A Quality Assurance Framework for the Wet Tropics Major Integrated Project Water Quality Monitoring Programs

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1 Introduction

The application of a Quality Assurance framework for monitoring programs is essential for the delivery of robust and reliable information that reflects the level of investment in the monitoring. The Wet Tropics Major Integrated Project, being delivered by Terrain NRM, has established Catchment Repair and Local Scale Monitoring programs. The WTMIP water quality monitoring programs were designed to collect representative water quality information representative of different landscapes, practices and treatments across the Johnstone and Tully regions. In addition, the programs are collecting data on a range of catchment and industry characteristics that are not only useful to the program but to stakeholders associated directly with the MIP and those involved in understanding the broader scale implications of the program.

Given the level of importance of this information and its applicability to a wide range of stakeholders, there needs to be a clear framework that ensures the quality, timeliness and representativeness of monitoring and sampling activities. This framework also needs to align and complement other activities in the MIP and through Terrain NRM's other activities and initiatives.

2 The QA Framework

An initial framework was developed in collaboration with the monitoring teams and further refined to produce the figure below. This outlines the key elements in this document. The intention of this framework is to highlight key focus areas, the elements that need to be quality assured and the processes by which these are to be undertaken. This framework and the document are not meant to be static, but should be updated through a continuous improvement process as each of the elements are applied.

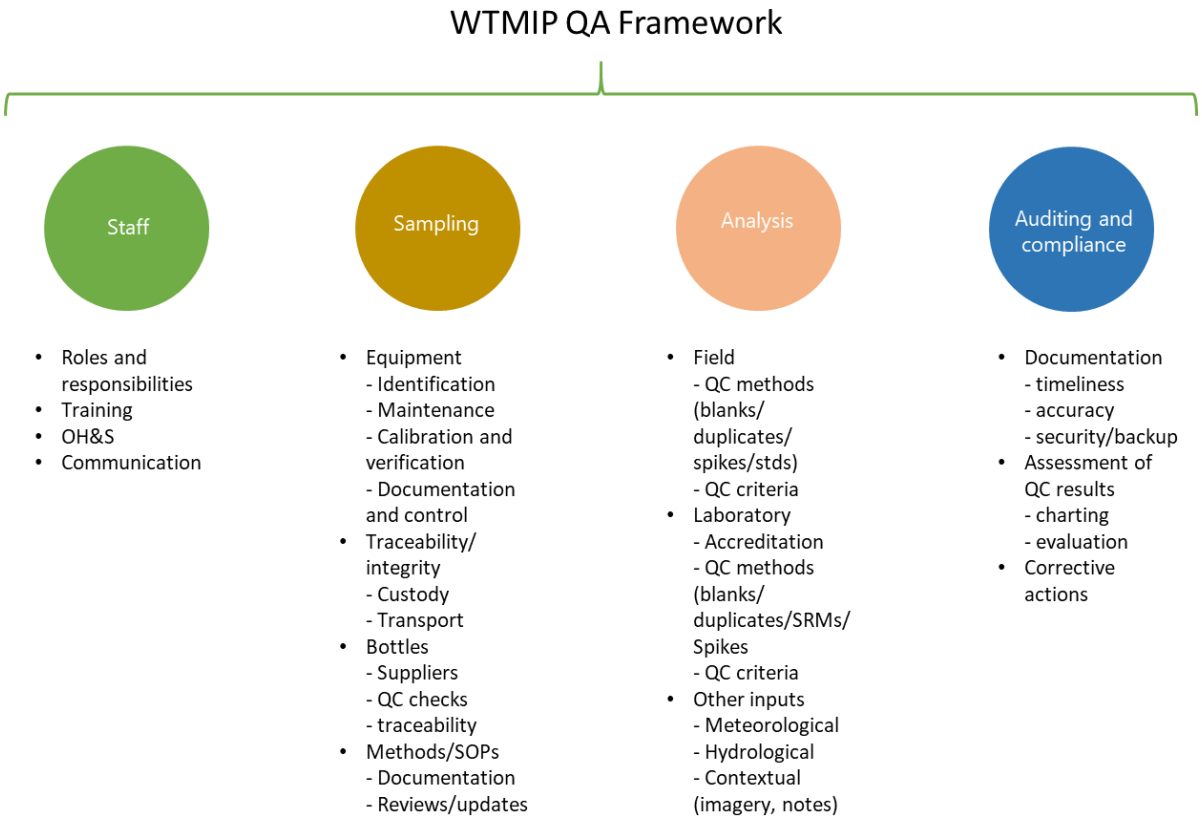


Figure 1. *QA Framework*

3 Staff

This section outlines the human resource elements of the monitoring program and how these all support ongoing quality assurance.

3.1 Roles and responsibilities

The Wet Tropics Major Integrated Project (MIP) program structure is outlined in the figure below. This shows linkages with other MIP programs.

