Monitoring along tributary WC21 includes water quality, pool water levels, surface flow, observations and recording impact. Monitoring is carried out in accordance with the Dendrobium Area 3B (DA3B) Watercourse Impact, Monitoring, Management and Contingency Plan (WIMMCP).

Flow monitoring is currently located at site WC21S1, approximately 470m downstream from DA3B mining operations (Figure 1). Monitoring is semi-automated, using logged pool depths which are converted to daily flow rates using a rating curve. Daily flow rates at the site have been recorded since June 2012.

At the request of DoPE an additional flow monitoring location has been selected (WC21S2), upstream of Longwall 11 (Figure 1). The location was chosen as the most hydrometrically suitable site in this section of WC21 not yet influenced by subsidence movements. The site captures the surface outflow of a small pool before continuing through a small channel and over a downstream step (Photo 1 and 2).

The location is approximately 115m upstream from Longwall 11. Manual flow monitoring will be carried out in-situ at the site using a Pigmy flow meter. Automated monitoring is not appropriate at the site due to geomorphological conditions. Frequency of flow gaugings will be in line with WIMMCP requirements of nearby monitoring i.e. undertaken on a weekly or monthly basis, depending on the location of the longwall. This will provide approximately 12 months of baseline data, prior to any influence of Longwall 12.

Photo 1: Proposed flow monitoring site WC21S2, looking downstream. Taken on 19/01.2016.

Photo 2: Proposed flow monitoring site WC21S2, looking across stream. Taken on 19/01.2016.

Methodology and Flow Calculation

Manual flow gauging using a Pigmy flow meter requires laminar flow across a relatively smooth cross section of the channel. A measuring tape is placed across the channel, perpendicular to the flow to measure the total width of the cross-section. Verticals are chosen across the width of the channel to obtain suitable representation of the cross-sectional area. The most appropriate sized propeller is chosen based on the depth of the water column. Readings are taken at depths generally according to the following:

Water Column Depth	Readings Taken at:
0-0.04m	Too shallow to gauge
0.4-0.1m	40% of total column depth
>0.1m	20%, 40% and 80% of total column depth

Revolutions of the propeller are recorded at each depth. Results are converted to average velocities for each subsection across the channel.

Calculation of discharge uses the mid-section discharge method. Discharge is the product of the average velocity and the cross-sectional area. The discharge of each subsection is summed to give total discharge of the point.

Q = Σ (v a)

Where:

Q = total discharge

v = velocity of each subsection

a = the individual area of a rectangular subsection

The mid-section method assumes that the velocity sample at each point represents the mean velocity of a rectangular subsection (Rantz et al, 1982). Subsection discharge is calculated using the following equation (Rantz et al, 1982):

$$q_x = v_x \left[\frac{(b_x - b_{(x-1)})}{2} + \frac{(b_{(x+1)} - b_x)}{2}\right] d_x$$

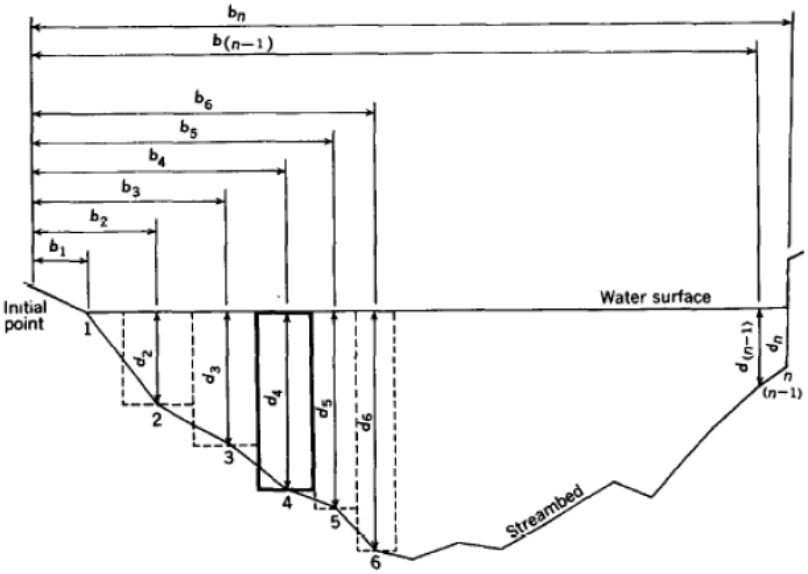
$$= v_x \left[\frac{b_{(x+1)} - b_{(x-1)}}{2}\right] d_x$$

Where:

q_x = discharge through subsection x,
v_x = mean velocity at vertical x,
b_x = distance from initial point to vertical x,
$b_{(x-1)}$ = distance from initial point to preceding vertical
$b_{(x+1)}$ = distance from initial point to next vertical, and
d_x = depth of water at vertical x

For example, the discharge calculation for Subsection 4 (darkened, solid box) in Figure 1 would look like the following (Rantz et al., 1982):

$$q_4 = v_4 \left[\frac{b_5 - b_3}{2}\right] d_4$$



EXPLANATION

1, 2, 3 ..... n	Observation verticals
$b_1, b_2, b_3, \ldots b_n$	Distance, in feet or meters, from the initial point to the observation vertical
$d_1, d_2, d_3, \ldots d_n$	Depth of water, in feet or meters, at the observation vertical
Dashed lines	Boundaries of subsections; one heavily outlined is discussed in text

Flow Data

Monitoring commenced on the 19th of January 2016 with 7 records to date (Table 1). Joint site inspections and measurements have been conducted with Water NSW.

