Modelled Data Report

Modelling of Surface Water Extraction in the Lower Reaches of the Roper River

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Bibliographic Reference

Scope of Works

The Department of Land Resource Management (the Department) was commissioned by Pendragon Environmental Solutions to apply model three surface water extraction regimes, representing possible mine water usage scenarios using an existing water resource model of the Tindall Limestone/Roper River system. The three water usage scenarios assumed a 12hr schedule and were modelled under four groundwater development scenarios in the Tindall Limestone aquifer within the Mataranka region. The scenarios required to be modelled (van der Westhuizen pers comms, 2012) are as summarised below:

- 108 m3/hr minimum expected usage;
- 480 m3/hr average estimated usage and
- 1200 m3/hr peak usage

The groundwater extraction scenarios were determined based on the Department's understanding of the groundwater system dynamics and current and future usage.
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Objective
The objective of this study was to model and report the resultant flows in the Roper River at specific sites due to surface water extraction on river flow dynamics of the Roper River between Judy Crossing (G9030010 / G9035122) and Red Rock (G9030250) using the existing coupled surface water groundwater model (Knapton, 2009).

Red Rock gauge is to be used as a proxy for flows at Roper Bar.

Study location
The proposed mine is located within the Roper River catchment and is expected to draw water from the Roper River upstream of Judy Crossing (G9030010) refer to Figure 1.

River description
The Roper River starts as the Roper Creek (also called Little Roper River) and becomes the Roper River downstream of the Waterhouse River junction near Mataranka. The Elsey Creek system drains the large Sturt Plateau region (Yin Foo and Matthews, 2001), which is located in the south-western section of the catchment. Flying Fox Creek flows into the non-tidal portion of the Roper River upstream of Roper Bar. The Wilton River flows in to the tidal section of the Roper River downstream of Roper Bar.

The Roper River flows generally in an easterly direction, although the geology of the catchment influences the direction of the drainage systems.
The middle section of Roper River has many areas along its length that are braided with multiple channels and have large evapotranspiration losses associated with them.

Large areas along the Roper River are subject to inundation during the wet season.

The normal tidal limit of the Roper River is at Roper Bar Crossing (shown on Figure 1). From this crossing, the Roper River traverses the alluvial coastal plain eastward for 145 km before entering the Gulf of Carpentaria. There are currently no large surface water storages on the Roper River or its tributaries.

Except for the areas where groundwater discharges to the Roper River, the river is a losing system with flow decreasing downstream. This is primarily due to evapotranspiration losses.

**Evapotranspiration losses**
Evapotranspiration losses from the headwaters of the Roper River to Red Rock are estimated at 2-3 m$^3$/s (Knapton, 2009). The evapotranspiration loss between Judy Crossing (G9030010) and Red Rock (G90302050) is approximately 0.6 m$^3$/s ± 0.15. This means that when flows at Judy Crossing are less than 0.6 m$^3$/s flows at Red Rock will cease. Based on modelling, historically this occurs about 5% of the time or 18 days a year.

**Current groundwater demands**
Current groundwater extraction near the head waters of the Roper River is estimated at 3.5 GL/yr (0.111 m$^3$/s); this represents 12% of the future projected demand which is expected to be around 29 GL/yr (0.92 m$^3$/s).

**Future groundwater demands**
The future groundwater demands were taken from the scenarios used as part of the Water Allocation Planning process. The future pumping scenario was estimated at an annual extraction of 29 GL which is approximately 0.92 m$^3$/s. The system takes approximately 40-50 years for approximately 50% of the applied pumping rate to be observed as a decrease in discharges to the river. The life time of the mining project is expected to be 30 years. Based on the response to the future proposed pumping scenario approximately 40-50% (0.36 to 0.45 m$^3$/s) of the future pumping scenario will be evident at the end of the project lifetime. This reduced rate has also been used as a scenario in the modelling.

