

TC MARCIA – WATER QUALITY AND TREATMENT CHALLENGES IN A CYCLONE IMPACTED RIVER



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TC MARCIA – WATER QUALITY AND TREATMENT CHALLENGES IN A CYCLONE IMPACTED RIVER

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ABSTRACT

Water quality and treatment challenges arose when the Fitzroy River was impacted by Tropical Cyclone (TC) Marcia which in 2015 caused a prolonged water quality event with sustained high levels of manganese. The nature of where rainfall produced by TC Marcia was received and how conditions led to the creation of high levels of manganese in raw water stored in the Fitzroy Barrage is outlined in this paper. With a small number of Australian Drinking Water Guidelines exceedances this paper looks at the way the treatment challenges were dealt with to continue to supply safe potable water to a community already under stress.

1.0 INTRODUCTION

Rockhampton Regional Council's (RRC) business unit Fitzroy River Water (FRW) produces potable water through the Glenmore Water Treatment Plant (GWTP) with raw water sourced from the RRC's high priority water allocation drawn from the Fitzroy Barrage on the Fitzroy River. Potable water produced by FRW provides water for some 109,336 persons (Census 2011) not only in Rockhampton and Gracemere but also to some communities in the Livingstone Shire Council. The Fitzroy River system is the largest river system that drains into Australia's east coast. On 20th February 2015 TC Marcia passed over Rockhampton and surrounds causing extensive damage in the region. For FRW there were several impacts that posed challenges for treatment and supply staff. These ranged from loss of power, telemetry and communications, localised flooding, increased chemical usage, the human factors of fatigue and stress, and a hydrological situation which created a prolonged water quality challenge for FRW staff to manage.

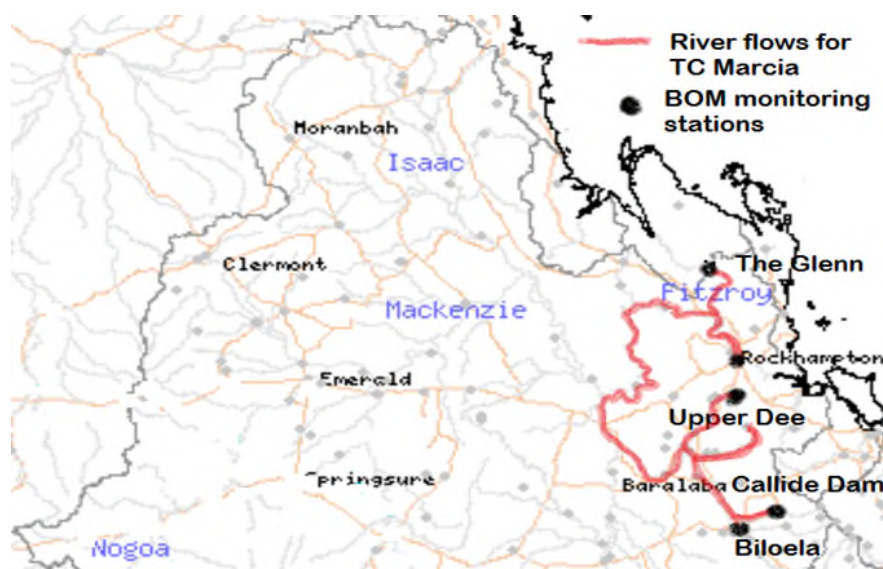


Figure 1: *Map that describes the main river flows for Tropical Cyclone Marcia. Map Source – Australian Bureau of Meteorology, 2016. Modifications – Szemes, 2016.*

TC Marcia isn't the first cyclone that Rockhampton has faced with an unnamed cyclone crossing the coast 2 – 3rd March 1949 at Keppel Sands then following the Fitzroy River into Rockhampton. Data for this period are limited whereas today monitoring stations through Bureau of Meteorology

(BOM) can be referenced for data. In the 2015 cyclone the Fitzroy system did not experience flooding throughout the entire system with flooding localised, most flows in the system coming through from the Dee, Don Callide and Dawson Rivers.

Localised rainfall from this cyclone, that which can be attributed to the cause of the prolonged water quality issues, came from the Alligator Creek system which feeds into the lower Fitzroy River at Yaamba, some 42 km north of the GWTP intake. Figure 1 above, marked in red describes where the main flows in this event originated. Table 1 presents rainfall data from several BOM stations; Alligator Creek system is listed as BOM registered site, The Glenn TM. Some of the sites listed reach second highest falls since record keeping began in those areas. At the peak flow the Fitzroy Barrage passed 158,052 ML through its gates on 27th March, seven days after the cyclone.

