



Australian Government

National Land & Water Resources Audit

An initiative of the Australian Government

ESTUARINE, COASTAL AND MARINE HABITAT INTEGRITY

INDICATOR HEADING

Estuarine, coastal and marine habitat condition

INDICATOR GUIDELINE

Turbidity/water clarity

Recommended by the Audit for further consideration

This version of the guideline has been developed through the National Land and Water Resources Audit and was informed by expert review and broad consultation on national indicators via national coordination committees and their associates. Version 1 – June 2008 does not yet have the final endorsement of any jurisdiction. The document is for guidance only and is presented to provide a basis for on-going discussion. It may require further consideration by a jurisdictional based reference group before national endorsement.

Turbidity/water clarity

Status of indicator agreement

The National Land & Water Resources Audit (the Audit) coordinates the collation of data to support reporting on natural resource condition required under the National NRM Monitoring and Evaluation Framework (National M&E Framework).

The National M&E Framework identifies three requirements for monitoring natural resource condition:

- a set of resource condition indicators to measure progress toward the agreed national outcomes on a medium and long term basis
- a set of indicators for monitoring community and social processes relevant to or affected by NRM programs, as well as measures of the adoption of sustainable development and production techniques
- contextual data pertinent to the indicator being considered.

The Audit Advisory Council has agreed to a process for achieving a practical set of indicators under the National Monitoring and Evaluation Framework.

This process is to:

- obtain on-going **recommendations** from the relevant **National Coordination Committees** for each thematic area (including “Matters for Target”) on appropriate indicators, protocols and information needs
- seek **endorsement** from the **Audit Advisory Council** that the indicators and protocols can be implemented at the national, state / territory and regional levels
- seek **agreement** from the Natural Resource Policies and Programs Committee (**NRPPC**) (or the Marine and Coastal Committee –**MACC**- for Estuarine, Coastal and Marine) that the indicators will be used and promoted by jurisdictions to underpin evaluations of NRM initiatives.

The NRPPC and MACC report to the Natural Resource Management Ministerial Council (NRMMC).

Introduction

This suite of “indicator guidelines” is relevant to the Estuarine, Coastal and Marine Habitat Integrity Matter for Target.

Two indicator headings are identified:

1. Estuarine, coastal and marine habitat extent and distribution
2. Estuarine, coastal and marine habitat condition.

Initially, 31 potential indicators were developed to measure the effect of the stressors on ecosystem condition (physical/chemical and biological) and habitat extent (Scheltinga et al., 2004). These indicators were reviewed at a national workshop (Souter and McKenzie, 2006) and further refined to 19 nationally agreed indicators (Table 1).

Drawing on a series of state/territory trials and national consultations; the documentation for the indicators has been modified from a “protocol” format that sought to define both measurement standards and reporting (information) products to one that presents “guidelines” for the collection and storage of monitoring data.

These “indicator guidelines” should be used as standards for the collection, collation and storage of data in order to assist NRM service providers and community groups make observations that can potentially be pooled and re-used at a later date.

Ten ECM indicators were prioritised and guidelines have been developed through extensive consultation and reviewed by key experts in the field.

Table 1. Nationally agreed ECM Resource Condition Indicators. Indicators prioritised for documentation and included in this document are shown with an asterisk.

Indicator heading	Indicator
Estuarine, coastal and marine habitat extent and distribution	1. Extent and distribution of key habitat types*
Estuarine, coastal and marine habitat condition	Biological condition 2. Algal blooms 3. Animal or plant species abundance* 4. Chlorophyll a* 5. Coral bleaching 6. Mass mortality events 7. Pest species (number, density, distribution)* 8. Targeted pathogen counts 9. Vertebrates impacted by human activities Physical/chemical condition 10. Dissolved oxygen* 11. Nutrients* 12. pH 13. Presence / extent of litter (marine debris)* 14. Salinity (EC) 15. Sedimentation/erosion rates* 16. Shoreline position 17. Temperature 18. Toxicants (in water / sediments / biota)* 19. Turbidity / water clarity*

Water clarity

Matter for target:

Estuarine, coastal and marine habitat integrity

Indicator heading:

Estuarine, coastal and marine habitat condition

Indicator name:

Water clarity

This document presents the recommended monitoring guidelines for collecting, collating and reporting information on water clarity for national, state/territory and regional application.

1. Definition

This indicator documents the water clarity of estuarine, coastal or marine waters.

AIM: To determine annual median turbidity levels and Secchi depth in estuarine or coastal waters and compare with local guidelines.