**Modelling**

**Methodology**
The integrated model deployed is documented in detail as part of the Gulf Water Study (Knapton, 2009a). Scenarios were developed either using a 12hr schedule with ramped pumping at the beginning and end of the pumping period or as a continuous 24hr pumping schedule at a flat rate
half of the 12hr pumping rate. The period at the full pumping rate for the 12 hr schedule begins at 0600hrs and ends at 1800hrs each day.

Proposed surface water demands
Details of the ilmenite mine proposal are presented in the NOI and PER documents.

Water usage has been estimated as follows based on a 12 hour pumping regime (van der Westhuizen pers comms, 2012):

- 108 m³/hr minimum expected usage,
- 480 m³/hr average estimated usage and
- 1200 m³/hr peak usage.

Scenarios
There is some uncertainty concerning the level of groundwater extraction that will occur over the lifetime of the mining project. Therefore the expected range of groundwater extraction regimes have been assessed to determine the likely impacts on the surface water system have been assessed. Four (4) separate groundwater extraction scenarios have been modelled each with the six (6) surface water extraction scenarios applied at the proposed pumping site upstream of Judy Crossing (refer to **Table 1**).

The four groundwater extraction scenarios are as follows:

1. Historic - to provide an assessment of surface water extraction using the available historic climatic condition data.

2. Current pumping (0.11 m³/s) - this provides an assessment of the expected range of flows if the current extraction regime continued into the future.

3. Future pumping 45% impact (0.40 m³/s) - as identified earlier the lag associated with the impacts of the full future expected pumping regime is estimated at greater than 50yrs. Over the lifetime of the project a maximum of 45% of the total extraction is expected to be evident. This scenario is considered to be the most likely situation at the end of the mining projects projected lifetime.

4. Future pumping with 100% impact (0.920 m³/s) - this scenario was included to provide an assessment of impacts if lag times are considerably shorter than expected and the full impact of the groundwater extraction on river discharge was greater than determine in Scenario 3.
Table 1  Scenarios run to assess surface water extraction impacts

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Anticipated usage</th>
<th>Duration [hr]</th>
<th>Rate [l/s]</th>
<th>Combined [l/s]</th>
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Specific Model Limitations
In addition to the limitations of the coupled model identified in Knapton (2009), it should also be noted that the effects of pool storage are poorly represented in the region between Judy Crossing and Red Rock.

Evapotranspiration losses along the section from Judy Crossing to Red Rock are approximately 0.6 m³/s ± 0.15. It would be expected that this extraction would show a diurnal response; the observed record at Red Rock shows no such daily variation. It is suggested that there is considerable buffering/lag due to pool storage and that the evapotranspiration losses are observed as an averaged response. Based on this assumption it would also be expected that the 12hr pumping regime would create a similar averaged response at Red Rock and flows to the pool downstream of Roper Bar.
**Results**

The results of the modelling scenarios are presented in an Excel 2007 binary spreadsheet (Judy_and_red_rock_flows.xlsb). Results have been extracted from the MIKE11 model at Judy Crossing (chainage 118085) and Red Rock (chainage 183757). The scenarios are separated into sheets based on the groundwater extraction scenario with the corresponding flows for Judy Crossing (JC) and Red Rock (RR). The flows are reported at a daily timestep for the minimum flows observed for that 24hr period.

The note on specific model limitations (see above) should be considered here as the 12hr results may actually generate a similar flow response at Red Rock as the 24hr pumping schedule.

**Observed and simulated historic discharge**

**Judy Crossing**

Simulated and available gauged data are presented in Figure 2. Climatic conditions post 1974 have resulted in flows at Judy Crossing not declining below approximately 0.8 m$^3$/s (refer to Figure 2). Exceedance curves for 1900-2008 and 1970-2008 are presented in Figure 3.

**Red Rock**

Simulated and available gauged data for Red Rock are presented in Figure 4. Exceedance curves for 1900-2008 and 1970-2008 are presented in Figure 5. The 1970-2008 data has been presented to demonstrate the difference in flow regime post 1974.
Figure 4 Historic simulated flows and observed gauged flows at Red Rock (G9030250).