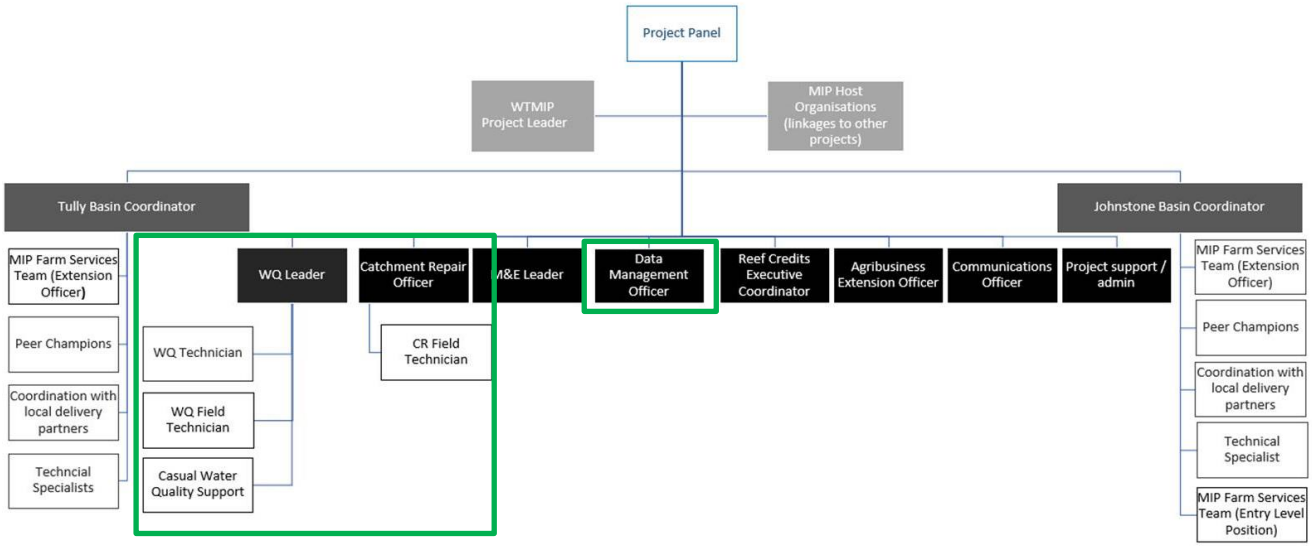


Figure 2. *MIP program structure (highlighting water quality monitoring key personnel)*

MIP Project Leader

The MIP Project Leader provides direction to, and oversight of, the MIP water quality monitoring activities and ensures resources are available for the implementation and continued development of the monitoring programs.

MIP Water Quality Leader

Overall direction, Laboratory liaison, Contracts and procurement, Training, Site Access, QC Assessment

This role specifies the direction, budget control and reporting for the monitoring program, and is also ultimately responsible for the implementation of the QA framework. Also, this role has the responsibility of laboratory liaison (for quality control requirements), contracts and procurement (that ensures that only quality assured suppliers are used), training and site access agreements. This role reports to the MIP Project Leader and Project Panel.

Catchment Repair Officer

Treatment Systems monitoring

The monitoring program includes the monitoring of catchment repair treatment systems currently being implemented by the MIP. This role therefore is responsible for the monitoring and evaluation of these treatment systems.

MIP Water Quality and Catchment Repair Technicians

Sampling program, QC Assessment, Equipment Maintenance

This role ensures the overall sampling program is implemented when required, including ensuring that equipment, bottles and laboratory resources are ready and available when required. They also have responsibilities to ensure that all equipment is maintained, within calibration and is regularly checked.

Data Management Officer – Data management systems, automated QC assessment
As part of data management, a dedicated role ensures that the development and maintenance of the data management system and automation of the QC results are performed and flagged appropriately.

Water Quality Technical Advisory Group
A group of technical specialists which supports WTMIP water quality monitoring activities by:

- Assisting with developing key networks in the water quality sector;
- Assisting with integration of WTMIP monitoring with other monitoring projects in the region;
- Sharing learnings about what has worked and what hasn't to date in the region including choice of equipment, sampling techniques, analysis and landholder engagement;
- Providing advice and assistance in developing the Local Scale Monitoring and implementing the action plan; and
- Providing mentoring support for the Local Scale Monitoring Team.

3.2 Training

Competencies for all field staff are mandatory for the following training programs:

- First Aid (Provide First Aid including CPR course number HLTAID003, delivered by First Aid Academy)
- Biosecurity (Panama TR4 training delivered by Biosecurity Queensland, Department of Agriculture and Fisheries)
- Four Wheel Driving (Level 1 4WD Advanced Training including winch operation delivered by Pro Drive Safe Cairns)
- Wildlife awareness (delivered by Conservation & Sustainability Services, Department of Environment and Science)
- Water quality sampling training (Quality assurance and quality control procedures for sampling in the Great Barrier Reef Catchment Loads Monitoring Program delivered by Water Quality and investigations, Environmental Monitoring and Assessment Science, Department of Environment and Science)
- SPOT Tracker use (in-house training based on internal policy and procedure).

These competencies are required prior to undertaking any monitoring program tasks, however when working in pairs and new staff members haven't completed all training, it will require at least one of the staff members to have completed the required competencies.

Any deviations from these training programs which may occur through on the job training are to be included in the relevant Standard Operating Procedure (SOP) for the particular task.

3.3 Occupational Health and Safety

Notwithstanding any other legal obligations, overall health and safety compliance for the program is covered within Terrain's Health and Safety Policies Manual. A risk assessment for MIP water quality monitoring has been completed for the program following the process outlined in the Manual with additional risk assessments undertaken as needed for tasks that fall outside the overarching water quality monitoring risk assessment.

Figure 3. *Terrain Health and Safety Manual*

3.4 Communication

Communication of data, results and quality control outcomes should always be through the MIP Water Quality Leader and/or Catchment Repair Officer unless otherwise delegated. Any delegations should be documented within this framework as part of the update process.

The level of information being obtained by the program is significant and not all parameters are required by the project team. It is likely that numerous requests for access to data and reports may be expected as the program progresses. All communications around access should be directed through the MIP Water Quality Leader and/or Catchment Repair Officer to ensure that suitable data sharing agreements are in place.

4 Sampling

The majority of the monitoring program effort requires the collection of samples in the field and transport of these to an analytical laboratory (currently Cairns Regional Council's laboratory with some analyses subcontracted to the Queensland Health and Forensic Science Services laboratory). The QA framework therefore has to ensure that proper quality assurance and quality control processes are outlined and documented as set out below.

4.1 Equipment

Identification
All equipment used in sampling should have a clear, unique identification tag and if operational should be clearly located in an area of workspace for operational equipment only. Non-operational equipment needs to be segregated and clearly labelled as out of use. Printed "Out of service" tags should be added to non-operational equipment and for those with potential repairs or damage should also have a "Danger" tag added to them.

