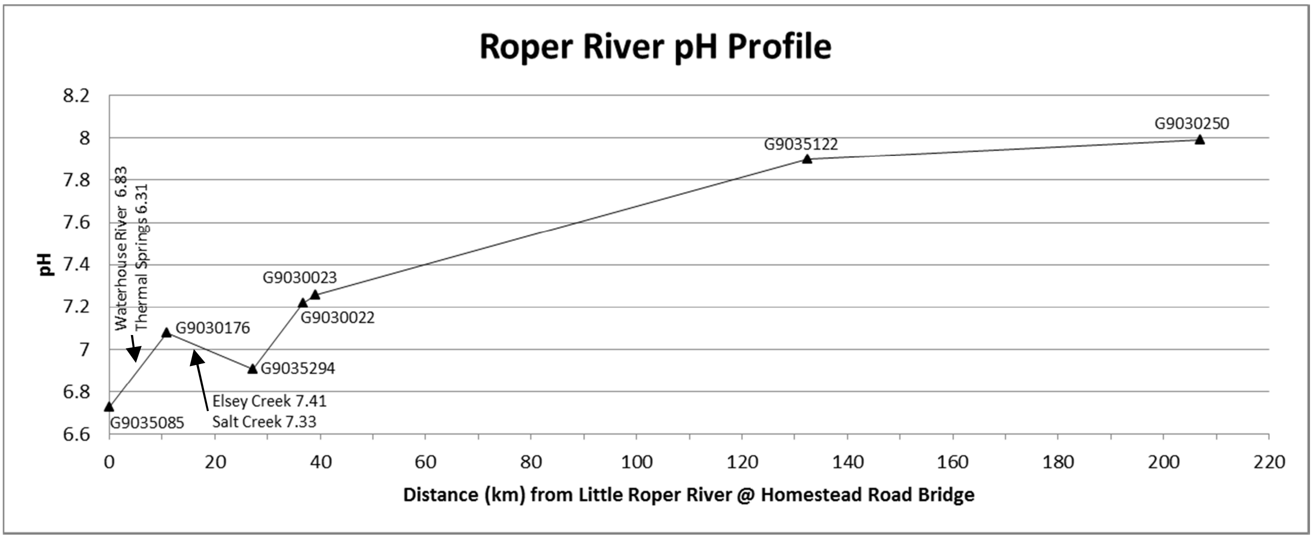

Figure 8 *Roper River pH Profile May 2014*

Dissolved Oxygen (DO)

Typical of groundwater discharge, very low DO was measured at Thermal Springs and on the Little Roper River downstream of Bitter Springs. Significantly higher DO was recorded at site G9030176 (Sat. 117%) indicating that a high level of mixing occurs between the river and the atmosphere. The upper Roper River is fairly broad and flows over several rockbars which forces atmospheric mixing and can dramatically increase DO such as seen in Figure 9.

Despite further mixing as the river passes over several more rock bars, DO saturation at G9035294 is significantly lower than further upstream. Further downstream at sites G9030022 and G9030023 DO levels have increased gradually to saturation point at both sites (96% and 101% respectively). DO levels decrease slightly downstream at G9035122 (87%) before returning to saturation levels at site G9030250.