Figure 5 Exceedance curves at Red Rock using simulated flows record.

Resulting flows at Judy Crossing and Red Rock from each of the scenarios are presented in Appendix A - Figure 6 to Figure 21. Flow exceedance curves at Judy Crossing and Red Rock from each of the scenarios are presented in Appendix B - Figure 22 to Figure 25.

Conclusions

Based on results the 24 hr pumping schedule will have much lower impact on minimum observed instantaneous flows at Judy Crossing and probably Red Rock than a 12hr pumping schedule.

However, it should be noted that the effects of pool storage are poorly represented in the model in the region between Judy Crossing and Red Rock. Evapotranspiration losses along the section from Judy Crossing to Red Rock are approximately 0.6 m$^3$/s ± 0.1. It would be expected that this extraction would show a diurnal response, although the observed record at Red Rock shows no such daily variation. Based on this information it is suggested that there is considerable buffering due to pool storage and the ET losses are observed as an averaged response. Based on this assumption it would be expected that the 12hr pumping regime would create a similar averaged response at Red Rock and flows to the pool downstream of Roper Bar.

Based on observed and simulated flows at Judy Crossing under recent climatic conditions (1970-2008) the maximum pumping rate should be no more than 480 m$^3$/hr (instantaneous extraction of
0.133 m\(^3\)/s) if a minimum flow of 0.67 m\(^3\)/s is maintained within the 20 percentile at this site. That is, an upstream cutoff of 0.67 m\(^3\)/s would need to be applied to meet this requirement.

- Based on the 1970-2008 historic exceedances, a cutoff of 0.67 m\(^3\)/s will result in extraction being stopped for less than 1% of the time.
- Based on the 1900-2008 historic exceedances, a cutoff of 0.67 m\(^3\)/s will result in extraction being stopped for 5% of the time (ie 18 days).

References
Appendix A - Discharge hydrographs

Judy Crossing

Figure 6: Judy Crossing historic record with scenarios using a 12 hr pumping schedule
Figure 7  Judy Crossing historic record with scenarios using a 24 hr pumping schedule.
Figure 8 Judy Crossing current pumping regime with scenarios using a 12 hr pumping schedule
Figure 9 Judy Crossing current pumping regime with scenarios using a 24 hr pumping schedule
Figure 10 Judy Crossing future pumping (45% impact) regime with scenarios using a 12 hr pumping schedule
Figure 11 Judy Crossing future pumping (45% impact) regime with scenarios using a 12 hr pumping schedule
Figure 12 Judy Crossing future pumping (100% impact) regime with scenarios using a 12 hr pumping schedule
Figure 13 Judy Crossing future pumping (100% impact) regime with scenarios using a 24 hr pumping schedule
Figure 14 Red Rock historic record regime with scenarios using a 12 hr pumping schedule
Figure 15 Red Rock historic record regime with scenarios using a 24 hr pumping schedule

Note: flows are the minimum for 24hr period
Figure 16 Red Rock current pumping regime with scenarios using a 12 hr pumping schedule
Figure 17 Red Rock current pumping regime with scenarios using a 24 hr pumping schedule

Note: flows are the minimum for 24hr period
Figure 18 Red Rock future pumping (45% impact) regime with scenarios using a 12 hr pumping schedule
Figure 19 Red Rock future pumping (45% impact) regime with scenarios using a 24 hr pumping schedule
Figure 20 Red Rock future pumping (100% impact) regime with scenarios using a 12 hr pumping schedule
Figure 21 Red Rock future pumping (100% impact) regime with scenarios using a 24 hr pumping schedule
Appendix B - Exceedance curves

Judy Crossing

Figure 22 Judy Crossing exceedance curves for 12 hr pumping schedule
Figure 23 Judy Crossing exceedance curves for 24 hr pumping schedule
Red Rock exceedance curves for 12 hr pumping schedule.
Figure 25 Red Rock exceedance curves for 24 hr pumping schedule