INDICATOR 1: Turbidity of a waterbody.

INDICATOR 2: Secchi depth of a waterbody.

2. Rationale

[BT]“Turbidity is a measure of water clarity or murkiness. It is an optical property that expresses the degree to which light is scattered and absorbed by molecules and particles. Turbidity results from soluble coloured organic compounds and suspended particulate matter in the water column. Suspended particulate matter may include clay and silt (e.g. suspended [inorganic] sediment), and [organic] detritus and organisms” (OzCoast and OzEstuaries, <http://www.ozcoast.org.au/indicators/turbidity.jsp>).

[BT]“Measurements of turbidity are very useful when the extent of transmission of light through water is the information sought, as in the case of estimation of the light available to photosynthetic organisms. Another strong point in favour of turbidity is that field measurement is straightforward and can be performed rapidly by monitoring teams. Turbidity is a measurement included in Waterwatch programs nationally. Because of the simplicity of the technique and its widespread use, large volumes of turbidity data are becoming available for national evaluation and interpretation. The turbidity of Australian coastal waters is an important issue in relation to benthic productivity, since many highly valued seagrass and algal bed communities have evolved in, and depend on, conditions of high light penetration (low turbidity)” (Ward *et al.*, 1998).

Increased turbidity reduces the amount of light available for photosynthesis which may decrease the phytoplankton biomass and therefore result in increased dissolved nutrients in the water column.

[BT]“Turbidity caused by suspended sediment can smother benthic organisms and habitats, and cause mechanical and abrasive impairment to the gills of fish and crustaceans (ANZECC/ARMCANZ, 2000b). Suspended sediment also transports contaminants (particulate nutrients, metals and other potential toxicants) (ANZECC/ARMCANZ, 2000b), promotes the growth of pathogens and waterborne diseases, makes marine pests difficult to detect (Neil, 2002) and can lead to dissolved oxygen depletion in the water column if it is caused by particulate organic matter. Overall, unnaturally high turbidity levels can lead to a reduction in the production and diversity of species.” (OzCoast and OzEstuaries, <http://www.ozcoast.org.au/indicators/turbidity.jsp>).

For further information on turbidity and fine sediment loads including a detailed explanation of what turbidity is, what causes turbidity, the significance of turbidity, coastal systems susceptible to turbidity, the impacts of fine sediment loads on coastal waterways and the biophysical parameters that may indicate that a waterway is receiving excess sediment loads, see the OzCoast and OzEstuaries website (<http://www.ozcoast.org.au/indicators/turbidity.jsp>).

Secchi depth is a measure of water clarity, and is measured in situ using a Secchi disc, as described in Australian Standard AS 3550.7-1993.

3. Monitoring methodology

Several different methods are available for measuring water clarity, ie from boats, shore or remote sensing. The methods used will depend on factors such as location and resources available but should be consistent with national/state guidelines.

The methodology below is currently the best identified for the majority of people. Local experts as well as the laboratory being used to perform the analysis should be consulted before conducting any monitoring program, particularly with regard to aspects of the quality control and quality assurance of data collected.

3.1 Monitoring locations

Turbidity and Secchi depth measurements should be taken from, the mid estuary and, where possible, from the upper and lower reaches of an estuary. In estuaries where little or no monitoring has been done before, initial samples should ideally be taken along the length of the estuary at intervals of 10% of the total length (but not closer than every 3 km). This will allow the ‘worst’ areas to be identified and continually monitored in the future. Areas near sediment point source inputs should also be monitored. A similar logic should be used to select sites within coastal waters.

3.2 Monitoring frequency required

The direct monitoring of turbidity and Secchi depth needs to be conducted on a monthly basis on the falling tide. Turbidity can be monitored continuously or during/after specific events. Generally, turbidity measurements are most useful when continuously monitored using moored, continuously recording sensors.

A profile of turbidity through different depths should be monitored to examine any stratification effects (ie lack of mixing).

3.3 Data measurement method

[BT] *Use of the Secchi disc for water clarity measurements*

The Secchi disc value is used as a semi-quantitative visual index of depth of light penetration into a waterbody. The black and white disc is lowered into the water

column and the distance below the water surface where the black/white interface disappears is the Secchi disc depth.

Equipment required:

- 300 mm diameter plastic disc painted with quadrants alternating in flat black and flat white waterproof paints
- A length of non-stretch rope (eg surveyor's Kinlon poly-chain) with measurement graduations
- 3 kg weight.