Table 1: *Rainfall for various parts of the Fitzroy River catchment during TC Marcia in February 2015.*

Source - Australian Government, Bureau of Meteorology, April 2015.

Site	Rainfall	Date span	System
The Glenn TM	260mm	19 -21/02/2015	Fitzroy
Rockhampton AWS	214mm	19 -21/02/2015	Fitzroy
Upper Dee TM	342mm	19 -21/02/2015	Dawson
Callide Dam Inflow TM	217mm	19 -21/02/2015	Dawson
Riverslea TM	76mm	19 -21/02/2015	Fitzroy / Mackenzie
Coolmaringa TM	24mm	20/02/2015	Mackenzie

2.0 DISCUSSION

GWTP is operated from a main control room, in which treatment and supply operators ensure that reticulation and sewerage systems are working and reservoirs are filled throughout Rockhampton and Gracemere as well as monitoring Mount Morgan. Immediately after the cyclone the control room was not only control for the operators but became an incident centre for FRW during the coming weeks. Below will be a brief outline of the events as they unfolded and in instances how they were dealt with.

On 20 February as TC Marcia hit GWTP, power was lost. Backup generator power maintained the SCADA system at control room, enabling some systems to remain online by telemetry but this was patchy and unreliable. At this stage without mains power, the water plant was not operational and raw water could not be processed or potable pumped into storages or reticulation. Phone services were lost, but radios had been deployed to key staff the previous day. FRW staff were on the ground on 21 March with assessment and reinstatement of infrastructure initiated. Ergon worked to restore power to GWTP as a priority with the water plant restarted approximately 18:30. Reservoirs were in various states of fill, Sewage Treatment Plants (STP) and Sewerage Pump Stations (SPS) were assessed throughout the day and backup generators were sourced for the most critical first.

At this point no notable treatment challenges arose for operators with all changes in raw water quality (turbidity, pH) dealt with and dose rates of chemical changed as required. On the 24th February operators recorded the 6am level of Riverslea (BOM monitoring weather station), the confluence of Mackenzie River and Fitzroy River, as 11.70m.

Some four days later this run, predominately from Dawson River started dropping while at

the same time through daily laboratory testing operators noted that the Dissolved Oxygen (DO) in raw water started to drop.

By the 3rd of March odorous raw water was coming through the Fitzroy Barrage storage with DO continuing to drop with levels below 1.00mg/L starting on 5th March. Pre-chlorination of the raw water was initiated at this point to increase oxidation with 20L drums of hypochlorite placed on the traveling bridges on the sediment tanks to dribble into the water to gain as much detention time as possible through the sediment and tube settler bays as possible as levels of manganese (Mn) had been detected in the raw water. Chlorine tablets were also placed into the weirs in the tube settler and carrier troughs in the sand filter bays. A challenge faced by operators at this point was the loss of the DO probe in the laboratory, a replacement was soon sourced. By the 9th March pre-dosing at the head of the plant was initiated through a system that was already in place. This gained a longer detention time and better mixing through the water column to oxidise manganese.

Complaints were coming in from residents with discoloured/dirty water at this stage. An aeration diffusion grid was fitted to the inlet to boost DO but with shallow water depth and short detention time the oxygen transfer rate was low and may not have been as effective as was intended but remained in place for entire event. On 5th March potable water recorded a manganese reading of 0.300mg/L, exceeding Australian Drinking Water Guidelines (ADWG) aesthetic value and on 11th March, 0.800mg/L exceeding ADWG health value, was the highest recorded leaving GWTP (Leyden, 2015). Plumbing crews and water quality officer collected samples with the lines in affected areas flushed. These samples were brought back to GWTP and levels of manganese were tested and recorded. Areas affected could be mapped and clusters of complaints noted for places of high incidence. Most of the 169 complaints received in March 2016 related to the appearance/discolouration, taste and odour of potable water.

Raw water samples were collected from dedicated points on the Fitzroy River to monitor the DO and the manganese levels in the raw water. Tests carried out by FRW staff and visual inspection discovered Alligator Creek was the predominate flow filling the Fitzroy Barrage impoundment and concurrently Barrage gates were starting to close. First flow from the rainfall related to the cyclone coming into the Fitzroy system was from Dawson River through Riverslea with enough in velocity to hold back flow from Alligator Creek. Alligator Creek raw water was complicated by the destructive influence of TC Marcia in that it presented poor water quality that was high in vegetative and other organic matter complexes with iron and manganese (Plumb, 2015), so that when the upstream flow slowed, Alligator Creek was then able to enter and subsequently fill the Fitzroy Barrage impoundment.