Date	Flow Point	ML/day
19/01/2016	WC21S2	0.2046038
28/01/2016		0.3758918
05/02/216		0.4151347
09/02/2016		0.1585094
11/02/2016		0.2191277
19/02/2016		0.1294272
24/02/2016		0.0687226

References

Rantz, S. E., and others. 1982. Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge. U.S. Geological Survey Water-Supply Paper 2175.

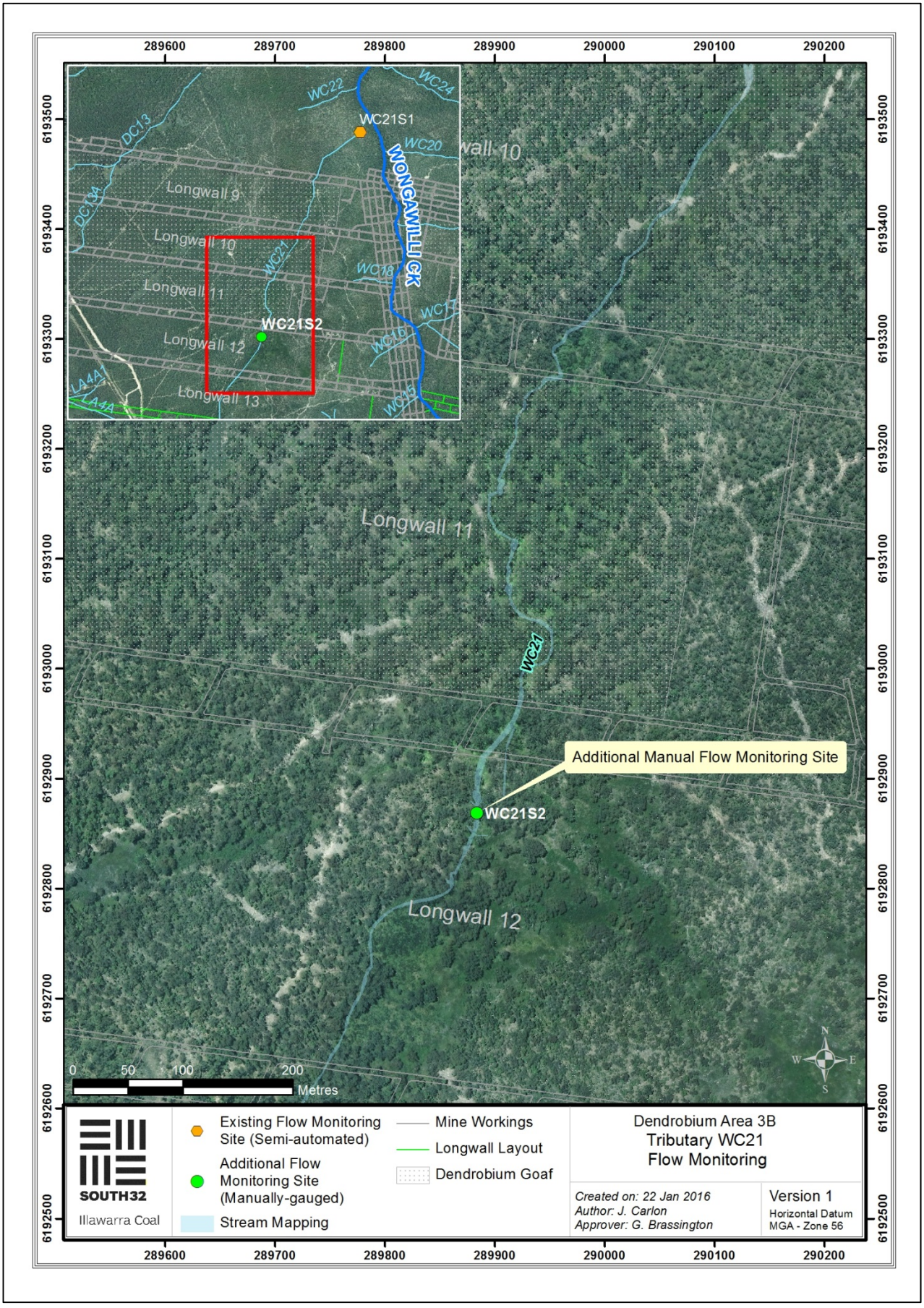


Figure 1: Tributary WC21 showing existing and proposed flow monitoring locations in relation to Dendrobium Area 3B mining operations.