Site procedures from boat

1. Prepare field recording sheets.
2. Locate the site using a Global Positioning System.
3. Remove sunglasses or tinted eyewear.
4. Lower the weighted Secchi disc into the water on the sunny side of the boat and ensure the disc lowers vertically into the water column.
5. Record the depth at which the black/white interface disappears as D1. This depth is measured from the top of the disc to the water surface. Measurement precision is half the distance between graduations on the rope or line.
6. Raise the disc slowly and record the depth at which the black/white interface becomes visible as D2.
7. The average of these two depths is the limit of visibility of the Secchi depth.
8. Record on the field recording sheet.

Important notes:

- Environment
 - Light environment: shade can either enhance or limit the perception of the black/white quadrants. For consistency both spatially and temporally, Secchi disc depth is taken away from shade.
 - Angle of the sun: observations should be taken between two hours after sunrise and two hours before sunset.
 - Water surface consistency: the consistency of the water surface, which can be affected by wind chop, ground swell, surface slicks and floating matter, can affect the perception of the black/white interface. The conditions of the day must be recorded at each site.
- Observer
 - Eyesight:– the perception of the black/white interface is affected by the visual acuity

of the observer. All observations should be made with corrected vision.

- Sunglasses: darkened or tinted glasses can affect the perception of the black/white interface and must be removed before observation.
- Observer accuracy: perception of the black/white interface is subjective and varies between observers.

Calibration of tether:

The Secchi disc tether is checked for graduation accuracy annually using a measuring tape.

Calibration of disc:

The black quadrants of the disc are repainted annually.

Use of a turbidity probe for water clarity measurements

A light beam is shone through a water sample and the light scattered off the particles present is measured by a photodiode at 90 degrees to the light source.

Equipment required:

- Turbidity probe mounted in a sonde, an instrument designed to be lowered through the water column. Alternatively, obtain water from the specified depths and use a field turbidity meter.

Procedures (middle of estuary, from boat):

1. Prepare field recording sheets.
2. Calibrate probe prior to sampling.

Site procedures:

3. Locate the site using a Global Positioning System.
4. While in a slow forward motion, cut the engine to prevent fouling.
5. Turn the meter on and place the sonde in the water.
6. Allow the probes to stabilise for a minimum of 90 seconds for the initial site reading.
7. Record information 0.2 m below the surface (to reduce the impact of surface slicks) on the field recording sheet.
8. Save the data in the hand-held data logger.
9. Repeat at 2 m intervals until the bottom is reached allowing a minimum of 30 seconds for the probes to stabilise at each depth. After 30 seconds, proof stability is attained by readings remaining constant for 10 seconds. If values fluctuate, continue measuring in 10

second increments until stability occurs

10. Between sites, fill the PVC tube holding the sonde with water from the previous site to maintain probe stability

Shore-based procedures:

1. Prepare field recording sheets.
2. Calibrate probe prior to sampling.

Site procedures:

3. Locate the site using a Global Positioning System.
4. Rinse a clean 20 L plastic bucket three times and fill with sample water.
5. Place the sonde in the bucket and allow to stabilise.
6. Before taking measurements, ensure the water sample is well mixed by continuously stirring the bucket with the sonde.
7. Record information on the field recording sheet.
8. Save the data in the hand-held data logger.
9. Between sites, fill the PVC sonde holding tube with water from the previous site to maintain probe stability.

Calibration of a turbidity probe (before going out into the field):

The turbidity probe must be calibrated weekly.

1. Remove the sensor guard and check the turbidity sensor for damage. Pay particular attention to the wiper. If the cloth for the wiper is damaged, replace the wiper.
2. Prepare and label six calibration cups with formazin turbidity standards as follows (these standards are chosen based on the range of turbidity of the water sampled):
 - 0 NTU rinse
 - 0 NTU standard
 - 400 NTU rinse
 - 400 NTU standard
 - 800 NTU rinse
 - 800 NTU standard.
3. Turn the meter on and choose the 3-point calibration from the turbidity calibration menu (some probes only use a 2-point calibration method, 0 NTU and another 'higher')

standard).

4. Rinse the turbidity sensor with distilled water and then dry and immerse the sensor in the 0 NTU rinse.
5. Dry again and place the sensor in the 0 NTU standard.
6. Engage the turbidity wiper and after it has stopped calibrate the first point. Record the pre-calibration value for the first point in the turbidity section of the Individual Sensor Calibration History Documentation.
7. Rinse the sensor with distilled water and repeat steps 1–6 using the 400 NTU and 800 NTU standards taking care to invert each standard to re-suspend the formazin in solution. Do not shake as air bubbles affect the sensor's accuracy.