Three weeks after the cyclone the Barrage gates were closing, leaving the impoundment containing very poor quality raw water. Table 2 shows the levels of dissolved iron, manganese, DO and the levels of dissolved and total organic carbon recorded during this period. The outlook for further rainfall at this point was not promising. Raw water testing was being conducted by FRW staff near Alligator Creek, upstream from confluence, FRW intake and several points further downstream to gauge overall water quality. With the DO dropping to <1.00mg/L FRW were faced with the prospect of months of extremely poor quality water, with the possibility of further exceedance of the ADWG health value for Mn, aesthetic quality issues which were becoming more evident by complaints received and potentially unsafe drinking water (Plumb, 2015).

Table 2: *Levels of iron, manganese, DO, DOC and TOC in the Fitzroy Barrage impoundment in early March 2015.*

Source – Plumb, 2015.

Iron	2-3 mg/L
Manganese	0.500 – 1.00 mg/L
Dissolved Oxygen	<1.00 mg/L
Dissolved and Total Organic Carbon	15 to 20 mg/L

FRW proposed an option to RRC’s Senior Management for a controlled release from the Fitzroy Barrage impound. Correspondence with Key Stakeholders commenced with the situation outlined and intention to release through the Fitzroy Barrage. The release was to allow better quality water from upstream in the Fitzroy River to replace the poor quality water currently stored. The exceedance of ADWG health value for manganese, the very poor quality test results from virtually the entire Fitzroy Barrage impoundment (42 km) on 11th March, and no sign of likely short-term improvement led to a slow release commencing at approximately 9pm. As this release required the Fitzroy Barrage to operate outside its Resource Operating Plan (ROP) – the regulator was informed of the actions taken by FRW (Plumb, 2015). The release was ceased at approximately 6am on 13th March, with a notable improvement in raw water quality immediately, although DO was still relatively low (below 2.00mg/L) and manganese still above ADWG health value of 0.500mg/L. Approximately 26, 546.51ML passed through the Barrage gates to achieve this improvement.

A challenge for operators was to ensure that levels of chlorine pre-dosing did not cause high levels of trihalomethanes (THM) in potable water. Below in Table 3 are key dates for chlorine pre-dose rate changes, kilograms per megalitre used to oxidise manganese to megalitres of pumped raw water, pre-dose and total of chlorine used for the day and percentage of chlorine used in this oxidation process. As can be seen on 20th March, 70 per cent of the total chlorine used went into oxidation of manganese, while by 16th July, pre-dose was down to 37.9 per cent. As the levels of manganese dropped away in the raw water, operators were able to reduce pre-dose rates to achieve manganese levels below the ADWG, this can be seen by looking at the 30th April and the 1st of May where the pre-dose rate was lowered and raised again to reduce manganese in potable supply.

Table 3: *Key dates where chlorine pre-dose rates were changed to reduce Mn in potable water along with amounts of chlorine used.*

Source – Fitzroy River Water records, 2015.

Date	Mn Raw mg/L	Mn Potable mg/L	Pre-dose Cl2 kg/ML	ML Pumped	Pre-dose Cl2 kg/D	Total Cl2 kg/D	% of Total Cl2 Used
20/03/15	0.800	0.047	6	72	432	613	70.0
14/04/15	0.278	0.090	5	58	290	416	69.7
30/04/15	0.115	0.004	3	50	150	267	56.2
01/05/15	0.125	0.039	4	48	192	283	67.8
01/06/15	0.101	0.007	3	62	186	308	60.4
10/06/15	0.119	0.005	2	60	120	233	51.5
18/06/15	0.078	0.006	1.5	42	63	147	42.9
29/06/15	0.087	0.006	1.1	42	46.2	140	33.0
16/07/15	0.070	0.008	1	50	50	132	37.9
18/07/15	0.076	0.015	0	54	0	132	0