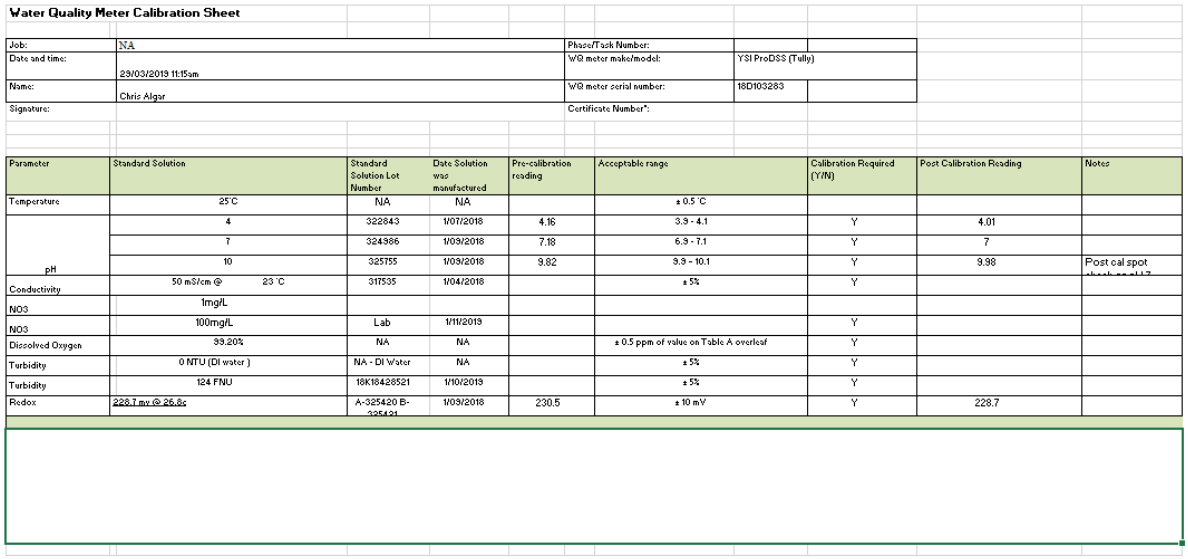
Currently, operational equipment is stored predominantly at the Terrain Tully and Cairns offices, with some gear held temporarily in the storeroom at the Innisfail Terrain office depending on operational needs.

Currency
All equipment needs to be audited on a regular basis to ensure it is still suitable for the required task. This will occur at least once per year or on next use, whichever is the longer. When a device or piece of equipment is no longer suitable, it is to be clearly labelled as out of use and segregated as noted above.

Maintenance
The maintenance of all field-based equipment, including any analytical instruments, is to be recorded electronically in the relevant spreadsheet and saved to SharePoint. These maintenance records are separate to any instrument calibration records, but should be retained in the same spreadsheet. Separate spreadsheets for the Local Scale Monitoring and Catchment Repair Monitoring programs have been prepared and contain all records of maintenance for all equipment. These are centrally stored and available to all monitoring staff when in the office or in the field.

Field instrument calibration
Each field instrument is to be calibrated in accordance with manuals (e.g. ProDSS, EXO2 and TriOS) or either monthly or prior to first use on the sampling event. For some instruments and depending on the length of the sampling event, regular checks with a single calibration standard may need to be performed a number of times per day, especially when in hot or wet weather where changes in temperature and/or humidity may be rapid (from inside to outside of a motor vehicle for example).

Records of each calibration are required for each instrument and entered manually in the calibration spreadsheet (as shown in the spreadsheet example below) or generated automatically by the calibration software. All records are to be stored on SharePoint. Where instrument data is not able to be saved electronically, a record that the calibration has been completed will still need to be kept, in addition to any notes regarding instrument and calibration performance.



Water Quality Meter Calibration Sheet

Job:	NA	Phase/Task Number:	
Date and time:	29/03/2019 11:15am	WQ meter make/model:	YSI ProDSS (Tully)
Name:	Chris Algar	WQ meter serial number:	18D103283
Signature:		Certificate Number*:	

Parameter	Standard Solution	Standard Solution Lot Number	Date Solution was manufactured	Pre-calibration reading	Acceptable range	Calibration Required (Y/N)	Post Calibration Reading	Notes
Temperature	25°C	NA	NA		± 0.5 °C			
pH	4	322843	1/07/2018	4.16	3.9 - 4.1	Y	4.01	
	7	324386	1/09/2018	7.18	6.9 - 7.1	Y	7	
	10	325755	1/09/2018	9.82	9.9 - 10.1	Y	9.98	Post cal spot
Conductivity	50 mS/cm @ 23 °C	317535	1/04/2018		± 5%	Y		
NO3	1mg/L							
NO3	100mg/L	Lab	1/11/2019			Y		
Dissolved Oxygen	99.20%	NA	NA		± 0.5 ppm of value on Table A overleaf	Y		
Turbidity	0 NTU (DI water)	NA - DI Water	NA		± 5%	Y		
Turbidity	124 FNU	18K18428521	1/10/2019		± 5%	Y		
Redox	228.7 mv @ 26.8c	A-325420 B-325421	1/09/2018	230.5	± 10 mV	Y	228.7	

Figure 4. *YSI ProDSS Calibration Sheet*

In-situ monitoring devices

For in-situ monitoring devices, it may be more difficult to perform regular calibrations due to the placement of devices. As such, calibration checks must be performed on installation, and at least once per month for each device. In addition, regular performance checks should be performed on at least a weekly basis to evaluate instrument drift, sensor irregularities, loss of signal etc. Thresholds and limits are set on eagle.io to trigger automated alert messages (via text and email) to notify water quality technicians of anomalies in the logged data. Refer to *WTMIP SOP 014: Management of telemetered water quality data on eagle.io* for further information.

On-site equipment checks should also be performed during each sampling event, or not less than once per month to check on the installation condition, including checks for damage, interference, debris or associated issues that may compromise the quality of the recorded data. The device sensors may need to be cleaned and validation samples collected.