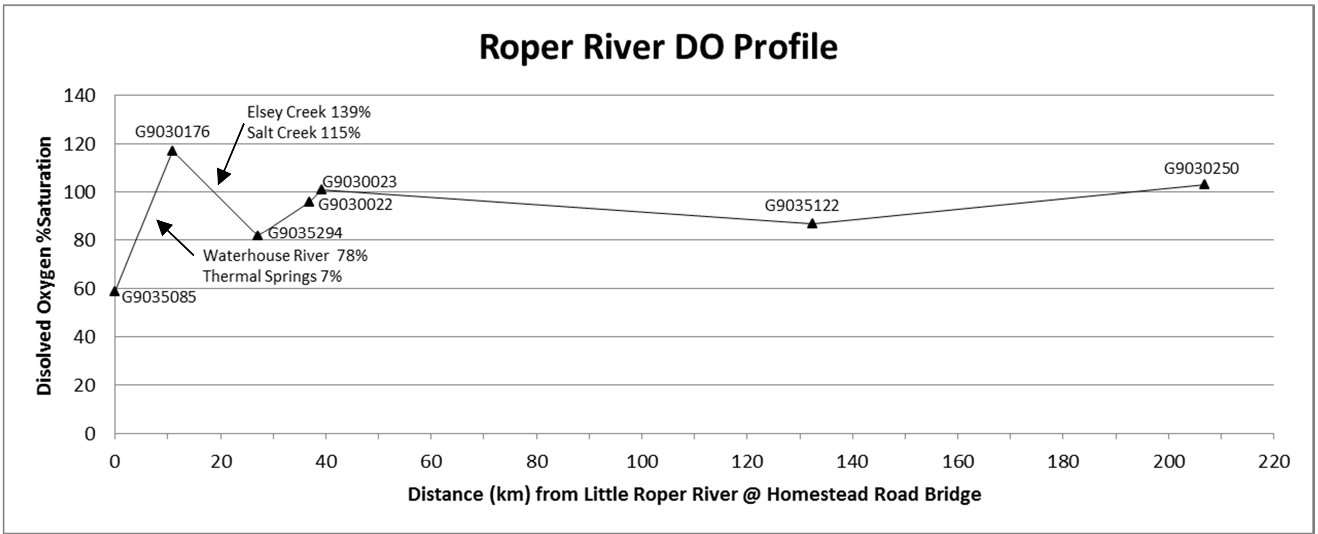

Figure 9 *Roper River DO Profile May 2014*

Environmental DO saturation levels vary significantly throughout the day depending upon water temperature, biological oxygen demand and channel geometry. Excluding direct groundwater discharge sites, measurements made where DO was less than fully saturated were also sites measured prior to 11:00am. Significant aquatic vegetation communities exist throughout the river which actively deplete DO when photosynthesis is not possible, such as overnight. Variations in DO saturation levels between sites are most likely due to time of measurement in the daily DO saturation cycle.

Turbidity

All sites measured have relatively low turbidity, with the springs having the lowest values. There are no obvious trends across the profile (Figure 9), other than a higher reading at G9035122 probably due to high water velocities at that site. Variations recorded are probably due to site specific causes such as bed material, water depth, water velocity, proximity to rapids or a combination of these.

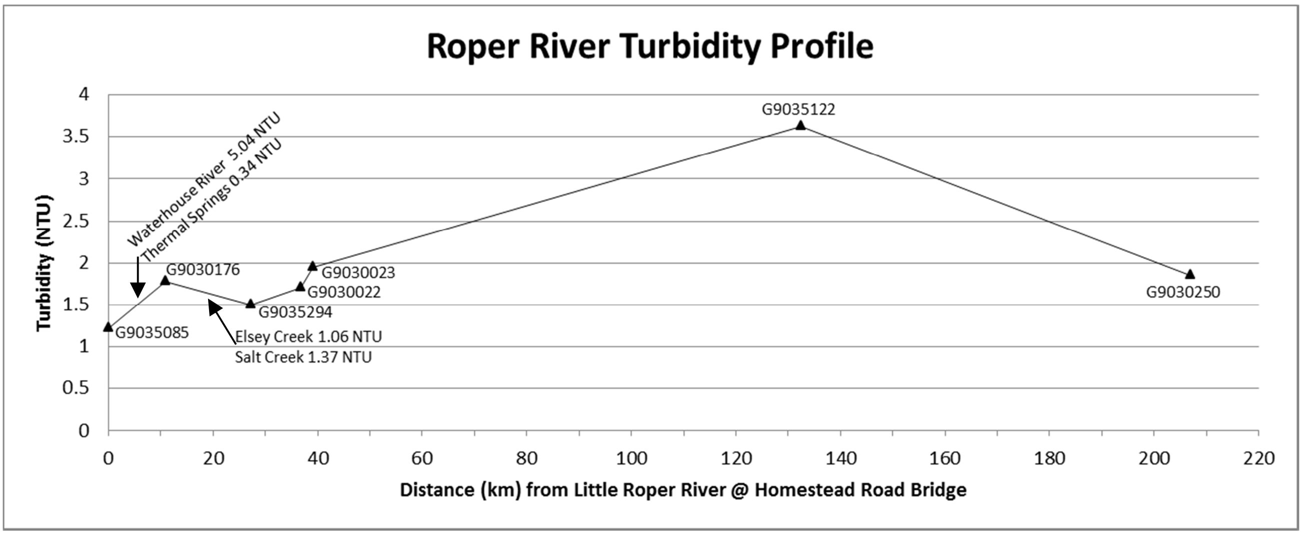

Figure 10 *Roper River Turbidity Profile May 2014*

Temperature

Water temperature varied between 24°C and 33°C, with the highest temperatures recorded downstream of significant groundwater discharge sites Mataranka Thermal Springs (33°C) and Little Roper River (31°C). Riverine water temperatures varied between 24°C and 27°C, with variations largely due to time of day the measurement was taken, and site characteristics. Figure 10 shows the temperature profile of the Roper River.

