Background information on water quality measurements using *in situ* water quality instruments

1 Purpose and scope

This document provides background information on *in situ* water quality measurements prior to undertaking water quality sampling.

2 Associated documents

Physical and chemical assessment:

- *Water quality sampling using in situ water quality instruments*
- *Chlorophyll a sample collection methods*
- *In situ water quality sampling using a Secchi disc*

3 Introduction

In situ water quality sampling is the measurement of physical and chemical parameters in a water body at the time of sampling. This is usually done because the measured parameters change rapidly (for example temperature). The data is as valid as data measured in a laboratory provided the field instruments are calibrated. *In situ* data are often required to aid the interpretation of other water quality results.

The most common method of measuring *in situ* water quality is with a multi-parameter water quality instrument (Figure 1). The sonde of a multi-parameter water quality instrument is a collection probes that measure individual parameters. Whilst the configurations of probes vary with each instrument, the most common are dissolved oxygen (DO), temperature, pH, electrical conductivity (EC), turbidity and depth. Probes are available that measure other parameters such as chlorophyll, oxidation reduction potential (ORP), ammonia, ammonium, nitrate and chloride. Single parameter instruments are also available (e.g. a pH meter).

Probes that measure nutrients and chlorophyll must be regularly checked against laboratory analysed samples. Chlorophyll probes, in particular, may only provide relative concentrations of chlorophyll in a water column, and need to be calibrated with chlorophyll in water samples collected on the same field trip.

4 Overview of measurements

4.1 Temperature

Accurate temperature measurements are required for accurate determinations of pH, specific electrical conductivity, and dissolved oxygen. Stratification is common in summer months when surface waters are much warmer than bottom waters. Accordingly, unless the water is shallow (less than 0.5m) and flowing, take temperature readings at different (measured) depths (along with other parameters) in order to define the stratification (if present). Use markings on meter cable if depth sensors are not available on your equipment.

Warm water is less capable of retaining dissolved oxygen than cold water. For this reason, temperature should be measured at the same place in the waterbody where dissolved oxygen is measured. This ensures the resulting data relate to the same body of water at the same time.

The toxicity of ammonia and cyanide changes depending on temperature. Therefore temperature must always be measured when monitoring ammonia and cyanide.

Figure 1: Testing waters with a multi-parameter water quality meter

4.2 pH

The pH measures the acidity or alkalinity of water, with a pH of 1 being strongly acidic, a pH of 7 being neutral, and a pH of 14 being strongly basic (or alkaline). Generally, the pH of fresh surface waters are between 6.5 and 8.0, and the pH of most marine waters is close to 8.2 (ANZECC and ARMCANZ 2000). Marine water generally has a stable pH as the high concentrations of dissolved carbonates provide a high buffering capacity (resistance to pH change) by neutralising any hydrogen ions (from acid). There are many processes (natural or human induced) that may elevate or decrease pH of water. For example, acid rock drainage (natural or human induced) or acid sulfate soils can decrease the pH of a water body to 2, or an algal bloom can increase pH readings to 9.5.

The pH changes the toxicity of ammonia, aluminium and cyanide, and must be measured at the same time and location when analysing for these chemicals.

4.3 Dissolved oxygen (DO)

Dissolved oxygen (DO) are reported in units of milligrams of oxygen gas (O_2) dissolved in each litre of water (i.e. mg/L) or as a percentage of the maximum amount of DO that is possible in a waterbody at a specified temperature and salinity (% saturation). Most multi-parameter water quality instruments containing DO sensors compensate automatically for temperature and salinity when calculating DO saturation (verify by checking the user manual for the instrument). DO concentrations are dependent on atmospheric pressure, and this is taken into account during instrument calibration.

Considerable differences between DO concentrations at the surface and at depth in waterbodies can result from stratification of the water column, due to temperature or salinity effects. This effect is usually most pronounced in summer months when surface waters are considerably warmer than deeper waters.

Degradation of a natural waterway, by interference in the natural flow and/or the build-up of excessive nutrients, can cause the development of stagnant conditions and excessive growth of aquatic plants and/or algae. Under natural conditions with high algal density during daylight, super-saturation (more than 100 per cent DO) can occur. Excess DO can lead to 'gas bubble disease' in fish, where oxygen bubbles can form in the vascular system, gill lamellae and eyes, amongst other organs, which can lead to death. In addition, where algal and plant growth is excessive (as indicated by high DO reading), algal and plant respiration at night can deplete the available dissolved oxygen sufficiently to result in a fish kill. Therefore, the time of day dissolved oxygen is collected can be important for interpretation of data. It is preferable (if possible) that DO readings are taken very early in the morning when the lowest dissolved oxygen levels will be present. DO at concentrations of less than 2 mg/L can be associated with fish kills. Low DO measurements are also often caused by the introduction of large loads of organic matter into waterways at the start of the wet season or due to organic matter from sewage spills.