4.2 Standard Operating Procedures

Procedures

The process of sampling is largely consistent with the Queensland Government's Monitoring and Sampling Manual (DES 2018) and is detailed in the following SOPs:

WTMIP in prep, WTMIP SOP 001: Wet Tropics Major Integrated Project, Local Scale Monitoring Program: Monitoring design overview and rationale – DRAFT

DES & WTMIP 2018. DES FM001 (WTMIP SOP 002): Manual water quality sampling for total suspended solids and nutrients

DES & WTMIP 2018. DES FM006 (WTMIP SOP 003): Manual water quality sampling for pesticides

WTMIP in prep, WTMIP SOP 004: Operation and maintenance of rising stage samplers for the collection of water quality samples during stream flow events - DRAFT

WTMIP in prep, WTMIP SOP 005: Operation and maintenance of YSI ProDSS hand-held water quality meter - DRAFT

WTMIP in prep, WTMIP SOP 006: Sampling piezometers for water quality analysis - DRAFT

WTMIP in prep, WTMIP SOP 007: Paddock surface water monitoring for nutrients, total suspended solids and pesticides - DRAFT

WTMIP in prep, WTMIP SOP 008: Washing intermediate sample containers used in paddock surface water and stream monitoring - DRAFT

WTMIP in prep, WTMIP SOP 009: Operation and maintenance of NECi photometers for field-based nitrate measurement - DRAFT

WTMIP in prep, WTMIP SOP 010: Operation and maintenance of TriOS OPUS and TriOS NICO optical nitrate sensors - DRAFT

WTMIP in prep, WTMIP SOP 011: Operation and maintenance of YSI EXO2 multiparameter sonde for in-stream high-frequency water quality monitoring - DRAFT

WTMIP in prep, WTMIP SOP 012: Operation and maintenance of in stream hydrological instruments - DRAFT

WTMIP in prep, WTMIP SOP 013: Operation and maintenance of tipping bucket rain gauge and Maximet compact weather station - DRAFT

WTMIP in prep, WTMIP SOP 014: Management of telemetered water quality data on eagle.io – DRAFT

WTMIP in prep, WTMIP SOP 015: Sampling Full-Stops for water quality analysis – DRAFT

WTMIP in prep, WTMIP SOP 016: Management of WTMIP data using EnviroSys and SharePoint - DRAFT

Where a method has not been formally documented as an SOP, the process followed should be as per any documented instruction manuals and these also recorded here as being a formal SOP until otherwise updated. Any draft SOP should be issued with an SOP code and date and clearly marked as DRAFT. Where a draft SOP is intended to replace an existing SOP, this should be clearly stated in the front of the draft SOP and also the above list updated accordingly.

SOPs are prepared by members of the WTMIP team and externally reviewed by at least one technical expert. Final approval for the adoption of each SOP is provided by the WTMIP Project Manager. All contributions to each SOP are recorded in the version control table at the back of the document.

Review process
All SOPs will be audited on a yearly basis where the actual practices being undertaken are evaluated against the method while sampling is being conducted. Where there is inconsistency between actual practice and the SOP, guidance should be sought immediately from the Water Quality Leader as to whether an update of the SOP is required, or whether this requires the sampler to be more consistent with the SOP. Where there is uncertainty as to how best to proceed, reference should be made back to the Queensland Government's monitoring and sampling manual (DES 2018) with ultimate guidance being based on *AS/NZS 5667.1:1998 (R2016) Water quality – Sampling – Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples*.

4.3 Integrity

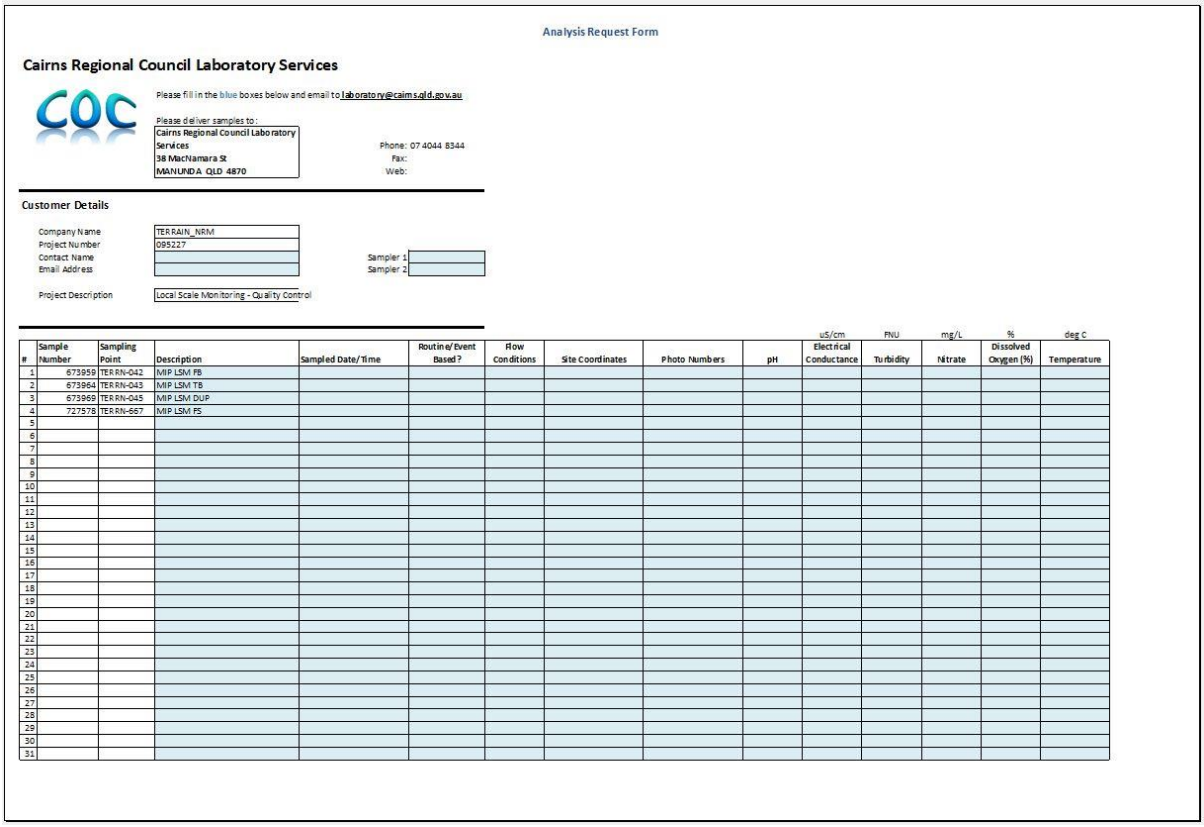
The WTMIP Monitoring Program is designed to collect representative information of landscapes, practices and treatments across the Johnstone and Tully regions. Given the wide range of uses this data may support, it is essential that the samples can be shown to be representative of the processes they are being used to evaluate. To do this, it is not only necessary to show that the samples have been collected appropriately using SOPs, but that they are collected in suitable vessels, transported to analytical laboratories correctly, and the quality of the whole sampling procedure verified through appropriate quality control checks.