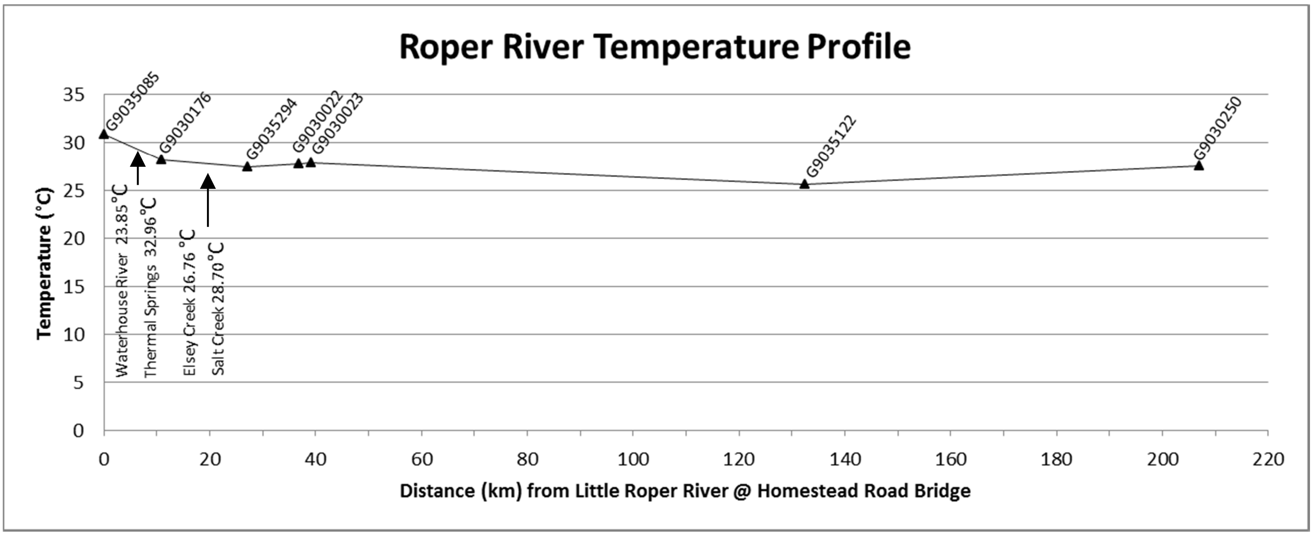

Figure 11 *Roper River Temperature Profile May 2014*

Total and soluble nutrients

Total nitrogen and phosphorus concentrations ranged from 110 to 350 µg/L and 16 to 30 µg/L respectively. Ammonia concentrations were low (<1 to 8 µg/L) throughout the catchment, with the exception of site G9035316 on the Waterhouse River, with 155 µg/L. The high concentration of NH_3 at this site is unusual and could not be confirmed. Nitrate was elevated at Mataranka Thermal Spring and the Little Roper River at Mataranka Homestead. Relatively high nitrate concentrations persist downstream of the hot spring but return to < 10 µg/L downstream of Elsie Homestead. Soluble phosphorus ranged from 3 to 8 µg/L.

Conclusion

Early dry season snapshot measurements conducted in the last week of May 2014 provides a very good seasonal depiction of discharge originating from the Tindall Limestone Aquifer. Investigation of recent regional rainfall activity and tributary inflows confirm snapshot measurements are almost entirely representative of groundwater discharges into the Roper River from the aquifer. Similar to the October 2013 snapshot measurements, the current measurements show that flows along the Roper River do not comply with the continuity principle of increasing flows moving downstream. River sections passing through the aquifer record strong gains in discharge, while sections not passing through the aquifer show overall system losses. This indicates no significant dry season inflows to the river other than via the Tindal Limestone Aquifer or if there is inflow from tributaries such as Flying Fox Creek, the additional recharge is lost to evaporation. Losses to total discharge may include evaporation, environmental consumption and water extractions and possibly losses to unidentified aquifers.

The current snapshot measurements appear to establish a trend of decreasing dry season baseflow since 2011, with current early dry season flows being below long term averages for the first time since 1997. This appears to result from decreasing rainfall over the region since 2011 although the current below average flows may be directly attributable to very low rainfall totals over the 2012/13 wet season. Near average rainfall totals for the 2013/14 wet season may see a rebound in early dry season baseflow during 2015.