The Queensland Water Quality Guidelines (DEHP 2009) present DO measurements as % saturation whereas DO measurements associated with fish kills tend to be presented as mg/L, and therefore both measures (mg/L and % saturation) should be recorded.

4.4 Electrical conductivity (EC)

Electrical conductivity (EC), often simply called conductivity, is a measure of the ability of water to conduct an electrical current. The ability to conduct an electric current is due to the presence of dissolved salts. Thus, EC is used to calculate salinity and the concentration of dissolved salts in a waterbody. The formal unit for conductivity is siemens per metre (S/m), however microsiemens per centimetre (µS/cm) is more commonly used when measuring fresh or brackish waters, and millisiemens per centimetre (mS/cm) when measuring estuarine and marine waters.

EC varies with temperature, and values reported are usually corrected to 25°C. Such data are known as Specific Conductance. A difference of 5°C can alter conductivity by approximately 10%. Many conductivity instruments have compensation functions so that EC at 25°C can be read directly (verify by checking the instruments manual). However, if the meter does not automatically compensate for the temperature, a manual correction can be made by using the formula:

$$K_{25} = \frac{K_t}{1 + 0.019\ (t-25)}$$

where:

K_{25} = corrected (25°C) electrical conductivity of the water (Specific Conductance)

K_t = electrical conductivity at the measured temperature (t°C)

t = water temperature (°C) where and when electrical conductivity is measured

4.5 Salinity

Salinity is the measure of the dissolved salt content of a body of water. Salinity in parts per thousand (g/L) can be calculated from conductivity at 25°C using the formula:

$$S = a_1(K_{25}) + a_2(K_{25})^2 + a_3(K_{25})^3 + a_4(K_{25})^4 + a_5(K_{25})^5 + a_6(K_{25})^6$$

where:

S = salinity (in g/kg, % or parts per thousand (‰))

K_{25} = electrical conductivity of the water at 25°C (in mS/cm)

$a_1 = 4.98 \times 10^{-1}$

$a_2 = 9.54 \times 10^{-3}$

$a_3 = -3.941 \times 10^{-4}$

$a_4 = 1.092 \times 10^{-5}$

$a_5 = -1.559 \times 10^{-7}$

$a_6 = 8.789 \times 10^{-10}$

4.6 Total dissolved solids

Total dissolved solids (TDS) include total dissolved salts but also non-ionised species (e.g. sugars, other organics and colloidal particles). Therefore, TDS values are often larger than total dissolved salt values for the same water sample.

Total dissolved solids are either determined by:

- filtering a water sample, evaporating a weighed amount of filtrate to dryness in a weighed dish, drying to a constant weight, , and determining the increased mass of the dish, or
- calculating the approximate TDS (for typical fresh waters) from conductivity using the formula:

$$TDS = MF \times K_{25}$$

where:

TDS = Total Dissolved Solids (mg/L)

MF = multiplication factor (0.64 for drinking water[1], 0.67 for livestock drinking water[2])

K_{25} = EC of the water at 25°C (mS/cm)

4.7 Turbidity

The turbidity of a water body is a measure of the presence of soluble, suspended and colloidal particles that hinder the transmission of light through water. Turbidity can potentially affect the rate of photosynthesis, and therefore the growth of plants or algae in the water body. Turbidity can be measured directly using probes, and is typically expressed using Nephelometric Turbidity Units (NTU).

4.8 Transparency

Transparency is a measure of how far light can pass through water. In waterways this translates to how deeply sunlight penetrates through the water. The degree of transparency at any given depth of water affects the rate of photosynthesis, and hence the growth of coral, plants or algae in the water body. Transparency can be measured using the Secchi disc (see *In situ water quality sampling using a Secchi disc* document). A Secchi disc has the advantage over a single turbidity reading as it integrates turbidity over depth (where variable turbidity layers are present).

5 References and additional reading

ANZECC and ARMCANZ 2000, *Australian and New Zealand guidelines for fresh and marine water quality*, Volume 2, Aquatic ecosystems, Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand.

DEHP (Department of Environment and Heritage Protection) 2009, *Queensland Water Quality Guidelines*, Version 3, ISBN 978-0-9806986-0-2.

NHMRC and NRMMC (National Health and Medical Research Council and National Resource Management Ministerial Council) 2011, *Australian drinking water guidelines*, National Water Quality Management Strategy, Paper 6. NHMRC and NRMMC, Commonwealth of Australia, Canberra. Available from: www.nhmrc.gov.au/guidelines/publications/eh52.

[1] Australian drinking water guidelines (NHMRC and NRMMC 2011)

[2] Australian and New Zealand guidelines for fresh and marine water quality (ANZECC and ARMCANZ 2000)