Bottle request process and documentation

Prior to each sampling event, monitoring staff will be responsible for contacting the laboratory and ordering suitable sample bottles for the required analytes. The laboratory will provide the appropriate bottles from previously prepared batches which are pre-labelled with the relevant project number, site names and bottle numbers. The Chain of Custody (CoC) specific to that bottle pack is also emailed to monitoring staff and should be recorded in the relevant sampling spreadsheet (see further below).

Chain of custody

A CoC form is to be used for all sampling activities where those samples are being transferred to another party (i.e. couriers, laboratory, other sampling staff) so that if any quality control issues arise, reference can be made back to how the samples were transferred from the point of collection to the point of analysis. The CoC also captures important metadata such as field observations, information on sample preservation/storage conditions and notes regarding why a sample was not collected. An example of this sheet is shown below.



Analysis Request Form

Cairns Regional Council Laboratory Services

Please fill in the blue boxes below and email to laboratory@cairns.qld.gov.au

Please deliver samples to:
Cairns Regional Council Laboratory Services
38 MacNamara St
MANUNDA QLD 4870

Phone: 07 4044 8344
Fax:
Web:

Customer Details

Company Name: TERRAIN_NRM
Project Number: 095227
Contact Name:
Email Address:
Sampler 1:
Sampler 2:

Project Description: Local Scale Monitoring - Quality Control

#	Sample Number	Sampling Point	Description	Sampled Date/Time	Routine/Event Based?	Flow Conditions	Site Coordinates	Photo Numbers	pH	uS/cm Electrical Conductance	FNU Turbidity	mg/L Nitrate	% Dissolved Oxygen (%)	deg C Temperature
1	673959	TERRN-042	MIP LSM FB											
2	673964	TERRN-043	MIP LSM TB											
3	673969	TERRN-045	MIP LSM DUP											
4	727578	TERRN-667	MIP LSM FS											
5														
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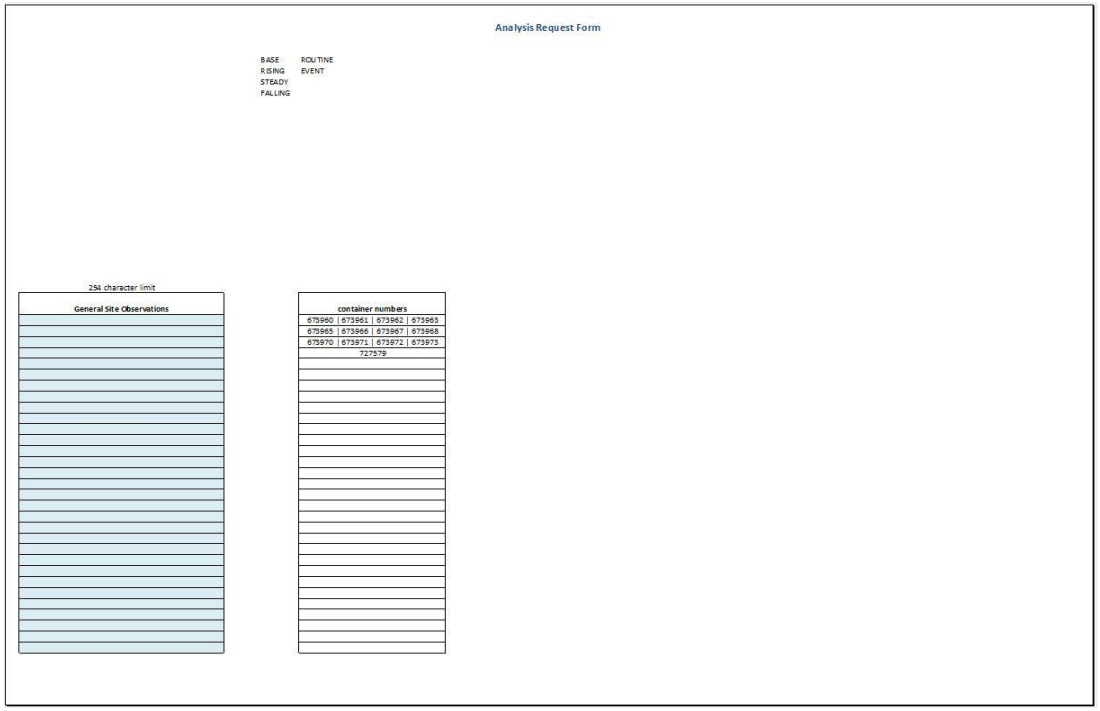