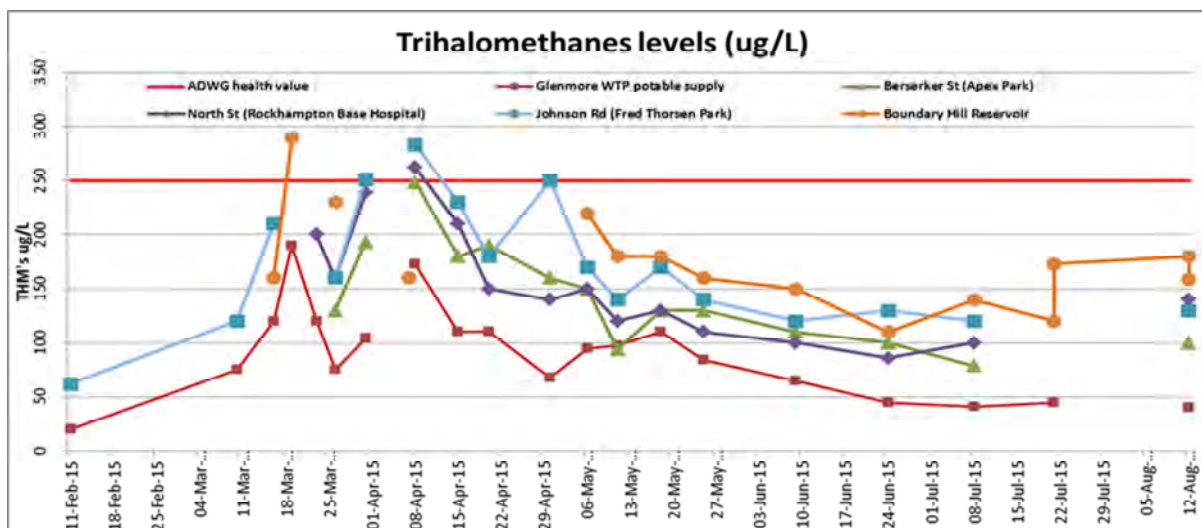


Figure 2: *Levels of THM's pre and post Tropical Cyclone Marcia.*
Source – Leyden, 2015.

Operators monitored mg/L of chlorine at various sites throughout plant processes over the following weeks as it was important to know manganese being oxidised, was taken out in process rather than reforming in reservoirs and throughout distribution system. It was also a way of ensuring that THMs formation potential was reduced, given that re-chlorination and detention time at reservoirs is a contributing factor for increased THM levels. Samples were collected and sampled for chlorine, turbidity and colour at the head of the plant, flocculation tank bay three, end of sediment tanks, end of tube settler bays, periodically samples from sand filters as well as normal laboratory sampling for potable. Manganese was tested daily until late August and is currently still tested for on a weekly basis by operators. Looking at Table 3 and Figure 2 a correlation between elevated THMs could be seen as most probably being attributed to the addition of pre-dosing at GWTP when observing, in particular, the percentage of total used chlorine. As the manganese in the raw water reduced and operators adjusted pre-dose levels, THMs reduced over time. Exceedance of the ADWG for THMs occurred several times in the early stages of pre-dosing when manganese levels were still high. Pre-dosing with chlorine concluded on 16th July 2015.

Human factors of fatigue and stress need to be mentioned as for many FRW staff homes were damaged, there was no electricity and it was extremely humid for many days after the cyclone had passed. Work stresses for FRW staff included increased hours, extra shifts, various frustrations of plant and infrastructure damage, no electricity, heat stress and initially poor communication with phones down and not all radios working. In addition, operators dealt with the added responsibility of being an after hour's point of call for water quality issues whilst dealing with normal responsibilities of operating the GWTP, monitoring reservoirs, STPs and SPSs, deploying staff to issues arising and relaying and recording relevant information. On 6th March there were 13 after hours calls from 5pm to 12am whilst the next day there were 50 after hours calls received by the operators on duty.

3.0 CONCLUSION

Tropical Cyclone Marcia provided significant water quality and treatment challenges for FRW. Initially, ensuring water production was the priority followed by the normal issues of rise in turbidity and changes in pH.

Vegetative damage caused in the headwaters of Alligator Creek provided high levels of dissolved and total organic carbon complexed with iron and manganese and then filled the Fitzroy Barrage impoundment with very poor quality water. That there was still flow coming through from upstream made it possible for the slow release in the impoundment to replenish the storage with improved quality water over time. For operators ensuring that chlorine pre-dosing levels were appropriate to achieve quality potable water was a priority. This event was not one that has occurred previously for GWTP operators and created some increased testing challenges. Overall the number of exceedances were few and staff responded, initiating testing of raw water quality, informing key stakeholders and government agencies of issues and actions, changes in chemical dose rates to meet ADWG health values to provide a safe potable water supply for the community.

4.0 ACKNOWLEDGEMENTS

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