Recommendations

The program of structured 'snapshot' measurements targeting start of dry season and end dry season flows along the Roper River will provide greater understanding of resource availability within the Tindal Limestone Aquifer. Snapshot measurements will also greatly add to our understanding of groundwater/surface water interactions within the Mataranka Tindall Limestone Basin. Combined with long term hydrological and hydrogeological datasets, the snapshot measurements will allow for better management decisions and assessment of their impacts. The continuation of the 'snapshot' measurement program will add to existing datasets with comparable hydrological conditions at an identical stage in the seasonal hydrological cycle. It is essential that future monitoring exercises are performed in a similar manner focusing on the monitoring program requirements as well as the recommendations from the assessment of the data collected.

Three possible areas for improvement of the 'snapshot' measurement program were identified during this snapshot period.

1. Monitoring of flows on the Waterhouse River immediately upstream of the aquifer rather than upstream of the Thermal Springs. This would allow the contributions from surface water and groundwater inflows to be better defined.
2. Monitoring of flow and water quality parameters immediately downstream of the confluence of the Little Roper and Waterhouse Rivers. While gaugings are conducted upstream on the two main tributaries, no measurements are conducted on the Roper River until almost 7km downstream of their confluence. Being highly connected to the aquifer, this would allow better definition of regional groundwater inflows between the two main tributaries and site G9030176.
3. Further investigation into the dynamics of surface water/groundwater interaction within Red Lily Lagoon. Red Lily Lagoon has been previously identified as the river reach crossing the eastern boundary of the aquifer, however within this reach the river also crosses a limestone outlier of the aquifer which appears to contribute significant additional discharge to the river (Karp, 2008; Wagenaar et al, 2013). Measurements taken along Red Lily Lagoon during the October 2013 snapshot measurement (Wagenaar et al, 2013) as well as some ad-hoc measurements taken during the May 2014 snapshot measurements appear to identify significant flow variation within this pool.

Groundwater monitoring was not performed during the snapshot measurement exercise and it is recommended that the snapshot exercise be extended to groundwater monitoring sites for the 2015 monitoring program. This information will give a more complete image of the catchment and aquifer conditions and will assist greatly in the assessment process.

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Appendix A - Monitoring Requirements

Objectives

The monitoring objectives of Tindall Limestone Aquifer (Mataranka) WAP is 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 snapshot measurements are based on surface water and groundwater monitoring requirements as documented in Table 1.1.

Table 1.1

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, turbidity 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 (Mataranka) WAP monitoring programs.

Field Measurement Standards

Water Levels

The main factors that have an influence on the accuracy of water level measurements at surface water and groundwater monitoring sites summarised in Table 1.2.

Table 1.2

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 deposited at gauge plates. Difficult to take readings without maintenance work

Type	Conditions	Influences	Description
	Gauge Plates	Unstable gauge posts	Unstable gauge posts 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

Stream Flow

Factors influencing accuracy of discharge measurements are 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 result from site conditions and actions by the operator and generally have a much greater impact on measurement accuracy. 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.
- **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. As far as possible, 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.
- 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.

Water Quality

- 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.

Appendix B – Water Levels

Site Number	Site Name	Date	Time	Level	Site Influences
G9030176	Roper River at DS Mataranka Homestead	26/05/2014	1750	0.441	
G9030250	Roper River at Red Rock	28/05/2014	1716	1.691	

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

Appendix C – Flow Measurements

The descriptions of "Site Influence" indicators are documented in Appendix A.

Site Number	Site Name	River System	Flow m^3/s	Date	Gauging Instrument	Site Influences	Rating Deviation%	Comment
G9030022	Roper River WAP Site 17	Roper	6.19	27/05/2014	StreamPro		N/A	Good even section, uniform velocity, repeatable transects.
G9030023	Roper River WAP Site 18	Roper	7.91	27/05/2014	StreamPro		N/A	Good even section, uniform velocity, repeatable transects.
G9030175	Roper River at Thermal Springs	Roper					N/A	
G9030176	Roper River at DS Mataranka Homestead	Roper	3.21	26/05/2014	StreamPro		13.71%	Good repeatable transects. Good gauging.
G9030250	Roper River at Red Rock	Roper	4.83	28/05/2014	StreamPro	WG	15.61%	Weedy section, measurement quality downgraded to satisfactory.
G9035085	Little Roper at Mataranka Homestead Crossing	Roper	1.824	28/05/2014	StreamPro		N/A	
G9035122	Roper River at Jude's Crossing	Roper	5.01	28/05/2014	StreamPro		N/A	Good repeatable transects, good section, inform velocity, good gauging.
G9035200	Elsey Ck at Roper Highway	Roper	0.960	27/05/2014			N/A	
G9035294	Roper River D/S Elsey Homestead	Roper	6.125	27/05/2014	StreamPro		N/A	
G9035085	Little Roper at Mataranka Homestead Xing	Roper	1.824	28/05/2014	StreamPro		N/A	
G9035399	Salt Creek at Roper Highway	Roper	0.006	27/05/2014	Visual		N/A	Approximate flow only.