Post calibration: go into run mode for meter and test the accuracy of the calibration. To do this:

1. Rinse the turbidity sensor with distilled water and then dry and immerse the sensor in the 0 NTU rinse.
2. Dry again and place the sensor in the 0 NTU standard.
3. Engage the turbidity wiper and after it has stopped, record the post-calibration value in the turbidity section of the Individual Sensor Calibration History Documentation.
4. Repeat steps 1 and 2 with the 400 NTU Standard and 800 NTU standard

The post calibration values should lie within the following acceptance limits:

- 0 NTU = +/- 0.1 NTU
- 200 NTU = +/- 10 NTU
- 800 NTU = +/-40 NTU

If the sensor is reading outside these limits, it must be recalibrated. If the sensor cannot be calibrated to read within these limits, it must be replaced/serviced. If only the lower standard (0 NTU) is outside the limit, a one-point calibration can be completed to bring the reading within the prescribed limits. If this fails, the sensor must be replaced/serviced.

3.4 Data collation / calculation method

Data for a specific site should be collated over the study period and the median value calculated and compared against the relevant guidelines.

3.5 Data storage and management

Data should be stored by state/territory agencies and by the collectors (if different) of the data. If possible, the public should have access to the data (and report summaries) through a website hosted by state/territory government.

3.6 Data analysis and interpretation

When examining 'ambient' turbidity and Secchi depth, data from at least one year should be used in the analysis. Median turbidity and Secchi depth values should be compared with the relevant water quality guidelines. 'National' default trigger values have been listed in the 'Water Quality Guidelines' for coastal waterways in different geographic regions (ANZECC/ARMCANZ, 2000a); these trigger values are superseded in Queensland by the 'Queensland Water Quality Guidelines' (EPA, 2006). Local guidelines (which supersede both national and state/territory ones) may be available for some estuaries.

Excerpts from the guidelines for State of the Environment reporting (Ward et al., 1998):

[BT]Turbidity is an operationally determined parameter that is related to the 'murkiness' of water. Depending on the instrument used, it is quantified by light either scattered from, or absorbed by, suspended particles and colloidal material, with perhaps minor contributions also from coloured dissolved organic matter (e.g. humic substances). Reasons for measuring turbidity differ slightly from those for other water quality indicators. Although increases in turbidity are often related to deterioration in water quality, it does not follow that the severity of the contamination can be assessed. For example, severe clouding of water by clay minerals and humic substances from soil disturbance may be unsightly, but not toxic to fish or other aquatic creatures. However, a lesser loading of metal-rich particles from mine tailings discharge, or high-clarity waters loaded with aluminium arising from run-off from acid sulphate soils, can devastate biota.

High turbidity values are the data of interest, and change in waters from low to high values. A problem encountered is one shared with other water quality indicators – the need for national baseline data that make it possible to distinguish values and patterns that depart from the norm and may indicate environmental problems or anomalies.

Shifts in long-term patterns (in space and time) of turbidity in estuarine and coastal waters are of concern given the unique values of Australia's seagrass beds and algal assemblages, but these can only be determined by evaluation against a baseline of data. In general terms, a tendency to increasing turbidity, for longer periods or over greater areas, would usually be considered detrimental.

High turbidity levels can be the result of tidal current resuspending sediments, inputs from catchment/shoreline erosion, dredging, dissolved organic matter and/or algal blooms. Further information on the interpretation of turbidity data can be found at the OzCoast and OzEstuaries website (<http://www.ozcoast.org.au/indicators/turbidity.jsp>).

The Department of the Environment, Water, Heritage and the Arts (Australian Government) provides water quality targets online for turbidity (<http://www.environment.gov.au/water/publications/quality/targets-online/index.php>).

3.7 Reliability, validity and quality assurance

Quality assurance and control measures are important to minimise avoidable errors in the data and thus give more confidence in the data collected and conclusions made. Individuals collecting the data must have had adequate training in sample collection. Instrument calibration and/or laboratory quality assurance should be regularly examined and recorded.

3.8 Metadata

Metadata documentation should be completed for all datasets (see Appendix A). The metadata statement should be consistent with current ANZLIC standards, which now comply with ISO 19115.

See the following web site for the Metadata Profile:

http://www.osdm.gov.au/ANZLIC_MetadataProfile_v1-1.pdf?ID=303

For the Metadata Guidelines see:

http://www.osdm.gov.au/ANZLIC_MetadataProfileGuidelines_v1-0.pdf?ID=397

4. Reporting / information products

4.1 Audiences

Regional natural resource managers will be the main audience for information on specific estuaries and coastal waters. State and national managers will be more interested in the collation of information up into regional summaries/reports.

