THE UNIVERSITY OF MELBOURNE

Commonwealth Environmental Water Office
Monitoring, Evaluation and Research Program

SOP Stream Metabolism

Standard Operating Procedures
Stream Metabolism v 1.0

27 June 2019

1. Introduction

The Standard Operating Procedure (SOP) for Stream Metabolism describes the purpose of stream metabolism monitoring at selected sites in the lower Goulburn River, how the monitoring will be conducted, who is responsible for specific tasks and how the collected data will be analysed and reported. The document is intended to be taken in the field during any stream metabolism monitoring event for the MER Program and should be updated throughout the life of the Monitoring, Evaluation and Research Program to reflect any agreed changes to method or procedure.

2. Objective and Hypotheses

This monitoring protocol for stream metabolism addresses the following Basin scale evaluation questions:

Short-term (one-year) and long-term (three year) questions:

- What did Commonwealth environmental water contribute to patterns and rates of decomposition?
- What did Commonwealth environmental water contribute to patterns and rates of primary productivity?

The key objective of the stream metabolism monitoring program is to determine the effects of environmental watering actions on the rates of gross primary production (GPP) and ecosystem respiration (ER) within the Goulburn River. These processes support and sustain aquatic foodwebs hence are directly related to ecosystem health and viable fish populations. Important drivers for these processes, notably nutrient, (water column) chlorophyll-a and organic carbon concentrations and light are collected concurrently to allow flow effects to be distinguished from nutrient variations, phytoplankton effects and daily weather fluctuations.

The Area Specific evaluation questions to consider are:

- How does the timing and magnitude of CEW delivery affect rates of GPP and ER in the lower Goulburn River?
- How do stream metabolism responses to CEW in the lower Goulburn River differ from CEW responses in the Edward Wakool system, which is physically different?

We expect that GPP and ER in the lower Goulburn River will respond to environmental flows in the following ways:

1. Under extended 'cease to flow' conditions of several weeks or more (which are extremely unlikely in the lower Goulburn River), the responses of GPP and ER will greatly depend on the available nutrient supplies and the time of year. High nutrients and warm conditions may lead to very high rates associated with excessive phytoplankton growth.
2. Under normal 'base' flow, rates of GPP and ER will be constrained to the low-moderate range, typically 1-5 mg O_2/L/Day.
3. With in-stream freshes, rates of GPP and ER will increase slightly to 3-8 mg O_2/L/Day. Larger increases will occur if significant backwater areas are reconnected to the main channel due to enhanced nutrient delivery.
4. Bankfull flows (although unlikely to be delivered through environmental releases) will lead to moderate increases in rate to 6-10 mg O_2/L/Day. Again, larger increases will occur if significant backwater areas are reconnected to the main channel due to enhanced nutrient delivery.
5. Overbank flows will have a much more dramatic effect on rates. Blackwater events arising from extensive ponding of water on the floodplain during hotter months will lead to extremely high ER rates and possible anoxia. Shorter duration inundation will likely cause stimulation of GPP through a large influx of nutrients. Rates of these processes may exceed 20 mg O_2/L/Day.

In all cases, daily rates will vary according to season, weather conditions and nutrient supply.

3. Indicators

Stream Metabolism is a Category I monitoring indicator for the MER Program. It requires continuous measurement of dissolved oxygen, temperature, surface light (PAR) and barometric pressure at a frequency of a reading every 10 minutes. Additionally, water samples for FRP, NOx, ammonia, TP, TN, Chlorophyll-a and DOC are collected at least monthly during data logger downloads and maintenance. Further adventitious samples will be collected when staff are on-site for other purposes and will especially target flow events. In situ water column light penetration measurements will also be performed concurrently with water sample collection.

Stream Metabolism assessments will also require daily discharge measurements at these sites as well as estimated mean water velocity at each discharge level (to enable estimation of upstream distance integrated by each probe). This distance is a function of water velocity and the re-aeration coefficient; the latter is directly determined from the analysis of the diel oxygen curve from the DO logger.

Daily rates of GPP and ER are extracted from the supplied daytime regression model implemented using a Bayesian framework in R and OpenBUGS software. The model provides estimates of uncertainty in these parameters, plus numerical and visual indicators of 'goodness of fit'.

4. Locations for Monitoring

Stream metabolism will be monitored at two sites in each of Zones 1 and 2.

Site Name	Zone	Zone	Easting	Northing
Murchison	1	55	340787	5946120
Darcy's Track-Gardiner Swamp	1	55	351770	5965722
Loch Gary	2	55	345976	5987892
McCoy's Bridge	2	55	330771	5994884

The Day's Rd site used in the LTIM Project has been replaced for the MER Program by the gauged site at Murchison. This allows more reliable access under all flow conditions and hence minimizes the loss of data from inaccessible probes under extended high flows.