Analysis Request Form

BASE
RISING
STEADY
FALLING

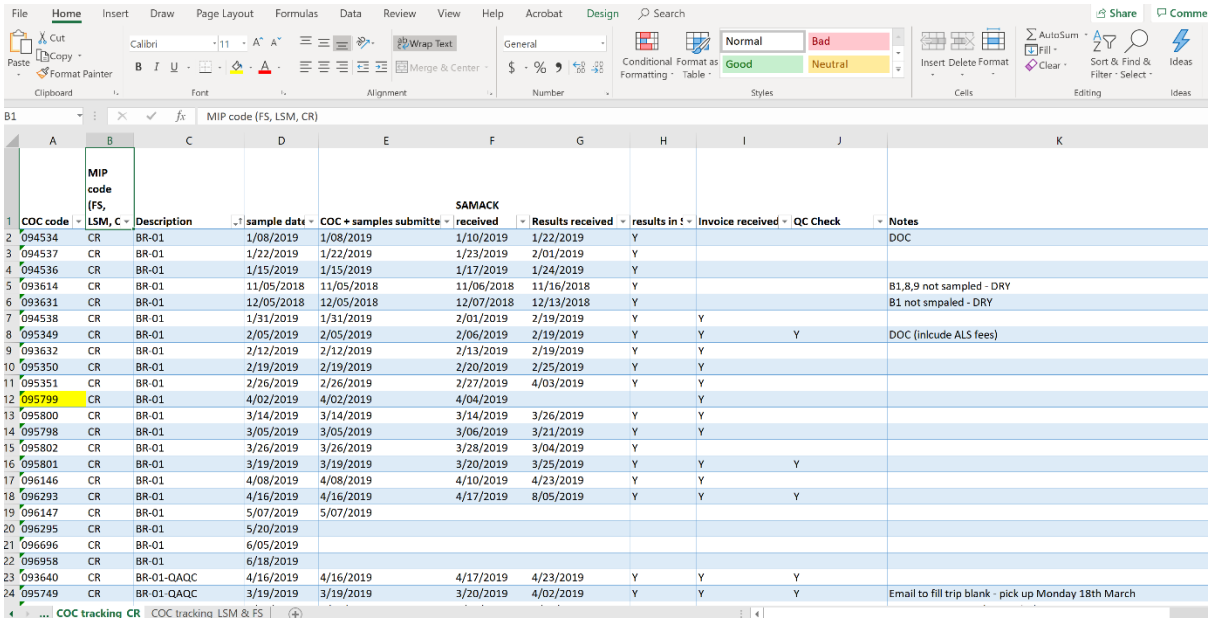
ROUTINE
EVENT

254 character limit

General Site Observations

container numbers
673960 | 673961 | 673962 | 673963
673965 | 673966 | 673967 | 673968
673970 | 673971 | 673972 | 673973
727579

A unique number is assigned to each CoC form and this is to be recorded in the sampling spreadsheet '_MIP_WQ_Sampling Info_MASTER' which is saved under 'Data Storage' in the MIP project area on SharePoint. An example of this sheet is shown below.



	COC code	MIP code (FS, LSM, C	Description	sample date	COC + samples submitte	SAMACK received	Results received	results in S	Invoice received	QC Check	Notes
2	094534	CR	BR-01	1/08/2019	1/08/2019	1/10/2019	1/22/2019	Y			DOC
3	094537	CR	BR-01	1/22/2019	1/22/2019	1/23/2019	2/01/2019	Y			
4	094536	CR	BR-01	1/15/2019	1/15/2019	1/17/2019	1/24/2019	Y			
5	093614	CR	BR-01	11/05/2018	11/05/2018	11/06/2018	11/16/2018	Y			B1,8,9 not sampled - DRY
6	093631	CR	BR-01	12/05/2018	12/05/2018	12/07/2018	12/13/2018	Y			B1 not smpaled - DRY
7	094538	CR	BR-01	1/31/2019	1/31/2019	2/01/2019	2/19/2019	Y	Y		
8	095349	CR	BR-01	2/05/2019	2/05/2019	2/06/2019	2/19/2019	Y	Y	Y	DOC (inlcude ALS fees)
9	093632	CR	BR-01	2/12/2019	2/12/2019	2/13/2019	2/19/2019	Y	Y		
10	095350	CR	BR-01	2/19/2019	2/19/2019	2/20/2019	2/25/2019	Y	Y		
11	095351	CR	BR-01	2/26/2019	2/26/2019	2/27/2019	4/03/2019	Y	Y		
12	095799	CR	BR-01	4/02/2019	4/02/2019	4/04/2019			Y		
13	095800	CR	BR-01	3/14/2019	3/14/2019	3/14/2019	3/26/2019	Y	Y		
14	095798	CR	BR-01	3/05/2019	3/05/2019	3/06/2019	3/21/2019	Y	Y		
15	095802	CR	BR-01	3/26/2019	3/26/2019	3/28/2019	3/04/2019	Y			
16	095801	CR	BR-01	3/19/2019	3/19/2019	3/20/2019	3/25/2019	Y	Y	Y	
17	096146	CR	BR-01	4/08/2019	4/08/2019	4/10/2019	4/23/2019	Y	Y		
18	096293	CR	BR-01	4/16/2019	4/16/2019	4/17/2019	8/05/2019	Y	Y	Y	
19	096147	CR	BR-01	5/07/2019	5/07/2019						
20	096295	CR	BR-01	5/20/2019							
21	096696	CR	BR-01	6/05/2019							
22	096958	CR	BR-01	6/18/2019							
23	093640	CR	BR-01-QAQC	4/16/2019	4/16/2019	4/17/2019	4/23/2019	Y	Y	Y	
24	095749	CR	BR-01-QAQC	3/19/2019	3/19/2019	3/20/2019	4/02/2019	Y	Y	Y	Email to fill trip blank - pick up Monday 18th March

Figure 5. *Sampling spreadsheet.*

Sample Identification process

Each sample is to be identified with a unique sample number. This is supplied by the laboratory as a batch or reference number and prelabelled in most cases.

5 Analysis

5.1 Field

Quality Control samples
There are a range of quality control samples required to ensure that the samples collected are free from contamination and representative of the processes or environments being sampled. As a minimum, the following quality control samples are required:

- *Trip blanks*: In each batch of samples, at least one bottle is to be retained as a trip blank for each sampling event (e.g. if two different sampling officers are travelling in separate vehicles for the same sampling event, then at least one trip blank should be used per vehicle). This bottle should be supplied by the laboratory and filled with reagent grade/ultra-pure MilliQ water, then transported in the same manner as samples being collected during the sampling event. This is to ensure the integrity of the transport process.
- *Field blank*: At least once per quarter per sampler, a field blank should be prepared, following the standard sampling procedure for each analyte, using MilliQ water provided by the laboratory. This is to check the cleanliness of the sampling procedure and the sampler's technique.
- *Known references (trip spike)*: At least once per quarter, a sample of known concentration should be subjected to the sample storage and transport process used in the WTMIP. This can be through spiking a sample bottle of natural stream water with a known amount of an analyte or analytes of interest (pre-prepared by the QLD Government, Department of Environment and Science, Water Quality and Investigations team). Ideally, this spike would be prepared from a multi-analyte certified reference material (CRM) with analytes of interest in similar concentration ranges to those expected in the samples. The spike sample is not opened at all during the sampling run. This is to ensure integrity of the whole sampling process, such that the known quantities are properly preserved and recovered to appropriate levels (typically 85-105% recovery) in the laboratory. This should be prepared by the laboratory already spiked, then this will cover the integrity of the storage and transport components of the process.
- *Replicates*: For at least every 20 samples, a replicate (sampling the same point twice) should be collected for the analytes of interest. These bottles should also transported in the same manner as other samples being collected during the sampling event. This is to ensure the integrity of the field sampling process and for assessing the performance of laboratory analysis.
  For rising stage samplers, at least one sample per runoff event (not at each rising stage sampler) should be split into a duplicate (if sufficient sample volumes are present). If insufficient volume is available for all analytes, then at least a duplicate for those analytes that can be assessed is still suitable.