4.2 Products

At the smallest reporting level (ie at the site scale) turbidity levels are probably most easily represented in tables, graphs (against time) or box plots showing the median and 20th and 80th percentiles for the location. Box plots are an easy way to visually compare the data with reference data/guidelines. Once sufficient information on turbidity levels is available for a location, it will be possible to produce graphs or tables showing trends/change and their statistical significance. These trends can then be reported as an estimate of change. The number of times turbidity levels exceed appropriate guidelines and the turbidity levels associated with extreme events resulting in increased sediment transport (eg floods) could also be reported.

When reporting at an estuary or larger scale, the number of sites in which annual median turbidity and/or Secchi depth measurements exceed the relevant guidelines should be reported (see Tables 1 and 2 for scoring categories).

Table 1. Scoring categories and indicator values for turbidity as an indicator of estuarine condition.

<i>Condition Indicator 1: turbidity</i>	
Condition score	Indicator values
Excellent	0% of sites exceed guidelines
Good	1-19% of sites exceed guidelines
Fair	20-50% of sites exceed guidelines
Poor	51-99% of sites exceed guidelines
Very Poor	100% of sites exceed guidelines

Table 2. Scoring categories and indicator values for Secchi depth as an indicator of estuarine condition.

<i>Condition Indicator 2: Secchi depth</i>	
Condition score	Indicator values
Excellent	0% of sites exceed guidelines
Good	1-19% of sites exceed guidelines
Fair	20-50% of sites exceed guidelines
Poor	51-99% of sites exceed guidelines
Very Poor	100% of sites exceed guidelines

4.3 Confidentiality

Data confidentiality is the responsibility of the data custodian.

4.4 Data collation/calculation method

The development of regional summaries/reports for state and national managers will require the collation of local datasets. Scoring categories provided for local scoring (Tables 1 and 2) can also be used for scoring at a regional level.

4.5 Data analysis, integration and interpretation information

Any national/regional level information products (ie interpreted products) need to be linked to the regional/local information that was used to create it (ie to the relevant state/territory and regional databases/information systems). Any specific methodologies, assumptions, additional data and changes in confidence in the interpreted products need to be stated.

4.6 Data access and storage

National level products should be developed with the needs of the various stakeholders in mind. Data access and storage for national level products should be through a nationally known and recognised web site such as 'OzCoast and OzEstuaries'. Links should then be made to state/territory and regional web sites to access the underlying products/datasets.

4.7 Product definition statement

Each product should have a product definition statement. The product definition statement follows the same general format as the metadata statement referred to in 3.8.

5. Current national activities

There are no national activities related to water clarity monitoring.

6. Future development

More relevant (ie at least state/territory) turbidity and Secchi depth guidelines need to be developed.

7. Links to other indicators

Animal or plant species abundance (indicator)

Sedimentation/erosion rates (indicator)

Turbidity/suspended particulate matter in aquatic environments (matters for targets)

8. Further information

ANZECC/ARMCANZ. 2000a, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.

http://www.mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_water_quality

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http://www.mincos.gov.au/publications/australian_guidelines_for_water_quality_monitoring_and_reporting

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9. Glossary

- Baseline data – Information collected to form a reference set for comparison of a second set of data collected at a later time; used to interpret changes over time usually after some condition has changed.
- Benthic – On the bed or bottom of a body of water or in the bottom sediments.
- Biomass – The total weight of all living organisms in a biological community or of a particular species/group.
- Spatial – Pertaining to space or distance.
- Temporal – Pertaining to time.

Appendix A: Metadata statement

Monitoring program	The name of the monitoring program
Custodian of data/Contact	The business name and address/contact details of the custodial organisation or responsible party
Summary of program	A brief narrative summary of the program
Geographic extent	The ordinary name(s) of the locations where the data was collected (ie study area)
Indicators monitored	List of all indicators monitored
Method of data collection	Summary of the methods used to collect the data
Past/future sampling	Description of when sampling started, how often it occurred, when it will finish
Quality assurance	Description of the quality control/assurance procedures used
Data access	1) Location: Where and how the data is stored. If it can be accessed remotely (ie from a website) 2) Format in which dataset is stored and available 3) Any restriction or legal prerequisites that may apply to access and use the data
Other comments	Any other comments
Information source(s)	Where information on the program can be found (eg reports, literature, websites)
Date metadata created	Date when the metadata record was created