Appendix D – Water Quality Measurements (physico-chemical parameters)

Site Number	Site Name	Date	Time	Temp (˚C)	pH	D.O. (mg/L)	DO % sat	E.C. (µS/cm)	Turb 1 (NTU)	Turb 2 (NTU)	General Chemistry Sample (500mL)	Total Nutrient Sample (250mL)	Nutrient Filtered Sample (125mL)
G9030022	Roper River WAP Site 17	27/05/2014	1650	27.76	7.22	7.54	96	1550	1.71	1.70	✓	✓	✓
G9030023	Roper River WAP Site 18	27/05/2014	1700	27.90	7.26	7.85	101	1540	2.11	1.79	✓	✓	✓
G9030175	Thermal Springs at Mataranka Homestead	28/05/2014	1200	32.96	6.31	0.50	7	978	0.45	0.23	✓	✓	✓
G9030176	Roper River at DS Mataranka Homestead	26/05/2014	1645	28.21	7.08	9.06	117	1266	1.65	1.91	✓	✓	✓
G9030250	Roper River at Red Rock	28/05/2014	1716	27.53	7.99	8.07	103	1137	1.96	1.74	✓	✓	✓
G9035085	Little Roper at Mataranka Homestead Crossing	28/05/2014	1500	30.85	6.73	4.37	59	1373	1.09	1.34	✓	✓	✓
G9035122	Roper River at Jude’s Crossing	28/05/2014	1100	25.65	7.9	7.06	87	1357	3.76	3.48	✓	✓	✓
G9035200	Elsey Ck at Roper Highway	27/05/2014	1405	26.76	7.41	11.03	139	1883	1.19	0.93	✓	✓	✓
G9035294	Roper River D/S Elsey Homestead	27/05/2014	1100	27.42	6.91	6.49	82	1603	1.44	1.56	✓	✓	✓
G9035316	Waterhouse River at US Thermal Springs	28/05/2014	0930	23.85	6.83	6.61	78	200	5.20	4.88	✓	✓	✓
G9035399	Salt Creek at Roper Highway	27/05/2014	1620	28.70	7.33	8.74	115	5443	1.35	1.39	✓	✓	✓

Appendix E – Water Quality Measurements (Nutrients)

Site Number	Site Name	Date	Time	NH3_N (mg/L)	NO2_N (mg_L)	NO3_N (mg/L)	PO4_P (mg/L)	Total N (mg/L)	Total P (mg/L)
G9030022	Roper River WAP Site 17	27/05/2014	1650	0.004	0.004	0.012	0.008	0.18	0.023
G9030023	Roper River WAP Site 18	27/05/2014	1700	0.002	<0.001	0.009	0.005	0.21	0.025
G9030175	Thermal Springs at Mataranka Homestead	28/05/2014	1200	<0.001	0.003	0.173	0.003	0.25	0.026
G9030176	Roper River downstream Mataranka Homestead	26/05/2014	1645	0.007	0.002	0.074	0.005	0.23	0.017
G9030250	Roper River at Red Rock	28/05/2014	1716	0.001	<0.001	0.004	0.004	0.26	0.030
G9035085	Little Roper at Mataranka Homestead Crossing	28/05/2014	1500	0.008	0.003	0.214	0.008	0.35	0.016
G9035122	Roper River at Jude's Crossing	28/05/2014	1100	0.003	0.006	0.004	0.006	0.21	0.016
G9035200	Elsey Ck at Roper Highway	27/05/2014	1405	0.004	0.005	0.005	0.005	0.25	0.017
G9035294	Roper River downstream Elsey Homestead	27/05/2014	1100	0.005	0.004	0.027	0.005	0.11	0.026
G9035316	Waterhouse River upstream Thermal Springs	28/05/2014	0930	0.155	0.007	0.021	0.006	0.20	0.019