All sites are at existing stream gauging stations. Stream metabolism monitoring using the mandated single-station approach for the MER Program requires a single dissolved oxygen logger per site. Hence daily metabolic parameters will be calculated from these four locations.

The distance upstream integrated by the daily metabolism measurements will be calculated from measurements of mean water velocity and the re-aeration coefficient from the metabolism modelling. This distance is discharge dependent, but is likely to range between 2 and 10 km in the Goulburn River. The selected monitoring sites were in part chosen because there are no major tributaries in the 10 km distance upstream from each probe.

5. Timing and frequency of sampling

Loggers are deployed continuously throughout the year at the Murchison, Darcy's Track, Loch Gary and McCoy's Bridge sites.

During deployments, stream metabolism will be monitored continuously at each site over the three year period, thus providing daily estimates of the metabolic parameters. Measurement of dissolved oxygen, temperature, surface light (PAR) and barometric pressure will be recorded every 10 minutes. Additionally, water samples for nutrient analysis (FRP, NOx, ammonia, chlorophyll-a, TP, TN and DOC) will be collected at least monthly during data logger downloads and maintenance. In addition, as noted above, water samples for these analyses will be collected when staff visit the monitoring sites for other activities, especially during flow events. The need for a strict maintenance, calibration check and possible recalibration means that one day's data is lost per month as the probe is removed from the stream for these activities.

6. Responsibilities and identifying key staff

Field program

Data downloading, calibration checks, probe maintenance, water sample collection and light penetration measurements will be conducted every 4-6 weeks by staff from ALS Environmental. ALS are suppliers of water quality data for the Goulburn Broken Catchment Management Authority under the *Regional Water Monitoring Partnership (RWMP)*. The intermediary between the MER Program and ALS will be Mr Dan Lovell, the Environmental Water Coordinator at the GBCMA.

Laboratory requirements (if any)

All chemical analyses will be undertaken by the ALS laboratory in Melbourne. The laboratory is NATA-accredited for each of the required analyses.

All samples collected will be immediately packed on dry ice in an esky and transported overnight (or sooner) to the laboratory.

The field sheets will provide sample identification and will be provided to the laboratory with the samples. The chain of custody within the lab is part of the NATA accreditation process, so standard laboratory data handling and security procedures through LIMS (Laboratory Information Management System) are already in place. NATA accreditation also mandates analysis-specific QA/QC procedures (e.g. blanks, spike recoveries, duplicates, standard reference materials) and these will all be performed as a matter of standard laboratory operation.

Procedure for transferring knowledge to new team members

This will be handled, if and when required, by ALS.

7. Monitoring Methods

This protocol uses the single station open water method as described in the previous LTIM Standard Operating Procedures Manual and comprises:

- Water level and stream characteristics (available from an established gauging station at each site)
- Discrete water quality samples (chlorophyll-a, total nitrogen, NOx, NH_4^+, total phosphorus, FRP, dissolved organic carbon)
- *In situ* logging within the water column (dissolved oxygen, temperature) at every stream metabolism site
- Logging of photosynthetically active radiation (PAR) and barometric pressure in a nearby terrestrial location, with the potential for a single PAR / barometric pressure station to capture all stream metabolism sites within 100 km.

This protocol is based on the single station open water stream metabolism method as detailed in Grace and Imberger (2006).

In addition, light penetration into the water column will be measured whenever water quality samples are taken. This estimate of light penetration allows GPP to be related to the estimated benthic region where photosynthesis will not be limited by light.

Field Methods (Water quality measurements)

Water quality variables are important for interpreting the stream metabolism results and are an input to the ecological response model for Basin scale evaluation. Water samples are collected for: chlorophyll-a, total nitrogen (TN), total phosphorus (TP), nitrate-nitrite (NOx), ammonium (NH_4), filterable reactive phosphorus (FRP) and dissolved organic carbon (DOC). In-situ spot measurements are taken for pH, turbidity and electrical conductivity (EC). These samples will be taken monthly as part of the regular spot water quality sampling undertaken by ALS. The visits will not necessarily correspond with the times when oxygen loggers are serviced, but will be done at a greater frequency required than from the LTIM/MER standard method.

Equipment

- Sample containers and appropriate preservatives (sourced from laboratory)
- 0.2 µm filters and suitable filtering device (e.g. syringe filter) for dissolved nutrients and carbon
- 47 mm glass fibre (GFC) filters and suitable filtering device for chlorophyll-a
- Pre-calibrated Water quality meter with pH, turbidity and electrical conductivity probes
- Deionised water for sample blanks
- Eskies and ice for sample preservation and storage; dry ice for sample transport to the laboratories.
- Datasheets and/or field computer
- Chain of custody sheets
- Copy of this protocol

Protocol

1. Surface water samples are collected at the time of DO logger downloads and at any other adventitious time when the site is visited. Surface water samples are collected close to the logger deployment location, avoiding near shore artefacts.