For each sampling event, quality controls are to be checked within one week of receipt of results from the laboratory such that any issues can be flagged and samples submitted to the laboratory for re-analysis if required.

Table 1. *QC Sample requirements*

QC Sample	Number to be collected
Trip blanks	1 per sampling run for each vehicle/sampler on each sampling occasion.
Field blank	4 per regular sampler per year (2 during ambient conditions, 2 during wet conditions).
Trip spike	4 per year (2 during ambient conditions, 2 during wet conditions).
Replicates	At least 24 per year. 1 every routine run (i.e. x 12) and at least 12 during events over the course of the year (i.e. approximately half during ambient condition events and half during wet condition events). 1 per runoff event (rising stage samplers).

Detection limits and Levels of Reporting
For each field instrument and in-situ device, detection limits and levels of reporting should be determined prior to first use. In most examples, the limits provided by manufacturers are not likely to be reliable and checks of instrument performance will need to be undertaken prior to first use. Procedures for this should be obtained from the manufacturer of the instrument.

5.2 Laboratory

All samples are to be analysed by a NATA accredited laboratory which has accreditation and signatories for all analytes of interest.

Quality control checks performed within the laboratory for the analytes of interest should be reported with each batch of samples, including analyte recoveries, blank and duplicate results (these are different to the QC samples submitted by the sampling team). If a failure of internal QC occurs during analysis of the sample batches, this is to be reported by the laboratory to the Water Quality Leader immediately and re-analysis undertaken. Note that the turnaround on this QC analysis needs to be less than two weeks, as samples are only held by the laboratory for two weeks from issue of their final report. Key areas for evaluation would be:

- Recoveries of known quantities (should be between 85-115% recovery for most analytes)
- Results of duplicates/replicates (should be within +/- 10% but also following the replicate acceptance flow chart (see Figure 6)
- Calibration results (if supplied)

5.3 Other inputs

Field monitoring equipment may also be used to collect supporting data other than just water quality information. This may include meteorological and hydrological information. In all cases, this equipment should be subject to similar testing and checking procedures as for the in-situ monitoring devices, including calibration, checking of instrument performance, and checking of device condition as outlined above. For current field-based equipment, this is yearly.

6 Auditing and compliance

6.1 Documentation

This quality assurance framework is one of a number of documents that are used to manage the WTMIP water quality monitoring programs. As part of the QA process, these documents need to be reviewed and assessed on at least an annual basis or whenever there is significant change in procedures (i.e. more than 10% change in documentation). The review process entails reading through the document by one or more team members familiar with the actions in the document to identify where there are deviations from the documented processes and the documents updated accordingly. Any changes are to be noted in the document control table at the back of each document, noting sections which have changed, the dates of the changes and who approved the changes. These changes also need to be communicated to all monitoring staff who use these documents.

Separate to this update process, an audit of current methods/SOPs should be conducted also on a yearly basis to evaluate whether the SOPs are being followed correctly, or if not, whether they need to be updated to reflect current practice or the staff retrained in the SOPs.

6.2 Information security and backup

All CoCs, SOPs and results are currently stored on SharePoint which are remotely backed up. Routine checking of archived documents and results should be completed on a quarterly basis. At least one results file and one SOP should be retrieved from archive to check that the process is working satisfactorily.

6.3 Assessment of QC results

In the development of a QA and QC process, assessment of quality control samples in a timely manner is essential in order to respond to any quality issues. If left for too long, it may be that the original samples are no longer able to be re-analysed because they have been discarded or not stored properly after analysis. To achieve this, a repeatable process to assess each QC sample type is required. Set out below are criteria for assessing QC samples and corrective actions to be taken in the case of QC failure. These are based on the requirements of *AS/NZS 5667.1.1998, Standard Methods for the Analysis of Water and Wastewater* (APHA, AWWA, WEF).

Table 2. *Quality codes and acceptance criteria*

Quality Codes	
A	The result is the best available given the technology, techniques and monitoring objectives at the time of classification.
B	The result is compromised in its ability to represent the parameter accurately because the bottle and/or procedural blanks indicated contamination
C	The result is compromised in its ability to represent the parameter accurately because the recovery of known quantities was non-optimal
D	The result is compromised in its ability to represent the parameter accurately because duplicate analysis did not provide sufficient reproducibility
E	The result is an estimate only due to the failure of two quality control criteria
F	The results should not be used due to the failure of more than two quality control criteria

Key QC sample types are:

Blanks – including bottle blanks, field blanks and travel blanks (in the case of this monitoring program, one combined trip blank sample is used to represent the bottle and travel blanks, and a field blank is used to assess the cleanliness of the sampling procedure)

Known quantities – including reference materials, spikes or standards (WTMIP QC samples)

Duplicates and replicates – where the same sample is either split into two separate samples (duplicate) or two separate samples are collected from the same point (replicate).

Process
The following assessment process is to be used for evaluating pass/fail of quality control samples:

If a batch of samples passes all quality control criteria, these should be considered suitable for use and assigned quality control code **A**.

Blanks

All analytes should record results less than the LOR (level of reporting). Where a result is obtained that is greater than the LOR then the blank should be retested. If the result is still greater than the LOR, then the batch of samples associated with that blank (e.g. from the same batch of bottles provided by the laboratory, from the same cooler used to transport samples in which the blank was travelling) should be considered potentially contaminated. These should be assigned quality code **B**.

Known quantities

All analytes should be within recovery ranges of 85-115% where greater than 10 times the LOR. Where a result is obtained that is outside of these criteria, the quality control sample should be retested. If the analyte recovery is still outside of these criteria, the samples associated with the batch where the known quantity sample was taken should be considered unlikely to have been fully recovered in analysis. These should be assigned quality code **C**.

Replicates and duplicates

All replicates and duplicates should be assessed against the following criteria:

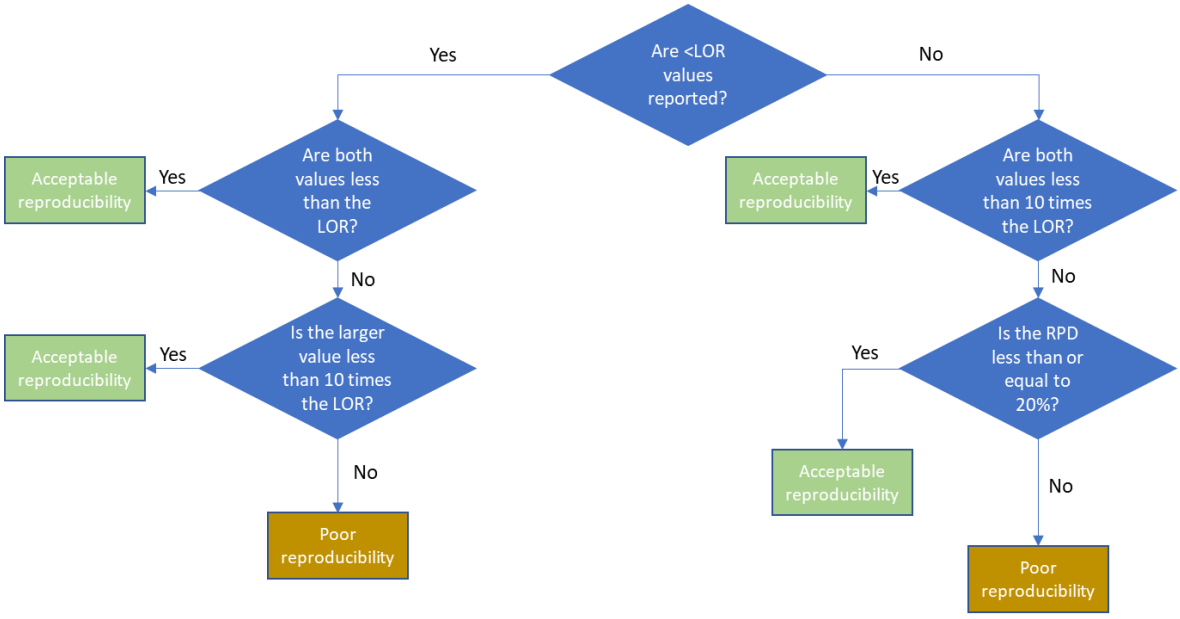


Figure 6. *Replicate and duplicate criteria assessment hierarchy*

Where a result is obtained that is assessed as poor reproducibility, the duplicate sample should be retested. If the duplicate results still is assessed as having poor reproducibility, the samples associated with the batch containing the duplicates should be considered as having poor reproducibility. These should be assigned quality control code **D.**

Where a batch of samples has failures of two quality control criteria, the results should be considered suspect and suitable as an estimate only. These should be assigned quality control code **E**.

Finally where a batch of samples has failure of all three quality control criteria, the samples should be considered unsuitable and not able to be reported. These should be assigned quality control code **F**.

6.4 Corrective Actions

If responses are required due to failures of any of the quality control criteria, it is the responsibility of the staff member to report the failure to the Water Quality Leader. The following hierarchy is to be used for corrective actions:

1. Retesting: The first response in any situation where a quality control sample fails is to require re-analysis and this should be recorded in the sampling spreadsheet '_MIP_WQ_Sampling Info_MASTER' within the notes column. Revised results will be re-issued from the reporting laboratory and will automatically supersede previous results uploaded in the EnviroSys database. EnviroSys maintains a change record for any data updated.
2. Failure of one quality control criteria: The results should be assigned the relevant quality code in the EnviroSys database and highlighted as requiring more detailed examination on the next sampling event.
3. Failure of more than one quality control criteria: The technicians responsible for collecting the samples should be consulted to see if there were any unusual situations (e.g. bad weather, lack of ice, bottle breakage etc) that may have led to a possible failure. If none were present, then the laboratory should also be consulted to examine if there were any potential issues during analysis that may lead

to the failure of quality control criteria. The results should be assigned the relevant quality code in EnviroSys and notes made in the sampling spreadsheet highlighting that a failure on the next round will trigger a detailed investigation.

4. Repeat failure of more than one quality control criteria: If a sample batch fails more than one criteria for the next round of sampling, detailed investigation should be undertaken. This includes consulting with field and laboratory staff as noted above, but should also consider potential for retraining, reassessment of SOPs and investigation of alternate laboratories to evaluate parallel analysis. The Water Quality Leader should also notify the WTMIP Leader regarding the issue for consideration of other remediation steps.

Results of all quality control results, and possible actions, should be stored in the sampling spreadsheet '_MIP_WQ_Sampling Info_MASTER' so that ongoing records are kept in case of repeat issues.

7 References

AS/NZS 5667.1.1998 (2016) Water quality - Sampling - Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples, Standards Australia, 1998 (reconfirmed 2016)

DES. 2018. Monitoring and Sampling Manual: Environmental Protection (Water) Policy. Brisbane: Department of Environment and Science, Queensland Government.

APHA, AWWA, WEF, Standard Methods for the Examination of Water and Wastewater – 21st Edition, American Public Health Association, American Water Works Association, Water Environment Federation, published by the American Public Health Association, 2005

8 Version Control

Document History	Date	Amendment:	Amended by:	Reviewed by:	Approved by:
Version 1.0	13/2/2020	First version of document prepared	Dr. Tony Weber (Alluvium) with input from Chris Algar, Suzette Argent, Emma-Lee Harper & Alicia Buckle (Terrain NRM)	Alicia Buckle, Emma-Lee Harper & Suzette Argent (Terrain NRM) Dr. Ryan Turner (DES, WQI)	Charles Hammond (Terrain NRM) 13/02/20