2. Avoid surface films, but if present, a description should be entered onto the field sheet.

3. Filtering for dissolved nutrients (NOx, NH_4^+, FRP, DOC) and chlorophyll-a must take place on site as samples are collected.

    - The syringe, filter and receiving bottle should all first be rinsed with a small volume (e.g. 5 mL) of the water sample. This filtered washing is then discarded. The filtered sample for analysis is then collected. The NATA-accredited laboratory will advise on the volume they require for analysis.

    - If the water is extremely turbid, a prefilter (e.g. GFC) may be used.

4. Samples must be stored on dry ice for transport to laboratories.

Field Methods (Stream Metabolism)

Stream metabolism measures for temperature, dissolved oxygen, light (PAR) and barometric pressure are logged at ten-minute intervals. Loggers are deployed continuously, or in the case of non-permanent river sites, for the period that the river is flowing. Consideration must be given to maintenance, cleaning and battery life and details of the length of deployment is provided in Monitoring, Evaluation and Research Plan.

Equipment

- Dissolved oxygen and temperature sensors with an integrated logger using optical (fluorescence) DO measurement. This equipment will be supplied through the RWMP.

- PAR sensor and logger (e.g. DataFlow Odyssey). The sensor will be calibrated against a laboratory-based sensor reading in µEs/m^2/s across the full range of PAR expected throughout a bright summer's day.

Protocol

<u>Preparation</u>
As per standard ALS protocols for the RWMP.

<u>Field method – PAR, barometric pressure</u>

1. Establish a suitable location, above the area likely to be inundated and in a clear open (unshaded) area. This could be a nearby paddock. Note that on private property locations a fence post near gate access may be suitable.
2. Secure PAR logger to existing structure or if necessary, a newly placed star picket.
3. Set loggers to read at 10 minute intervals.

Field method – water column measures

As per standard ALS protocols for the RWMP. This includes probe calibration checks and recording of probe calibration completion.

In addition, light penetration measurements will be taken with a vertically aligned 2pi PAR sensor at two depths in the water column: 1) The sensor is just submerged below the water surface; 2) at a depth of 1.0 m.

Laboratory methods

The NATA accredited laboratories will perform the requisite chemical analyses using their standard methods with all appropriate QA/QC.

8. Data Analysis and Reporting

This method adopts the approach of determining gross primary production (GPP), ecosystem respiration (ER) and reaeration rate (K_{O2}) from the diel dissolved oxygen curves using the daytime regression model reviewed by Kosinski (1984). A statistical model to evaluate these parameters, 'BASEv2' – BAyesian Single-station Estimation – will be used in MER and is the same model used for the LTIM Project. The model (Grace et al. 2015) was updated during 2016 in accordance with methodological recommendations contained within Song et al. (2016).

The model requires data for dissolved oxygen in mg O_2/L, temperature, PAR and barometric pressure (in atmospheres) at 10 minute intervals. The salinity also needs to be entered. This will be approximated as 0 unless the electrical conductivity increases above 500 µS/cm, in which case salinity = 6 x 10^{-4} x EC (Based on conversion factor of 1 µS/cm = 0.6 mg/L TDS). The program provides estimates of GPP and ER in mg O_2/L/Day with uncertainties for each and goodness of fit parameters.

Subsequent data analysis involves correlating the daily estimates for the two metabolic parameters with the collected explanatory variables (nutrients, DOC, chlorophyll-a, light) as well as daily discharge and season.

Reporting will involve compilation of metabolic rates (primary production and respiration), reaeration coefficients, discharge and PAR on a daily basis and water quality and nutrient concentrations when collected. Diel profiles of water temperature, PAR and dissolved oxygen concentrations will be added to the same MDMS database used in the LTIM Project as the primary data resource.

9. References

Grace M, Imberger S (2006) Stream Metabolism: Performing and Interpreting Measurements, Monash University.

Grace MR, Giling DP, Hladyz S, Caron V, Thompson RM, Mac Nally R (2015) Fast processing of diel oxygen curves: estimating stream metabolism with BASE (BAyesian Single-station Estimation). Limnology & Oceanography: Methods, 13, 103-114.

Kosinski RJ (1984) A comparison of the accuracy and precision of several open-water oxygen productivity techniques. Hydrobiologia, 119, 139-148.

Song C, Dodds WK, Trentman MT, Rüegg J, Ballantyne F (2016) Methods of approximation influence aquatic ecosystem metabolism estimates. Limnology and Oceanography: Methods, 14, 557–569.

angus.webb@unimelb.edu.au